PALAEONTOLOGICAL HERITAGE:
Basic Assessment for the Proposed Development of the 325MW Kudusberg Wind Energy Facility and associated infrastructure, between Matjiesfontein and Sutherland in the Western and Northern Cape Provinces: BA REPORT

Report prepared for:

CSIR – Environmental Management Services
P O Box 320
Stellenbosch, 7599
South Africa

Report prepared by:

Dr John Almond - Natura Viva cc
P.O. Box 12410, Mill Street
Cape Town, 8010
South Africa

October 2018

SPECIALIST EXPERTISE

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, Limpopo, Northwest, Gauteng, KwaZulu-Natal and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has served as 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 for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

SPECIALIST DECLARATION

I, **Dr John Edward Almond**, as the appointed independent specialist, in terms of the 2014 EIA Regulations, hereby declare that I:

- I act as the independent specialist in this application;
- I 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;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management Act;
- 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 have no vested interest in the proposed activity proceeding;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I have ensured that information containing all relevant facts in respect of the specialist input/study was distributed or made available to interested and affected parties and the public and that participation by interested and affected parties was facilitated in such a manner that all interested and affected parties were provided with a reasonable opportunity to participate and to provide comments on the specialist input/study;
- I have ensured that the comments of all interested and affected parties on the specialist input/study were considered, recorded and submitted to the competent authority in respect of the application;
- all the particulars furnished by me in this specialist input/study are true and correct; and
- I realize 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 Specialist: **Dr John Edward Almond**

Date: **24 August 2018**

EXECUTIVE SUMMARY

Kudusberg Wind Farm (Pty) Ltd, is proposing to develop a wind energy facility (WEF) of up to 325 megawatt (MW) generation capacity on a site located between Matjiesfontein and Sutherland in the mountainous Klein Roggeveld region, Western and Northern Cape Provinces. The WEF project area is underlain by continental sediments of the Abrahamskraal Formation (Lower Beaufort Group, Karoo Supergroup) of Middle Permian age (*c*. 256-270 Ma) which are generally considered to be of high palaeontological sensitivity (SAHRA Palaeotechnical Report for the Northern Cape, SAHRIS website, Komsberg REDZ in SEA for Wind & Solar Photovoltaic Energy in South Africa, CSIR 2015). However, several previous palaeontological field assessments in the Klein Roggeveld region of the south-western Karoo as well as the recent 6-day palaeontological field survey of the Kudusberg WEF project area suggest that the Beaufort Group bedrocks here are generally fossil-poor, apart from fairly common horizons with plant debris or low-diversity invertebrate trace fossils. None of the fossil sites recorded during the field survey lie within the proposed development footprint. They include two plant fossil sites and one lungfish burrow site that are of scientific research interest as well as a few *equivocal* records of vertebrate burrows and tracks.

In terms of palaeontological heritage resources, the overall impact significance of the construction phase of the proposed wind energy facility is assessed as **VERY LOW (negative), before and after mitigation.** This assessment applies to the wind turbine locations, laydown areas, internal and external access roads, the on-site substation, construction yards, underground cables, 33 kV powerlines and associated WEF infrastructure within the study area.

Given the similar underlying geology, there are no preferences on palaeontological heritage grounds for any particular layout among the various options under consideration. These include different options for routing of access roads into the northern sector of the project area, turbine layouts and siting of construction yards and the on-site substation. No significant further impacts on fossil heritage are anticipated during the operational and decommissioning phases of the WEF. The no-go alternative (*i.e.* no WEF development) will have a neutral impact on palaeontological heritage.

There are no fatal flaws in the Kudusberg WEF development proposal as far as fossil heritage is concerned. *Provided that* the recommendations for palaeontological monitoring and mitigation outlined below are followed through, there are no objections on palaeontological heritage grounds to authorisation of the Kudusberg WEF project. Cumulative impacts on palaeontological heritage resources that are anticipated as a result of the numerous alternative energy developments currently proposed or authorised for the Klein-Roggeveld region (including additional impacts envisaged for the Kudusberg WEF project) are predicted to be very low (negative), *provided that* the proposed monitoring and mitigation recommendations made for these various projects are followed through. Unavoidable residual negative impacts (low significance) may be partially offset by the improved understanding of Karoo palaeontology resulting from appropriate professional mitigation.This is regarded as a significant *positive* impact for Karoo palaeontological heritage.

The great majority of the Kudusberg WEF project area is assessed as being of low palaeontological sensitivity due to the scarcity of significant fossil vertebrate, plant and other remains here. Sensitive no-go areas within the proposed development footprint itself have not been identified in this study. Scientifically-important fossil plant and lung fish burrow sites as well as the *equivocal* vertebrate burrows and tracks recorded here all lie well outside (> 50 m) the proposed development footprint (Appendix 1 and Figs. 51 & 52) and therefore no mitigation measures regarding them are recommended here. Pending the potential discovery of significant new fossil remains during the construction phase - in which event the Chance Fossil Finds Protocol appended to this report should be applied (Appendix 2) – no specialist palaeontological mitigation or monitoring is recommended for the Kudusberg WEF project.

The Environmental Site Officer (ESO) responsible for the Kudusberg WEF development should be made aware of the potential occurrence of scientifically-important fossil remains (*e.g.* vertebrate bones, teeth, burrows and trackways, petrified wood, plant-rich beds) within the development footprint. During the construction phase all major clearance operations (*e.g.* for new access roads, turbine placements) and deeper (> 1 m) excavations should be monitored for fossil remains on an on-going basis by the Environmental Site Officer. Should substantial fossil remains be encountered at surface or exposed during construction, the Environmental Site Officer should safeguard these, preferably *in situ*. They should then alert the relevant provincial heritage management authority as soon as possible - *i.e.* Heritage Western Cape for the Western Cape (Contact details: Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 086-142 142. Fax: 021-483 9842. Email: hwc@pgwc.gov.za) and SAHRA for the Northern Cape (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). This is to ensure that appropriate action (*i.e.* recording, sampling or collection of fossils, recording of relevant geological data) can be taken by a professional palaeontologist at the developer's expense. A protocol for Chance Fossil Finds is appended to this report. These mitigation recommendations must be incorporated into the Environmental Management Programme (EMPr) for the Kudusberg WEF.

LIST OF ABBREVIATIONS

amsl	Above mean sea level
BA	Basic Assessment
DEA	Department of Environmental Affairs
EMPR	Environmental Management Programme
ESO	Environmental Site Officer
Ga	Billion years ago / old
HWC	Heritage Western Cape
Ma	Million years ago / old
PIA	Palaeontological impact assessment
REDZ	Renewable Energy Development Zone
SAHRA	South African Heritage Resources Agency
SEA	Strategic Environmental Assessment
WEF	Wind Energy Facility

COMPLIANCE WITH THE APPENDIX 6 OF THE 2014 EIA REGULATIONS

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	Addressed in the Specialist Report
1. (1) A specialist report prepared in terms of these Regulations must contain- a) details of- i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	P1
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	P2
c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1
(cA) an indication of the quality and age of base data used for the specialist report;	Section 1.1
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 1.3, 1.6
d) the date, duration and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 1.1
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 1.1
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 1.3, 1.6
g) an identification of any areas to be avoided, including buffers;	Section 1.6
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;	Figs 11, 51
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.1
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 or activities;	Section 1.3, 1.6
k) any mitigation measures for inclusion in the EMPr;	Section 1.7
l) any conditions for inclusion in the environmental authorisation;	Section 1.6, 1.9
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 1.6, 1.9
n) a reasoned opinion- i. as to whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 1.9
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	n/a
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Any relevant comments received on the DBAR will be incorporated in the finalised report
q) any other information requested by the competent authority.	n/a
2) Where a government notice *gazetted* by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	

TABLE OF CONTENTS

TABLES

FIGURES

1 PALAEONTOLOGICAL HERITAGE

1.1 INTRODUCTION AND METHODOLOGY

1.1.1 Scope and Objectives

The present report represents a Palaeontological Heritage Impact Assessment (PIA) undertaken as part of a Basic Assessment Process required for the proposed development of the 325 MW Kudusberg Wind Energy Facility near Sutherland in the Northern and Western Cape Provinces. This Basic Assessment Process is being co-ordinated by the CSIR, Stellenbosh (Contact details: Ms Minnelise Levendal. CSIR, Implementation Unit (Environmental Management Services) PO Box 320 Stellenbosch 7599. Tel: + 27-21 888-2495. Cell: 083 309 8159. Fax: 021-888 2693. E-mail: mlevendal@csir.co.za). The PIA forms a component of the multi-disciplinary Heritage Impact Assessment for the WEF development that is being co-ordinated by Ms Katie Smuts (Contact details: Caledon Street, Stanford Tel: 072 796 7754 Email: katie.smuts@gmail.com).

1.1.2 Terms of Reference

As defined by the CSIR, the Terms of Reference for the present PIA study, as a component of the over-arching Heritage Impact Assessment of the Kudusberg WEF project, are as follows:

General ToR:

- A key task for the specialists is to review the existing sensitivity mapping from the SEA for the project area and provide an updated sensitivity map for the Kudusberg WEF project site.
- Adhere to the requirements of specialist studies in terms of Appendix 6 of the NEMA EIA Regulations (2014), as amended.
- Identify and assess the potential impacts of the proposed Kudusberg WEF project and its associated infrastructure by assessing the impacts during the construction, operational and decommissioning phases.
- Identify and assess cumulative impacts from other Wind and Solar PV projects located within a 50 km radius from the Kudusberg WEF that already have received Environmental Authorisation (EA), are preferred bidders and/or may still be identified as having received a positive Environmental Authorisation at the start of this BA process.
- Propose mitigation measures to address possible negative effects and to enhance positive impacts to increase the benefits derived from the project.
- Use the Impact Assessment Methodology as provided by the CSIR.
- Assess the project alternatives and the no-go alternative.
- Provide a recommendation as to whether the project must receive Environmental Authorisation of not and Identify any aspects which are conditional to the findings of the assessment which are to be included as conditions of the Environmental Authorisation.

Specific ToR:

- Describe and map the palaeontological heritage features of the site and surrounding area. This is to be based on desk-top reviews, fieldwork, available databases, findings of the Wind and Solar SEA (CSIR, 2015) and findings from other palaeontological heritage studies in the area, where relevant. Include reference to the grade of heritage feature and any heritage status the feature may have been awarded.
- Assess the impacts and provide mitigation measures to include in the environmental management plan.
- Map palaeontological heritage sensitivity for the site. Clearly show any “no-go” areas in terms of heritage (*i.e*. “very high” sensitivity) and provide recommended buffers or set-back distances.
- Identify and assess potential impacts from the project on palaeontology, as required by heritage legislation

1.1.3 Approach and Methodology

The PIA for the proposed Kudusberg WEF is based on geological and palaeontological data acquired (1) during a preliminary desktop analysis of the broader study region combined with (2) a 6-day field survey of key sectors of the project area by the palaeontologist (Dr Almond) and an experienced field assistant, focusing on potentially fossiliferous sites with informative bedrock exposure.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations, etc.) represented within the study area are determined from geological maps and satellite images. 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). 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 and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008a, 2008b) and are shown on the palaeosensitivity map on the SAHRIS (South African Heritage Resources Information System) website. The likely impact of the proposed development on local fossil heritage is then determined based on (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 and ground clearance envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint – as in the present case - a field assessment study by a professional palaeontologist is usually warranted.

The focus of palaeontological field assessment 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, 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 field 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 field assessment studies. To do so, a fossil collection permit from SAHRA is required and all fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Note that while fossil localities recorded during field work 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 must 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.

Based on the desktop and field 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 and taphonomic data) – is usually most effective during the preconstruction phase or, in some cases in the construction phase when fresh fossiliferous bedrock has already been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority. In the present case the authorities concerned are Heritage Western Cape for the Western Cape

(Contact details: Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 086-142 142. Fax: 021-483 9842. Email: hwc@pgwc.gov.za) and SAHRA for the Northern Cape (Contact details: South African Heritage Resources Agency. Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). It should be emphasized that, *provided that* appropriate mitigation is carried out, most developments involving bedrock excavation can make a positive contribution to our understanding of local palaeontological heritage.

1.1.4 Assumptions and 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 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 present case, site visits to the various loop and borrow pit study areas in some cases considerably modified our understanding of the rock units (and hence potential fossil heritage) represented there.

In the case of the present study area in the Klein Roggeveld region near Sutherland (Western and Northern Cape) exposure of potentially fossiliferous bedrocks is very limited, due to extensive cover by superficial sediments and karroid *bossieveld* vegetation. However, sufficient exposures were examined to allow a realistic assessment of their palaeontological sensitivity (See Appendix 1), while a substantial amount of relevant geological and palaeontological data is available from previous PIAs in the region (See, for example, references under Almond). Confidence levels for this assessment are accordingly rated as *medium*. Comparatively few academic palaeontological studies have been carried out in the region so any new data from impact studies here are of scientific interest.

1.1.5 Source of Information

This combined desktop and field-based palaeontological assessment report is based on:

(1 A short project outline and kmz data provided by the CSIR;
(2) A review of the relevant scientific literature, including several previous palaeontological impact assessments in the broader Klein Roggeveld – Sutherland region (See References and discussion about cumulative impacts in Section 1.6);
(3) Published topographical and geological maps (1: 250 000 Sheet 3320 Sutherland) and accompanying sheet explanations (Theron 1983, Cole & Vorster 1999) as well as Google Earth© satellite imagery;
(4) A six-day field study of the Kudusberg WEF study area (17-20 July and 4 -6 August 2018);
(5) The author's extensive field experience with the formations concerned and their palaeontological heritage (*cf* References under Almond).

1.2 DESCRIPTION OF PROJECT ASPECTS RELEVANT TO PALAEONTOLOGICAL HERITAGE IMPACTS

Kudusberg Wind Farm (Pty) Ltd is proposing to construct up to a 325 MW Wind Energy Facility (WEF) at a site to the west of the R354 between Sutherland and Matjiesfontein known as Kudusberg. The site is situated in the mountainous Klein Roggeveld region of the Great Karoo, RSA (Figs. 1 to 4) and site spans the boundary between the Western Cape and Northern Cape (Cape Winelands and Namakwa District Municipalities respectively). It comprises several adjoining land parcels, as shown in map Figure 4 below. The proposed WEF will be located within the Renewable Energy Development Zone 2 (REDZ 2), known as the Komsberg REDZ that was published in terms of Section 24(3) of the National Environmental Management Act, 1998 (NEMA) in GN R114 of 16 February 2018. The REDZs were identified through a Strategic Environmental Assessment (SEA) conducted by the Council for Scientific and Industrial Research (CSIR) with palaeontological sensitivity data contributed by the present author (Almond *in* Fourie *et al.* 2015).

A Basic Assessment (BA) Process, contemplated in terms of Regulation 19 and 20 of the Environmental Impact Assessment Regulations, 2014, is required to obtain Environmental Authorisation for this large-scale WEF, as required in terms of NEMA.

The various farms concerned with the Kudusberg WEF total *c*. 13 000 ha in area, of which the WEF will involve some 200 ha (Fig. 4). The main infrastructural components of the WEF of particular relevance to the present palaeontological heritage study (Figs. 2 & 3) include:

- Up to 56 wind turbines of 3 to 6.5 MW generation capacity that will be situated along ridges within turbine corridors. The footprint of each wind turbine, including foundations & hard standing areas, is *c*. 90 m x 50 m (total footprint for 56 turbines = 25.2 ha) during construction and for ongoing maintenance purposes for the lifetime of the turbines.
- Internal access roads (up to 12 m wide), including structures for stormwater control would be required to access each turbine and the substation, with a total footprint of about 82.44 ha. Existing roads to be used will be upgraded / extended where needed.
- Electrical transformers (690 V/33 kV) adjacent to each turbine (2 m x 2 m, up to 10 m x 10 m) to step up the voltage to 33 kV.
- Underground 33 kV cabling between turbines to be buried along access roads, where feasible, with overhead 33 kV lines grouping turbines to cross valleys and ridges outside of the road footprints to reach the onsite 33/132 kV substation.
- On-site 33/132 kV substation (footprint *c*. 2.25 ha) (3 site options under consideration).
- Construction yard/s with an area of *c*. 12.6 ha which includes an on-site concrete batching plant for use during the construction phase and for offices, administration, operations and maintenance buildings during the operational phase (3 site options under consideration).
- Minor improvements (*e.g.* upgrading of water crossings, widening of intersections) to the access route to the project area from the R354 Matjiesfontein – Sutherland tar road in the east *via* the unpaved R356 road leading to the main WEF access road (MN04469/OG51) which branches off towards the south. Two 4-6 km long access road alternatives branching off the MN04469 are under consideration.

The assessments, conclusions and recommendations made in this PIA report apply to the *revised* layout of the Kudusberg WEF (October 2018) as shown in Figure 3. None of the small changes in proposed layout made since the originally proposed layout – largely involving the siting of several crane pads and turbines, the layout of construction camps and re-routing of common access road – affect the assessments, conclusions and recommendations made in the draft PIA report of August 2018.

It is noted that the connection of the proposed WEF to the National Grid via 132 kV transmission lines will be the subject of a separate BA process.

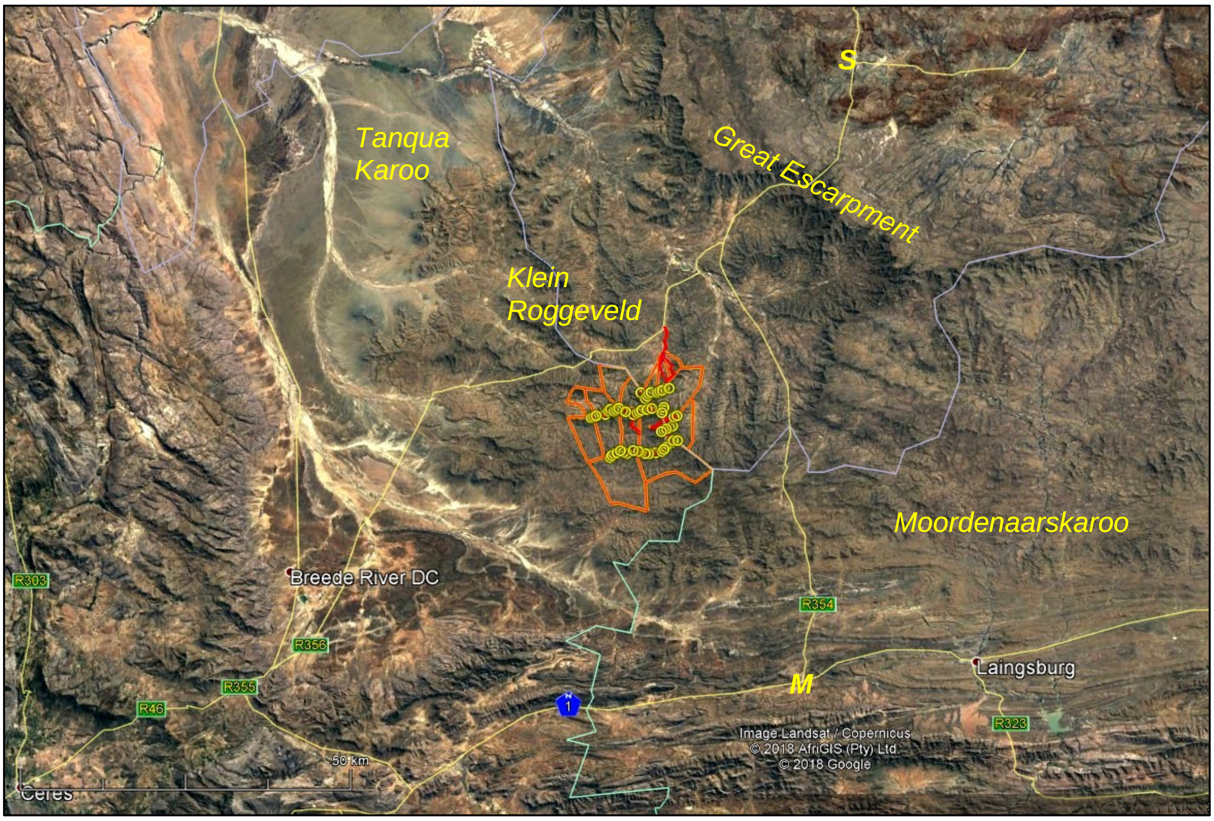

Figure 1. Google Earth© satellite image of the south-western Karoo showing the location of the proposed Kudusberg WEF (orange polygon) in the mountainous Klein Roggeveld region lying between the Cape Fold Belt and the Great Escarpment (Sutherland – S; Matjiesfontein - M). Note that the WEF project area spans the boundary between the Western and Northern Cape (dark blue line). N towards the top of the image.

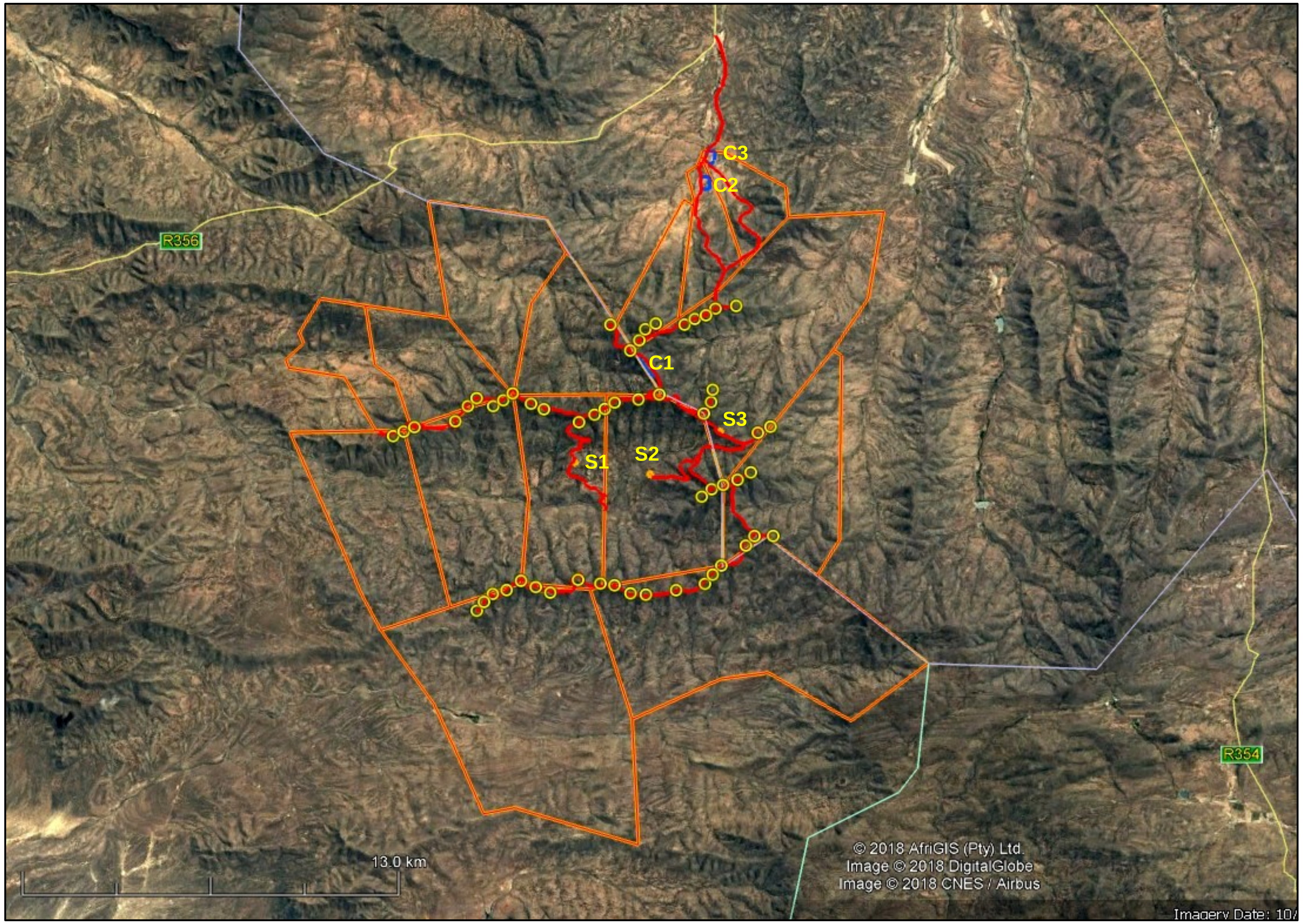

Figure 2. Google Earth© satellite image of the Kudusberg WEF project area (orange polygons outlining constituent land parcels) showing the highly-dissected, mountainous terrain here. Also shown is a provisional layout for the turbine positions (yellow circles) and internal and external access roads (red). Location options under consideration for the on-site substation (S1-3, orange) and construction camp (C1-3, blue) are also indicated. Details of the revised project layout (October 2018) are shown in Figure 3. N towards the top of the image.

