# HERITAGE IMPACT ASSESSMENT: TWO NEW TRANSMISSION LINES, SWITCHING STATION AND ACCESS ROAD FOR THE AUTHORISED DE AAR 2 SOUTH WIND ENERGY FACILITY, DE AAR, NORTHERN CAPE

(Assessment conducted under Section 38 (8) of the National Heritage Resources Act (No. 25 of 1999) as part of Basic Assessment)

Prepared for

**Arcus Consultancy Services South Africa (Pty) Ltd**

On behalf of

**Mulilo De Aar 2 South (Pty) Ltd**

Draft for Comment: May 2022

Revised Draft: July 2022

ACO Associates cc
Archaeology and Heritage Specialists


Prepared by

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|---|---|
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| (p) any other information requested by the competent authority | N/A |
| 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 |

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

| | (For official use only) |
|---|---|
| File Reference Number: | |
| NEAS Reference Number: | DEA/EIA/ |
| Date Received: | |

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

**PROJECT TITLE**

New Transmission Corridors for the De Aar 2 South WEF, Northern Cape

**Kindly note the following:**

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
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4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
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**Departmental Details**

**Postal address:**
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447
Pretoria
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**Physical address**:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Environment House
473 Steve Biko Road
Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

**SPECIALIST INFORMATION**

| | | | | |
|---|---|---|---|---|
| Specialist Company Name: | ACO Associates cc | | | |
| B-BBEE | Contribution level (indicate 1 to 8 or non-compliant) | 4 | Percentage Procurement recognition | 100% |
| Specialist name: | John Gribble | | | |
| Specialist Qualifications: | Master of Arts (Archaeology) | | | |
| Professional affiliation/registration: | Association of Southern African Professional Archaeologists (Membership number: 043) | | | |
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## 1. DECLARATION BY THE SPECIALIST

I, John Gribble, declare that –

- I act as the independent 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 favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, 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 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;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

ACO Associates cc

Name of Company:

9 July 2022

Date

## 3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, John Gribble, ~~swear under oath~~ / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signature of the Specialist

ACO Associates

Name of Company

**9 July 2022**

Date

**Rev. James Gribble**
COMMISSIONER OF OATHS
MARRIAGE OFFICER (V3146) - REPUBLIC OF SOUTH AFRICA
"Windfall", 123 Woodgate Road, Plumstead 7800

Signature of the Commissioner of Oaths

**9 July 2022**

Date

## DETAILS OF THE SPECIALIST

This study has been undertaken by John Gribble BA Hons, MA (ASAPA) and Gail Euston-Brown BA of ACO Associates CC, archaeologists and heritage consultants.

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## CONSULTANT DECLARATION OF INDEPENDENCE

I, John Gribble, declare that – general declaration:

- I act as the independent 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 favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, 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 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;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

**Signature of the specialist:**

**Name of company (if applicable):** ACO Associates CC

**Date:** 11 July 2022

## EXECUTIVE SUMMARY

### *Project Name*

Two New Transmission Lines, a Switching Station and associated Access Road for the authorised De Aar 2 South Wind Energy Facility (DA2S WEF).

### *Location*

The approximate co-ordinates of the beginning and end of the transmission lines are:

-30.591491°S / 24.280503°E (WEF Switching Station);

-30.689627°S / 24.094009°E (Vetlaagte MTS); and

-30.678107°S / 24.122838°E (Wag n' Bietjie MTS

The approximate centrepoint co-ordinate of the switching station is: -30.590594°S / 24.281752°E.

The approximate co-ordinates of the beginning and end of the access road are: -30.654161°S / 24.374586°E and -30.590899°S / 24.282961°E

### *Locality Plan*

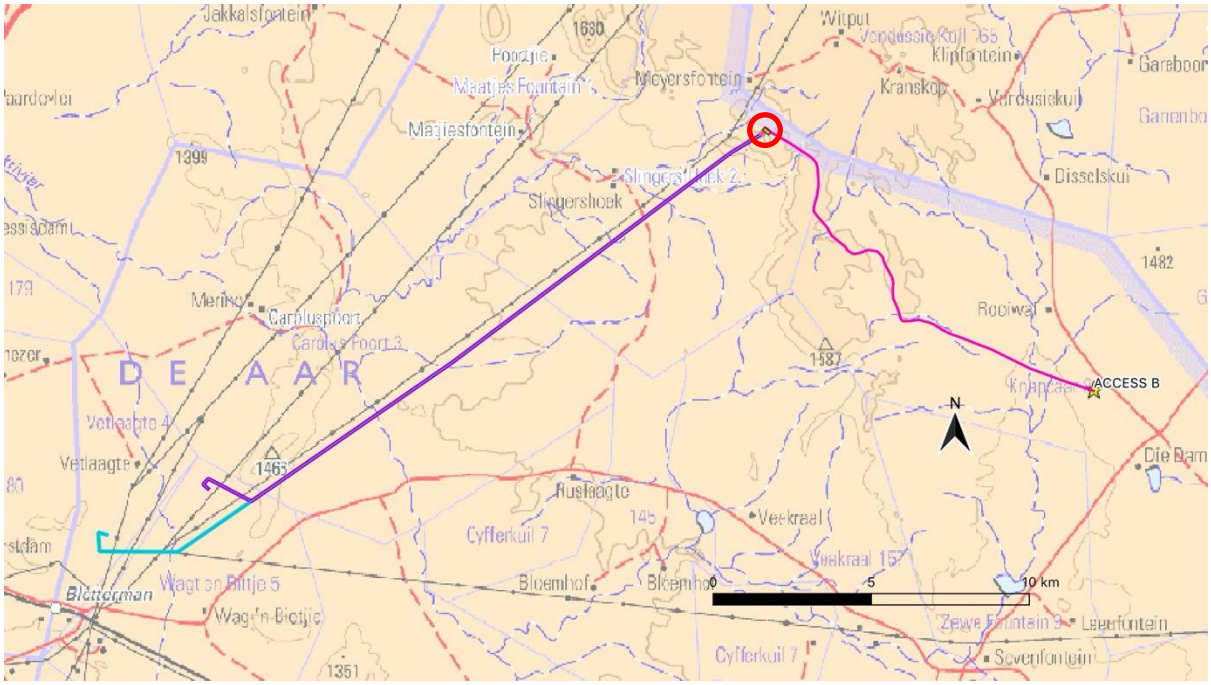



Figure 1: Extract from 1:250 000 topographical map sheet showing the route of new transmission lines (pale blue and purple lines) and the access road (pink line) for the authorised DE Aar 2 South WEF. The location of the switching station is circled. (Source: 1:250 000 chart 3024, National Geo-spatial Information, http://www.ngi.gov.za).

### *Description of Proposed Development*

Mulilo are proposing two new transmission line options, to connect the authorised DA2S WEF into the national grid to the south-west of De Aar. Both line options follow the same south-westerly alignment from the switching station for approximately 17 km at which point Option 1

splits off to the proposed Wag ‘n Bietjie Main Transmission Substation (MTS), approximately 1,2 km to the north-west. The Option 2 transmission line to the Vetlaagte MTS continues to the south-west from the Option 1 split for a further 2,5 km before also angling to the north-west towards the Vetlaagte MTS location approximately 2 km distant.

The proposed transmission line will consist of either steel monopole or lattice tower structures with maximum heights of 31 m, including foundations and insulators. The grid connection will have a capacity of up to 132 kV. Existing access roads and jeep tracks will be utilised wherever possible but new line and servitude clearances will meet the statutory requirements.

The project will also include the construction of a 132 kV switching station, 100 m x 100 m in extent, within the authorised DA2S WEF site and the construction of an access road from the east to the switching station.

***Findings***

The palaeontological impact assessments conducted by Almond (2012c) and Bamford (2020) for the project area indicate that the transmission lines and a portion of the access road cross a range of geological rock and sediment types, of which the Ecca and Beaufort shales are the most likely to preserve fossils. In both cases, however, previous research has shown that fossils are rare in the area. There is thus a very small chance of fossils being encountered during the construction of these elements of the project. The switching station and the portion of the access road on the dolerite uplands are both located on non-fossiliferous igneous rock and there is thus no potential for palaeontological impacts here.

To mitigate any potential impacts, the palaeontological impact assessment proposed the implementation of a Fossil Chance Find Protocol at the commencement, and for the life of the construction of the transmission lines, switching station and access road which will ensure the conservation and reporting of any finds of fossil material.

The environmental control officer (ECO) must look out for fossils and any fossil finds must be reported to SAHRA and conserved (preferably *in situ*). Significant chance fossil finds must be recorded and sampled by a qualified palaeontologist, together with pertinent contextual data (stratigraphy, sedimentology, taphonomy). Any recovered fossil material must be curated within an approved repository (museum/university fossil collection) by the palaeontologist.

The ACO walkover surveys of the of the transmission lines, switching station and access road in 2020 and 2022, and previous archaeological surveys of the farms Vetlaagte, Badenhorst Dam and Du Plessis Dam, identified a large number of archaeological occurrences which include Middle and Late Stone Age archaeological material, possible historic period stone structures, Khoikhoi stone kraal complexes, some rock engravings and scattered occurrences of historical period archaeological material.

The volume of and apparently ubiquitous nature of the Middle Stone Age artefacts scattered across the landscape, and the fact that much of this material was found to be in secondary, or disturbed context, means that the combined overall impact of activities associated with this project on Middle Stone Age material will be low.

By contrast, the context of much of the Late Stone Age artefacts noted during the survey appears to be better preserved than the Middle Stone Age material and is thus of greater

archaeological significance. More occurrences that could be called sites were noted with the Late Stone Age material, and the assessment found that if these sites were to be lost or damaged as a result of the construction of the transmission lines, switching station and access road, the impact would be medium, although this could be reduced to low through the application of measures to mitigate potential loss or damage.

The possible Khoi kraal and other stone structures noted during the survey represent a little-known aspect of the history and archaeology of this area. Their damage or destruction would result in a loss of heritage, and the impact significance would be medium. The application of measures to mitigate potential loss or damage, however, would reduce the impact significance to low.

Damage to or the destruction of the possible ruined “wolwehok” on Slingershoek would have a moderate impact significance. The application of measures to mitigate potential loss or damage, however, would reduce the impact significance to low.

No impacts are expected to graves or burials, engravings and rock art, historical archaeological sites and materials or the built environment.

The following mitigation measures are recommended with regard to archaeological rsources:

- One cluster of archaeological sites requires mitigation, in the form of artefact mapping, recording and collection by the project archaeologist prior to the commencement of construction of the transmission lines. This is JG050-JG052 / GEB013-GEB014, a dense early Holocene LSA stone scatter with ostrich eggshell eroding out of the bank of a stream in the Brak River Valley.

  The active erosive nature of this cluster of sites suggests that they retain contextual archaeological value and it is recommended that the mitigation take the form of the mapping, recording and collection by the archaeologist of exposed artefactual material, prior to the commencement of any activities related to the installation of the transmission lines.

- Other sites on or close to the transmission lines, switching station and access road route require mitigation by avoidance. Although not directly on the proposed cable or road alignments or switching station site, some of these sites are close enough to potentially be impacted or suffer damage as a direct, or indirect result of the installation of this infrastructure.

  These sites, each with the buffer described below, must be considered no-go areas during construction activities for the transmission lines, switching station and access road and those nearest the activity areas must be clearly marked as out of bounds:
  - G067–JG072 / GEB025. A buffer of 50 m must be implemented around the outer limits of this cluster of sites;
  - The possible Khoi kraals and shepherds’ huts (JG040; JG064-JG066). A 40 m buffer must be implemented around each site;
  - The possible “wolwehok” (JG036). A 20 m buffer must be implemented around this structure;
  - The rock engraving (JG044). A 20 m buffer must be implemented around this

occurrence;
- The two deflated stone tool clusters (JG122 and JG123). A buffer of 30 m must be implemented around each; and
- GEB105. A buffer of 40 m must be implemented around this waypoint.

If any of these buffers cannot be implemented or maintained, then these sites will require mitigation, in the form of artefact mapping, recording and collection by the project archaeologist prior to the commencement of construction of the transmission lines or access road.

Prior to the installation of the transmission lines, the project archaeologist must review pylon positions once these have been determined, to ensure that they will not impact on any recorded heritage resources. The micro-siting of pylon positions may be required, which should also be done in consultation with the archaeologist.

In the event of any new heritage resources being encountered during the installation of the transmission lines or the construction of the switching station or access road, SAHRA must be consulted immediately so that mitigatory action can be determined and be implemented if necessary. Such mitigation is at the cost of the developer, while time delays and diversion of machinery/plant may be necessary until mitigation in the form of conservation or archaeological sampling is completed.

Should any human remains be encountered at any stage during the construction or earthworks associated with this project, work in the vicinity must cease, the remains must be left *in situ* but made secure and the project archaeologist and SAHRA must be notified immediately so that mitigatory action can be determined and be implemented.

**Conclusion:** Provided that the mitigation measures set out above are implemented, the overall impact of the proposed installation of the DA2S WEF transmission lines, switching station and access road is tolerable and generally of low heritage significance.

It is our considered opinion, therefore that the proposed activity is acceptable in heritage terms.

***Author/s and Date***

Heritage Impact Assessment: John Gribble, ACO Associates, 2022.

Archaeological Impact Assessment: Incorporated in the HIA.

Palaeontological Impact Assessments: John Almond, 2012; Marion Bamford, 2020.

## ACKNOWLEDGEMENTS AND THANKS

ACO Associates wishes to acknowledge the help and support of the following farmers and landowners along the proposed grid connection route, switching station and access road who graciously allowed us access to their land for the survey:

- Henk Weydeman, Eskom (Hydra Substaiton);
- Barend van der Merwe (Wag ‘n Bietjie);
- ‘Duppie’ Pienaar (Carolus Poort / Vetlaagte);
- Diederik Albertyn (Carolus Poort / Rusoord);
- Geit and Fia van der Merwe (Slingershoek);
- The Emthanjeni Municipality; and
- Mr and Mrs Vermeulen (Knapdaar).

## GLOSSARY

**Archaeology:** Remains resulting from human activity which are in a state of disuse and are in or on land and which are older than 100 years, including artefacts, human and hominid remains and artificial features and structures.

**Cultural landscape:** The combined works of people and natural processes as manifested in the form of a landscape

**Early Stone Age:** The archaeology of the Stone Age between 700 000 and 2 500 000 years ago**.**

**Fossil:** Mineralised bones of animals, shellfish, plants and marine animals. A trace fossil is the track or footprint of a fossil animal that is preserved in stone or consolidated sediment.

**Heritage:** That which is inherited and forms part of the National Estate (Historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999.

**Holocene:** The most recent geological time period which commenced 10 000 years ago.

**Hornfels:** A type of indurated shale used in the production of stone tools in the Karoo.

**Late Stone Age:** The archaeology of the last 20 000 years associated with fully modern people.

**Lithology**: The description of the physical characteristics of a rock unit, visible at outcrop, in hand or in core samples.

**Lockshoek**: A non-microlithic tool industry named by Sampson which is present in the Karoo and dates from the late Pleistocene/early Holocene, c. 10 000 years ago. The Lockshoek is contemporary with the Oakhurst/Albany Industries and.is charactised by large sidescrapers, frontal scrapers, endscrapers, thick backed adzes and a wide variety of ground stone implements.

**Midden:** A pile of debris, normally shellfish and bone that have accumulated as a result of human activity.

**Middle Stone Age**: The archaeology of the Stone Age between 20 000-300 000 years ago associated with early modern humans.

**Miocene:** A geological time period (of 23 million - 5 million years ago).

**National Estate:** The collective heritage assets of the Nation

**Palaeontology:** Any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or trace.

**Pleistocene:** A geological time period (of 3 million – 10 000 years ago).

**Pliocene:** A geological time period (of 5 million – 3 million years ago).

**SAHRA:** South African Heritage Resources Agency – the compliance authority which protects

national heritage.

**Smithfield:** This term was coined in 1929 for a number of interior stone tools assemblages, made on indurated shale, and dating to the last 2000 years of the Later Stone Age. Various variants have been identified in different parts of the country but the term has not been clearly defined.

**Structure (historic):** Any building, works, device or other facility made by people and which is fixed to land, and includes any fixtures, fittings and equipment associated therewith. Protected structures are those which are over 60 years old.

**Wilton:** A Late Stone Age microlithic industry dating to between 6000 and 4000 years ago.

## ACRONYMS

| | |
|---|---|
| **DA2S WEF** | De Aar 2 South Wind Energy Facility |
| **DFFE** | Department of Fisheries, Forestry and the Environment |
| **ECO** | Environmental Control Officer |
| **ESA** | Early Stone Age |
| **GPS** | Global Positioning System |
| **HIA** | Heritage Impact Assessment |
| **LSA** | Late Stone Age |
| **MSA** | Middle Stone Age |
| **MTS** | Main Transmission Substation |
| **Mya** | Million years ago |
| **NHRA** | National Heritage Resources Act |
| **PHRA** | Provincial Heritage Resources Agency |
| **SAHRA** | South African Heritage Resources Agency |
| **SAHRIS** | South African Heritage Resources Information System |
| **WEF** | Wind Energy Facility |

# 1 INTRODUCTION

ACO Associates cc (ACO) was appointed by Arcus Consultancy Services South Africa (Pty) Ltd (Arcus), on behalf of Mulilo De Aar 2 South (Pty) Ltd (Mulilo) to carry out a heritage impact assessment (HIA) of two new transmission lines, a switching station and a proposed access road for the authorised De Aar 2 South wind energy facility (DA2S WEF), east of De Aar in the Northern Cape (Figure 1 and Figure 2).

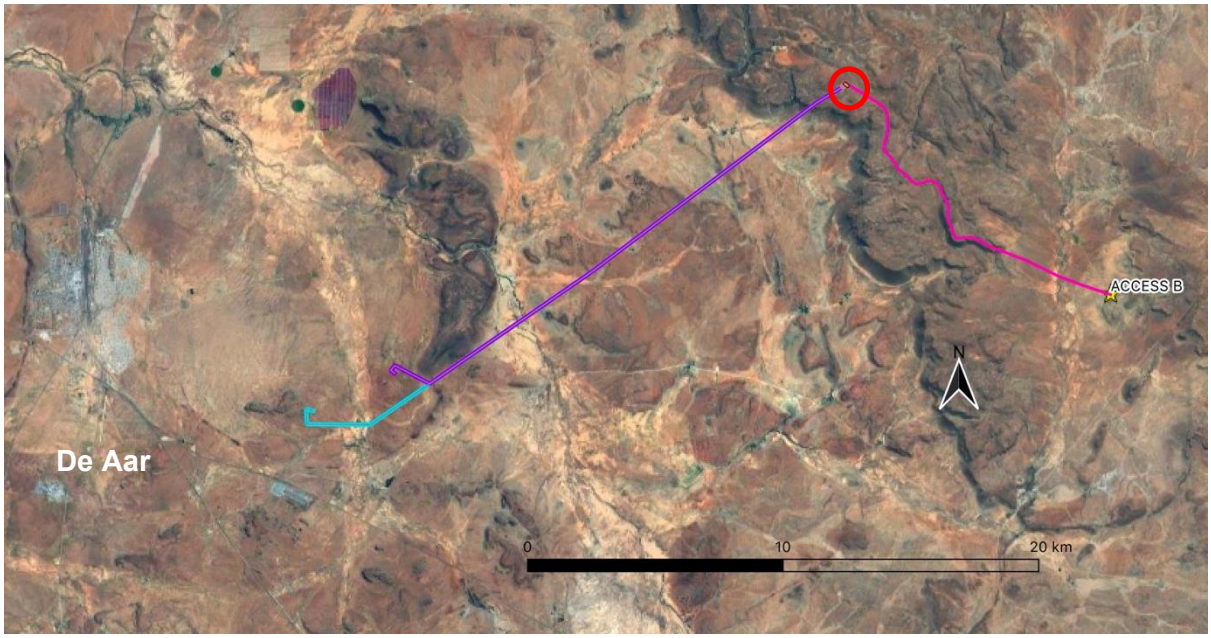



Figure 2: Proposed new transmission line route options (blue = Vetlaagte; purple = Wag ‘n Bietjie) between the he DA2S WEF switching station (circled) and the proposed MTS. The new access road is shown as a pink line (Source: Google Earth).

# 2 DEVELOPMENT PROPOSALS

Mulilo are proposing two new transmission line options, to connect the authorised DA2S WEF into the national grid to the south-west of De Aar.

Both proposed transmission line options follow the same south-westerly alignment from the switching station for approximately 17 km at which point Option 1 splits off to the proposed Wag ‘n Bietjie MTS, approximately 1,2 km to the north-west (Figure 3).

The Option 2 transmission line to the Vetlaagte MTS continues to the south-west from the Option 1 split for a further 2,5 km before also angling to the north-west towards the MTS location approximately 2 km distant (Figure 3).

The proposed transmission line will consist of either steel monopole or lattice tower structures with maximum heights of 31 m, including foundations and insulators. The grid connection will have a capacity of up to 132 kV. Existing access roads and jeep tracks will be utilised wherever possible but new line and servitude clearances will meet the statutory requirements.

The project will also include the construction of a 132 kV switching station, 100 m x 100 m in extent, within the authorised DA2S WEF site and an access road from the east to the switching station (Figure 4).

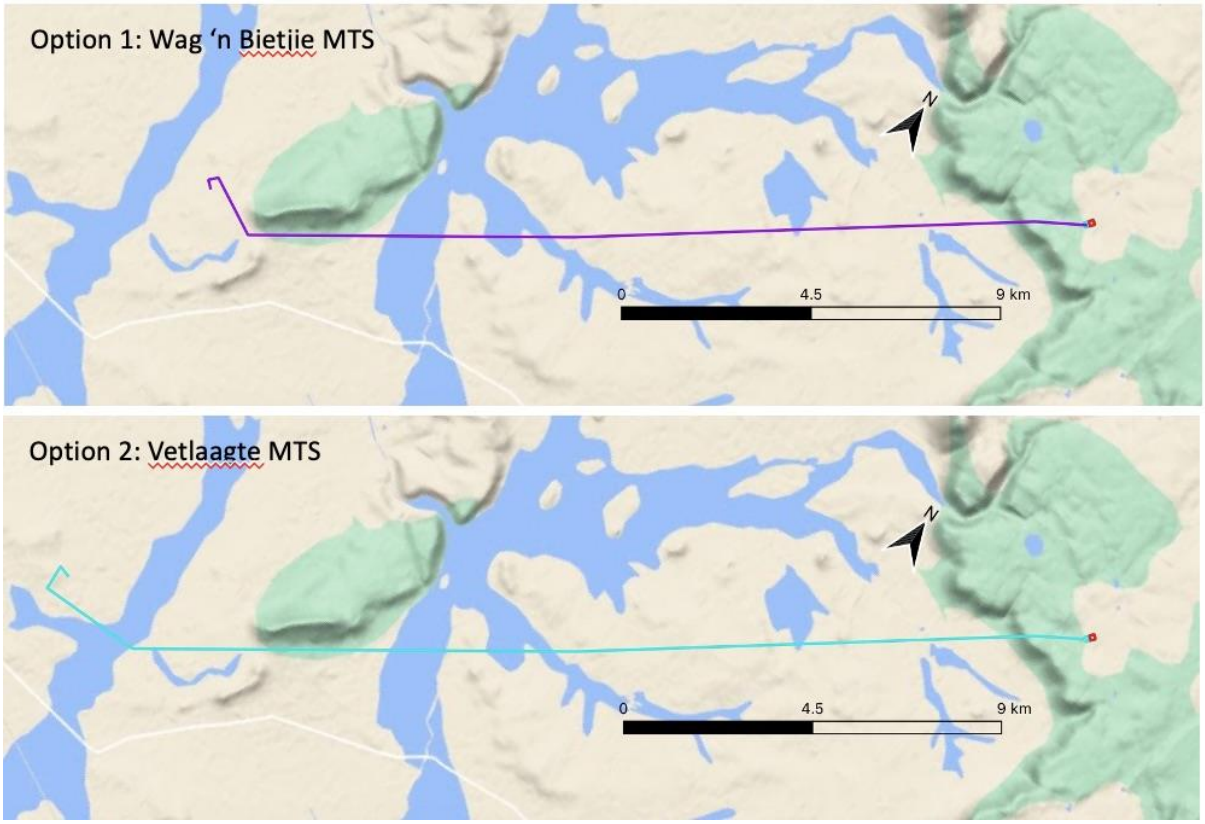



Figure 3: Comparison of the two proposed line options (Source: Google Terrain).

## 3 TERMS OF REFERENCE

ACO Associates was commissioned to produce a HIA as part of a Basic Assessment (BA) process for this project, as required by the National Environmental Management Act (No. 107 of 1998), as amended.

The HIA aims to identify heritage resources which may be impacted during the *construction*, *operation* and *decommissioning* phases of the transmission lines, switching station and access road to assess their significance and provide recommendations for mitigation.

This document therefore includes the following:

- A desk-top level literature review to assess the potential for archaeological, cultural and historic sites in the proposed development area;
- Archaeological field work to identify and document (collect GPS coordinates and photograph) heritage resources, that may be affected by the project, on the ground; and
- A desk-top palaeontological impact assessment (PIA) to assess whether palaeontological features will be affected by the project.

The results of the studies listed above are integrated in this HIA report along with an assessment of the sensitivity and significance of any heritage resources, an evaluation of the potential impacts on them of the construction, operation and decommissioning of the project, and recommendations for measures to mitigate any negative impacts of the project on them.

The HIA must be submitted for comment to the South African Heritage Resources Agency

(SAHRA) and the Northern Cape Provincial Heritage Resources Authority (Ngwao-Boswa Jwa Kapa Bokone), the relevant statutory commenting bodies under the National Environmental Management Act, as amended.

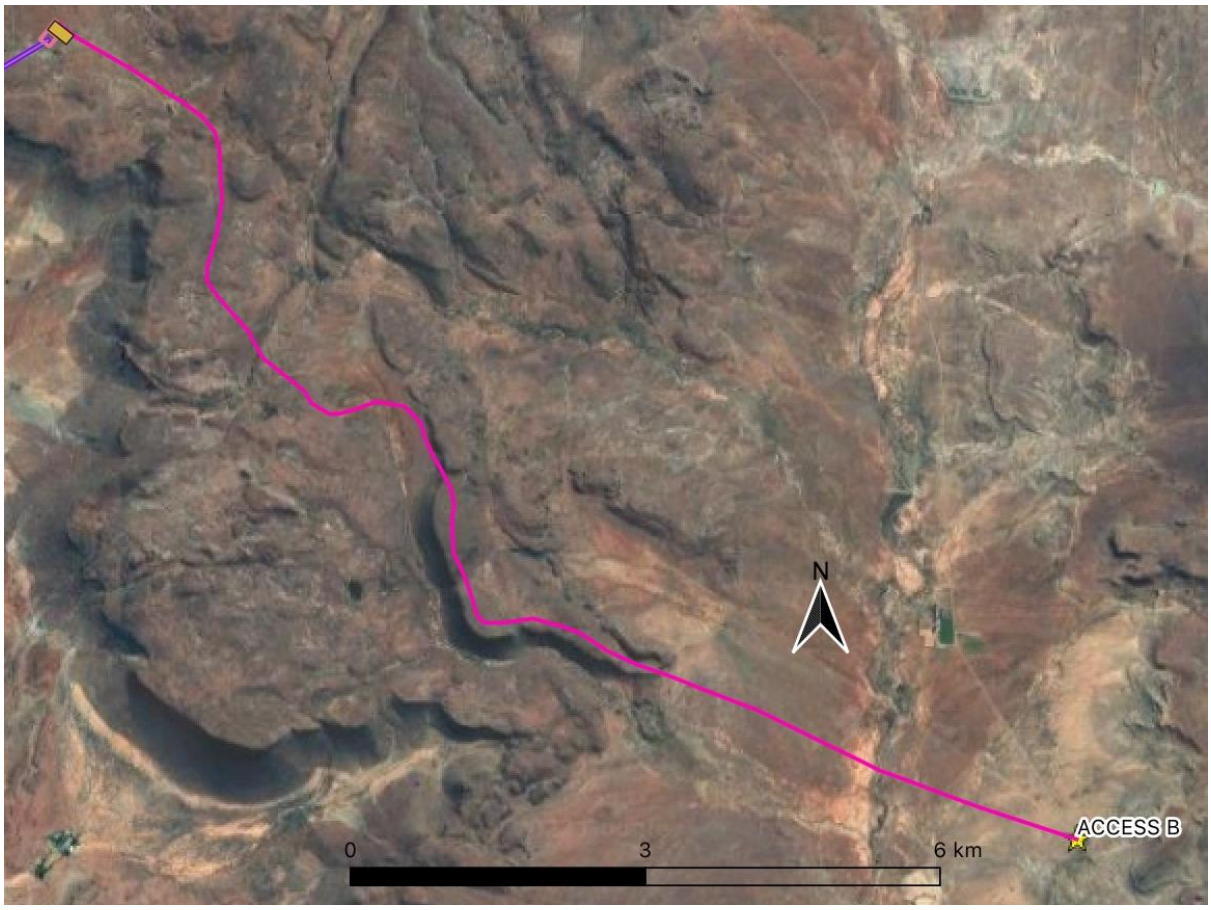



Figure 4: Proposed alignment of the access road (pink line) to the switching station (yellow rectangle) (Source: Google Earth).

# 4 RELEVANT LEGISLATION

## *4.1 National Heritage Resources Act (No 25 of 1999)*

The National Heritage Resources Act (NHRA) came into force in 2000 with the establishment of the SAHRA, replacing the National Monuments Act (No. 28 of 1969 as amended) and the National Monuments Council as the national agency responsible for the management of South Africa's cultural heritage resources.

The NHRA reflects the tripartite (national/provincial/local) nature of public administration under the South African Constitution and makes provision for the devolution of cultural heritage management to the appropriate, competent level of government. In the Northern Cape this is the Northern Cape Provincial Heritage Resources Authority, Ngwao-Boswa Jwa Kapa Bokone. At present, however, archaeological and palaeontological heritage management in the Northern Cape is being managed on an agency basis by SAHRA.

The NHRA gives legal definition to the range and extent of what are considered to be South Africa's heritage resources. According to Section 2(xvi) of the Act a heritage resource is "any place or object of cultural significance". This means that the object or place has aesthetic,

architectural, historical, scientific, social, spiritual, linguistic or technological value or significance.

In terms of the definitions provided in Section 2 of the NHRA, heritage resources potentially relevant to this assessment are:

- Material remains of human activity which are in a state of disuse and are in or on land [which includes land under water] and which are older than 100 years, including artefacts, human and hominid remains and artificial features;
- Rock art, being any form of painting, engraving or other graphic representation on a fixed rock surface or loose rock or stone, which was executed by human agency and which is older than 100 years;
- Any fossilised remains or fossil trace of animals or plants which lived in the geological past [other than fossil fuels or fossiliferous rock intended for industrial use] and any site which contains such fossilised remains or trace;
- Any movable property of cultural significance which may be protected in terms of any provisions of the NHRA, including any archaeological artefact or palaeontological specimen; and
- Intangible heritage such as traditional activities, oral histories and places where significant events happened.

As per the definitions provided above, these cultural heritage resources are protected by the NHRA and a permit from SAHRA (currently) is required to destroy, damage, excavate, alter, deface or otherwise disturb any such site or material.

It is also important to be aware that in terms of Section 35(2) of the NHRA, all archaeological objects and palaeontological material is the property of the State and must, where recovered from a site, be lodged with an appropriate museum or other public institution.

Section 38 of the NHRA requires a Heritage Impact Assessments (HIA) for certain kinds of development. In relation to this project, the relevant development activity is the construction of a road, wall, powerline, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length (Section 38(1)(a)).

### *4.1.1 Grading of Heritage Resources*

The South African heritage resources management system is based on grading, which provides for assigning the appropriate level of management responsibility to a heritage resource. Heritage resources were assessed according to criteria specified in the NHRA.

Grading, according to Winter & Oberholzer (2013) is “generally based on the intactness, rarity and representivity of the resource, as well as its role in the larger landscape or cultural context”.

Section 3 of the NHRA suggests the following criteria for assigning heritage significance:.

- Importance in the community or pattern in South Africa’s history;
- Possession of uncommon, rare or endangered aspects of South Africa’s natural or cultural heritage;
- Potential to yield information that will contribute to an understanding of South Africa’s natural or cultural heritage;

- Importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects;
- Importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
- Importance in demonstrating a high degree of creative or technical achievement during a particular period;
- Strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;
- Strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa; and
- Significance in relating to the history of slavery in South Africa.

The generally accepted heritage resource grades are shown in Table 1 below.

Table 1: Grading of heritage resources (Source: Baumann & Winter 2005: Box 5).

| Grade | Level of significance | Description |
|---|---|---|
| 1 | National | Of high intrinsic, associational and contextual heritage value within a national context, i.e. formally declared or potential Grade 1 heritage resources. |
| 2 | Provincial | Of high intrinsic, associational and contextual heritage value within a provincial context, i.e. formally declared or potential Grade 2 heritage resources. |
| 3A | Local | Of high intrinsic, associational and contextual heritage value within a local context, i.e. formally declared or potential Grade 3A heritage resources. |
| 3B | Local | Of moderate to high intrinsic, associational and contextual value within a local context, i.e. potential Grade 3B heritage resources. |
| 3C | Local | Of medium to low intrinsic, associational or contextual heritage value within a national, provincial and local context, i.e. potential Grade 3C heritage resources. |

### *4.2 National Environmental Management Act (Act No 107 of 1998)*

The National Environmental Management Act (NEMA), as amended, provides a framework for the integration of environmental issues into the planning, design, decision-making and implementation of plans and development proposals that are likely to have a negative effect on the environment.

Regulations governing the environmental authorisation process have been promulgated in terms of NEMA and include the EIA Regulations, 2014 as amended (GNR R326/2017) and Listing Notices 1 – 3 (GNR 324, 325 and 327/2017). These regulations were amended in April 2017 by Government Notices 324, 325, 326 and 327.

The development proposed for this project triggers a number of activities in the Listing Notices and, in terms of GNR 325 therefore, the project will be subject to a Basic Assessment process and Mulilo will be required to obtain a positive Environmental Authorisation from the Department of Fisheries, Forestry and the Environment (DFFE) prior to commencement of the proposed activities.

## 5 METHODOLOGY

This study was commissioned as a heritage impact assessment and attempts to assess the impacts of the proposed transmission lines, switching station and access road on the heritage resources of the area.

### *5.1 Archaeological Desktop Review*

In 2020 ACO conducted an assessment for the previous grid connection proposed between the DA2S WEF to the Eskom Hydra Substation (Gribble & Euston-Brown, 2020). Much of the transmission line routes being assessed in this current HIA follows the same alignment as the grid connection alignments proposed in 2020 (see Figure 5) and that study and associated fieldwork was thus used as the basis for the current report.

Similarly, a survey by Webley and Halkett (2015) as part of the HIA for the DA2S WEF visited areas close to and overlapping portions of the proposed access road and their findings were also used to inform this report.

Most recently, a pre-construction walkdown survey was conducted of the new transmission line between the Hydra substation and the Mulilo Solar PV Cluster 1 on the farm Badenhorst Dam (1/180) (Gribble & Euston-Brown, 2021) located less than 1 km west of Option 2: Vetlaagte transmission line.

A number of other previous published archaeological reports and unpublished archaeological, heritage and palaeontological impact assessments have been conducted for projects in the vicinity of De Aar and around the proposed grid connection routes (see **Error! Reference source not found.**). The following reports, available on the SAHRIS online platform (https://sahris.sahra.org.za/) or in ACO's project archive, were therefore reviewed and have contributed to this assessment:

- Archaeological Scoping Study: Establishment of an Ammunition Disposal Plant, Sinclair's Dam 133, De Aar, Northern Cape, South Africa (ArchaeoMaps Heritage Consultancy, 2008);
- Archaeological Impact Assessment: Establishment of an Ammunition Disposal Plant, Sinclair's Dam 133, De Aar, Northern Cape, South Africa (ArchaeoMaps Heritage Consultancy, 2009);
- Archaeological impact assessment proposed Photovoltaic Power Generation Facility in De Aar, Northern Cape (Agency for Cultural Resource Management, 2010);
- Archaeological impact assessment of a proposed wind energy facility near De Aar, Northern Cape (Agency for Cultural Resource Management, 2010);
- Heritage scoping assessment for the proposed establishment of the ACED De Aar Solar Energy Facility, Northern Cape Province (J van Schalkwyk, 2011);
- Proposed De Aar Wind Energy Facility on the North and South Plateau, Northern Cape Province (Archaeology Contracts Office, 2011);
- Heritage Scoping Report for the proposed establishment of the Inca Energy PV Power Plant, De Aar, Northern Cape Province (Van Schalkwyk, 2011);
- Archaeological impact Assessment: proposed establishment of the Inca Solar Energy Facility, De Aar, Northern Cape (Heritage Contracts and Archaeological Consulting, 2011);
- Concentrated Solar Power EIA, De Aar: Heritage Impact Assessment (PGS, 2011 & 2012);
- Heritage Impact Assessment Scoping Report for De Aar Solar One Photovoltaic Power Plant, Northern Cape (Bekker, 2012a);
- Phase 2 Heritage Impact Assessment De Aar Solar One Photovoltaic Power Project (Bekker, 2012b);

- Proposed establishment of a solar energy facility near De Aar, Northern Cape Province: Phase 1 Archaeological Impact Assessment Report (Kruger, 2012);
- Proposed solar power generation facilities on the remaining extent of the farm Vetlaagte No. 4, De Aar, Northern Cape Province: Palaeontological specialist study - combined desktop and field-based assessments (Almond, 2012);
- Two wind energy facilities on the Eastern Plateau near De Aar, Northern Cape Province proposed by Mulilo Renewable Energy (Pty) Ltd: palaeontological specialist study - combined desktop and field-based assessments (Almond, 2012b);
- Proposed Mulilo Renewable Energy PV2, PV3 and PV4 photovoltaic energy facilities on Farms Paarde Valley, Badenhorst Dam and Annex Du Plessis Dam near De Aar, Northern Cape Province. Palaeontological specialist study: combined desktop and field-based assessments (Almond, 2012a);
- Heritage Impact Assessment for three solar energy facilities at De Aar, Western Cape (sic) (Orton 2012);
- Proposed Photovoltaic (solar) energy facilities on du Plessis Dam Farm near De Aar: Palaeontological specialist study - combined desktop and field-based assessments, (Almond, 2013);
- Heritage Impact Assessment for multiple proposed solar energy facilities on De Aar 180/1 (Badenhorst Dam farm), De Aar, Northern Cape (Orton and Webley 2013a);
- Heritage Impact Assessment for multiple proposed solar energy facilities on Du Plessis Dam 179, De Aar, Northern Cape (Orton and Webley 2013b);
- Proposed construction of a 132 kV transmission line from the Longyuan Mulilo De Aar 2 North Wind Energy Facility on the Eastern Plateau (De Aar 2) near De Aar, Northern Cape (PGS, 2014);
- Archaeological impact assessment for the proposed Castle Wind Energy Facility, De Aar, Northern Cape (Heritage Contracts and Archaeological Consulting, 2014);
- Heritage Impact Assessment: Walkdown of final layout of the Longyuan Mulilo De Aar 2 North Wind Energy Facility, Northern Cape Province (ACO Associates, 2014);
- Addendum: Proposed Wind Energy Facility situated on the Eastern Plateau (South) near De Aar, Northern Cape Province (Webley and Halkett, 2015);
- Archaeological Impact Assessment: proposed photovoltaic power generation facility in De Aar, Northern Cape (Archer, no date); and
- A Palaeontological Desktop Study of the area to be affected by the proposed Photovoltaic Power Project on Portion 3 of farm Hartebeestplaats 135 (Brink, no date).

