# Palaeontological Impact Assessment for the proposed Radley Dam, Malelane, Mpumalanga Province

**Desktop Study**

**For**

**Henwood Environmental Solutions (Pty) Ltd**

**17 March 2018**

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# Expertise of Specialist

The Palaeontologist Consultant is: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 30 years research; 22 years PIA studies

# Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Henwood, Environmental Solutions (Pty) Ltd, Nelspruit, 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

Henwood Environmental Solutions (Pty) Ltd has been contracted to carry out an EMPr for the proposed construction of an earth dam just south of Malelane, Mpumalanga province. The site lies on ancient rocks of the Onverwacht Group (3600 – 3438 Ma). Microfossils (bluegreen algae, less than 10 microns in diameter) have been reported from the same sediments about 100 km to the southwest, so there is a very small chance that microfossils could occur in chert bands, if chert occurs on the site. It is recommended, therefore, that if chert occurs on the site then hand samples of the chert should be sent to the University of Johannesburg, Geology Department, for further analysis. Microfossils are not visible to the naked eye so could not be identified in the field, only in a laboratory. As far as the palaeontological heritage is concerned the project can continue and no further assessment is required.

# Table of Contents

# 1. Background

Henwood Environmental Solutions has been appointed to carry out the EIA and WULA for a proposed dam in the Malelane area. The National Heritage Resources Act (Act 25 of 1999) and the National Environmental Management Act (Act 107 of 1998) requires that the proposed development must be preceded by the relevant impact assessment, in this case for palaeontology.

The proposed activity will entail the construction of a dam with the following features:

| | |
|---|---|
| Type of Dam | Earthfill structure |
| Crest level of non-overspill crest (NOC) | 387m |
| Full supply level | 382m |
| Total freeboard | 5m |
| Maximum wall height | 16m |
| Type of spillway | Side Channel Spillway |
| Spillway width | 23m |
| Crest width | 4 |
| Embankment length | 233m |
| Upstream slope gradient | 1(v):3,0(H) |
| Downstream slope gradient | 1(v):2,0(H) |
| Storage capacity | 314 565m³ |
| Water surface area at FSL | **67 172m³** |

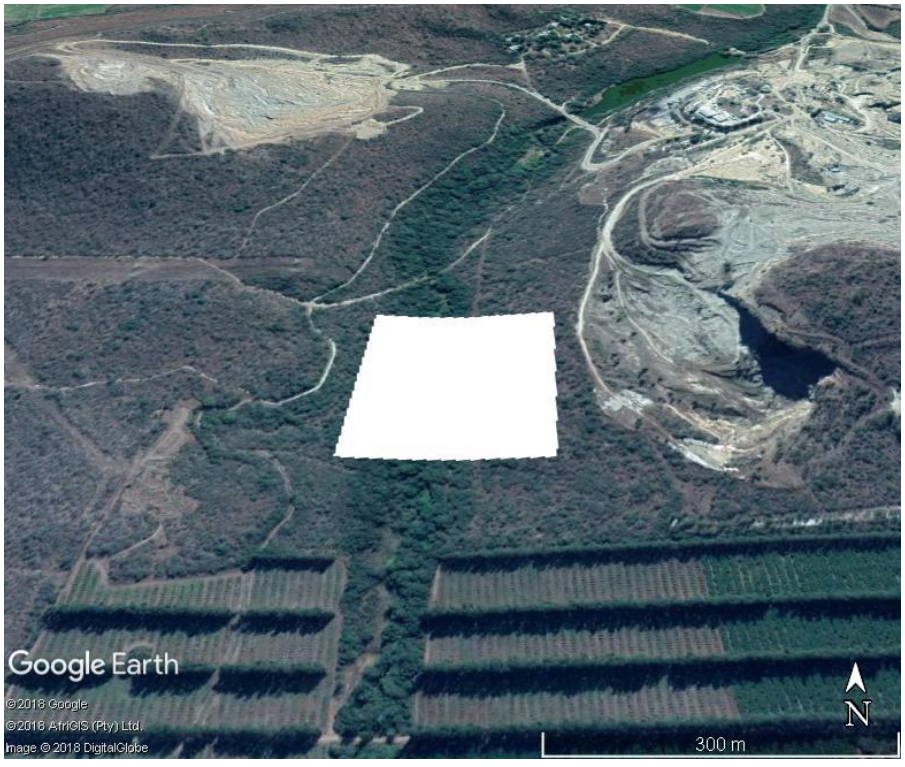


Figure 1: Detailed map from Google Earth of the proposed Radleys Dam, near Malelane, just south of the N4 highway, Mpumalanga.

