BANZAI ENVIRONMENTAL

PALAEONTOLOGICAL DESKTOP ASSESSMENT

HARMONY WEST WITS RECLAMATION AND DEPOSITION PROJECT

May 2026

COMPILED FOR: Environmental Impact Management Services (Pty) Ltd (EIMS)

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.

PALAEONTOLOGICAL CONSULTANT: Banzai Environmental (Pty) Ltd

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SIGNATURE: 

The 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: Checklist for Specialist studies conformance with Appendix 6 of the EIA Regulations of 2014 (as amended).		
Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	**The relevant section in the report**	**Comment where not applicable.**
1.(1) (a) (i) Details of the specialist who prepared the report	Page ii and Section 3 of Report – Contact details and company and Appendix 1	-
(ii) The expertise of that person to compile a specialist report including a curriculum vita	Section 3 – refer to Appendix 1	-
(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 – Methods and ToR	-
(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 7	-
(d) The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Executive Summary, Section 8	Desktop Assessment
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 4 Approach and Methodology	-
(f) details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Executive Summary, Section 8	

Table 1: Checklist for Specialist studies conformance with Appendix 6 of the EIA Regulations of 2014 (as amended).		
Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	**The relevant section in the report**	**Comment where not applicable.**
(g) An identification of any areas to be avoided, including buffers	Executive Summary, Section 8	
(h) A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 4 – Geological and Palaeontological history	
(i) A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.1 – 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	Executive Summary, Section 8	
(k) Any mitigation measures for inclusion in the EMPr	Executive Summary, Section 8	
(l) Any conditions for inclusion in the environmental authorisation	Executive Summary, Section 8	
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Executive Summary, Section 8	
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Executive Summary, Section 8	
(n)(iA) A reasoned opinion regarding the acceptability of the proposed activity or activities; and		
(n)(ii) If the opinion is that the proposed activity, activities, or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Executive Summary, Section 8	-

Table 1: Checklist for Specialist studies conformance with Appendix 6 of the EIA Regulations of 2014 (as amended).		
Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	**The relevant section in the 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 was handled as part of the Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) process.
(p) A summary and copies of any comments that were received during any consultation process	N/A	Not applicable. To date, no comments regarding heritage resources that require input from a specialist have been raised.
(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	

LIST OF ABBREVIATIONS

BA	Basic Assessment
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
CA	Competent Authority
ECO	Environmental Control Officer
EIMS	Environmental Impact Management Services (Pty) Ltd
EMPr	Environmental Management Programme
ESO	Environmental Site Officer
Ga	Gigaannum (billions of years ago)
HIA	Heritage Impact Assessment
Ma	Millions of years ago
MISS	Microbially induced sedimentary structures
NEMA	National Environmental Management Act
NHRA	National Heritage Resources Act
PDA	Palaeontological Desktop Assessment
PIA	Palaeontological Impact Assessment
PSSA	Palaeontological Society of South Africa
SAHRA	South African Heritage Resources Agency
SAHRIS	South African Heritage Resources Information System
S&EIA	Scoping & Environmental Impact Assessment
ToR	Terms of Reference
TSF	Tailings Storage Facility

GLOSSARY OF TERMS

Fossil

A fossil is the preserved remnants or vestiges of a long-dead organism, generally from millions of years ago. Fossils can be mineralized skeletons, shells, or other hard pieces of ancient animals and plants, as well as impressions, moulds, and casts left in sedimentary rock when the organism's remains decomposed and left an impression. Fossils provide valuable insights into the evolution and biodiversity of ancient species, allowing scientists to study and understand their evolution and biodiversity.

Heritage

That which is inherited and forms part of the National Estate (historical places, objects, fossils as defined by the National Heritage Resources Act No 25 of 1999).

Heritage resources

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

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

Palaeontology

Palaeontology, also referred to as "palaeontology" in American English, is the scientific study of ancient life and the history of life on Earth as recorded in the fossil record. Palaeontologists are scientists who study and analyse the remnants of plants, animals, and other species from the distant past, as well as traces of their activity such as footprints and burrows. Palaeontologists attempt to understand the evolution, diversity, and interactions of life forms throughout Earth's history by researching fossils and the geological environment in which they are found, which can provide vital insights into the planet's geological and biological past.

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

EXECUTIVE SUMMARY

Banzai Environmental was appointed by Environmental Impact Management Services (Pty) Ltd (EIMS) to conduct a Palaeontological Desktop Assessment (PDA) for the proposed West Wits Reclamation and Deposition Project, located near Carletonville in the Merafong City Local Municipality, West Rand District Municipality, Gauteng Province. The assessment was undertaken in accordance with the National Environmental Management Act (NEMA, Act No. 107 of 1998) and the National Heritage Resources Act (NHRA, Act No. 25 of 1999, Section 38), with the aim of determining whether fossil material could potentially be present within the development footprint, evaluating the likely impact of the proposed development on palaeontological heritage, and identifying appropriate mitigation measures where necessary.

The study area is underlain by sedimentary and volcanic strata of the Rooihoogte, Timeball Hill, and Hekpoort Formations of the Pretoria Group (Transvaal Supergroup), with post-depositional diabase intrusions also present. The northern section of the pipeline corridor runs along the margin of the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup). According to the SAHRIS Palaeosensitivity Map, the Timeball Hill Formation is rated High in palaeontological sensitivity, the Hekpoort Formation Moderate, Rooihoogte Formation Low and the diabase Zero, and the Malmani Subgroup Very High (Almond et al., 2013). These findings are consistent with the DFFE National Environmental Web-Based Screening Tool, which places the broader study area within a High to Very High sensitivity zone.

It is important to note, however, that this elevated sensitivity is driven primarily by microbially induced sedimentary structures, stromatolitic horizons, and carbonate-hosted microbial assemblages, not by discrete, recoverable macrofossils. Where the pipeline corridor approaches the Malmani Subgroup, construction will be undertaken above ground on surface-mounted supports, with ground disturbance confined to localised, shallow footings. Taken together, the microscopic nature of the palaeontological material and the minimal subsurface disturbance anticipated meant that a formal site investigation was not considered necessary.

In terms of palaeontological impact, the construction phase is the only development phase with the potential to affect palaeontological heritage. Pre-mitigation, construction-phase impacts are rated Medium to High; with appropriate mitigation in place, residual impacts are reduced to Medium to Low. No significant palaeontological impacts are anticipated during the operational or decommissioning phases. The No-Go Alternative would result in a Neutral impact on palaeontological heritage, while cumulative impacts are considered Low both pre- and post-mitigation, falling within acceptable limits. On this basis, the proposed development is not considered sensitive in terms of palaeontological resources, and no further studies, ground-truthing, or specialist mitigation are recommended.

If any fossils are detected, the Chance Find Protocol must be implemented and adhered to throughout all phases of construction. Should fossil remains or trace fossils be encountered at any stage, whether on the surface or exposed by excavation, the Environmental Control Officer (ECO) or site manager must immediately halt activities in the affected area, preserve the material *in situ* where feasible, and notify SAHRA: (111 Harrington Street, Cape Town; PO Box 4637, Cape Town, 8000 Tel: 021 462 4502; Fax: +27 (0)21 462 4509; www.sahra.org.za).

Any fossil material recovered from the site requires a collection permit from SAHRA prior to removal, and must ultimately be housed in an accredited institution, a recognised museum or university collection. All reporting and fieldwork must meet the minimum standards for palaeontological impact studies as set out by SAHRA (2012).

