

**Palaeontological Impact Assessment for
the proposed development of the
Harmony
Central PV Facility, north east of
Virginia,
Free State Province**

CTS22_101

Desktop Study (Phase 1)

For

CTS Heritage

03 July 2022

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Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, mASSAf
Experience: 33 years research and lecturing in Palaeontology
25 years PIA studies and over 300 projects completed

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by CTS Heritage, Cape Town, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

A Palaeontological Impact Assessment was requested for the proposed Central PV facility for Harmony Mines, north east of Virginia and southwest of Welkom, Free State.

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

The proposed site lies on the potentially fossiliferous sands and alluvium of the Quaternary. The area has been greatly disturbed by farming and mining activities and no potential traps for Quaternary fossils (pans) are visible from the satellite imagery. Nonetheless, a Fossil Chance Find Protocol should be added to the EMP. Based on this information it is recommended that no further palaeontological impact assessment is required unless fossils are found by the contractor, environmental officer or other designated responsible person once excavations have commenced. Since the impact will be low, as far as the palaeontology is concerned, the project should be authorised. There is no preference for either of the alternative sites because the geology is the same.

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i. Background

Harmony Gold mines is proposing to develop photovoltaic farms (PVs) with grid connections on some of its properties in the Free State. This report is for the Central PV Facility located northeast of Virginia and southwest of Welkom in the Free State Province. It is located within the Local Municipality of Matjhabeng and the District Municipality Lejweleputswa. It will be on the existing Glen Harmony Mine (Figures 1-2).

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

Table 1: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) - Requirements for Specialist Reports (Appendix 6).

| | A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain: | Relevant section in report |
|-----|---|-----------------------------------|
| ai | Details of the specialist who prepared the report, | Appendix B |
| aii | The expertise of that person to compile a specialist report including a curriculum vitae | Appendix B |
| b | A declaration that the person is independent in a form as may be specified by the competent authority | Page 1 |
| c | An indication of the scope of, and the purpose for which, the report was prepared | Section i. |
| ci | An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed - date of this report | Yes |
| cii | A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change | Section 5 |
| d | The date and season of the site investigation and the relevance of the season to the outcome of the assessment | N/A |
| e | A description of the methodology adopted in preparing the report or carrying out the specialised process | Section ii. |
| f | The specific identified sensitivity of the site related to the activity and its | Section 4 |

| | A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain: | Relevant section in report |
|-----|--|-----------------------------------|
| | associated structures and infrastructure | |
| g | An identification of any areas to be avoided, including buffers | N/A |
| h | A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers; | N/A |
| i | A description of any assumptions made and any uncertainties or gaps in knowledge; | Section vii. |
| 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 vi. |
| k | Any mitigation measures for inclusion in the EMPr | Section 8, Appendix A |
| l | Any conditions for inclusion in the environmental authorisation | N/A |
| m | Any monitoring requirements for inclusion in the EMPr or environmental authorisation | Section 8, Appendix A |
| ni | A reasoned opinion as to whether the proposed activity or portions thereof should be authorised | Section 6 |
| nii | If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan | Sections 6, 8 |
| o | A description of any consultation process that was undertaken during the course of carrying out the study | N/A |
| p | A summary and copies of any comments that were received during any consultation process | N/A |
| q | Any other information requested by the competent authority. | N/A |
| 2 | Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply. | N/A |