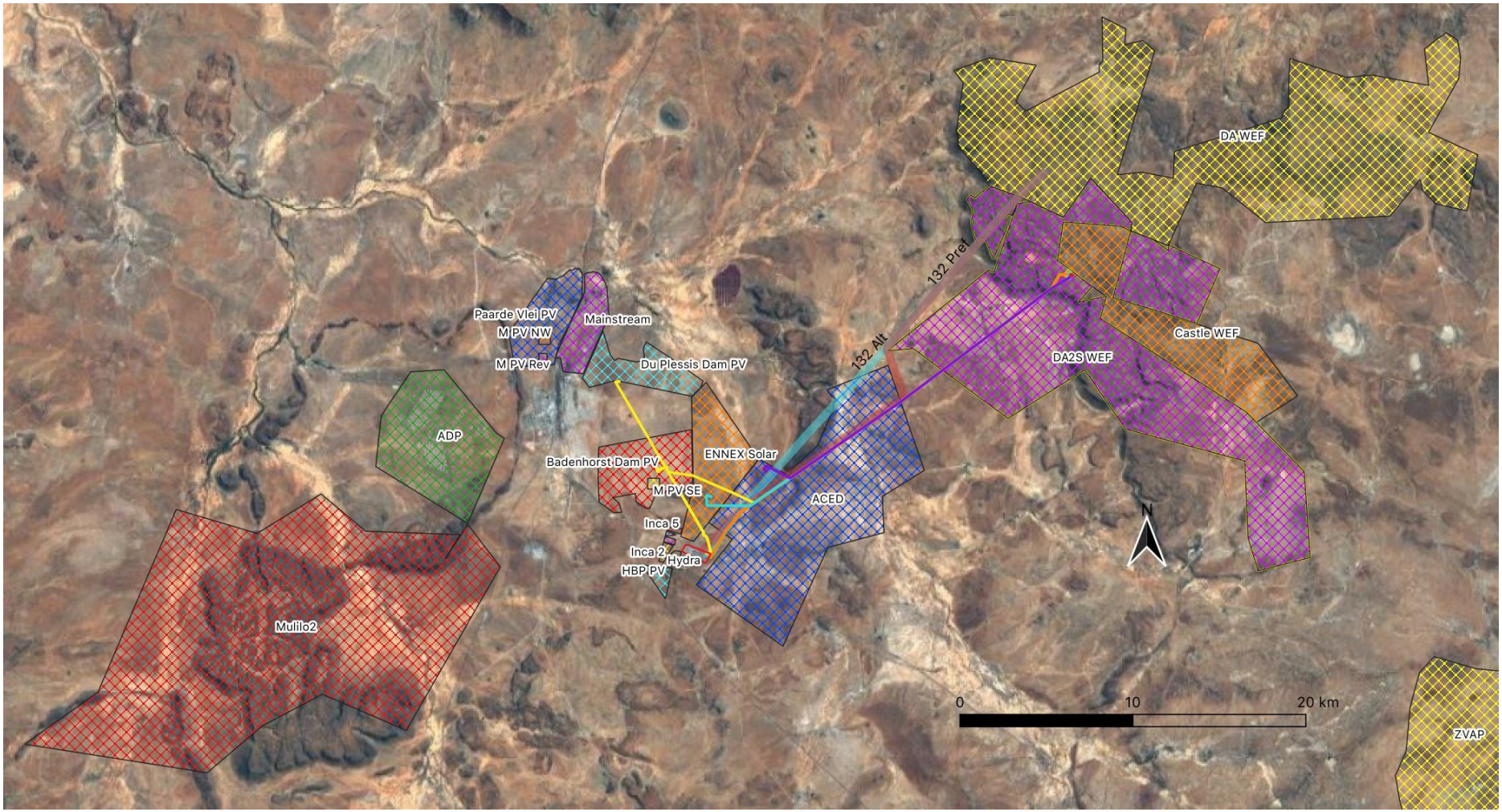



Figure 5: Previous heritage assessments carried out in the vicinity of the proposed grid connection routes. The yellow and orange lines associated with the current purple and blue transmission line options represent the previous proposed DA2S WEF grid connection options (Source: Google Earth).

The grid connection routes also lie less than 35 km west of the study area of the Zeekoei Valley Archaeological Survey (ZVAS), a major archaeological survey undertaken by a team led by Garth Sampson in the late 1970s and early 1980s (see Figure 6). The project surveyed 5,000 square kilometres of the catchment of the Zeekoei River (from the Sneeuberg Mountains to the Gariep River Valley) and recorded some 10,000 archaeological sites representing a history of human occupation covering at least 250,000 years. Sampson identified seven industries or phases of human history within his study area, each of which are legible on the landscape today, and each of which represent a pre-colonial layer of the human history of the Karoo (Sampson, 1985).

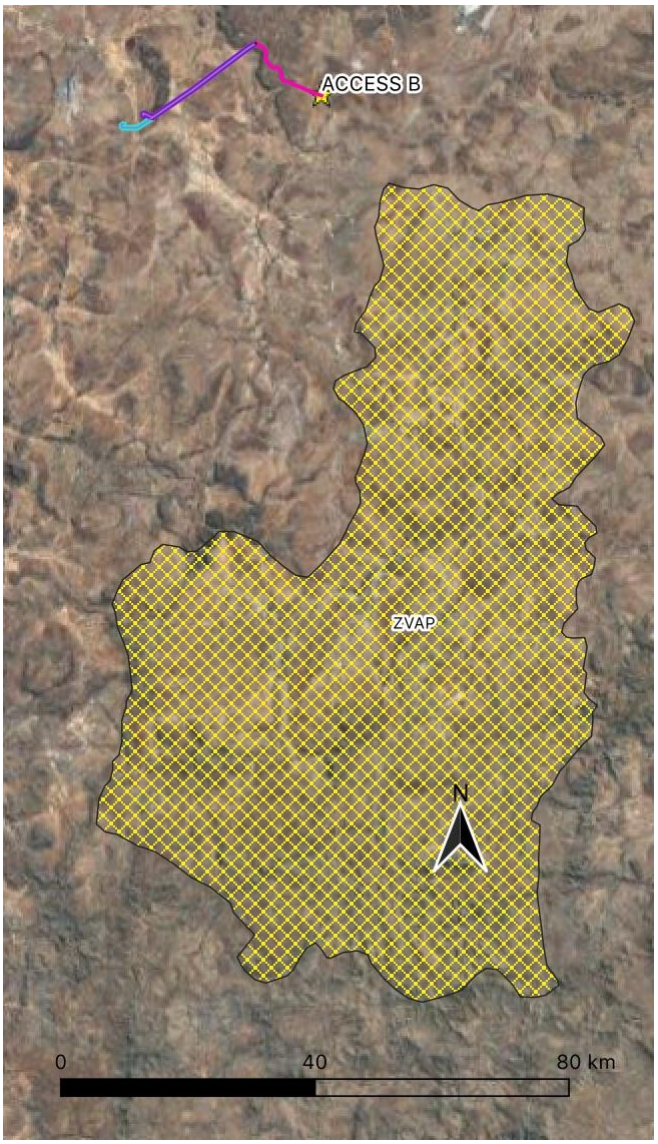



Figure 6: Proximity of the proposed transmission line routes, access road and switching station to the Zeekoei Valley Archaeological Survey study area (After Sampson 1985).

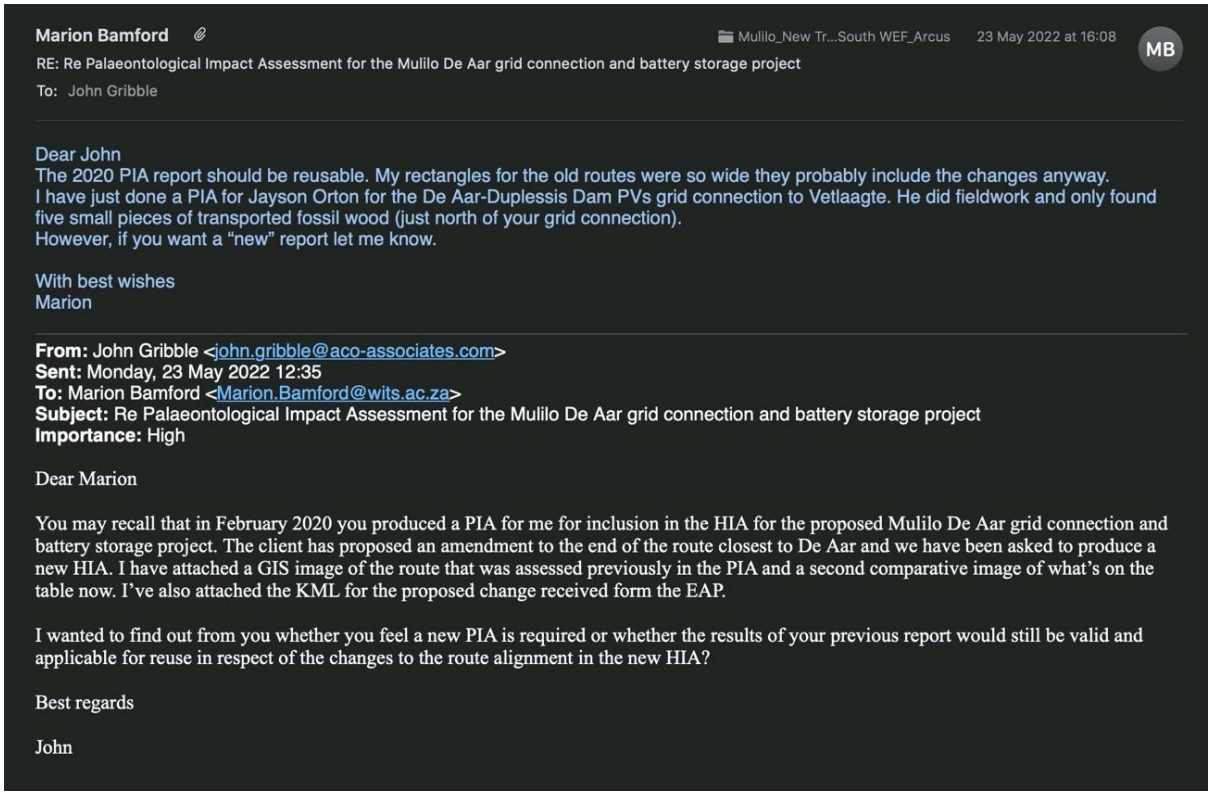
## *5.2 Palaeontological Assessment*

According to the SAHRIS palaeosensitivity map the transmission lines and access road traverse an area with a range of palaeontological sensitivities, while the switching station is located on volcanic dolerites which have no palaeontological potential or sensitivity.

Two palaeontological impact assessments (PIA) have been conducted previously for the area covered by this project. In 2012 a combine desktop and field-based PIA was produced by Dr John Almond for the De Aar 2 North and South WEFs (Almond, 2012c). This assessment covered the area within which the switching station and the access road will be constructed. More recently, Dr Marion Bamford of the University of the Witwatersrand produced a PIA for the HIA for the original DA2S WEF grid connection routes (Bamford, 2020).

At the time of writing this HIA Dr Almond was out of the country and could not be reached for comment on the continuing validity of the findings of his 2012 PIA. However, in recent correspondence with Dr Bamford about the validity and applicability of her 2020 report to the current HIA (see Figure 7), she indicates that given the overlap for most of the previous and current transmission line routes there is no reason why the 2020 report cannot be reused in the new HIA.

Based on this, Bamford (2020) has thus been reused as the PIA in this current HIA, supplemented where necessary by Almond (2012c). The results are presented in this report and the Bamford (2020) and Almond (2012c) PIA are attached in full as Appendix A.



**Marion Bamford** Mulilo_New Tr...South WEF_Arcus 23 May 2022 at 16:08 MB

RE: Re Palaeontological Impact Assessment for the Mulilo De Aar grid connection and battery storage project

To: John Gribble

Dear John
The 2020 PIA report should be reusable. My rectangles for the old routes were so wide they probably include the changes anyway.
I have just done a PIA for Jayson Orton for the De Aar-Duplessis Dam PVs grid connection to Vetlaagte. He did fieldwork and only found five small pieces of transported fossil wood (just north of your grid connection).
However, if you want a "new" report let me know.

With best wishes
Marion

**From:** John Gribble <john.gribble@aco-associates.com>
**Sent:** Monday, 23 May 2022 12:35
**To:** Marion Bamford <Marion.Bamford@wits.ac.za>
**Subject:** Re Palaeontological Impact Assessment for the Mulilo De Aar grid connection and battery storage project
**Importance:** High

Dear Marion

You may recall that in February 2020 you produced a PIA for me for inclusion in the HIA for the proposed Mulilo De Aar grid connection and battery storage project. The client has proposed an amendment to the end of the route closest to De Aar and we have been asked to produce a new HIA. I have attached a GIS image of the route that was assessed previously in the PIA and a second comparative image of what's on the table now. I've also attached the KML for the proposed change received form the EAP.

I wanted to find out from you whether you feel a new PIA is required or whether the results of your previous report would still be valid and applicable for reuse in respect of the changes to the route alignment in the new HIA?

Best regards

John

Figure 7: Email correspondence with Dr Marion Bamford regarding the reuse of the 2020 PIA

### *5.3 Archaeological Field Assessment*

A physical archaeological survey of the previous grid connection route was undertaken by John Gribble and Gail Euston-Brown of ACO Associates between 11-13 February 2020. Further fieldwork conducted by the same team between 30 June and 2 July 2022 aimed at assessing the access road, revisiting the switching station area and, if time allowed, surveying those areas of the new transmission lines not previously surveyed.

For both surveys, the grid connection route and access road alignments and the area to be

covered by the switching station, along with other relevant data such as the results of the previous surveys were loaded onto hand-held GPS receivers (on the WGS84 datum) carried by each member of the field team. Travelled tracks were logged (Figure 8) and waypoints were entered into the GPS at the location of any identified heritage resources (Figure 9). Assessment focussed on a corridor of 150 m on either side of the proposed grid lines and access road.

Although the veld was lush on both occasions, this did not unduly influence the outcome of the study as ground visibility was generally good.

All heritage resources located were recorded, photographs were taken of most finds and the resource was graded according to the Baumann and Winter (2005) system set out in the guidelines for involving heritage practitioners in EIAs and referred to above (Table 1). No trial holes were dug and all observations were based on visible surface material. No archaeological material was removed from the project area, but recorded and photographed *in situ*.

Appendix B contains the detail of the observations made in the field in 2020 and 2022.

The analysis of heritage resources, which were almost exclusively pre-colonial archaeological material, is based upon the experience of the team members who are familiar with the standard classification systems for artefactual material in use to the degree that they can roughly date and characterise an archaeological site based on its visible content and artefacts.

## *5.4 Restrictions and Assumptions*

### *5.4.1 Palaeontology*

Based on the geology of the project area and the palaeontological record of the Karoo as we know it, it can be assumed that the formation and layout of the dolerites, sandstones, shales and sands in the area are typical and that some do contain fossil plant, wood, invertebrate traces and vertebrate material. This is borne out by previous site visit PIAs which identified occasional traces fossils and fragments of silicified wood occur in the Tierberg Formation (Ecca Group) and silicified wood, trace fossils and bone fragments in the Adelaide Subgroup rocks (see for example Almond 2012a and 2012c).

### *5.4.2 Archaeology*

Arrangements made by ACO with Eskom prior to the 2020 survey to provide accompanied direct access along the existing grid connection servitudes were changed at the last minute (a consequence of load shedding demands on Eskom staff at the Hydra substation). This meant that access to the proposed grid connection routes had to be on a farm by farm basis, which reduced the survey time on the route alignments.

Access constraints caused by extremely wet and muddy conditions and personal injury to one of the field team during the 2022 survey meant that the branches of the transmission lines to the two MTS options, and a small portion of the access road between the switching station and the Slingerhoek / Knapdaar farm boundary could not be surveyed (see Figure 8).

In respect of these areas, however, pervious archaeological surveys have been conducted in the vicinity of the branches of the transmission lines to the two MTS options for proposed solar energy facilities. Kruger (2012) surveyed much of Vetlaagte in 2012, and in 2011 and 2013 ACO Associates conducted field assessments on Badenhorst Dam (Orton, 2012; Orton and

Webley 2013a). More recently ACO Associates conducted a walkdown survey of the Mulilo Total Hydra transmission line (Gribble & Euston-Brown 2021) (Figure 10).

The receiving environment on both farms is very similar to that encountered elsewhere on the grid connection route by ACO in 2020, and the archaeological material reported by Kruger (2012), Orton (2012), Orton and Webley (2013a) and Gribble and Euston-Brown (2021) – MSA and LSA lithic scatters, a number of Khoi kraals and circular stone structures associates with rocky ridges and outcrops, and some historical remains – is what would have been expected, based on the results of the 2020 ACO survey of the rest of the grid connection routes and the other assessments in the wider area listed earlier. A handful of archaeological occurrences were identified by these studies close to the proposed 2020 Option 2 grid connection alignment, and these are considered in the archaeological assessment below.

In respect of that portion of the access road not surveyed, the results of the 2020 and 2022 ACO surveys, as well as the fieldwork conducted by Webley and Halkett (2015) and by Orton and Webley (ACO Associates, 2014) for the DA2S and DA2N WEFS provides a good indication of the archaeological potential of the area (Figure 11).

Lack of access to these portions of the project is thus not considered a serious limitation as the results of the remainder of the survey, together with other the other referred to provide a good indication of the heritage resources that can be anticipated in the portions of current transmission lines that were not accessed.

## 6 RECEIVING ENVIRONMENT

This part of the Northern Cape is characterized by wide plains interspersed with koppies and mountains formed by igneous intrusions. The transmission lines crosses a variety of terrains. At its eastern terminus, the switching station is located on an extensive, flat mountain plateau which rises at least 100 m above the surrounding plains. The plateau is generally flat with rocky outcrops and is covered in typical Karoo scrub and grasses (Plate 1). There are more dense clusters of trees in some of the deeply incised valleys and a number of dry stream beds which flow periodically after summer rains cross the area.

Below the plateau, the transmission line routes traverses a series of flat valley bottoms divided by intrusive dolerite koppies (Plate 2). These flat valley bottoms are almost without exception seasonal river and stream drainages, the largest of which is the Brak River on Carolus Poort 3/3 and here the land is low-lying and following the rains prior to the fieldwork was swampy with thick silty Quaternary sediments (Plate 3). In many of these areas, vegetation is more sparse and there are large open eroded and deflated surfaces where archaeological material is often exposed (Plate 4). At the time of the 2022 survey the vegetation cover on the portion of the access road alignment below the dolerite plateau was thick, with dense grass covering the area (Plate 5). Despite this, ground visibility was sufficient for archaeological survey purposes.

Sampson's (2015:4-5) description of the geography of the Zeekoei Valley is remarkably similar to the physical environment encountered in the area surveyed for the proposed grid connections: valley floors bifurcated by dolerite dykes and sills which form clusters of low hills and ridges and in many places the underlying Beaufort shales indurated or baked by the intrusive dolerites to form a metamorphic rock known as hornfels.

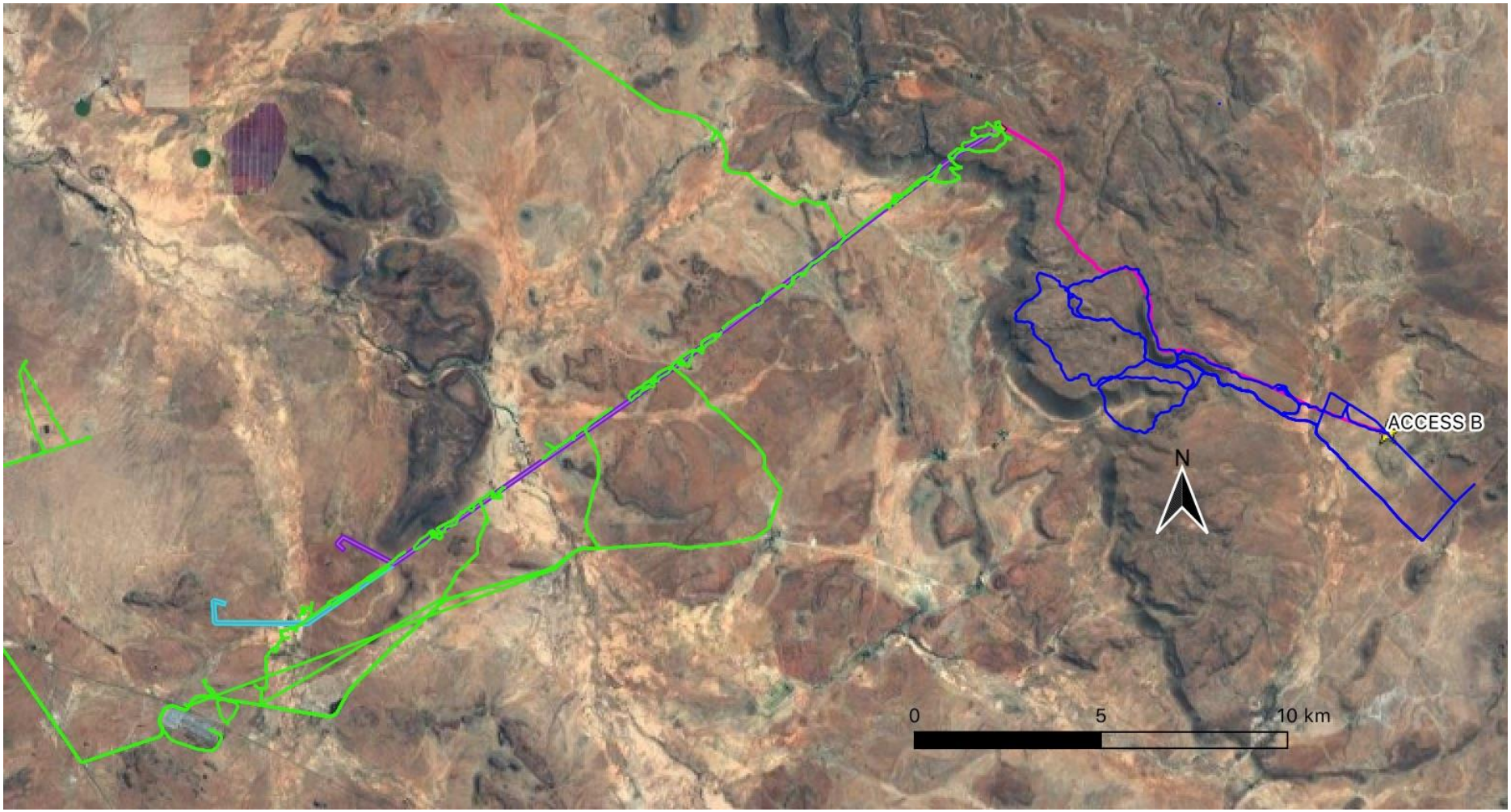



Figure 8: ACO Associates survey tracks (2020 = green; 2022 - blue) overlaid on proposed new grid connection routes and switching station (pale blue and purple) and access road (pink) (Source: Google Earth).

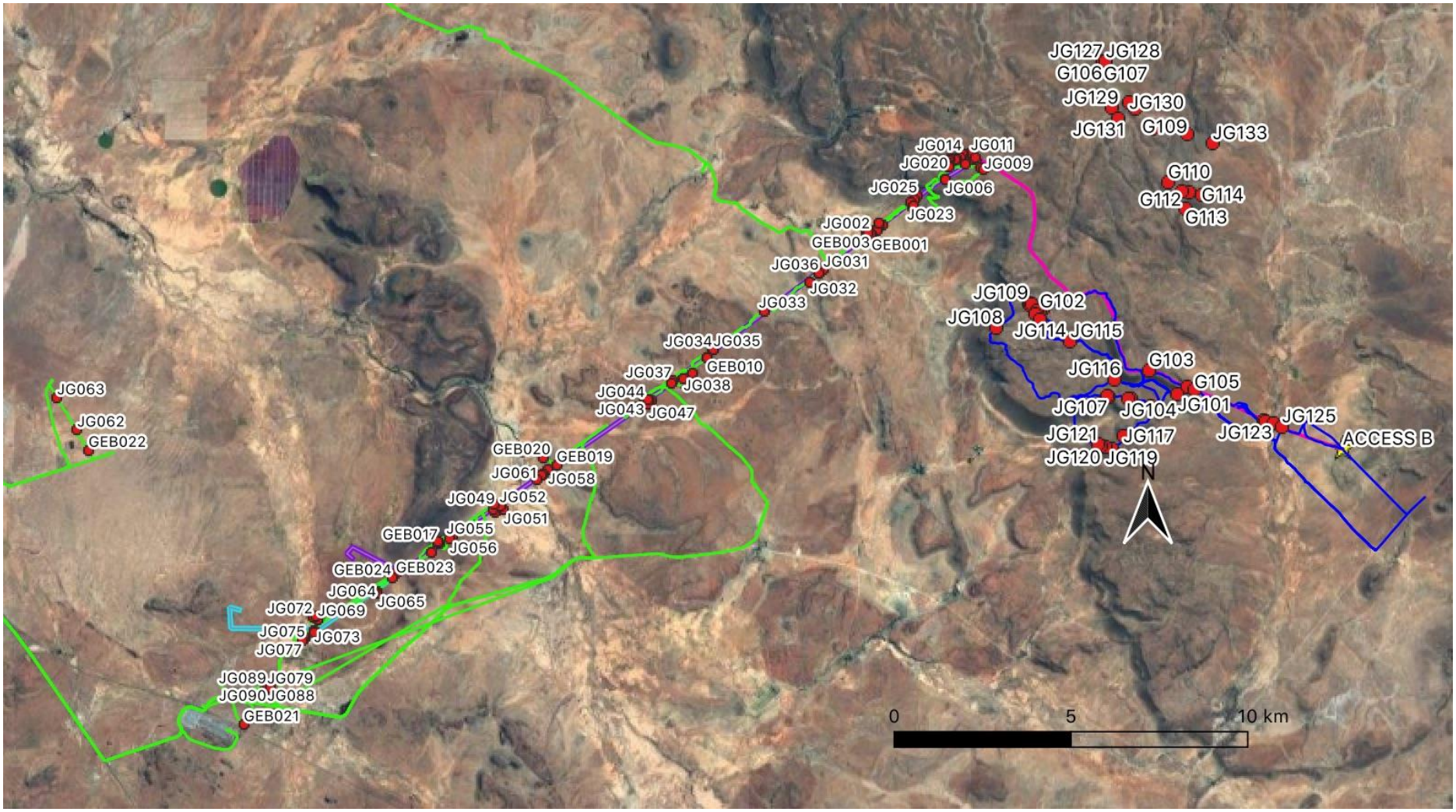



Figure 9: Waypoints denoting archaeological occurrences recorded during the 2020 and 2022 ACO surveys of the proposed transmission line routes, switching station area and access road (Source: Google Earth).

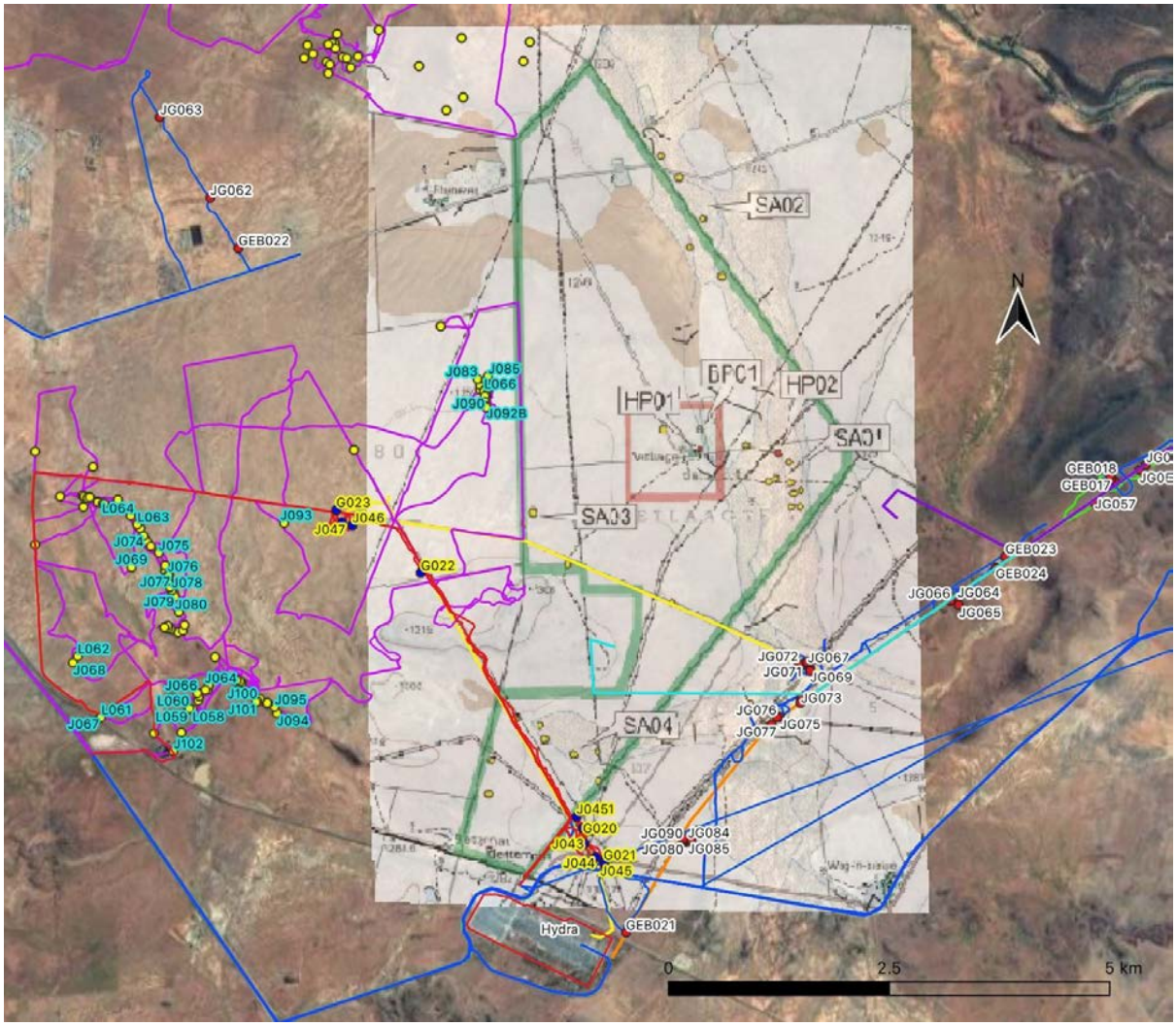



Figure 10: Overlay of Kruger (2012) (inserted map), Orton and Webley (2013a) and Gribble and Euston-Brown (2020 and 2021) survey results on the farms Vetlaagte and Badenhorst Dam with current proposed Option 1: Vetlaagte (pale blue) and Option 2: Wag ‘n Bietjie (purple) transmission line routes. Purple lines / blue numbered points = Orton and Webley 2013; dark blue lines and white numbered points = Gribble and Euston-Brown 2020 and red lines / yellow numbered points = Gribble and Euston-Brown 2021.

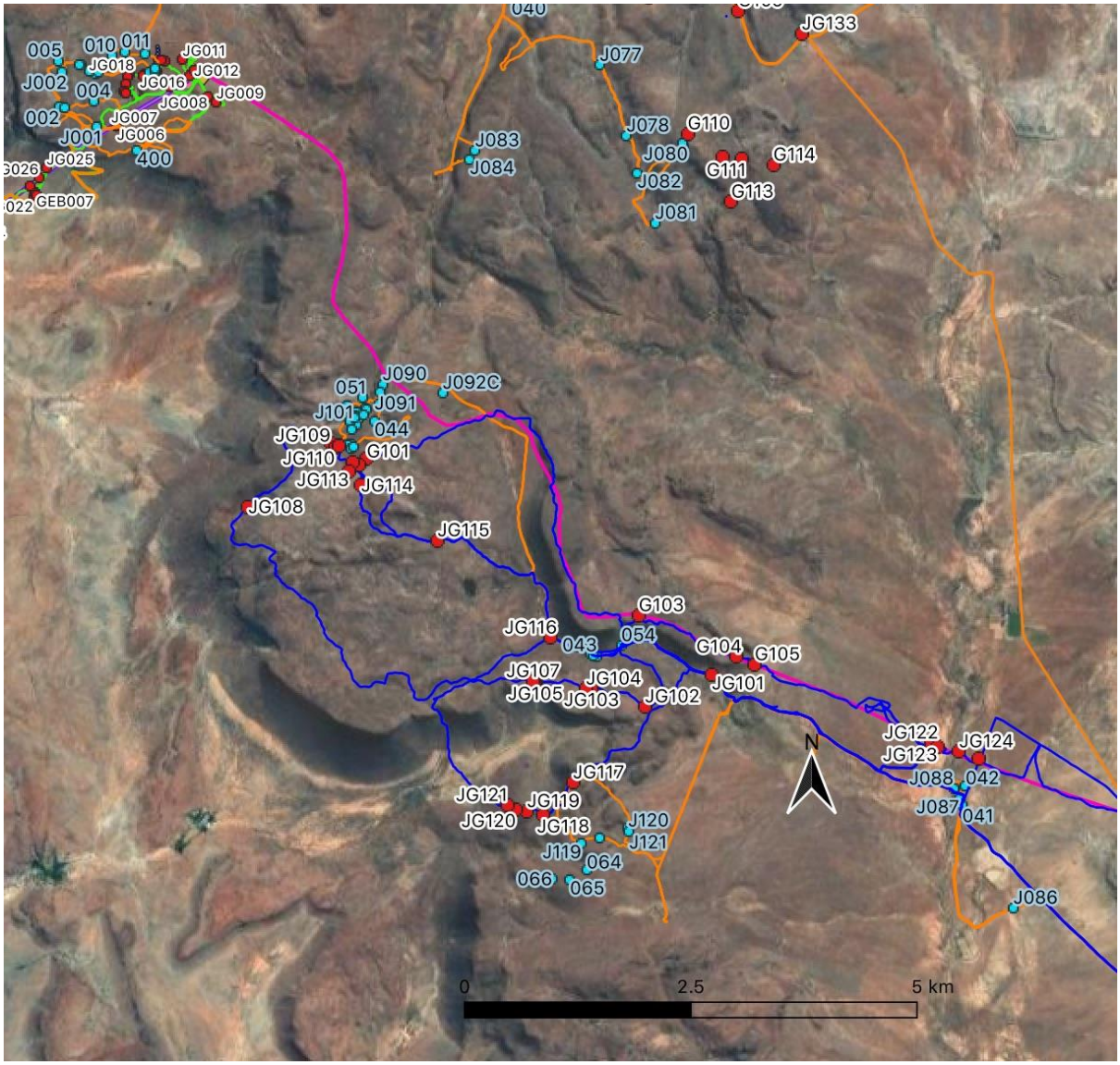



Figure 11: Overlay of ACO Associates (2014) and Webley and Halkett (2015) survey results for the DA2S and DA2N WEFS (orange lines and blue numbered points) with the results of the 2020 and 2022 surveys (blue lines and white numbered points) for the current project.

Plate 1:View across upland plateau.

Plate 2: View from the plateau across the proposed alignment of the transmission lines. De Aar and the proposed MTS sites are located below the hills on the horizon. Note the open erosive areas in the foreground which are typical of the valley bottoms traversed by the route. The yellow line shows the approximate route of the transmission line. The existing power line is visible to the right of the proposed route.

Plate 3: View to the east across the Brak River valley along the proposed transmission line routes. The proposed route will run to the right of the pylons in the photograph. Note the erosive surface in the foreground and the Brak River in the distance.

Plate 4: Example of an area of erosion and deflation with exposed archaeological material (JG077 – see Appendix B) on the farm Wag ‘n Bietjie (Re 5).

Plate 5:View to north-west from near Access B showing the nature of the terrain covered by the access road towards the mountains where the switching station will be constructed.

## *6.1 Palaeontological Context*

The Karoo is a vast palaeontological landscape consisting of multiple layers of sediments that contain an array of fossils, ranging from fish, early vertebrates, plant remains to trace fossils. It is considered to be one of the most complete fossil repositories on the planet.

The geology and paleontology of the region has been a subject of research since the early 20th century. The flat plains of the modern Karoo are underlain by a series of shale and mudstone strata which represent some 400 million years of depositional history (Visser et al, 1977).

The basal rocks of the Karoo sequence are known as the Dwyka formation and are a glacial deposit laid down during the Permo-Carboniferous glaciation (c. 300 million years ago (Mya)).

This was followed by the deposition of the Ecca formation, sediments deposited in a shallow sea that covered much of what is now the interior of South Africa. Ecca shales form the base of many of the large flat plains of the Upper Karoo (Truswell, 1977; Tankard et al, 1982; Visser, 1977).

The best-known depositional event of the Karoo sequence is the laying down of the Beaufort shales about 230 Mya. These shales are a rich, stratified sequence of fish, reptilian and amphibian remains that are fossilized in Permian and Triassic period swamp deposits (Truswell, 1977; Visser, 1977; Oelofsen and Loock, 1987).

At the end of the Triassic period (c. 252-201 Mya) a series of geological upheavals took place as the Pangaea super continent fragmented. Triassic period vulcanism led to dolerite intrusions through the shales of the Karoo which formed vertical dykes and horizontal sills following the bedding planes of the shales. These geological structures give rise to a very characteristic topography of the Karoo with its mesas, hillocks and sharp ridges (Visser, 1986).

De Aar is in the north central part of the Karoo Basin and the predominant rocks are those of the Beaufort shales of middle to late Permian in age (c. 276-252 Mya). The Beaufort shales are overlain by Ecca Group sediments, in the De Aar area the Tierberg Formation of the Ecca Group, which represent the gradual filling up of the shallow palaeo sea within the Karoo Basin, that was terminated by the Triassic Drakensberg volcanics.

Intruding through the shales are large expanses of late Triassic / early Jurassic dolerite which, being more weathering-resistant, tends to form the relief in the area, with the mountains to the north and northeast of De Aar being formed by a huge exposure of dolerite. Smaller dykes appear as long lines or circular exposures of dark weathered boulders and rocks.

In the water courses of the area much younger sands and alluvium of the Quaternary Kalahari Sands have been deposited. These sediments were transported from farther north in the past when there was likely much more rainfall in the system, and more recently with flash flooding. Their composition and origin can be very mixed (Bamford, 2020).

## *6.2 Archaeological Context*

Our understanding of the pre-colonial archaeology of the Upper Karoo is derived in large part from the exhaustive archaeological survey of the Zeekoei River Valley by Prof Garth Sampson (1985, 1992, 2015) of Southern Methodist University in the United States referred to earlier.

This large-scale and detailed survey produced a comprehensive and unparalleled body of archaeological information which can be extrapolated to this HIA to inform our understanding of the pre-colonial heritage of the area to be affected by the proposed transmission lines.

The ZVAS identified a long sequence of archaeological material in the Upper Karoo indicating the occupation of the region by our forebears since the Early Stone Age (ESA) Acheulian (after 1 million years ago), through multiple Middle Stone Age (MSA) phases, four Later Stone Age (LSA) phases to herder sites, many with low stone-walled kraals and Khoekhoe-like, thin-walled ceramics, dating to within the last 2,000 years (Sampson, 1985; 2015:3).

The Acheulian sites in the Zeekoei Valley are reported by Sampson (1985) as clustering close to sources of tool-making stone raw material, rather than being close to sources of water and tend to be found on the flats rather than on ridges and hills.

The many Middle Stone Age artefact occurrences reported by Sampson (1985) are almost exclusively “open sites”, a factor probably of the lack of rock shelters and overhangs in the Karoo geology. He describes the open sites as occurring in erosion features along stream banks, but makes it clear that MSA artefacts are widely distributed across the landscape, in the form of “ancient litter” and are frequently found on the edges of pans, streams and at the base of small hills or koppies.

Sampson (1985) recorded thousands of Later Stone Age sites in the Zeekoei River Valley, which are attributed to the ancestors of the San peoples and, after 2,000 years ago, to

Khoekhoen pastoralists. As with the MSA sites, the LSA material is generally found in the open due to the scarcity of rock shelters and comprise large scatters of stone tools. Other traces of the San presence in the Karoo can be found as rock engravings on dolerite boulders (Webley and Orton, 2011:14).

The earlier phase of the LSA dates to around 10,000 years ago and is described by Sampson (1985) as the Lockshoek. This industry is contemporary with the Oakhurst/Albany Industries and is characterised by large sidescrapers, frontal scrapers, endscrapers, thick backed adzes and a wide variety of ground stone implements. These sites are overwhelmingly found near water points (Webley and Orton, 2011:14).