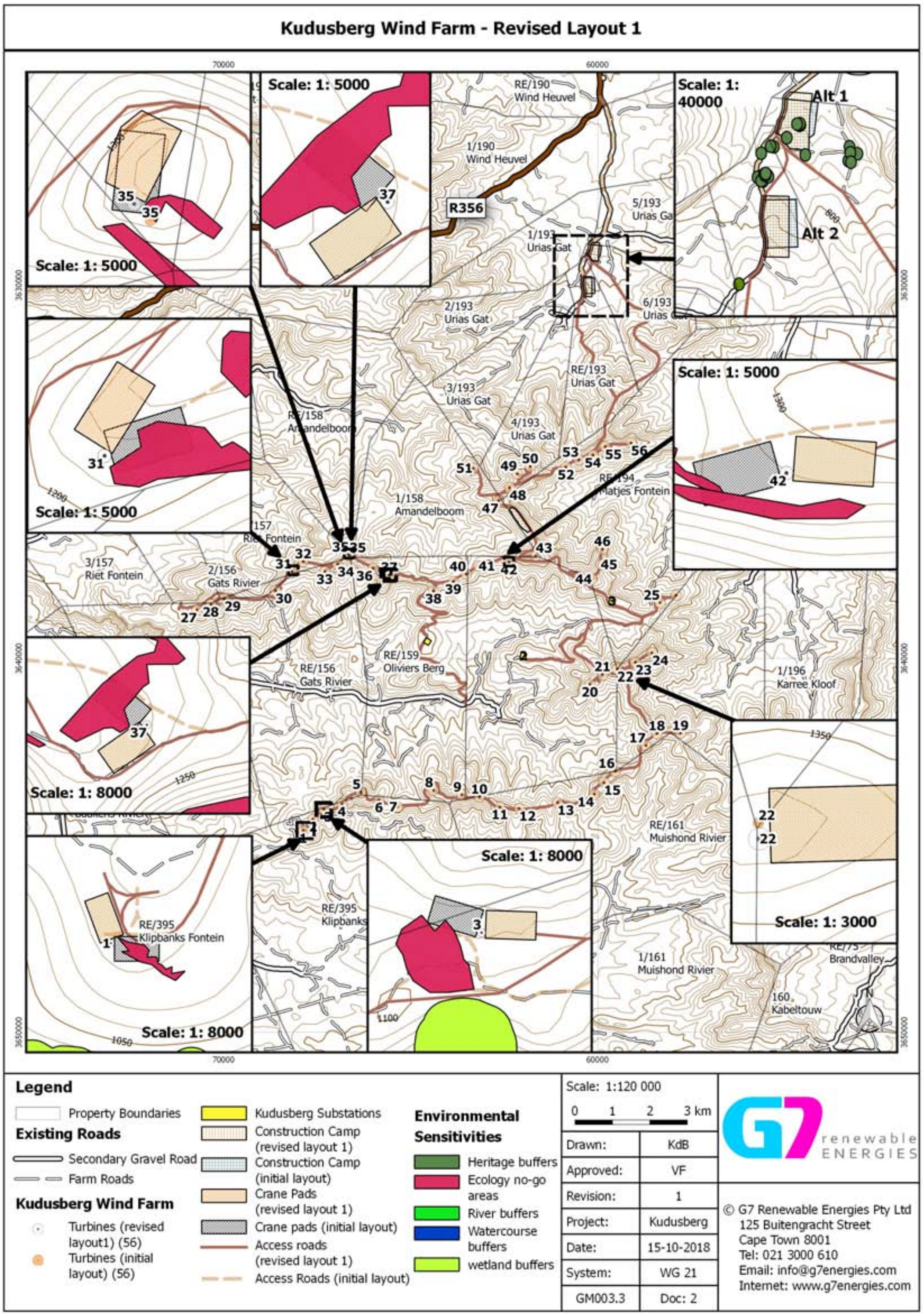

Figure 3. Topographic map of the Klein Roggeveld WEF project area showing the main infrastructural components of the proposed Kudusberg WEF. This figure details the revised layout for the WEF (October 2018) that is assessed in this report (Image prepared by G7 Renewable Energies (G7)).

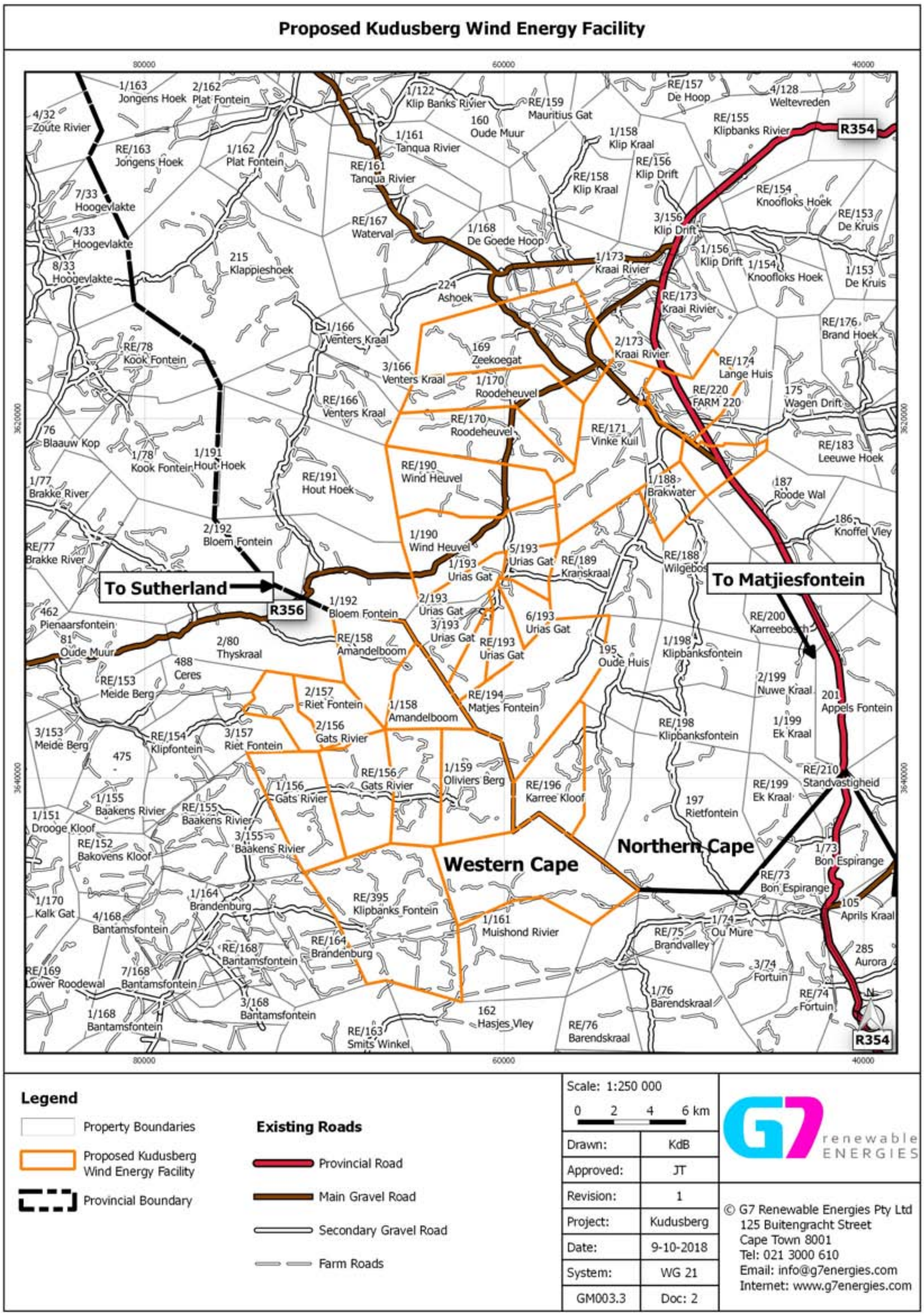

Figure 4. Map of the Klein Roggeveld region between Matjiesfontein and Sutherland showing the numbered land parcels concerned in the project area for the proposed Kudusberg WEF (orange polygon). Minor improvements to the access route to the project area from the R354 tar road in the east *via* the unpaved R356 road to the north of the main WEF project area may be required during the construction phase; the land parcels affected are also shown here (Image prepared by G7 Renewable Energies (G7)).

1.3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The Kudusberg WEF study area is embedded within highly-dissected, hilly to mountainous terrain of the Klein-Roggeveld region, spanning the boundary between the Western and Northern Cape. This remote, semi-arid subregion of the Great Karoo of South Africa is situated between the rugged Cape Fold Mountains in the south, the arid *vlaktes* of the Ceres – Tanqua Karoo in the west and the steep Roggeveld Escarpment – part of the Great Escarpment - to the northeast (Figs. 1 to 4). The R354 tar road between Matjiesfontein and Sutherland runs well to the east of the area while the R356 gravel road skirts it on the northern side. The core project area where most of the WEF infrastructure will be situated is dominated by broadly west-east trending uplands with summit ridges and plateaux at elevations of around 1200-1360 m amsl (*e.g.* Oliviersberg 1367 m amsl). Mountain slopes are generally fairly gentle with prominent-weathering ridges or *kranzes* of Beaufort Group sandstones imparting a distinctive banded appearance that is very pronounced on satellite images (Figs. 5 to 8). The slopes are clothed in karroid *bossieveld* vegetation (the spotting on satellite images is due to *heuweltjies*) and incised by numerous small, intermittently flowing streams. The area is drained by westward- and northward-flowing tributaries of the Tanquarivier drainage system such as the Ongeluksrivier, Muishondrivier, Kareekloofrivier and Uriasgatrivier. Away from the numerous drainage lines, dry waterfalls and sandstone ridges (Figs. 9 & 10), levels of bedrock exposure in the study area - notably that of the recessive-weathering mudrock facies - are generally very low. This is largely due to extensive cover by alluvial and colluvial deposits, sandy to gravelly soils as well as karroid *bossieveld* vegetation (Central Mountain Shale Renosterveld, Koedoesberg – Moordenaars Karoo).

Figure 5. View south-eastwards from the crest of the central turbine ridge (Loc. 011) towards Oliviersberg homestead and the Oliviersberg range with higher ridges of the Klein Rogggeveld in the background.

Figure 6. View eastwards along the western portion of the southern turbine ridge (Koedoesberge) showing flat-lying, poorly-exposed Abrahamskraal Formation along the ridge crest, coarse colluvial gravels in the foreground (Loc. 119).

Figure 7. View eastwards along the central turbine ridge from near Loc. 136 showing occasional prominent-weathering, tabular sandstones of the Abrahamskraal Formation.

Figure 8. View south-westwards towards the main northern turbine ridge showing flat to gently-dipping Abrahamskraal Formation with sheet-like sandstone units in the background and weathered grey-green mudrocks in the foreground (Loc. 056).

Figure 9. Seasonally dry stream valley on Oliviers Berg 159 that is deeply incised into mudrocks beneath a resistant channel sandstone capping that builds a dry waterfall further upstream (Loc. 003a).

Figure 10. Good vertical and panel sections through Abrahamskraal Formation mudrocks and channel sandstones along the stream valley due SE of Oliviersberg farmstead (Loc. 103).

1.3.1 Geological setting

The geology of the Klein Roggeveld region near Sutherland is outlined on the 1: 250 000 scale geology sheet 3220 Sutherland (Council for Geoscience, Pretoria; Theron 1983, Cole & Vorster 1999) (Fig. 11). The region lies on the gently folded northern margins of the Permo-Triassic Cape Fold Belt (CFB). The only major sedimentary bedrock unit mapped within the Kudusberg WEF project area on the 1: 250 000 scale geological map is the **Abrahamskraal Formation** (Pa, pale green in Fig. 11) which forms the basal subunit of the **Lower Beaufort Group** (**Karoo Supergoup**) in the western portion of the Main Karoo Basin of South Africa (Johnson *et al.* 2006). The continental (fluvial and lacustrine) mudrocks and sandstones or *wackes* (impure sandstones) of the very thick Abrahamskraal Formation are of Middle Permian age, with an estimated age of 265-270 Ma. Underlying basinal, prodeltaic and deltaic sediments of the Tierberg, Kookfontein and Waterford and Formations (Ecca Group) only crop out outside and to the west and south of the present study area (yellow, orange and brown areas in Fig. 11). The Early Jurassic Karoo Dolerite Suite (*c*. 182 Ma = million years old; Duncan & Marsh 2006) is not mapped within the study area and Karoo dolerite was not encountered during the present field study. It is represented by a few narrow dolerite dykes intruded into the Lower Beaufort Group country rocks along W-E to WNW-ESE fracture lines further to the east in the Klein Roggeveld region. The Palaeozoic bedrocks in the WEF study area are extensively mantled by a wide spectrum of Late Caenozoic superficial deposits. They include scree and other slope deposits (colluvium and hillwash), river and stream alluvium including coarse pediment gravels or "High Level Gravels", down-wasted surface gravels, calcretes and various soils. These geologically youthful and, for the most part, unconsolidated sediments are generally of low palaeontological sensitivity and are also only briefly treated in this study. None of them are mapped at 1: 250 000 scale.

All these sedimentary rock units are potentially fossiliferous, although only the Abrahamskraal Formation is considered to be of high palaeontological sensitivity (*cf* Almond & Pether 2008a, 2008b, SAHRIS website, Komsberg REDZ heritage account in Fourie *et al.* 2015). The Abrahamskraal succession in the

Klein Roggeveld broadly youngs towards the northeast and levels of tectonic deformation are generally low on the fringes of the Cape Fold Belt. As shown on the geological map, the Abrahamskraal bedrocks are folded along broadly west-east trending axes and dips may range up to 50º (Fig. 13), with subhorizontal bedding characteristic of major ridge crests (Figs. 6, 8 & 14). However, steeper subvertical dips do occur – for example along the W-E zone north of the Oliviersberg on Oliviersberg 159.

A very short, illustrated account of the main sedimentary rock units encountered within the study area during fieldwork is presented in this section of the report. Fossil material recorded within the study area from these sediments is documented in the following section. GPS data and brief descriptions for all numbered geological and palaeontological localities mentioned in the text are provided in Appendix 1.

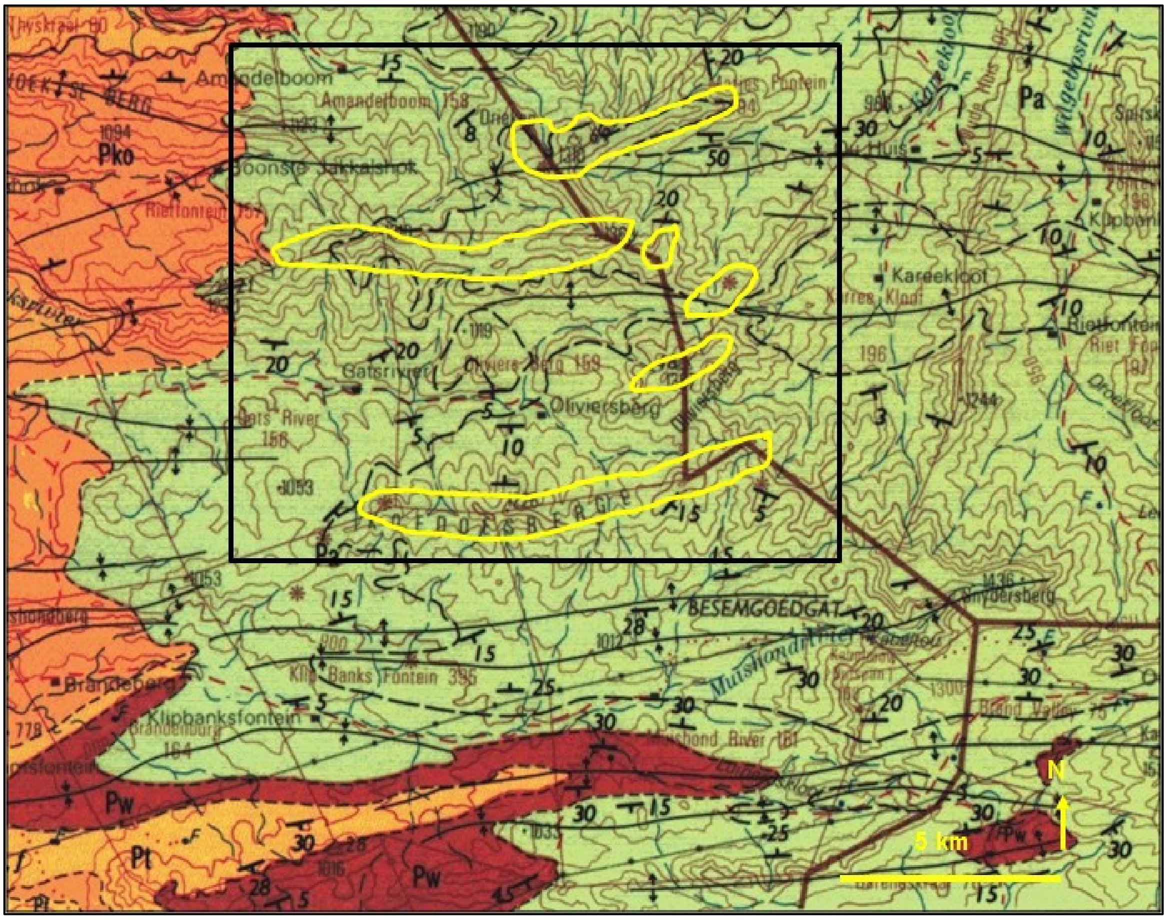

Figure 11. Extract from 1: 250 000 scale geology sheet 3220 Sutherland showing the *approximate* location of the core project area for the proposed Kudusberg WEF, located *c*. 60 km southwest of Sutherland, Western and Northern Cape Provinces (black rectangle) (Map published by Council for Geoscience, Pretoria). The main wind turbine corridors are indicated by the elongate yellow shapes (*cf* Figs. 2 & 3). The core development area – where most of the key WEF infrastructure (wind turbines, internal access roads, on-site substation *etc*) will be situated - overlies the outcrop area of Middle Permian continental sediments of the Abrahamskraal Formation (Lower Beaufort Group, Karoo Supergroup) (Pa, pale green). Thin black lines indicate broadly west-east trending fold axes within the Abrahamskraal Formation bedrocks, while the dashed line marks the incoming of reddish mudrocks within the Abrahamskraal succession. Basinal and deltaic sediments of the Ecca Group occur to the west and south of the WEF project area (yellow, orange and brown areas on the map). Karoo dolerite intrusions have not been mapped in this area. A wide spectrum of Late Caenozoic superficial deposits that *are* present here but are not mapped at 1: 250 000 scale include: alluvium (sandy to gravelly river deposits, including consolidated High-Level Gravels), colluvium (scree deposits, hillwash), pediment and downwasted surface gravels, pedocretes (calcretes) and soils.

1.3.1.1 Abrahamskraal Formation

The Abrahamskraal Formation is a very thick (*c*. 2.5 km) succession of fluvial deposits laid down in the Main Karoo Basin by meandering rivers on an extensive, low-relief floodplain during the Middle Permian Period, some 265-270 million years ago (Rossouw & De Villiers 1952, Johnson & Keyser 1979, Turner 1981, Theron 1983, Smith 1979, 1980, 1990, 1993a, 1993b, Smith & Keyser 1995a, Loock *et al*., 1994, Cole & Vorster 1999, McCarthy & Rubidge 2005, Johnson *et al*., 2006, Almond 2010a, Day 2013a, Day & Rubidge 2014, Wilson *et al.* 2014). These sediments include (a) lenticular to sheet-like channel sandstones, often associated with thin, impersistent intraformational breccio-conglomerates (larger clasts mainly of reworked mudflakes, calcrete nodules, *plus* sparse rolled bones, teeth, petrified wood), (b) well-bedded to laminated, grey-green, blue-grey to purple-brown floodplain mudrocks with sparse to common pedocrete horizons (calcrete nodules formed in ancient soils), (c) thin, sheet-like crevasse-splay sandstones, as well as more (d) localized playa lake deposits (*e.g.* wave-rippled sandstones, dark laminated mudrocks, limestones, evaporites). Several greenish- to reddish-weathering, silica-rich "chert" horizons are also found. Many of these appear to be secondarily silicified mudrocks or limestones but at least some contain subaerial or reworked volcanic ash (tuffs, tuffites). Thin, fine-grained tuffs with a pale greenish, cherty appearance also occur here and are of value for radiometric dating (*cf* Lanci *et al.* 2013 who obtained Middle Permian, Wordian ages for tuffs low down within the Abrahamskraal Formation in the western Karoo). A wide range of sedimentological and palaeontological observations point to deposition of the Abrahamskraal sediments under seasonally arid climates. These include, for example, the abundance of pedogenic calcretes and evaporites (silicified gypsum pseudomorphs or "desert roses"), reddened mudrocks, sun-cracked muds, "flashy" river systems, sun-baked fossil bones, well-developed seasonal growth rings in fossil wood, rarity of fauna, and little evidence for substantial bioturbation or vegetation cover (*e.g.* root casts) on floodplains away from the river banks.