These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the proposed West Wits Reclamation and Deposition Project.

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1. INTRODUCTION

Randfontein Estates Limited (a subsidiary of Harmony Gold Mining Company) (hereafter referred to as the applicant) has appointed Environmental Impact Management Services (Pty) Ltd (EIMS) as the Environmental Assessment Practitioner (EAP) to assist with undertaking the required authorisation processes and to compile and submit the required documentation in support of application for the proposed new Deelkraal II Tailings Storage Facility (TSF) project and associated infrastructure on a site located approximately 13km southwest of Carltonville in the Merafong City Local Municipality, West Rand District Municipality, Gauteng Province (i.e. the Proposed Harmony West Wits Reclamation and Deposition Project).

The Applicant requires additional deposition capacity for West Wits region's operations. The applicant plans on constructing the Deelkraal 2 Tailings Storage Facility (TSF) to cater for the additional future capacity. This TSF will receive residue from Kusasalethu, and Savuka plants and will also assist in returning process water for reclaiming the existing Deelkraal 1 TSF and Kusasalethu TSF for processing at Kusasalethu plant. Additional planned infrastructure includes slurry, potable, sewage and return water pipelines, access roads, pump stations, a return water dam and a power line. Proposed upgrades to the existing Kusasalethu plant are also proposed as part of the project.

The Savuka Plant treats tailings from the Savuka Dormant TSFs (Old North TSFs) at a rate of 330 000 tpm and deposits the subsequent tailings on Savuka 5 & 7 TSFs. Harmony plans on remining Deelkraal Dormant TSF and Kusasalethu TSF. These TSFs will be processed through the Kusasalethu Plant at 500 000 tpm. The planned Life of Mine (LOM) for the West Wits region exceed the available deposition capacity of the existing TSFs Therefore, a readily available buffer TSF is required for present reclamation operations to seamlessly continue before Deelkraal Dormant TSF and Kusasalethu TSF are remined.

The only viable readily available TSF options are the extension of Deelkraal Dormant TSF and Blyvoor Gold TSF 6. Blyvoor Gold TSF 6 is not owned by Harmony. The Kusasalethu Plant will accommodate future reclamation operations and will therefore need site/s to deposit the tailings. Harmony owns virgin ground, located adjacent to the Deelkraal Dormant TSF, that can be used i.e. the proposed Deelkraal II TSF. The footprint geometry will accommodate the future reclamation operations deposition rate and capacity. The proposed TSF will cover an area of approximately 450 ha as shown in Error! Reference source not found.-2.

The West Wits Reclamation and Deposition (WWR) Concept Study explores ways to unlock the potential of recycling historic gold tailings using the existing Kusasalethu and Savuka process plants and infrastructure. The Concept Study (SGS Bateman, 2024) evaluated different options for the treatment of the Deelkraal and Kusasalethu Tailings Storage Facilities (TSF) at the existing processing plants. The reworked tailings will be deposited on a new TSF, referred to as Deelkraal #2, assumed to be constructed on a site adjacent to the existing Deelkraal TSF. While reviewing the preliminary metallurgy testwork results it became evident that the Deelkraal TSF contained higher grades of accessible gold and it was

agreed that that TSF would be reclaimed first, with the Kusasalethu TSF being reclaimed thereafter (SGS Bateman, 2024). Based on current designs the maximum height for a TSF on this site would be 65 m high.

In addition to the Deelkraal II TSF, additional infrastructure is also proposed, as follows:

- A new Return Water Dam in the vicinity of the Deelkraal II TSF;
- Upgrades to the existing Kusasalethu plant including new gold and uranium sections;[1]
- Slurry pipelines:
    - Reclaimed Slurry from Deelkraal 1 to Kusasalethu (10,6km);
    - Kusasalethu Barren Tailings to Deelkraal 2 (10,2km); and
    - Reclaimed Slurry from Kusasalethu TSF to Kusasalethu Plant (2km).
    - Slurry pipeline from Kusasalethu Plant to Savuka TSF (4,97km); and
    - Slurry pipeline from Savuka plant to DF5 TSF (2,9km).
    -
- Process Water Pipelines:
    - Process Water Feed from Kusasalethu Plant to Deelkraal Reclamation(9.54km) –
    - Return Water Feed to Kusasalethu Process Water Tank (9,58km); -
    - Driefontein DP2 Pump Station to North Boundary Dam (4,78km); -
    - DP2 feed to Tau Tona Reverse Osmosis Plant (0,1km); -
    - Nursery Pumpstation #3 to Kusasalethu Process Water Tank (9km); and
    - 2 Process Water pipelines from Kusasalethu Plant to Savuka White Tanks (8km).
- Powerlines:
    - Powerline from Kusasalethu Plant to the existing Deelkraal TSF (9.2km);
    - Powerline from Kusasalethu Plant to the Kusasalethu TSF (1.8km); and
- Potable Water pipeline from Rand Water supply point to the Deelkraal TSF (8.52km).
- New Deelkraal TSF reclamation plant.
- New access roads adjacent to pipelines and around TSF, in areas where no access road is already in place.
- New Reclamation Pump Stations.
- Topsoil stockpiles.
- Ancillary construction infrastructure including workshops and laydown areas.

All pipelines listed above will be flanged steel pipelines installed above-ground on pre-cast concrete plinths and a 3.5m wide access road, adjacent to the pipelines, will be cleared/graded to provide access for construction, maintenance and inspections (for areas where no access road is already in place). The

[1] These upgrades will be located within the existing plant's footprint

diameter of the pipelines will be confirmed in the EIA phase once further design information becomes available.

Of particular relevance to this palaeontological assessment is the design of all proposed pipelines. All slurry, process water, and potable water pipelines will be installed as flanged steel pipelines above ground on pre-cast concrete plinths, with no subsurface trenching. A 3.5 m wide access road will be cleared adjacent to the pipelines where no access road is already in place. This above-ground installation method significantly limits the depth and extent of ground disturbance across the development footprint, and is a critical factor in the palaeontological impact assessment, particularly where the pipeline corridor runs along the margin of the Malmani Subgroup (see Sections 5 and 8).

1.1 Assumptions and limitations

The geology of the area is the focal point of geological maps, and the sheet explanations of the Geological Maps were not intended to focus on palaeontological heritage. Many inaccessible areas of South Africa have never been examined by palaeontologists, and data is typically dependent solely on aerial pictures. Locality and geological information in museums and university databases is out of date, and data acquired in the past is not always adequately documented.

Comparable Assemblage Zones in other places are also used to provide information on the existence of fossils in areas that have not before been recorded. When similar Assemblage Zones and geological formations are used for Impact studies, it is commonly assumed that exposed fossil exists within the footprint.