This report is the palaeontological impact assessment for the project.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (2014)

| **A specialist report prepared in terms of the Environmental Impact Regulations of 2014 must contain:** | **Relevant section in report** |
|---|---|
| Details of the specialist who prepared the report | Appendix A |
| The expertise of that person to compile a specialist report including a curriculum vitae | Appendix A |
| A declaration that the person is independent in a form as may be specified by the competent authority | Page 1 |
| An indication of the scope of, and the purpose for which, the report was prepared | Section 1 |
| The date and season of the site investigation and the relevance of the season to the outcome of the assessment | N/A |
| A description of the methodology adopted in preparing the report or carrying out the specialised process | Section 2 |
| The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure | Section ii<br>**Error! Reference source not found.** |
| An identification of any areas to be avoided, including buffers | N/A |
| 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 |
| A description of any assumptions made and any uncertainties or gaps in knowledge; | Section 5 |
| 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 4 |
| Any mitigation measures for inclusion in the EMPr | n/a |
| Any conditions for inclusion in the environmental authorisation | n/a |
| Any monitoring requirements for inclusion in the EMPr or environmental authorisation | n/a |
| A reasoned opinion as to whether the proposed activity or portions thereof should be authorised | N/A |
| 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 | N/A |
| A description of any consultation process that was undertaken during the course of carrying out the study | N/A |

| | |
|---|---|
| A summary and copies if any comments that were received during any consultation process | N/A |
| Any other information requested by the competent authority. | N/A |