There have since been several attempts, only partially successful, to subdivide the very thick Abrahamskraal Formation succession in both lithostratigraphic (rock layering) and biostratigraphic (fossil) terms (*cf* Loock *et al.* 1994, Day & Rubidge 2014). The precise stratigraphic range of the Lower Beaufort Group beds represented within the Kudusberg WEF study area has not been determined with any confidence. On the basis of proximity to the mapped Ecca – Beaufort boundary, the presence of a basal sandstone-rich package as well as another sandstone package higher up along the crests of the turbine ridges (*e.g.* Koedoesberge) *plus* the abundance of maroon mudrocks and the paucity of vertebrate fossil remains, it is concluded that most of the succession represented here belongs to the **Combrinkskraal Member** *sensu lato* of Loock *et al.* (1994). The two sandstone packages might then correspond to the **Combrinkskraal** and **Grootfontein Members** of Day and Rubidge (2014) (Fig. 12), one or both of which are recorded to the southwest of Sutherland (Ouberg Pass and Verlatenkloof). However, detailed field mapping is required to test this.

The Combrinkskraal Member *sensu lato* is not clearly differentiated by Loock *et al.* (1994), apart from to say that it comprises grey and maroon overbank mudrocks, with thin siltstone and sandstone interbeds and occasional calcareous concretions, while the channel sandstones are sheet-like. This description would apply to much of the lower Abrahamskraal Formation succession of the Klein-Roggeveld region. The sedimentology of the basal Abrahamskraal Formation (*Eodicynodon* Assemblage Zone) has been outlined by Rubidge (1995b; see also Rubidge *et al.* 2000, Smith *et al.* 2012). According to these authors, the depositional setting is interpreted as a subaerial delta plain featuring low-sinuosity perennial river channels with intervening floodplains and lakes. Upward-fining cycles are characteristic. Channel sandstones are fine-grained, single- to multi-storey with generally sharp, erosive bases, often associated with mudrock and calcrete intraclasts breccio-conglomerates. Mudrocks are thin-bedded or massive, predominantly grey to olive green in hue, and often feature small to sizeable reddish-brown carbonate concretions.

The Abrahamskraal Formation in the Klein-Roggeveld study region as a whole is a succession of continental fluvial rocks characterized by numerous lenticular to (most commonly) laterally-extensive, sheet-like sandstones with intervening, more recessive-weathering mudrocks (Stear 1980, Le Roux 1985, Loock *et al.* 1994, Cole & Vorster 1999, Wilson *et al.* 2014). The channel sandstone units are up to several (5 m or more) meters thick and vary in geometry from extensive, subtabular sheets to single-storey lenticles or multi-storey channel bodies. The prominent-weathering, laterally-persistent sandstone ledges generate a distinctive ridged, stepped or terraced topography on hill slopes in the area (Figs. 13 &

14). The sheet sandstones are generally pale-weathering (enhanced by epilithic lichens), fine- to medium-grained, well-sorted and variously massive or structured by horizontal lamination (flaggy, with primary current lineation) or, more rarely, tabular to trough cross-bedding. Greyish hues of some freshly broken sandstone surfaces suggest an "impure" clay-rich mineralogy (*i.e.* wackes). Current ripple cross-lamination and horizontal lamination is common towards the tops of the sandstone beds. These may also feature well-preserved palaeosurfaces with swales or pools, wave ripples (locally variable wave crest azimuths), falling water marks, adhesion warts, microbial mat textures, trace fossils and rills (Figs. 43 & 44). The lower contacts of the sandstones are often gradational or erosive on a small scale, especially lower down in the Abrahamskraal succession. Channel sandstones higher in the succession may be associated with lenticular to sheet-like basal breccias of reworked mudflake and calcrete intraclasts that may infill small-scale erosive gullies; such breccias were rarely observed within the present study area, however (Figs. 16 & 50).

Lower Beaufort Group bedrock exposure levels within the Kudusberg WEF study are generally very low, especially as far as the mudrock facies are concerned; surface exposure of these is mainly confined to limited stream and erosion gullies on steeper hillslopes as well as along major drainage lines such as the valleys of the Ongeluksrivier and Kareekloofrivier (Figs. 9, 10, 19 to 22). Mudrock exposure along the ridge crests where most wind turbines will be located is very limited (Figs. 15 & 41). Most of the upland outcrop area – including the majority of the turbine ridges - is mantled with colluvium, soils and vegetation (Figs. 34 & 35), with the exception of prominent narrow ridges of sandstone that impart a striped appearance to the landscape (Figs. 5, 13 & 14). A moderately high but subordinate proportion of the Abrahamskraal overbank mudrocks within the study area are purple-brown to maroon, while non-reddish mudrocks may be more blue-green than greenish-grey, especially lower down in the succession. Horizons of small (pebble to cobble-sized) pedogenic calcrete concretions are moderately common at some horizons within the overbank mudrock packages (Fig. 25) but are on the whole sparse in the lowermost Abrahamskraal Formation. The sphaeroidal to irregular calcrete nodules are usually pale grey or ferruginised to rusty brown. They may show septarian cracking internally. Larger (several dm-scale) diagenetic concretions are usually ferruginous, rusty brown, and sphaeroidal, lenticular to irregular in form and may form laterally extensive, prominent-weathering beds (Fig. 24). A thin (< 10 cm) horizon of pale grey-green siliceous rock cropping out near the eastern wind mast on Koedoesberg is interpreted as a tuff (volcanic ash) (Figs. 30 & 35) (*cf* Lanci *et al.* 2013).

A spectrum of channel sandstone geometries is seen within the lower Abrahamskraal Formation in the study area (*cf* Wilson *et al.* 2014). Good examples of vertically-stacked, upwardly-expanding channel bodies are encountered at intervals, for example on Oliviers Berg 159 (Fig. 17). It is notable that most of the sandstone bodies within the study area show a markedly laterally-persistent, tabular geometry comparable to that of the underlying Waterford Formation. They are mostly fine- to very fine-grained with gradational rather than sharp, erosive bases and often cap small-scale (few m) upward-coarsening, upward-thickening sedimentary packages. These pass from massive mudrock through thin-bedded siltstone and fine-grained wacke into thicker-bedded wackes and cleaner-washed sandstones (Figs. 19 to 22). Diagenetic lenticles, beds and large concretions of rusty-hued ferruginous carbonate are more ubiquitous within the dominantly grey, blue- to grey-green mudrock facies than pale grey calcrete nodules, although both may occur within the same exposures. Features such as basal gullying, well-developed channel breccio-conglomerates containing reworked calcrete nodules, silicified gypsum pseudomorphs (Fig. 26) or sand-infilled mudcracks are not frequently found compared to higher members within the Abrahamskraal Formation. Extensive development of soft-sediment loading at the base of thicker sandstone units or entailing the complete break-up into balls-and-pillows of thinner beds, is commonly seen within the lowermost Abrahamskraal Formation beds, some of which may even involve maroon mudrocks (Fig. 23). These characteristics, which are shared in part with the deltaic Waterford Formation, contrast in several respects to the "typical" fluvial *Eodicynodon* AZ sediments described earlier. This, together with possible evidence for local channel collapse and large-scale slumping of the sediment prism, may suggest that the lowermost Abrahamskraal Formation in the study area was deposited in a more swampy, unstable delta plain setting with perennially high watertables. Horizons rich in stellate to sphaeroidal gypsum pseudomorphs and pedogenic calcrete nodules suggest contrasting periods of arid, evaporative conditions. Lacustrine (playa lake or perhaps interdistributary bay) packages characterised by very dark, laminated to thin-bedded mudrocks and heterolithic intervals, loading and dewatering features, desiccation cracks, plant debris and stem casts as well as low-diversity trace fossil assemblages represent wetter intervals on the floodplain / delta platform (Figs. 27 to 29, 43 to 48). Occasional packages of distinctive, tabular-bedded, khaki- to yellowish-brown, crumbly ("biscuity"), medium-grained sandstones (Fig. 18) contrast with the typical very fine-grained, well-sorted grey-green wackes that predominate at this stratigraphic level. The former are locally associated with horizons of mudrock intraclast breccia and reworked plant material, giving them a more typical fluvial character reminiscent of the younger Koornplaats Member of the Abrahamskraal Formation (Figs. 49 & 50).

A transitional, highly variable depositional model for the lower Abrahamskraal Formation, oscillating between deltaic and fluvial settings, might also partially explain the paucity of vertebrate fossils (and perhaps also of woody remains) in these beds, due to palaeoecological as well as preservational (diagenetic) constraints. It is also possible that protracted intertonging of subaqueous and subaerial delta platform facies may have occurred along the diachronous Ecca – Beaufort boundary in the SW Karoo, especially in areas favoring local subsidence of a thick, river-dominated delta prism (This is also implied by Theron 1983, p. 8). Further detailed sedimentological studies and mapping that lie outside the scope of the present report are required to delineate and characterize the Ecca – Beaufort boundary in the study region.

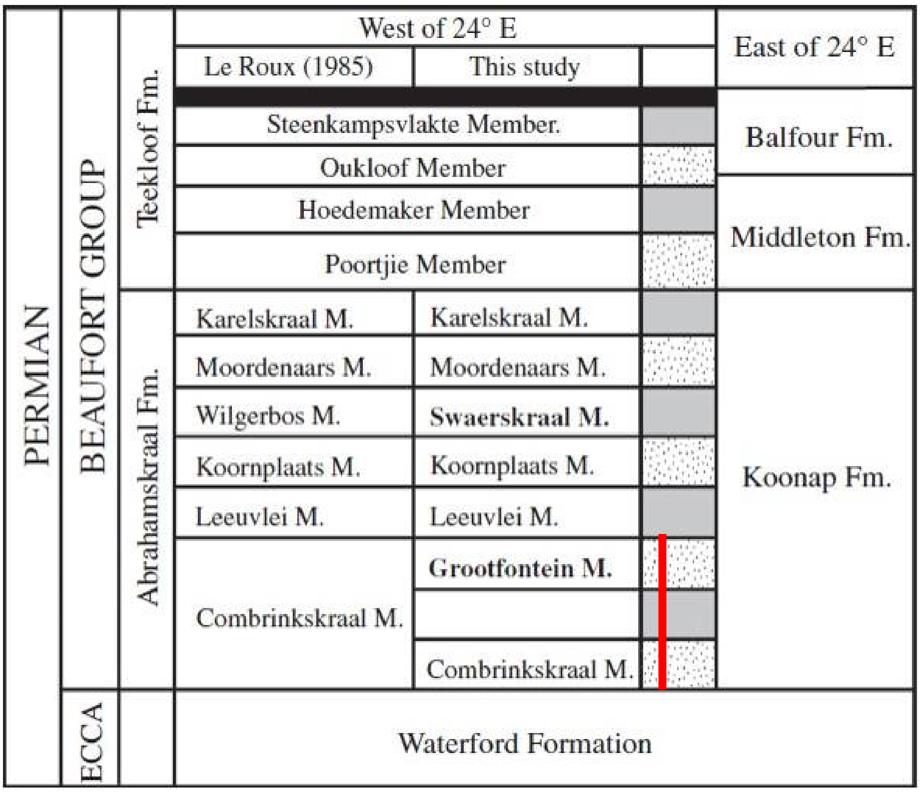

Figure 12. Revised subdivision of the Abrahamskraal Formation (Day and Rubidge 2014). The red bar indicates stratigraphic members that are *probably* represented within the Kudusberg WEF study area, but this requires testing through detailed field mapping. Yellowish-brown, crumbly sandstones with associated reworked plant material, such as are typical for the Koornplaats Member, are also recorded in the study area.

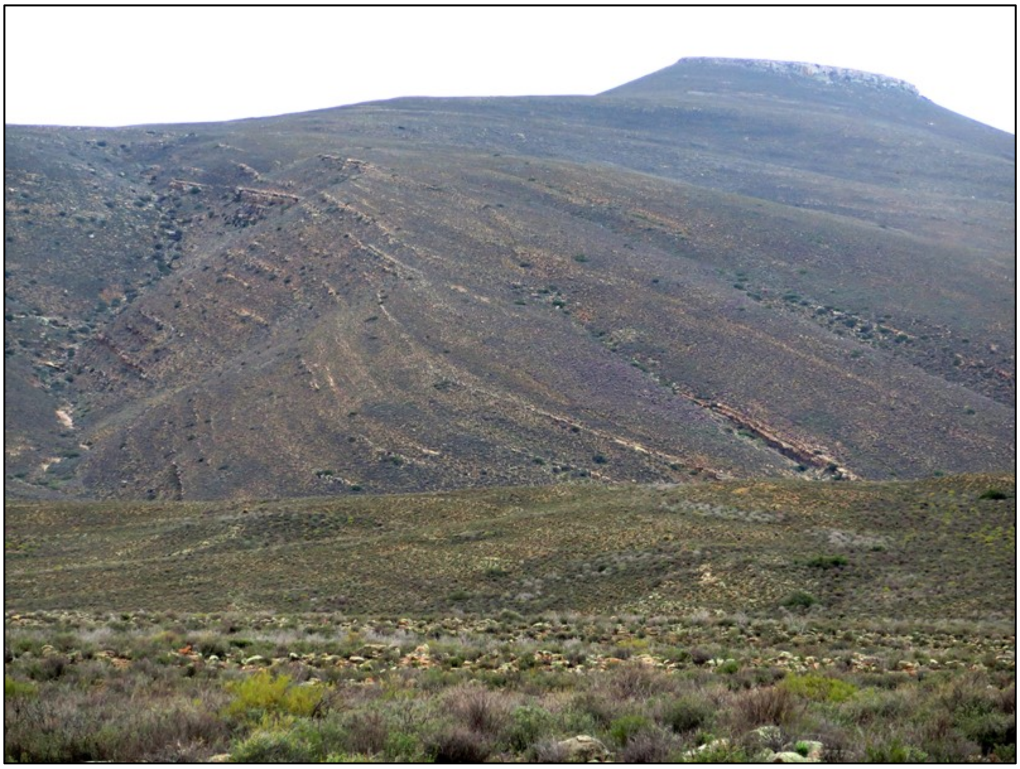

Figure 13. Steeply south-dipping, closely-spaced sheet sandstones on the southern slopes of the central turbine ridge, Gats Rivier 156. They are probably referable to the Combrinkskraal Member at the base of the Abrahamskraal Formation

Figure 14. Flat-lying Abrahamskraal Formation sheet sandstones building the crest of the central turbine ridge, Oliviers Berg 159 – possibly the Grootfontein Member package (Loc. 013).

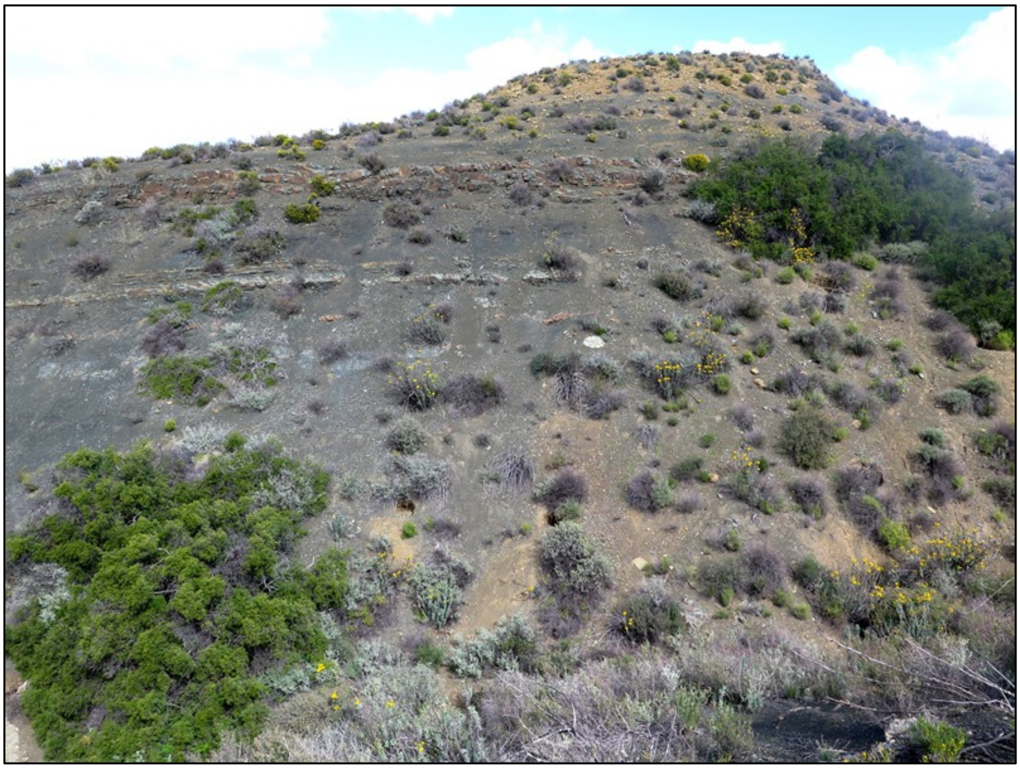

Figure 15. Rare exposure of the thick, mudrock-dominated interval between the Combrinkskraal and Grootfontein Member sandstone packages, close to the crest of central turbine ridge near the wind mast on Gats Rivier 156 (Loc. 019).

Figure 16. Sharp, erosive-based, multi-storey channel sandstone package containing lenses of mudflake intraclast breccia along internal erosion surfaces (arrows). The underlying finer-grained sediments show an upward-coarsening and –thickening trend (Loc. 021).

Figure 17. Vertical superposition of increasingly wide, lenticular channel sandstones (multistorey confined sand body) with convex-downward overbank succession at the base (Loc. 113).

Figure 18. Distinctive yellowish-brown, tabular, crumbly channel sandstone facies that occurs at intervals within the lower Abrahamskraal Formation and is often associated with transported plant remains (Loc. 142).

Figure 19. Upward-coarsening and - thickening mudrock to sandstone package typical of the Combrinkskraal Member *sensu lato* (Loc. 110).

Figure 20. Thin upward-coarsening package within the lower Abrahamskraal Formation showing gradational lower contact of the upper wackes as well as the common occurrence of both purple-brown (oxidized) and grey-green (reduced) facies (Hammer = 30 cm) (Loc. 023)

Figure 21. Good vertical section through the lower Abrahamskraal Formation close to the Uitkyk Pass, Oliviers Berg 159. The lower mudrock-sandstone packages show an upward-coarsening trend with sharp tops, while the upper ones are typical fluvial sharp-based, upward-fining packages (Loc. 017).

Figure 22. Stacked thin, upward-coarsening packages with abundant reddish mudrocks, capped by an erosive-based channel sandstone, incised valley exposure of the Combrinkskraal Member (Loc. 029).

Figure 23. Local collapse and disruption of Abrahamskraal Formation wackes to form floating load "blobs" within a massive mudrock matrix (Hammer = 30 cm) (Loc. 025).

Figure 24. Horizon of lenticular ferruginous carbonate diagenetic concretions within fine-grained overbank mudrocks, suggesting high water tables on the floodplain. Note the general upward-coarsening trend within the sediment package (Loc. 116).

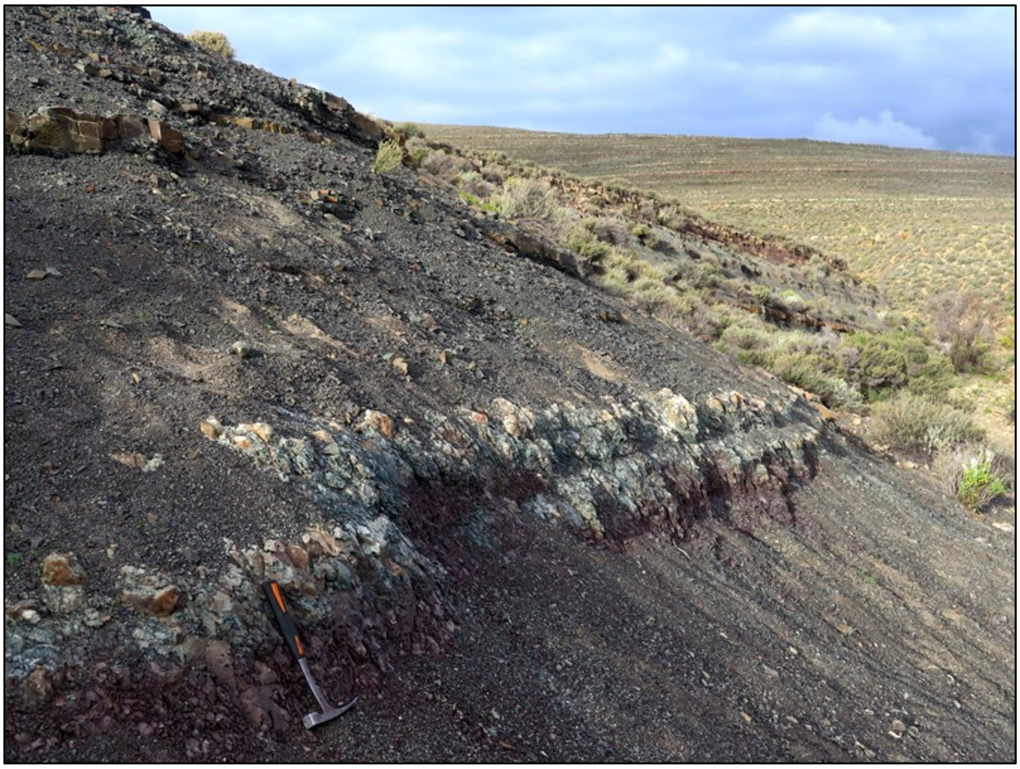

Figure 25. Horizon of pebble- to cobble-sized ferruginous palaeocalcrete concretions marking an ancient palaeosol within grey-green hackly mudrocks (Hammer = 30 cm). Such palaeosol horizons are a major focus in surveys for vertebrate fossil remains (Loc.110).

Figure 26. Weathered-out sphaeroidal clumps of radiating quartz crystals whose lenticular shape shows they are pseudomorphs after gypsum (*cf* desert roses). Horizons rich in evaporate minerals – often associated with lacustrine deposits and mudcracks - suggest periods of intense evaporation on the Middle Permian floodplain (Loc. 020).

Figure 27. Laminated to thin-bedded, dark grey siltstones of probable lacustrine origin overlain by fine-grained sandstone package showing small-scale channel features (Loc. 038).

Figure 28. Basally-loaded, fine-grained, ripple cross-laminated wacke with reworked plant debris and small-scale mudcracks on its upper surface (arrowed horizon) overlain by thin-bedded heterolithic facies showing evidence for dewatering (*e.g.* flame structures) (Loc. 040).

Figure 29. Curious vertical, tapering, subcylindical structure penetrating upwards through and deforming interbedded wackes and mudrocks of the Abrahamskraal Formation (Hammer = 30 cm) (Loc. 131). This may be a dewatering feature.

Figure 30. Float blocks of yellowish-green fine-grained tuff (volcanic ash) within surface gravels close to the Koedoesberge east wind mast (Scale in cm). The source bed crops out in this area (Loc. 108). Tuff units such as this are of considerable value for accurately dating Beaufort Group succession.