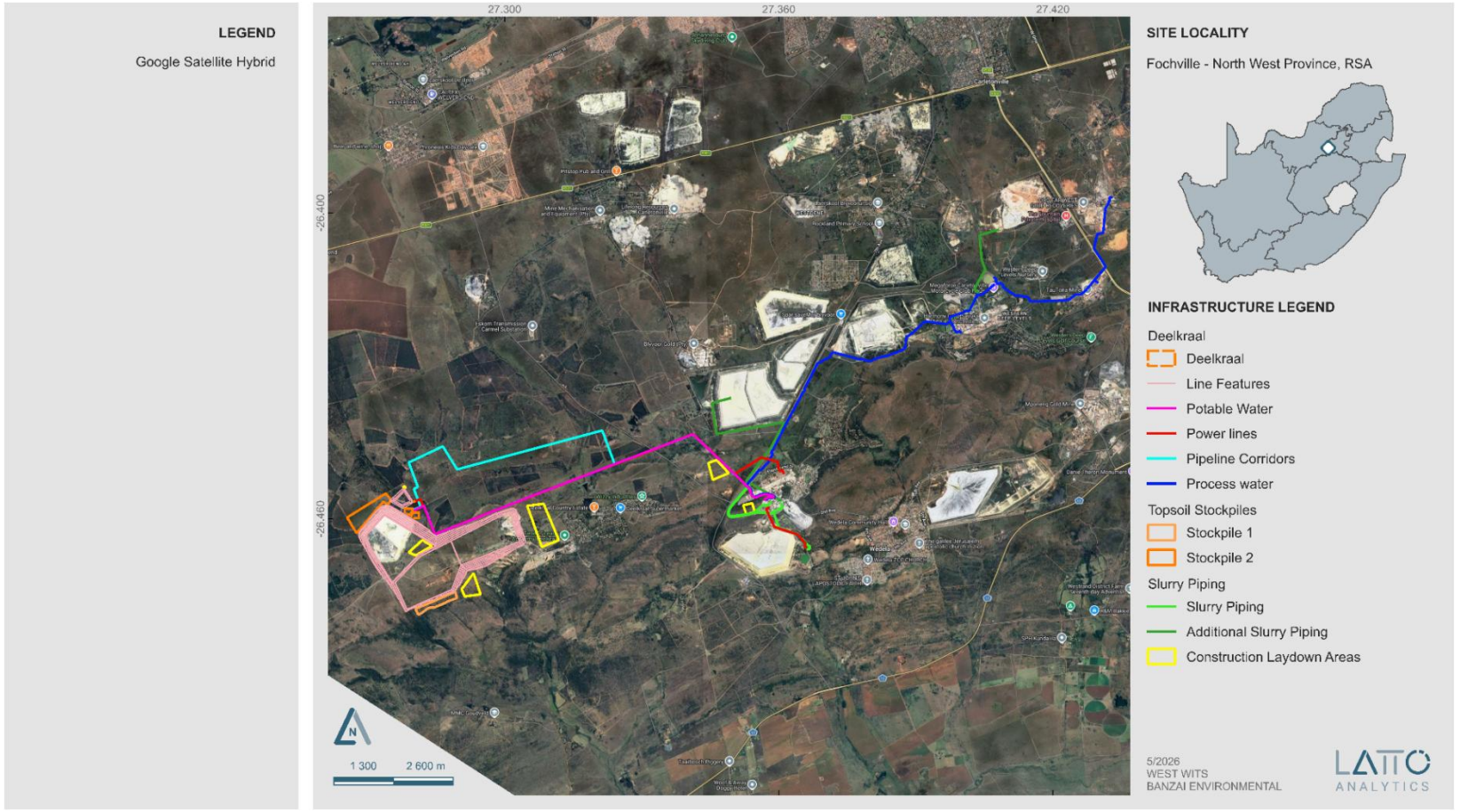


Figure 1: Regional locality of the proposed new Deelkraal II TSF project and associated infrastructure southwest of Carltonville in the Merafong City Local Municipality, West Rand District Municipality, Gauteng Province.



Figure 2: Regional topography of the proposed Harmony West Wits Reclamation and Deposition Project showing the development footprint in the context of Randfontein NU, Ventersdorp NU, Boskop SP and Emfuleni NU...

2. QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

This study has been conducted by Mrs Elize Butler, palaeontologist of Banzai Environmental (Pty) Ltd. She has conducted approximately 950 palaeontological impact assessments for developments in the Free State, KwaZulu-Natal, Eastern, Western, and Northern Cape, Northwest, Gauteng, Limpopo, and Mpumalanga. She has an MSc (*cum laude*) in Zoology (specializing in Palaeontology) from the University of the Free State, South Africa and has been working in Palaeontology for more than thirty years. She has experience in locating, collecting, and curating fossils, including exploration field trips in search of new localities in the Karoo Basin. She has been a member of the Palaeontological Society of South Africa (PSSA) since 2006 and has been conducting PIAs since 2014.

A short CV is attached in Appendix 2 while a detailed CV could be provided on request.

3. LEGISLATION

The cultural and palaeontological heritage in South Africa is safeguarded by an extensive legal framework that facilitates the identification, assessment, and management of heritage resources. The National Heritage Resources Act (NHRA, Act 25 of 1999) serves as the foundation of this framework, delineating heritage resources as components of the national estate, which include cultural, historical, archaeological, palaeontological, and geological elements of importance. Section 3 of the NHRA explicitly encompasses “all items retrieved from the soil or waters of South Africa, including archaeological and palaeontological artefacts, meteorites, and rare geological specimens.” Palaeontological heritage is non-renewable and safeguarded by Section 35, which prohibits the disturbance, destruction, or removal of fossils without a valid permit from SAHRA or the pertinent Provincial Heritage Resources Authority (PHRA). Fossil specimens must be gathered and preserved in a recognised institution in accordance with SAHRA's minimal standards.

The NHRA is governed nationally by SAHRA and provincially by PHRAs, establishing a three-tier system that reflects South Africa's cooperative governance framework. This method facilitates the identification, safeguarding, and preservation of heritage treasures for the advantage of current and future generations.

3.1 Supporting Legislation and Regulations

Heritage and palaeontological management are incorporated into the comprehensive environmental framework, specifically via the National Environmental Management Act (NEMA, Act 107 of 1998) and the Environmental Impact Assessment (EIA) Regulations (GN 982, 2014, updated by GN 326, 2017). Section 23(2)(b) of NE

MA mandates integrated environmental management to "identify, predict, and assess the actual and potential impacts on the environment, socio-economic conditions, and cultural heritage."

Government Notice 320 (GN 320, Government Gazette 43110, 20 March 2020) delineates broad prerequisites for executing initial site sensitivity verification in the absence of a specific assessment process. GN 320 necessitates desktop analysis, first site inspections, verification of land usage, and the submission of corroborative documentation (e.g., photographs). Table 1 encapsulates these standards and their alignment within this report.

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Table 1:GN 320 Reporting Requirements

GN 320	Relevant section in report
2.2(a) Desktop analysis using satellite imagery	Section 1
2.2(b) Preliminary on-site inspection	Executive Summary and Section 7
2.3(a) Confirm or dispute environmental sensitivity	Executive Summary and Section 7
2.3(b) Motivation and evidence	Executive Summary and Section 7

3.2 Heritage Screening – DFFE National Web-based Environmental Screening Tool

A heritage screening was performed utilising the DFFE National Web-based Environmental Screening Tool, as mandated by GN 982. The April 2025 standards state that thematic layers for cultural, archaeological, and paleontological resources encompass only a finite number of documented sites, which may be extensively dispersed and perhaps located at any development site. The directives specify:

A Heritage Impact Assessment is required for all developments, irrespective of the sensitivity indicated on the archaeological and cultural heritage theme layers. A Palaeontological Impact Assessment is required for all developments according to the SAHRIS PalaeoSensitivity Map, regardless of the indicated sensitivity.