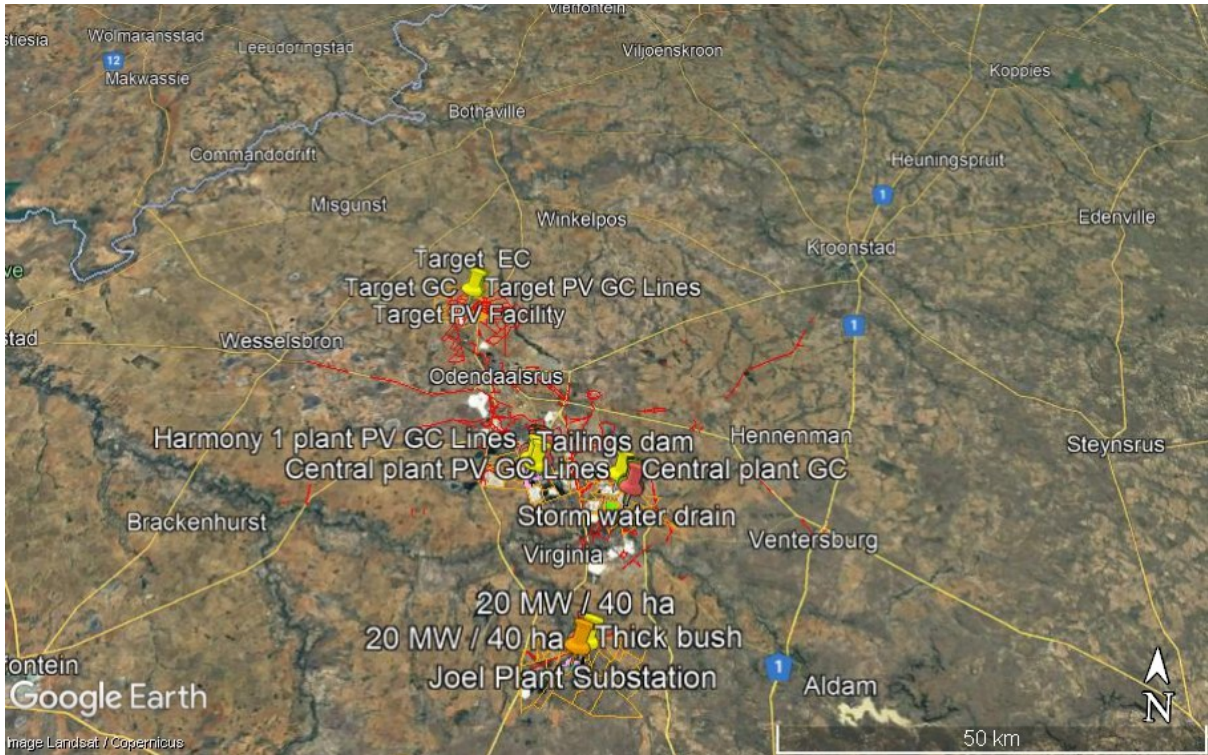


Figure 1: Google Earth map of the general area to show the relative land marks. The Central PV facility will be northeast of Virginia shown by the label.