The Lockshoek is followed by the 'Interior Wilton' (IW) which Sampson describes as including small convex scrapers, adzes, drills, reamers as well as ceramics in the final phase of the IW. Unlike the Lockshoek, IW sites are found on hills and ridges with commanding views of rivers and valleys (Webley and Orton, 2011:14).

The Interior Wilton is followed by the Smithfield which is characterised by abundant endscrapers made on elongated flakes, often with extensive trimming down the margins. Sampson's Smithfield is generally associated with ceramics (Webley and Orton, 2011:14).

The introduction of pastoralism (sheep, goats and, later, cattle) roughly 2,000 years along with the arrival of the Khoekhoen may have resulted in changes in land use. It is suggested the Khoekhoen followed a transhumant lifestyle, and are likely to have utilized the grazing opportunities of the Karoo on a seasonal basis (Webley and Orton, 2011:14).

By the early 18th century the San appear to have retreated to the Great Karoo ahead of the expansion north and east from the Dutch settlement around the Cape of mobile colonial stock farmers or trekboers. Here they managed to eke out an existence which includes hunting, gathering and raiding the livestock of the trekboers, resulting in the "Bushman War". Eventually kommandos dispatched from regional centres such as Graaff Reinet prevailed and the "wild bushman" of the Karoo were rendered extinct by the early 19th century (Webley and Orton, 2011:14).

The most recent archaeological layer in the Karoo landscape relates to the historical occupation of the area by stock farmers of European descent from the late 18th century, but is a layer which is not well-documented. These European pastoralists, were highly mobile – hence the name trekboers – moving between winter and summer grazing on and off the Great Escarpment. Land ownership was informal and only became regulated after the implementation of the quitrent system of the 19th century used by the Government to control the lives and activities of the farmers. However, judging by the kinds of artefacts and structures found on the landscape, many of the farms in the Upper Karoo are likely to have been used before land was formally granted or loaned in the early 19th century (Sampson and Sampson, 1994).

The town of De Aar was established on the farm of that name at the site of an important railway junction created by the Cape Government Railways in the last two decades of the 19th century on the line between the Kimberley diamond fields and Cape Town. In 1899 the Friedlander brothers, who ran a trading store and hotel at the junction, purchased the farm and after the end of the South African War surveyed the land for the establishment of a town. The municipality was created a year later (https://en.wikipedia.org/wiki/De_Aar).

# 7 HERITAGE RESOURCES

The archaeological survey of the grid connection routes documented a large number of pre-colonial archaeological sites and lithic scatters, but only a handful of occurrences of colonial period archaeological material or structures were noted.

The archaeological finds are too extensive to describe individually in this report and are thus presented in Appendix B. They include Middle and Late Stone Age archaeological material, possible historic period stone structures, Khoikhoi stone kraal complexes and a single occurrence of late 19th / early 20th century historical material.

## *7.1 Palaeontology*

According to the palaeontological desktop studies by Bamford (2020) and Almond (2012c) (see Appendix A), the area covered by the transmission line options, access road and switching station crosses a range of geological rock and sediment types (Figure 12) and almost the full range of palaeontological sensitivities described on the SAHRIS palaeomap (**Error! Reference source not found.**).

The dolerite contains no fossils because they do not occur in intrusive, volcanic rock. Furthermore, when igneous dykes intrude through the overlying sediments they tend to physically destroy any fossils in their paths and the heat they generate can destroy or alter fossils in the vicinity. The dolerites have a zero palaeontological sensitivity.

The Quaternary sands in the water courses are young enough to preserve fossils but having been washed down slopes and streams into rivers, any fossils would have been transported from their sites of origin and their context and associations with other fossil material in the assemblage will have been lost. These sediments are indicated as moderately sensitive by SAHRIS.

In contrast, the Ecca and Beaufort shales are much more likely to preserve fossils and many years of research by geologists and palaeontologists in the Karoo (for example, Rubidge, 1995, 2005; Johnson et al., 2006; Rubidge et al., 2016) has produced a detailed lithology and described the terrestrial flora and vertebrate fauna of these rocks. From this and other parts of the Karoo the Tierberg Formation has produced a number of trace fossils of worm burrows, root casts and invertebrate trackways (van Dijk et al., 2002; Almond, 2013). Fossil plants are rare in this part of the Karoo basin but there are records of fragments of silicified wood from east of De Aar (Almond, 2013).

The Adelaide Subgroup, undifferentiated in this area, can be divided into the Abrahamskraal or Koonap Formations and the Teekloof or Middleton and Balfour Formations. Expected vertebrate fossils are a variety of dinocephaleans, gorgons and therocephaleans and some fish but according to Almond's site surveys (Almond, 2012a, 2012b, 2012c), vertebrate fossils are rare as there is little exposure.

Potential fossil plants are typical Permian impressions of *Glossopteris* leaves, lycopods, sphenophytes and ferns, and silicified wood (Anderson and Anderson, 1085). Only fossil wood has been seen in the Adelaide Subgroup in this area (Almond, 2012a). The samples have not been collected or identified.

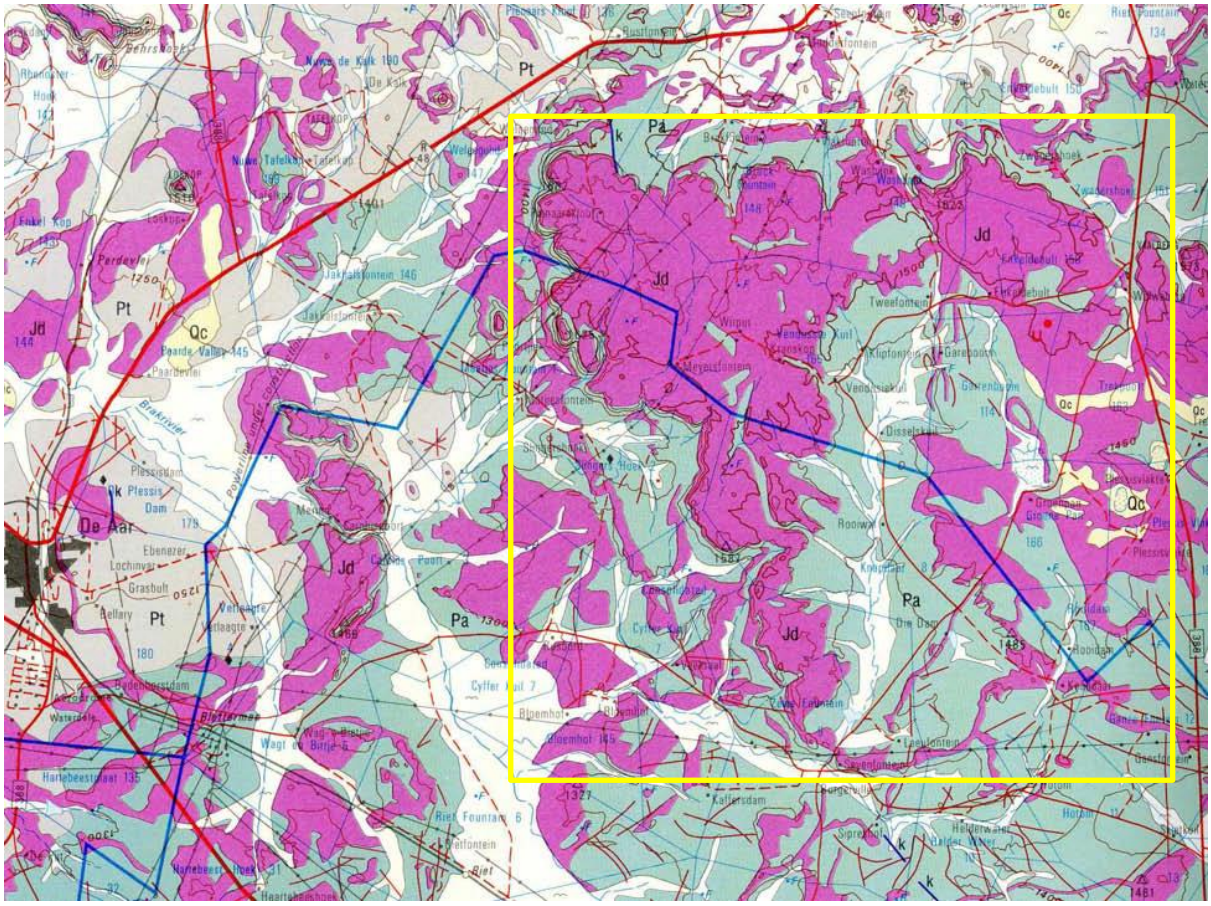



Figure 12: Geological map of the De Aar area. The key rock or sediment types on the routes are: pink = Jurassic dolerite dykes, pale green = Adelaide Subgroup shales, grey = Tierberg Formation shales and mudstones, white = Quaternary Kalahari sands. The area under consideration in this report lies within the yellow block (Map enlarged from the Geological Survey 1: 250 000 map 3024 Colesburg).

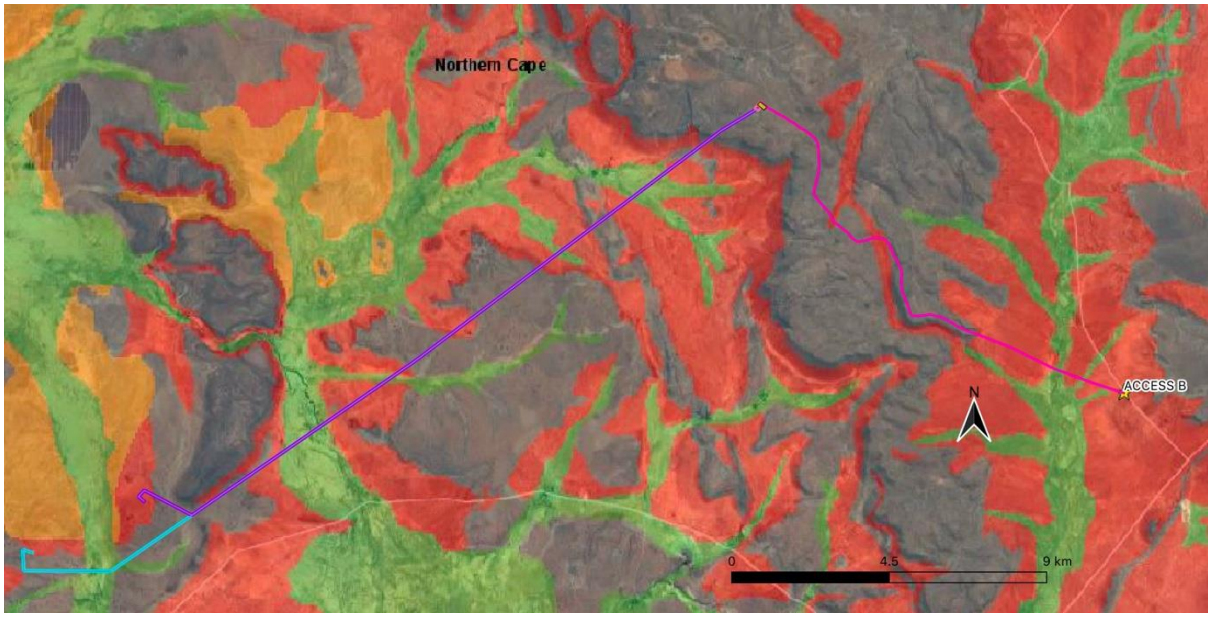



Figure 13: Overlay of the SAHRIS palaeosensitivity map on the proposed transmission line options (pale blue and purple), switching station (circled) and access road (pink). The background colours indicate the following degrees of sensitivity: red = very high; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero (Source: https://sahris.sahra.org.za/map/palaeo)

## 7.2 Pre-colonial Archaeology

### 7.2.1 Early Stone Age

No ESA material was identified in either the 2020 or 2022 ACO surveys of the proposed transmission line options, access road or switching station, or in the surveys of surrounding areas by Kruger (2012), Orton (2012), Orton and Webley (2013a) and Gribble and Euston-Brown (2021).

### 7.2.2 Middle Stone Age

MSA material was encountered across much of the area surveyed. The MSA artefacts encountered were made on a now very heavily patinated and weathered hornfels. Although black when broken or flaked, hornfels acquires a reddish-brown protective skin or patination with exposure to the elements and most of the MSA material recorded during the survey was both heavily patinated and edge-worn (Plate 6). Artefacts include cores, flakes, blades and snapped blades. Few diagnostic MSA elements, apart from occasional triangular flakes with dorsal ridges removed or long blades with parallel dorsal scars, were noted. Some flakes and blades have signs of utilisation damage. No bifacially worked points (Still Bay) or artefacts typical of the Howieson's Poort were seen. No other associated archaeological material (bone, ostrich eggshell, etc.) was found with the MSA lithics.

Similar to what has been described by Sampson (1985) in the nearby Zeekoei Valley and by Kruger (2012), Orton (2012), Webley and Orton (2011, 2013a; 2013b) and Gribble and Euston-Brown (2021) for a number of other projects in the area, much of the MSA material was found lying on harder, gravelly substrate in areas of where the orange sand that mantles the landscape has been eroded by water or deflated by wind (Plate 7).

Discrete, clearly definable MSA sites were difficult to identify because material is generally visible only in areas where the overlying orange sand has been stripped away and because the landscape is liberally spread with material, a type of "ancient litter" (Webley and Orton, 2011).

Plate 6: Examples of weathered and patinated MSA stone artefacts found widely distributed across the survey area.

Plate 7: MSA lithics being exposed by erosion (JG012). Most of the stone visible in this image is MSA material.

A few dense scatters were identified and recorded as archaeological sites – JG046, JG058-9 – and what may be a MSA quarry on the plateau where the wind energy facility is to be constructed and the transmission lines start. The potential quarry, JG008 is a dense concentration of MSA lithics noted across a wide area (at least 100 m in all directions) on and in the orange sand surrounding a dolerite koppie. Excavated material from an antbear hole contained hornfels chunks and cobbles from ±30 cm below the surface and this weathered hornfels lag deposit may be a source of raw material being exploited by MSA people. LSA flakes and “freshly” retouched MSA flakes were noted in places on this site.

The 2022 survey noted an extensive, albeit patchy spread MSA lithic “litter” across the lower, easterly portion of the proposed access road route. MSA material was present right across this area between waypoints G105 and JG124 (see Figure 11 above) and although dense in places, the lithics generally appear to be a deflated, worn and heavily patinated lag of deposit.

### *7.2.3 Late Stone Age*

The LSA artefact assemblages encountered are all made on hornfels, with occasional isolated pieces of other raw materials such as agate, a yellow mudstone, a banded, indurated shale and crustal quartz noted on a few sites.

Most of the LSA artefacts have a pale grey patina or are black and sharp, suggesting that they were relatively recently flaked. Smithfield industry artefact scatters, with no evidence of associated pottery and characterised by endscrapers (or duckbill scrapers) made on long flakes were noted in places (JG061, for example) as were sites containing early Holocene, Lockshoek lithics, dating to c.10,000 years ago (JG050 and JG068) (Plate 8). Both industries are typical of what is expected in this part of the Karoo according to Sampson (1985).

Plate 8: Smithfield lithics from site JG061 (left) and possible Lockshoek material from JG050 (right).

### *7.2.4 Stone Features and Kraals*

Circular packed stone features were noted at places within the survey area.

Some of these features are almost certainly from the colonial era and are probably shepherds' huts. Two such features were noted near the transmission lines (GEB020 and JG065). They are roughly 1.5-1.8 m across internally with a narrow opening on one side – usually the east. Surviving walls are generally 50-60 cm high (see examples in Plate 9).

Complexes of circular Khoi kraals are a feature of the region and large numbers were recorded by Sampson in the Zeekoei Valley. These features tend to form clusters of circular or sub-circular packed stone walls, and are often located in the lee of koppies or rocky outcrops.

A number of possible Khoi kraals were identified in 2020 along the transmission lines, although only one appears unequivocally to be a Khoi kraal complex. This latter complex (JG082 and JG084) now falls well outside the scope of possible impact from the proposed new transmission lines.

Other possible kraals were noted at JG039, JG040, JG064 and JG066.

Plate 9: Possible shepherds' huts (GEB020 and JG090) The latter is no longer on the transmission line routes (Photo: J Gribble).

### *7.2.5 Engravings and Rock Art*

Webley and Orton (2011) reported rock engravings on dolerite boulders on a koppie behind the main farmhouse at Slingers Hoek and a rock gong with an associated fine-line engraving that looks to be of an animal were recorded on the farm Badenhorst Dam (Orton and Webley, 2013a). During the 2020 ACO field assessment, Duppie Pienaar of Carolus Poort talked of San rock paintings in a valley overlooking the Brak River. None of these sites are close to the proposed new transmission lines and none will be impacted by the proposals.

The only rock engraving encountered during this survey was what appears to be a modern engraving on a dolerite boulder on a koppie on the farm Carolus Poort 2 (JG044) (Plate 10). The engraving is located on the north side of the koppie and consists of two long thin parallel lines with seven "bars" scratched between them. It is about 10 m from the LSA stone scatter JG043.

Plate 10: Rock engraving (JG044) on Carolus Poort 2. The position of the engraving is marked by the arrow on the image on the right.

## *7.3 Historical Archaeology*

A small number of historical artefacts were noted at only one place along the grid connection route assessed in 2020. These were on and below the koppie near the southern terminus of the line above the Hydra substation on which the Khoi kraal complex discussed earlier was located (Gribble and Euston-Brown, 2020).

This thin scatter of ceramics, glass and metal of late 19$^{th}$ / early 20$^{th}$ century date, which includes a shovel head with an embossed broad arrow, denoting British government property suggests occupation may have dated to around the South African War (Plate 11), is no longer on the proposed transmission line routes and will thus not be affected by the proposal.

The 2011 and 2013 surveys of Badenhorst Dam (Orton, 2012; Orton and Webley, 2013a) identified similarly thin and ephemeral scatters of historical material at several places on the farm, none of which will be affected by either Vetlaagte or Wag ‘n Bietjie transmission line routes options proposed for this project.


Plate 11: Shovel head with embossed broad arrow denoting British government property.

### *7.4 Graves, Cairns and Stone Features*

No graves or potential burial cairns were encountered during the survey, although Duppie Pienaar of Carolus Poort indicated that four South African War graves of Boer fighters are located near his farmhouse. These are a substantial distance from the proposed transmission lines and will not be impacted by the proposals.

It should be noted that pre-colonial graves are often completely unmarked and can be located anywhere where the soil is suitable for digging a grave.

A small ruined stone structure was recorded next to the road on a dolerite platform on the farm Slingershoek (JG036). The surviving packed stone walls are roughly 1.5 x 1 m in length and stand approximately 20-30 cm. The structure has been interpreted as a colonial period “wolwehok” or vermin trap (Plate 12 and Plate 13).

Plate 12: Ruins of a possible colonial era “wolwehok” or vermin trap on the farm Slingershoek (JG036).

Plate 13: Example of a intact stone built wolwehokke. Left, example encountered near Noupoort, and right, an example recorded by James Walton at Herenlogement (Sources: ACO Associates; https://www.vassa.org.za/walton-old-cape-farmsteads/wolwehok-herenlogement/)

### *7.5 Built Environment*

No historical buildings were recorded anywhere within the proposed transmission lines corridor, on the switching station site or in the access road corridor.

The closest farm werf to the transmission lines is Slingershoek, which is a little less than a kilometre distant, on the far side of an existing powerline.

The farm werf complexes closest to the access road are Die Dam, approximately 3 km south-east of the start of the access road, and Rooiwal roughly 1,5 km to north of the access road route.

### *7.6 Cultural Landscape*

The transmission lines traverse a cultural landscape of clear significance to a succession of pre-colonial and, to a lesser degree, colonial people, as demonstrated by the presence of the widespread archaeological sites and materials described above.

This cultural landscape is essentially a series of layers of occupation and use by our ancestors that have become superimposed on the land surface. And the land surface itself, while not cultural, is nevertheless of heritage value as a vast palaeontological repository.

Early, Middle and Later Stone age people left cultural debris on the land surface – stone tool scatters, engravings, kraals, etc – spanning at least half a million years. More recently the landscape received the imprint of the European colonisation of the region as it was used and then settled by colonial Trekboers who imposed their structure on the land in the form of farm buildings, dams and fence alignments. Most recently still has been the introduction into the landscape of modern industrial elements such as railway tracks and electrical infrastructure.

## 8 IMPACT ASSESSMENT

This impact assessment makes use of the method developed by Hacking (2001), with a minor change to the terminology related to the duration of impacts, to better suit its application to heritage resources. Because of the non-renewable nature of heritage resources, the duration of the effect of impacts which result in changes to the resource will always be permanent and this is reflected in the tables which follow.

## *8.1 Nature of Impacts*

Heritage resources are highly context sensitive and the main cause of impacts to such sites is physical disturbance of the material itself and its context.

The installation of the De Aar 2 South WEF transmission lines and the construction of the switching station and access road can have a number of direct and indirect impacts on the heritage resources and qualities of an area. In the case of De Aar, there is also the cumulative impact of the numerous powerlines and other renewable energy infrastructure within the surrounding landscape to consider.

During the construction of the transmission lines, switching station and access road the following physical impacts to the landscape and any heritage resources that lie in or on it can be expected:

- The leveling of ground for the switching station and for pylons located on hillsides;
- The excavation of foundations for pylons and for elements of the switching station;
- Leveling of ground to for the construction of the access road and the roads or tracks to service both the installation of the powerline and its longer-term maintenance; and
- Introduction of vehicles, machinery and people into environment.

Lastly, the introduction of substantial industrial features can have an impact on the cultural landscape.

The best method for managing impacts to heritage resources is avoidance or exclusion of the site from activities associated with the project. If this is not possible, then some form of mitigation will be required to manage the impacts. This is generally considered a second best approach as *in situ* preservation, wherever possible is always the preferred option.

## *8.2 Extent of impacts*

The fieldwork undertaken to inform this assessment identified MSA, LSA lithic material and Khoi and colonial era stone structures of a generally relatively low, local archaeological significance, widely distributed across the landscape.

The impacts to archaeological material in the area of the construction of the transmission lines, switching station and access road will be relatively small and localized, although where individual sites or structures are affected, the impact will be high.

## *8.3 Significance of Impacts*

Based on the information that has been collected, indications are that impacts on heritage resources arising from the installation of the transmission lines and construction of the switching station and access road will be as follows:

- **Palaeontological resources**: Given the nature of the proposed project, activities may impact upon fossils if they are present close to the ground surface in the development footprint. The geological mapping indicates that both transmission line options and the access road will cross areas where the bedrock is the correct age to contain fossils, particularly trace fossils and silicified wood fragments within the Tierberg Formation.

  However, site visits and PIAs conducted in the area (for example Almond, 2012b) and

a palaeontological site survey for the De Aar South 2 WEF (Almond, 2012c) have recorded very few fossils.

If existing service roads and access points are used during the construction of the transmission lines, this will reduce the potential for impacts on fossil resources. The very small footprint of pylon foundations also means that the impact on the fossil heritage resources from the installation of the transmission lines is assessed to be very low. The construction of the access road may impact fossil resources along that portion of the route below the dolerite massifs. However, in this lower-lying portion of the route impacts from the road will be largely confined to Quaternary sands and, possibly, to Adelaide Subgroup rocks which are is potentially fossiliferous (vertebrates and silicified wood). Impacts to fossil resources where the access road traverses the dolerite uplands and on the site of the switching station are not expected as the underlying bedrock is non-fossiliferous.

Taking all of the above into account, the significance of potential impacts to fossil heritage resources is extremely low.

- **MSA**: The volume of and apparently ubiquitous nature of the MSA artefacts scattered across the landscape, and the fact that most of this material is in secondary, or disturbed context, means that the combined overall impact significance of activities associated with the installation of the transmission lines on MSA material will be low.

- **LSA**: The context of much of the LSA material noted during the survey appears to be better preserved than the MSA material and is thus of greater archaeological significance. More occurrences that could be called sites were noted with the LSA material, and the possible association of OES with some of the early Holocene material eroding out the banks of the Brak River, for example, makes some of these sites of particular interest and importance. If these sites, highlighted in Appendix B and described in Section 7.2.4 above, were lost or damaged as a result of the construction of the transmission lines, the switching station or the access road, the impact significance would be medium. The application of measures to mitigate potential loss or damage, however, would reduce the impact significance to low.

- **Kraals and Stone Structures**: The possible Khoi kraal and other stone structures noted during the survey represent a little-known aspect of the history and archaeology of this area. Their damage or destruction would result in a loss of heritage, and the impact significance would be medium. The application of measures to mitigate potential loss or damage, however, would reduce the impact significance to low.

- **Graves, cairns and stone features**: No graves or potential burial cairns were noted during either the 2020 or 2022 surveys.

  Damage to or the destruction of the possible ruined “wolwehok” on Slingershoek would have a moderate impact significance. The application of measures to mitigate potential loss or damage, however, would reduce the impact significance to low;

No impacts are expected to engravings and rock art, historical archaeological sites and

materials or the built environment.

The likely impacts of the construction, operation and decommissioning of the transmission lines, switching station and access road on identified heritage resources are assessed as follows:

Table 2: Palaeontological Impact Assessment

| **Impact Phase: Transmission Lines, Switching Station and Access Road Construction, Operation and Decommissioning** | | |
|---|---|---|
| Possibility of encountering fossils during groundworks | | |
| | **Without Mitigation** | **With Mitigation** |
| **Extent** | Local (Low) | Local (Low) |
| **Duration** | Permanent (High) | Permanent (High) |
| **Intensity / Severity** | Low | Low |
| **Consequence of Impact** | Medium | Medium |
| **Probability** | Low | Low |
| **Confidence** | High | High |
| **Status** | Negative | Neutral/Positive |
| **Significance** | Low | Low |
| | | |
| **Can the impact be reversed?** | **No** – palaeontological heritage resources are non-renewable and key contextual data for fossils (sedimentology, taphonomy) is difficult to reconstruct following disturbance. | |
| **Will impact cause irreplaceable loss or resources?** | **Possible but unlikely** – well-preserved, scientifically valuable fossils are scarce or uncommon within the project area and those that do occur probably occur widely across the region. | |
| **Can impact be avoided, managed or mitigated?** | **Yes** – it can be managed and mitigated through the effective implementation of a Chance Fossil Find Protocol by the ECO and a professional palaeontologist. | |
| **Mitigation measures:** | • Implementation of a Chance Fossil Find Protocol (see Appendix C)<br>• Reporting by the ECO of any chance fossil finds to SAHRA and their conservation (preferably *in situ*).<br>• Recording and judicious sampling of significant chance fossil finds by a qualified palaeontologist, together with pertinent contextual data (stratigraphy, sedimentology, taphonomy); and<br>• Curation of any recovered fossil material within an approved repository (museum / university fossil collection) by a qualified palaeontologist. | |
| **Can any residual risk be monitored/managed?** | **Yes** - through ongoing application of the Chance Fossil Find Protocol by the ECO. | |
| **Will this impact contribute to any cumulative impacts?** | **Yes** - cumulative impacts, although at an extremely low level, on local fossil heritage resources are anticipated. The cumulative impact is of very low significance. | |

Table 3: Archaeological Impact Assessment

| **Impact Phase: Transmission Lines, Switching Station and Access Road Construction, Operation and Decommissioning** | | |
|---|---|---|
| Possible impacts to archaeological sites and materials | | |
| | **Without Mitigation** | **With Mitigation** |
| **Extent** | Local (Low) | Local (Low) |
| **Duration** | Permanent (High) | Permanent (High) |
| **Intensity / Severity** | Low | Low |
| **Consequence of Impact** | Medium | Medium |

| | | |
|---|---|---|
| **Probability** | High | Low |
| **Confidence** | High | High |
| **Status** | Negative | Neutral/Positive |
| **Significance** | Medium | Low |
| | | |
| **Can the impact be reversed?** | **No** – impacts to archaeological resources cannot be reversed, but can be mitigated. | |
| **Will impact cause irreplaceable loss or resources?** | **No** - the archaeological occurrences recorded are well represented in other areas and provided the recommended mitigation measures are implemented, there should be no irreplaceable loss of resources. | |
| **Can impact be avoided, managed or mitigated?** | **Yes** – impacts can be avoided or mitigated through the implementation of the mitigation measures listed below. | |
| **Mitigation measures:** | **General:**<br>• Do not disturb any old stone kraals or ruins and do not remove stone from walls, or artefacts from the earth.<br>• Any chance discoveries of human remains must be reported immediately to the project archaeologist and SAHRA. Remains must be made safe, and left in situ until a decision about their mitigation is made by the archaeologist and SAHRA.<br>**Specific:**<br>• The project archaeologist must review pylon positions, once these have been determined, to ensure that they will not impact on any recorded heritage resources. The micro-siting of pylon positions may be required, which should also be done in consultation with the archaeologist.<br>• In the event of any new heritage resources being encountered during construction, SAHRA must be consulted immediately so that mitigatory action can be determined and be implemented if necessary.<br>• One cluster of archaeological sites requires mitigation, in the form of artefact mapping, recording and collection by the project archaeologist prior to the commencement of construction of the transmission lines. This is:<br>  • JG050-JG052 / GEB013-GEB014.<br>• The following sites, each with the buffer described below, must be considered no-go areas during construction activities and those nearest the route alignments must be clearly marked as out of bounds:<br>  • JG067–JG072 / GEB025. A buffer of 50 m must be implemented around the outer limits of this cluster of sites.<br>  • The possible Khoi kraals and shepherds' huts (JG040; JG064-JG066). A 40 m buffer must be implemented around each site;<br>  • The possible "wolwehok" (JG036). A 20 m buffer must be implemented around this structure;<br>  • The rock engraving (JG044). A 20 m buffer must be implemented;<br>  • The two deflated stone clusters (JG122 and JG123). A buffer of 30 m must be implemented around each; and<br>  • GEB105. A buffer of 40 m must be implemented around this waypoint.<br>If any of these buffers cannot be implemented or maintained, then these sites will require mitigation, in the form of artefact mapping, recording and collection by the project archaeologist prior to the commencement of construction of the transmission lines or access road. | |

| | |
|---|---|
| **Can any residual risk be monitored/managed?** | **Yes** – the continued avoidance of identified heritage resources during the lifetime of the transmission lines, switching station and access road will ensure that residual risk can be managed and is of low significance. |
| **Will this impact contribute to any cumulative impacts?** | **Yes** – but the implementation of measures to mitigate project level impacts can do much to reduce cumulative impacts. |

### *8.4 Cumulative Impacts*

Cumulative impacts, or effects, can be described as "changes to the environment that are caused by an action in combination with other past, present and future human actions". They are the result of multiple activities whose individual direct impacts may be relatively minor but which, in combination with others result are significant environmental effects (DEAT 2004:5).

For the most part, cumulative effects or aspects thereof are too uncertain to be quantifiable, due mainly to a lack of data availability and accuracy. This is particularly true of cumulative effects arising from potential or future projects, the design or details of which may not be finalised or available and the direct and indirect impacts of which have not yet been assessed.

For practical reasons, the identification and management of cumulative impacts are limited to those effects generally recognised as important on the basis of scientific concerns and/or concerns of affected communities.

In respect of potential cumulative impacts on palaeontological resources of the installation of the DA2S WEF transmission lines and the construction of the switching station and access road, the mixed nature of the geology of the area and the low level of surface and near surface exposure of fossil-bearing rocks where they do occur in the area suggests that the cumulative impact will be low.

Archaeological material and sites are potentially far more at risk from the cumulative impacts, given their widespread occurrence and exposure across the area. Multiple human activities in the landscape, of which the installation of the transmission lines and construction of the switching station and access road are the latest, can erode the integrity of these resources through their physical damage or destruction. At an individual project level these impacts may not appear to be significant, but the cumulative effects of multiple developments on archaeological resources can be high. The implementation of measures at individual project level can, however, do much to mitigate and reduce cumulative impacts.

For the cultural landscape, the presence of a good deal of existing infrastructure in the area - the railway system, the N9 and the electrical and linear infrastructure related to the Hydra substation and the various wind and solar energy facilities surrounding De Aar – suggests that the presence of the additional transmission lines are unlikely to be out of place in the local environment, although they will add to the cumulative effects of modern development on the cultural landscape.

### *8.5 The No-Go Alternative*

Not implementing the proposal will result in no impacts to heritage resources.

## 9 PROPOSED MITIGATION MEASURES

Palaeontology: With regard to palaeontological resources, the Fossil Chance Find Protocol

attached to this report as Appendix C must be implemented at the commencement and for the life of the transmission lines, switching station and access road construction activities.

The environmental control officer (ECO) must look out for fossils and any fossil finds must be reported to SAHRA and conserved (preferably *in situ*). Significant chance fossil finds must be recorded and sampled by a qualified palaeontologist, together with pertinent contextual data (stratigraphy, sedimentology, taphonomy). Any recovered fossil material must be curated within an approved repository (museum/university fossil collection) by the palaeontologist.

Archaeology: The field survey identified a substantial number of archaeological occurrences and sites, although in most cases the material noted was difficult to define as discrete sites and can be viewed as part of a widespread archaeological litter across the landscape which becomes visible in areas where erosion or deflation of the overlying soils occurs.

The following mitigation measures are recommended:

- One cluster of archaeological sites requires mitigation, in the form of artefact mapping, recording and collection by the project archaeologist prior to the commencement of construction of the transmission lines. This is JG050-JG052 / GEB013-GEB014, a dense early Holocene LSA stone scatter with ostrich eggshell eroding out of the bank of a stream in the Brak River Valley.

  The active erosive nature of this cluster of sites suggests that they retain contextual archaeological value and it is recommended that the mitigation take the form of the mapping, recording and collection by the archaeologist of exposed artefactual material, prior to the commencement of any activities related to the installation of the transmission lines.

- Other sites on or close to the transmission lines, switching station and access road route require mitigation by avoidance. Although not directly on the proposed cable or road alignments or switching station site, some of these sites are close enough to potentially be impacted or suffer damage as a direct, or indirect result of the installation of this infrastructure.

  These sites, each with the buffer described below, must be considered no-go areas during construction activities for the transmission lines, switching station and access road and those nearest the activity areas must be clearly marked as out of bounds:
  - G067–JG072 / GEB025. A buffer of 50 m must be implemented around the outer limits of this cluster of sites;
  - The possible Khoi kraals and shepherds' huts (JG040; JG064-JG066). A 40 m buffer must be implemented around each site;
  - The possible "wolwehok" (JG036). A 20 m buffer must be implemented around this structure;
  - The rock engraving (JG044). A 20 m buffer must be implemented around this occurrence;
  - The two deflated stone tool clusters (JG122 and JG123). A buffer of 30 m must be implemented around each; and
  - GEB105. A buffer of 40 m must be implemented around this waypoint.

If any of these buffers cannot be implemented or maintained, then these sites will require mitigation, in the form of artefact mapping, recording and collection by the project archaeologist prior to the commencement of construction of the transmission lines or access road.

- Prior to the installation of the transmission lines, the project archaeologist must review pylon positions once these have been determined, to ensure that they will not impact on any recorded heritage resources. The micro-siting of pylon positions may be required, which should also be done in consultation with the archaeologist.

- In the event of any new heritage resources being encountered during the installation of the transmission lines or the construction of the switching station or access road, SAHRA must be consulted immediately so that mitigatory action can be determined and be implemented if necessary. Such mitigation is at the cost of the developer, while time delays and diversion of machinery/plant may be necessary until mitigation in the form of conservation or archaeological sampling is completed.

- Should any human remains be encountered at any stage during the construction or earthworks associated with this project, work in the vicinity must cease, the remains must be left *in situ* but made secure and the project archaeologist and SAHRA must be notified immediately so that mitigatory action can be determined and be implemented.

## 10 CONCLUSION

Provided that the mitigation measures set out above are implemented, the overall impact of the proposed installation of the DA2S WEF transmission lines, switching station and access road is tolerable and generally of low heritage significance. It is our considered opinion, therefore that the proposed activity is acceptable in heritage terms.

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## APPENDIX A: PALAEONTOLOGICAL IMPACT ASSESSMENTS – BAMFORD (2020) & ALMOND (2012C)

(See separate pdf files)

# Palaeontological Impact Assessment for the proposed Mulilo De Aar grid connection and battery storage project, Northern Cape Province

**Desktop Study (Phase 1)**

**For**

**ACO Associates**

**23 February 2020**
**Updated: 29 September 2022**

**Prof Marion Bamford**
Palaeobotanist
P Bag 652, WITS 2050
Johannesburg, South Africa
Marion.bamford@wits.ac.za

# Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 31 years research; 3years PIA studies

# Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by ACO Associates, 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 Mulilo – De Aar grid connection and battery storage facility between several Photovoltaic Facilities and Hydra Substation, east of De Aar, Northern Cape Province. This is part of a large project to generate clean electricity in the Northern Cape.

To comply with 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 project.

The proposed routes lie on Permian Karoo sediments, Jurassic dolerites and Quaternary sands and alluvium. The dolerite is non-fossiliferous so the proposed SAS2 WEF facility will not impact on the fossil heritage. Parts of Route 2 DA2S Line option 2 part 2 (and Route 1) lie on Quaternary sands with very low impact, and Adelaide Subgroup rocks. The latter is potentially fossiliferous (vertebrates and silicified wood). The DA2S Line option 2 part 1 route and connection to Mulilo De Aar PV are on rocks of the Tierberg Formation (trace fossils and wood fragments). For both strata, the fossils are sporadic and rare and the 132 kV steel monopole structure including foundations and insulators (pole) footprint is so small that the impact would be very small. Since there is a small chance of finding fossils once excavations have commenced, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no palaeontological site visit is required unless the responsible person on site finds fossils and then a palaeontologist should be called to assess and collect if required.

# Table of Contents

# 1. Background

Mulilo De Aar 2 South (Pty) Ltd ("Mulilo") are seeking approval for grid connection routes and a battery storage facility in Eastern Cape Province.

Grid Connection

Two routes must be assessed for authorisation, (this will allow flexibility to use / not use the battery storage facilities). Mulilo are proposing to construct a **Route 1**: new grid connection transmission power line, approximately 23 km in length, to connect the authorised De Aar 2 South Wind Energy Facility (DA2S WEF) to the Eskom Hydra Substation near De Aar, Northern Cape Province. For approximately 12km from the Eskom Hydra Substation, the proposed line follows approved grid-connection transmission line route for the operational Longyuan Mulilo De Aar 2 North WEF. Thereafter, the proposed new line follows a direct path northeast for a further 11 km up onto the plateau. The entire proposed route for the new line follows and is adjacent to the existing HYD-RO 220kV transmission line; **Route 2:** (part 1 and 2 both required), Part 1 (Connecting various Battery storage facilities (separate BAs) and Part 2 (From the On-site Substation to Via battery storage facilities). The grid connection is for up to 400 kV. The corridor to be assessed is 200m (i.e. 100m either side of all grid lines in the KMZ).

The proposed project will include a 132 kV switching station (100m x 100m). The proposed transmission line would consist of the following infrastructures:

- 132 kV steel monopole structure including foundations and insulators;
- Existing access roads and jeep tracks
- Line and servitude clearances to meet the statutory requirements

Battery Storage Facility (Location to follow)

- Footprint <20 ha
- Height <30m,
- Dangerous / hazardous material <500m³
- Above footprint must include an onsite substation:
  - up to 132kV,
  - 3-bay,
  - 50m x 50m x 30m (H)
  - Substations Buildings to house metering, scada and switchgear, office, spares storage and ablutions.