Both HIA and PIA are required to adhere to Section 38(3) of the NHRA or Section 41(1) of the KwaZulu-Natal Amafa and Research Institute Act (KNARIA, Act 5 of 2018) for developments in KwaZulu-Natal. Should be conducted by a certified expert; Adhere to the stipulations of GN 326 Appendix 6; and for submission to SAHRA, meet the applicable minimum standards (2007 for HIA; 2012 for PIA).

According to the DFFE National Environmental Web-based Screening Tool, the palaeontological sensitivity of the broader development area is classified as High to Very High. This is consistent with the

SAHRIS PalaeoMap, which records Very High (red) sensitivity for the Malmani Subgroup and High (orange) sensitivity for the Rooihoogte and Timeball Hill Formations.

3.3 Section 38: Heritage Impact Assessments

Section 38 of the NHRA regulates the administration of heritage resources concerning development. Specific forms of development necessitate a Heritage Impact Assessment (HIA), including: Linear constructions including roads, pipelines, canals, or electricity lines that surpass 300 meters; Bridges or other constructions surpassing 50 meters; Changes that modify site characteristics, including those beyond 5,000 m², involving three or more properties, or rezoning exceeding 10,000 m².

Upon activation, SAHRA or the pertinent PHRA must be informed, and the HIA is required to: Identify and delineate heritage resources within the impacted region; Evaluate importance and possible effects; Evaluate viable alternatives; Propose suitable mitigation and management strategies.

3.4 Integration with Environmental Assessment

Section 38(8) of the NHRA permits the amalgamation of historic evaluations with NEMA EIA processes, thereby eliminating redundancy. Palaeontological Impact Assessments (PIAs) can be executed as a component of the Heritage Impact Assessment (HIA) under the overarching Environmental Impact Assessment (EIA) framework. This guarantees the prompt identification, safeguarding, and administration of fossil heritage throughout development planning.

If no environmental process is necessary, but the development activates Section 38(1) of the NHRA, SAHRA or the pertinent PHRA assumes the role of the authorising authority and may mandate a comprehensive HIA, encompassing public participation and stakeholder interaction.

4. METHODS AND TERMS OF REFERENCE

This Palaeontological Assessment is part of the HIA Report. The PDA's goals are to: 1) identify the palaeontological significance of the rock formations in the footprint; 2) evaluate the palaeontological magnitude of the formations; 3) clarify the impact on fossil heritage; and 4) make recommendations for how the developer might protect and minimize potential harm to fossil heritage, according to the "SAHRA APM Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports".

Calculations of the palaeontological state of each rock segment and the potential impact of development on fossil history take into account the palaeontological status of the rocks, the type of development, and the amount of bedrock removed.

The Provisional DFFE Screening Tool, the SAHRIS Palaeosensitivity map, all Palaeontological Impact Assessment reports for the same area, Google Earth images, topographical and geological maps, as well as academic articles about specimens from the development area and Assemblage Zones, are all used to create scoping reports.

When the development footprint has a moderate to high palaeontological sensitivity, a field-based assessment is necessary. A desktop or field assessment of the exposed rock is used to evaluate the significance of the proposed development's impact, and recommendations for more research or mitigation are made. Excavations for the project often only take place during the building phase, changing the terrain and destroying or permanently encasing fossils at or below the ground surface. Then, access to Fossil Heritage will no longer be available for academic study.

When doing a site investigation, a palaeontologist examines the local development as well as the quantity and variety of fossils found there. This can be demonstrated by looking at representative fossiliferous rock exposures (most igneous and metamorphic rocks are not fossiliferous, whereas sedimentary rocks contain fossil heritage). Examined rock exposures frequently contain a sizeable portion of the stratigraphic unit, which is primarily made up of recently exposed (unweathered) rock. These exposures may be man-made (such as quarries, open building excavations, even railway and road cuttings) or natural (such as cliffs, and dongas as well as rocky outcrops along stream or river banks). It is usual practice for palaeontologists to record well-preserved fossils (GPS, and stratigraphic data) during field assessment examinations.

Although mitigation is often done prior to construction, it may take place if potentially fossiliferous bedrock is revealed. Fossil collection and documentation are examples of mitigation. A permit from SAHRA must be obtained before beginning any fossil excavation, and the material must be stored at an authorized facility. When mitigation is properly used, it is possible to have a positive impact by raising awareness of the palaeontological past of the area.

By physically evaluating bedrock outcrops to determine their lithology and fossil richness and crisscrossing the development footprint, one can assess an area's fossil potential. Because the presence of fossils at the surface is so unexpected, an average sample size of the region is investigated. To be clear, however, the lack of fossils in a development footprint does not automatically suggest that there is no palaeontologically important material present on the site (on or below the ground surface).

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;
- Describe of the proposed project and provide information regarding the developer and consultant who commissioned the study;
- Describe location of the proposed development and provide geological and topographical maps
- Provide palaeontological and geological history of the affected area;
- Identify sensitive areas to be avoided (providing shapefiles/kmls) in the proposed development;
- Evaluate 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 are impacts that result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities.
- Fair assessment of alternatives (infrastructure alternatives have been provided);
- Recommend mitigation measures to minimise the impact of the proposed development; and
- Detail the implications of specialist findings for the proposed development (such as permits, licenses etc).

5. GEOLOGICAL AND PALAEONTOLOGICAL HISTORY

The West Wits Reclamation and Deposition study area lies near Carletonville in Gauteng Province, mapped on the 1:250 000 West Rand 2626 (1986) geological sheet (Council for Geoscience, Pretoria). The local geology comprises sedimentary and volcanic strata of the Pretoria Group, specifically the Rooihoogte, Timeball Hill (Vt), and Hekpoort (Vh) Formations, all forming part of the Transvaal Supergroup, together with unfossiliferous diabase (di) intrusions (Figure 3). The northern section of the pipeline corridor additionally runs along the margin of the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup).

According to the SAHRIS Palaeosensitivity Map, palaeontological sensitivity across the study area varies considerably: the Malmani Subgroup is rated Very High (red), the Timeball Hill Formation High (orange),

the Hekpoort Formation Moderate (green), the Rooihoogte Formation Low (blue), and the diabase Zero (grey) (Almond et al., 2013). This is consistent with the DFFE National Environmental Web-Based Screening Tool, which places the broader study area within a High to Very High sensitivity zone. It is important to note, however, that this elevated rating is driven primarily by microbially induced sedimentary structures (MISS), stromatolitic horizons, and carbonate-hosted microbial assemblages, not by discrete, recoverable macrofossils. Where the pipeline corridor approaches the Malmani Subgroup, construction will be undertaken above ground on surface-mounted supports, with ground disturbance confined to localised, shallow footings. Given the microscopic nature of the palaeontological material and the minimal subsurface disturbance anticipated, a formal site investigation was not considered necessary.

Within the study area the Malmani Subgroup is present but undifferentiated, forming a roughly 2 km-thick sequence of limestones and dolomites deposited in warm, shallow seas over billions of years as marine microorganisms and fine-grained sediment slowly accumulated. The higher magnesium content of the dolomites distinguishes them from typical limestones, and the unit is associated historically with lime mines and palaeocave fossil deposits.

What makes the Malmani carbonates particularly significant is their stromatolite assemblage, among the oldest fossils preserved on Earth. These layered, dome-like structures were built progressively by cyanobacteria, microscopic photosynthesising organisms that thrived when the atmosphere contained very little free oxygen. Over geological time, their metabolic activity gradually transformed that atmosphere in what is known as the Great Oxidation Event (Eroglu et al., 2017). Although intact algal cells are rarely recovered, the stromatolite structures themselves are well documented (Truswell and Eriksson, 1972, 1973, 1975; Eriksson and Altermann, 1998; Sumner, 2000; Schopf, 2006) and continue to provide valuable insight into early Earth conditions.