# 2. 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;
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.

# 3. Geology and Palaeontology

## i. Project location and geological context

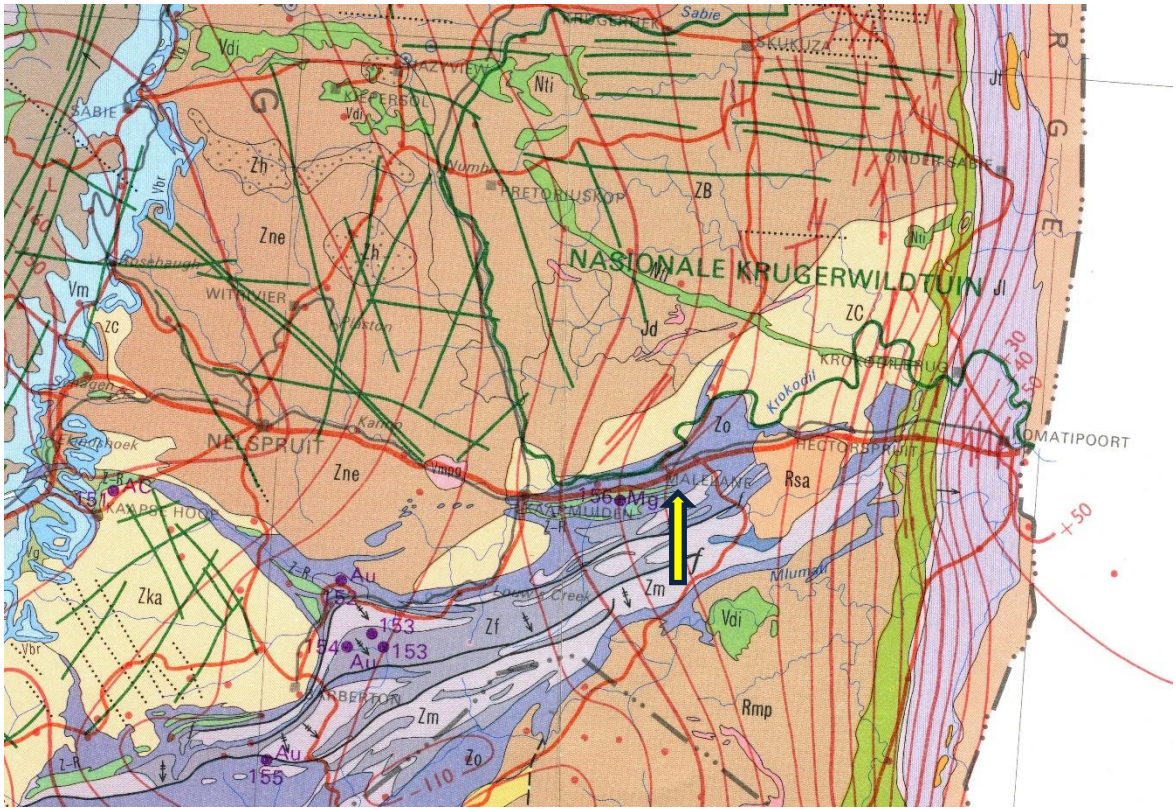


Figure 2: Geological map of the area around Malelane, Mpumalanga Province where the proposed Rdleys Dam will be constructed. The proposed site is indicated by the yellow arrow. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 1 000 000 map 1984.

Table 2: Explanation of symbols for the geological map and approximate ages (Cornell et al., 2006; Duncan and Marsh, 2006; Erikssen et al., 2006. Johnson et al., 2006; Partridge et al., 2006). SG = Supergroup; Fm = Formation.

| Symbol | Group/Formation | Lithology | Approximate Age |
|---|---|---|---|
| P-Tr | Permo-Triassic | Undifferentiated Karoo sediments, shale, coal, sandstone, mudstone | Ca 300 – 180 Ma |
| Jm | Movene Fm, Lebombo Group | Basalt | Ca 195 – 160 Ma |
| Jj | Jozini Fm, Lebombo Group | Rhyodactite | Ca 178 Ma |
| Jl | Letaba Fm, Lebombo Group | Picritic basalt | Ca 183 Ma |
| Jt | Tshokwane granophyre | Granophyre | Ca 140 Ma |
| Rmp | Mpuluzi Granite | Quartz monzonite | |

| Symbol | Group/Formation | Lithology | Approximate Age |
|---|---|---|---|
| ZC | Unnamed | Granite | |
| ZB | Unnamed | Potassic granite and granodiorite | |
| Zm | Moodies Group, Barberton Sequence | Sandstone, shale, conglomerate | >3300 Ma |
| Zf | Figtree Group, Barberton Sequence | Greywacke, shale, chert, dacitic volcanic rocks | |
| Zo | Onverwacht Group, Barberton Sequence | Lava, pyroclastic rocks | |

The proposed site lies on several outcrops of the oldest rocks in South Africa, those of the Barberton Greenstone Belt (BGB), which is mid Archean in age (3600- 3100 Ma; Brandl et al., 2006) and in particular on the Onverwacht Group. There are also a number of plutons and batholiths in the area that range in age from 3509 to 3104 Ma. The Barberton Greenstone Belt is one of the best studied granite-greenstone terrane in the world (Brandl et al., 2006) because it is one of the oldest known, it is composed of a unique sequence of the best-preserved, first-formed lithologies on the planet, and geologists have used it as a model to interpret other greenstone belts (ibid). The Barberton Supergroup comprises three major lithostratigraphic units (Fig 3) with the Onverwacht group at the base, the Figtree Group in the middle and the Moodies Group at the top. It is thought that these sediments formed in an oceanic setting, followed by island arc development as a consequence of some primitive form of Archaean plate tectonic processes (ibid).