A Palaeontological Impact Assessment was requested for the project. To comply with 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 presented herein.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (amended 2017)

| | **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 1 |
| 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 2 |
| f | The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure | Section 4 |
| g | An identification of any areas to be avoided, including buffers | N/A |
| h | A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers; | N/A |
| i | A description of any assumptions made and any uncertainties or gaps in knowledge; | Section 5 |
| 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 4 |
| k | Any mitigation measures for inclusion in the EMPr | 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 | Appendix A |
| ni | A reasoned opinion as to whether the proposed activity or portions thereof should be authorised | N/A |
| 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 | N/A |
| 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 if any comments that were received during any consultation process | N/A |
| q | Any other information requested by the competent authority. | N/A |

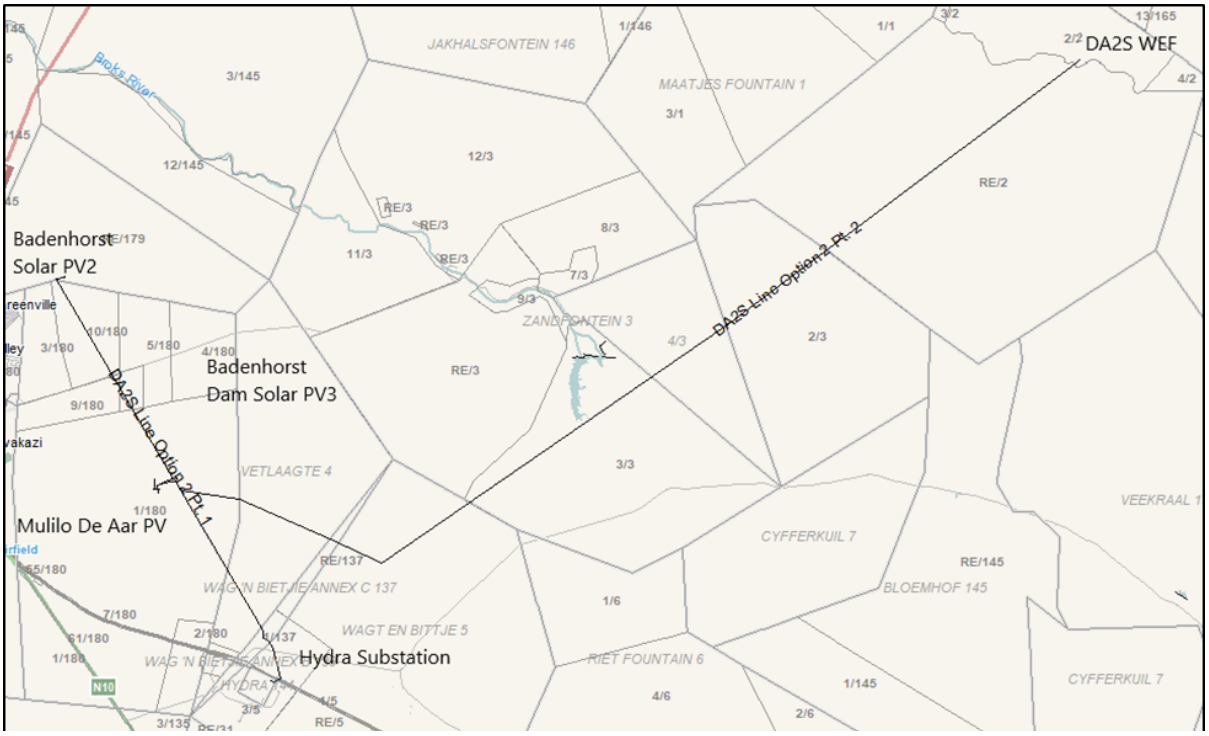


Figure 1: Diagram of the DA2S line Option 2 with part 1 near De Aar and Part 2 heading north eastwards. The proposed battery storage facility WEF is at the northeastern end.

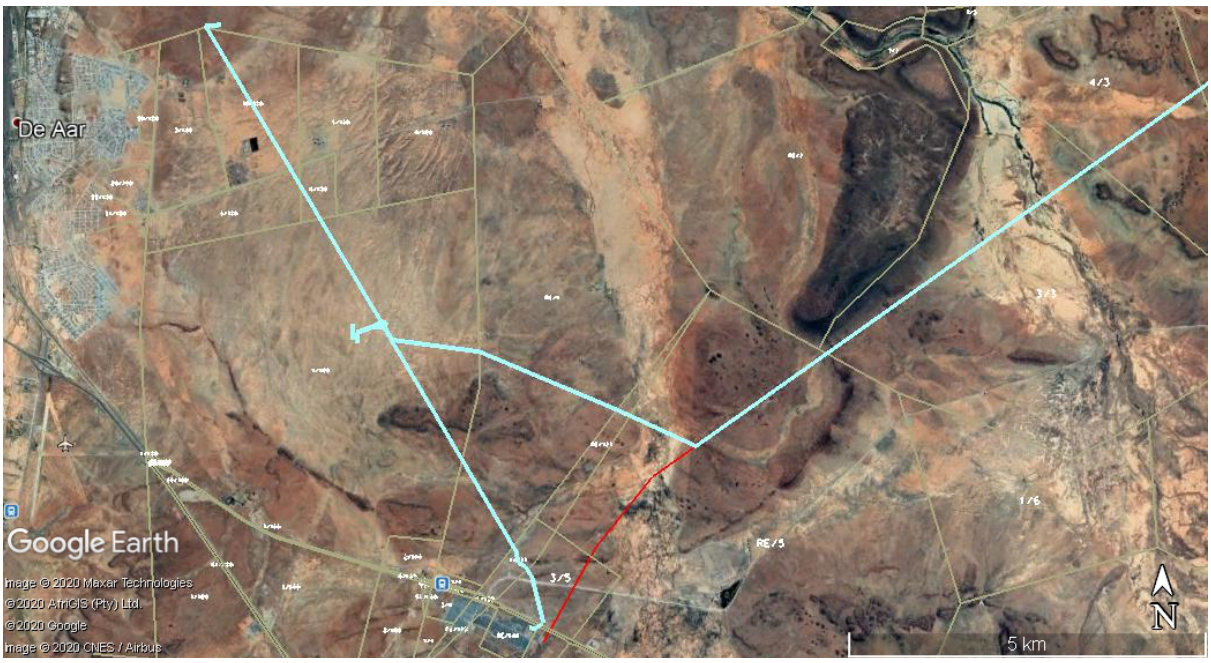


Figure 2: Google Earth map of the proposed routes for the Mulilo De Aar project. The routes near De Aar to connect PVs facilities are shown in blue lines with the red line being a

proposed new connection (here called Route 1 south). Route 2 includes the northwest-southeast route and connections to WEFs.


Figure 3: Google Earth map of the proposed routes for the Mulilo De Aar grid connection project. The routes near De Aar to connect PVs facilities are shown in blue lines with the red line showing a proposed new connection to a potential battery storage facility on the mountain top. (here called Route 1 north). De Aar is off the map to the southwest.

# 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 (*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*).

# 3. Geology and Palaeontology

## i. Project location and geological context

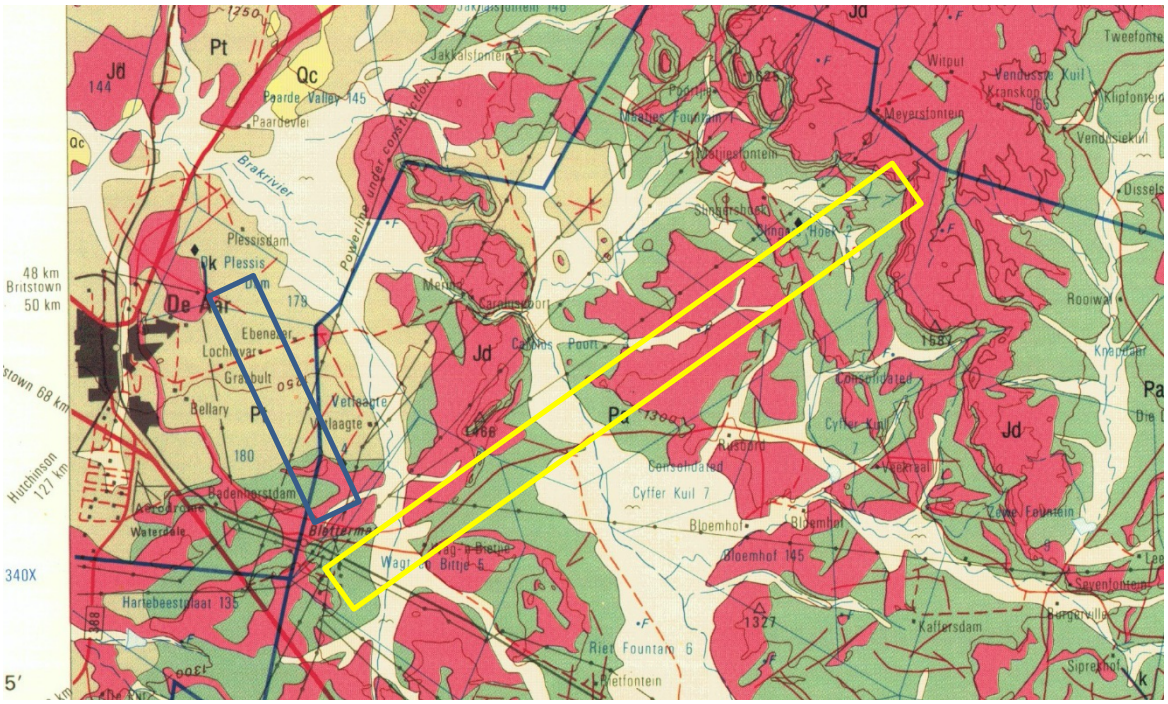


Figure 4: Geological map of the whole are of the proposed Mulilo De Aar project. Within the yellow rectangle, the southwestern end includes the red line from Figure 2 (new connection line) and the northeastern end includes the red line from Figure 3 (proposed battery storage facility). The blue rectangle includes the existing powerline from De Aar to Hydra. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 3024 Colesburg.

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

| Symbol | Group/Formation | Lithology | Approximate Age |
|---|---|---|---|
| Q | Quaternary Kalahari sands | Alluvium, sand, calcrete | Neogene, ca 25 Ma to present |
| Jd | Jurassic dykes | Dolerite dykes, intrusive | Jurassic, approx. 183 Ma |
| Pa | Adelaide Subgroup, Beaufort Group, Karoo Supergroup | Blue-grey silty mudstones, sandstones | “middle” Permian, Lower Beaufort Group. |
| Pt | Tierberg Formation, Ecca Group, Karoo SG | Blue-grey to black mudstones, concretions; siltstones sandstones near the top | “early” Permian, Ecca Group |

De Aar is in the north central part of the Karoo Basin and the predominant rocks are those of the Beaufort, middle to late Permian in age. There are large expanses of Jurassic aged dolerite that intruded through the Karoo sediments at the time when Africa was separating from South America and the Drakensberg volcanics erupted. Generally to the south and east are the younger Adelaide

Subgroup rocks. This subgroup has been divided into a number of formations based on lithology and fossil content but in this area the formations are not recognisable. The mudrocks are massive and weather to form blocky material (Johnson et al., 2006)

To the north and west are the slightly older Tierberg Formation (Ecca Group) sediments that are similar to the overlying Adelaide subgroup shales and mudstones. This succession of rocks represents the gradual filling up of the Karoo Basin that was then terminated by the Drakensberg volcanics.

The more weathering-resistant dolerite dykes tend to form the relief in the area, with the mountains to the north and northeast being formed by a huge exposure of dolerite. Smaller dykes show as long lines or circular exposures of dark weathered boulders and rocks

Along some of the water courses much younger sands and alluvium of the Quaternary Kalahari Sands have been deposited (white in the geological map, Figure 4). These sediments have been transported from farther north in the past when there was likely much more rainfall in the system, and more recently with flash flooding. Their composition and origin can be very mixed.

## ii. Palaeontological context

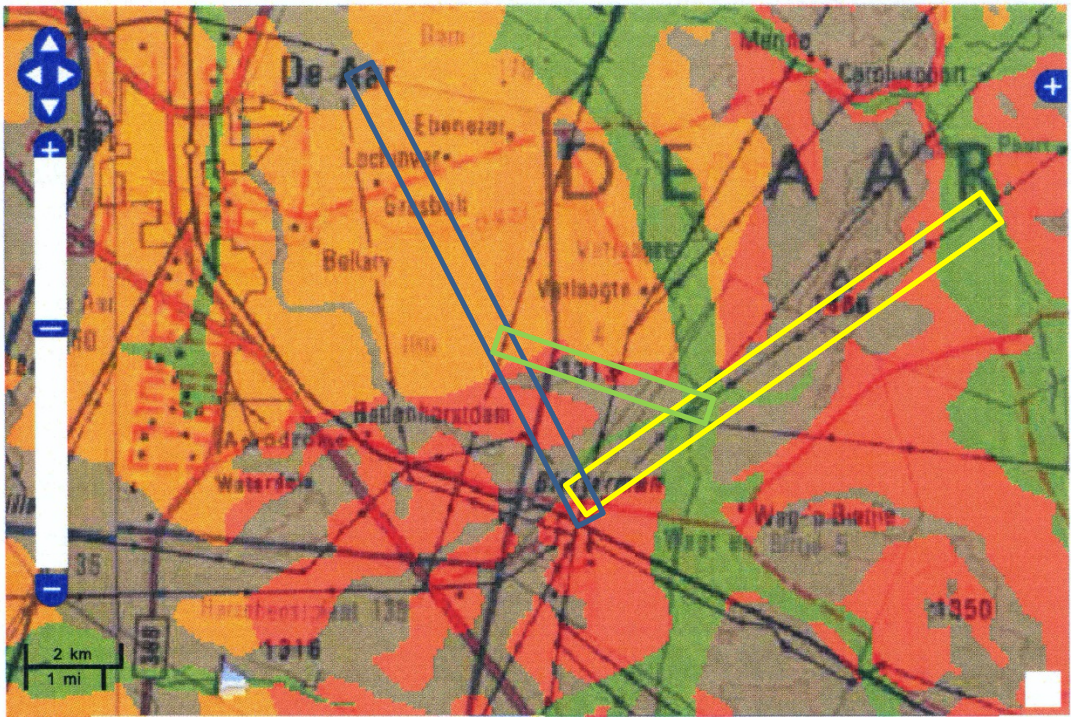


Figure 5: SAHRIS palaeosensitivity map for the site for the proposed Mulilo De Aar project. Route 1 and Route 2 part 2 are shown within the yellow rectangle. Route 2 part 1 within the blue rectangle and existing link/line within the green rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

The Palaeontological Assessment is presented from the location point of view, not the proposed routes and options, because there is a large degree of overlap.

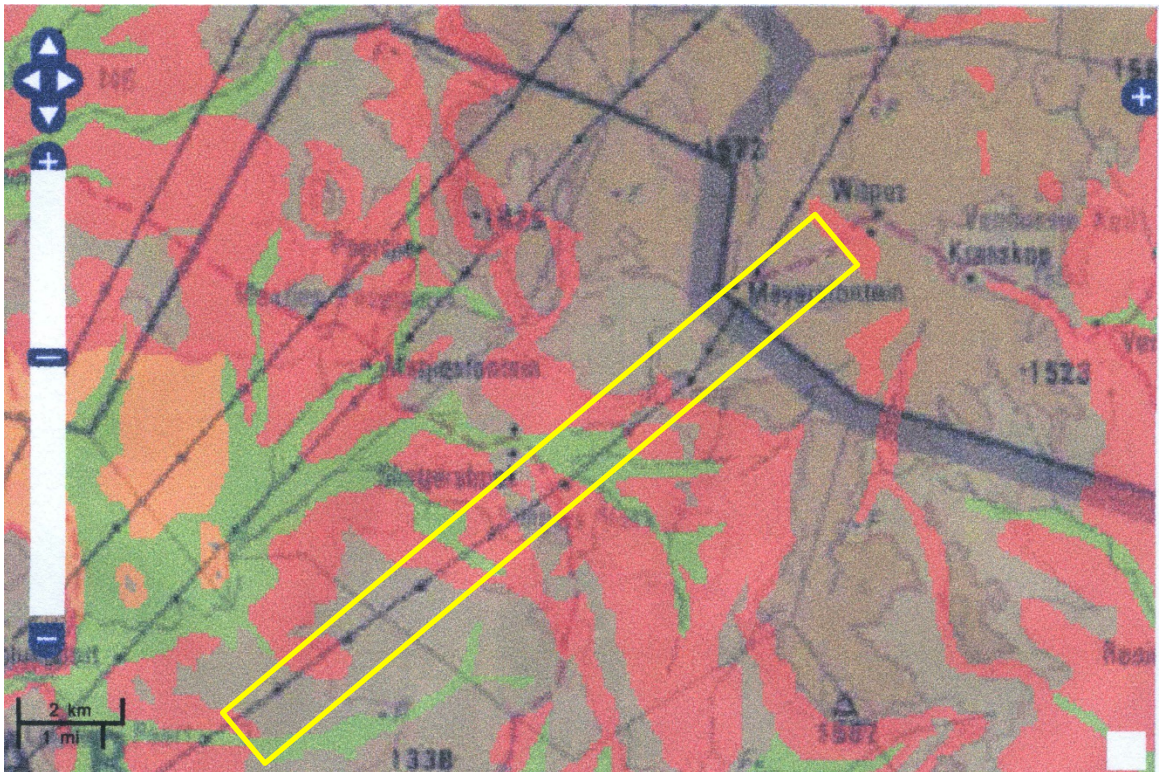


Figure 6: Northeastern section of the De Aar – WEF line with Route 1 and Route 2 part 2 within the yellow rectangle. De Aar is off the map to the southwest. The proposed site for the Battery storage facility is in the uppermost part of the rectangle on the mountain top. See Figure 5 for SAHRIS colour coding.

From the SAHRIS maps above the area is indicated as having the whole range of sensitivities along the various proposed routes. The dolerite has no fossils (grey) because they do not occur in volcanic rocks. As the dykes intrude through the overlying sediments they tend to physically destroy any fossils that might have been in their paths, and the heat can destroy or alter fossils in the near vicinity.

The Quaternary sands (Figure 4) along the water courses are young enough to preserve fossils but by their nature, washed down slopes and streams into rivers, any fossils would have been transported from its site of origin into the river system. The context of the fossils and associated fossils in the assemblage will have been lost. Only robust fossil fragments can survive the journey but their scientific value is greatly reduced because they lack original context. These sediments are indicated as moderately sensitive on the maps (green; Figures 5 and 6).

In contrast, the Ecca and Beaufort rocks are much more likely to preserve fossils. Their distribution, however, is unpredictable but they can be easier to locate on hillsides and slopes. Based on many years of research by geologists and palaeontologists in the Karoo (Rubidge, 1995, 2005; Johnson et al., 2006; Rubidge et al., 2016 and many other references) the lithology and terrestrial flora and vertebrate fauna have been closely correlated, and the fauna used as a biostratigraphic framework. From this and other parts of the Karoo the

Tierberg Formation has produced a number of trace fossils of worm burrows, root casts and invertebrate trackways (van Dijk et al., 2002; Almond, 2013). Fossil plants are rare in this part of the Karoo basin but there are records of fragments of silicified wood from east of De Aar (Almond, 2013).

The Adelaide Subgroup, undifferentiated in this area, can be divided into the Abrahamskraal or Koonap Formations and the Teekloof or Middleton and Balfour Formations. Without fossils it is not possible to distinguish the strata based only on lithology. The relevant assemblage zones are, from the base upwards, the *Eodicynodon, Tapinocephalus, Pristerognathus, Tropidostoma* and *Cistecephalus* zones. Expected vertebrate fossils are a variety of dinocephaleans, gorgons and therocephaleans and some fish. According to Almond's site surveys (Almond 2012a, 2012b, 2012c), vertebrate fossils are rare as there is little exposure.

Potential fossil plants are typical Permian impressions of *Glossopteris* leaves, lycopods, sphenophytes and ferns, and silicified wood (Anderson and Anderson, 1085). Only fossil wood has been seen in the Adelaide Subgroup in this area (Almond, 2012a). The samples have not been collected or identified.

Dr John Almond (Natura Viva) has carried out a number of site visits around De Aar for other aspects of the project (Almond, 2012a, b, c, 2013). He found very few fossils because the area has a large amount of non-fossiliferous dolerite, and the Permian sediments are covered by sand and soil to a large extent.

# 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** | **H** | Definite/ Continuous |

| | | |
|---|---|---|
| **(of exposure to impacts)** | **M** | Possible/ frequent |
| | **L** | Unlikely/ seldom |

**TABLE 3B: IMPACT ASSESSMENT**

| **PART B: ASSESSMENT** | | |
|---|---|---|
| **SEVERITY/NATURE** | **H** | - |
| | **M** | - |
| | **L** | - |
| | **L+** | The Tierberg Fm sediments might preserve trace fossils of fossil woo fragments; The Adelaide Subgroups rocks might preserve fossil bones; it is less likely to preserve fossil plant impressions. The impact would be low. |
| | **M+** | - |
| | **H+** | - |
| **DURATION** | **L** | - |
| | **M** | - |
| | **H** | Where manifest, the impact will be permanent. |
| **SPATIAL SCALE** | **L** | Since only the possible fossils within the area would be trace fossils and wood fragments from the *Glossopteris* flora in the Tierberg Fm shales and rare vertebrate bones and wood in the Adelaide Subgroup, the spatial scale will be localised within the site boundary. |
| | **M** | - |
| | **H** | - |
| **PROBABILITY** | **H** | **-** |
| | **M** | **-** |
| | **L** | It is unlikely that any fossils would be found in the loose Quaternary sand; trace fossils and wood fragments might occur in the Tierberg Fm and vertebrate bones and wood in the Adelaide Subgroup rocks. Therefore, 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 correct age to contain fossils, in particular trace fossils and silicified wood fragments in the Tierberg Formation, in the DAS2 line option 1, part 1. Site visits and PIAs have already been done for the two farms in the area, namely 1/180 and Vetlaagte (Almond, 2012b). Site surveys have also been done for the DAS2 WEF area when the proposed PV facilities on the mountain top were being researched (Almond 2012c). Since roads and access have already been developed along all the routes, and the new poles have a very small footprint, the impact on the fossil heritage is very low. Therefore, a Fossil Chance Find Protocol has been added to this report. Once excavations have commenced for the pole foundations, the responsible person/environmental officer should look out for fossils. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely 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 dolomites, sandstones, shales and sands are typical for the country and some do contain fossil plant, wood, invertebrate traces and vertebrate material. The sands of the Quaternary period would not preserve fossils in context. From previous site visit PIAs we know that rare traces fossils and fragments of silicified wood occur in the Tierberg Formation (Ecca Group) and silicified wood, trace fossils and bone

fragments occur in the Aldelaide Subgroup rocks. Non- fossiliferous dolerite and sand are widespread.

# 6. Response to SAHRA Comment (14 September 2022)

In an interim comment on the Draft Basic Assessment report for the proposed new transmission lines, switching station and access road in support of the authorised De Aar 2 South Wind Energy Facility, SAHRA commented that this PIA does not "assess the impact of the proposed developments and their associated activities, including the service roads and new access road".

However, this PIA did assess the areas that will be affected by the transmission line, its service road and the infrastructure related to the transmission substation and switching station (see Figures 5 and 6 above) and only the area affected by the WEF access road shown on Figure 7 below was not assessed.

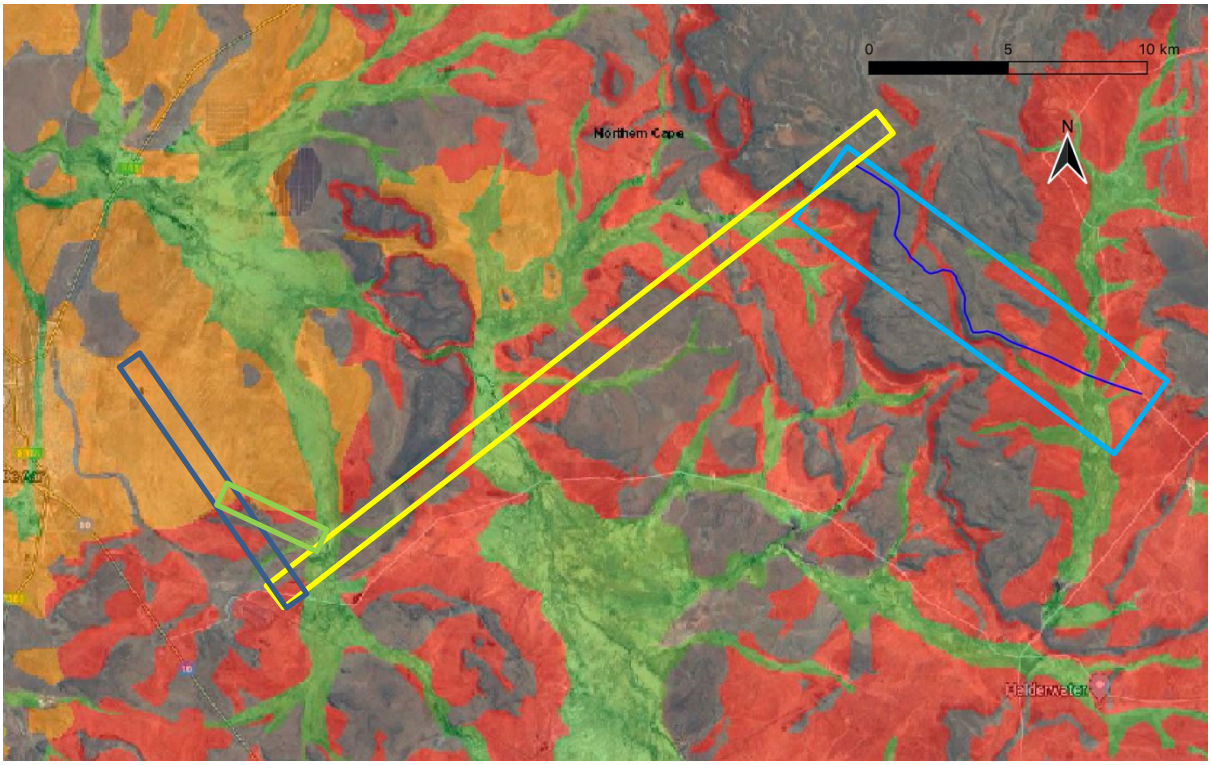


Figure 7: SAHRIS palaeosensitivity map for the site for the proposed Mulilo De Aar project. The transmission lines and infrastructure related to the transmission substation, and switching station previously assessed are within the yellow, green and dark blue rectangles. The proposed access road is the dark blue line within the pale blue rectangle.

More than half the length of the access road will be on non-fossiliferous dolerite so there will be no impact upon fossil heritage.

The south-eastern portion of the access road is partly on the Adelaide Subgroup and partly on Quaternary river alluvium. Although alluvium is considered to be moderately fossiliferous in parts of the country this is dependent on the source rocks of the sands. On the access road

the source rocks are the non-fossiliferous dolerite and the Adelaide subgroup. Since the Adelaide Subgroup has not been divided into its respective formations this implies that there are no fossils present. In practice, the vertebrate palaeontologists source the rocky outcrops to search for *in situ* exposures as any transported rocks (fossils) are out of context and so of limited scientific value for researchers. Therefore, surface finds would be of no value; only below ground *in situ* fossils are of scientific value.

# 7. Conclusions

Based on experience and the findings from previous palaeontological site visits to the area, it is very unlikely that any fossils would be impacted upon by the foundations for some poles (132 kV steel monopole structure including foundations and insulators) or by the access road because the fossils are sporadic and of common forms. The proposed site for a battery storage facility at DAS2 WEF and more than half the access road is on non-fossiliferous dolerite so would not impact upon the fossil heritage at all. The route between Hydra and this facility (Routes 1 and 2) has several potentially fossiliferous patches but prior field surveys by John Almond show that fossils are rare. The same applies to the DAS2 line option 2 Part 1 – fossils may be present but the footprint is so small that an impact is unlikely on the fossils. Since there is a small chance that fossils may occur in the Quaternary river alluvium, Tierberg Formation and Adelaide Subgroup mudstones and shales, a Fossil Chance Find Protocol should be added to the EMPr: if fossils are found once excavations have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample, with a SAHRA permit.

# 8. References

Almond, J.E. 2012a. Proposed Mulilo Renewable Energy PV2, PV3 and PV4 photovoltaic energy facilities on Farms Paarde Valley, Badenhorst Dam and Annex Du Plessis Dam near De Aar, Northern Cape Province. Palaeontological specialist study: combined desktop and field-based assessments, 45 pp. Natura Viva cc, Cape Town.

Almond, J.E. 2012b. Proposed solar power generation facilities on the remaining extent of the farm Vetlaagte No. 4, De Aar, Northern Cape Province. Palaeontological specialist study: combined desktop and field-based assessments, 33 pp. Natura Viva cc, Cape Town.

Almond, J.E. 2012c. Two wind energy facilities on the Eastern Plateau near De Aar, Northern Cape Province proposed by Mulilo Renewable Energy (Pty) Ltd. Palaeontological specialist study: combined desktop and field-based assessments, 55 pp. Natura Viva cc, Cape Town.

Almond, J.E., 2013. Palaeontological specialist study: Combined desktop and field-based assessments, proposed Photovoltaic (solar) energy facilities on du Plessis Dam Farm near De Aar, Northern Cape. 20pp. Natura Viva cc, Cape Town.

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

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McCarthy, T.S., 2006. The Witwatersrand 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 155-186.

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.

Rubidge, B.S. (Ed.) 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Biostratigraphy, Biostratigraphic Series No. 1., 46 pp. Council for Geoscience, Pretoria.

Rubidge, B.S. 2005. Re-uniting lost continents – fossil reptiles from the ancient Karoo and their wanderlust. 27th Du Toit Memorial Lecture. South African Journal of Geology 108, 135-172.

Rubidge B.S., Day, M.O., Barbolini, N., Hancox, P.J., Choiniere, J.N., Bamford, M.K., Viglietti, P.A., McPhee, B.W., Jirah, S., 2016. Advances in Karoo biostratigraphy in the Permo-Triassic non-marine realm: significance for understanding basin development. In: Linol, B. and de Wit, M., (Eds), Origin and Evolution of the Cape Mountains and Karoo Basin. Regional Geology Reviews, pp. 141-149. , DOI 10.1007/978-3-319-40859-0_14

Van Dijk, D.E., Channing, A., van den Heever, J.A. 2002. Permian trace fossils attributed to tetrapods (Tierberg Formation, Karoo Basin, South Africa). Palaeontologia africana 38: 49-56.

# 9. Chance Find Protocol

**Monitoring Programme for Palaeontology – to commence once the excavations and associated 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, insects, bone, trace fossils) should be put aside in a suitably protected place. This way the project activities will not be interrupted.

3. Photographs of similar fossil plants must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 1.5). 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/miners then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
7. If no good fossil material is recovered then no site inspections by the palaeontologist will not 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.

## Appendix A – Examples of fossils from the Permian Karoo.

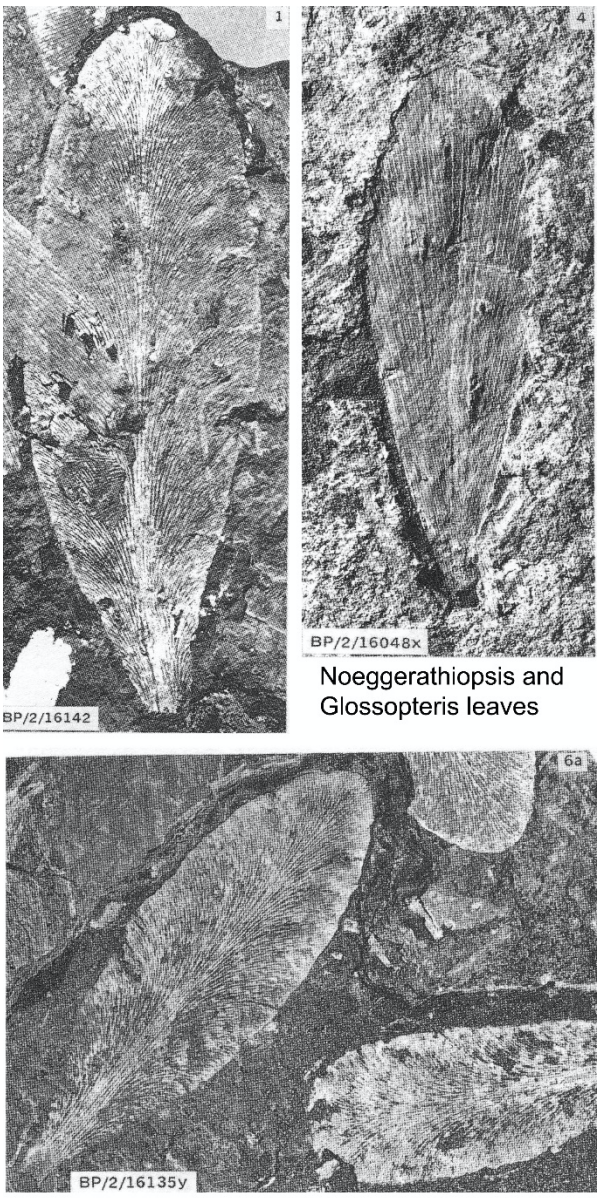


Figure 7: examples of Permian *Glossopteris* leaf impressions.

Figure 8: Vertebrate bones embedded in the mudstone.


Figure 9: a common trace fossil of worm burrows.

Figure 10: piece of silicified wood. Note the knots for branches.

## Appendix B – Details of specialist

# Curriculum vitae (short) - Marion Bamford PhD
# January 2020

### 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.

**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 | 7 | 0 |
| Masters | 10 | 4 |
| PhD | 12 | 5 |
| Postdoctoral fellows | 10 | 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 –

Journal of African Earth Sciences: 2020 -

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
- 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
-

## xi) Research Output

Publications by M K Bamford up to December 2019 peer-reviewed journals or scholarly books: over 140 articles published; 5 submitted/in press; 8 book chapters.
Scopus h-index = 27; Google scholar h-index = 32; -i10-index = 80
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)

# PALAEONTOLOGICAL SPECIALIST STUDY: COMBINED DESKTOP AND FIELD-BASED ASSESSMENTS

# Two wind energy facilities on the Eastern Plateau near De Aar, Northern Cape Province proposed by Mulilo Renewable Energy (Pty) Ltd

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**naturaviva@universe.co.za**

**January 2012**

***SUMMARY***

*Mulilo Renewable Energy (Pty) Ltd is proposing to construct two wind energy facilities on the Eastern Plateau, situated approximately 20 km east of the town of De Aar, Northern Cape. The Northern and Southern Projects each have a total capacity of 150 to 200 MW, generated by between 100 and 145 wind turbines of 1.5 to 2.5 MW capacity. The study sites are situated within the Emthanjeni and Renosterberg Local Municipalities of the Northern Cape.*

*Most of the WEF development footprint is situated in portions of the study area that are underlain by unfossiliferous dolerite or doleritic colluvium (scree, gravels etc) and is therefore unproblematic in fossil heritage terms. The Ecca and Beaufort Group sediments cropping out in more peripheral regions of the study area generally have a moderate to high palaeontological sensitivity respectively. However, their outcrop areas are almost entirely mantled in a thick layer of superficial deposits of probable Pleistocene to Recent age. These superficial deposits include various soils, alluvium, gravels and – at least in some areas - a very well-developed calcrete hardpan. These superficial sediments are generally of low palaeontological sensitivity, with the exception of superficial sheetwash and subsurface gravels that often contain reworked petrified wood fragments. Rare kimberlite pipes of Cretaceous age are unfossiferous and do not preserve crater lake deposits (or diamonds).*

*Upper Ecca Group bedrocks in the De Aar area contain locally abundant fossil as well as low diversity trace fossil assemblages typical of the Middle Permian Waterford Formation, rather than the Tierberg Formation as mapped. The trace fossils include various invertebrate burrows as well as possible tracks and partial body impressions of large crocodile-like amphibians. Well-preserved, silicified fossil wood is abundant in the upper Ecca succession.*

*Natural and artificial exposures of Lower Beaufort Group bedrocks (Adelaide Subgroup) are exceedingly sparse in the De Aar region. Several of these localities yielded fragmentary to semi-articulated vertebrate remains that are among the first ever recorded in this part of the Karoo. They include skull and postcranial remains of small therapsids (probably the small dicynodont Diictodon) as well as a partial specimen of the rare tortoise-like parareptile Eunotosaurus. Other fossil groups recorded from these rocks include transported plant material (horsetail ferns), well-preserved silicified wood, and low diversity trace fossils including both invertebrate and vertebrate scratch burrows. These fossil remains probably belong to the Pristerognathus Assemblage Zone of late Middle Permian age. It is concluded that fossils are sparsely distributed but not very rare within the Lower Beaufort Group near De Aar; the main constraint is lack of bedrock exposure. The*

*potentially fossiliferous Beaufort Group rocks are unlikely to be directly impacted by the proposed Mulilo WEF projects, however, since they mostly lie outside their development footprints.*

*Fossils exposed at the surface or underground may be damaged, disturbed or sealed-in during the construction phase of the proposed wind energy facilities near De Aar. However these developments are inferred to be of LOW significance in terms of palaeontological heritage resource conservation because:*

- *By far the greater part of the development footprint of each project is underlain by unfossiliferous dolerite;*

- *The potentially fossiliferous Karoo Supergroup rocks within the development footprints (wind turbines, laydown areas, transmission lines, access roads and other infrastructure) are generally buried beneath a mantle of fossil-poor superficial sediments (soils, alluvium, gravels, calcretes) that may be up to several meters deep ;*

- *The Karoo Supergroup rocks are often extensively disrupted by near-surface secondary calcrete formation. Baking by dolerite intrusion has often further compromised their original fossil heritage locally.*

*The various possible locations of the on-site electrical substations for the other newly proposed energy facilities (solar energy) near De Aar are of equally low impact significance in fossil heritage terms since they all overlie dolerite. The construction of new access roads and transmission lines in this region is likewise considered to be of low significance as far as fossil heritage is concerned. Any potential future changes in infrastructure layout for the WEF projects will not materially affect the conclusions and recommendations made in this palaeontological report.*

*Given the low overall palaeontological sensitivity of the Eastern Plateau region near De Aar, and the widespread occurrence elsewhere in the Great Karoo of most of the fossils so far recorded there, the successive or concurrent development here of the two wind energy facilities that have been proposed by Mulilo Renewable Energy (Pty) Ltd does not pose a significant cumulative impact on local fossil heritage.*

*In view of the overall low significance of the proposed developments on palaeontological heritage resources, it is concluded that no further palaeontological heritage studies or specialist mitigation are required for these WEF projects, pending the exposure of any substantial fossil remains (e.g. vertebrate bones and teeth, large blocks of petrified wood, vertebrate trackways) during the construction phase. The Environmental Control Officer (ECO) responsible for these developments should be alerted to the possibility of fossil remains being found on the surface or exposed by fresh excavations during construction. Should substantial fossil remains be discovered during construction, these should be safeguarded (preferably in situ) and the ECO should alert the South African Heritage Resources Association (SAHRA) so that appropriate mitigation (e.g. recording, sampling or collection) can be undertaken by a professional palaeontologist.*

*The specialist involved would require a collection permit from SAHRA. Fossil material must be curated in an approved repository (e.g. museum or university collection) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA.*

*These recommendations should be incorporated into the Environmental Management Programme (EMP) for the two Mulilo WEF developments near De Aar.*

## 1. INTRODUCTION & BRIEF

The company Mulilo Renewable Energy (Pty) Ltd is proposing to construct two wind energy facilities (WEFs), each with a total capacity of 150 to 200 MW, on the Eastern Plateau situated approximately 20 km east of the town of De Aar, Northern Cape (Figs. 1 & 2). The study sites are situated within the Emthanjeni and Renosterberg Local Municipalities of the Northern Cape. An outline of the major features of each of the two wind energy facilities is given below in Table 1. The land parcels concerned in each project, currently zoned for agriculture, are as follows:

**NORTHERN SITE**

- Pienaarskloof (Farm No. 136 Portions 1)
- Pienaarskloof (Farm No. 136 Portions 6)
- Brack Fountain (Farm No. 148 Portions 2, 4 and Remainder)
- Vendussie Kuil (Farm No. 165 Portions 1 )
- Washbank (Farm No. 149 Portion 1)
- Enkeldebult (Farm No. 150 Portion 4)
- Zwagershoek (Farm No. 151 Portion 1)
- Enkeldebult (Farm No. 150 Remainder)
- Zwagershoek (Farm No. 151 Portion 2)
- Vendussie Kuil (Farm No. 165 Portion 7)

**SOUTHERN SITE**

- Slingershoek (Farm No. 2 Remainder)
- Knapdaar (Farm No. 1 Portion 8)
- Maatjiesfountain (Farm No. 5 Portion 1)
- Vendussie Kuil (Farm No. 165 Portion 2)
- Slingershoek (Farm No. 2 Portion 2 and Farm No. 4 Portion 2)
- Vendussie Kuil (Farm No. 165 PortionS 11 and Remainder)

**Table 1: Outline of the two proposed wind energy facilities on the Eastern Plateau, De Aar**

| Project | No. of turbines (approximate) | Turbine size (MW) | Project size (MW) | Size (ha) | Footprint (approximate) |
|---|---|---|---|---|---|
| **North** | ***c*. 145** | **1.5-2.5 MW** | **150-200** | **14 500** | **<1% (145 ha)** |
| **South** | ***c*. 105** | **1.5-2.5 MW** | **150-200** | **9 200** | **<1% (92 ha)** |

Power generated by the two WEFs would be transmitted to the national grid *via* two of five proposed substations connecting into three existing transmission lines that traverse the site and linking into the existing Hydra Substation situated some 7 km southeast of De Aar (Fig. 2). It should be noted that the turbine and other infrastructure layouts shown in Figs. 3 and 4 are only preliminary. Future changes in infrastructure layout will not materially affect the conclusions and recommendations made in this palaeontological assessment report.