The Rooihoogte Formation is the oldest stratigraphic unit in the study area and the lowermost succession of the Pretoria Group. It consists predominantly of reddish-brown to greenish-grey shales, ferruginous mudstones, and subordinate siltstones and sandstones, interpreted as products of fluvial and deltaic environments. The fine-grained nature of these sediments has allowed the preservation of MISS and rare stromatolitic horizons, representing some of the oldest evidence of life on the Kaapvaal Craton (Altermann and Nelson, 1998; Button, 1986).

The Timeball Hill Formation conformably overlies the Rooihoogte Formation and consists of well-bedded shales, mudstones, and characteristic banded iron formations (BIFs) deposited under low-energy, prodelta to distal marine shelf conditions. The unit is notable for preserving rare acritarchs, stromatolites, and laminated organic-rich shales. Acritarchs, microscopic organic-walled microfossils, are regarded as among the earliest indicators of eukaryotic life (Altermann, 2001; Eriksson and Catuneanu, 2004).

The Hekpoort Formation conformably overlies the Timeball Hill Formation and is composed primarily of subaerial basaltic and andesitic lava flows with infrequent volcaniclastic interbeds, dating to approximately 2.05 Ga. As an igneous unit it is largely unfossiliferous; however, rare weathered interflow sedimentary horizons may locally preserve microbial textures, offering limited but scientifically meaningful insight into the evolution of the terrestrial biosphere during the Palaeoproterozoic (Eriksson et al., 2001). This restricted palaeontological potential is reflected in the formation's Moderate sensitivity rating.

The diabase intrusions in the study area are Jurassic in age and therefore younger than the sedimentary and volcanic rocks they intrude, having been emplaced during tectono-thermal events associated with Gondwana rifting. As entirely igneous medium-grained mafic bodies forming sills and dykes, they are considered palaeontologically sterile. The thermal aureoles associated with their emplacement may also have locally altered or destroyed fossil-bearing potential in the immediately adjacent host rocks (Johnson et al., 2006).

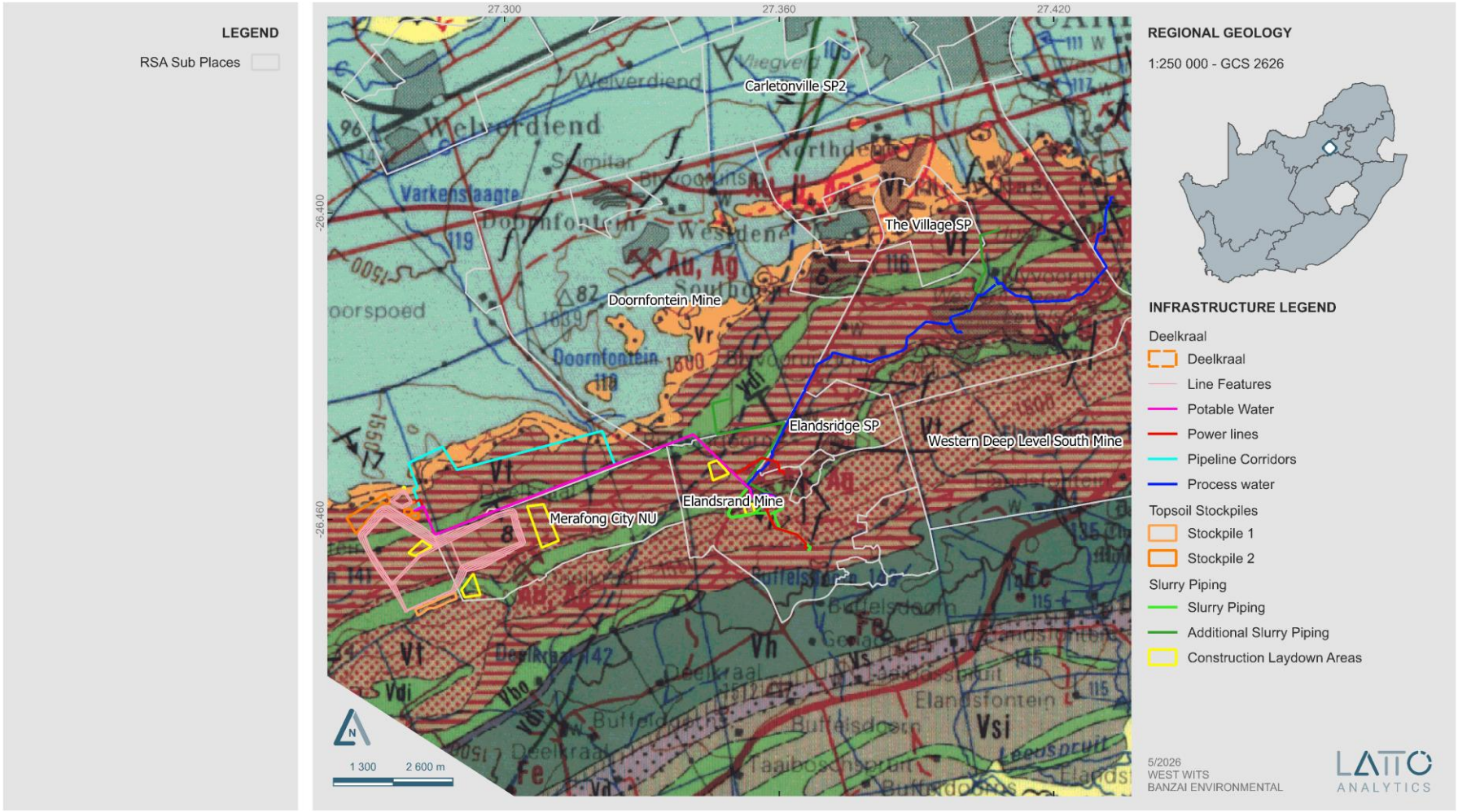


Figure 3: Extract of the 1:250 000 West Rand 2626 (1986) Geological Map (Council for Geoscience, Pretoria) indicating that the study area is underlain by unfossiliferous diabase (di) and sediments of the Timeball Hill (Vt), Rooihoogte (Vr) and Hekpoort (Vh) Formations of the Pretoria Group (Transvaal Supergroup). The northern section of the pipeline corridor runs along the margin of the Malmani Subgroup (Chuniespoort Group). Map source: SAHRIS (www.sahra.org.za).