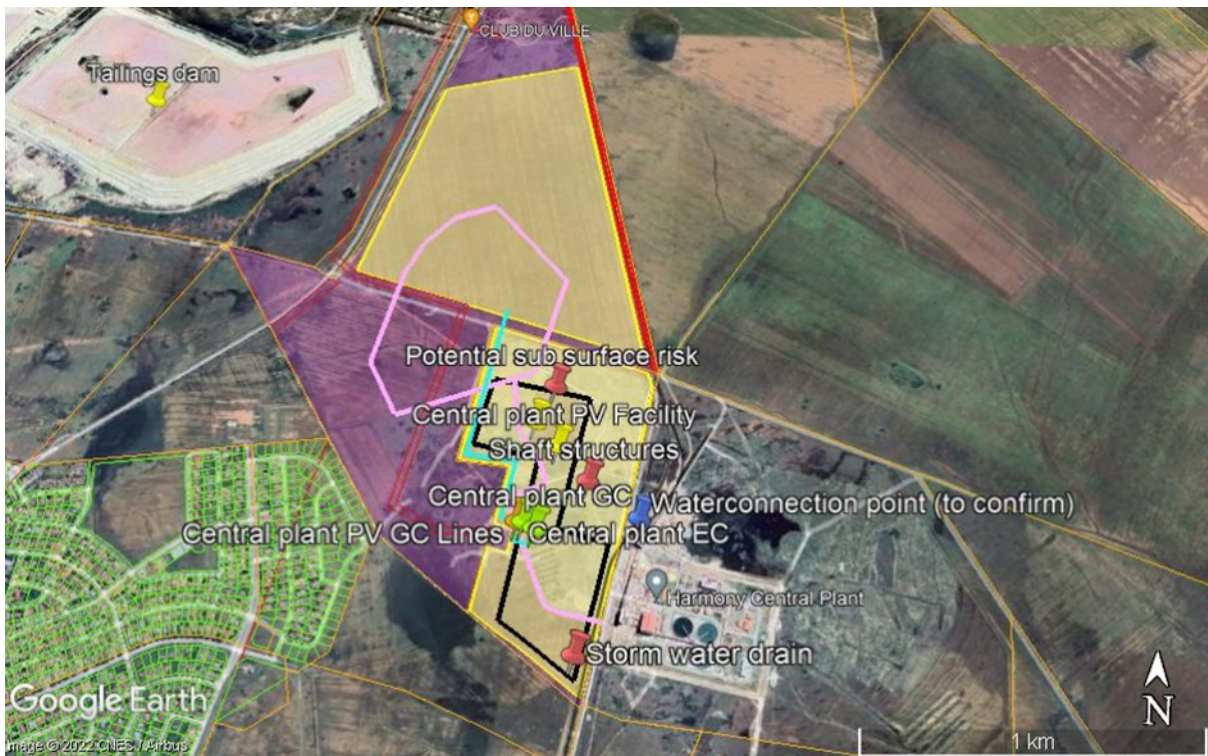


Figure 2: Google Earth Map of the proposed development of the Central PV facility with the sections shown by the pink and yellow outlines.

ii. Methods and Terms of Reference

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

The methods employed to address the ToR included:

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

iii. Geology and Palaeontology

iv. Project location and geological context

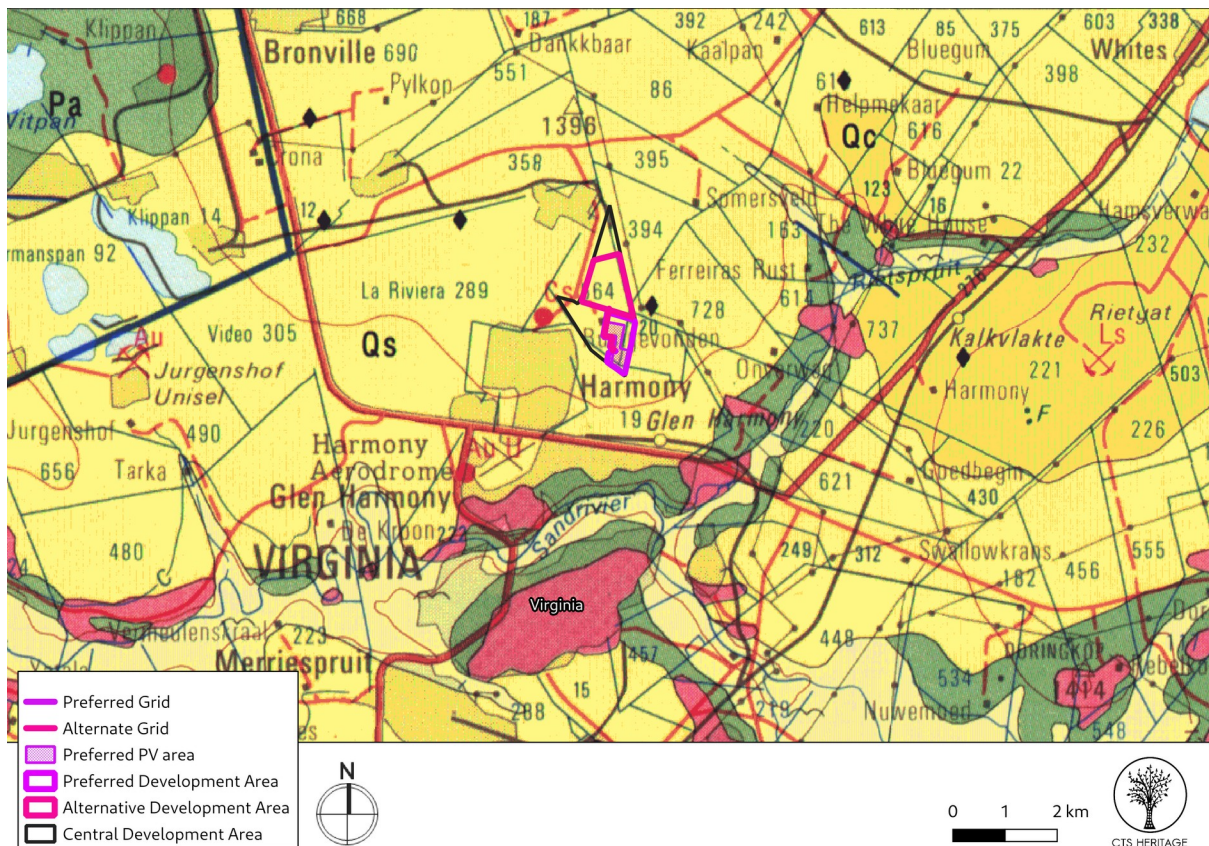


Figure 3: Geological map of the area around the proposed Central PV facility. The location of the proposed project is indicated within the pink and lilac outlines. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2626 West Rand.

Table 2: Explanation of symbols for the geological map and approximate ages (Johnson et al., 2006; Partridge et al., 2006). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

| Symbol | Group/Formation | Lithology | Approximate Age |
|---------------|---|---|----------------------------------|
| Qs | Quaternary sand | Alluvium, sand, soil | Quaternary, ca 1.0 Ma to present |
| Qc | Quaternary calcrete | Sand calcrete, limestone | Quaternary, ca 1.0 Ma to present |
| Jd | Jurassic dykes | Dolerite | Jurassic Ca 183 Ma |
| Pa | Adelaide Subgroup, Beaufort Group, Karoo SG | Sandstones, shales, siltstones, mudstones | Late Permian Ca 260-251 Ma |

The project lies in the north-central part of the main Karoo Basin where some of Beaufort rocks are present. Much of the area is covered by young sands and alluvium of Quaternary age (Figure 3).

The Karoo Supergroup rocks cover a very large proportion of South Africa and extend from the northeast (east of Pretoria) to the southwest and across to almost the KwaZulu Natal south coast. It is bounded along the southern margin by the Cape Fold Belt and along the northern margin by the much older Transvaal Supergroup rocks. Representing some 120 million years (300 - 183Ma), the Karoo Supergroup rocks have preserved a diversity of fossil plants, insects, vertebrates and invertebrates. It is divided into the basal Dwyka Group, Ecca, Beaufort and Stormberg Groups. Extensive dolerite dykes cut through the sequence of Karoo rocks during the Jurassic, associated with the Drakensberg volcanics. These dolerite dykes are of igneous origin and do not preserve fossils.

Only a few outcrops of the **Adelaide Subgroup** (Beaufort Group) are present in the region. These shales were deposited in a meandering river to braidplain setting in the inland Karoo sea as it gradually filled with sediments (Johnson et al., 2006). For the Adelaide Subgroup east of 24°E, three formations are recognised in the Adelaide Subgroup, the basal Koonap Formation, Middleton Formation and thick upper Balfour Formation.

The Quaternary Kalahari sands form an extensive cover of much younger deposits over much of the Northern Cape Province, Botswana and northern Free State. Haddon and McCarthy (2005) proposed that the Kalahari basin formed as a response to down-warp of the interior of the southern Africa, probably in the Late Cretaceous. This, along with possible uplift along epeirogenic axes, back-tilted rivers into the newly formed Kalahari basin and deposition of the Kalahari Group sediments began. Sediments included basal gravels in river channels, sand and finer sediments. A period of relative tectonic stability during the mid-Miocene saw the silcretisation and calcretisation of older Kalahari Group lithologies, and this was followed in the Late Miocene by relatively minor uplift of the eastern side of southern Africa and along certain epeirogenic axes in the interior. More uplift during the Pliocene caused erosion of the sand that was then reworked and redeposited by aeolian processes during drier periods, resulting in the extensive dune fields that are preserved today.