1.3.1.2 Late Caenozoic Superficial Deposits

Late Caenozoic alluvial deposits in the Kudusberg WEF study area, as exposed in river or stream banks and erosion gulley sections, reach thicknesses of up to few meters and are dominated by well-bedded to massive pale buff silts, sands and gravelly sands, with lenticles of fine to coarse, poorly-sorted gravel. They are well seen along the banks of the Ongeluksrivier, Kareekloofrivier and their various unnamed tributaries, for example (Figs. 31 & 32). The coarse, poorly-sorted basal gravels are dominantly composed of angular to subrounded wacke clasts, usually semi-indurated with partial to extensive calcrete cementation, and may show well-developed current imbrication. High Level Gravel terraces and abandoned bars of coarse bouldery to cobbly gravels perched up to several meters above modern stream level is encountered locally along major drainage lines and are probably of Pleistocene age.

Thick (up to several meters) mixed alluvial, colluvial and sheetwash deposits on hillslopes are exposed by gulley or stream erosion where they are seen to consist of poorly-sorted sandy matrix as well as angular, blocky sandstone clasts (Fig. 36). The colluvium may form a semi-consolidated rubbly, clast-supported breccia bed locally. Elsewhere diamictites or matrix-supported breccias consisting of angular, dispersed sandstone blocks within a poorly-sorted sandy to silty matrix (locally calcretised) may be debrites emplaced by gravity flow on steeper slopes. Upland hillslopes and plateaux above the escarpment, where most of the key WEF infrastructure will be concentrated, are generally mantled by angular downwasted rock debris - predominantly Karoo sandstones or wackes (Figs. 34 & 35) - but in some areas the bedrocks are mantled in fine gravels and sandy soils (Fig. 8). Prominent-weathering sandstone *kranzes* along and above the escarpment are associated with scree aprons of angular to well-rounded blocks and corestones of Beaufort Group sandstone. Colluvial sandstone rubble, often dominated by well-rounded corestones of fine-grained wacke, overlies sandstone channel bodies of the Abrahamskraal Formations exposed along stream beds, hillslopes and hillcrests. On lower valley slopes close to drainage lines the colluvial gravels may be overlain by a well-developed calcrete hardpan.

Low-lying *vlaktes* on the northern and eastern margins of the study area (*e.g.* Uriasgatrivier and Matjiesfontein Kloof and Kareekloofrivier Valleys) are mantled in sandy to finely-gravelly alluvial soils that may reach a depth of a few meters and show calcrete development in the subsurface (Fig. 37). Close to drainage lines these finer-grained alluvial deposits are underlain by thick, coarse, semi-consolidated alluvial gravels at depth.

Figure 31. Coarse, crudely-imbricated High Level Gravels of probable Pleistocene age overlying a slightly elevated pediment surface, incised river valley on Oliviers Berg 159 (Loc. 027).

Figure 32. River bank section through semi-consolidated, poorly-sorted, coarse alluvial gravels interbedded with lenses of sandy alluvium, Oliviers Berg 159 (Loc. 022).

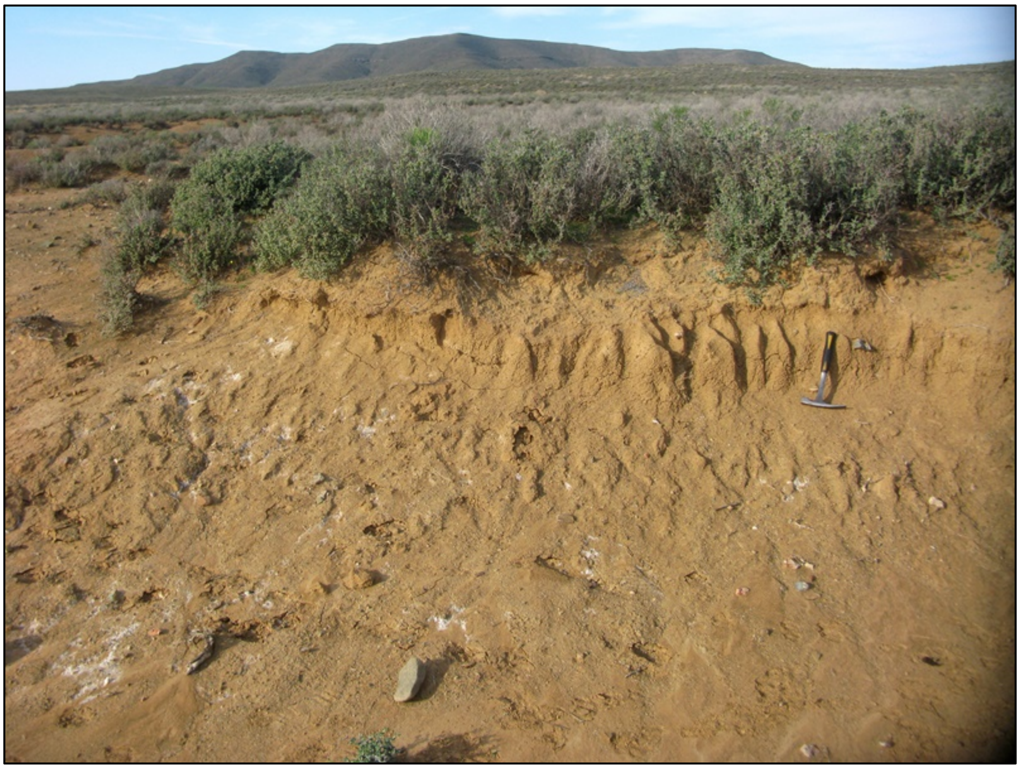

Figure 33. Erosion gulley exposures of Quaternary sandy alluvium showing local development of pale creamy subsurface calcrete, Uriasgatrivier (Loc. 058) (Hammer = 30 cm) (Loc. 058).

Figure 34. Subangular to well-rounded corestones of Abrahamskraal Formation wacke downwasted onto sandy soils along the crest of the central turbine ridge (Loc. 014).

Figure 35. Rubbly, angular surface gravels of wacke and volcanic tuff mantling flatter-lying areas along the southern turbine ridge near the wind mast (Loc. 108).

Figure 36. Thick, sandy colluvial debris with dispersed, angular wacke clasts exposed on lower valley slopes (Hammer = 30 cm). Some of these poorly-sorted deposits may have been emplaced by gravity-driven debris flows (Loc. 023).

1.3.2 Palaeontological heritage

In this section of the report fossil biotas recorded from the Abrahamskraal Formation and Late Caenozoic superficial sediments in the Klein Roggeveld region and elsewhere are outlined, together with new palaeontological data from the Kudusberg WEF project area itself.

Fossil biotas of the Lower Beaufort Group (Adelaide Subgroup)

Despite the scarcity of body fossil remains within the lowermost part of the succession, the overall palaeontological sensitivity of the Lower Beaufort Group sediments is generally rated as high to very high. This is due to the considerable scientific interest of fossils reflecting Middle Permian terrestrial ecosystems occurring here (*cf* Almond & Pether 2008b, SAHRIS palaeosensitivity map, Komsberg REDZ heritage assessment in Fourie *et al.* 2015).

A chronological series of mappable fossil biozones or assemblage zones (AZ), defined mainly by their characteristic tetrapod faunas, has been established for the Main Karoo Basin of South Africa (Rubidge 1995, 2005, Van der Walt *et al.* 2010, Smith *et al.* 2012). Maps showing the distribution of the Beaufort Group assemblage zones within the Main Karoo Basin have been provided by Keyser and Smith (1979) and Rubidge (1995, 2005). The latest Karoo fossil biozonation map (Van der Walt *et al.* 2010) assigns the lower Abrahamskraal Formation beds in the present study area, located on the south-western margins of the Lower Beaufort Group outcrop area, to the *Tapinocephalus* Assemblage Zone. However, recent magnetostratigraphic, radiometric and lithostratigraphic studies suggest that the Combrinkskraal Member *sensu lato* of the Abrahamskraal Formation belongs to the slightly older ***Eodicynodon* Assemblage Zone** of Middle Permian (Guadalupian / Wordian) age (*c*. 268-265 Ma) (Lanci *et al.* 2013, Day & Rubidge 2014, p. 233 and refs. therein).

Fossil biotas of the *Eodicynodon* Assemblage Zone have been summarized by Rubidge (1995) and more recently by Smith *et al.* (2012). This early Middle Permian biota is characterized by a limited variety of primitive therapsids, most notably the small dicynodont *Eodicynodon* (by far the commonest taxon), very rare large-bodied herbiovorous and carnivorous dinocephalians such as *Tapinocaninus* and anteosaurids, as well as equally rare gorgonopsians and scylacosaurid therocephalians (Fig. 37) (See also Rubidge & Oelofsen 1981, Rubidge 1987, Rubidge 1991, Rubidge *et al.* 1994, Rubidge 1995, Rubidge *et al.* 2000, Rubidge 2005, Govender 2002, Jinnah & Rubidge 2007, Abdala *et al.* 2008, Nicolas and Rubidge 2010). The fauna is of considerable biogeographic significance in that it includes some of the earliest and most primitive examples of several therapsid subgroups recorded anywhere in the world. Associated fossils include disarticulated palaeoniscoid fish and amphibians (rhinesuchid temnospondyls), freshwater bivalves *plus* a small range of invertebrate ichnogenera such as the arthropod trackway *Umfolozia*. Records of glossopterid “seed ferns” and the widely occurring sphenophyte ferns *Equisetum* and *Schizoneura* (Anderson & Anderson 1985, Rubidge *et al.* 2000) have recently been supplemented by spectacularly rich plant-insect Lagerstätte discovered within lacustrine deposits near Sutherland (Moyo *et al.* 2018, Prevec & Matiwane 2018, Davids *et al.* 2018). Petrified wood is apparently – and perhaps surprisingly - absent in the lowermost Beaufort Group, in contrast to the underlying Waterford Formation; it is unclear why this is so. Vertebrate fossils – especially identifiable, articulated specimens - tend to be very rare indeed in this biozone, as indicated by the fossil chart of Loock *et al.* (1994) as well as the fossil site maps of Keyser & Smith (1977-78) and of Nicolas (2007) (Fig. 38). The fossils are also typically difficult to extract from their resistant rock matrix. They are mainly found within overbank, lake margin mudrocks in association with small pedogenic calcrete nodules or - in the case of the dinocephalians - within or at the base of channel sandstones (Smith *et al.* 2012). Several casts of large (*c*. 15 cm wide), subhorizontal to gently-inclined, straight tetrapod burrows, in one case associated with unidentified, scrappy postcranial and tooth material, are reported by Almond (2016c) from the *Eodicynodon* AZ in the Brandvalley WEF project area situated just south of the present study area. The burrows reported there occur within the sandstone package along the crest of the Klein-Roggeveld Escarpment on Muishond Rivier 161 (possibly the Grootfontein Member of Day & Rubidge 2014). They may represent the oldest known tetrapod burrows reported from the Karoo Supergroup of South Africa (and even perhaps from Gondwana), although this claim remains to be confirmed.

No vertebrate body fossils (bones or teeth) were recorded from the Lower Abrahamskraal Formation in the Kudusberg WEF project area during the recent field survey, despite the availability here of several excellent bedrock exposures, some with well-developed pedogenic calcrete horizons. The marked scarcity of fossil tetrapods and woody plants combined with vertebrate burrowing might reflect environmentally-challenging conditions in the Karoo Basin in Middle Permian (Wordian) times. A few examples of sizeable (several dm diameter), subcylindrical sandstone bodies encased in mudrock that *might* represent vertebrate burrow casts were encountered here (Fig. 39). However, none of these show diagnostic burrow features (*e.g.* ventro-lateral scratch marks) and they are conservatively regarded as equivocal dubiofossils. A horizon of thin-bedded, dark grey mudstones of probable lacustrine origin exposed just below the crest of the central turbine ridge contains several dispersed to closely-spaced, subcylindrical burrow casts of lungfish (6-8 cm diameter; Fig. 40) (*cf* Hasiotis *et al.* 1993). Several occurrences of possible, but unconfirmed, sand-cast tetrapod burrows as well as probable lungfish burrows have recently been reported from the lower Abrahamskraal Formation - *i.e.* the Combrinkskraal *sensu lato* and Leeuvlei Members - in the Klein-Roggeveld region (*e.g.* Almond 2010c, 2015c, 2015d, 2016b, Odendaal & Loock 2015). Well-preserved trackways and swimming trails attributed to temnospondyl amphibians (or perhaps another tetrapod group) are reported from the lower Abrahamskraal Formation above and below the Great Escarpment near Sutherland (Almond 2016i). A washed-out sandstone palaeosurface on Oliviers Berg 159 (Loc. 029b) bears *possible* tetrapod limb impressions, but these are admittedly rather vague and require closer analysis. Low diversity invertebrate trace fossil assemblages of the *Scoyenia* ichnofacies – for the most part poorly-preserved horizontal and oblique burrows - occur widely in association with damp substrates such as the margins of lakes and water courses within the Lower Beaufort Group. They are seen, for example, on wave rippled palaeosurfaces and within channel sandstone packages at several localities on Oliviers Berg 159 and Gats Rivier 156 (Figs. 42 to 44).

The commonest plant fossils recorded from the Lower Abrahamskraal Formation - including the present field study - comprise dispersed to concentrated, fragmentary impressions of sphenophytes (horsetail ferns and their relatives) preserved within overbank mudrocks and on sandstone bed tops (*cf* Anderson & Anderson 1985, Rubidge *et al.* 2 000). They include segmented, striated stems of reedy horsetails (*Phyllotheca*) as well as strap-shaped, longitudinally-ridged leaves referred to the genus *Schizoneura*. Two distinctive forms of *Schizoneura* – probably *S. africana* and *S. gondwanensis* – are recorded within probable lacustrine facies on Matjes Fontein 194 (Figs. 45 & 46). Whorled leaves of the former species surrounding a vertical stem are occasional preserved *in situ*. The sphenophytes here, which also include an undescribed species of equisetalean (Dr R. Prevec, pers comm., 2018), occur in association with long-leaved lycopods (*cf Cyclodendron*) (Fig. 48) and other unidentified, reworked and probably partially-decomposed plant remains (Fig. 47). The plant fossils are preserved as secondarily mineralised compressions or low-relief moulds. Excavation of fresh material from this site may well yield better preserved plant specimens and perhaps an associated arthropod fauna (*cf* Moyo *et al.* 2018). Dense concentrations of small cylindrical, sandstone-infilled tubes commonly exposed in cross-section on bedding planes of flaggy sandstones probably represent stem casts of reedy swamp vegetation such as horsetails rather than *Skolithos* invertebrate dwelling burrows as commonly supposed.

The only fossil woody remains encountered in the Kudusberg WEF project area comprise poorly-preserved, ferruginised stem moulds up to a few cm in diameter that are associated with reworked, finely-striated sphenophytes and other unidentified plant debris. The fossil plant material is preserved within medium- to coarse-grained sandstones, on sandstone bedding planes, as well as associated with mudrock intraclast breccias within a yellowish-weathering, tabular-bedded sandstone package reminiscent of the Koornplaats Member (Figs. 49 & 50). The apparent absence, or at least great scarcity, of petrified (silicified) wood within the lowermost Abrahamskraal Formation is puzzling in view of the abundant well-preserved material seen within the underlying Waterford Formation (*cf* Almond 2016b). However, sandstone palaeosurfaces in the earliest Beaufort Group beds not infrequently bear large linear tool marks that are plausibly attributed to current-entrained logs. A good example is recorded from just outside the Kudusberg WEF study area on Klip Banks Fontein 395 (Almond 2010a). Spectacularly rich Middle Permian plant-insect assemblages of inferred Guadalupian (Roadian) age, including glossopterids, have recently been reported from the Sutherland area (Moyo *et al.* 2018, Prevec & Matiwane 2018, Davids *et al.* 2018).

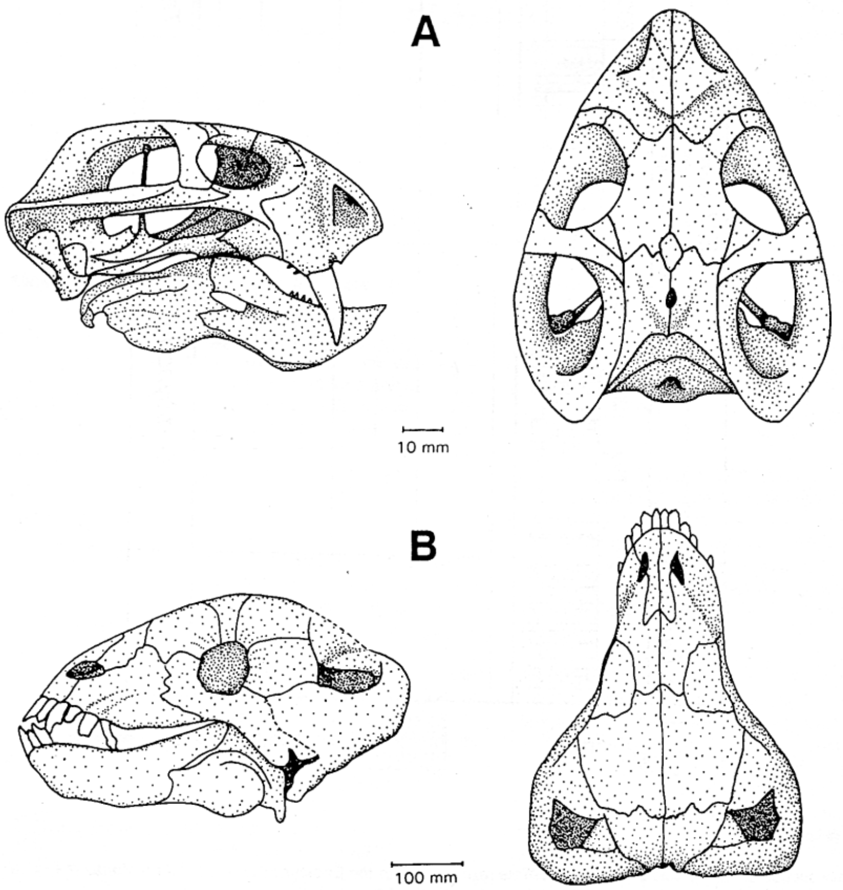

Figure 37. Skulls of two key fossil therapsids from the *Eodicynodon* Assemblage Zone: A – the small dicynodont *Eodicynodon*; B – the rhino-sized dinocephalian *Tapinocaninus* (From Rubidge 1995). Note that fossil vertebrate remains are very rare in sediments of this zone.

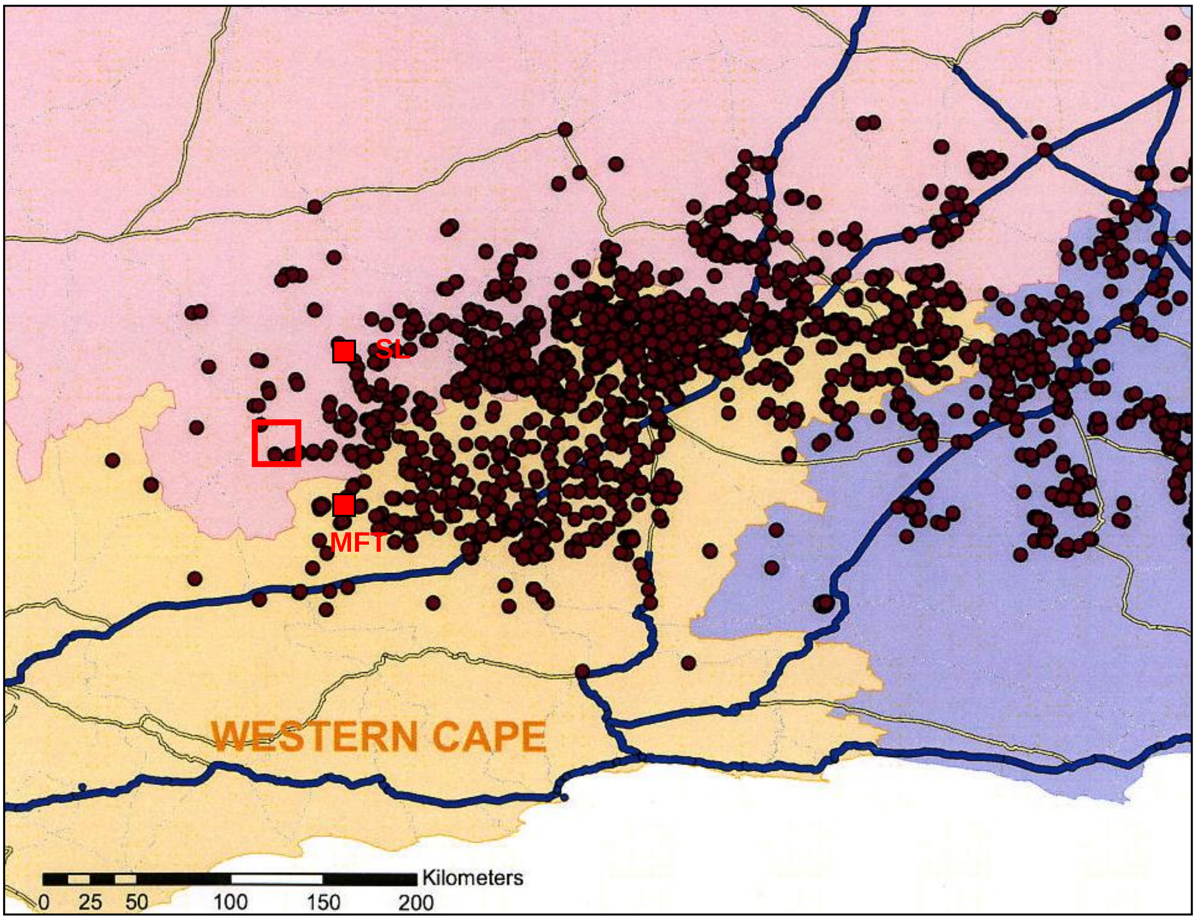

Figure 38. Distribution of recorded vertebrate fossil sites within the south-western portion of the Main Karoo Basin (modified from Nicolas 2007). The approximate location of the Kudusberg WEF study area is indicated by the open red square. Note the lack of known fossil sites in this part of the Karoo. SL = Sutherland. MFT = Matjiesfontein.

Fossils within Late Caenozoic superficial sediments

The diverse Late Caenozoic superficial deposits within the South African interior have been comparatively neglected in palaeontological terms. However, sediments associated with ancient drainage systems, springs and pans in particular may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises (*e.g.* Skead 1980, Klein 1984b, 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, Brink & Rossouw 2000, Rossouw 2006, De Ruiter *et al.* 2010, Backwell *et al.* 2017). Other late Caenozoic fossil biotas that may occur within these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites, invertebrate burrows, rhizocretions), 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 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.

No fossil remains were recorded within the Late Caenozoic superficial deposits within the Kudusberg WEF project area during the recent field survey.

Figure 39. Isolated subcylindrical sandstone body (to left of 30 cm-long hammer) enclosed in massive Abrahamskraal Formation overbank mudrock – *possibly* a large vertebrate burrow cast (unconfirmed) (Loc. 043).