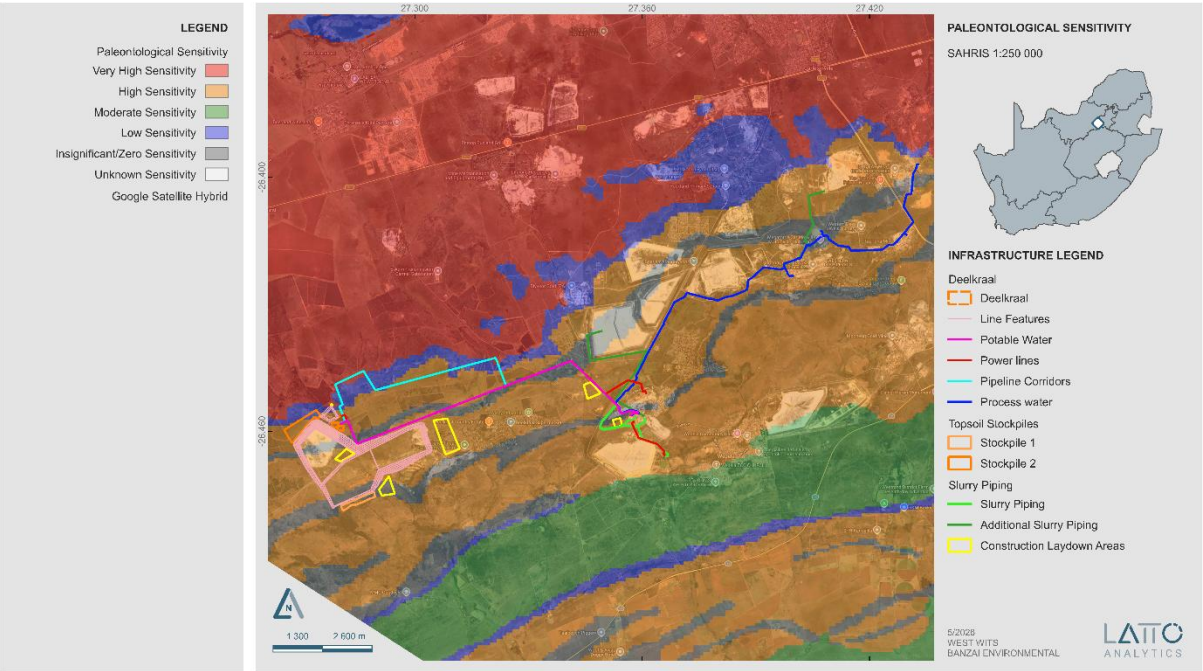


Figure 4: Extract of the SAHRIS PalaeoMap (Council for Geosciences, Pretoria) indicating the palaeontological sensitivity of the proposed Harmony West Wits Reclamation and Deposition Project development area. The Malmani Subgroup is classified as Very High (red), Timeball Hill Formation as High (orange), the Hekpoort Formation as Moderate (green), the Rooihoogte as Low (blue) and and diabase as Zero (grey). Map source: SAHRIS (www.sahra.org.za).

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

Colour	**Sensitivity**	**Required Action**
RED	VERY HIGH	Field assessment and Chance Find Protocol required
ORANGE	HIGH	Desktop assessment required; field assessment likely based on outcome
GREEN	MODERATE	Desktop assessment required
BLUE	LOW	No palaeontological studies required; Chance Find Protocol required
GREY	INSIGNIFICANT/ZERO	No palaeontological studies are required
WHITE/CLEAR	UNKNOWN	Minimum desktop assessment required

The Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup), present along the northern margin of the pipeline corridor, is classified as Very High (red) in palaeontological sensitivity. Construction in this zone will be

above ground on pre-cast concrete plinths, with ground disturbance confined to localised shallow footings (see Section 5).

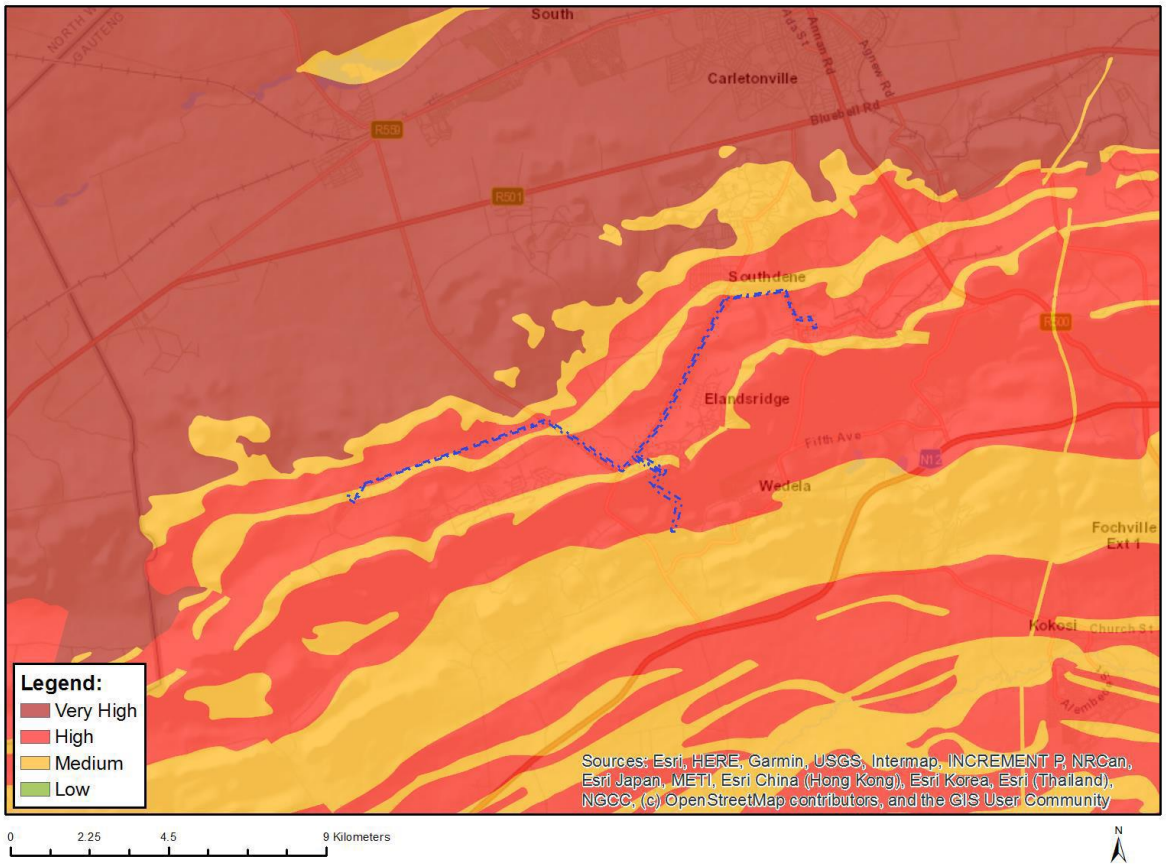


Figure 5: Palaeontological sensitivity of the proposed Harmony West Wits Reclamation and Deposition Project development area according to the DFFE National Environmental Web-based Screening Tool (2023), indicating High (red) and Medium (yellow) palaeontological sensitivity.

The SAHRIS PalaeoMap (Figure 3) indicates a Very High (red) Palaeontological Sensitivity for the study area, consistent with the DFFE Screening Tool (Figure 4). However, this elevated sensitivity rating is attributable primarily to the presence of microbially induced sedimentary structures (MISS) and stromatolitic horizons within the Rooihoogte and Timeball Hill Formations, features that are microscopic to mesoscopic in nature and are not recoverable as discrete macrofossils during a standard field-based site investigation. Similarly, the Very High sensitivity assigned to the Malmani Subgroup relates to its stromatolite assemblage, which, while scientifically significant, does not constitute visible, collectable fossil material in the conventional sense.

Given that the palaeontological sensitivity of the study area is driven by microbial structures rather than macrofossils, and that the proposed pipeline will be constructed above ground with ground disturbance limited to localised, shallow footings, a formal palaeontological site investigation was not considered necessary. The likelihood of encountering significant, recoverable fossil material during construction is considered negligible.