There are numerous pans in the Kalahari, generally 3-4 km in diameter (Haddon and McCarthy, 2005). According to Goudie and Wells (1995) there are two conditions required for the formation of pans. Firstly, the fluvial processes must not be integrated, and second, there must be no accumulation of aeolian material that would fill the irregularities or depressions in the land surface. Favoured materials or substrates for the formation of pans in South Africa are Dwyka and Ecca shales and sandstones (ibid).

v. Palaeontological context

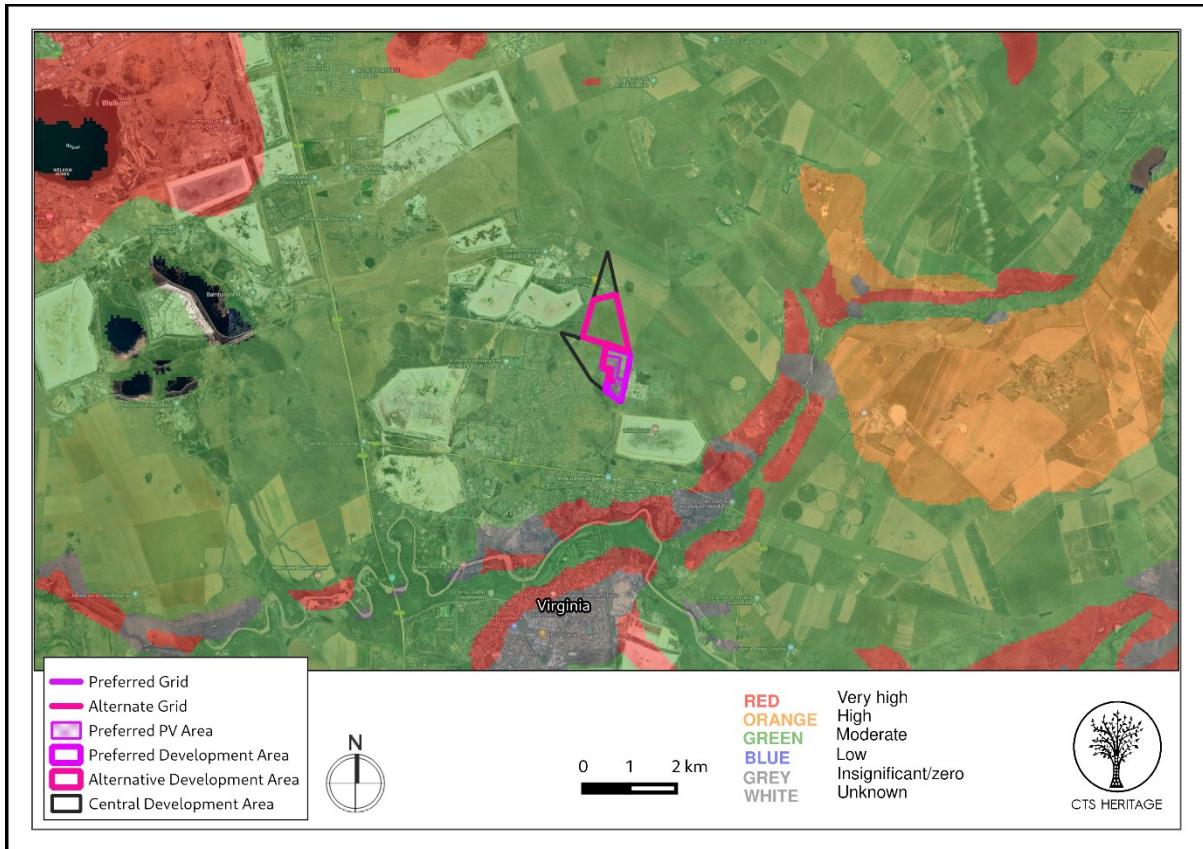


Figure 4: SAHRIS palaeosensitivity map for the site for the proposed Harmony Central PV Facility just northeast of Virginia shown within the pink and purple outlines. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

The palaeontological sensitivity of the area under consideration is presented in Figure 4. The site for development is on Quaternary sands. Six formations are recognised in the Kalahari Group but they are not often indicated on the geological maps. A more recent review by Botha (2021) attempts to correlate the Quaternary sediments but they are difficult to date or to determine their source. In this part of the Free State the Hoopstad Aeolian sands are present. According to Harmse (1963, in Botha, 2021) this extensive red and grey sandy soil cover is associated with three generations of aeolian sand sheets. Moreover, these generations of aeolian sand form the soil substrate in the heart of the nation's maize cultivation region, yet their geological origin and age remains understudied (Botha, 2021, p. 825).