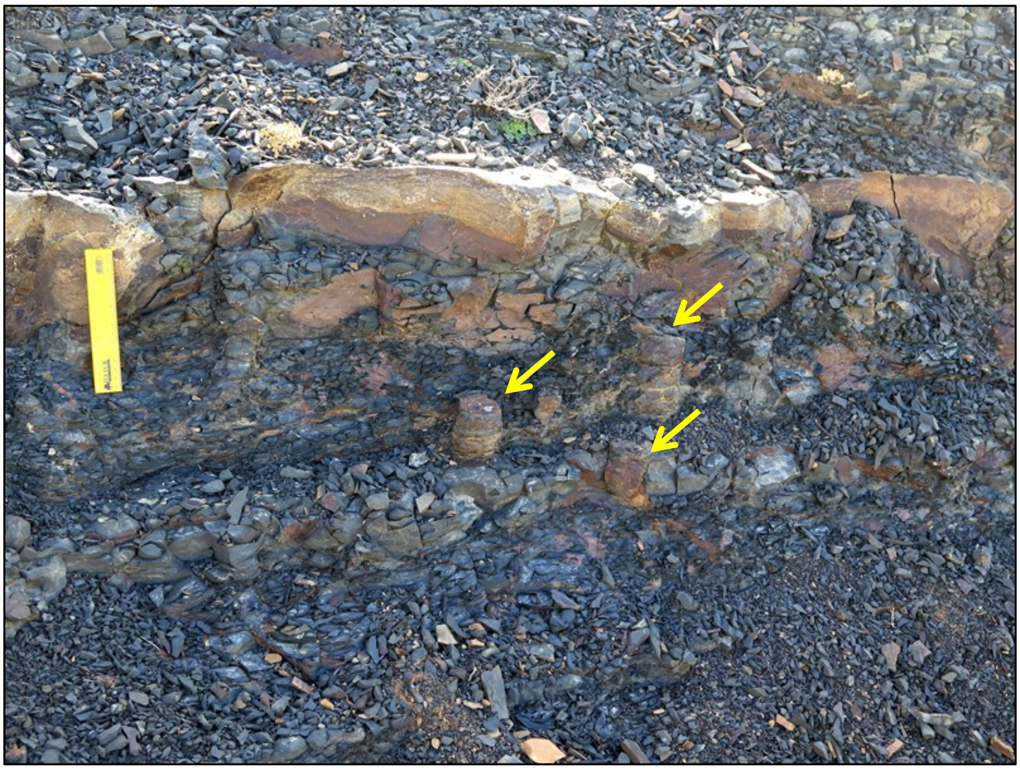

Figure 40. Array of vertical, subcylindrical casts of lungfish burrows (arrowed) within laminated dark grey lacustrine mudrocks underlying the ferruginised casting sandstone (Scale = 15 cm) (Loc. 135). This locality lies fairly close to the crest of the central turbine ridge crest but outside the development footprint (*cf* Figs. 41 & 52).

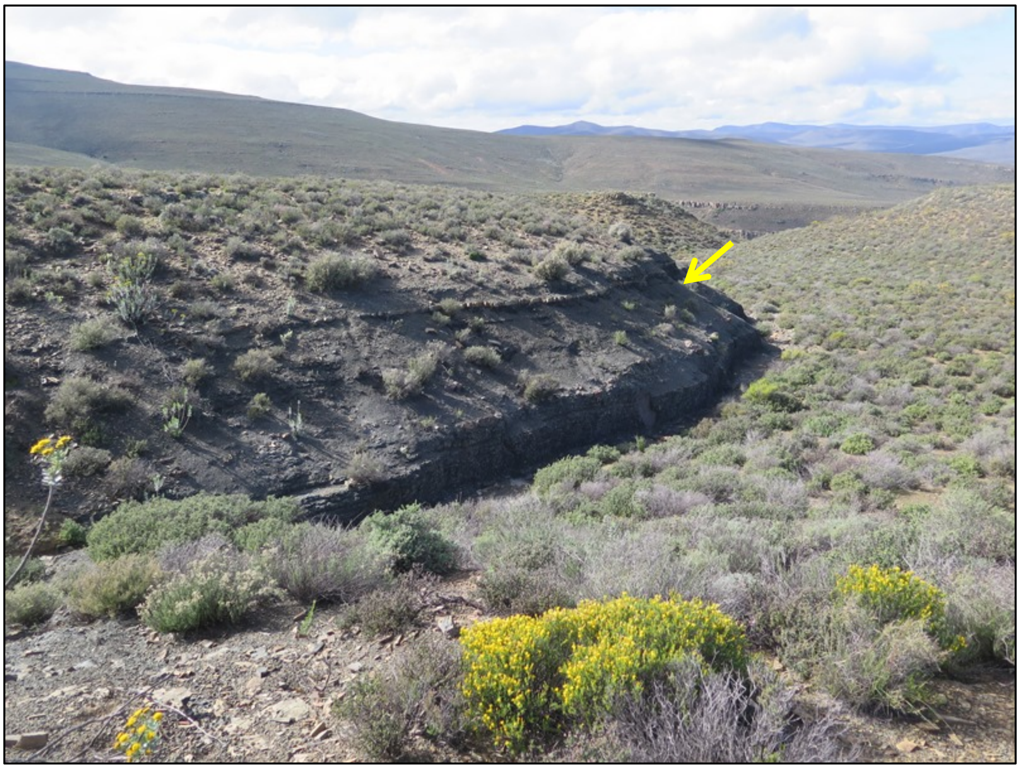

Figure 41. Geological setting of the fossil lungfish burrow assemblages seen in the previous figure (fossil horizon is arrowed), located close to the crest of the central turbine ridge (Loc. 135).

Figure 42. Pale (possibly tuffitic) speckled and laminated sandstone bed within the Abrahamskraal Formation showing dark cross-sections through infilled cylindrical invertebrate burrows (Scale in cm and mm) (Loc. 141).

Figure 43. Wave rippled sandstone bed top with poorly-preserved, silt-infilled, small-scale cylindrical burrows of the *Scoyenia* ichnofacies (Scale in cm and mm) (Loc. 103)

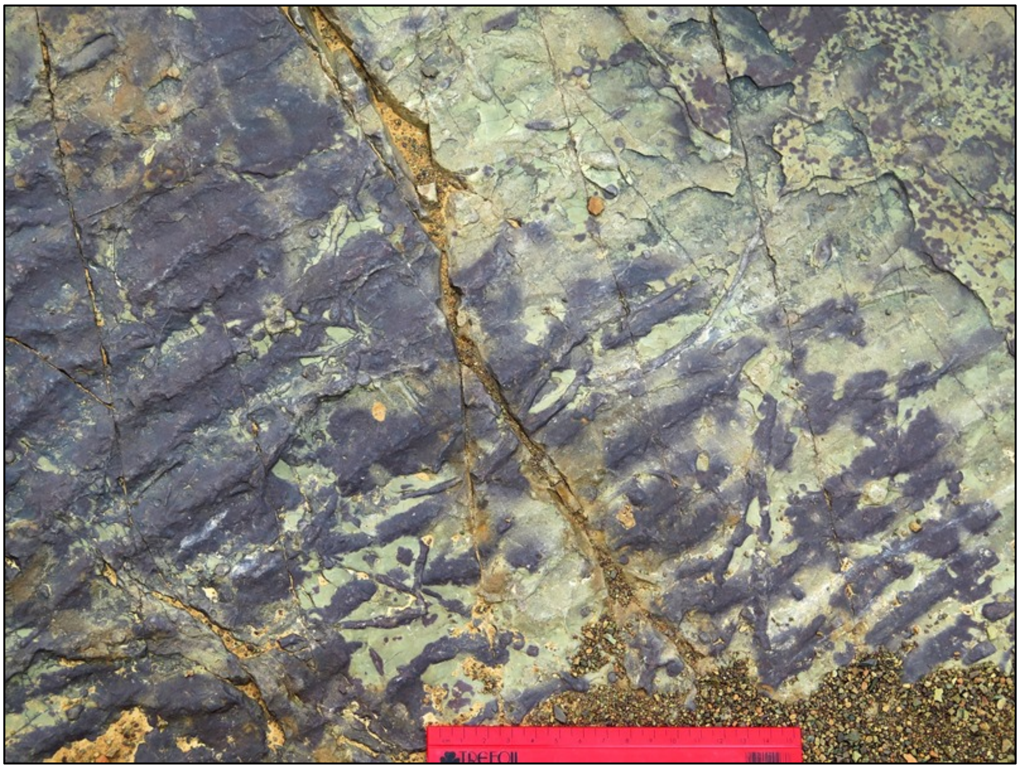

Figure 44. Wave-rippled sandstone bed top preserving straight to arcuate, subhorizontal invertebrate burrows (Scale in cm) (Loc. 103)

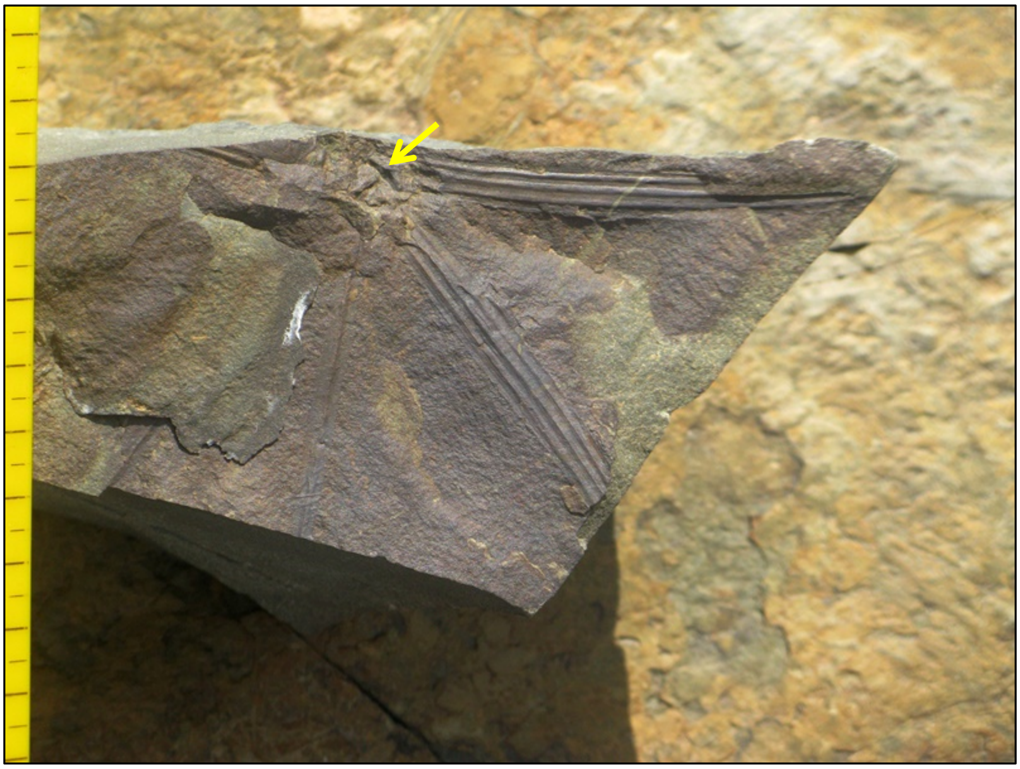

Figure 45. Float block of Abrahamskraal wacke preserving an *in situ* vertical stem cast (arrowed) and partial horizontal leaf whorl of the sphenophyte fern *Schizoneura africana* (Scale in cm) (Loc. 039).

Figure 46. Sandstone bed top with overlapping plant fossil moulds, possibly including the opposite-leaved sphenophyte fern *Schizoneura gondwanensis*. The longitudinally-striated leaves are c. 7 cm long (Loc. 039).

Figure 47. Partially mineralised compression or mould of a plant axis (possibly equisetalean) (Scale in cm) (Loc. 041).

Figure 48. Secondarily mineralised fossil mould within a dark grey wacke interpreted as a compressed, long-leaved lycopod such as *Cyclodendron*. The narrow, strap-shaped leaves are *c.* 7 cm long (Loc. 041).

Figure 49. Poorly-preserved, ferruginised moulds of woody stems associated with a mudrock intraclast breccia within a yellowish-brown sandstone package, Gats Rivier 156 (Loc. 143) (Scale = *c*. 15 cm). Similar preservation is common in the Koornplaats Member of the Abrahamskraal Formation.

Figure 50. Thin- to medium-bedded sandstone package containing reworked, fragmentary plant debris in association with tabular wackes and a thin intraclast breccia (at level of 30 cm-long hammer), Gats Rivier 143 (Loc. 143).

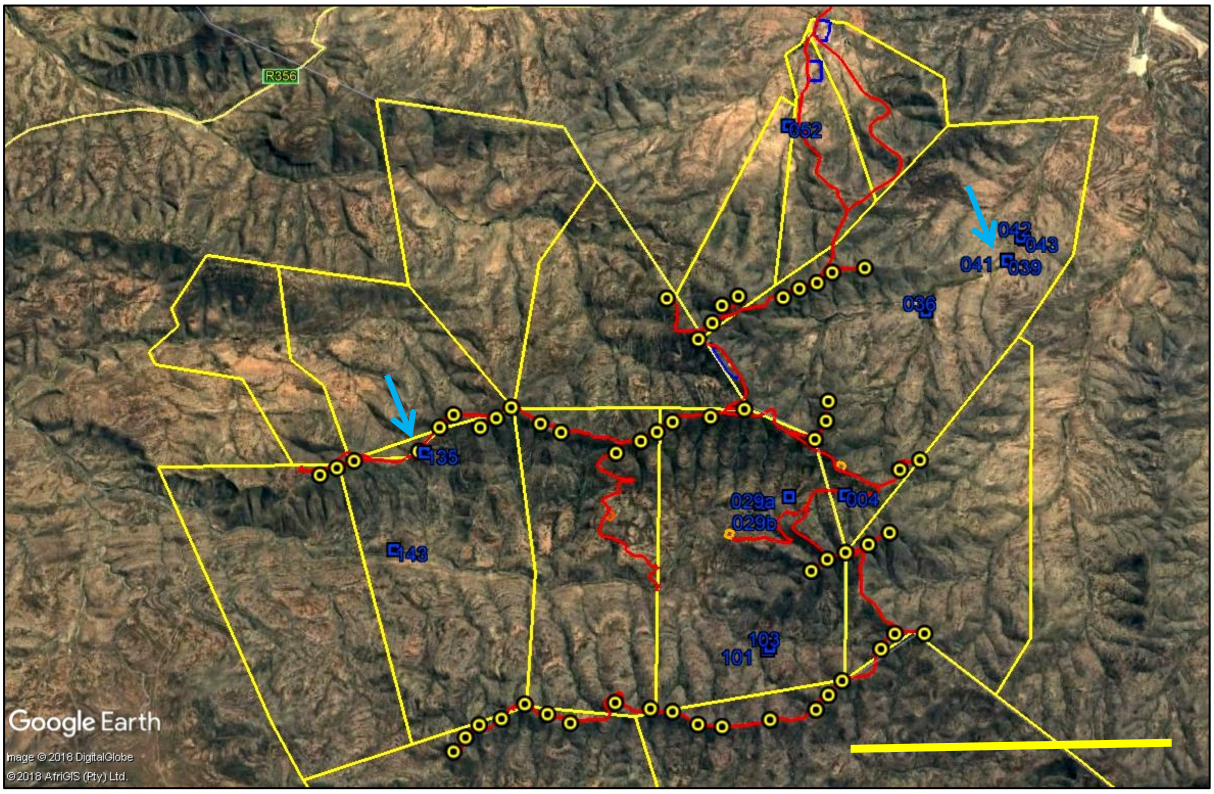

Figure 51. Google Earth© satellite image of the core Kudusberg WEF project area in the Klein Roggeveld region showing numbered fossil sites recorded during the field survey (blue) in relation to the proposed layout of wind turbines (yellow dots) and access roads (red lines). Note that (1) none of the identified sites lies directly within the development footprint and (2) the majority of sites are of low palaeontological heritage significance (Proposed Field Rating IIIC). Scientifically-important fossil plant and lung fish burrow sites (Locs. 038-041,135 &143) (Proposed Field Rating IIIA) as well as the *equivocal* vertebrate burrows and tracks (Locs. 29b, 042 & 043) all lie well outside (> 50 m) the proposed development footprint and do not require mitigation as part of the WEF development (See also Fig. 52 and locality details tabulated in Appendix 1). Scale bar = 7 km. N towards the top of the image.

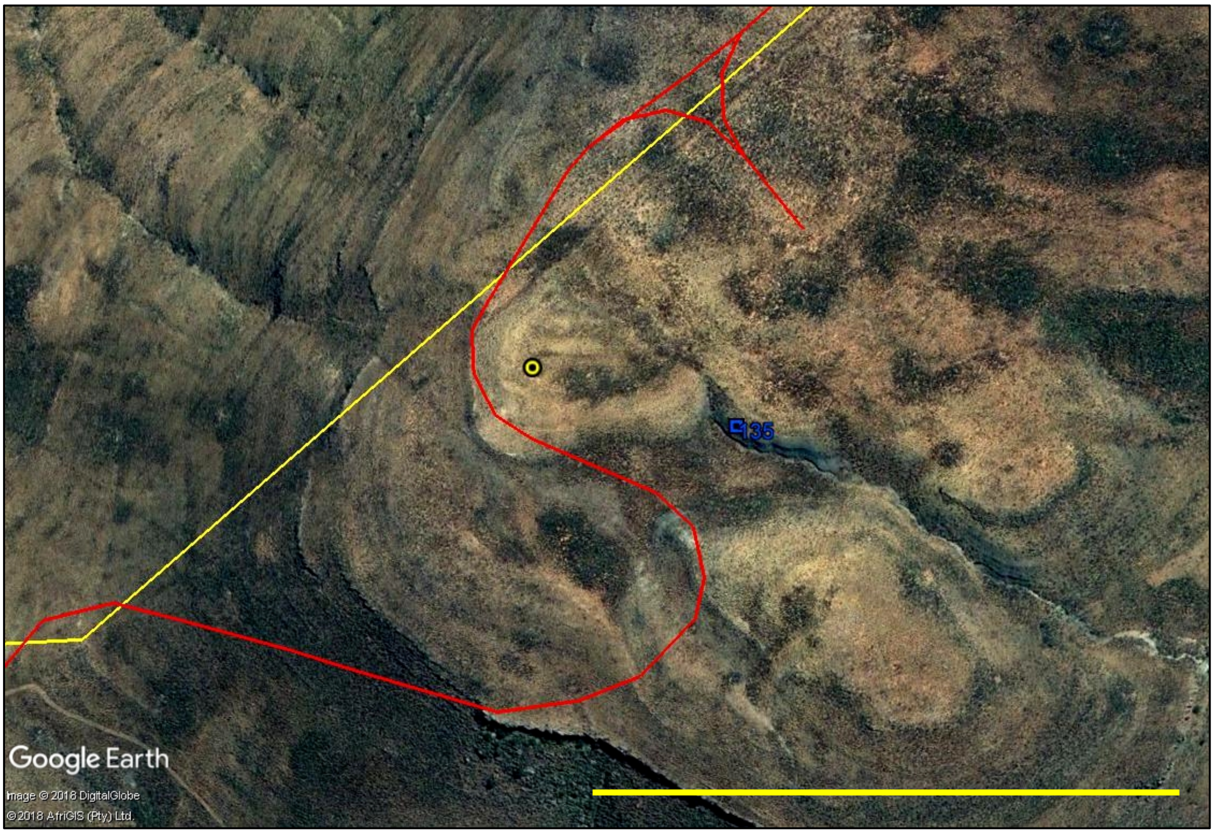

Figure 52. Close-up satellite image of fossil site Loc. 135 (assemblage of lungfish burrows within lacustrine mudrocks) situated close to the crest of the central turbine ridge on Gats Rivier 156. It lies in an erosion gulley over 50 m from the nearest proposed access road (red) and wind turbine position (yellow dot) (Fig. 41) and is therefore unlikely to be impacted by the WEF development. Mitigation is therefore not proposed for this site. Scale bar = 300 m. N towards the top of the image.

1.4 APPLICABLE LEGISLATION AND PERMIT REQUIREMENTS

The present combined desktop and field-based palaeontological heritage assessment report contributes to the consolidated heritage assessment for the proposed Kudusberg WEF and falls under the South African Heritage Resources Act (Act No. 25 of 1999). It will also inform the Environmental Management Programme (EMPr) for this alternative energy project (See Section 1.8).

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act include, among others:

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

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.
(2) All archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the

responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(4) No person may, without a permit issued by the responsible heritage resources authority—

(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;

(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;

(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;

(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and

(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have been published by SAHRA (2013).

Please note that:

- All South African fossil heritage is protected by law (South African Heritage Resources Act, 1999) and fossils cannot be collected, damaged or disturbed without a permit from the relevant Provincial Heritage Resources Agency (in this case Heritage Western Cape & SAHRA);
- Any mitigation recommendations made by the palaeontological specialist and approved by the relevant Heritage management Authority or Authorities must be incorporated into the Environmental Management Program (EMPr) for the Kudusberg WEF alternative energy project;
- The suitably qualified palaeontologist concerned with potential mitigation work will need a valid fossil collection permit from Heritage Western Cape / SAHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection);
- All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies developed by SAHRA (2013).

1.5 IDENTIFICATION OF KEY ISSUES

1.5.1 Key Issues Identified

The proposed Kudusberg WEF study area is located in a region of the Great Karoo that is underlain by potentially-fossiliferous sedimentary rocks of Late Palaeozoic and younger, Late Tertiary or Quaternary, age. In particular, these include (1) Middle Permian continental deposits of the Abrahamskraal Formation (Lower Beaufort Group, Karoo Supergroup) that may contain scientifically important fossils of Permian vertebrates and terrestrial plants as well as (2) Late Caenozoic alluvium that may contain important mammalian remains such as teeth and bones (These rock units and fossils are described in more detail in Section 1.3 of this report).

The high palaeontological heritage sensitivity of the Palaeozoic bedrocks in the Komsberg REDZ2 focus area has been emphasized by Fourie *et al.* (2015) as well as on the SAHRIS palaeosensitivity map maintained by SAHRA.

The construction phase of the proposed WEF will entail extensive surface clearance as well as excavations into the superficial sediment cover and underlying bedrock, *e.g.* for new access roads, wind turbine placements, on-site substation, underground cables, laydown areas and construction yards. Construction of the WEF may adversely affect potential fossil heritage within the development footprint by damaging, destroying, disturbing or permanently sealing-in fossils preserved at or beneath the surface of the ground that are then no longer available for scientific research or other public good. The planning, operational and de-commissioning phases of the WEF are unlikely to involve further adverse impacts on local palaeontological heritage and are therefore not separately assessed in this report.

1.5.2 Identification of Potential Impacts

The potential impacts identified during the PIA assessment are as follows:

1.5.3 Construction Phase

Potential Impact 1: Disturbance, damage or destruction of fossil heritage resources preserved at or below the ground due to ground clearance and excavations

1.5.4 Operational Phase

No significant impacts on palaeontological heritage anticipated.