6. 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)
- Google Earth© satellite imagery.
- A Google Earth map with polygons of the proposed development was obtained from EIMS.
- 1:250 000 West Rand 2626 (1986) Geological Map (Council for Geosciences, Pretoria)
- Palaeosensitivity map on SAHRIS (South African Heritage Resources Information System) website
- Department of Forestry, Fisheries and the Environment (DFFE) Screening tool report
- Published geological and palaeontological literature as well as PIAs in the area.

7. IMPACT ASSESSMENT METHODOLOGY

The EIMS Impact Assessment Methodology was utilized for this project.

Table 3: Summary of Impacts

Identifier	
Discipline	Palaeontology
Impact	Loss of fossil Heritage
Alternative	No
Phase	Construction
Event	Normal Operation
Pre-Nature	-1
Pre-Extent	1
Pre-Duration	5
Pre-Magnitude	4
Pre-Reversibility	5
Consequence	-3.75
Pre-Probability	3
Pre-Mitigation Significance	-11.25
Pre-Mitigation Significance	-Medium to High
Post-Nature	-1
Post-Extent	1
Post-Duration	5
Post-Magnitude	1
Post-Reversibility	5
Consequence2	-3
Post-Probability	2
Post-mitigation Significance	-6
Post-Mitigation Significance	- Medium to Low
Confidence	
Cumulative Impact	1
Irreplaceable loss	3
Priority Factor	-1.25
Final score	-7.5
Post-Mitigation Significance	- Medium to Low

8. FINDINGS AND RECOMMENDATIONS

The West Wits Reclamation and Deposition study area is underlain by sedimentary and volcanic strata of the Rooihoogte, Timeball Hill, and Hekpoort Formations of the Pretoria Group (Transvaal Supergroup), as well as post-depositional diabase intrusions. According to the SAHRIS Palaeosensitivity map, the Rooihoogte and Timeball Hill Formations are classified as High Sensitivity, the Hekpoort Formation has a Moderate Sensitivity, and the diabase is rated as having Zero Palaeontological Sensitivity (Almond *et al*, 2013; SAHRIS website). In alignment with these Sensitivities, the National Department of Forestry, Fisheries and the Environment (DFFE) screening tool identifies the broader study area as falling within a High Palaeontological Sensitivity.

The geological and palaeontological context of the Harmony West Wits Reclamation and Deposition Project is described in detail in Section 5. In summary, the study area is underlain by the Rooihoogte, Timeball Hill, and Hekpoort Formations of the Pretoria Group, with post-depositional diabase intrusions. The northern section of the pipeline corridor runs along the margin of the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup), which carries a Very High palaeontological sensitivity rating on the SAHRIS PalaeoMap. The DFFE National Environmental Web-Based Screening Tool places the broader study area within a High to Very High sensitivity zone.

The pipeline will be installed above ground on pre-cast concrete plinths. Ground disturbance in this zone is confined to shallow footings for support structures. No bulk excavation or trenching is proposed. The elevated Very High sensitivity of the Malmani Subgroup is driven by microbially induced sedimentary structures (MISS), stromatolitic horizons, and carbonate-hosted microbial assemblages, not by discrete, recoverable macrofossils. These two factors together, the nature of the palaeontological material and the above-ground construction method, justify the desktop-only approach and confirm that a formal site investigation was not required.

In terms of palaeontological impact, the construction phase is the only development phase with the potential to affect palaeontological heritage. Pre-mitigation, construction-phase impacts are rated Medium to High; with appropriate mitigation in place, residual impacts are reduced to Medium to Low. No significant palaeontological impacts are anticipated during the operational or decommissioning phases. The No-Go Alternative would result in a Neutral impact on palaeontological heritage, while cumulative impacts are considered Low both pre- and post-mitigation, falling within acceptable limits. On this basis, the proposed development is not considered sensitive in terms of palaeontological resources, and no further studies, ground-truthing, or specialist mitigation are recommended.

That said, the unexpected is always possible. A Chance Find Protocol must be implemented and adhered to throughout all phases of construction. Should fossil remains or trace fossils be encountered at any

stage — whether on the surface or exposed by excavation — the Environmental Control Officer (ECO) or site manager must immediately halt activities in the affected area, preserve the material in situ where feasible, and notify SAHRA: 111 Harrington Street, Cape Town; PO Box 4637, Cape Town, 8000 Tel: 021 462 4502; Fax: +27 (0)21 462 4509; www.sahra.org.za.

Any fossil material recovered from the site requires a collection permit from SAHRA prior to removal, and must ultimately be housed in an accredited institution, a recognised museum or university collection. All reporting and fieldwork must meet the minimum standards for palaeontological impact studies as set out by SAHRA (2012).

These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the proposed West Wits Reclamation and Deposition Project.

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9. MITIGATION AND EMPR REQUIREMENTS

The naturally preserved remnants (or traces) of plants or animals imbedded in rock are known as fossils. These plants and animals existed millions of years ago in the geologic past. Fossils are incredibly valuable and difficult to replace. It is possible to identify the environmental conditions that occurred in a certain geographical area millions of years ago by analysing fossils.

This fact sheet is intended for construction workers and foremen. It describes what to do if fossil material is discovered accidently during construction.

It is the responsibility of the project's Environmental Site Officer (ESO) or site manager to train the workers and foremen on what to do if a fossil is accidently discovered. In the absence of the ESO, a member of staff must be designated to be accountable for the effective application of the chance discovery protocol so that the conservation of fossil material is not jeopardized.

If fossils are discovered during excavation, the following method shall be followed.

9.1 Legislation

Cultural Heritage in South Africa (includes all heritage resources) is protected by the National Heritage Resources Act (Act No 25 of 1999) (NHRA). According to Section 3 of the Act, all Heritage resources include “all objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens”.

The NHRA protects and owns the state's palaeontological legacy, which is unique and non-renewable. It is consequently the responsibility of the state to manage and protect fossils on behalf of South African citizens. According to Section 35 of the NHRA, palaeontological resources may not be excavated, broken,

transferred, or destroyed by any development without previous assessment and a permit from the relevant heritage resources authority.

9.2 Chance Find Procedure

- If a chance find is made, the person responsible for the find must immediately stop working, and all work in the immediate vicinity of the find must stop as well.
- The individual who discovered the item must immediately notify his or her direct supervisor, who must then notify his or her management and the ESO or site manager. The ECO or site manager must notify the relevant Heritage Agency (South African Heritage Resources Agency, SAHRA) of the discovery. (Contact information: SAHRA, 111 Harrington Street, Cape Town, South Africa. PO Box 4637, Cape Town 8000, South Africa. Fax: +27 (0)21 462 4509. Tel: 021 462 4502. Web address: www.sahra.org.za). Photographs of the find from various perspectives, as well as GPS coordinates, must be submitted to the Heritage Agency.
- Within 24 hours of the discovery, a preliminary report must be sent to the Heritage Agency, which must include the following: 1) the date of finding; 2) a description of the discovery; and 3) a description of the fossil and its context (depth and position of the fossil), as well as GPS coordinates.
- Photographs of the discovery (the more the merrier) must be of high quality, in focus, and accompanied by a scale. Photographs of the vertical part (side) where the fossil was discovered are also required.
- Upon receipt of the preliminary report, the Heritage Agency will notify the ESO (or site manager) whether a palaeontologist rescue excavation or collection is required.
- The place must be guarded to prevent future damage. There should be no attempt to remove material from their environment. Stabilize the exposed items and cover them with a plastic sheet or sand bags. The Heritage organization will also be able to advise on the best way to protect the find.
- If the fossil cannot be stabilized, the ESO (site manager) may carefully collect the fossil.
- Once the Heritage Agency has received the written authorization, the developer may continue with the development on the affected area.
- Fossil finds must be placed in tissue paper and in an appropriate box while necessary care must be taken to remove any fossil material from the rescue site.