The present combined desktop and field-based assessment (Phase 1 draft scoping report) forms part of the combined Environmental Impact Assessment (EIA) process for both the North and South WEF projects near De Aar that is being co-ordinated by Aurecon South Africa (Pty) Ltd, Cape Town (DEA ref. no. 12/12/20/2463/1 (SOUTH); NEAS ref. no. DEAT/EIA/0000577/2011; DEA ref. no. 12/12/20/2463/2 (NORTH); NEAS ref. no. DEAT/EIA/0000578/2011).

In accordance with the National Heritage Resources Act, No.25of1999,(NHRA) a palaeontological heritage assessment is required as part of a Heritage Impact Assessment for these projects since their development footprints overlie potentially fossiliferous Palaeozoic rocks of the Karoo Supergroup (Ecca and Beaufort Groups). The various categories of heritage resources recognised as part of the National Estate in Section 3 of the NHRA include, among others:

- geological sites of scientific or cultural importance
- palaeontological sites
- palaeontological objects and material, meteorites and rare geological specimens

The Terms of Reference for the present palaeontological heritage draft scoping report, as specified by Aurecon South Africa (Pty) Ltd, are briefly to undertake a Palaeontology Impact Assessment of the site in accordance with the requirements of Section 38(3) of the NHRA which should include:

(1) Conducting a detailed desk-top level investigation to identify all palaeontological significant geological units in the proposed development areas.

(2) Undertaking field work to verify results of the desktop investigation.

(3) Documentation (GPS coordinates and map) of all sites, objects and structures identified on the candidate sites.

(4) Compilation of a report which should include:

- Identification of palaeontologically significant sites within the proposed development areas;
- Assessing the sensitivity and significance of palaeontological resources of the site;
- Evaluation of the potential impacts of construction, operation and maintenance of the proposed development on palaeontological resources;
- Recommendation of mitigation measures to ameliorate any negative impacts on areas of palaeontological importance;
- Preparation of a heritage resources management plan which includes recommendations on the management of the objects, sites or features, and also guidelines on procedures to be implemented if previously unidentified palaeontological resources are uncovered during later developments in the area.

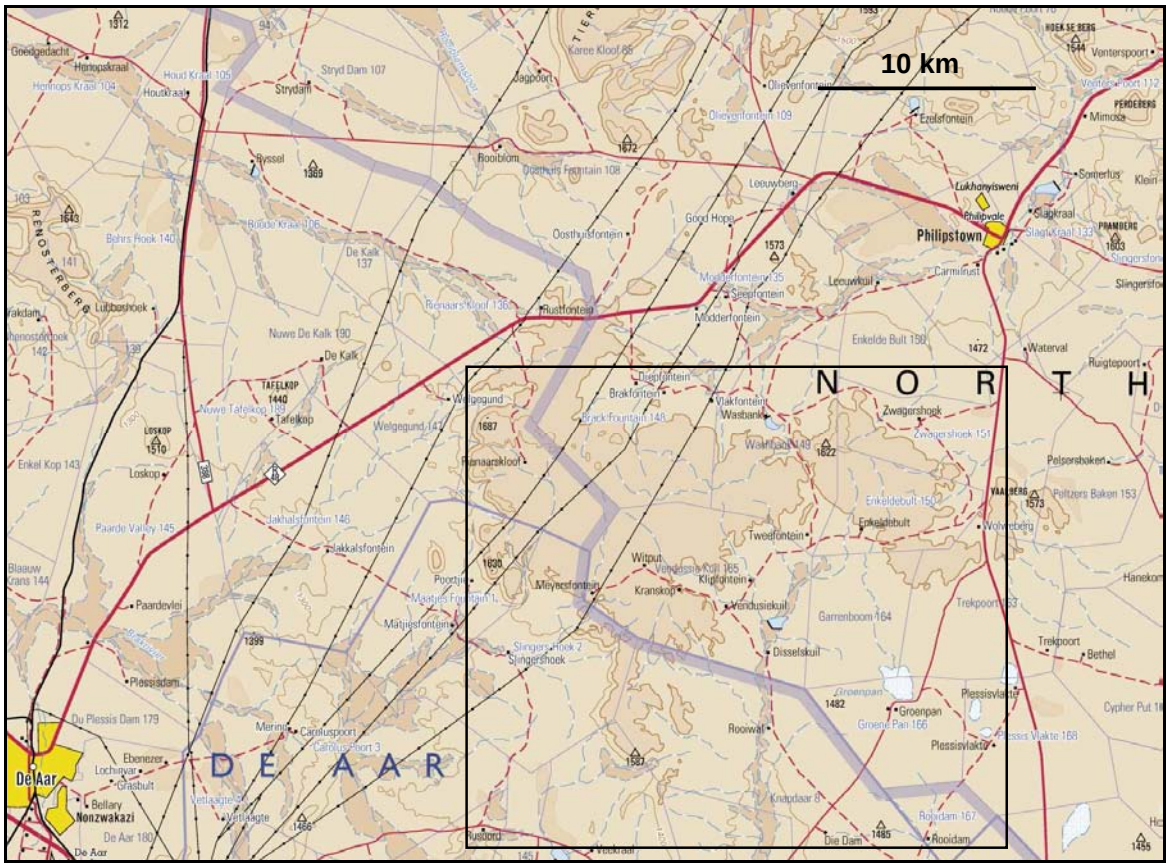


**Fig. 1. Extract from 1: 250 000 topographical sheet 3024 Colesberg showing the *approximate* location the proposed Mulilo wind energy facilities on the Eastern Plateau some 20km east of De Aar, Northern Province (Courtesy of the Chief Directorate: National Geospatial Information, Mowbray).**

**Fig. 2 (Following page). Google Earth© satellite image of the area to the east of De Aar, Northern Cape, showing outline of land parcels concerned in the North and South Projects on the Eastern Plateau (red), the provisional location of the five proposed electrical substations (labelled), and the existing transmission lines crossing the WEF sites (white lines). The Eastern Plateau is largely underlain by Jurassic dolerites that appear rusty brown in satellite images).**


220kV Susbstation
132kV Substation
220kV Susbstation
132kV Substation
De Aar
Hill St
10
Hydra Substation
Hydra Substation
220kV Susbstation
Image © 2012 DigitalGlobe
© 2012 AfriGIS (Pty) Ltd.
Image © 2012 GeoEye
© 2012 Cnes/Spot Image
R389
30°35'57.49" S 24°16'07.19" E elev 1387 m

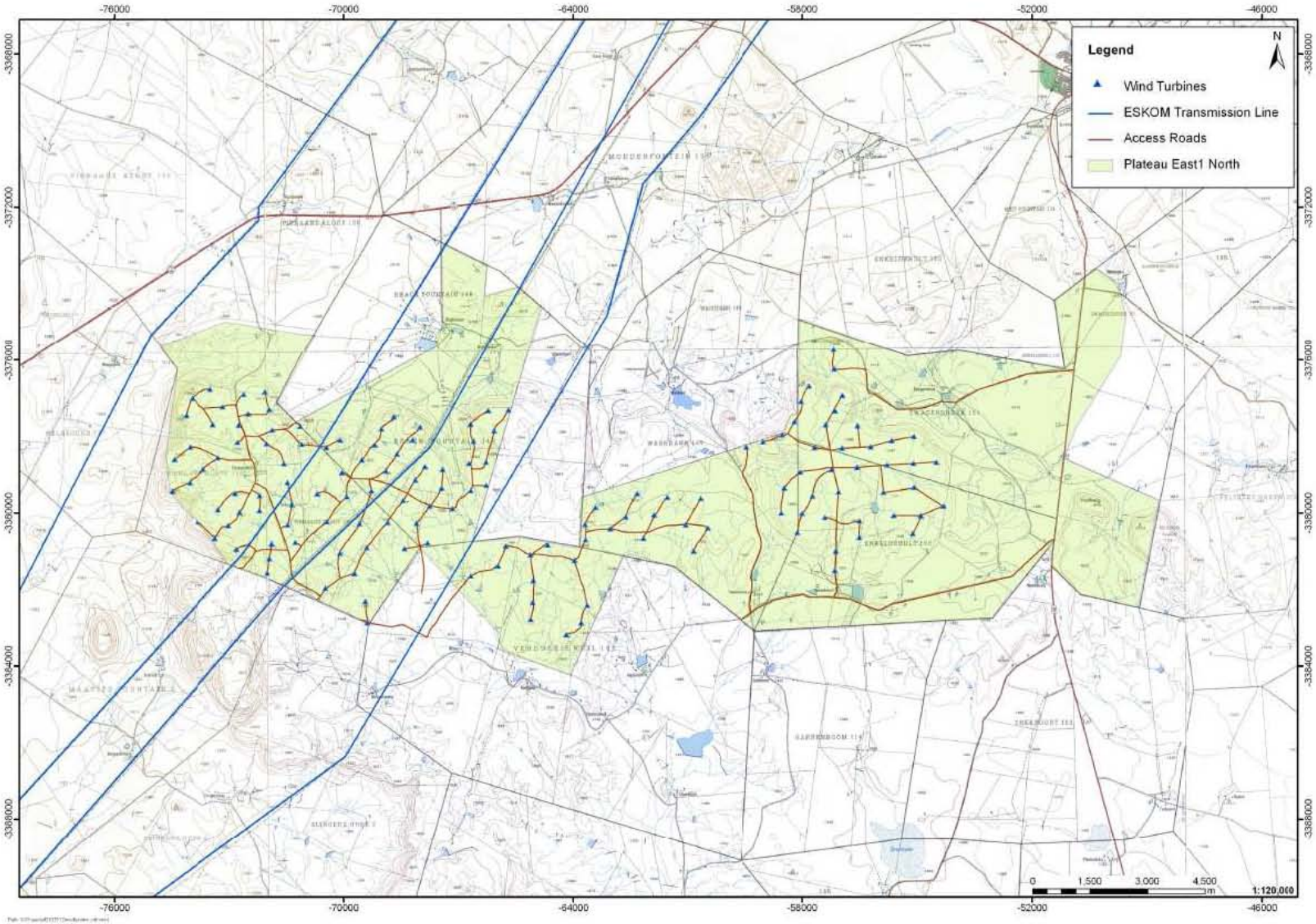


**Fig. 3. Provisional layout of land parcels, wind turbines and access roads for the Northern Project, De Aar WEF (Image kindly supplied by Aurecon South Africa (Pty) Ltd). Blue lines are existing transmission lines.**

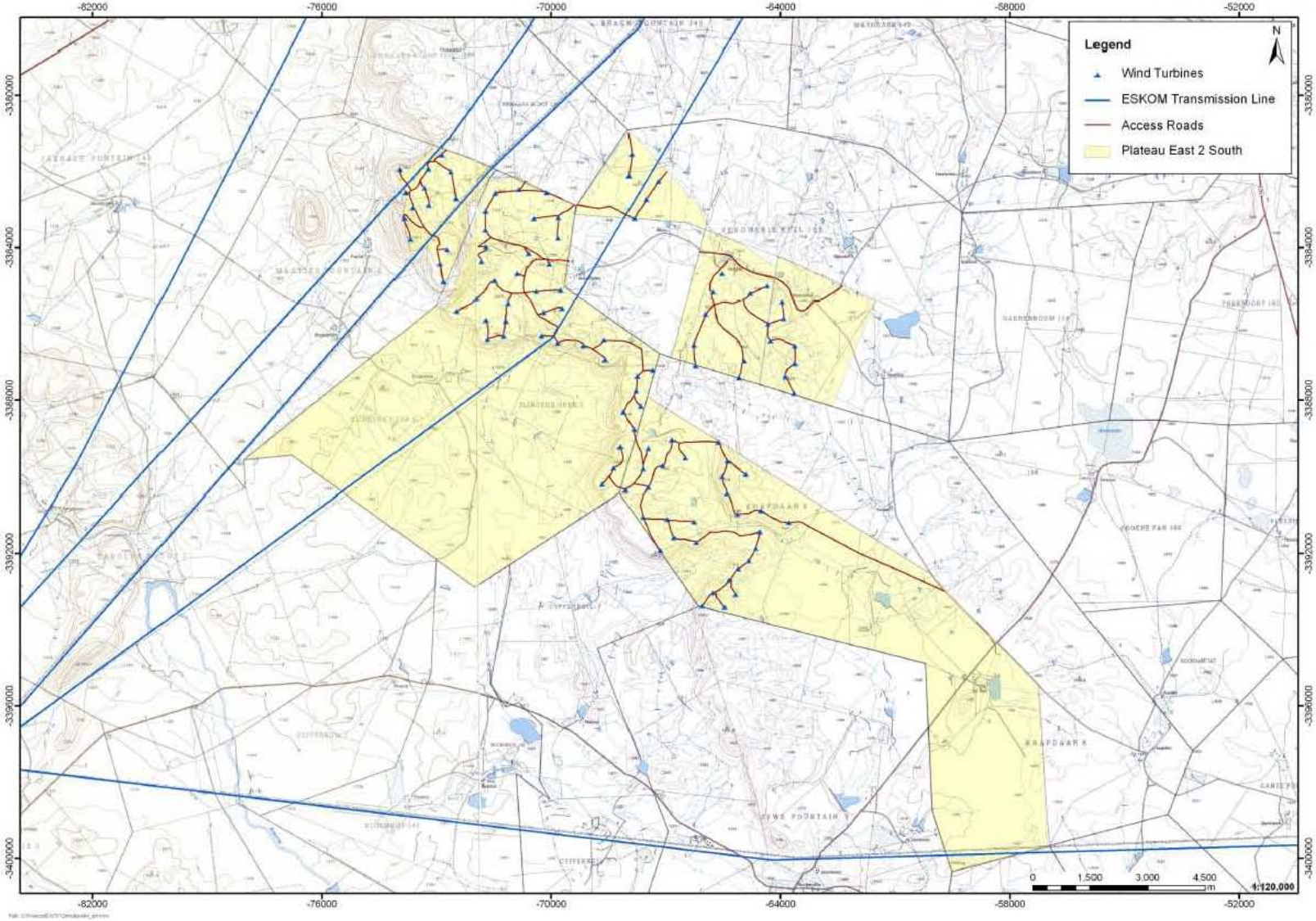


**Fig. 4. Provisional layout of land parcels, wind turbines and access roads for the Southern Project, De Aar WEF (Image kindly supplied by Aurecon South Africa (Pty) Ltd). Blue lines are existing transmission lines.**

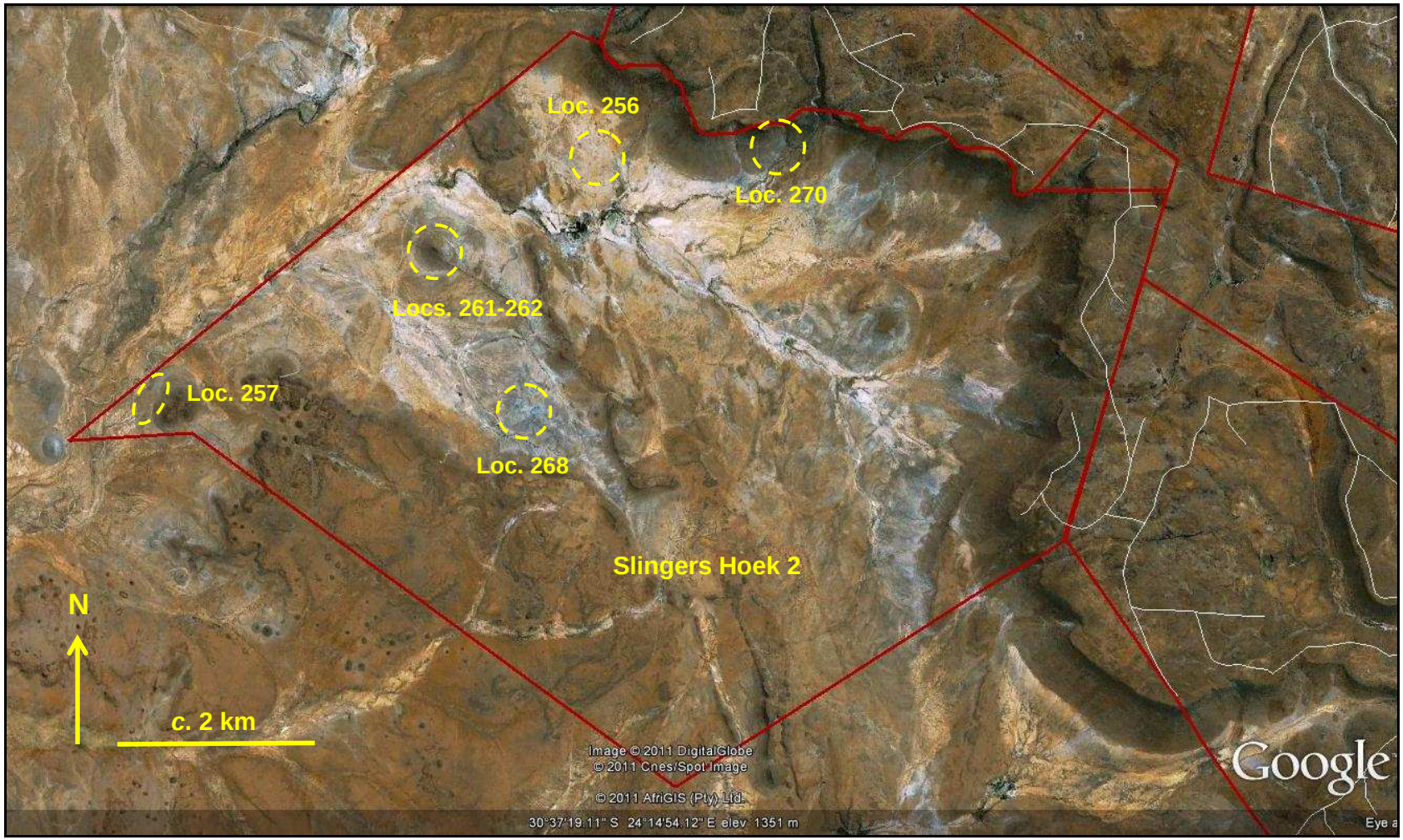


**Fig. 5. Google Earth© satellite image of the farm Slingers Hoek 2 on the western boundary of the Mulilo De Aar WEF Southern Project. Several potentially fossiliferous surface exposures of Karoo Supergroup rocks were examined here (grey areas on the escarpment as well as on the *koppies* and *vlaktes* below). Locality numbers refer to sites where Late Palaeozoic vertebrate, plant and trace fossils were recorded. Many grey areas proved to have no substantial bedrock exposure (*e.g.* only surface gravels present, or area largely obscured by summer grasses). Note almost total absence of fossiliferous bedrock exposure on dolerite plateau (rusty brown areas) which is where the WEF footprint is largely located. The Karoo dolerites have intruded and baked the surrounding Karoo Supergroup sediments.**

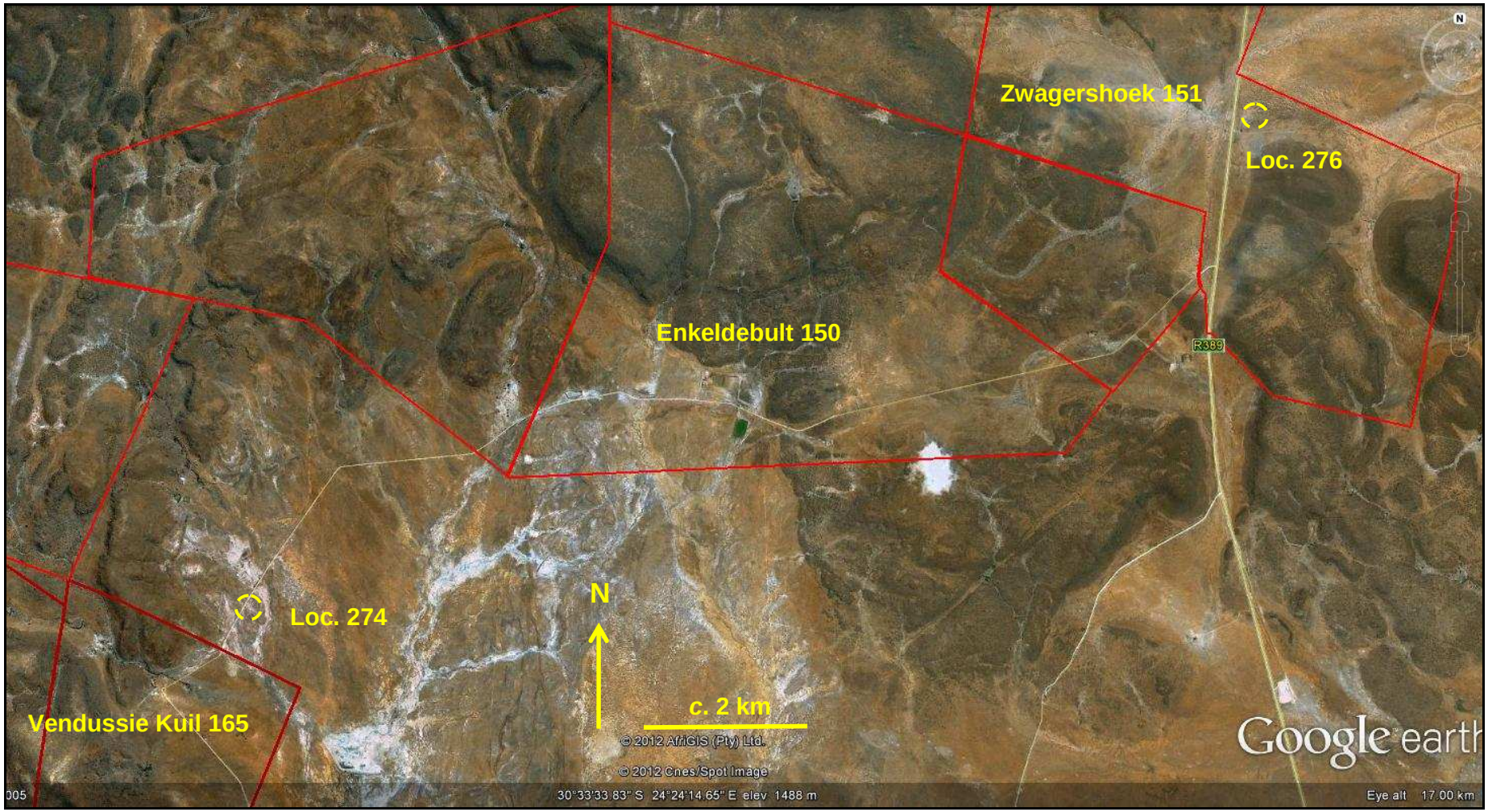


**Fig. 6. Google Earth© Satellite image of the eastern portion of the Mulilo De Aar WEF Northern Project showing the position of two Beaufort Group vertebrate fossil localities within the Lower Beaufort Group, one of which lies just outside the WEF study area.**

### 1.1. Approach used for this specialist palaeontological study

This palaeontological report provides an assessment of the observed or inferred palaeontological heritage within the two De Aar WEF areas, with recommendations for specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, including recent palaeontological assessments for development projects in the De Aar region by the author and others (*e.g.* Almond 2012); (2) published geological maps and accompanying sheet explanations, and (3) palaeontological field assessments carried out on 8 to 12 January 2012. Because the level of natural rock exposure within those parts of the study area underlain by the Ecca Group was generally very poor, the far better exposed stratotype section of the main rock units involved (Tierberg and Waterford Formations) on the farm Swartkoppies, some 47 km north-east of De Aar, was also inspected for fossil remains associated with these formations.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following scoping during the compilation of the final report, should a final report be required). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most notably the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field-based assessment by a professional palaeontologist is usually warranted.

The focus of the field-based assessment work is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present (*N.B.* Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, and fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the scoping study where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localized (*e.g.* GPS and stratigraphic data) samples of fossil material during scoping studies. All fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Before fieldwork commenced, a preliminary screening of satellite images and 1: 50 000 maps of the De Aar study area was conducted to identify sites of potentially good bedrock exposure to be examined in the field (See, for example, Fig. 5). Allof these sites, which were relatively few in number, were situated around the periphery of the study area and outside the development footprint, away from the main dolerite intrusions underpinning the Eastern Plateau. The sites included both natural exposures (*e.g.* stream beds, steep escarpment slopes, gullies) as well as artificial exposures such as dams, borrow pits and quarries.

Note that while fossil localities recorded during fieldwork within the study area itself are obviously highly relevant, most fossil heritage here is embedded within rocks beneath the land surface or

obscured by surface deposits (soil, alluvium *etc*) and by vegetation cover. In many cases where levels of fresh (*i.e.* unweathered) bedrock exposure are low, the hidden fossil resources have to be *inferred* from palaeontological observations made from better exposures of the same formations elsewhere in the region but outside the immediate study area. Therefore a palaeontologist might reasonably spend far *more* time examining road cuts and borrow pits close to, but outside, the study area than within the study area itself. Field data from localities even further afield (*e.g.* an adjacent province) may also be adduced to build up a realistic picture of the likely fossil heritage within the study area.

On the basis of the desktop and field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations, although pre-construction recording of surface-exposed material may sometimes be more appropriate. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*i.e.* SAHRA, Cape Town). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

### 1.2. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information.

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g*. of commercial mining companies) - that is not readily available for desktop studies.

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:

(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous “drift” (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

In the case of palaeontological field studies in the De Aar region, the main limitations are:

- Very extensive intrusion of the potentially fossiliferous Karoo Supergroup bedrocks by dolerite. Weathered dolerite colluvium (scree) and sheetwash blanket most of the hill slopes in the area, *i.e.* the very regions where fossiliferous bedrocks are usually exposed;

- High levels of bedrock cover by thick alluvial and colluvial soils as well as extensive calcrete hardpans;

- Conflicting views among geologists concerning the stratigraphic subdivision and palaeoenvironmental interpretation of the Ecca – Beaufort transition rocks in the De Aar / Philipstown area.

These limitations were in part addressed through palaeontological surveying of areas beyond the boundaries of the De Aar WEFs (*e.g.* type section through Tierberg Formation at Swartkoppies; stream sections west of Slingers Hoek 2). Confidence levels in the conclusions presented here are in consequence moderately high.

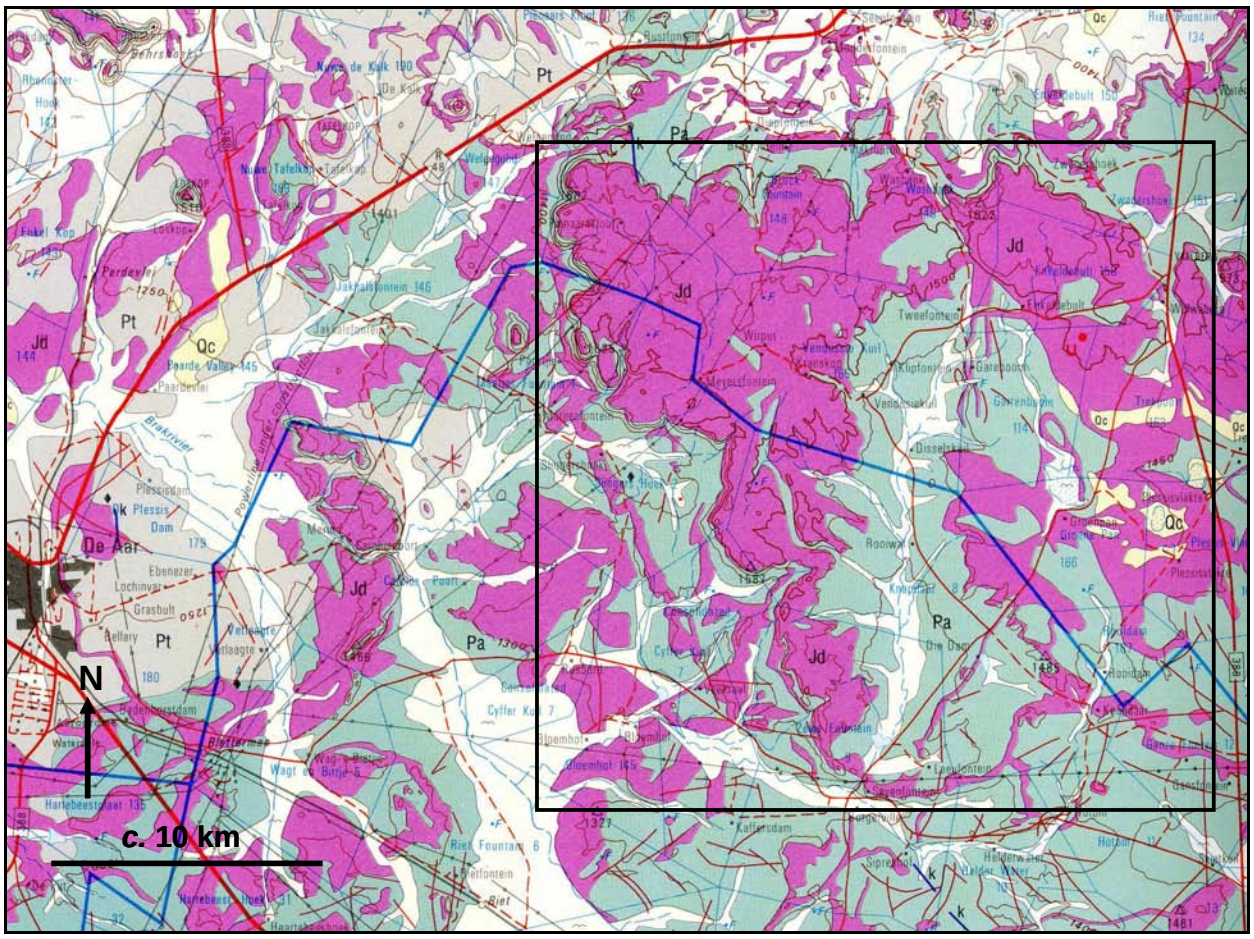


**Fig. 7. Geological map of the region east of De Aar, Northern Cape, showing in very broad outline the location of the Mulilo WEF on the Eastern Plateau *c.* 20km east of De Aar (Abstracted from 1: 250 000 geology sheet 3024 Colesberg, Council for Geoscience, Pretoria). Please refer to Figs. 3 & 4 for precise boundaries of the North and South study areas.**

**The following rock units are mapped within or close to the De Aar WEF study areas:**

**grey (Pt) = Tierberg Formation (Ecca Group) (*NB* According to the author these sediments should rather be assigned to the Waterford Formation following recent fieldwork in the study area – see discussion in text)**

**pale green (Pa) = Adelaide Subgroup (Lower Beaufort Group)**

**pink (Jd) = intrusive dykes and sills of the Karoo Dolerite Suite**

**dark yellow (T-Qc) = Neogene to Quaternary calcretes**

**white = Quaternary to Recent superficial deposits (alluvium, colluvium *etc*)**

**small black diamond symbol = Kimberlite pipe (*e.g.* Slingers Hoek 2)**

## 2. GEOLOGICAL BACKGROUND

The Northern and Southern Projects near De Aar are centred on the Eastern Plateau located some 20m east of town, east and south of the R48 tar road between De Aar and Philipstown as well as west of the north-south R389 tar road between Philipstown and Hanover (Fig. 1). This irregularly-shaped topographic eminence, reaching elevations of 1687m amsl (Tafelkop), is largely constructed by a major, sheet-like dolerite body (sill) that has intruded and baked older country rocks of the Karoo Supergoup. Along the western and northern edges of the plateau the tough-weathering dolerite sill caps a fairly steep escarpment of some 160-260m height that is cut by numerous rocky stream gorges or *klowe*, normally flowing only after summer rains. The escarpment slopes are almost entirely mantled in doleritic colluvium (scree, sheet wash), with very little bedrock exposure of Karoo Supergroup country rocks beneath the sill, apart from a few more prominent-weathering Beaufort Group sandstones (Fig. 8). The plateau itself is fairly rugged, typical dolerite terrain, with scattered koppies of well-jointed, masonry-like dolerite corestones surrounded by aprons of rusty-brown dolerite scree and reddish-brown ferruginous soils and calcrete (Fig. 14). There is almost no Karoo Supergroup exposure in this area. It is drained by a network of small intermittent streams that flow eastwards into an unnamed north-south flowing tributary of the Brakrivier. Intermittently flowing channels of the Brakrivier also drain the lower-lying *vlaktes* at the western foot of the plateau, at elevations of around 1300-1400m amsl., while the north-eastern plateau is drained by tributaries of the Hondeblafrivier. The terrain surrounding the plateau is less rugged, being underlain by softer-weathering mudrocks and sandstones of the Karoo Supergroup, and extensively mantled with alluvium and soils (Fig. 8). Calcrete hardpans are commonly well-developed here, especially in the vicinity of dolerite intrusions. Bedrock exposures are scarce, due to cover by thick superificial deposits as well as karroid vegetation and summer grasses, but occasional examples occur within stream beds, on steeper hillslopes, as well as in artificial excavations such as farm dams, borrow pits and road cuttings.

**Fig. 8. View of northwestern portion of the Eastern Escarpment area near De Aar showing thin, prominent dolerite capping and paucity of Karoo Supergroup bedrock exposure either along the escarpment slopes or in the *vlaktes* beneath.**

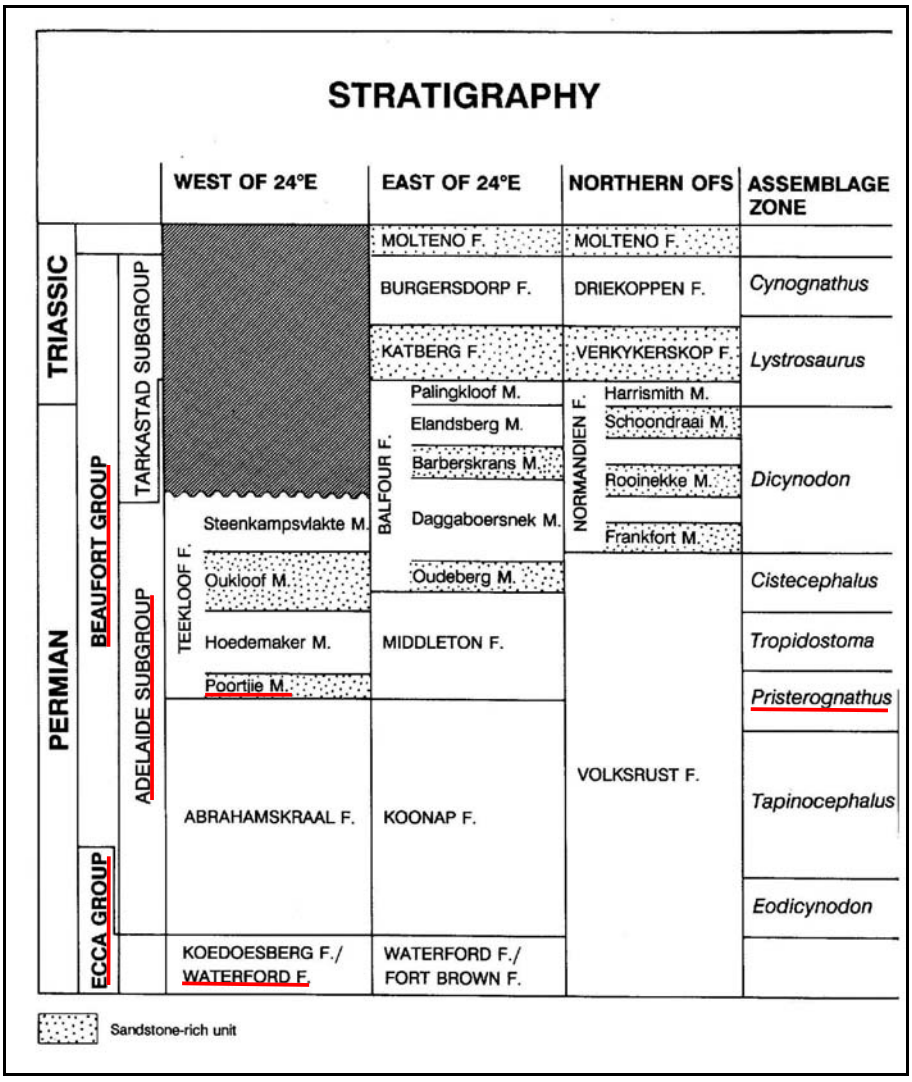


**Fig. 9. Stratigraphic subdivision of the Beaufort Group in the Main Karoo Basin of South Africa (From Rubidge 1995). The uppermost Ecca Group sediments in the De Aar study area are assigned here to the Waterford Formation (but mapped as Tierberg Formation), and in particular to the storm-influenced Carnarvon-type facies of this unit. In this area these marine shelf to foreshore sediments are overlain by a sandstone-rich fluvial succession that is probably equivalent to the Poortjie Member (Teekloof Formation) of the Lower Beaufort Group / Adelaide Subgroup, characterized by fossils of the *Pristerognathus* Assemblage Zone, with little or no representation of the Abrahamskraal Formation. Further palaeontological and stratigraphic work is needed to test this preliminary assessment, however.**

The geology of the Mulilo Renewable Energy WEFs project areas near De Aar is outlined on the 1: 250 000 geology sheet 3024 Colesberg (Le Roux 1993) (Fig. 7) . As far as the Karoo Supergroup is concerned the region is of special geological and palaeontological interest in that the stratigraphic boundary between the Ecca Group, largely composed of marine (actually freshwater inland sea) rocks, and the overlying continental sediments of the Beaufort Group runs between the escarpment edge and De Aar. This marine-to-land transition across an ancient Ecca Sea shoreline has been much discussed in the geological literature, but many details remain to be resolved (*e.g.* Visser & Loock 1974, Smith & Zawada 1988, 1989, Rust *et al.* 1991, Rubidge *et al.* 2000, Viljoen 2005). As discussed below, the precise stratigraphic position and classification of the Ecca and Beaufort Group rocks in the De Aar – Philipstown region remain ambiguous, and the identification and distribution of the various formations as shown on geological maps (Fig. 7) does

not accord with palaeoenvironmental data shown by the rocks on the ground. The stratigraphic subdivision of the uppermost Ecca Group and lowermost Beaufort Group succession in the Main Karoo Basin is given in Fig. 9, which also shows the fossil assemblage zones recognised in these rocks – mainly based on vertebrate fossils (See Section 4.2).

The geology of the main rock units represented within the Mulilo De Aar WEFs study areas is briefly outlined in the following section, with brief notes and illustrations of features noted during the present palaeontological field assessment. GPS locality information of all numbered fossil and geology localities mentioned in the text are given in an appendix to this report.

## 2.1. Upper Ecca Group

The **Tierberg Formation** (**Pt**) (Ecca Group, Karoo Supergroup) is a recessive-weathering, mudrock-dominated succession – predominantly consisting of dark, well-laminated, carbonaceous shales with subordinate thin, fine-grained sandstones (Prinsloo 1989, Le Roux 1993, Viljoen 2005, Johnson *et al*., 2006). The Tierberg shales are Lower to Mid Permian in age and were deposited in a range of offshore, quiet water environments below wave base. These include basin plain, distal turbidite fan and distal prodelta settings in ascending order (Viljoen 2005, Almond 2008a). Thin coarsening-upwards cycles occur towards the top of the formation with local evidence of soft-sediment deformation, ripples and common calcareous concretions. A restricted, brackish water environment is reconstructed for the Ecca Basin at this time. Close to the contact with Karoo dolerite intrusions the Tierberg mudrocks are baked to a dark grey hornfels with a reddish-brown crust or patina (Prinsloo 1989).