Quaternary sands and alluvium do not preserve fossils because they are transported and porous. For preservation of fossils, a low energy deposit with sedimentation of fine grained silts or muds that exclude decomposing organisms such as bacteria, fungi and invertebrates is required to maintain a highly reducing environment (Cowan, 1995). Only if there are traps such as palaeo-pans or palaeo-springs that provide traps for water and fine sediments, would plants or bones be preserved

and fossilised. No such features are visible in the satellite imagery in the project footprint.

vi. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in Table 3:

Table 3a: Criteria for assessing impacts

| PART A: DEFINITION AND CRITERIA | | |
|---|-----------|--|
| Criteria for ranking of the SEVERITY/NATURE of environmental impacts | H | Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action. |
| | M | Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints. |
| | L | Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. |
| | L+ | Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. |
| | M+ | Moderate improvement. Will be within or better than the recommended level. No observed reaction. |
| | H+ | Substantial improvement. Will be within or better than the recommended level. Favourable publicity. |
| Criteria for ranking the DURATION of impacts | L | Quickly reversible. Less than the project life. Short term |
| | M | Reversible over time. Life of the project. Medium term |
| | H | Permanent. Beyond closure. Long term. |
| Criteria for ranking the SPATIAL SCALE of impacts | L | Localised - Within the site boundary. |
| | M | Fairly widespread - Beyond the site boundary. Local |
| | H | Widespread - Far beyond site boundary. Regional/ national |
| PROBABILITY (of exposure to impacts) | H | Definite/ Continuous |
| | M | Possible/ frequent |
| | L | Unlikely/ seldom |

Table 3b: Impact Assessment

| PART B: Assessment | | |
|---------------------------|----------|---|
| SEVERITY/NATURE | H | - |
| | M | - |

| PART B: Assessment | | |
|---------------------------|-----------|---|
| | L | Quaternary sands and soils do not preserve fossils; so far there are no records from the Quaternary of plant or animal fossils in this region so it is very unlikely that fossils occur on the site. The impact would be negligible |
| | L+ | - |
| | M+ | - |
| | H+ | - |
| DURATION | L | - |
| | M | - |
| | H | Where manifest, the impact will be permanent. |
| SPATIAL SCALE | L | Since the only possible fossils within the area would be trapped fossils in the pans or springs, the spatial scale will be localised within the site boundary. |
| | M | - |
| | H | - |
| PROBABILITY | H | - |
| | M | - |
| | L | It is very unlikely that any fossils would be found in the loose soils and sands that cover the area. Nonetheless, a Fossil Chance Find Protocol should be added to the eventual EMPr. |

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are the right age to contain fossils but are covered by soils. Furthermore, the material to be excavated are soils and this does not preserve fossils. Since there is a small chance that fossils were trapped in pans that might occur below the soils and may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is low.

vii. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the sandstones, shales and sands are typical for the country and might contain trapped fossils. The sands of the Quaternary period would not preserve fossils. The area has been disturbed from farming and mining so no fossils would be present on the surface.

viii. Recommendation

Based on experience and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the overlying sands and soils of the Quaternary. There is a very small chance that fossils may occur in pans or springs but no such feature is visible in the satellite imagery. Nonetheless, a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found by the environmental officer, or other responsible person once excavations for foundations and amenities have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample. Since the impact on the palaeontological heritage would be low, as far as the palaeontology is concerned, the project should be authorised. There is no preference or either of the alternative sites as the geology is the same.

ix. References

Anderson, J.M., Anderson, H.M., 1985. Palaeoflora of Southern Africa: Prodrum of South African megaflores, Devonian to Lower Cretaceous. A.A. Balkema, Rotterdam. 423 pp.