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APPENDIX 1

Assessment Methodology

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

Determination of Significance

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

(P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and Reversibility (R) applicable to the specific impact.

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

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

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

Criteria for Determining Impact Consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. Highly localised, limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property or site boundary, or the area within a few hundred meters of the site)
	3	Local (i.e. beyond the site boundary within the Local administrative boundary (e.g. Local Municipality) or within consistent local geographical features, or the area within 5 km of the site)
	4	Regional (i.e. Far beyond the site boundary, beyond the Local administrative boundaries within the Regional administrative boundaries (e.g. District Municipality), or extends into different distinct geographical features, or extends between 5 and 50 km from the site).
	5	Provincial / National / International (i.e. extends into numerous distinct geographical features, or extends beyond 50 km from the site).
Duration	1	Immediate (<1 year, quickly reversible)
	2	Short term (1-5 years, less than project lifespan)
	3	Medium term (6-15 years)
	4	Long term (15-65 years, the impact will cease after the operational life span of the project)
	5	Permanent (>65 years, no mitigation measure of natural process will reduce the impact after construction/ operation/ decommissioning).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected)
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected, or affected environmental components are already degraded)
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; moderate improvement for +ve impacts; or where change affects area of potential conservation or other value, or use of resources).
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease; high improvement for +ve impacts; or where change affects high conservation value areas or species of conservation concern)

	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease, substantial improvement for +ve impacts; or disturbance to pristine areas of critical conservation value or critically endangered species)
Reversibility	1	Impact is reversible without any time and cost.

	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring very high time and cost.
	5	Irreversible Impact.

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

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

Probability/ Likelihood Scoring

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

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

$$S = C \times P$$

Determination of Significance

	5- Very High[1]	**5**	10	15	20	25

	4- High	4	8	12	16	20
	3- Medium	3	6	9	12	15
	2- Low	2	4	6	8	10
	1- Very low	1	2	3	4	5

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

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

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

Significance Scores

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

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

Impact Prioritization

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

Cumulative impacts; and

The degree to which the impact may cause irreplaceable loss of resources.

To ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impacts' post-mitigation significance (post-mitigation). This prioritisation factor does not aim to detract

from the significance ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the post-mitigation significance based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 5: Criteria for Determining Prioritisation

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

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 5. The impact priority is therefore determined as follows:

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

The result is a priority score which ranges from 2 to 6 and a consequent PF ranging from 1 to 1.5 (Refer to Table below).

Determination of Prioritisation Factor

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

In order to determine the final impact significance (FS), the PF is multiplied by the post-mitigation significance scoring. The ultimate aim of the PF is an attempt to increase the post mitigation environmental risk rating by a factor of 0.5, if all the priority attributes are high (i.e. if an impact comes out with a high medium environmental risk after the conventional impact rating, but there is significant cumulative impact

potential and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a higher significance).

Final Environmental Significance Rating

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

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

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

Nature	-1	Likely to result in a negative/ detrimental impact	CONSEQUENCE ENVIRONMENT
	1	Likely to result in a positive/ beneficial impact	

Extent	1	Activity (i.e. Highly localised, limited to the area applicable to the specific activity)		
	2	Site (i.e. within the development property or site boundary, or the area within a few hundred meters of the site)		
	3	Local (i.e. beyond the site boundary within the Local administrative boundary (e.g. Local Municipality) or within consistent local geographical features, or the area within 5 km of the site)		
	4	Regional (i.e. Far beyond the site boundary, beyond the Local administrative boundaries within the Regional administrative boundaries (e.g. District Municipality), or extends into different distinct geographical features, or extends between 5 and 50 km from the site).		
	5	Provincial / National / International (i.e. extends into numerous distinct geographical features, or extends beyond 50 km from the site).		
Duration	1	Immediate (<1 year, quickly reversible)		
	2	Short term (1-5 years, less than project lifespan)		
	3	Medium term (6-15 years)		
	4	Long term (15-65 years, the impact will cease after the operational life span of the project)		
	5	Permanent (>65 years, no mitigation measure of natural process will reduce the impact after construction/ operation/ decommissioning).		
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected)		
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected, or affected environmental components are already degraded)		
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; moderate improvement for +ve impacts; or where change affects area of potential conservation or other value, or use of resources).		
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease; high improvement for +ve impacts; or where change affects high conservation value areas or species of conservation concern)		
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease, substantial improvement for +ve impacts; or disturbance to pristine		

		areas of critical conservation value or critically endangered species)		
Reversibility	1	Impact is reversible without any time and cost.		
	2	Impact is reversible without incurring significant time and cost.		
	3	Impact is reversible only by incurring significant time and cost.		
	4	Impact is reversible only by incurring prohibitively high time and cost.		
	5	Irreversible Impact		
Probability	1	Improbable (Rare, the event may occur only in exceptional circumstances, the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <5% chance).	PROBABILITY	
	2	Low probability (Unlikely, impact could occur but not realistically expected; >5% and <20% chance).		
	3	Medium probability (Possible, the impact may occur; >20% and <50% chance).		
	4	High probability (Likely, it is most probable that the impact will occur- > 50 and <90% chance).		
	5	Definite (Almost certain, the impact is expected to, or will, occur, >90% chance).		
Cumulative Impact	1	Low: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.	PRIORITISATION FACTOR	
	2	Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.		
	3	High: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.		
Irreplaceable loss of resources	1	Low: Where the impact is unlikely to result in irreplaceable loss of resources.		
	2	Medium: Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.		
	3	High: Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).		
Degree of Confidence	Low	<30% certain of impact prediction		
	Medium	>30 and < 60% certain of impact prediction		
	High	>60% certain of impact prediction		

APPENDIX 2
CURRICULUM VITAE

PROFESSION:	Palaeontologist
YEARS' EXPERIENCE:	30 years in Palaeontology
EDUCATION:	University of the Orange Free State
	B.Sc Botany and Zoology, 1988
	University of the Orange Free State
	B. Sc (Hons) Zoology, 1991
	University of the Free State
	M. Sc. *Cum laude* (Zoology), 2009

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

EMPLOYMENT HISTORY

Research Assistant	National Museum, Bloemfontein 1993 – 1997
Principal Research Assistant	National Museum, Bloemfontein
and Collection Manager	1998–2022
Banzai Environmental	2016 to present

Elize Butler has conducted approximately 900 Paleontological Impact Assessments for developments in the Free State, KwaZulu-Natal, Eastern, Northern and Western Cape, Northwest, Gauteng, Limpopo, and Mpumalanga. She has an MSc (*cum laude*) in Zoology (specializing in Palaeontology) from the University of the Free State, South Africa. She has experience in locating, collecting, and curating fossils. She has been a member of the Paleontological Society of South Africa (PSSA) since 2006 and has been conducting PIAs since 2014.

MEMBERSHIP

Paleontological Society of South Africa (PSSA) 2006-currently.

A full CV is available on request.