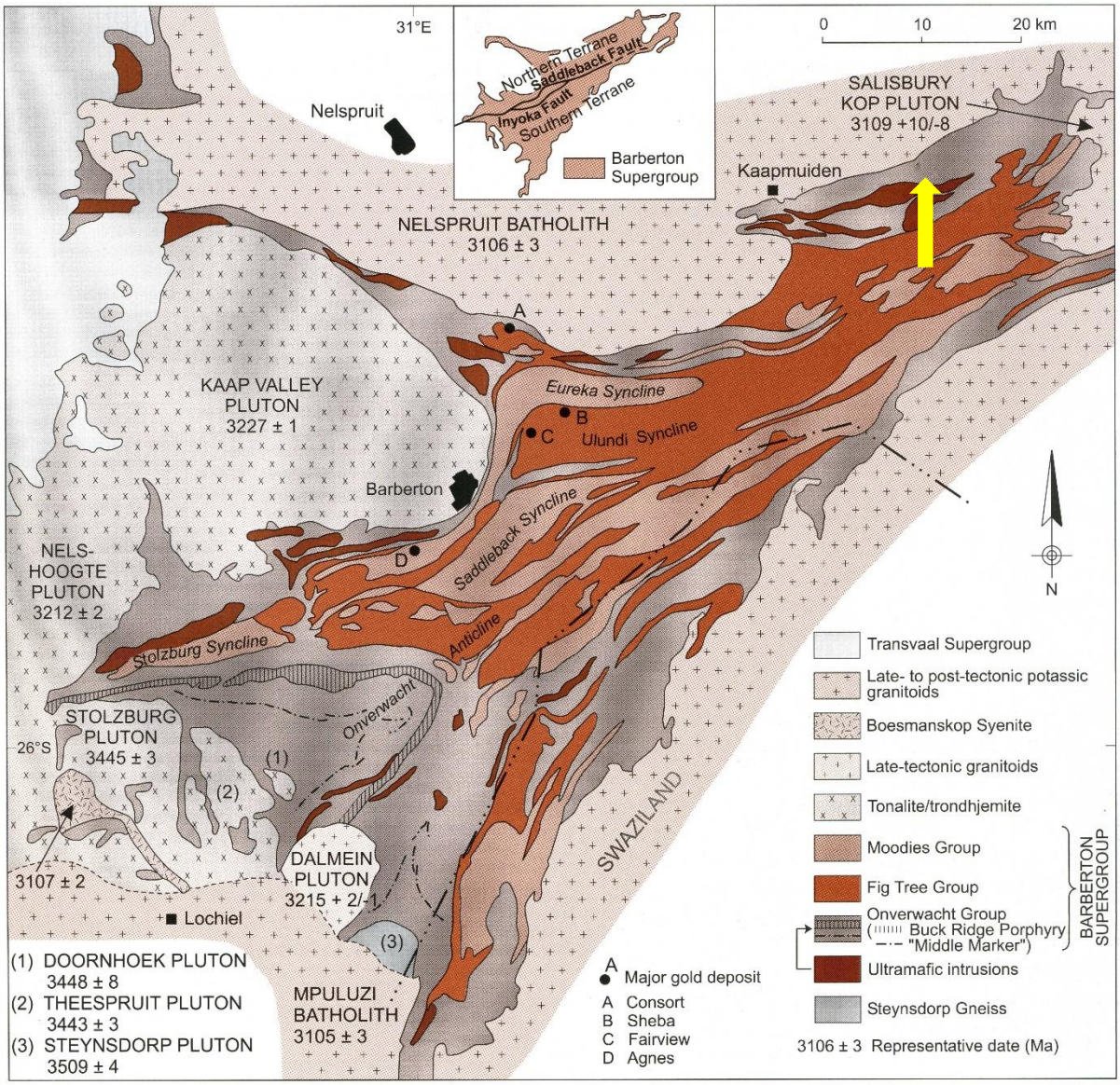


Figure 3: Map showing the updated geological groups in the Barberton Greenstone Belt (from Brandl et al., 2006, figure 2, page 11) with a focus on the three main stratigraphic divisions and the volcanic rock types. Malelane, arrow, is in the northeast part.

Most research has been done on the southern part of the BGB and little on the northern part, where Malelane is situated. Currently the Onverwacht Group is divided into six formations as follows (basal to top): Sandspruit Fm, Theespruit Fm, Komatie Fm, Hoogenoeg Fm, Kromberg Fm, Mendon Fm (Brandl et al., 2006).

The Lebombo Mountains to the east of South Africa are igneous in origin and comprise easily distinguishable formations of different types of basalt and rhyolite (Duncan and Marsh, 2006). Running parallel to these mountains is a north-south exposure of Karoo sequence deposits that has not been well studied. The parallel Karoo rocks are far to the east of the proposed dam site and will not be discussed further,

## ii. Palaeontological context

Even though the rocks of the Onverwacht Group are so old microfossils have been reported from them, for example the oldest cyanobacteria or bluegreen algae from the Kromberg Formation type site along the Komati River (Walsh, 1992; Altermann et al., 2006; Schopf 2006). Recently Kremer and Kazmierczak (2017) have found more microfossils from this general area in the Songimvelo Nature Reserve cherts (some 100km southwest of Malelane). They interpreted the presumably coccoidal cyanobacteria thriving as benthic and possibly, at least in part, as benthic planktonic communities from the Kromberg Formation. It should be noted that the microfossils are mostly less than 10 microns in diameter and can only be seen in thin section under a microscope at 1000x magnification.