It should be noted here that the stratigraphic as well as palaeoenvironmental interpretation of the Ecca / Beaufort boundary rocks in the De Aar – Philipstown area is more complex and unresolved than that suggested by the brief treatment in the Britstown sheet explanation by Le Roux (1993). For mapping purposes, the base of the first prominent-weathering sandstone within the Ecca / Beaufort boundary succession has been taken as the base of the Beaufort Group in this region (ibid., p. 4, following Nel 1977). The marine / lacustrine, uppermost Ecca Group rocks here, though mapped as offshore / basinal Tierberg Formation, have in fact many features in common with the shallow shelf, storm-dominated, sandstone-rich facies seen at the top of the Ecca succession in the Carnarvon area to the west. These uppermost Ecca Group rocks were previously assigned to the **Carnarvon Formation** that has since been incorporated into the **Waterford Formation** (*e.g.* Johnson *et al.* 2006). They tend to be more sandstone-rich than the overlying Beaufort Group. The “Carnarvon Facies” is characterised by upward-coarsening, yellowish-weathering, sandstone-rich successions containing storm-generated hummocky cross-stratification and wave ripples, large ferruginous carbonate concretions (*koffieklip*), ball-and-pillow load structures, and pervasive low intensity bioturbation by low diversity trace fossil assemblages. The latter have been assigned to the shallow marine *Cruziana* Ichnofacies as well as the marginal marine *Skolithos* and *Scoyenia* Ichnofacies (*e.g.* Siebrits 1987, Smith & Zawada 1988, 1989, Prinsloo 1989, Rust *et al.* 1991 and references therein). Petrified wood and other plant remains (*e.g.* leaf compressions) are locally abundant. The inshore shelf (shoreface) Carnarvon facies rocks have a gradational contact with the underlying offshore Tierberg mudrocks and are in turn conformably overlain by continental (subaerial), fluvial sediments of the Lower Beaufort Group. For the purpose of the present fossil heritage study, the upper Ecca Group sediments within the study area are assigned to the Waterford Formation, despite their attribution to the Tierberg Formation on the published 1: 250 000 geological map (Fig. 7) and the key SACS publication by Viljoen (2005).

Good exposures of typical Carnarvon-type facies of the Waterford Formation are seen in riverine exposures on Slingers Hoek 2 as well as between here and the De Aar – Philipstown tar road (Figs. 10, 11). They include tabular-bedded, well-jointed, buff to yellowish-hued tempestite sandstones with often beautifully developed wave-rippled tops, well-developed horizontal to low angle cross-lamination (hummocky cross-stratification), thin mud pebble basal conglomerates (with occasional reworked calcrete clasts), abundant bioturbation, horizons of spectacular convolute lamination and load balls (dewatering or load structures) and occasional large *koffieklip* / *ysterklip*

ferruginous carbonate concretions. Locally the dark grey, thin-bedded Ecca mudrocks underlying the sandstones are also exposed in the river banks.

Generally the Ecca Group bedrocks are almost entirely mantled with lenses and layers fine to coarse alluvial gravels. These are overlain in turn by shallow to deep silty to sandy soils of brownish to orange-brown hues, with patches of downwasted surface gravels (sandstone, mudrock, hornfels, quartzite, dolerite, reworked silicified wood) and cream-coloured reworked calcrete (Fig. 10).

**Fig. 10. Stream bed exposure of typical wave-rippled, tabular-bedded sandstones of the Waterford Formation (Carnarvon facies) on Slingers Hoek 2. Note thick cover by bedded alluvial gravels and reddish-brown soils (Hammer = 30 cm).**

**Fig. 11. Storm-generated swaley and hummocky cross-stratified sandstones of the Waterford Formation (Carnarvon facies), Slingers Hoek 2 (Hammer = 30 cm).**

## 2.2. Lower Beaufort Group

The **Adelaide Subgroup** (**Pa**) (Lower Beaufort Group, Karoo Supergroup) was deposited by large-scale meandering river systems flowing northwards from the youthful Cape Fold Belt across the extensive floodplains of the ancient Karoo Basin (Smith 1980, Rubidge 1995, Johnson *et al*. 2006). The sediments mainly comprise fine-grained overbank mudrocks with subordinate lenticular channel sandstones. These last commonly have a basal conglomeratic lag of rolled mudflake pellets and calcrete nodules, the latter reflecting the prevailing semi-arid climates in Middle to Late Permian times. Small, often transient playa[1] lakes were also present on the floodplain. In the Britstown – Williston - Colesberg sheet areas the Lower Beaufort succession consists largely of blocky-weathering, blue-grey and reddish floodplain mudrocks, showing occasional mudcracks. There are also subordinate siltstones, fine-grained, lenticular, current cross-bedded channel sandstones, flat-laminated crevasse-splay sandstones, and occasional playa lake deposits (Prinsloo, 1989, Viljoen 1989, Le Roux 1993). Carbonate concretions, including ferruginous *koffieklip*, as well as calcrete nodules (pedogenic limestones) and silicified gypsum rosettes ("desert roses") are common.

The precise stratigraphic assignment of the Lower Beaufort Group sediments east of De Aar is unresolved. According to the most recent fossil biozonation map of the Beaufort Group (Van der Walt *et al*. 2010) the sediments here are assigned to the *Pristerognathus* Assemblage Zone that characterises the uppermost Abrahamskraal Formation *plus* the Poortjie Member of the Teekloof Formation west of longitude 24º East, as well as the uppermost Koonap Formation and basal Middleton Formation to the east (Rubidge 1995) (Figs. 9 and 27). De Aar is situated on the (arbitrary) cut-off line between these two stratigraphic schemes. The lowermost Beaufort Group rocks in the region to the east of town contain numerous, closely-spaced sandstones with a yellowish hue, resembling in this respect the **Poortjie Member** recognised in the western part of the Karoo Basin. An assignation of these rocks to the Poortjie Member is supported (but not yet

[1] A nearly level area at the bottom of an undrained desert basin, sometimes temporarily covered with water.

confirmed) by the sparse fossil vertebrate remains recorded during the present palaeontological field assessment, but these specimens have yet to be prepared and formally identified. According to Smith and Keyser (1995) the Poortjie Member is some 120m thick at Victoria West and thins to the north. There remains a possibility that the Adelaide Subgroup succession in the Eastern Escarpment area, which is well over 100m thick, includes Teekloof Formation successions above the Poortjie Member proper, *i.e*. equivalents of the mudrock-dominated Hoedmaker Member, and therefore perhaps also fossil assemblages of the Late Permian *Tropidostoma* Assemblage Zone (*cf*. Fig. 9). Further stratigraphic and palaeontological fieldwork would be needed to test this idea.

Compared with the older Abrahamskraal Formation rocks of the Adelaide Subgroup, the Teekloof Formation has a generally higher proportion of sandstones while reddish mudrocks are more abundant here. Multi-storied sandstones are common in the basal arenaceous Poortjie Member. Thin, impersistent lenses of pinkish "cherts" are probably altered volcanic ashes (Johnson & Keyser 1979, Theron 1983, Smith & Keyser 1995, Rubidge *et al.* 2010). Several economically interesting uranium ore deposits occur within the Poortjie Member in association with brown-weathering, ferruginous channel sandstones ("koffieklip") and transported plant material. Interesting accounts of the sedimentology and palaeontology of the Poortjie Member are given by Stear (1978) as well as by Cole and Smith (2008). The Poortjie Member has a thickness of some 200m in the western part of the Main Karoo Basin, while the entire Teekloof succession is *c*. 1000m thick (Cole *et al.* 1990, Cole & Voster 1999). Recent, unpublished radiometric dating of zircons from tuff layers within the Poortjie Member gives an age of 261.3 Ma (Rubidge *et al.* 2010 and pers. comm. 2010), placing this stratigraphic unit within the Gaudalupian Epoch (late Middle Permian). Previously the Poortjie Member was considered to be earliest Late Permian or Lopingian in age (*cf* Smith & Keyser 1995, Rubidge 2005).

Only a handful of sites featuring well-exposed Lower Beaufort Group bedrocks were found during the present field assessment; many of the areas initially identified from satellite images proved disappointing on further investigation (*e.g.* only reworked surface gravels present, or no mudrock facies, or dense grass cover). The most informative sites include the steep slopes of a small koppie, Spitskop (Locs. 261-262), and along the western escarpment (Loc. 270, Fig. 12) on Slingers Hoek 2, gentler hillslopes on Slingers Hoek 2 (Loc. 268) and Knapdaar 8 (Loc. 273), as well as stream gulley exposures on Vaalberg (Zwagershoek 151, Loc. 275) and the northern escarpment on Brak Fountain 148 (Loc. 277, Fig. 13) and Pienaarskloof 136 (Loc. 279). Good artificial exposures of Lower Beaufort rocks were also examined in borrow pits on Slingers Hoek 2 (Loc. 268), near Klipfontein homestead on Vendussie Kuil 165 (Loc. 274), and near Vaalberg on Zwagershoek 151 (Loc. 276). Sites which yielded vertebrate fossil material are indicated on satellite images in Figs. 5 and 6 (See Section 4.2. below).

The Lower Beaufort succession in the study area features numerous thin (several meter), often multi-storey channel sandstones of buff to yellowish-brown hue, as is typical of the Poortjie Member further to the west. Some sandstones are notably pale, apparently massive and poorly consolidated; this may be an effect of dolerite baking, although interbedded well- and poorly-consolidated sandstones at the same locality argue against this. Erosive channel bases with thin mudflake conglomerates were occasionally seen. Mudrocks are hackly weathering, predominantly grey-green to blue-grey, but occasionally purple-brown. Thin horizons of pedogenic calcrete nodules occur, but are not common, though locally they are so (*e.g.* Loc. 260, 273, 276), as are more often large ferruginous carbonate concretions (*koffieklip*). Some of the latter are meter-size in thickness and diameter, and clearly have secondarily replaced the original Beaufort Group sandstone, retaining primary sedimentary structures of the latter such as ripple cross lamination (Locs. 273, 275, 278). Occasional horizons of load balls suggest episodes when sandstones were rapidly deposited on top of water-rich, unstable muds. The Beaufort Group mudrocks and sandstones exposed near-surface are often disrupted to a depth of several meters by a dense network of calcrete veins (Loc. 276, Fig. 18).

**Fig. 12. One of the few good exposures of Lower Beaufort Group sediments along the western escarpment, Slingers Hoek 2. Note numerous, closely-spaced thin sandstones here. The poorly exposed beds underlying the upper part of the slope (some 80m high in total) are mainly baked siltstones and might perhaps overlie the Poortjie Member succession.**

**Fig. 13. Excellent exposure of Lower Beaufort sandstone and mudrock facies in a stream kloof along the northern escarpment, Brack Fountain 148 (Loc. 277). Despite ideal conditions, no fossil vertebrates were found here.**

## 2.3. Karoo Dolerites

The **Karoo Dolerite Suite** (**Jd**) is an extensive network of basic igneous bodies (dykes, sills) that were intruded into sediments of the Main Karoo Basin in the Early Jurassic Period, about 183 million years ago (Duncan & Marsh 2006). These dolerites form part of the Karoo Igneous Province of Southern Africa that developed in response to crustal doming and stretching preceding the break-up of Gondwana. Hard cappings of blocky, reddish-brown to rusty-weathering dolerite are a very typical feature of the flat-topped *koppies* in the Great Karoo region. As seen from geological maps (Fig. 7), extensive dolerite intrusion of both the upper Ecca Group as well as the Lower Beaufort Group rocks is observed in the De Aar region. A major dolerite sill caps the Eastern Escarpment and underlies most of the Mulilo WEFs development footprints. The country rocks adjacent to the intrusions have often been extensively baked or thermally metamorphosed. Mudrocks are altered to flinty hornfels ("lydianite" of some authors), while sandstones are metamorphosed to resistant-weathering, siliceous quartzites, as well seen for example in stream sections on Pienaarskloof 136 (Fig. 15) and the roadside quarry adjacent to the R48 on Brack Fountain 148. The Karoo rocks within the thermal aureole of the dolerite intrusions are also often chemically altered; they tend to be silicified, more brittle and contain numerous irregular *vugs* (cavities) lined or infilled with secondary minerals.

Rocky ridges and numerous low, rocky koppies of well-jointed, masonry-like dolerite, as well as zones of dolerite corestones emerging from the soil, are abundantly seen on the Eastern Plateau (Fig. 14). Here dolerite colluvium and ferruginous doleritic soils almost entirely obscure the Karoo Supergroup country rocks. Very thick calcrete development overlying deeply-weathered dolerite (corestones, onionskin weathering *etc*) is seen in several quarries near De Aar (Almond 2012) and extensively calcretised doleritic alluvium is exposed in stream beds along the foot of the escarpment (Fig. 19).

**Fig. 14. Typical dolerite scenery at Kranskop (Vendussie Kuil 165). Note abundant scree of well-rounded dolerite corestones and extensive cover by summer grasses.**

**Fig. 15. Stream bed exposure of contact between the roof of a dolerite sill (massive dark rock in foreground) with well-bedded and jointed quartzites (baked sandstones, buff) and hornfels (baked mudrocks, dark grey) of the Lower Beaufort Group, Pienaarskloof 136 (Hammer = 30 cm).**

### 2.4 Kimberlite pipes

Numerous **kimberlite pipes** of Jurassic to Cretaceous age intrude the Karoo Supergroup rocks north of Victoria West, including several examples to the east of De Aar. They are variously assigned to the Victoria West and Group II Provinces (Skinner & Truswell 2006) and do not contain diamonds. According to Le Roux (1993) the ultramafic kimberlite pipe rocks in the Colesberg sheet area are highly weathered with no obvious surface expression. They can usually be located only on the basis of characteristic mineral assemblages (garnet, phlogopite mica) found in ant heaps, termite mounds and prospecting holes. The only mapped example within the Mulilo WEFs study area comprises one example on Slingers Hoek 2 (diamond symbol on geology map Fig. 7). Kimberlite rocks are unfossiliferous, although rich Cretaceous to Paleocene fossil assemblages may be found in associated craterlake facies (not preserved here).

## 2.5. Superficial deposits

Quaternary to Recent superficial deposits ("drift") cover all but the steepest slopes of the Karoo koppies and escarpment of the Eastern Plateau as well as most of the plains at their feet, including dry river courses such as the Brakrivier and Hondeblafrivier in the broader De Aar study region. Various types of superficial deposits of geologically young, Late Caenozoic age (Miocene / Pliocene to Recent, *i.e.* < 5 Ma) occur throughout the Great Karoo region (Prinsloo 1989, Le Roux 1993, with more extensive discussion in Holmes & Marker 1995, Cole *et al.* 2004, Partridge *et al*. 2006). They include pedocretes (*e.g.* calcretes), colluvial slope deposits (dolerite, sandstone and hornfels scree *etc*), sandy, gravelly and bouldery river alluvium, as well as spring and pan sediments. These colluvial and alluvial deposits may be extensively calcretised (*i.e.* cemented with soil limestone), especially in the neighbourhood of dolerite intrusions.

Thin (usually < 1m) horizons of coarse, angular gravels mantle the Palaeozoic bedrocks over much of the lower-lying portions of the study area, as seen in several quarry and riverine exposures. Gravel clasts mostly consist of locally-derived Beaufort Group sandstones, hornfels and quartzite as well as weathered to fresh dolerite, including large rounded dolerite corestone boulders. The highly porous gravel layers may be preferentially calcretised (Fig. 18). Quarry sections near De Aar show that a large proportion of the Karoo and dolerite bedrocks are mantled with a thick (up to 4m, though often much less), irregular and variable layer of secondary calcrete (Almond 2012). This may be massive or multi-layered, and contains lenticular to laterally persistent horizons of gravels (quartzite, hornfels, siltstone, sandstone, dolerite). The thickest calcrete horizons probably infill depressions in the pre-Holocene landscape and are often associated directly or indirectly with weathered dolerite. For the most part they are probably Pleistocene in age. Calcretes seen in the De Aar study area are very variable in character and in many or most cases are probably composite horizons that have developed in several phases over thousands or tens of thousands of years. Veins, networks and sheets of calcrete extend downwards from the main hardpan into the underlying superficial sediments or bedrock (Fig. 18). Doleritic alluvium in stream beds may be heavily calcretised (Fig. 19).

Buff to orange alluvial soils situated between the basal gravels and calcrete hard pan may be partially consolidated with networks of calcrete veins and sparse gravels clasts. They are probably Pleistocene in age. Younger, unconsolidated orange-brown to brown surface soils, overlying the calcrete hardpan, may be of alluvial, sheet wash or even in part aeolian origin. These superficial soils are probably Holocene in age. They contain, or are locally overlain by, downwasted surface gravels, concentrated by downwasting and sheetwash processes (Fig. 17).

Thick to very thick (4-6m) successions of well-bedded, orange-brown silty and gravelly alluvium is exposed in the banks of incised streams and *dongas* in the *vlaktes* to the west of the Eastern Plateau (Fig. 16). Locally abundant flaked hornfels stone artifacts assignable to the Middle Stone Age found within laterally persistent gravel horizons (sometimes calcretised) close to the base of these alluvial successions show that they are no more than some 300 000 years old (and perhaps considerably younger). A Late Pleistocene age seems most likely.

**Fig. 16. Thick, well-bedded alluvial deposits overlying Ecca Group bedrocks in a stream bed just west of the study area (Jakkalsfontein 146). The laterally persistent gravel interbeds contain numerous Middle Stone Age flaked hornfels artefacts (Hammer = 30 cm).**

**Fig. 17. Thick (3-4m) composite succession of silty superficial deposits, capped by downwasted surface gravels, overlying weathered Beaufort Group mudrocks near Tweefontein homestead, Vendussie Kuil 165.**

**Fig. 18. Heavily calcretised surface gravels rich in dolerite clasts overlying weathered Lower Beaufort Group mudrocks that are traversed by a network of calcrete veins, borrow pit near Vaalberg, Zwagershoek 151 (Hammer = 30 cm).**

**Fig. 19. Heavily calcretised bouldery doleritic alluvium in a stream bed near the western escarpment, Slingers Hoek 2.**

## 4. PALAEONTOLOGICAL HERITAGE

Fossil biotas recorded from each of the main stratigraphic units mapped in the study area are briefly reviewed in this section. GPS locality information of all fossil localities mentioned in the text are given in an appendix to this report. Bedding dips of the Karoo Supergroup sediments in the study region are generally horizontal to very shallow. Low levels of tectonic deformation and cleavage development are expected here, favouring good fossil preservation. However, extensive dolerite intrusion has compromised fossil heritage in the Karoo Supergroup sediments due to resulting thermal metamorphism. In addition, pervasive calcretisation and chemical weathering of many near-surface bedrocks has further compromised their original fossil heritage.

### 4.1. Upper Ecca Group

The fossil record of the **Tierberg Formation** has been reviewed in detail by Almond (2008a). Rare body fossil records include disarticulated microvertebrates (*e.g.* fish teeth and scales) from calcareous concretions in the Koffiefontein sheet area (Zawada 1992) and allochothonous plant remains (drifted leaves, petrified wood). The latter become more abundant in the upper, more proximal (prodeltaic) facies of the Tierberg (*eg* Wickens 1984). Prinsloo (1989) records numerous plant impressions and unspecified "fragmentary vertebrate fossils" within fine-grained sandstones in the Britstown sheet area. Dark carbonaceous Ecca mudrocks are likely to contain palynomorphs (*e.g.* pollens, spores, acritarchs).

The commonest fossils by far in the Tierberg Formation are sparse to locally concentrated assemblages of trace fossils that are often found in association with thin event beds (*e.g.* distal turbidites, prodeltaic sandstones) within more heterolithic successions. A modest range of ten or so different ichnogenera have been recorded from the Tierberg Formation (*e.g.* Abel 1935, Anderson 1974, 1976, Wickens 1980, 1984, 1994, 1996, Prinsloo 1989, De Beer *et al*., 2002, Viljoen 2005, Almond 2008a). These are mainly bedding parallel, epichnial and hypichnial traces, some preserved as undertracks. Penetrative, steep to subvertical burrows are rare, perhaps because the bottom sediments immediately beneath the sediment / water interface were anoxic. Most Tierberg ichnoassemblages display a low diversity and low to moderate density of traces. Apart from simple back-filled and / or lined horizontal burrows (*Planolites, Palaeophycus*) they include arthropod trackways (*Umfolozia*) and associated resting impressions (*Gluckstadtella*), undulose fish swimming trails (*Undichna*) that may have been generated by bottom-feeding palaeoniscoids, horizontal epichnial furrows (so-called *Scolicia*) often attributed to gastropods (these are also common in the co-eval Collingham Formation; Viljoen 1992, 1994), arcuate, finely striated feeding excavations of an unknown arthropod (*Vadoscavichnia*), beaded traces ("*Hormosiroidea*" or "*Neonereites*"), small sinusoidal surface traces (*Cochlichnus*), small star-shaped feeding burrows (*Stelloglyphus*) and zigzag horizontal burrows (*Beloraphe*), as well as possible narrow (<1cm) *Cruziana* scratch burrows. The symmetrical, four-pronged trace *Broomichnium* (= *Quadrispinichna* of Anderson, 1974 and later authors) often occurs in groups of identical size (*c*. 3.5cm wide) and similar orientation on the bedding plane. This trace has frequently been misinterpreted as a web-footed tetrapod or arthropod trackway (*e.g.* Van Dijk *et al*. 2002 and references therein). However, Braddy and Briggs (2002) present a convincing case that this is actually a current-orientated arthropod resting trace (cubichnion), probably made by small crustaceans that lived in schools of similar-sized individuals and orientated themselves on the seabed with respect to prevailing bottom currents. Distinctive broad (3-4cm), strap-shaped, horizontal burrows with blunt ends and a more-or-less pronounced transverse ribbing occur widely within the Tierberg mudrocks. They have been described as "fucoid structures" by earlier workers (*e.g.* Ryan 1967) by analogy with seaweeds, and erroneously assigned to the ichnogenera *Plagiogmus* by Anderson (1974) and *Lophoctenium* by Wickens (1980, 1984). Examples up to one metre long were found in Tierberg mudrocks near Calvinia in 1803 by H. Lichtenstein, who described them as "eel fish". These are among the first historical records of fossils in South Africa (MacRae 1999). These as yet unnamed burrows are infilled with organized arrays of faecal pellets (Werner 2006). Sandstone sole surfaces with casts of complex networks of anastomosing (branching and fusing) tubular burrows have been attributed to the ichnogenus *Paleodictyon*

(Prinsloo 1989) but may more appropriately be assigned to *Megagrapton* (Almond 1998). These so-called graphoglyptid burrows are associated with turbidite facies from the Ordovician to Recent times and have been interpreted as gardening burrows or *agrichnia* (Seilacher, 2007). Microbial mat textures, such as *Kinneyia*, also occur in these offshore mudrocks but, like the delicate grazing traces with which they are often associated, are generally under-recorded.

As discussed previously (Section 3.1.) it is considered likely that the Ecca Group rocks in the study area belong to the **Waterford Formation** rather than the Tierberg Formation as mapped. Rare fragments of poorly-preserved tetrapod bone are recorded in channel lags within the upper Waterford Formation in the Williston sheet area (Viljoen 1989) and the southern Great Karoo. These probably belong to aquatic temnospondyl amphibians ("labyrinthodonts") but large fish and terrestrial therapsids might also be represented. Scattered palaeoniscoid fish scales and fish coprolites are common in the Waterford Formation, and several genera of non-marine bivalves have been described from the southern Karoo (Bender *et al*. 1991, Cooper & Kensley 1984).

Upper delta platform facies of the Waterford Formation (including the Koedoesberg Formation of earlier authors) contain abundant, low diversity trace assemblages of the *Scoyenia* ichnofacies. They are dominated by the rope-like, horizontal and oblique burrows of the ichnogenus *Scoyenia* that has been attributed to small arthropods (possibly insects) and / or earthworms. These tubular, meniscate back-filled scratch burrows characterise intermittently moist, firm substrates such as channel and pond margins on the upper delta platform (Smith & Almond 1998, Buatois & Mángano 2004, 2007). Good examples, often associated with wave-rippled surfaces, are recorded from Waterford thin-bedded sandstones and siltstones in the Roggeveld Escarpment zone by Wickens (1984, 1996) and Viljoen (1989). Offshore delta platform facies of the Waterford Formation have very impoverished, poorly-preserved ichnofaunas due to rapid sedimentation rates with abundant soft-sediment deformation and perhaps also to fluctuating salinities.

Petrified wood and other plant material of the *Glossopteris* Flora (*e.g. Glossopteris, Phyllotheca*) is also common in the Waterford Formation (Theron 1983, Anderson & Anderson 1985, Viljoen 1989, Wickens 1984, 1996, Rubidge *et al*. 2000). Leaves and stems of arthrophytes (horsetails) such as *Schizoneura* have been observed in vertical life position. Substantial fossil logs (so-called "*Dadoxylon*") showing clearly developed seasonal growth rings are mostly permineralised with silica but partially or completely calcified material is also known (Viljoen 1989). At least two different genera of gymnospermous woods, *Prototaxoxylon* and *Australoxylon,* have been identified so far (Bamford 1999, 2004).

The storm-dominated shelf sediments of the Carnarvon-type facies of the Waterford Formation, as seen near De Aar, are typically associated with pervasive low intensity bioturbation by low diversity trace fossil assemblages. The latter have been assigned to the shallow marine *Cruziana* Ichnofacies as well as the marginal marine *Skolithos* and *Scoyenia* Ichnofacies (*e.g.* Rust *et al.* 1991 and references therein). Good examples of these traces are illustrated by Siebrits (1987), Prinsloo (1989) and Rust *et al.* (1991) (Fig. 21). Prominent trace fossil taxa include cm-sized horizontal to oblique burrows with striated walls (*cf Palaeophycus striatus*) and vertical spreiten burrows of the ichnogenus *Teichichnus*. Possible arthropod feeding traces of the ichnogenus *Cruziana* are also reported here. Petrified wood ("*Dadoxylon*") showing well-developed seasonal growth lines and other plant remains (*e.g.* leaf compressions) are locally abundant.

**Fig. 20. Locally abundant fragments of silicified wood that have been reworked from upper Ecca beds into surface sheetwash gravels near the base of the escarpment on Slingers Hoek 2 (Loc. 256).**

Low diversity but abundant ichoassemblages dominated by *Teichichnus*, *Palaeophycus striatus*, meniscate backfilled *Planolites*, dense, narrow epichnial grooves ("*Scolicia*"), and various other unidentified vertical and horizontal burrows were recorded from the tops of, as well as within, wave-rippled Ecca sandstones exposed along the western slopes of Rooiberg at the western border of Slingers Hoek 2 (Loc. 257, 258) (Fig. 22).

An extensive wave-rippled sandstone surface exposed in a stream bed near the homestead on Jakhalsfontein 146 (Loc. 265), just outside the WEFs study area, features numerous impressions of what are probably moderately large tetrapod tracks, although distinct, regular trackways could not be discerned (Figs. 23-25). Some of the tracks appear to be pentadactyl (5-toed), though most are unclear and were probably preserved as undertracks, *i.e.* impressed below the sediment / water interface. Washed-out ripples, linear tool marks (drift wood?) and possible algal mat textures suggest very shallow water conditions, perhaps at the margins of a marine or deltaic embayment (*N.B.* salinities in the Ecca Sea at this time were probably freshwater). Several broad, spatulate depressions with asymmetrically pushed-up margins might be resting impressions of the same animals. These are most likely to be large (crocodile-sized) temnospondyl amphibians whose rare skeletal remains are known from the Ecca Group of South Africa and Namibia (Fig. 26). Beautiful body and tail resting impressions of these elusive animals have been recorded on wave-rippled sandstones along the margins of the Ecca Sea near Estcourt, KZN (McCarthy & Rubidge 2005, Rossouw 2010). Another, less likely, possibility is that these possible tracks were generated by wading therapsids. The De Aar rippled palaeosurface warrants further scientific study, and possible special protection, but falls outside the present WEFs project area

Sheetwash and other near-surface gravels overlying the Ecca Group outcrop area consistently contain small cherty fragments of silicified woods reworked from the underlying bedrocks (*e.g.* Locs. 256, 257, Slingers Hoek; Fig. 20). Larger petrified wood samples also occur within subsurface gravels overlying Ecca bedrocks where these are exposed at surface near De Aar (Almond 2012). The woods typically show well-developed seasonal growth rings and preservation of the original woody microstructure appears to be very good; this should facilitate identification

and possible dating of the samples (*cf* Bamford 1999, 2004). The only other Ecca plant fossils recorded during the present field study were ferruginised stem fragments of arthrophytes (horsetail ferns) within shallow marine sandstones at Loc. 257 on Slingers Hoek 2. Fern- or moss-like dendrites composed of the manganese mineral pyrolusite are locally common in well-jointed Ecca sandstones but these are pseudofossils.

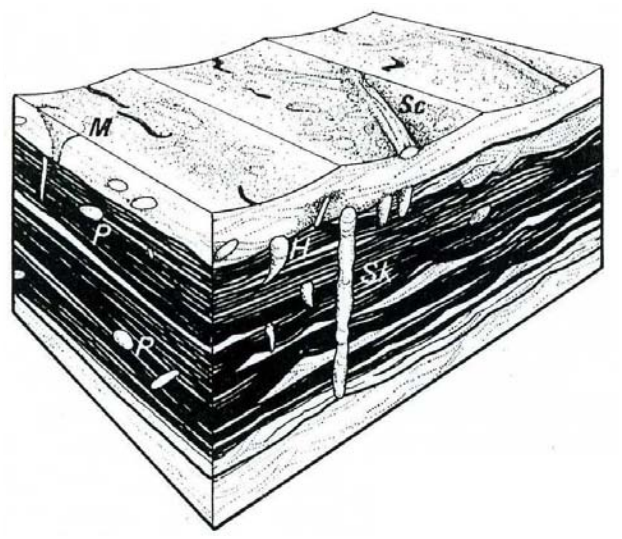


**Fig. 21. Schematic figure showing typical trace fossil assemblages within the storm-influenced, wave ripple laminated Carnarvon facies of the Waterford Formation (From Rust *et al.* 1991). Ichnogenera shown here include vertical burrows *Monocraterion* (M), *Skolithos* (Sk) and *Rosselia* or *Histioderma* (H) as well as horizontal burrows *Planolites* (P) and *Palaeophycus* (Sc).**

**Fig. 22. Striated-walled horizontal burrows of *Palaeophycus striatus*, a typical Carnarvon facies trace fossil, from thin-bedded Ecca sandstones on Slingers Hoek 2 (Loc. 257) (Scale in cm).**

**Fig. 23. Slightly washed-out, wave-rippled sandstone surface on Jakhalsfontein 146, just west of the WEF study area, showing irregular trains of possible amphibian track marks (Scale = 16 cm).**

**Fig. **. Same surface as in previous figure showing broad spatulate body impression (above, arrowed) as well as indistinct tracks (Hammer = 30 cm).**


**Fig. 25. Single track-like impression from the Jakhalsfontein wave-rippled palaeosurface apparently showing five digit impressions (Scale marked in cm).**

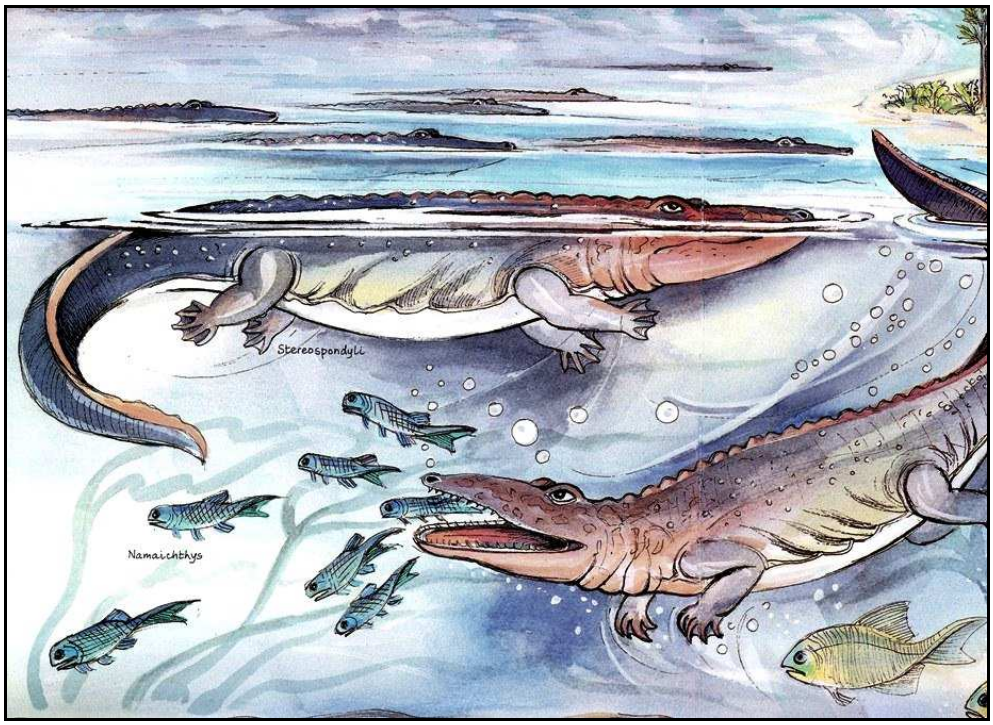


**Fig. 26. Artist's reconstruction of large, crocodile-sized amphibians of the Ecca Sea that must have enlivened the ancient Karoo nights with their muddy burps (From Schneider & Marais 2004).**

## 4.2. Adelaide Subgroup

The overall palaeontological sensitivity of the Lower Beaufort Group sediments is high (Rubidge 1995, Almond & Pether 2008). These fluvial and lacustrine sediments have yielded one of the richest fossil records of land-dwelling plants and animals of Permo-Triassic age anywhere in the world. Well-preserved tetrapod fossils, from isolated skulls and post-cranial bones to fully articulated skeletons, are mainly found in overbank mudrocks, often in association with pedogenic calcretes (palaeosol horizons). Disarticulated, water-worn bones occur in the channel lag conglomerates and sandstones (Smith 1980, 1993). Playa lake deposits may be associated with disarticulated amphibian bones and a range of trace fossils (*e.g. Scoyenia*). Fossils embedded within metamorphosed sediments (quartzites, hornfels) adjacent to dolerite intrusions may be well-preserved, but are very difficult to prepare out from the matrix and therefore usually of limited scientific value.

A chronological series of mappable fossil biozones or assemblage zones (AZ), defined mainly on their characteristic tetrapod faunas, has been established for the Main Karoo Basin of South Africa (Rubidge 1995). Maps showing the distribution of the Beaufort assemblage zones within the Main Karoo Basin have been provided by Kitching (1977), Keyser and Smith (1979) and Rubidge (1995). The first two articles do not specify an assemblage zone for the study area near De Aar). As mentioned earlier (Section 3.2) the sediments here are assigned to the *Pristerognathus* Assemblage Zone according to the most recent fossil biozonation map of the Beaufort Group published by Van der Walt *et al*. (2010) (Fig. 27). The paucity of fossil data for the Lower Beaufort succession in the Colesberg sheet explanation (Le Roux 1993) also suggests that this region is palaeontologically under-explored; any new fossil finds here are consequently of palaeontological significance. This is emphasized by the absence of fossil records from the De Aar area in the recent maps of Karoo vertebrate fossil sites produced by Nicolas (2007) (Fig. 28).

Fossils of the *Pristerognathus* Assemblage Zone characterize the arenaceous Poortjie Member as well as the uppermost beds of the underlying Abrahamskraal Formation in the western Main Karoo Basin as well as the laterally equivalent beds spanning the Koonap / Middleton Formation boundary in the eastern Karoo (Smith & Keyser 1995) (Fig. 9). This important terrestrial biota is dominated by various therapsids ("mammal-like reptiles") such as the moderate-sized therocephalian carnivore *Pristerognathus* as well as several gorgonopsian predators / scavengers and herbivorous dicynodonts (Figs. 29 to 31). The commonest genus by far is the small burrowing dicynodont *Diictodon* (Keyser and Smith 1977-78, Smith & Keyser 1995b, MacRae 1999, Cole *et al*., 2004, Rubidge 2005, Almond 2010, Nicolas 2007, Nicolas & Rubidge 2010). There are also large, rhino-sized herbivorous pareiasaur reptiles (*Bradysaurus* spp.), small, superficially tortoise-like parareptiles like *Eunotosaurus*, crocodile-like temnospondyl amphibians (*Rhinesuchus*), palaeoniscoid bony fish, vascular plant fossils of the *Glossopteris* Flora (fossil wood, leaves *etc*) and various trace fossils, including invertebrate and therapsid burrows as well as tetrapod trackways. The comparatively low number of specimens and major taxa represented in fossil collections from this biozone has been highlighted by Nicolas (2007). The fossil biota of the *Pristerognathus* AZ is of special interest because it possibly represents an impoverished post-extinction recovery fauna following a late Mid Permian extinction event that preceded the well-known end-Guadalupian biotic crisis (*cf* Benton 2003, Retallack *et al.,* 2006, Lucas 2009).