1.5.5 Decommissioning Phase

No significant impacts on palaeontological heritage anticipated

1.5.6 Cumulative impacts

Cumulative impact 1: Potential loss of a significant fraction of fossil heritage preserved within the lower Abrahamskraal Formation of the SW Karoo through multiple wind farm developments in the Klein Roggeveld – Sutherland region.

1.6 ASSESSMENT OF IMPACTS AND IDENTIFICATION OF MANAGEMENT ACTIONS

1.6.1 Results of the Field Study

A desktop review of the palaeontology of the Middle Permian Abrahamskraal Formation in the Klein Roggeveld, including several palaeontological heritage impact assessments for WEF and other developments in the region, shows that well-preserved fossil remains are generally scarce in this sector of the Great Karoo. However, several scientifically important occurrences of vertebrate bones, teeth, burrows and trackways are recorded here, as well as rare petrified wood and plant-rich lacustrine beds with diverse associated insect faunas (Section 1.3). A six-day palaeontological survey of numerous exposures of Abrahamskraal Formation bedrocks as well as Late Caenozoic superficial sediments within the Kudusberg WEF project area (Appendix 1) suggests that fossils are also rare here, although the local occurrence of important fossil remains in the subsurface obviously cannot be excluded. The fossils observed mainly comprise horizons with reworked, fragmentary vascular plants as well as low-diversity trace fossil assemblages that are of low conservation and research interest. Scientifically-important fossil plant and lung fish burrow sites occur at Locs. 038-041,135 &143 (See Appendix 1). No fossil vertebrates were recorded, but a few occurrences of *equivocal* vertebrate burrows and poorly-preserved tetrapod tracks were found (Locs. 29b, 042 & 043). None of the recorded fossil sites lies within the proposed WEF footprint (Appendix 1 and Figs. 51 & 52) and they should not be threatened by the proposed development. The Permian bedrocks are mostly mantled with Late Caenozoic colluvial and alluvial deposits as well as surface gravels and gravelly soils. This applies to the great majority of the ridge crests where the wind turbines will be situated as well as to the footprints of the access roads and various site options for the on-site substation and construction yards (Figs. 2 and 3).

1.6.1.1 Assessment of impacts on fossil heritage

The potential impact of the proposed Kudusberg WEF development (*revised* layout of October 2018) on local fossil heritage resources is evaluated here and summarized in Table 1 below (Section 1.7). This assessment applies only to the construction phase of the WEF development since further significant impacts on fossil heritage during the planning, operational and decommissioning phases of the WEF are not anticipated. The assessment applies to the key infrastructure described in Section 1.2 that will be situated within the main WEF project area, as shown in Figures 2 and 3, *i.e.* wind turbines, access roads, on-site substation, underground cables and 33 kV transmission lines, construction yard(s) and associated infrastructure. A separate Basic Assessment processes will be undertaken to assess the connection of the WEF to the national grid.

1.6.2 Disturbance, damage or destruction of fossils (Construction Phase)

The destruction, damage or disturbance out of context of legally-protected fossils preserved at the ground surface or below ground that may occur during construction of the WEF entail *direct negative* impacts to palaeontological heritage resources that are confined to the development footprint (*site specific*). These impacts can often be mitigated but cannot be fully rectified (*i.e.* they are *permanent / non-reversible*). All of the sedimentary formations represented within the study area contain fossils of some sort, so impacts at some level on fossil heritage are definite. However, most (but not all) of the fossils concerned are probably of widespread occurrence elsewhere within the outcrop areas of the formations concerned (*low irreplaceability*), while unique, well-preserved fossils are rare in this region of the Karoo. The probability of loss of *unique or rare, scientifically-important fossil heritage* is therefore rated as *very unlikely*. Because of the generally sparse occurrence of scientifically important, well-preserved, unique or rare fossil material within the bedrock formations concerned here - notably those underlying the proposed wind turbine sites and access roads - as well as within the overlying superficial sediments (soil, alluvium, colluvium etc), the consequence of the anticipated palaeontological impacts is conservatively rated as *slight*.

As a consequence of (1) the paucity of irreplaceable, unique or rare fossil remains within the development footprint, as well as (2) the extensive superficial sediment cover overlying most potentially-fossiliferous bedrocks within the Kudusberg WEF study area, **the overall impact significance of the construction phase of the proposed wind energy project is assessed as *VERY LOW* (*negative status*).** This assessment applies to the wind turbines, laydown areas, access roads (including both alternatives on Urias Gat 193), on-site substation (all three site options), construction camps (all three site options) and associated infrastructure within the WEF project area. A comparable very low impact significance is inferred for all project infrastructure alternatives and layout options under consideration that are outlined in Section 1.2 and Figures 2 and 3, including different options for routing of access roads, turbine layouts and siting of construction camp(s) and the on-site substation. **There are no preferences on palaeontological heritage grounds for any particular layout among the various options under consideration.**

1.6.2.1 Proposed monitoring and mitigation

Since scientifically valuable fossils are rare within the Kudusberg WEF project area and none of the recorded fossil sites lie within the development footprint (Figs. 51 & 52), no specialist palaeontological monitoring or mitigation is recommended for this development, pending the potential discovery of significant new fossil material here during the construction phase.

The ECO should be made aware of the possibility of important fossil remains (bones, teeth, petrified wood, plant-rich horizons *etc*) being found or unearthed during the construction phase. Monitoring of all major surface clearance and deeper (> 1m) excavations for fossil material by the Environmental Site Officer on an on-going basis during the construction phase is therefore recommended. Significant fossil finds should be safeguarded and reported at the earliest opportunity to Heritage Western Cape (Western Cape sites) or SAHRA (Northern Cape sites) for recording and sampling by a professional palaeontologist. A protocol for Chance Fossil Finds is appended to this report. These recommendations must be included within the EMPr for the Kudusberg WEF development.

Provided that the recommended monitoring and mitigation measures outlined here and tabulated in Section 1.8 (Table 2) are followed through, residual impacts for the Kudusberg WEF are rated as *very low.* Inevitable loss of some fossil heritage during the construction phase may be - at least partially - offset by an improved understanding of local palaeontological heritage through professional recording and mitigation of any significant new fossil finds (*positive* impact).

No significant further impacts on fossil heritage are anticipated during the operational and decommissioning phases of the WEF. The no-go alternative (*i.e.* no WEF development) will have a neutral impact on palaeontological heritage.

There are no fatal flaws in the Kudusberg WEF development proposal as far as fossil heritage is concerned. *Provided that* the proposed recommendations for palaeontological monitoring and mitigation are fully implemented, there are no objections on palaeontological heritage grounds to authorization of the Kudusberg WEF project.

Due to the generally low levels of bedrock exposure within the study area and the unavoidably superficial, reconnaissance level of the brief field assessment of the extensive study area, confidence levels for this palaeontological heritage assessment are only moderate (*medium*). These conclusions are supported, however, by several previous palaeontological field assessments undertaken in the broader Klein Roggeveld region by the author (See References and following discussion on cumulative impacts).

1.6.2.2 Cumulative Impacts

Cumulative impacts addressed here concern the *potential* loss of a significant fraction of scientifically valuable fossil heritage preserved within the lower Abrahamskraal Formation of the SW Karoo through multiple alternative energy developments in the Klein Roggeveld – Sutherland region.

Cumulative impacts inferred for the various alternative energy developments in the Klein-Roggeveld region between Matjiesfontein and Sutherland have been assessed here based on desktop and field-based palaeontological impact assessment reports for these projects, the great majority of which were submitted by the present author (See projects listed in the text below, Table 1 and references provided below under Almond and SAHRIS website). Several of the projects concerned lie within a radius of some 50-70 km of the proposed Kudusberg WEF project area (Fig. 53) Relevant published palaeontological literature for the region has also been taken into account (*e.g.* Loock *et al.* 1994, Day & Rubidge 2014). This assessment applies only to the construction phases of the WEF developments, since significant additional impacts on palaeontological heritage during the operational and de-commissioning phases are not anticipated.

It should be emphasized that, in the case of palaeontological heritage, it only makes sense to consider cumulative impacts on *comparable fossil assemblages* present in the same formations that are represented in the present study area as well as in the broader study region. For example, impacts on Early Permian aquatic fossil invertebrates in the Whitehill Formation (Ecca Group) that crops out in WEF project areas to the southwest of the Kudusberg WEF study area are not directly relevant to - or cannot be weighed against - impacts on Middle Permian fossil assemblages of terrestrial vertebrates in the Lower Beaufort Group that is represented in the present study area. The analysis in Table 2 is therefore restricted to considering cumulative impacts on fossil heritage preserved within rock units and fossil assemblages that are represented in the Kudusberg WEF study area as well as in nearby project areas – specifically the lower Abrahamskraal Formation (*Eodicynodon* Assemblage Zone – See Section 1.3). Since potentially-fossiliferous consolidated Late Caenozoic alluvial deposits will normally not be impacted in WEF developments because they usually lie along well-buffered drainage lines they are not considered for the purpose of this analysis.

WEF projects in the SW Karoo close to the Kudusberg WEF project area that share comparable fossil assemblages in the lower Abrahamskraal Formation include the following: Kareebosch WEF (Almond 2014), Karusa WEF (Almond 2015c), Rietkloof WEF (Almond 2016b), Brandvalley WEF (Almond 2016c), Esizayo WEF (Almond 2016f), Maralla West WEF (Almond 2016h) and Maralla East WEF (Almond 2016i). Additional PIAs (palaeontological impact assessments) of relevance include those for the Eskom Gamma-Omega 765kV transmission line (Almond 2010a) and the Komsberg Substation (Almond 2015b). Other WEF projects in the wider region, such as the Perdekraal East WEF (Almond 2015a), Soetwater WEF (Almond 2015d), Gunsfontein WEF (Almond 2015g), Komsberg West WEF (Almond 2015f), Komsberg East WEF (Almond 2015e), Sutherland WEF (Almond 2010c), Suurplaat WEF (Almond 2010b) and the Great Karoo WEF (for which no field-based palaeontological study was done) are underlain by younger rocks within the Lower Beaufort Group, or by much older Dwyka Group and Ecca Group rocks. These successions contain different, significantly older or younger fossil assemblages and so are not relevant to the present cumulative impact assessment. This also applies to further alternative energy facilities within the Cape Fold Belt near Touwsrivier and Laingsburg, such as the Konstabel WEF (Almond 2010d) and the Witberg WEF (Hart & Miller 2010) which are underlain by older bedrocks, as well as to solar energy facilities above the Great Escarpment near Sutherland that overlie younger portions of the Abrahamskraal Formation.

In all the strictly *relevant* field-based palaeontological studies listed above the palaeontological sensitivity of the project area and the palaeontological heritage impact significance for the developments concerned has been rated as *low*. In all cases it was concluded by the author that, despite the undoubted occurrence of scientifically-important fossil remains (notably fossil vertebrates, vertebrate trackways and burrows, petrified wood and – as more recently discovered – rich lacustrine plant-insect assemblages), the overall impact significance of the proposed developments was low because the probability of significant impacts on *scientifically important, unique or rare fossils* was slight. While fossils do indeed occur within most of the formations present, they tend to be sparse – especially as far as fossil vertebrates are concerned - while the great majority represent common forms that occur widely within the outcrop areas of the rock units concerned. Important exceptions include (1) rich horizons of fossil plants and associated insect faunas from lacustrine beds (Prevec & Matiwane 2018) and (2) vertebrate burrows attributed to small therapsids, and also to lungfish (Almond 2016b, Almond 2016c). Well-preserved vertebrate trackways made by temnospondyl amphibians or other, unidentified tetrapods that have been found both above and below the Great Escarpment near Sutherland (Almond 2016e) are not really relevant here because they occur within significantly younger sediments of the Lower Beaufort Group.

Cumulative impacts for the Kudusberg WEF in the context of comparable alternative energy projects proposed or authorised in the Klein-Roggeveld region are assessed in Table 2. **It is concluded that the cumulative impact significance of the Kudusberg WEF and other regional projects is *very low* (*negative*), *provided that* the proposed monitoring and mitigation recommendations made for all**

these various projects are followed through. Unavoidable residual negative impacts may be partially offset by the improved understanding of Karoo palaeontology resulting from appropriate professional mitigation. This is regarded as a *positive* impact for Karoo palaeontological heritage. However, *without* mitigation the magnitude or consequence of cumulative (negative, direct) impacts of such a large number of WEFs affecting the same (albeit sparsely) fossiliferous rock successions would be significantly higher (*moderate consequence*) and probable (*likely*). The cumulative impact significance without mitigation is accordingly assessed as low.

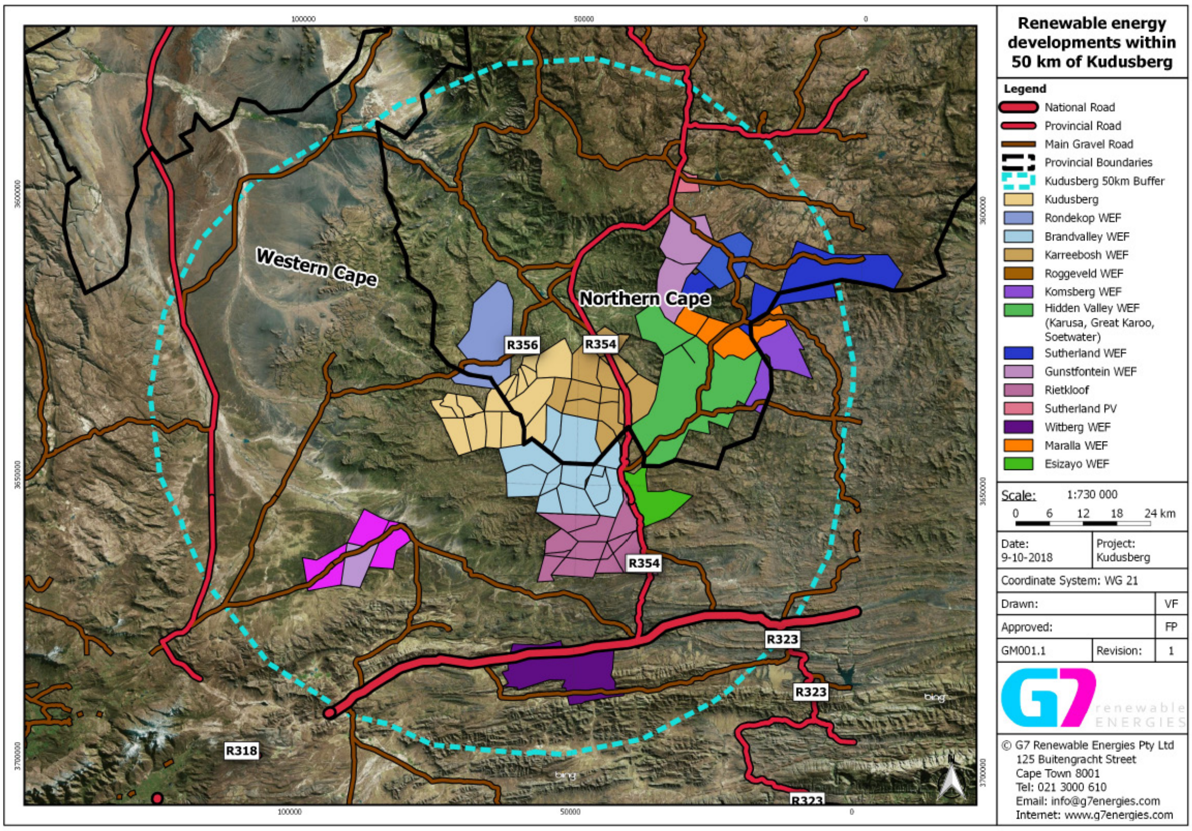

Figure 53. Map of the Klein Roggeveld region, SW Great Karoo, showing project areas for the numerous WEF developments proposed within a c. 50 km radius of the Kudusberg WEF project area (*N.B.* not all these developments have been approved) (Image provided by the G7 Renewable Energies (G7)).

Table 1.List of other WEF projects within a 50 km radius of the proposed Kudusberg WEF site:

DEA REFERENCE NUMBER	EIA PROCESS	APPLICANT	PROJECT TITLE	EAP	TECHNOLOGY	MEGAWATT	STATUS
WIND PROJECTS							
14/12/16/3/3/2/967	Scoping and EIA	Biotherm Energy (Pty) Ltd	Proposed 140 MW Esizayo Wind Energy Facility and its associated infrastructure near Laingsburg within the Laingsburg Local Municipality in the Western Cape	WSP/Parsons Brinckerhoff	Wind	140 MW	Approved
East -14/12/16/3/3/2/962 West- 14/12/16/3/3/2/693	Scoping and EIA	Biotherm Energy (Pty) Ltd	East: Proposed 140 MW Maralla West Wind Energy Facility on the remainder of the farm Welgemoed 268, the remainder of the farm Schalkwykskraal 204 and the remainder of the farm Drie Roode Heuvels 180 north of the town of Laingsburg within the Laingsburg and Karoo Hoodland Local Municipalities in the Western and Northern Cape Provinces	WSP/Parsons Brinckerhoff	Wind	140 MW	Approved

DEA REFERENCE NUMBER	EIA PROCESS	APPLICANT	PROJECT TITLE	EAP	TECHNOLOGY	MEGAWATT	STATUS
			West: Proposed 140 MW Maralla West Wind Energy Facility on the remainder of the Farm Drie Roode Heuvels 180, the remainder of the farm Annex Drie Roode Heuvels 181, portion 1 of the farm Wolven Hoek 182 and portion 2 of the farm Wolven Hoek 182 north of the town of Laingsburg within the Karoo Hoodland Local Municipality in the Northern Cape Province				
12/12/20/1966/AM5	Amendment	Witberg Wind Power (Pty) Ltd	Proposed establishment of the Witberg Wind Energy Facility, Laingsburg Local Municipality, Western Cape Province	Environmental Resource Management (Pty) Ltd / Savannah Environmental Consultants (Pty) Ltd	Wind	140 MW	Approved
12/12/20/1783/2/AM1	Scoping and EIA	South Africa Mainstream Renewable Power Perdekraal West (Pty) Ltd	Proposed development of a Renewable Energy Facility (Wind) at the Perdekraal Site 2, Western Cape Province	Environmental Resource Management (Pty) Ltd	Wind	110 MW	Under construction
12/12/20/1783/1	Scoping and EIA	South Africa Mainstream Renewable Power Perdekraal East (Pty) Ltd	Proposed development of a Renewable Energy Facility (Wind) at the Perdekraal Site 2, Western Cape Province	Savannah Environmental Consultants (Pty) Ltd	Wind	150 MW	Approved
14/12/16/3/3/2/899	Scoping and EIA	Rietkloof Wind Farm (Pty) Ltd	Proposed Rietkloof Wind Energy (36 MW) Facility within the Laingsburg Local	EOH Coastal & Environmental Services	Wind	36 MW	Approved

DEA REFERENCE NUMBER	EIA PROCESS	APPLICANT	PROJECT TITLE	EAP	TECHNOLOGY	MEGAWATT	STATUS
			Municipality in the Western Cape Province				
TBC	BA		Proposed Rietkloof Wind Energy Facility, Western Cape, South Africa	WSP	Wind	140 MW	In progress
14/12/16/3/3/2/826	Scoping and EIA	Gunstfontein Wind Farm (Pty) Ltd	Proposed 200 MW Gunstfontein Wind Energy Facility on the Remainder of Farm Gunstfontein 131 south of the town of Sutherland within the Karoo Hooglands Local Municipality in the Northern Cape Province, south of Sutherland.	Savannah Environmental Consultants (Pty) Ltd	Wind	200 W	Approved
12/12/20/1782/AM2	Scoping and EIA	Mainstream Power Sutherland	Proposed development of 140 MW Sutherland Wind Energy Facility, Sutherland, Northern and Western Cape Provinces	CSIR	Wind	140 MW	Approved
Karusa - 12/12/20/2370/1 Soetwater -12/12/20/2370/2	Scoping and EIA	African Clean Energy Developments Renewables Hidden Valley (Pty) Ltd	Proposed Hidden Valley Wind Energy Facility on a site south of Sutherland, Northern Cape Provinces (Karusa & Soetwater)	Savannah Environmental Consultants (Pty) Ltd	Wind	140 MW each	Preferred bidders. Construction to commence in 2019
12/12/20/2370/3	Scoping and EIA	African Clean Energy Developments Renewables Hidden Valley (Pty) Ltd	Proposed Hidden Valley Wind Energy Facility on a site south of Sutherland, Northern Cape Provinces (Greater Karoo))	Savannah Environmental Consultants (Pty) Ltd	Wind	140 MW	Approved
West -14/12/16/3/3/2/856 East - 14/12/16/3/3/2/857	Scoping and EIA	Komsberg Wind Farm (Pty) Ltd	Proposed 275 MW Komsberg West Wind Energy Facility near Sutherland within the Northern and Western Cape Provinces	Savannah Environmental Consultants (Pty) Ltd	Wind	140 MW each	Approved

DEA REFERENCE NUMBER	EIA PROCESS	APPLICANT	PROJECT TITLE	EAP	TECHNOLOGY	MEGAWATT	STATUS
			Proposed 275 MW Komsberg East Wind Energy Facility near Sutherland within the Northern and Western Cape Provinces				
12/12/20/1988/1/AM1	Amendment	Roggeveld Wind Power (Pty) Ltd	Proposed Construction of the 140 MW Roggeveld Wind Farm within the Karoo Hoogland Local Municipality and the Laingsburg Local Municipality in the Western and Northern Cape Provinces	Savannah Environmental Consultants (Pty) Ltd	Wind	140 MW	Preferred bidders. Construction to commence in 2019.
14/12/16/3/3/2/807/AM1	Scoping and EIA Amendment	Karreebosch Wind Farm (Pty) Ltd	Proposed Karreebosch Wind Farm (Roggeveld Phase 2) and its associated infrastructure within the Karoo Hoogland and Laingsburg Local Municipalities in the Northern and Western Cape Provinces	Savannah Environmental Consultants (Pty) Ltd	Wind	140 MW	Approved
14/12/16/3/3/2/900	Scoping and EIA	Brandvalley Wind Farm (Pty) Ltd	Proposed 147 MW Brandvalley Wind Energy Facility North of the Town of Matjiesfontein within the Karoo Hoogland, Witzenberg and Laingsburg Local Municipalities in the Northern and Western Cape Provinces	EOH Coastal & Environmental Services	Wind	140 MW	Approved
TBA	Scoping and EIA	Rondekop Wind Farm (Pty) Ltd	Proposed establishment of the Rondekop WEF, south-west of Sutherland in the Northern Cape	SiVEST SA (Pty) Ltd	Wind	325 MW	In process
West 14/12/16/3/3/2/856 East 14/12/16/3/3/2/857	Scoping and EIA	Komsberg Wind Farms (Pty) Ltd	Komsberg East and West WEF	Arcus Consulting Services (pty) Ltd	Wind	140 MW each	

DEA REFERENCE NUMBER	EIA PROCESS	APPLICANT	PROJECT TITLE	EAP	TECHNOLOGY	MEGAWATT	STATUS
TBC	BA	ENERTRAG SA (Pty) Ltd	Proposed Development of the Tooverberg Wind Energy Facility and the associated grid connection near Touws River, Western Cape Province)	SiVEST SA (Pty) Ltd	Wind	140 MW	In process
SOLAR PROJECTS							
12/12/20/2235	BA	Inca Sutherland Solar (Pty) Ltd	Proposed Photovoltaic (PV) Solar Energy Facility on A Site South Of Sutherland, Within The Karoo Hoogland Municipality Of The Namakwa District Municipality, Northern Cape Province	CSIR	Solar	10 MW	Approved

1.7 IMPACT ASSESSMENT SUMMARY

Potential impacts on palaeontological heritage are assessed below in Table 2 for the construction phase of the Kudusberg WEF. Further significant impacts on fossil heritage during the operational and decommissioning phases of the WEF are not anticipated. Cumulative impacts in the context of comparable WEF developments in the Klein Roggeveld region (< 50 km radius) are assessed in Table 2.