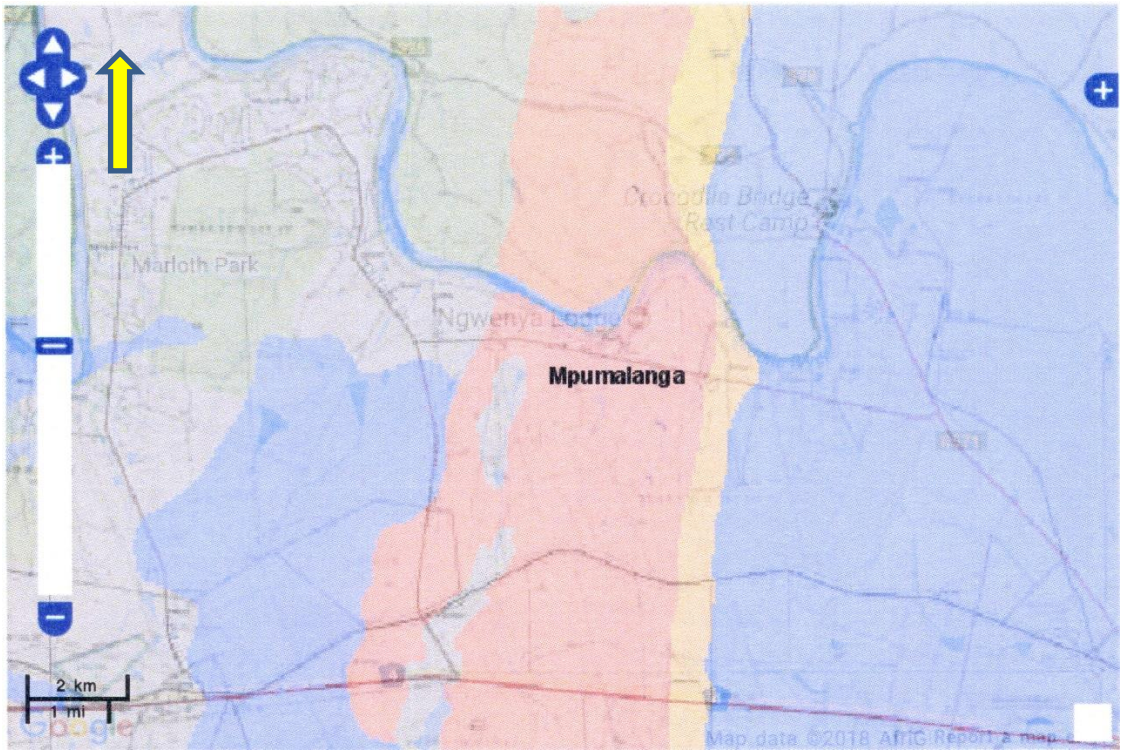


Figure 3: SAHRIS palaeosensitivity map of the region around Malelane. The site in the blue/grey area (arrow). Colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

# 4. 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** | - |
| | **L** | There is a small chance of fossils being found here |
| | **L+** | - |
| | **M+** | |
| | **H+** | - |
| **DURATION** | **L** | - |
| | **M** | - |
| | **H** | Where manifest, the impact will be permanent. |
| **SPATIAL SCALE** | **L** | The spatial scale is extremely small. |
| | **M** | - |
| | **H** | - |
| **PROBABILITY** | **H** | **-** |
| | **M** | |
| | **L** | There is a very small chance of finding fossils in the cherts in the rocks but they are microscopic and wold NT be visible to the naked eye. |

Based on the nature of the project, the surface soils will be excavated to a depth of several metres and will be used to form the dam wall. Associated structures are also planned from the local soil. Only if chert bands are visible in the rocks and only if these are going to be disturbed, should they be sampled (GPS coordinates and hand specimens of rock taken) and posted to a research facility (university or museum – for example the University of

Johannesburg geologists work on rocks of this age ). Since there is no chance of finding fossils in the soils and granites there would be no impact on the fossil heritage. There is no chance of finding fossils BEFORE excavations commence so a phase 2 or site visit is NOT recommended at this stage. Taking account of the defined criteria, the potential impact to fossil heritage resources is very low.