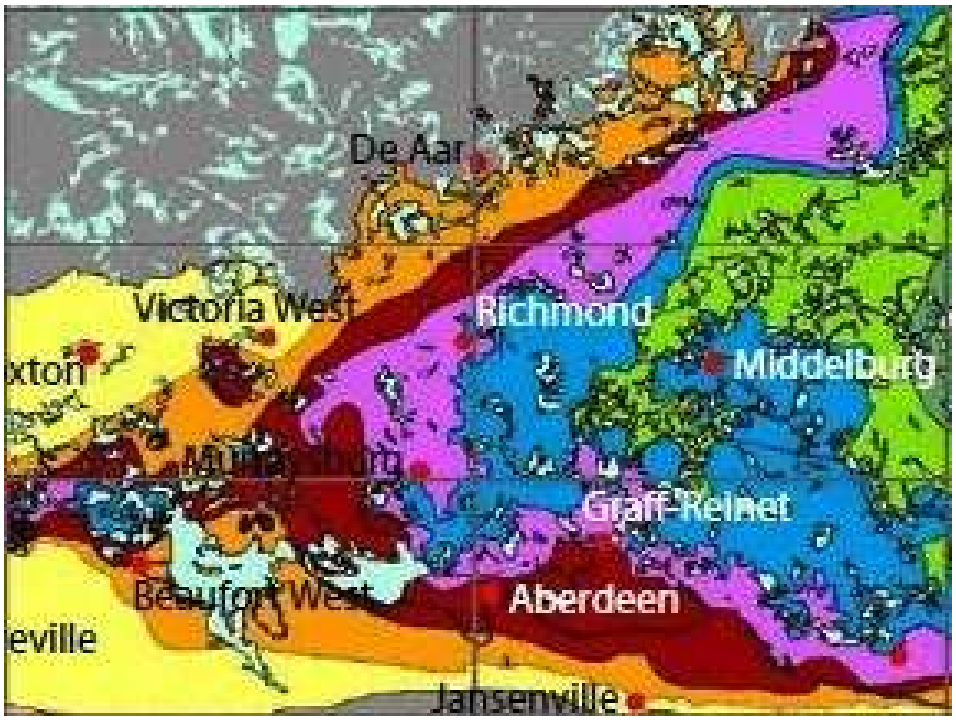


**Fig. 27. Abstract from recent fossil assemblage zone map for the Main Karoo Basin published by Van der Walt *et al.* (2010). The study region to the southeast of De Aar is assigned here to the *Pristerognathus* Assemblage Zone (orange), with the overlying *Tropidostoma* Assemblage Zone (red) only appearing well to the southeast. It is likely that the map will be refined in future in the light of new vertebrate fossil discoveries.**

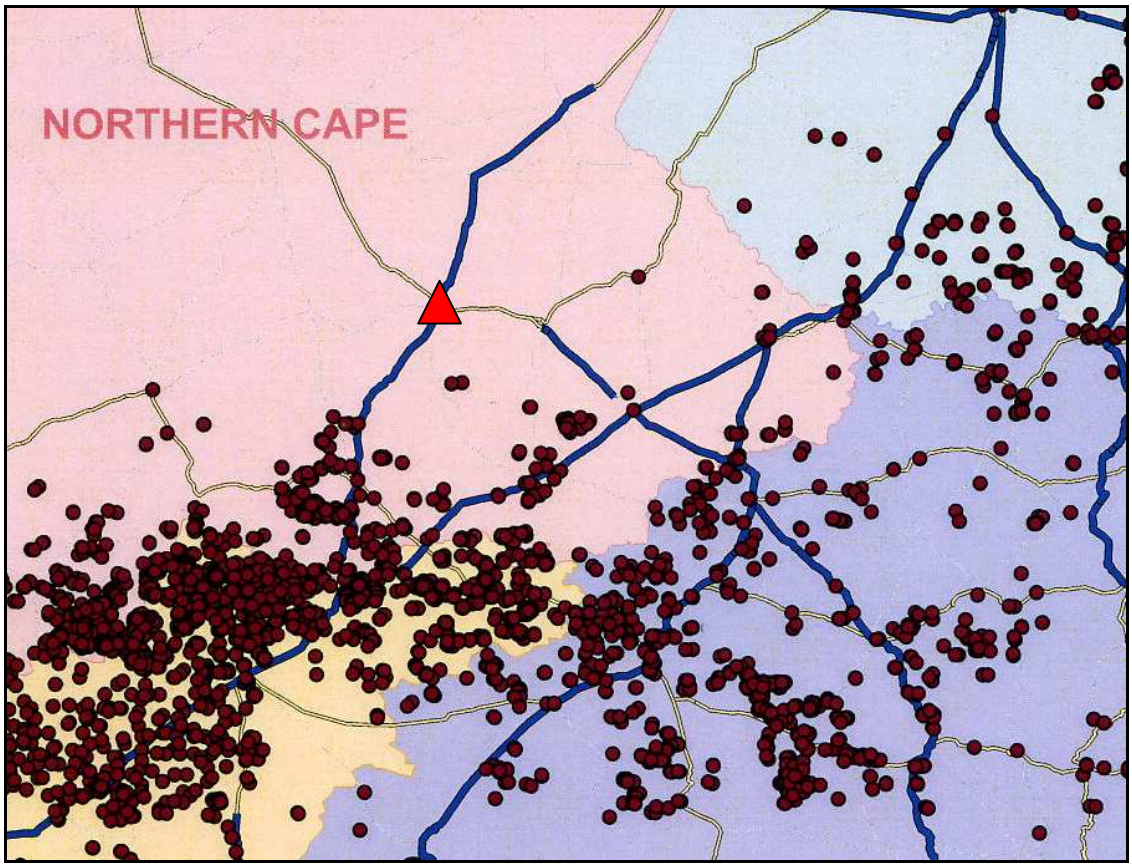


**Fig. 28. Distribution map of recorded vertebrate fossil sites within the Beaufort Group of the Great Karoo around the junction of the Western, Northern and Eastern Cape and the Free State (From Nicolas 2007). Note absence of documented fossil sites from the De Aar area (red triangle). This is in large part probably due to the low levels of bedrock exposure, as well as general lower abundance of fossils in the *Pristerognathus* Assemblage Zone.**

Most fossils in the *Pristerognathus* Assemblage Zone are found in the softer-weathering mudrock facies (floodplain sediments) that are usually only exposed on steeper hill slopes and in stream gullies. Fossils here are often associated with pedogenic limestone nodules or calcretes (Smith 1993, Smith & Keyser 1995). The mudrocks lie between the more resistant-weathering channel sandstones, which in the Poortjie Member display a distinctive "golden yellow" tint. Fossil skeletal remains also occur in the lenticular channel sandstones, especially in intraformational lag conglomerates towards the base, but are usually very fragmentary and water-worn ("rolled bone").

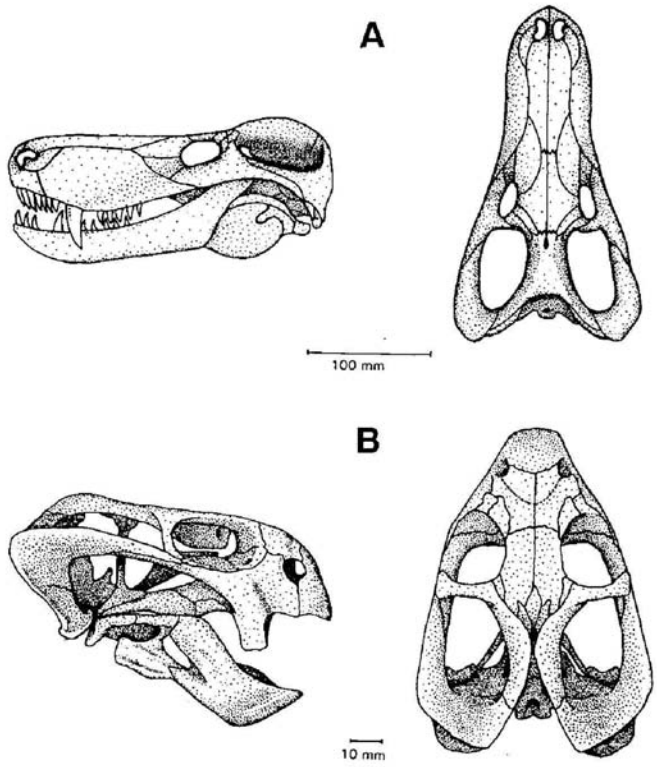


**Fig. 29. Skulls of typical therapsids from the *Pristerognathus* Assemblage Zone: A. the dog-sized carnivorous therocephalian *Pristerognathus* and B. the small herbivorous dicynodont *Diictodon* (From Smith & Keyser 1995).**

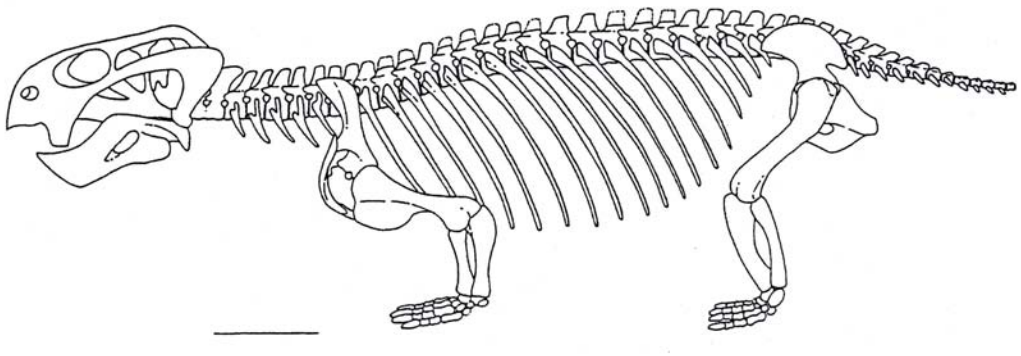

**Fig. 30. Skeletal reconstruction of the dassie-sized burrowing dicynodont *Diictodon* (From Ray & Chinsamy 2003) (Scale bar = 5cm).**

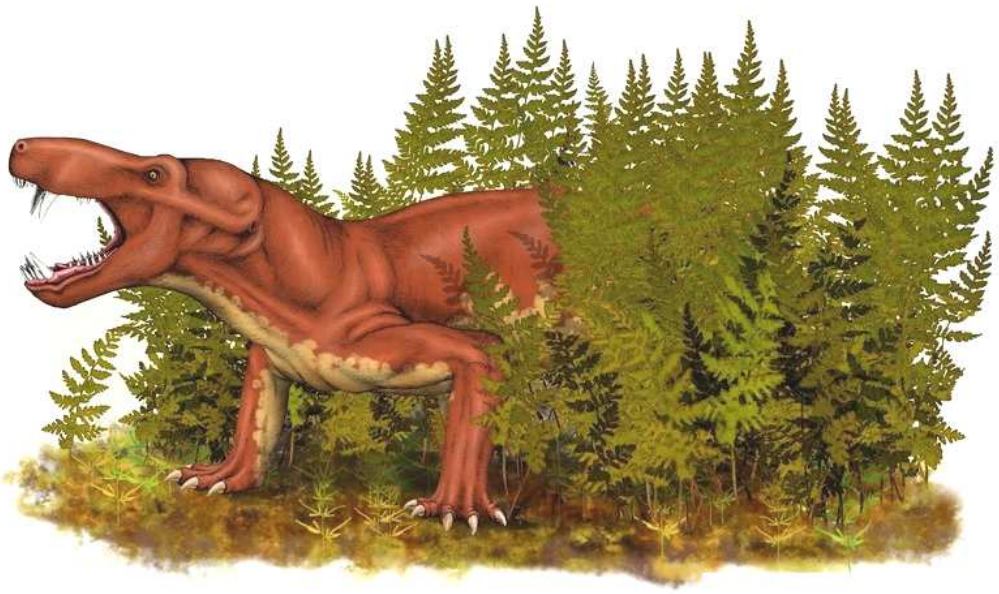

**Fig. 31. Artist's reconstruction of the dog-sized therocephalian *Pristerognathus*.**

The search for fossil vertebrate material within Lower Beaufort Group bedrocks within the De Aar study area was a top priority during field assessment because of the scientific importance of these fossils for biostratigraphy and evolutionary studies, as well as their conservation significance. As was expected, only a small number of vertebrate specimens, mostly fragmentary, were recorded, but these are among the first known from this area (Fig. 28) and are therefore of considerable scientific value. Vertebrate remains were found at five sites (Locs. 262, 262, 268, 274, 276; these sites are shown on satellite images in Figs. 5 and 6) which represent in fact a fairly high proportion of the total number of sites with significant Beaufort Group bedrock exposure examined. This suggests that fossil vertebrates are sparse but *not* exceedingly rare in these beds, which accords with the author's previous experience of the *Pristerognathus* Assemblage Zone (*e.g.* Almond 2010). Only some of the vertebrate fossils are potentially identifiable, and they will require preparation from the rock matrix before this can be done with confidence. Specimens include:

- Semi-articulated postcrania of a small vertebrate with distinctive broad ribs from Loc. 261, Slingers Hoek 2 (Fig. 32a). This may be an example of the rare parareptile *Eunotosaurus* that ranges through the *Tapinocephalus* and *Pristerognathus* Assemblage Zones of the Lower Beaufort Group (Rubidge 1995) (Fig. 32b);
- Isolated limb bones of small vertebrates, probably *Diictodon*, from Loc. 262 and Loc. 268, Slingers Hoek 2 (Figs. 34 & 35);
- Fragmentary material of one or more small vertebrates (probably *Diictodon*) from Loc. 274, Vendusie Kuil 165 (Fig. 33);
- A partial skull of a small therapsid from Loc. 276, Zwagershoek 151 (Fig. 36).

A fragment of a large vertebrate burrow cast (*c*. 14 cm across) with a distinctive bilobed, scratch-marked ventral surface was found at Loc. 270 (Slingers Hoek 2). Similar burrow infills, attributed to small dicynodonts, are well known from the *Pristerognathus* Assemblage Zone in the Beaufort West area (Almond 2010 and refs. therein). Other trace fossils in the Beaufort Group include poorly-preserved horizontal burrows that probably belong to the ichnogenus *Scoyenia*, attributed to arthropods.

Plant remains are very scarce in the Lower Beaufort rocks. Transported stem fragments of sphenophytes (horsetail ferns) occur on sandstone soles at Loc. 270, Slinger's Hoek 2 (Fig. 37). Compared with the underlying upper Ecca Group, fossil wood is rare. A fine piece of silicified log

showing well-developed seasonal growth rings was recorded from the farmstead stoep at Die Dam (Knapdaar 8; Fig. 38). However, this was collected by the previous farm owners from an unrecorded location some decades ago (Mnr C.J. Vermeulen, pers. comm., 2012), so its Lower Beaufort provenance is not firmly established.

**Fig. 32a. Part and counterpart of a sandstone float block enclosing the semi-articulated post-crania (backbone, ribs *etc*) of a small vertebrate with distinctive broad ribs (arrowed), possibly the reptile *Eunotosaurus* (width of each block as shown *c*. 3.5 cm). Spitskop on Slingers Hoek 2 (Loc. 261). Compare Fig. 32b.**

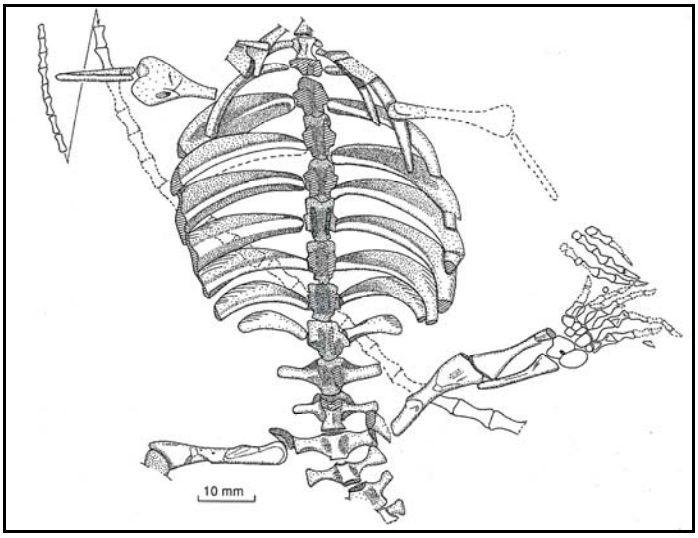


**Fig. 32b. Drawing of trunk and limbs of the small, superficially tortoise-like parareptile *Eunotosaurus* showing distinctive broad ribs (Note scale).**

**Fig. 33. Scattered postcranial and skull (top RHS) remains of one or more small therapsids (probably *Diictodon*), in part still embedded within mudrock (Scale in cm). Borrow pit near Klipfontein homestead, Vendussiekuil 165.**

**Fig. 34. Isolated limb bone of a small-bodied vertebrate (probably therapsid) embedded within a channel sandstone, Spitskop, Slingers Hoek 2 (Loc. 262) (Length 5.5 cm).**

**Fig. 35. Fragment of sun-cracked limb bone embedded in channel sandstone, Slingers Hoek 2 (Loc. 262) (length of fragment *c*. 3 cm).**


**Fig. 36. Skull roof of a small unidentified therapsid embedded within a calcrete nodule, snout facing to LHS (Scale in cm and mm). Borrow pit near Vaalberg, Zwagershoek 151 (Loc. 276).**

**Fig. 37. Sole surface of a channel or crevasse splay sandstone showing casts of reworked, longitudinally-striated sphenophyte stems (horsetail ferns, arrowed). The stems are *c*. 1 cm wide.**

**Fig. 38. Large piece of silicified log showing very well-developed seasonal growth rings. Specimen collected by previous owners of the farm Die Dam and inferred to be from the Lower Beaufort Group. Block is 18cm across maximum diameter.**

### 4.3. Karoo Dolerite Suite

The dolerite outcrops in the De Aar WEFs study areas are in themselves of no palaeontological significance. These are high temperature igneous rocks emplaced at depth within the Earth's crust so they do not contain fossils. However, as a consequence of their proximity to large dolerite intrusions in the Great Escarpment zone, some of the Ecca and Beaufort Group sediments in the study area will have been thermally metamorphosed or "baked" (*ie*. recrystallised, impregnated with secondary minerals) (Fig. 18). Embedded fossil material of phosphatic composition, such as bones and teeth, is frequently altered by baking – bones may become blackened, for example - and can be very difficult to extract from the hard matrix by mechanical preparation (Smith & Keyser 1995). Thermal metamorphism by dolerite intrusions therefore tends to reduce the palaeontological heritage potential of Beaufort Group sediments. In some cases (*e.g.* fossil moulds of mesosaurid reptiles and palaeoniscoid fish) baking may enhance the quality of preservation of Ecca fossils while other fossil groups (*e.g*. carbonaceous remains of plants, organic-walled palynomorphs) are more likely to be compromised.

### 4.4. Quaternary to Recent superficial deposits

The central Karoo drift deposits have been comparatively neglected in palaeontological terms. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Good examples are the Pleistocene mammal faunas at Florisbad, Cornelia and Erfkroon in the Free State and elsewhere (Wells & Cooke 1942, Cooke 1974, Skead 1980, Klein 1984, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al*. 1995, MacRae 1999, Meadows & Watkeys 1999, Churchill *et al*. 2000 Partridge & Scott 2000). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, tortoise remains, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant material such as peats or palynomorphs (pollens) in organic-rich alluvial horizons (Scott 2000) and diatoms in pan sediments. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest (*e.g.* Smith 1999 and refs. therein). Ancient solution hollows within extensive calcrete hardpans such as seen here may have acted as animal traps in the past. As with coastal and interior limestones, they might occasionally contain mammalian bones and teeth (perhaps associated with hyaena dens) or invertebrate remains such as snail shells.

The often well-developed superficial deposits within the De Aar study area were searched for fossil remains, largely without success. Three to four centimetre wide vertical spreiten burrows attributed to an unknown invertebrate were recorded from thick bedded alluvium on Jakhalsfontein 146, just west of the study area (Fig. 39). A systematic search of gravels within these beds might eventually yield Pleistocene vertebrate bones and teeth. Numerous Middle Stone Age artefacts embedded within these gravels point towards a long Pleistocene human occupation of the region, so fossil human remains are also a possibility, albeit a remote one (*cf* Late Pleistocene skull of *Homo sapiens* from alluvial deposits in the Eastern Cape Karoo near Hofmeyr, Grine *et al.* 2007). Well-developed calcrete hardpans near De Aar display large calcretized plant root casts or rhizoliths (Almond 2012).

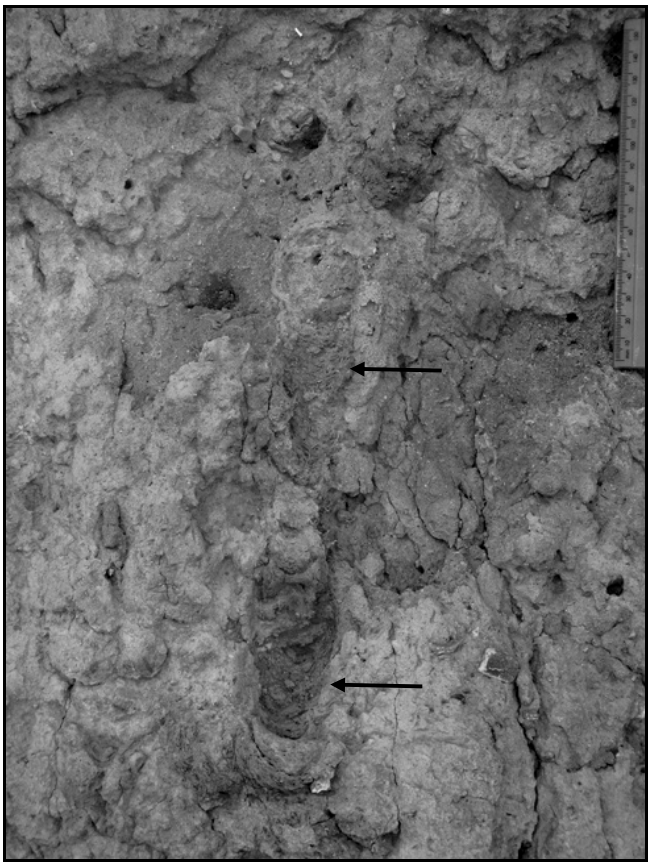

**Fig. 39. Vertical spreiten burrow (arrowed) with downwardly convex menisci exposed within silty alluvium on farm Jakkalsfontein 146 (Loc. 263, Fig. **) (Scale in cm).**

## 5. ASSESSMENT OF SIGNIFICANCE OF PALAEONTOLOGICAL HERITAGE IMPACTS

The two Mulilo WEF projects near De Aar are located in an area of the Karoo that is underlain by potentially fossiliferous sedimentary rocks of Palaeozoic and younger, probably Quaternary age (Sections 3 & 4). The construction phase of these renewable energy developments will entail numerous, but mostly shallow, excavations into the superficial sediment cover and in some areas into the underlying bedrock as well. These include, for example, excavations for the wind turbine foundations, underground cables, new electricity transmission lines and substations, as well as new gravel access roads and any control / administrative buildings. In addition, substantial areas of bedrock will be sealed-in or sterilized by infrastructure such as lay-down and standing areas for the wind turbines as well as new access roads. All these developments may adversely affect fossil heritage within the development footprint by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good.

The significance of expected impacts on palaeontological heritage resources within each of the two De Aar WEF study areas are assessed separately for the construction phase in Tables 2A, 2B below, according to the assessment methodology specified by Aurecon. Please note that:

- the operational and decommissioning phases of the WEFs will not involve further significant adverse or other impacts on palaeontological heritage;

- substantial differences in impacts between alternative sites for on-site substations are not anticipated - all sites under consideration are situated on unfossiliferous dolerite;

- impacts from the construction of associated new road infrastructure and transmission lines is treated as part of the overall impact of each WEF development, and have not been considered separately.

**Table 2A: Evaluation of impacts of proposed Mulilo De Aar WEF (Northern Project) on fossil heritage resources**

| CRITERIA | CATEGORY | COMMENTS |
|---|---|---|
| Extent | Site specific | Limited to development footprint |
| Magnitude | Low | Highly significant fossil material (*e.g.* vertebrate remains) is sparsely distributed within the study area and almost entirely *outside* the development footprint, which is mostly underlain by unfossiliferous dolerite. Similar fossils occur widely outside the study area. |
| Duration | Long term | Permanent. |
| Significance | Low (without mitigation)<br>Very low (after mitigation) | Specialist monitoring or mitigation measures therefore not proposed for this project. |
| Probability | Unlikely | Commoner bedrock fossils (*e.g.* trace fossils, petrified wood) in the broader study region occur largely *outside* the development footprint. |
| Confidence | Sure | Limited by low levels of bedrock exposure within study areas (This is partially compensated by study of better exposures elsewhere) |
| Reversibility | Irreversible | Loss of fossil heritage is generally permanent. |

The WEF development footprint for the Northern Project, including two potential substation sites, is almost entirely underlain by unfossiliferous dolerite, with the exception of the flatter-lying areas in the northeast (Zwagershoek 151) where rare fossil vertebrate remains have been recorded from Beaufort Group sediments during this field study. However, construction of WEF infrastructure within this more sensitive north-eastern area is not anticipated according to the current provisional development plan. Therefore the overall impact significance of the WEF Northern Project as far as fossil heritage is concerned is LOW.

**Table 2B: Evaluation of impacts of proposed Mulilo De Aar WEF (Southern Project) on fossil heritage resources**

| CRITERIA | CATEGORY | COMMENTS |
|---|---|---|
| Extent | Site specific | Limited to development footprint |
| Magnitude | Low | Highly significant fossil material (*e.g.* vertebrate remains) is sparsely distributed within the study area and almost entirely *outside* the development footprint, which is mostly underlain by unfossiliferous dolerite. Similar fossils occur widely outside the study area. |
| Duration | Long term | Permanent. |
| Significance | Low (without mitigation)<br>Very low (after mitigation) | Specialist monitoring or mitigation measures therefore not proposed for this project. |
| Probability | Unlikely | Commoner bedrock fossils (*e.g.* trace fossils, petrified wood) in the broader study region occur largely *outside* the development footprint. |
| Confidence | Sure | Limited by low levels of bedrock exposure within study areas (This is partially compensated by study of better exposures elsewhere) |
| Reversibility | Irreversible | Loss of fossil heritage is generally permanent. |

Potentially fossiliferous bedrocks of the Ecca and Beaufort Groups occur extensively in the western (Slingers Hoek 2) and south-eastern (Knapdaar 8 / Die Dam) portions of the Southern Project study area. However, the development footprint itself, including the potential substation site, is almost entirely situated above unfossiliferous dolerite. The overall impact significance of the WEF Southern Project as far as fossil heritage concerned is therefore LOW.

## 6. CONCLUSIONS & RECOMMENDATIONS

The fossil record and inferred palaeontological sensitivity of fossil heritage within each of the main rock units represented in the two Mulilo WEF study areas near De Aar is summarized in Table 3 below (See also Almond & Pether 2008). The Ecca and Beaufort Group sediments here generally have a moderate to high palaeontological sensitivity respectively, while the superficial sediments and dolerite intrusions are of low to zero sensitivity. Rare kimberlite pipes of Cretaceous age are unfossiferous and not associated with preserved crater lake deposits (or diamonds).

Most of the WEFs development footprint is situated in portions of the wider study area that are underlain by unfossiliferous dolerite or doleritic colluvium (scree, gravels *etc*) and is therefore unproblematic in fossil heritage terms. The potentially fossiliferous sediments of the Karoo Supergroup (Ecca and Beaufort Groups) that underlie peripheral portions of the two study areas are almost entirely mantled in a thick layer of superficial deposits of probable Pleistocene to Recent age. These superficial deposits include various soils, alluvium, gravels and – at least in some areas - a very well-developed calcrete hardpan.

The upper Ecca Group bedrocks in the De Aar area contain locally abundant fossil wood (of palaeontological interest for dating and palaeoenvironmental studies) as well as low diversity trace fossil assemblages typical of the Middle Permian Waterford Formation, rather than the Tierberg Formation as mapped. The trace fossils include various invertebrate burrows as well as possible tracks and partial body impressions of large crocodile-like amphibians. Well-preserved, silicified fossil wood is abundant in the upper Ecca succession.

Although natural and artificial exposures of Lower Beaufort Group bedrocks (Adelaide Subgroup) are exceedingly sparse in the De Aar region, several of these localities yielded fragmentary to semi-articulated vertebrate remains that are among the first ever recorded in this part of the Karoo. They include skull and postcranial remains of small therapsids (probably the small dicynodont *Diictodon*) as well as a partial specimen of the rare tortoise-like parareptile *Eunotosaurus*. Further preparation of the specimens is required to confirm their identity, however. Other fossil groups recorded from these rocks in the study area include transported plant material (horsetail ferns) and well-preserved silicified wood. These fossil remains probably belong to the *Pristerognathus* Assemblage Zone of late Middle Permian age that is associated to the west with the Poortjie Member of the Teekloof Formation. It is concluded that fossils are sparsely distributed but *not* very rare within the Lower Beaufort Group near De Aar; the main constraint is lack of bedrock exposure. These potentially fossilferous rocks are unlikely to be directly impacted by the proposed WEF developments, however.

The diverse Pleistocene to Recent superficial deposits in the study region are of low palaeontological sensitivity as a whole. Calcretized rhizoliths (root casts) and possible invertebrate burrows of probable Quaternary age occur within calcrete hardpans near De Aar. Well-preserved Permian fossil wood material occurs widely within surface and subsurface gravels overlying the upper Ecca Group, from which it has been clearly reworked.

Fossils exposed at the surface or underground may be damaged, disturbed or sealed-in during the construction phase of the proposed WEFs near De Aar. However these developments are inferred to be of LOW significance in terms of palaeontological heritage resource conservation because:

- By far the greater part of the development footprint of each project is underlain by unfossiliferous dolerite;

- The potentially fossiliferous Karoo Supergroup rocks within the development footprints (wind turbines, laydown areas, transmission lines, access roads and other infrastructure) are generally buried beneath a mantle of fossil-poor superficial sediments (soils, alluvium, gravels, calcretes);

- The Karoo Supergroup rocks are often extensively disrupted by near-surface secondary calcrete formation. Baking by dolerite intrusion has often further compromised their original fossil heritage.

The various possible locations of the on-site electrical substations for the new energy facilities near De Aar are of equally low impact significance in fossil heritage terms since they all overlie dolerite. The construction of new access roads and transmission lines in this region is likewise considered to be of low significance as far as fossil heritage is concerned. Future changes in infrastructure layout for the WEF projects will not materially affect the conclusions and recommendations made in this palaeontological report.

Given the low overall palaeontological sensitivity of the Eastern Plateau region near De Aar, and the widespread occurrence elsewhere in the Great Karoo of most of the fossils so far recorded there, the successive or concurrent development here of the two WEFs that have been proposed by Mulilo does not pose a significant cumulative impact on local fossil heritage.

In view of the overall low significance of the proposed developments on palaeontological heritage resources, it is concluded that no further palaeontological heritage studies or specialist mitigation are required for these WEF projects, pending the exposure of any substantial fossil remains (*e.g.* vertebrate bones and teeth, large blocks of petrified wood) during the construction phase. The ECO responsible for these developments should be alerted to the possibility of fossil remains being found on the surface or exposed by fresh excavations during construction. Should substantial fossil remains be discovered during construction, these should be safeguarded (preferably *in situ*) and the ECO should alert SAHRA so that appropriate mitigation (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist.

The specialist involved would require a collection permit from SAHRA. Fossil material must be curated in an approved repository (*e.g.* museum or university collection) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA.

These recommendations should be incorporated into the EMP for the two Mulilo WEF developments near De Aar.

## 7. ACKNOWLEDGEMENTS

Ms Louise Corbett and Mr Simon Clark of Aurecon, Cape Town, are both thanked for commissioning this study, for kindly providing the necessary background information, and for editing the draft report. I am, as ever, very grateful to Ms Madelon Tusenius for logistical backup and companionship in the field, as well as for finding a significant proportion of the fossil material recorded. The co-operation and hospitality of land-owners in the study area is much appreciated, in particular that of Anita and Johan van der Merwe at Slingers Hoek 2 and of C.J. Vermeulen at Die Dam. Mnr Vermeulen kindly donated the magnificent piece of fossil wood shown here in Fig. 18. I am grateful to Professor Bruce Rubidge (Bernard Price Institute for Palaeontological Research, WITS) for helpful discussions on Karoo stratigraphy and identification of vertebrate fossil remains found during this field study.

**Table 3: Palaeontological record and sensitivity of rocks units represented in the broader De Aar study region**

| TABLE 1: FOSSIL HERITAGE IN THE DE AAR AREA | | | | |
|---|---|---|---|---|
| **GEOLOGICAL UNIT** | **ROCK TYPES & AGE** | **FOSSIL HERITAGE** | **PALAEONT-OLOGICAL SENSITIVITY** | **RECOMMENDED MITIGATION** |
| **Superficial deposits ("drift")** | **Alluvium, colluvium (scree), pan sediments, surface gravels, calcrete hardpans *etc*<br><br>NEOGENE / QUATERNARY TO RECENT** | **Sparse remains of mammals (bones, teeth), reptiles, ostrich egg shells, molluscs shells, trace fossils (calcretized termitaria, rhizoliths), plant remains, palynomorphs, diatoms; reworked Karoo-age silicified wood clasts and stone artefacts in surface or subsurface gravels** | **LOW** | **Any substantial fossil finds to be reported by ECO to SAHRA** |
| **Kimberlite pipes (diamond symbol)** | **Ultramafic kimberlite CRETACEOUS** | **None within pipe itself** | **ZERO** | **None** |
| **Karoo Dolerite Suite (Jd)** | **Intrusive dolerite sills & dykes<br><br>EARLY JURASSIC** | **NONE** | **ZERO** | **None** |
| **Adelaide Subgroup (Pa)<br><br>BEAUFORT GROUP** | **Floodplain mudrocks with lenticular channel sandstones, tabular crevasse splay sandstones, minor playa lake sediments<br><br>LATE MIDDLE PERMIAN** | **Important but low diversity terrestrial vertebrate fauna (esp. therapsids) of *Pristerognathus* Assemblage Zone, petrified wood, plant remains (incl. fossil wood, leaf & stem impressions), freshwater molluscs, trace fossils (trackways, burrows, coprolites)** | **HIGH** | **Any substantial fossil finds to be reported by ECO to SAHRA** |
| **Tierberg and Waterford Formations (Pt)<br><br>ECCA GROUP** | **Dark basinal, prodelta and submarine fan mudrocks with minor sandstones (Tierberg Fm) OR<br><br>Storm-influenced coastal sandstones and mudrocks (Carnarvon facies of Waterford Fm)<br><br>EARLY TO MIDDLE PERMIAN** | **Locally abundant trace fossils, petrified wood, plant debris, microvertebrates** | **MEDIUM** | **Any substantial fossil finds to be reported by ECO to SAHRA** |

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## 9. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape as well as Limpopo, Gauteng and the Free State for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

### Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed alternative energy projects, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

**Dr John E. Almond**
**Palaeontologist**
***Natura Viva* cc**

## APPENDIX B: 2020 FIELD-BASED ARCHAEOLOGICAL OBSERVATIONS

Green highlights = mitigation required.

Orange highlights = buffer required.

Please note that certain sites have more than one co-ordinate.

| Transmission Lines and Switching Station – 2020 Survey | | | | | |
|---|---|---|---|---|---|
| **Waypoint** | **Latitude** | **Longitude** | **Description** | **Grade** | **Photograph** |
| JG001 | -30.606480° | 24.253572° | MSA stone scatter on and around existing Hydra line and service road. Very large and extends to east as far as berm modern farm. Tools noted on berm. See also GEB001-007 which defines the visible extent of one lithic scatter. Lithics exposed on eroded / deflated area of shallow river valley bottom. Density 20 + pieces/m2. Hornfels. Heavily patinated but with some, possibly later unpatinated pieces noted. Flakes, blades, cores and chips. Some retouch and possibly prepared platforms. Very edgeworn. | 3C |  |
| JG002 | -30.606459° | 24.254711° | | |  |
| JG003 | -30.606649° | 24.255231° | | | |
| JG004 | -30.604886° | 24.257939° | Eroded / deflated scatter of edgeworn, patinated MSA lithics. Less dense but otherwise similar to JG001-003 / GEB001-007. One of two less patinated pieces noted one with retouch along edge - possible Lockshoek LSA sidescraper. Shaley flake - grey with light patina. Also khaki/mustard flake of what looks like mudstone. | 3C | |

| | | | | | |
|---|---|---|---|---|---|
| JG006 | -30.595005° | 24.273707° | Large weathered MSA flake (HF) in roadway. | NCW |  |
| JG007 | -30.595000° | 24.273710° | Further similar MSA lithics from vicinity of JG006 | NCW | |
| JG008 | -30.592464° | 24.282744° | Worn and patinated MSA lithics in high density across very wide area (at least 100 m in all directions). Lying on and in orange sand on and around a low dolerite koppie. Possible quarry site for hornfels lag deposit. Antbear burrow kicked up hornfels chunks from ± 20-30 cm down and flaked material. Suggests good flakeable material below sand. Evidence of material being washed together in recent rainwater runnels. Some possible LSA flakes noted and later retouch on earlier MSA flakes. | 3C |  <br>  |

| | | | | | |
|---|---|---|---|---|---|
| JG009 | -30.592936° | 24.283568° | Part of same site as JG008 | 3C |  |
| JG010 | -30.590711° | 24.280878° | Walked from road to BESS - litter of patinated and worn MSA everywhere. In orange sand. | NCW |   |
| JG011 | -30.589299° | 24.280219° | Endscraper in / near BESS. Nearby lithics in eroded channels/rivulets | NCW |  |

| | | | | | |
|---|---|---|---|---|---|
| JG012 | -30.590268° | 24.281356° | MSA scatter in rainwater runnel | NCW |  |
| JG013 | -30.589434° | 24.278496° | Scatter of LSA HF lithics in sandy, sloping hollow between rocky outcrops. Some possibly on earlier MSA flakes of which there are examples present. Smithfield? - large sidescraper type flake. Also broken blade with endscraper retouch (crossmend). Site overlooks river gully. All material in orange sand. Exposed by erosion. | 3C |   |

| | | | | | |
|---|---|---|---|---|---|
| JG014 | -30.589408° | 24.278082° | Dense MSA slope wash on side of river gully below JG013. Very waterworn. In dolerite cobbles and scree. | 3C |  |
| JG015 | -30.590345° | 24.277628° | Further MSA lithics and later, possibly Smithfield (including endscrapers) in erosion wash and runnels. | 3C |  |
| JG016 | -30.590532° | 24.276526° | LSA, with some possible MSA, lithic scatter on dolerite outcrop. Eroded. | 3C |   |

| | | | | | |
|---|---|---|---|---|---|
| JG017 | -30.590717° | 24.276331° | Lithics eroding out of deposit on opposite side of outcrop to JG016. Mix of MSA with some early Holocene LSA material - large sidescraper. Single piece of flaked agate. View to BESS from dogleg. | 3C |   |
| JG018 | -30.590532° | 24.274909° | Dense MSA waterworn lithics in erosion gully. Very rolled. | 3C |  |
| JG019 | -30.590824° | 24.274807° | Same as JG018. Appears to be long, continuous scatter. Quarrying? | 3C | |
| JG020 | -30.591415° | 24.274568° | Same as JG018/JG019. | 3C | |
| JG021 | -30.592031° | 24.274437° | Same as JG018/JG019/JG020. | 3C | |
| JG022 | -30.601148° | 24.265414° | MSA on slope wash. Mostly very rolled and patinated. ± 10 pieces/m2. | 3C | |
| JG023 | -30.600768° | 24.265531° | Same as JG022. | 3C | |

| | | | | | |
|---|---|---|---|---|---|
| JG024 | -30.600680° | 24.265576° | Large MSA hornfels flake with "fresh" retouch. | NCW |  |
| JG025 | -30.598577° | 24.266719° | Approximate upper limit on slope of stone tools. Gets shaley above. | Not Graded | |
| JG026 | -30.599426° | 24.265971° | Stone scatter - general and of varying density down slope above and below this mark. | NCW | |
| JG027 | -30.600102° | 24.265106° | Rough hornfels core/flaked cobble - LSA? | NCW |  |
| JG028 | -30.605219° | 24.256954° | Patinated (black/grey) hornfels lithics in erosion fan. Extension/part of general scatter on either side? | NCW | |

| | | | | | |
|---|---|---|---|---|---|
| JG029 | -30.605770° | 24.256471° | Hornfels lithic scatter on eroded flat. Patinated and worn (black/grey). | NCW |  |
| JG030 | -30.606202° | 24.256341° | Same as JG029 above. | NCW | |
| JG031 | -30.614816° | 24.242742° | Exposed hornfels carpet. Some worn and patinated MSA. | NCW |   |
| JG032 | -30.617445° | 24.239304° | Boulder outcrop on ridge. Stopped to check for engraving (nothing). But ubiquitous lithics scatter. Possible mix of MSA and LSA. Hornfels (worn & patinated) but also flake on banded ironstone. | 3C |  |

| | | | | | |
|---|---|---|---|---|---|
| | | | | |  |
| JG033 | -30.623782° | 24.227876° | Low level MSA scatter - patinated and worn hornfels. | NCW |  |

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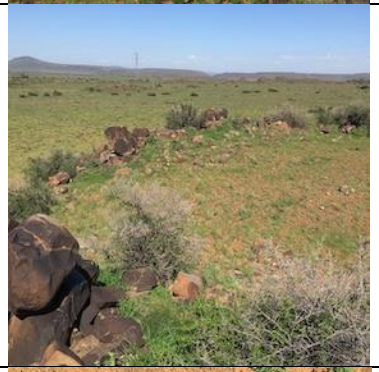
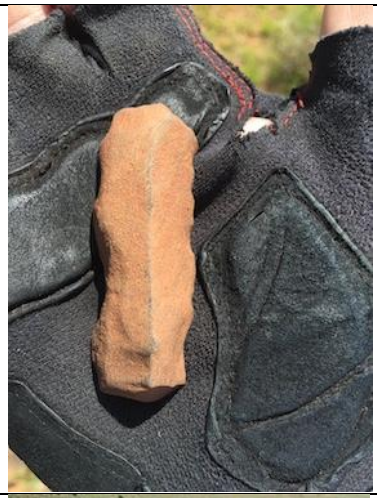
|---|---|---|---|---|---|
| | | | | |  |
| JG034 | -30.632295° | 24.214686° | Isolated hornfels flakes. Heavily patinated MSA. In red sand with dolerite cobbles. Adjacent to Carolus Poort 2 / Slingerhoek fence. | NCW | |
| JG035 | -30.632187° | 24.214838° | Small LSA agate flake. | NCW |  |

| | | | | | |
|---|---|---|---|---|---|
| JG036 | -30.615468° | 24.241709° | Packed stone ruin - possibly old wolvehok. | 3C |  |
| JG037 | -30.639067° | 24.204355° | Area of patinated black dolerite boulders next to watercourse (approximately 30 x 100 m). Heavily patinated hornfels flakes and chunks noted - probably MSA. Low density visible on surface. Half circle of boulder may be portion of kraal. | 3C |  |
| JG038 | -30.638589° | 24.207245° | Isolated MSA lithics (4-5) in open area of wash. | NCW |  |

| | | | | | |
|---|---|---|---|---|---|
| JG039 | -30.637487° | 24.209534° | Possible Khoi kraal. Dolerite boulders in rough circle in lee of two small rocky outcrops. Approximately 10 x 7 m across. | 3C |  |
| JG040 | -30.633936° | 24.213173° | Cleared raised area between three rocky outcrops. Possible kraal. ± 30 x 50 m. Small hand-size cobbles cover the surface, mixed with shale. Larger dolerite rocks and boulders in line around outside. 1 x LSA hornfels flake and some patinated MSA lithics (flakes and chunks) noted on surface. (Same as GEB010). | 3C |  |
| JG041 | -30.643307° | 24.199117° | MSA lithics eroding out of shallow slope. Very worn and heavily patinated. Mostly flakes. Hornfels. | NCW |  |

| | | | | | |
|---|---|---|---|---|---|
| JG042 | -30.643273° | 24.198368° | Isolated MSA denticulated piece. Worn and heavily patinated hornfels. Upslope of JG041 on slopes of koppie. | NCW |  |
| JG043 | -30.643418° | 24.197404° | Dense scatter of unpatinated LSA hornfels on western edge of koppie top. Lies against line of boulders on edge. 30-40 pieces/m2. Concentrated in approximately 3m2. Chips, chunks, flakes, cores, blades. Single piece with retouch noted. Some MSA present too - some red patination. | 3C |  |