Table 2. Impact assessment summary table for the Construction Phase:

Impact pathway	Nature of potential impact/risk	Status[1]	Extent[2]	Duration[3]	Consequence	Probability	Reversibility of impact	Irreplace-ability of receiving environment/ resource	Significance of impact/risk = consequence x probability (before mitigation)	Can impact be avoided?	Can impact be managed or mitigated?	Potential mitigation measures	Significance of residual risk/ impact (after mitigation)	Ranking of impact/ risk	Confidence level
PALAEONTOLOGICAL HERITAGE															
CONSTRUCTION PHASE															
Direct Impacts															
Surface clearance & excavations	Disturbance, damage or destruction of fossils	Negative	Site specific	Perma-nent	Slight	Unlikely	Non-reversible	Low	Very low	No	Yes	Monitoring of major excavations for fossil material by the ESO on an on-going basis during construction phase. Significant fossil finds to be reported to Heritage Western Cape (Western Cape sites) or SAHRA (Northern Cape sites) for recording and sampling by a professional palaeontologist	Very low	5	Medium

[1] Status: Positive (+) ; Negative (-)
[2] Site; Local (<10 km); Regional (<100); National; International
[3] Very short-term (instantaneous); Short-term (<1yr); Medium-term (1-10 years); Long-term (project duration); Permanent (beyond project decommissioning)

Table 3. Cumulative impact assessment summary table

Impact pathway	Nature of potential impact/risk	Status[4]	Extent[5]	Duration[6]	Consequence	Probability	Reversibility of impact	Irreplace-ability of receiving environment/ resource	Significance of impact/risk = consequence x probability (before mitigation)	Can impact be avoided?	Can impact be managed or mitigated?	Potential mitigation measures	Significance of residual risk/ impact (after mitigation)	Ranking of impact/ risk	Confidence level
PALAEONTOLOGICAL HERITAGE															
CONSTRUCTION PHASE															
Direct Impacts															
Surface clearance & bedrock excavations	Disturbance, damage or destruction of significant fraction of fossil heritage within the lower Abrahamskraal Formation (Karoo Supergroup)	Negative	Regional	Perma-nent	Slight	Unlikely	Non-reversible	Low	Very Low	No	Yes	Monitoring of major excavations for fossil material by the ESO on an on-going basis during construction phase. Significant fossil finds to be reported to Heritage Western Cape (Western Cape sites) or SAHRA (Northern Cape sites) for recording and sampling by a professional palaeontologist	Very Low	5	Medium

[4] Status: Positive (+) ; Negative (-)
[5] Site; Local (<10 km); Regional (<100); National; International
[6] Very short-term (instantaneous); Short-term (<1yr); Medium-term (1-10 years); Long-term (project duration); Permanent (beyond project decommissioning)

1.8 INPUT TO THE ENVIRONMENTAL MANAGEMENT PROGRAM

Recommendations for palaeontological monitoring and mitigation by the ECO for the construction phase of the Kudusberg WEF are tabulated below for inclusion in the EMPr (See also the tabulated Chance Fossil Finds Protocol in Appendix 2). Pending the discovery of significant new fossil remains during construction, no specialist palaeontological mitigation or monitoring is considered necessary. All recorded fossil sites (Figs. 51 & 52) lie outside the development footprint. No recommendations are made for the operational and de-commissioning phases of the development (*N.B.* The Chance Fossil Finds Protocol still applies).

Impact	**Mitigation/Management Objectives**	**Mitigation/Management Actions**	**Monitoring**		
			Methodology	***Frequency***	***Responsibility***
A. CONSTRUCTION PHASE					
A.1. PALAEONTOLOGICAL IMPACTS					
Potential impact on fossil heritage as a result of the proposed Kudusberg WEF and associated infrastructure.	Avoid or minimize impacts to fossils sites on site.	▪ Alert ECO to potential for important new fossil finds during the construction phase (Provide Fossil Finds Protocol). ▪ Appoint suitably qualified palaeontologist for professional mitigation should new fossil sites be discovered.	▪ Monitoring of all major surface clearance and deeper (> 1m) excavations for fossil material (bones, teeth, petrified wood, plant-rich beds *etc*). ▪ Significant fossil finds to be safeguarded and reported to Heritage Western Cape (Western Cape sites) or SAHRA (Northern Cape sites). ▪ Recording and sampling of important new fossil finds and relevant geological data.	▪ On-going during construction phase. ▪ As soon as possible after fossils are found. ▪ As soon as possible after fossils are found.	▪ ECO ▪ ECO ▪ Professional palaeonto-logist

1.9 CONCLUSION AND RECOMMENDATIONS

Kudusberg Wind Farm (Pty) Ltd is proposing to develop a wind energy facility (WEF) of up to 325 MW generation capacity on a site located between Matjiesfontein and Sutherland in the mountainous Klein Roggeveld region, Western and Northern Cape Provinces. The WEF project area is underlain by Middle Permian (*c*. 265-270 Ma.) continental sediments of the Abrahamskraal Formation (Lower Beaufort Group, Karoo Supergroup) that are generally considered to be of high palaeontological sensitivity (SAHRA Palaeotechnical Report for the Northern Cape, SAHRIS website, Komsberg REDZ *in* SEA for Wind & Solar Photovoltaic Energy in South Africa, CSIR 2015). However, several previous palaeontological field assessments in the Klein Roggeveld region of the south-western Karoo suggest that the Beaufort Group bedrocks here are generally fossil-poor, apart from fairly common horizons with plant debris or low-diversity invertebrate trace fossils. Occasional scientifically important fossil finds of large tetrapod (*i.e.* terrestrial vertebrate) burrows and trackways, disarticulated skeletal remains (dispersed bones, teeth), petrified wood and rich assemblages of plants and insects within lacustrine sediments have been recorded from these beds but they are very rare. The Late Caenozoic superficial sediments (alluvium, colluvium, calcretes, soils, surface gravels *etc*) overlying the Palaeozoic bedrocks are generally of low palaeontological sensitivity but may contain important mammalian bones and teeth. None of the fossil sites recorded during the 6-day palaeontological field survey of the Kudusberg WEF project area lie within the proposed development footprint. They include two plant fossil sites and one lungfish burrow site that are of scientific research interest as well as a few *equivocal* records of vertebrate burrows and tracks (Fig. 51 and Appendix 1).

In terms of palaeontological heritage resources, the overall impact significance of the construction phase of the proposed wind energy project is assessed as VERY LOW (negative), both before and after mitigation. This is a consequence of (1) the paucity of irreplaceable, unique or rare fossil remains within the development footprint as well as (2) the extensive superficial sediment cover overlying most potentially-fossiliferous bedrocks within the Kudusberg WEF study area. Furthermore, some of the near-surface bedrocks are highly weathered. This assessment applies to the wind turbine corridors, laydown areas, access roads, the on-site substation, construction yards, underground cables, 33kV powerlines and other associated WEF infrastructure within the study area.

Given the similar underlying geology, a comparable very low impact significance is inferred for all project infrastructure alternatives and layout options under consideration, including different options for routing of access roads into the northern sector of the project area, turbine layouts and siting of construction yards and the on-site substation. **There are therefore no preferences on palaeontological heritage grounds for any particular layout among the various options considered. No significant further impacts on fossil heritage are anticipated during the operational and decommissioning phases of the WEF.** The no-go alternative (*i.e.* no WEF development) will have a neutral impact on palaeontological heritage.

There are no fatal flaws in the Kudusberg WEF development proposal as far as fossil heritage is concerned. *Provided that* the recommendations for palaeontological monitoring and mitigation outlined below are followed through, there are no objections on palaeontological heritage grounds to authorisation of the Kudusberg WEF project. Cumulative impacts on palaeontological heritage resources that are anticipated as a result of the numerous alternative energy developments currently proposed or authorised for the Klein-Roggeveld region - including additional impacts envisaged for the Kudusberg WEF project – are predicted to be **very low (**negative), *provided that* the proposed monitoring and mitigation recommendations made for these various projects are followed through. Unavoidable residual negative impacts (low significance) may be partially offset by the improved understanding of Karoo palaeontology resulting from appropriate professional mitigation. This is regarded as a significant *positive* impact for Karoo palaeontological heritage.

The great majority of the Kudusberg WEF project area is assessed as being of low palaeontological sensitivity due to the scarcity of significant fossil vertebrate, plant and other remains here. Sensitive no-go areas within the proposed development footprint itself have not been identified in this study. Scientifically-important fossil plant and lung fish burrow sites (Locs. 038-041,135 &143) as well as the *equivocal* vertebrate burrows and tracks (Locs. 29b, 042 & 043) all lie well outside (> 50 m) the proposed development footprint (Appendix 1 and Figs. 51 & 52) and no mitigation measures regarding them are recommended here (*N.B.* Taping-off the sites might only draw unwelcome attention to the fossils). Pending the potential discovery of significant new fossil remains during the construction phase - in which event the Chance Fossil Finds Protocol appended to this report should be applied (Appendix 2) – no specialist palaeontological mitigation is recommended for the Kudusberg WEF project.

The ECO responsible for the Kudusberg WEF development should be made aware of the potential occurrence of scientifically-important fossil remains (*e.g.* vertebrate bones, teeth, burrows and trackways, petrified wood, plant-rich beds) within the development footprint. During the construction phase all major clearance operations (*e.g.* for new access roads, turbine placements) and deeper (> 1 m) excavations should be monitored for fossil remains on an on-going basis by the ESO Should substantial fossil remains be encountered at surface or exposed during construction, the ECO should safeguard these, preferably *in situ*. They should then alert the relevant provincial heritage management authority as soon as possible - *i.e.* Heritage Western Cape for the Western Cape (Contact details: Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 086-142 142. Fax: 021-483 9842. Email: hwc@pgwc.gov.za) and SAHRA for the Northern Cape (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). This is to ensure that appropriate action (*i.e.* recording, sampling or collection of fossils, recording of relevant geological data) can be taken by a professional palaeontologist at the developer's expense.

These mitigation recommendations must be incorporated into the EEMPr for the Kudusberg WEF.

Please note that:

- All South African fossil heritage is protected by law (South African Heritage Resources Act, 1999) and fossils cannot be collected, damaged or disturbed without a permit from SAHRA or the relevant Provincial Heritage Resources Agency (in this case Heritage Western Cape);
- The palaeontologist concerned with potential mitigation work will need a valid fossil collection permit from Heritage Western Cape / SAHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection);
- All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies developed by SAHRA (2013).

1.10 REFERENCES

ABDALA, F., RUBIDGE, B.S. & VAN DEN HEEVER, J. 2008. The oldest therocephalians (Therapsida, Eutheriodontia) and the early diversification of the Therapsida. Palaeontology 51, 1011-1024.

ALMOND, J.E. 2005. Palaeontological scoping report: Proposed golf estate, Sutherland, Northern Cape, 10 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2008a. Fossil record of the Loeriesfontein sheet area. Unpublished report for the Council for Geoscience, Pretoria, 32pp.

ALMOND, J.E. 2008b. Palaeozoic fossil record of the Clanwilliam sheet area. Unpublished report for the Council for Geoscience, Pretoria, 49pp.

ALMOND, J.E. 2010a. Eskom Gamma-Omega 765kV transmission line: Phase 2 palaeontological impact assessment. Sector 1, Tanqua Karoo to Omega Substation (Western and Northern Cape Provinces), 95 pp + appendix. Natura Viva cc, Cape Town.

ALMOND, J.E. 2010b. Palaeontological impact assessment: desktop study – Proposed Suurplaat wind energy facility near Sutherland, Western Cape, 33 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2010c. Proposed Mainstream wind farm to the southeast of Sutherland, Northern Cape and Western Cape Provinces. Palaeontological impact assessment: pre-scoping desktop study, 19 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2011. Proposed photovoltaic solar energy facility on the farm Jakhals Valley (RE/99) near Sutherland, Karoo Hoogland Municipality, Northern Cape Province. Palaeontological specialist study: combined desktop and field assessment, 34 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2013. Proposed Spitskop Wind Energy Facility, Somerset East and Albany Magisterial Districts, Eastern Cape Province. Palaeontological specialist study: combined desktop & field-based assessment, 81 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2014. Proposed Karreebosch Wind Farm (Roggeveld Phase 2) near Sutherland, Northern Cape Province. Palaeontological heritage assessment: combined desktop & field-based study, 63 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015a. Proposed Perdekraal East Wind & Solar Renewable Energy Facility near Touwsrivier, Ceres Magisterial District, Western Cape Province. Palaeontological impact assessment: field study, 68 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015b. Proposed expansion of the existing Komsberg Main Transmission Substation on Farm Standvastigheid 210 near Sutherland, Northern Cape Province. Paleontological heritage assessment: combined desktop & field-based study (basic assessment), 39 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015c. Authorised Karusa Wind Farm near Sutherland, Namaqua District Municipality, Northern Cape Province. Palaeontological heritage assessment: combined desktop & field-based study, 57 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015d. Authorised Soetwater Wind Farm near Sutherland, Namaqua District Municipality, Northern Cape Province. Palaeontological heritage assessment: combined desktop & field-based study, 57 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015e. Komsberg East Wind Energy Facility near Sutherland, Laingsburg District, Western Cape. Palaeontological scoping assessment: combined desktop and field-based study, 51 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015f. Komsberg West Wind Energy Facility near Sutherland, Laingsburg and Sutherland Districst, Western and Northern Cape. Palaeontological scoping assessment: combined desktop and field-based study, 55 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015g. Proposed Gunstfontein Wind Energy Facility near Sutherland, Karoo Hoogland Local Municipality, Northern Cape Province. Palaeontological heritage assessment: combined desktop & field-based study, 62 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016a. Square Kilometre Array (SKA) core and Phase 1 development area, Great Karoo, Northern Cape - palaeontological heritage, 38 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016b. Proposed Rietkloof Wind Energy Facility near Laingsburg, Laingsburg District, Western Cape Province. Palaeontological heritage assessment: combined desktop & field-based study, 82 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016c. Proposed Brandvalley Wind Energy Facility near Laingsburg, Western & Northern Cape Provinces. Palaeontological heritage assessment: combined desktop & field-based study, 69 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016d. Esizayo Wind Energy Facility near Laingsburg, Western Cape: palaeontological heritage. Scoping report, 7 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016e. Maralla Wind Energy Facility near Sutherland, Northern Cape and Western Cape: palaeontological heritage. Scoping report, 8 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016f. Esizayo Wind Energy Facility near Laingsburg, Central Karoo District Municipality, Western Cape: palaeontological heritage assessment, 63 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016g. Proposed 400 kV powerline connection for the Esizayo Wind Energy Facility near Laingsburg, Central Karoo District Municipality, Western Cape: palaeontological heritage basic assessment, 28 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016h. Maralla West Wind Energy Facility near Sutherland, Sutherland Magisterial District, Northern Cape: palaeontological heritage assessment, 51 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016i. Maralla East Wind Energy Facility near Sutherland, Sutherland & Laingsburg Magisterial Districts, Northern & Western Cape: palaeontological heritage assessment, 64 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. & PETHER, J. 2008a. Palaeontological heritage of the Western Cape. Interim SAHRA technical report, 20 pp. Natura Viva cc., Cape Town.

ALMOND, J.E. & PETHER, J. 2008b. Palaeontological heritage of the Northern Cape. Interim SAHRA technical report, 124 pp. 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, 423 pp. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

BACKWELL, L., STEININGER, C., NEVELING, J., ABDALA, F., PEREIRA, L., MAYER, E., ROSSOUW, L., DE LA PEÑA, P. & BRINK, J. 2017. Holocene large mammal mass death assemblage from South Africa. Quaternary International (2017), https://doi.org/10.1016/j.quaint.2017.11.055

BAMFORD, M. 1999. Permo-Triassic fossil woods from the South African Karoo Basin. Palaeontologia africana 35, 25-40.

BAMFORD, M.K. 2004. Diversity of woody vegetation of Gondwanan southern Africa. Gondwana Research 7, 153-164.

BENDER, P.A. 2004. Late Permian actinopterygian (palaeoniscid) fishes from the Beaufort Group, South Africa: biostratigraphic and biogeographic implications. Council for Geoscience Bulletin 135, 84 pp.

BENDER, P.A., RUBIDGE, B.S., GARDINER, B.S., LOOCK. J.C. & BREMNER, A.T. 1991. The stratigraphic range of the palaeoniscoid fish *Namaichthys digitata* in rocks of the Karoo sequence and its palaeoenvironmental significance. South African Journal of Science 87: 468-469.

BENDER, P.A. & BRINK, J.S. 1992. A preliminary report on new large mammal fossil finds from the Cornelia-Uitzoek site. South African Journal of Science 88: 512-515.

BOONSTRA, L.D. 1969. The fauna of the Tapinocephalus Zone (Beaufort Beds of the Karoo). Annals of the South African Museum 56: 1-73.

BOUSMAN, C.B. *et al.* 1988. Palaeoenvironmental implications of Late Pleistocene and Holocene valley fills in Blydefontein Basin, Noupoort, C.P., South Africa. Palaeoecology of Africa 19: 43-67.

BRINK, J.S. 1987. The archaeozoology of Florisbad, Orange Free State. Memoirs van die Nasionale Museum 24, 151 pp.

BRINK, J.S. et al. 1995. A new find of *Megalotragus priscus* (Alcephalini, Bovidae) from the Central Karoo, South Africa. Palaeontologia africana 32: 17-22.

BRINK, J.S. & ROSSOUW, L. 2000. New trial excavations at the Cornelia-Uitzoek type locality. Navorsinge van die Nasionale Museum Bloemfontein 16, 141-156.

BUATOIS, L. & MANGANO, M.G. 2004. Animal-substrate interactions in freshwater environments: applications of ichnology in facies and sequence stratigraphic analysis of fluvio-lacustrine successions. In: McIlroy, D. (Ed.) The application of ichnology to palaeoenvironmental and stratigraphic analysis. Geological Society, London, Special Publications 228, pp 311-333.

CHURCHILL, S.E. et al. 2000. Erfkroon: a new Florisian fossil locality from fluvial contexts in the western Free State, South Africa. South African Journal of Science 96: 161-163.

COLE, D.I. 2005. Prince Albert Formation. SA Committee for Stratigraphy, Catalogue of South African Lithostratigraphic Units 8: 33-36.

COLE, D.I., SMITH, R.M.H. & WICKENS, H. DE V. 1990. Basin-plain to fluvio-lacustrine deposits in the Permian Ecca and Lower Beaufort Groups of the Karoo Sequence. Guidebook Geocongress '90, Geological Society of South Africa, PO2, 1-83.

COLE, D.I. & BASSON, W.A. 1991. Whitehill Formation. Catalogue of South African Lithostratigraphic Units 3, 51-52. Council for Geoscience, Pretoria.

COLE, D.I. & WICKENS, H. DE V. 1998. Lower Karoo Supergroup: glacial, basinal and terrestrial environments in the southwestern part of the main Karoo Basin. Guidebook 10th Gondwana Conference. University of Cape Town, South Africa, Pr1, 1-77.

COLE, D.I., NEVELING, J., HATTINGH, J., CHEVALLIER, L.P., REDDERING, J.S.V. & BENDER, P.A. 2004. The geology of the Middelburg area. Explanation to 1: 250 000 geology Sheet 3124 Middelburg, 44 pp. Council for Geoscience, Pretoria.

COLE, D. & SMITH, R. 2008. Fluvial architecture of the Late Permian Beaufort Group deposits, S.W. Karoo Basin: point bars, crevasse splays, palaeosols, vertebrate fossils and uranium. Field Excursion FT02 guidebook, AAPG International Conference, Cape Town October 2008, 110 pp.

COLE, D.I. & VORSTER, C.J. 1999. The metallogeny of the Sutherland area, 41 pp. Council for Geoscience, Pretoria.

COOPER, M.R. & KENSLEY, B. 1984. Endemic South American Permian bivalve molluscs from the Ecca of South Africa. Journal of Paleontology 58: 1360-1363.

DAVIDS, L., PREVEC, R., MATIWANE, A. & NEL, A. Insect fauna and associated plant-insect interactions at the Ouberg Pass and Onder karoo locality: implications for the evolution of insect utilisation of plants in the middle Permian of the Karoo Basin of South Africa. Proceedings of the 20th Biennial Conference of the Palaeontological Society of Southern Africa, Bloemfontein July 4- July 6, 2018, p. 13.

DAY 2013a. Middle Permian continental biodiversity changes as reflected in the Beaufort Group of South Africa: a bio- and lithostratigraphic review of the *Eodicynodon*, *Tapinocephalus* and *Pristerognathus* assemblage zones. Unpublished PhD thesis, University of the Watwatersrand, Johannesburg, 387 pp plus appendices.

DAY, M. 2013b. Charting the fossils of the Great Karoo: a history of tetrapod biostratigraphy in the Lower Beaufort Group, South Africa. Palaeontologia Africana 48, 41-47.

DAY, M. & RUBIDGE, B. 2010. Middle Permian continental biodiversity changes as reflected in the Beaufort Group of South Africa: An initial review of the *Tapinocephalus* and *Pristerognathus* assemblage zones. Proceedings of the 16th conference of the Palaeontological Society of Southern Africa, Howick, August 5-8, 2010, pp. 22-23.

DE RUITER, D.J., BROPHY, J.K., LEWIS, P.J., KENNEDY, A.M., STIDHAM, T.A., CARLSON, K.B. & HANCOX, P.J. 2010. Preliminary investigation of Matjhabeng, a Pliocene fossil locality in the Free State of South Africa. Palaeontologia Africana 45, 11-22.

DUNCAN, A.R. & MARSH, J.S. 2006. The Karoo Igneous Province. Pp. 501-520 in Johnson. M.R., Anhaeusser, C.R. & Thomas, R.J. (eds.) The geology of South Africa. Geological Society of South Africa, Johannesburg & the Council for Geoscience, Pretoria.