Botha, G.A., 2021. Cenozoic stratigraphy of South Africa: current challenges and future possibilities. South African Journal of Geology 124, 817-842.

Goudie, A.S., Wells, G.L., 1995. The nature, distribution and formation of pans in arid zones. Earth Science Reviews 38, 1-69.

Haddon, I.G., McCarthy, T.S., 2005. The Mesozoic-Cenozoic interior sag basins of Central Africa: The Late-Cretaceous-Cenozoic Kalahari and Okavango basins. Journal of African Earth Sciences 43, 316-333.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.deV., Christie, A.D.M., Roberts, D.L., Brandl, G., 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. Pp 461 - 499.

Plumstead, E.P., 1969. Three thousand million years of plant life in Africa. Geological Society of southern Africa, Annexure to Volume LXXII. 72pp + 25 plates.

x. Chance Find Protocol

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

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

xi. Appendix A – Examples of fossils from the Quaternary alluvium and sands



Figure 5: Photographs of different types of fossils that have been recovered from Quaternary alluvial and riverine deposits. Note their fragmentary nature.

xii. Appendix B – Details of specialist

**Curriculum vitae (short) - Marion Bamford
PhD**

June 2022

I) Personal details

Surname : **Bamford**
First names : **Marion Kathleen**
Present employment : Professor; Director of the Evolutionary
Studies Institute.
Member Management Committee of the NRF/DST
Centre of
Excellence Palaeosciences, University of the
Witwatersrand,
Johannesburg, South Africa
Telephone : +27 11 717 6690
Fax : +27 11 717 6694
Cell : 082 555 6937
E-mail : marion.bamford@wits.ac.za ;
marionbamford12@gmail.com

ii) Academic qualifications

Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April
1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November
1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.
NRF Rating: C-2 (1999-2004); B-3 (2005-2015); B-2 (2016-2020); B-1
(2021-2026)

iii) Professional qualifications

*Wood Anatomy Training (overseas as nothing was available in South
Africa):*

1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale,
Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude
Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale,
Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) Membership of professional bodies/associations

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

vii) Supervision of Higher Degrees

All at Wits University

| Degree | Graduated/ completed | Current |
|----------------------|-------------------------|---------|
| Honours | 13 | 0 |
| Masters | 11 | 3 |
| PhD | 11 | 6 |
| Postdoctoral fellows | 15 | 1 |

viii) Undergraduate teaching

Geology II - Palaeobotany GEOL2008 - average 65 students per year
Biology III - Palaeobotany APES3029 - average 45 students per year
Honours - Evolution of Terrestrial Ecosystems; African Plio-Pleistocene
Palaeoecology; Micropalaeontology - average 12-20 students per year.

ix) Editing and reviewing

Editor: Palaeontologia africana: 2003 to 2013; 2014 - Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology:
2010 -
Associate Editor Open Science UK: 2021 -
Review of manuscripts for ISI-listed journals: 30 local and international
journals
Reviewing of funding applications for NRF, PAST, NWO, SIDA, National
Geographic, Leakey Foundation

x) Palaeontological Impact Assessments

Selected from the past five years only - list not complete:

- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klippoortjie and Finaalspan 2017 for Delta BEC
- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- Isondlo and Kwasobabili 2018 for GCS

- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO
- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for EnviroPro
- Skeerpoort Farm Mast 2020 for HCAC
- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala
- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for EnviroPro
- Frankfort-Windfield Eskom Powerline 2020 for 1World
- Beaufort West PV Facility 2021 for ACO Associates
- Copper Sunset MR 2021 for Digby Wells
- Sannaspos PV facility 2021 for CTS Heritage
- Smithfield-Rouxville-Zastron PL 2021 for TheroServe

xi) Research Output

Publications by M K Bamford up to January 2022 peer-reviewed journals or scholarly books: over 160 articles published; 5 submitted/in press; 10 book chapters.

Scopus h-index = 30; Google scholar h-index = 35; -i10-index = 92

Conferences: numerous presentations at local and international conferences.