# 5. 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 gneisses, schists, granites and basalts are typical for the country and, except for the cherts, do not contain any fossil plant, insect, invertebrate and vertebrate material. They is a very small chance that the chert bands within the Kromberg Formation of the Onverwacht Group may contain microfossils of early unicellular bluegreen algae but these are not visible to the naked eye. No fossils, however, have been reported from this region.

# 6. Recommendation

Based on the age of the sediments and occurrence of fossils in this farmation, although no fossils have been recorded from this area, there is a very small chance that fossils would be identified in samples analysed in a laboratory, from the proposed site but only once excavations have commenced. No further palaeontological assessment is required. It is recommended that if chert is excavated then a hand sample should be sent to the University of Johannesburg, Department of Geology, for their records and possible further research. As far as the palaeontological heritage is concerned the proposed dam contruction can proceed.

# 7. References

Altermann, W. Kazmierczak, J. Oren, A., Wright, D.T., 2006. Cyanobacterial calcification and its rock-building potential during 3.5 billion years of earth history. Geobiology 4, 147-166.

Duncan, A.R., Marsh, J.S., 2006. The Karoo Igneous Province. 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 501-520.

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.

Knoll, A.H., Bergmann, K.D., Strauss, J.V., 2016. Life: the first two billion years. Philosophical Transactions of the Royal Society B 371, 20150493.

Kremer, B., Kazmierczak, J., 2017. Cellularly preserved microbial fossils from ca 3.4 Ga deposits of South Africa: A testimony of early appearance of oxygenic life? Precambrian Research 285, 117-129.

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.

Walsh, M.M., 1992. Microfossils and possible microfossils from the Early Archean Onverwacht Group, Barberton Mountain Land, South Africa. Precambrian Research, 54, 271-293.

**Appendix A** – Details of specialist

# Curriculum vitae (short) - Marion Bamford PhD January 2018

## 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
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Cell : 082 555 6937
E-mail : marion.bamford@wits.ac.za ; marionbamford12@gmail.com

**ii) Academic qualifications**

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

**iii) Professional qualifications**

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

**iv) Membership of professional bodies/associations**

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

**vii) Supervision of Higher Degrees**

All at Wits University

| Degree | Graduated/completed | Current |
|---|---|---|
| Honours | 5 | 2 |
| Masters | 6 | 3 |

| | | |
|---|---|---|
| PhD | 9 | 3 |
| Postdoctoral fellows | 5 | 3 |

**viii) Undergraduate teaching**
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 2-8 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 –
Cretaceous Research: 2014 -

Review of manuscripts for ISI-listed journals: 25 local and international journals

# x) Palaeontological Impact Assessments

Selected – list not complete:

- Thukela Biosphere Conservancy 1996; 2002 for DWAF
- Vioolsdrift 2007 for Xibula Exploration
- Rietfontein 2009 for Zitholele Consulting
- Bloeddrift-Baken 2010 for TransHex
- New Kleinfontein Gold Mine 2012 for Prime Resources (Pty) Ltd.
- Thabazimbi Iron Cave 2012 for Professional Grave Solutions (Pty) Ltd
- Delmas 2013 for Jones and Wagener
- Klipfontein 2013 for Jones and Wagener
- Platinum mine 2013 for Lonmin
- Syferfontein 2014 for Digby Wells
- Canyon Springs 2014 for Prime Resources
- Kimberley Eskom 2014 for Landscape Dynamics
- Yzermyne 2014 for Digby Wells
- Matimba 2015 for Royal HaskoningDV
- Commissiekraal 2015 for SLR
- Harmony PV 2015 for Savannah Environmental
- Glencore-Tweefontein 2015 for Digby Wells
- Umkomazi 2015 for JLB Consulting
- Ixia coal 2016 for Digby Wells
- Lambda Eskom for Digby Wells
- Alexander Scoping for SLR
- Perseus-Kronos-Aries Eskom 2016 for NGT
- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC

## xi) Research Output

Publications by M K Bamford up to January 2018 peer-reviewed journals or scholarly books: over 110 articles published; 5 submitted/in press; 8 book chapters.
Scopus h index = 22; Google scholar h index = 24;
Conferences: numerous presentations at local and international conferences.

## xii) NRF Rating

NRF Rating: B-2 (2016-2020)
NRF Rating: B-3 (2010-2015)
NRF Rating: B-3 (2005-2009)
NRF Rating: C-2 (1999-2004)