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|---|---|---|---|---|---|
| | | | | |  |
| JG044 | -30.643353° | 24.197522° | (Modern) graffiti on boulder. On same koppie as JG043. North side about 10m from stone scatter. Two long thin parallel lines with seven"bars" scratched between them. | 3C |  |
| JG045 | -30.643845° | 24.198110° | Hornfels lithics in bare patches on eastern slope of koppie. Some larger and worn and patinated. Most still "fresh" black. Couple of pieces, including an endscraper middle-patinated (grey) Mostly flakes and chips. Large, fresh chunky core found about 10 m SE. | 3C |  |

| | | | | | |
|---|---|---|---|---|---|
| JG046 | -30.644182° | 24.198144° | Heavily patinated hornfels MSA eroding down hillside. Dense. Some reuse of MSA - fresh flakes and chips. | 3C |  |
| JG047 | -30.644174° | 24.198304° | | | |
| JG049 | -30.666640° | 24.159428° | Barren, vegetation free areas have with lithics. Not dense - item every few metres. LSA, including duckbilled scraper. Not patinated. Hornfels | 3C |  |

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| JG050 | -30.667187° | 24.161105° | Very dense LSA exposure on erosion slope. Material being exposed as bank along river channel erodes back. Suggest buried until recently. Very fresh and unpatinated hornfels. One small piece of flaked white agate. Possibly retouched piece of brown mudstone/ironstone. Formal/retouched pieces. Endscrapers (slugs?). Orangean sidescraper. Edge scraper. OES pieces noted. Possibly associated if material buried until recently? Some dolerite cobbles with flake scars. Seems to be ± 40-50 cm below modern ground level. | 3A |   |
| JG051 | -30.667280° | 24.161474° | Eastern edge of JG050 at this location. | 3A | |

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| JG052 | -30.666300° | 24.160471° | Same as JG050 and JG051 above. On eroding slope. OES present in quantities. | 3A |  |
| JG053 | -30.667739° | 24.159290° | Odd collection of broken cobbles. Rough hornfels or dolerite. On pan surface. Completely isolated. | NCW |  |
| JG054 | -30.667240° | 24.158969° | Same as JG054 above. | NCW |  |

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| JG055 | -30.673205° | 24.148478° | Isolated edge-flaked cobble. Dolerite. Large. On edge of streambed. Period unknown | NCW |  |
| JG056 | -30.673672° | 24.147800° | Odd looking boulder field - shaped? In soil below is the same patinated/worn MSA hornfels assemblage seen elsewhere but in higher concentration here than lower down slope. Boulders are on a level platform on slope. | 3C |  |
| JG057 | -30.676632° | 24.143262° | Eroded wash on slope. Worn MSA lying in sheet wash. Wide area. | NCW | |
| JG058 | -30.658561° | 24.172766° | Scattered, patinated hornfels MSA lithics on slope between koppie and river. Visible where there is erosion of the surface sand - in runnels. | NCW |  |
| JG059 | -30.659533° | 24.171604° | Random point in same sort of wash as JG058 - more extensive on this lower slope. Same general occurrence of rolled, patinated MSA stone. Extensive erosion runnels across landscape going down to river. | NCW |  |

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| JG060 | -30.659719° | 24.171280° | Smithfield(?) lithics on hornfels on eroded surface. Also patinated, earlier lithics present. ± 10/m2. Cores, flakes, chunks, blades. Retouch on number of pieces. Endscrapers too (ph). Appears to be visible in ± 5m radius around waypoint - odd pieces further away. Suggest it may be more widely present under covering sand. | 3C |  <br>  |
| JG061 | -30.660573° | 24.170073° | Scatter of hornfels lithics - fairly thin (± 3/m2) - on eroding sandy mound in erosion wash. Lithics actively eroding, not on sheet wash. Hornfels, unpatinated - flakes, blades. Of the 17 lithics randomly picked up in area of 5 m2, 6 had retouch. 5 = endscraper type and 1 x side/end scraper. | 3C |  |

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| JG062 | -30.649812° | 24.053184° | Open areas of low level presence of hornfels (patinated/worn) wherever soil denuded and exposed - right along line. | NCW |  |
| JG063 | -30.642762° | 24.048078° | As above. | NCW | |
| JG064 | -30.685039° | 24.129275° | Possible Khoi kraal? - not hugely convincing but there seems to be packed stone along with naturally occurring boulders of dolerite outcrop (ph). Isolated flaked stone in vicinity. | 3C |  |
| JG065 | -30.685468° | 24.129430° | Small stone structure. Circular - (actually more oval) - opening to east. Packed cobbles/rocks from dolerite outcrop it nestles against. On S side of outcrop = 3-4 courses of stone. Walls stand 50-70 cm high. No artefacts seen associated. There is a low level presence of the patinated/worn hornfels lithics, as well as a scatter around outcrop of more freshly flaked hornfels. Internal dimensions of structure approximately 1m wide x 1.5m long. External = 2m wide x 2.5m long. | 3C |  |

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| JG066 | -30.685123° | 24.128588° | Possible kraal. Rocky outcrop with cleared centre approximately 14m x 10m. No obvious standing/packed walls, but there does seem to be a clear rocky circle. | 3C |  |
| JG067 | -30.690737° | 24.114019° | Stone tools on erosion slope down in wash - MSA blade with later retouch. Extension / same as GEB025 to the west. | 3A | |
| JG068 | -30.691042° | 24.114248° | Further exposure like JG067 and GEB025. Shale background with hornfels lithics. Calcrete like nodules present. Below ± 40-50 cm orange sand. | 3A |  <br>  |

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| JG069 | -30.691134° | 24.114276° | Same as JG068 above. | 3A |  |
| JG070 | -30.691206° | 24.114263° | Same as JG068 and JG069 above. | 3A |  |
| JG071 | -30.690651° | 24.113478° | Opposite side of wash hollow. Same eroding slope with lithics. As on other side, mainly fresh hornfels (whole range), but some older, grey patinated pieces too. | 3A |  |
| JG072 | -30.690631° | 24.113098° | Similar exposure to JG067-071. Less dense artifactually. But mix of old and new. | 3A | |
| JG073 | -30.693613° | 24.113338° | Large hornfels sidescraper, isolated in eroded area (same surface as JG067-072) but in larger river eroded system. | NCW |  |

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| JG074 | -30.694075° | 24.113321° | Concentration of hornfels (probably LSA) lithics on eroded surface. | 3C |  |
| JG075 | -30.695239° | 24.111199° | Lithics in erosion gully. Grey patinated hornfels flakes. | 3C |  |
| JG076 | -30.695336° | 24.110892° | Lithics (hornfels, fresh) on calcrety eroded surface. Below bottom of orange sand. | NCW | |
| JG077 | -30.695918° | 24.110349° | Dense (± 20/m2) scatter of large, fresh HF lithics. In sand. Still eroding out. Area approximately 10 x 20 m. 1 x flaked agate pebble. Some banded ironstone. Mainly large flakes and cores. No retouched pieces noted. | 3A |  |

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| JG078 | -30.705940° | 24.101496° | Hornfels scatter in neck between koppies. Fresh. Associated with piece of grass-tempered pottery. Has views to north and south. Protected in hollow. Scatter covers large part of hollow. | 3C |  |
| JG079 | -30.705935° | 24.101464° | | | |
| JG080 | -30.706201° | 24.101419° | | | |
| JG081 | -30.706136° | 24.101435° | Modern stone circle (?) with glass and burned plastic. Old spade head with broad arrow. "R Steelface". | 3C |  |
| JG082 | -30.706104° | 24.101675° | Centre stone kraal - circular with JG083 (stone bothy) in kraal. | 3C |  |
| JG083 | -30.706149° | 24.101740° | Stone bothy in kraal. Approximately 1.5 x 1.5 cm. Entrance to East. | 3C | |
| JG084 | -30.706069° | 24.101819° | Kraal 2? | 3C | |
| JG085 | -30.706136° | 24.101832° | Line of kraal 2 wall. Not fully enclosed/circular | 3C | |
| JG086 | -30.706028° | 24.101865° | Line of kraal 2 wall. Not fully enclosed/circular | 3C | |
| JG087 | -30.706021° | 24.101766° | Line of kraal 2 wall. Not fully enclosed/circular | 3C | |

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| JG088 | -30.705949° | 24.101484° | Possible kraal 3 on far side of hollow. Walls not complete. | 3C |  |
| JG089 | -30.705877° | 24.101336° | | | |
| JG090 | -30.705959° | 24.101346° | Bothy 2. Circular ± 1.8 x 1.8 m. Door to East. | 3C |  |
| GEB001 | -30.607424° | 24.255003° | Same site as JG014 | 3C | |
| GEB002 | -30.607083° | 24.254997° | Same site as JG014 | 3C | |
| GEB003 | -30.606883° | 24.254721° | Same site as JG014 | 3C | |
| GEB004 | -30.606765° | 24.254087° | Same site as JG014 | 3C | |
| GEB005 | -30.591628° | 24.278963° | Scatter of biggish worn, patinated MSA flakes in deflation hollows. Area ± 10 x 10 m | 3C | |
| GEB006 | -30.592196° | 24.274613° | Scatter of lithics in hollow between small hills, in front of treed area. Worn, patinated MSA, including an endscraper, and a couple of small unpatinated LSA flakes. All lithics are hornfels. Area ± 15 x 15 m. | NCW | |
| GEB007 | -30.600890° | 24.265697° | Worn, patinated MSA flakes scattered all alongside the fence. Gets denser about half-way up towards the mountain. | NCW | |
| GEB008 | -30.604612° | 24.256805° | Just a few lithics on flat area, near pylon. Includes one side scraper. | NCW | |

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| GEB009 | -30.639628° | 24.204219° | One patinated hornfels MSA flake amongst area of dolerite boulders. On outskirts of JG037. | NCW |  |
| GEB010 | -30.634055° | 24.213184° | Just a handful of MSA flakes in hollow on top of hill which is surrounded by boulders. Possible kraal - the centre of hill has been cleared of boulders (Same as JG040). | 3C |  |
| GEB011 | -30.643086° | 24.198144° | Scatter of lithics around foot of small hill (top of hill recorded by John - JG043). Fresh, unpatinated hornfels and ? flakes. A flake every metre or so. They appear to run all around the base of the hill. | 3C | |
| GEB012 | -30.644727° | 24.195703° | Light scatter of patinated hornfels flakes in a slight hollow surrounded by boulder outcrops. | NCW |  |

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| GEB013 | -30.666459° | 24.160531° | Same as JG050 next to river channel. Quite a few pieces of OES, particularly in the runnels. | 3A |  |
| GEB014 | -30.666493° | 24.160731° | On the other side of little hill to GEB013, so it is a continuation of this site. | 3A |  |
| GEB015 | -30.665938° | 24.159066° | A scatter of unpatinated hornfels flakes across an area of ± 20 x 20 m. A number of cores and some OES. | 3C |  |
| **Access Road – 2022 Survey** | | | | | |

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| JG101 | -30.641875° | 24.332748° | Dense cluster of hornfels lithics eroding out of the red coversands in a donga system. Some heavily patinated MSA pieces but mostly appears to be LSA (Smithfield?). Blade dominated with a few retouched pieces. 2 x endscrapers. Number of bladelet cores. Visible eroding out over ±50 $m^2$ but lithic number are lower. | 3A |   |
| JG103 | -30.643049° | 24.320822° | Lithic scatter on outcropping dolerite. Mostly heavily patinated and slightly worn MSA on hornfels. Triangular flakes and core. Some LSA lithics present in a small area (±2 $m^2$). Lithics visible in area of ±20 x 5 m. | 3C |  |

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| JG104 | -30.643048° | 24.320256° | Dense LSA scatter on hornfels. ±20 pieces / $m^2$. Mostly fresh but some with light grey patination. Bladelets, one with retouched end and an endscraper noted. Smithfield? More lithics noted in surrounding unvegetated areas. | 3C |  |
| JG105 | -30.642532° | 24.315251° | Ephemeral scatter of red patinated and worn MSA lithics made on hornfels. Visible in ±4 $m^2$. Maximum of 5 pieces / $m^2$. | NCW | |
| JG106 | -30.642578° | 24.315167° | Dense scatter of patinated MSA lithics. Hornfels. On dolerite substrate in red coversand. Exposed by erosion in an area ±1.5 m wide x 3 m long. 20-30 pieces / $m^2$. | 3C | |
| JG107 | -30.642416° | 24.315013° | Mixed MSA and LSA (Lockhoek?) scatter. Same context and density as JG1067 but with LSA in the majority. | 3C | |
| JG108 | -30.627496° | 24.286731° | Ephemeral scatter of red patinated MSA on hornfels. Covers area of approximately 20 $m^2$. | NCW | |
| JG109 | -30.622084° | 24.294946° | Extensive and dense (in patches) MSA lithic scatter. Heavily rolled and patinated hornfels. Eroding out of a thin coversand on a wider dolerite plaat on the edge of a stream. Occasional piece of LSA reuse. | 3C | |
| JG110 | -30.622435° | 24.295375° | On opposite side of stream from JG109. LSA in profusion with some patinated MSA. Eroding out of banks of red sand. No retouched pieces noted, however. | 3C | |
| JG111 | -30.622286° | 24.295744° | | 3C | |
| JG112 | -30.623695° | 24.297081° | MSA and LSA lithics in shallow erosion gully. Includes a large Lockshoek sidescraper. In area of ±2 x 15 m. | 3C | |
| JG113 | -30.624503° | 24.296758° | Dense but very worn “scree” of MSA hornfels lithics. Lage flakes. Some could be ESA | 3C | |
| JG114 | -30.625666° | 24.297928° | Mixed assemblage of LSA and MSA lithics on hornfels “scree”. The hornfels cobbles and pebbles are the source of the raw material for the artefacts. At least 60 $m^2$ in extent. | 3C | |
| JG115 | -30.630393° | 24.305521° | LSA stone scatter. Smithfield artefacts on hornfels. 2 x quartz crystal. Rough extent = 50 x 50 m. | 3C | |

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| JG116 | -30.638698° | 24.316766° | Fresh hornfels lithics in road cutting. With OES and bone fragments including tortoise. Visible in small area of ±4 $m^2$. Possibly sealed context site. Both Smithfield and Lockshoek material present. | 3A |  |
| JG117 | -30.651064° | 24.318968° | Heavily patinated and worn MSA scatter on level, open nek between two koppies. Hornfels. Large blades, cores and chunks. Most dense in area of ±15 $m^2$ but more lithics likely in surrounding area. | 3C | |
| JG118 | -30.653848° | 24.316049° | Hornfels outcropping and scree on nek between koppies. Some possible MSA lithics although much of the breakage is probably natural. Possible raw material source. | NCW | |
| JG119 | -30.653510° | 24.314419° | Ephemeral MSA scatter on dolerite boulder slope just below summit of a high koppie. Hornfels and patinated light red. 1 x Levallois flake noted, otherwise flakes, some blades and chunks. ±10 $m^2$ area. | NCW | |
| JG120 | -30.653391° | 24.313339° | Band of hornfels and lightly baked grey shale. Lots of natural breakage but some MSA flakes seen including some very large flakes (bigger than a hand) which may be ESA. The lithics extend to roughly the position of JG121 down the slope. Looks like linked to exposure in the flanks of a dolerite outcrop of good hornfels. | NCW | |
| JG121 | -30.652999° | 24.312500° | | | |
| JG122 | -30.647676° | 24.354586° | Possibly in situ exposure of lithics on eroded “pan” surface. Approximately 30 lithics. Lightly patinated with fresher flaking. Very large ESA/MSA(?) triangular flake with (later) retouch. Approximately 4 x 3 m in extent. | 3A |  |

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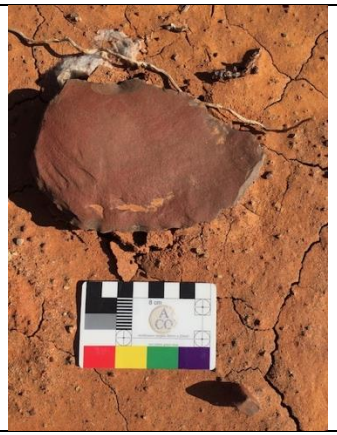
| | | | | |  |
| JG123 | -30.647980° | 24.355170° | Deflated surface with mix of MSA and fresher (Lockshoek?) lithics. On hard gravel lag. Blades, flakes and chunks. MSA lithics look like two periods – one more patinated than the other. | 3C | |
| JG126 | -30.569132° | 24.313862° | Kraal and hut complex within dolerite heuweltjies. 2 x packed dolerite boulder kraals. Wall height up to 75 cm. Rectangular. ±5 x 9 m (JG124) and 14 x 11 m (JG125). 2 x circular huts (G106 and G107) approximately 2 m across. Small collection of ceramics – at least 2 x dishes and 1 x cup. Fragments of clear glass bottle and some tins. | 3C | |
| JG!27 | -30.569229° | 24.313845° | | | |
| G106 | -30.569347° | 24.313751° | | | |
| G107 | -30.569481° | 24.314021° | | | |
| JG128 | -30.569205° | 24.314513° | Packed stone circular hut approximately 50 m east of the rest of the complex. Roughly same dimensions as other huts. | 3C | |
| JG130 | -30.578140° | 24.320469° | Kranskop farm complex – house, barn, kraal and more modern workers' cottages. Complex is well maintained but appears not be currently be in use. G108 is a small family graveyard on the eastern edge of the complex. Names on the graves are Venter. | 3A | |
| G108 | -30.579597° | 24.321990° | | | |
| JG131 | -30.581717° | 24.317755° | Scatter of worn and patinated MSA lithics (hornfels) on flat dolerite plaat between hills. Wet with seasonal seep crossing the plaat. Approximately 5 $m^2$. 5-10 pieces of stone / m. | NCW | |
| JG132 | -30.583990° | 24.326553° | Ephemeral litter (5-6 pieces) of worn and patinated hornfels. MSA | NCW | |
| JG133 | -30.587128° | 24.341673° | Vendusie Kuil farm complex. Old barn / store with more modern (1970s?) flat roofed farmhouse. Older building behind house housing electrical generator. 3 x labourer's | 3A | |

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| | | | cottages on hill behind house. | | |
| G101 | -30.623441° | 24.298500° | Ephemeral scatter of worn and patinated MSA hornfels lithics along a small stream. Lithics extend about 30 m along the stream. Some fresh flakes noted. No formal tools seen | NCW | |
| G102 | -30.623936° | 24.297779° | Dense lithic scatter on low rocky outcrop SW of G101. Well patinated MSA flakes but also fresh LSA(?) lithics. Three cross-mending pieces of pottery noted. Lithics recorded in an approximately 40 m radius of the outcrop. | 3A | |
| G103 | -30.636792° | 24.325497° | Scatter of heavily patinated MSA lithics on top of hilltop. Dolerite surface with boulders. Flakes, blades and chunks noted in approximately 10 m area. | 3C | |
| G104 | -30.640330° | 24.335196° | Scatter of mixed MSA (patinated) and LSA lithics on grassy river floodplain. Widely scattered. No formal tools noted. Lithics continue all the way to G105. | NCW | |
| G105 | -30.640978° | 24.337012° | Lithic scatter becomes more dense at G105 with 50 pieces / $m^2$ in places. Mix of freshly flaked LSA and some older, more patinated pieces. All hornfels. Visible in area of roughly 30 x 30 m.<br><br>A mixed lithic scatter extends form here across the entire Laydown Area and access road area to the east of G105 | 3C | |
| G109 | -30.585153° | 24.335351° | Worn and patinated MSA flakes and cores in an area of roughly 25 $m^2$. Ephemeral | NCW | |
| G110 | -30.595656° | 24.330355° | LSA site on top of a koppie in open area approximately 50 x 60 m. Hornfels. Cores, flakes and chips/chunks predominate. About 40-50 pieces / m in the densest areas. | 3C | |
| G111 | -30.597811° | 24.335694° | Scatter of hornfels lithics between dolerite outcrops. Not dense. But covering and area of 50 x 40m. Mix of MSA and LSA. | 3C | |
| G112 | -30.597615° | 24.333814° | Small scatter of patinated and worn MSA lithics on flat rocky waterway. Retouch (old) still visible on some. Area of ap[proximately 30 x 20 m, but lithics noted more widely across whole hillside. | NCW | |
| G113 | -30.601482° | 24.334688° | Area of hornfels cobbles many of which seem to have been flaked. Big flakes also present. Quarry site? | 3C | |
| G114 | -30.598322° | 24.338857° | Packed rock cairn. Possible boundary marker? | 3C | |

## APPENDIX C: FOSSIL CHANCE FIND PROTOCOL

**Monitoring Programme for Palaeontology – to commence once pylon excavations and associated activities begin.**

- The following procedure is only required if fossils are seen on the surface and when excavations commence.
- When excavations begin the rocks must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone, trace fossils) must be put aside in a suitably protected place. This way the project activities will not be interrupted.
- Photographs of similar fossil plants must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones. This information will be built into the EMP's training and awareness plan and procedures.
- Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.
- If there is any possible fossil material found by the developer/environmental officer/miners then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
- 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.
- If no good fossil material is recovered then no site inspections by the palaeontologist will not 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.
- If no fossils are found and the excavations have finished then no further monitoring is required.

## APPENDIX D: HIA SPECIALIST CURRICULUM VITAE

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|---|---|
| **Name:** | John Gribble |
| **Profession:** | Archaeologist (Maritime) |
| **Date of Birth:** | 15 November 1965 |
| **Parent Firm:** | ACO Associates cc |
| **Position in Firm:** | Senior Archaeologist |
| **Years with Firm:** | 4+ |
| **Years of experience:** | 32 |
| **Nationality:** | South African |
| **HDI Status:** | n/a |

**Education:**

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| 1979-1983 | Wynberg Boys' High School |
| 1986 | BA (Archaeology), University of Cape Town |
| 1987 | BA (Hons) (Archaeology), University of Cape Town |
| 1990 | Master of Arts, (Archaeology) University of Cape Town |

**Employment:**

- September 2017 – present: ACO Associates, Senior Archaeologist and Consultant
- 2014-2017: South African Heritage Resources Agency, Manager: Maritime and Underwater Cultural Heritage Unit
- 2012-2018: Sea Change Heritage Consultants Limited, Director
- 2011-2012: TUV SUD PMSS (Romsey, United Kingdom), Principal Consultant: Maritime Archaeology
- 2009-2011: EMU Limited (Southampton, United Kingdom), Principal Consultant: Maritime Archaeology
- 2005-2009: Wessex Archaeology (Salisbury, United Kingdom), Project Manager: Coastal and Marine
- 1996-2005: National Monuments Council / South African Heritage Resources Agency, Maritime Archaeologist
- 1994-1996: National Monuments Council, Professional Officer: Boland and West Coast, Western Cape Office

**Professional Qualifications and Accreditation:**

- Member: Association of Southern African Professional Archaeologists (ASAPA) (No. 043)
- Principal Investigator: Maritime and Colonial Archaeology, ASAPA CRM Section
- Field Director: Stone Age Archaeology, ASAPA CRM Section
- Class III Diver (Surface Supply), Department of Labour (South Africa) / UK (HSE III)

**Experience:**

I have more than 30 years of professional archaeological and heritage management experience. After completing my postgraduate studies and a period of freelance archaeological work in South Africa and aboard, I joined the National Monuments Council (NMC) (now the South African Heritage Resources Agency (SAHRA)) in 1994. In 1996 I become the NMC's first full-time maritime archaeologist and in this regulatory role was responsible for the management and protection of underwater cultural heritage in South Africa under the National Monuments Act, and subsequently under the National Heritage Resources Act.

In 2005 I moved to the UK to join Wessex Archaeology, one of the UK's biggest archaeological consultancies, as a project manager in its Coastal and Marine Section. In 2009 I joined Fugro EMU Limited, a marine geosurvey company to set up their maritime archaeological section. I then spent a year at TUV SUD PMSS, an international renewable energy consultancy, where I again provided maritime archaeological consultancy services to principally the offshore renewable and marine aggregate industries.

In August 2012 I established Sea Change Heritage Consultants Limited, a maritime archaeological consultancy. Sea Change traded until 2018, providing archaeological services to a range of UK maritime sectors, including marine aggregates and offshore renewable energy. Relevant experience includes specialist archaeological consultancy for more than two dozen offshore renewable energy projects and aggregate extraction licence areas in UK waters including:

- Lynn and Inner Dowsing OWF;
- Humber Gateway OWF;
- Sheringham Shoal OWF;
- Race Bank OWF;
- Docking Shoal OWF;
- Triton Knoll OWF;
- Neart na Gaoithe OWF;
- Dogger Bank OWF;
- Hornsea OWF;
- Navitus Bay OWF;
- Aggregate Area 392/393, Hilbre Swash;
- Area 478, East English Channel;
- Area 372/1, North Nab;
- Areas 401 & 2;
- Area 466, North West Rough; and
- Area 447, Cutline.

In the UK I was also involved in strategic projects which developed guidance and best practice for the UK offshore industry with respect to the marine historic environment. This included the principal authorship of two historic environment guidance documents for COWRIE and the UK renewable energy sector (*Historical Environment Guidance for the Offshore Renewable Energy Sector* (2007) and *Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector* (2010)). I was also manager and lead author in the development of the archaeological elements of the first Regional Environmental Assessments for the UK marine aggregates industry, and in the 2009 *UK Continental Shelf Offshore Oil and Gas and Wind Energy Strategic Environmental Assessment* for Department of Energy and Climate Change. More recently I undertook a review of the potential impacts of marine mining on South Africa's palaeontological and archaeological heritage resources for the Council for Geoscience, on behalf of the Department of Mineral Resources. In 2013-14 I was lead author and project co-ordinator on *The UNESCO Convention on the Protection of the Underwater Cultural Heritage 2001: An Impact Review for the United Kingdom* and in 2016 I was co-author of a Historic England / Crown Estate / British Marine Aggregate Producers Association funded review of marine historic environment best practice guidance for the UK offshore aggregate industry.

I returned to South African in mid-2014 where I was re-appointed to my earlier post at SAHRA: Manager of the Maritime and Underwater Cultural Heritage Unit. In July 2016 I was appointed as Acting Manager of SAHRA's Archaeology, Palaeontology and Meteorites Unit.

I left SAHRA in September 2017 to join ACO Associates as Senior Archaeologist and Consultant. Since being at ACO I have carried out a number of offshore impact assessments (see list of recent projects below) and authored a review of the potential impacts of marine mining on South Africa's palaeontological and archaeological heritage for the Council for Geoscience, on behalf of the Department of Mineral Resources.

I have been a member of the Association of Southern African Professional Archaeologists (No. 043) for more than twenty years and am accredited by ASAPA's Cultural Resource Management section.

I have been a member of the ICOMOS International Committee for Underwater Cultural Heritage since 2000 and served as a member of its Bureau between 2009 and 2018.

Since 2010 I have been a member of the UK's Joint Nautical Archaeology Policy Committee.

I am a member of the Advisory Board of the George Washington University / Iziko Museums of South Africa / South African Heritage Resources Agency / Smithsonian Institution 'Southern African Slave Wrecks Project' and serve on the Heritage Western Cape Archaeology, Palaeontology and Meteorites Committee.

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## APPENDIX E: SITE SENSITIVITY VERIFICATION REPORT

(See separate pdf file)

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11 July 2022

Ms Aneesah Alwie
Arcus Consultancy Services South Africa (Pty) Ltd
Ikon Centre
24 Hans Strijdom Ave
Cape Town, 8000

Dear Aneesah

**SITE SENSITIVITY VERIFICATION REPORT: MULILO DA2S TRANSMISSION CORRIDOR, SWITCHING STATION AND ACCESS ROAD**

In terms of the general requirements for undertaking an initial site sensitivity verification published by the Department of Environmental Affairs in Government Gazette 45421 on 10 May 2019, a Site Sensitivity Verification Report is required to confirm or dispute the results, for any environmental theme, of the Screening Tool Report generated as part of the environmental impact assessment process.

A Screening Tool Report for the Mulilo DA2S New Transmission Corridor generated on 27 October 2021, identified archaeological and cultural heritage and palaeontology as two of the development site environmental sensitivities. The Screening Tool Report records the archaeological and cultural heritage sensitivity as Low and the palaeontological sensitivity as Very High within the proposed transmission corridor.

This letter serves as the required Site Sensitivity Verification Report (SSVR) for the proposed Mulilo DA2S Transmission Corridor, but also includes the archaeological and cultural heritage and palaeontological sensitivity of the Switching Station and Access Road which now form part of this project, all to be constructed east of De Aar in the Northern Cape.

As set out in the general requirements for undertaking an initial site sensitivity verification referred to above, the Site Sensitivity Verification must be:

- undertaken by an environmental assessment practitioner or a registered specialist with expertise in the relevant environmental theme being considered;
- undertaken through the use of:
    - a desk top analysis, using satellite imagery; and
    - a preliminary on-site inspection to identify any discrepancies with the environmental status quo versus the environmental sensitivity as identified on the national web based environmental screening tool, such as new developments, infrastructure, etc.; and
- recorded in the form of a report that:
    - confirms or disputes the environmental sensitivity as identified by the national web based environmental screening tool;
    - contains a motivation and evidence (e.g. photographs) of either the verified or different environmental sensitivity; and
    - is submitted together with the relevant reports prepared in accordance with the requirements of the Environmental Impact Assessment Regulations.

This Site Sensitivity Verification Report has been produced by John Gribble, a consulting archaeologist who is a member of (Membership # 43) and accredited by the Southern African

Association of Professional Archaeologists (ASAPA), and who has more than 30 years' experience of cultural resource management.

The report is based on both extensive desk-based work for this and other development-related impact assessment projects conducted in the De Aar area in recent years, and on two field assessments to identify heritage resources specifically conducted for this project by John Gribble and Gail Euston-Brown of ACO Associates, in 2020 and 2022.

**Findings**:

The archaeological and cultural heritage and palaeontological sensitivities indicated in the Screening Tool Report for the Mulilo DA2S New Transmission Corridor are reproduced in Figure 1 below:


Figure 1: The archaeological and cultural heritage (left) and palaeontological (right) sensitivities indicated in the Screening Tool Report.

Archaeology and Cultural Heritage: The Screening Tool Report indicates a generally sparse occurrence of archaeological and cultural heritage resources of significance in the vicinity of the transmission corridor.

The findings of the numerous heritage assessments carried out in the area in recent years, including the two specific assessments for this project indicate, however, that there is a widespread and general occurrence of archaeological material across the area, which is largely dominated by a ubiquitous "litter" of Middle Stone Age lithic material that is present almost everywhere. This material is, in the main, in secondary context and cannot generally be said to form discrete archaeological sites and is considered to be of low archaeological significance and sensitivity.

In contrast, Later Stone Age archaeological material, also widely recorded in the area, more often occurs as definable sites, sometimes in sealed contexts and accompanied by bone and other archaeological material. These sites are considered to be of moderate and sometime high, local archaeological significance.

No Early Stone Age archaeological material has been reported from the area.

While the archaeological and cultural heritage map in Screening Tool Report is thus accurate at a broad and very general scale, this dataset has an inherent failing within the Screening Tool in that is relies on point-plotted archaeological site data, which is generally not available for much of South Africa.

The De Aar area is a case in point with the hundreds of sites and archaeological occurrences identified by the numerous archaeological and cultural heritage assessments caried out in the area in the last few years, almost none of which are yet shown in the data available in the Screening Tool.

Palaeontology: With respect to the palaeontological sensitivity of the project area indicated in the Screening Tool Report, it is worth noting that while the table identifies the area as Very High

sensitivity, the mapping indicates a much more varied range of palaeontological sensitivities across the area (see Figure 1 above). This varied palaeontological potential accords with the numerous palaeontological impact assessments carried out in the area and with both the geological map of the region and SAHRA's palaeo-sensitivity map (Figure 2 and Figure 3 below):

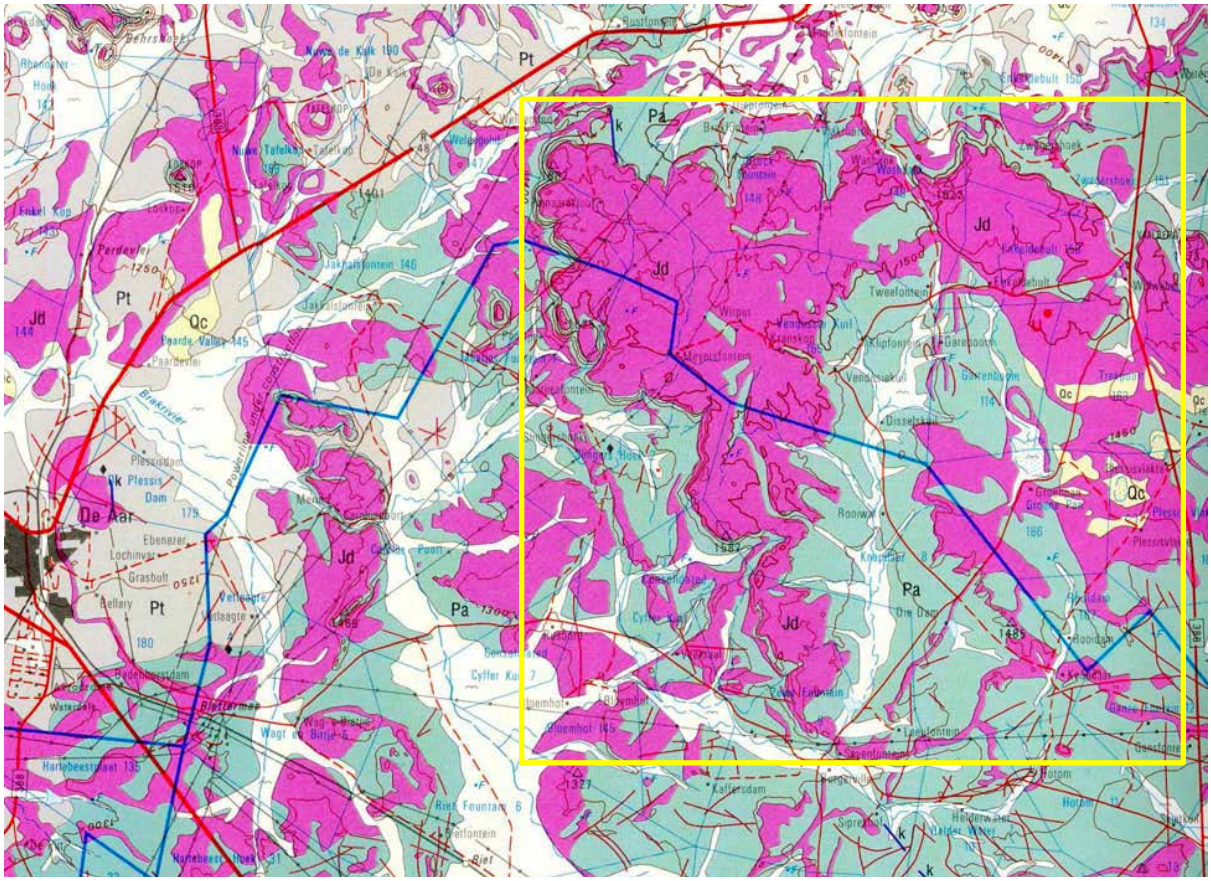


Figure 2: Geological map of the De Aar area. The key rock or sediment types on the routes are: pink = Jurassic dolerite dykes, pale green = Adelaide Subgroup shales, grey = Tierberg Formation shales and mudstones, white = Quaternary Kalahari sands. The area under consideration in this report lies within the yellow block (Map enlarged from the Geological Survey 1: 250 000 map 3024 Colesburg).

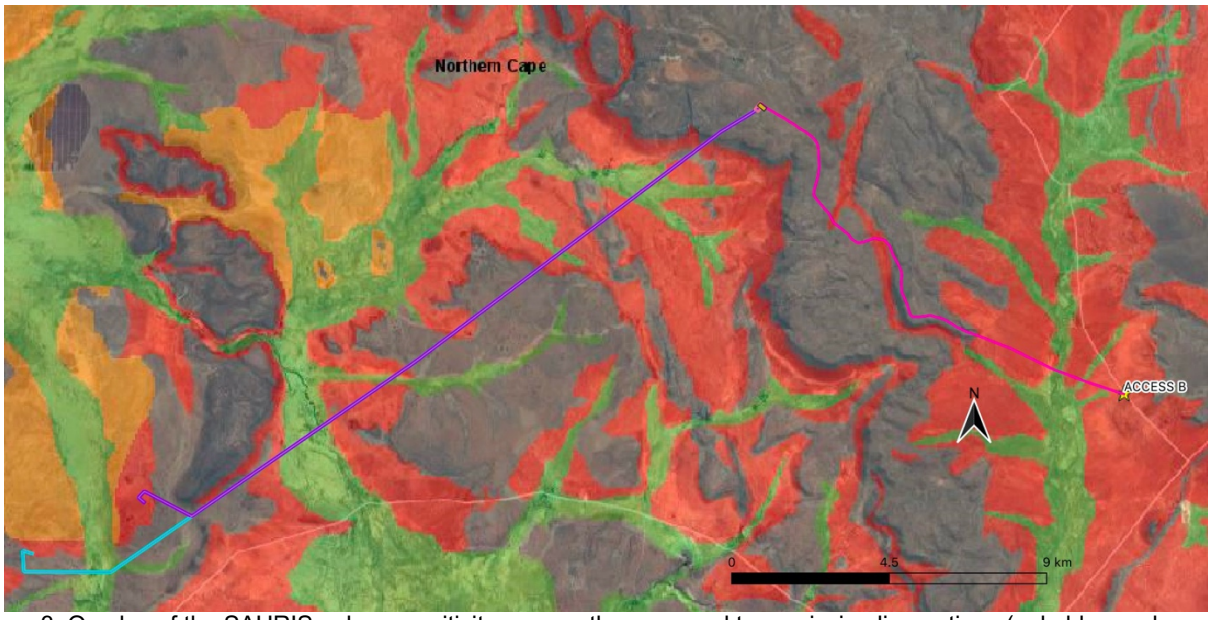


Figure 3: Overlay of the SAHRIS palaeosensitivity map on the proposed transmission line options (pale blue and purple), switching station (circled) and access road (pink). The background colours indicate the following degrees of sensitivity: red = very high; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero (Source: https://sahris.sahra.org.za/map/palaeo).

Based on the above, this report disputes both the archaeological and cultural heritage and palaeontological sensitivities indicated by the Screening Tool Report.

While partially correct, the actual sensitivities of these themes is much more nuanced and varied than the Screening Tool Report indicates and the evidence for this is presented in the HIA for this project and in the numerous other projects referenced in that report.

Yours sincerely

John Gribble

for ACO Associates cc