FILDANI, A., DRINKWATER, N.J., WEISLOGEL, A., MCHARGUE, T., HODGSON, D.M. & FLINT, S.S. 2007. Age controls on the Tanqua and Lainsgburg deep-water systems: new insights on the evolution and sedimentary fill of the Karoo Basin. Journal of Sedimentary Research 77, 901-908.

FOURIE, W., ALMOND, J. & ORTON, J. 2015. Heritage scoping assessment specialist report. Strategic environmental assessment for wind and solar photovoltaic energy in South Africa. Appendix 3, 79 pp. CSIR and Department of Environmental Affairs, RSA.

GOVENDER, R. 2002. The postcranial anatomy of the most basal tapinocephalid dinocephalian *Tapinocaninus pamelae* (Amniota, Therapsida). Unpublished PhD thesis, University of Witwatersrand, Johannesburg, South Africa, 109pp.

HART, T. & MILLER, D. 2010. Proposed Witberg Wind Farm (Alternative Layout 3). Unpublished report prepared for ERM Southern Africa. St James: ACO Associates.

HASIOTIS, S.T., MITCHELL, C.E. & DUBIEL, R. 1993. Application of morphologic burrow interpretations to discern continental burrow architects: Lungfish or crayfish? Ichnos 2,315-333.

HODGSON, D.M., FLINT, S.S., HODGETTS, D., DRINKWATER, N.J., JOHANNESSON, E.J. & LUTHI, S.M., 2006. Stratigraphic evolution of Permian submarine fan systems, Tanqua depocenter, South Africa. Journal of Sedimentary Research 76, p. 19–39.

HILL, R.S. 1993. The geology of the Graaff-Reinet area. Explanation to 1: 250 000 geology Sheet 3224 Graaff-Reinet, 31 pp. Council for Geoscience, Pretoria.

JINNAH, Z.A. & RUBIDGE, B.S. 2007. A double-tusked dicynodont and its biostratigraphic significance. South African Journal of Science 103, 51-53.

JIRAH, S. & RUBIDGE, B.S. 2010. Sedimentological, palaeontological and stratigraphic analysis of the Abrahamskraal Formation (Beaufort Group) in an area south of Merweville, South Africa. Proceedings of the 16th conference of the Palaeontological Society of Southern Africa, Howick, August 5-8, 2010, pp. 46-47.

JIRAH, S. & RUBIDGE, B.S. 2014. Refined stratigraphy of the Middle Permian Abrahamskraal Formation (Beaufort Group) in the southern Karoo Basin. Journal of African Earth Sciences 100, 121–135.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape Province. Unpublished PhD thesis, Rhodes University, Grahamstown, 336 pp.

JOHNSON, M.R., VAN VUUREN, C.J., VISSER, J.N.J., COLE, D.I., WICKENS, H. DE V., CHRISTIE, A.D.M., ROBERTS, D.L. & BRANDL, G. 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson. M.R., Anhaeusser, C.R. & Thomas, R.J. (eds.) The geology of South Africa, pp. 461-499. Geological Society of South Africa, Johannesburg & the Council for Geoscience, Pretoria.

JORDAAN, M.J. 1990. Basin analysis of the Beaufort Group in the western part of the Karoo Basin. Unpublished PhD thesis, University of the Orange Free State, Bloemfontein, 271 pp.

KEYSER, A.W. & SMITH, R.M.H. 1977-78. Vertebrate biozonation of the Beaufort Group with special reference to the Western Karoo Basin. Annals of the Geological Survey of South Africa 12: 1-36.

KINGSLEY, C.S. 1977. Stratigraphy and sedimentology of the Ecca Group in the Eastern Cape Province, South Africa. Unpublished PhD thesis, University of Port Elizabeth, 286 pp.

KITCHING, J.W. 1977. The distribution of the Karroo vertebrate fauna, with special reference to certain genera and the bearing of this distribution on the zoning of the Beaufort beds. Memoirs of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, No. 1, 133 pp (incl. 15 pls).

KLEIN, R. 1980. Environmental and ecological implications of large mammals from Upper Pleistocene and Holocene sites in southern Africa. Annals of the South African Museum 81, 223-283.

KLEIN, R.G. 1984. The large mammals of southern Africa: Late Pliocene to Recent. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 107-146. Balkema, Rotterdam.

LANCI, L, TOHVER, E., WILSON A. & FLINT, S. 2013. Upper Permian magnetic stratigraphy of the lower Beaufort Group, Karoo Basin. Earth and Planetary Science Letters (2013), http://dx.doi.org/10.1016/j.epsl.2013.05.017.

LOCK, B.E. & JOHNSON, M.R. 1976. A crystal tuff from the Ecca Group near Lake Mentz, eastern Cape Province. Transactions of the Geological Society of South Africa 77, 373-374.

LOOCK, J.C., BRYNARD, H.J., HEARD, R.G., KITCHING, J.W. & RUBIDGE, B.S. 1994. The stratigraphy of the Lower Beaufort Group in an area north of Laingsburg, South Africa. Journal of African Earth Sciences 18: 185-195.

LUCAS, D.G. 2009. Global Middle Permian reptile mass extinction: the dinocephalian extinction event. Geological Society of America Abstracts with Programs 41, No. 7, p. 360.

MACRAE, C. 1999. Life etched in stone. Fossils of South Africa, 305 pp. The Geological Society of South Africa, Johannesburg.

McCARTHY, T. & RUBIDGE, B. 2005. The story of Earth and life: a southern African perspective on a 4.6-billion-year journey. 334pp. Struik, Cape Town.

McLACHLAN, I.R. & ANDERSON, A. 1973. A review of the evidence for marine conditions in southern Africa during Dwyka times. Palaeontologia africana 15: 37-64.

MEADOWS, M.E. & WATKEYS, M.K. 1999. Palaeoenvironments. In: Dean, W.R.J. & Milton, S.J. (Eds.) The karoo. Ecological patterns and processes, pp. 27-41. Cambridge University Press, Cambridge.

MILLER, D. 2011. Roggeveld Wind Farm: palaeontology study, 7 pp. Appendix to Archaeological, Heritage and Paleontological Specialist Report prepared by ACO Associates, St James.

MOYO, S., PREVEC, R., MATIWANE, A., NEL, A, GARROUSTE, R. & DAY, M.O. 2018. Preliminary report on the first mid-Permian ecosystem from South Africa, as revealed by a new Lagerstätte near Sutherland, Northern Cape. Proceedings of the 20th Biennial Conference of the Palaeontological Society of Southern Africa, Bloemfontein July 4- July 6, 2018, p. 23-24.

NICOLAS, M.V. 2007. Tetrapod diversity through the Permo-Triassic Beaufort Group (Karoo Supergroup) of South Africa. Unpublished PhD thesis, University of Witwatersrand, Johannesburg.

NICOLAS, M. & RUBIDGE, B.S. 2010. Changes in Permo-Triassic terrestrial tetrapod ecological representation in the Beaufort Group (Karoo Supergroup) of South Africa. Lethaia 43, 45-59.

ODENDAAL, A.I. AND LOOCK, J.C. 2015. Lungfish burrows in the lower Beaufort Group in the south-western part of the Karoo Basin. Origin and Evolution of The Cape Mountains and Karoo Basin “Imbizo”, 25-27 November 2015, NMMU, poster.

OELOFSEN, B.W. 1981. The fossil record of the Class Chondrichthyes in southern Africa. Palaeontologia africana 24: 11-13.

OELOFSEN, B.W. 1986. A fossil shark neurocranium from the Permo-Carboniferous (lowermost Ecca Formation) of South Africa. In: Uyeno, T, Arai, R., Taniuchi, T & Matsuura, K. (Eds.) Indo-Pacific fish biology. Proceedings of the Second International Conference on Indo-Pacific Fishes. Ichthyological Society of Japan, Tokyo, pp 107-124.

OELOFSEN, B.W. 1987. The biostratigraphy and fossils of the Whitehill and Iratí Shale Formations of the Karoo and Paraná Basins. In: McKenzie, C.D. (Ed.) Gondwana Six: stratigraphy, sedimentology and paleontology. Geophysical Monograph, American Geophysical Union 41: 131-138.

PARTRIDGE, T.C. & MAUD, R.R. 1987. Geomorphic evolution of southern Africa since the Mesozoic. South African Journal of Geology 90: 179-208.

PARTRIDGE, T.C. & SCOTT, L. 2000. Lakes and Pans. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.145-161. Oxford University Press, Oxford.

PARTRIDGE, T.C., BOTHA, G.A. & HADDON, I.G. 2006. Cenozoic deposits of the interior. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 585-604. Geological Society of South Africa, Marshalltown.

PARTRIDGE, T.C. & SCOTT, L. 2000. Lakes and pans. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.145-161. Oxford University Press, Oxford.

PREVEC, R. & MATIWANE, A. 2018. A missing link in Glossopteris evolution: new species of Liggetonia from a middle Permian Lagerstätte in South Africa. Proceedings of the 20th Biennial Conference of the Palaeontological Society of Southern Africa, Bloemfontein July 4- July 6, 2018, p. 26.

ROSSOUW, L. 2006. Florisian mammal fossils from erosional gullies along the Modder River at Mitasrust Farm, Central Free State, South Africa. Navorsinge van die Nasionale Museum Bloemfontein 22, 145-162.

ROSSOUW, P.J. & DE VILLIERS, J. 1952. Die geologie van die gebied Merweville, Kaapprovinsie. Explanation to 1: 125 000 geology sheet 198 Merweville, 63 pp. Council for Geoscience, Pretoria.

RUBIDGE, B.S. 1984. The cranial morphology and palaeoenvironment of *Eodicynodon* Barry (Therapsida: Dicynodontia). Navorsinge van die Nasionale Museum Bloemfontein 4, 325-402.

RUBIDGE, B.S. 1987. South Africa’s oldest land-living reptiles from the Ecca-Beaufort transition in the southern Karoo. South African Journal of Science 83, 165-166.

RUBIDGE, B.S. 1991. A new primitive dinocephalian mammal-like reptile from the Permian of southern Africa. Palaeontology 34, 547-559.

RUBIDGE, B.S. (Ed.) 1995a. 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. 1995b. Biostratigraphy of the *Eodicynodon* Assemblage Zone. Pp. 3 to 7 *in* 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. & OELOFSEN, B.W. 1981. Reptilian fauna from Ecca rocks near Prince Albert, South Africa. South African Journal of Science 77, 425-426.

RUBIDGE, B.S., KING, G.M. & HANCOX, P.J. 1994. The postcranial skeleton of the earliest dicynodont synapsid *Eodicynodon* from the Upper Permian of South Africa. Palaeontology 37, 397-408.

RUBIDGE, B.S., HANCOX, P.J. & CATUNEANU, O. 2000. Sequence analysis of the Ecca-Beaufort contact in the southern Karoo of South Africa. South African Journal of Geology 103, 81-96.

RUBIDGE, B.S., ERWIN, D.H., RAMEZANI, J., BOWRING, S.A. & DE KLERK, W.J. 2010. The first radiometric dates for the Beaufort Group, Karoo Supergroup of South Africa. Proceedings of the 16th conference of the Palaeontological Society of Southern Africa, Howick, August 5-8, 2010, pp. 82-83.

RUBIDGE, B.S., HANCOX, P.J. & MASON, R. 2012. Waterford Formation in the south-eastern Karoo: implications for basin development. South African Journal of Science 108, Article #829, 5 pp. http://dx.doi.org/10.4102/sajs. v108i3/4.829

RUBIDGE, B.S., ERWIN, D.H., RAMEZANI, J., BOWRING, S.A. & DE KLERK, W.J. 2013. High-precision temporal calibration of Late Permian vertebrate biostratigraphy: U-Pb zircon constraints from the Karoo Supergroup, South Africa. Geology published online 4 January 2013. doi: 10.1130/G33622.1.

RUST, I.C., SHONE, R.W. & SIEBRITS, L.B. 1991. Carnarvon Formasie: golf-oorheesde sedimentasie in 'n vlak Karoosee. South African Journal of Science 87, 198-202.

SAHRA 2013. Minimum standards: palaeontological component of heritage impact assessment reports, 15 pp. South African Heritage Resources Agency, Cape Town.

SCHNEIDER, G. & MARAIS, C. 2004. Passage through time. The fossils of Namibia. 158 pp. Gamsberg MacMillan, Windhoek.

SCOTT, L. 2000. Pollen. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.339-35. Oxford University Press, Oxford.

SEILACHER, A. 2007. Trace fossil analysis, xiii + 226pp. Springer Verlag, Berlin.

SIEBRITS, L.B. 1989. Die geologie van die gebied Sakrivier. Explanation of 1: 250 000 geology sheet 3020, 19 pp. Council for Geoscience, Pretoria.

SKEAD, C.J. 1980. Historical mammal incidence in the Cape Province. Volume 1: The Western and Northern Cape, 903pp. Department of Nature and Environmental Conservation, Cape Town.

SMITH, A.B. 1999. Hunters and herders in the Karoo landscape. Chapter 15 in Dean, W.R.J. & Milton, S.J. (Eds.) The Karoo; ecological patterns and processes, pp. 243-256. Cambridge University Press, Cambridge.

SMITH, R.M.H. 1979. The sedimentology and taphonomy of flood-plain deposits of the Lower Beaufort (Adelaide Subgroup) strata near Beaufort West, Cape Province. Annals of the Geological Survey of South Africa 12, 37-68.

SMITH, R.M.H. 1980. The lithology, sedimentology and taphonomy of flood-plain deposits of the Lower Beaufort (Adelaide Subgroup) strata near Beaufort West. Transactions of the Geological Society of South Africa 83, 399-413.

SMITH, R.M.H. 1986. Trace fossils of the ancient Karoo. Sagittarius 1 (3), 4-9.

SMITH, R.M.H. 1987a. Morphological and depositional history of exhumed Permian point bars in the southwestern Karoo, South Africa. Journal of Sedimentary Petrology 57, 19-29.

SMITH, R.M.H. 1987b. Helical burrow casts of therapsid origin from the Beaufort Group (Permian) of South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology 60, 155-170.

SMITH, R.M.H. 1988. Fossils for Africa. An introduction to the fossil wealth of the Nuweveld mountains near Beaufort West. Sagittarius 3, 4-9. SA Museum, Cape Town.

SMITH, R.M.H. 1989. Fossils in the Karoo – some important questions answered. Custos 17, 48-51.

SMITH, R.M.H. 1990. Alluvial paleosols and pedofacies sequences in the Permian Lower Beaufort of the southwestern Karoo Basin, South Africa. Journal of Sedimentary Petrology 60, 258-276.

SMITH, R.M.H. 1993a. Sedimentology and ichnology of floodplain paleosurfaces in the Beaufort Group (Late Permian), Karoo Sequence, South Africa. Palaios 8, 339-357.

SMITH, R.M.H. 1993b. Vertebrate taphonomy of Late Permian floodplain deposits in the southwestern Karoo Basin of South Africa. Palaios 8, 45-67.

SMITH, R.M.H. & KEYSER, A.W. 1995a. Biostratigraphy of the *Tapinocephalus* Assemblage Zone. Pp. 8-12 in Rubidge, B.S. (ed.) Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

SMITH, R.M.H. & ALMOND, J.E. 1998. Late Permian continental trace assemblages from the Lower Beaufort Group (Karoo Supergroup), South Africa. Abstracts, Tercera Reunión Argentina de Icnologia, Mar del Plata, 1998, p. 29.

SMITH, R., RUBIDGE, B. & VAN DER WALT, M. 2012. Therapsid biodiversity patterns and paleoenvironments of the Karoo Basin, South Africa. Chapter 2 pp. 30-62 in Chinsamy-Turan, A. (Ed.) Forerunners of mammals. Radiation, histology, biology. xv + 330 pp. Indiana University Press, Bloomington & Indianapolis.

STEAR, W.M. 1978. Sedimentary structures related to fluctuating hydrodynamic conditions in flood plain deposits of the Beaufort Group near Beaufort West, Cape. Transactions of the Geological Society of South Africa 81, 393-399.

STEAR, W.M. 1980a. The sedimentary environment of the Beaufort Group uranium province in the vicinity of Beaufort West, South Africa. Unpublished PhD thesis, University of Port Elizabeth, 188 pp.

STEAR, W.M. 1980b. Channel sandstone and bar morphology of the Beaufort Group uranium district near Beaufort West. Transactions of the Geological Society of South Africa 83: 391-398.

THERON, J.N. 1983. Die geologie van die gebied Sutherland. Explanation of 1: 250 000 geological Sheet 3220, 29 pp. Council for Geoscience, Pretoria.

THERON, J.N., WICKENS, H. DE V. & GRESSE, P.G. 1991. Die geologie van de gebied Ladismith. Explanation of Sheet 3320. 99 pp. Geological Survey / Council for Geoscience, Pretoria.

TURNER, B.R. 1981. The occurrence, origin and stratigraphic significance of bone-bearing mudstone pellet conglomerates from the Beaufort Group in the Jansenville District, Cape Province, South Africa. Palaeontologia africana 24, 63-73.

VAN DER WALT, M., DAY, M., RUBIDGE, B., COOPER, A.K. & NETTERBERG, I. 2010. A new GIS-based biozone map of the Beaufort Group (Karoo Supergroup), South Africa. Palaeontologia Africana 45, 1-5.

VILJOEN, J.H.A. 1992. Lithostratigraphy of the Collingham Formation (Ecca Group), including the Zoute Kloof, Buffels River and Wilgehout River Members and the Matjiesfontein Chert Bed. South African Committee for Stratigraphy, Lithostratigraphic Series No. 22, 10 pp.

VILJOEN, J.H.A. 1994. Sedimentology of the Collingham Formation, Karoo Supergroup. South African Journal of Geology 97: 167-183.

VISSER, J.N.J. 1992. Deposition of the Early to Late Permian Whitehill Formation during a sea-level highstand in a juvenile foreland basin. South African Journal of Geology 95: 181-193.

VISSER, J.N.J. 1994. A Permian argillaceous syn- to post-glacial foreland sequence in the Karoo Basin, South Africa. In Deynoux, M., Miller, J.M.G., Domack, E.W., Eyles, N. & Young, G.M. (Eds.) Earth's Glacial Record. International Geological Correlation Project Volume 260, pp. 193-203. Cambridge University Press, Cambridge.

VISSER, J.N.J. 1997. Deglaciation sequences in the Permo-Carboniferous Karoo and Kalahari Basins of southern Africa: a tool in the analysis of cyclic glaciomarine basin fills. Sedimentology 44: 507-521.

VISSER, J.N.J. 2003. Lithostratigraphy of the Elandsvlei Formation (Dwyka Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 39, 11 pp.

VISSER, J.N.J., VON BRUNN, V. & JOHNSON, M.R. 1990. Dwyka Group. South African Committee for Stratigraphy Catalogue of South African Lithostratigraphic Units 2, 15-17. Council for Geoscience, Pretoria.

WICKENS, H. DE V. 1984. Die stratigraphie en sedimentologie van die Group Ecca wes van Sutherland. Unpublished MSc thesis, University of Port Elizabeth, viii + 86 pp.

WICKENS, H. DE V. 1994. Submarine fans of the Ecca Group. Unpublished PhD thesis, University of Port Elizabeth. 350 pp.

WICKENS, H. DE V. 1996. Die stratigraphie en sedimentologie van die Ecca Groep wes van Sutherland. Council for Geosciences, Pretoria Bulletin 107, 49pp.

WILSON, A., FLINT, S., PAYENBERG, T., TOHVER, E. & LANCI, L. 2014. Architectural styles and sedimentology of the fluvial Lower Beaufort Group, Karoo Basin, South Africa. Journal of Sedimentary Research 84, 326-348.

ZAWADA, P.K. 1992. The geology of the Koffiefontein area. Explanation of 1: 250 000 geology sheet 2924 Koffiefontein, 30 pp. Council for Geoscience, Pretoria.

1.11 ACKNOWLEDGEMENTS

Ms Katie Smuts is thanked for commissioning this PIA report as part of the over-arching Heritage Basic Assessment for the Kudusberg WEF development. I am grateful to Ms Minnelise Levendal and Ms Lizande Kellerman of the CSIR, Stellenbosch, as well as to Ms Karen de Bruyn of G7 Renewable Energies (Pty) Ltd, Cape Town, for providing relevant background information for the project and for facilitating access to the study area. Ms Madelon Tusenius, Ms Katie Smuts and Ms Emmylou Bailey are all thanked for logistical support and companionship in the field, as well as for assisting with the acquisition of palaeontological data. Dr Rose Prevec and Dr Rob Gess of the Albany Museum, Grahamstown are thanked for very helpful discussions on Permian plant fossils.

APPENDICES

Appendix 1: GPS data for key geological and fossil sites

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

Please note that fossil locality data is not for general publication for heritage conservation reasons.

Loc	GPS data	Comments
001	S32° 53' 26.7" E20° 16' 56.9"	Gats Rivier 156. Lenticular multi-storey channel sandstone bodies – possibly Combrinkskraal Mb of Abrahamskraal Fm - near Gatsrivier Springbok accommodation. Colluvial gravels on valley floor dominated by well-rounded corestones of greyish wacke showing rusty-brown surface patina. Underlain by continuous pale cream calcrete hardpan that is well-exposed in farm tracks.
002	S32° 52' 52.5" E20° 19' 42.7"	Oliviers Berg 159. Views towards central ridge from valley floor. Laterally-extensive tabular channel sandstone bodies on hillslopes and along ridge crests=.
003a	S32° 52' 36.0" E20° 20' 43.7"	Oliviers Berg 159. Deeply-incised “dry” river valley below channel sandstone capping. Extensive dark grey overbank mudrock exposure in banks and bed of river valley.
004	S32° 52' 29.7" E20° 21' 50.8"	Oliviers Berg 159, close to Substation 3 site. Stream bed exposures of Abrahamskraal Fm sandstone bedding surfaces. Flat bedding, primary current lineation implies high current velocity (upper flow regime). Vague arcuate horizontal burrows preserved as epichnial ridges (Proposed Field Rating IIIC: Local Resource. No mitigation required). Possible dendritic rill marks (falling water levels / microbial mat textures), moulds of small angular mudflake intraclasts. Small sphaeroidal ferruginous diagenetic concretions. Purple-brown overbank mudrocks and single storey sandstone interbed – probably crevasse splay.
005	S32° 53' 02.0" E20° 20' 46.7"	Oliviers Berg 159. Viewpoint to SW towards main southern Koedoesberge ridge – gently convex skyline, gentle hillslopes dissected by numerous stream gullies, few prominent-weathering, laterally-persistent sandstone *kranzes* – perhaps represent major distributary channels on delta platform.
006	S32° 52' 59.6" E20° 20' 14.3"	Oliviers Berg 159. Substation 2 site. Flat-lying to gently sloping, mantled with scattered coarse sandstone colluvial rubble, silty soils, karroid bossieveld vegetation. No Karoo mudrock exposure.
007	S32° 53' 20.6" E20° 19' 09.9"	Oliviers Berg 159. Views towards Oliviersberg homestead from Uitkyk Pass. Oliviersberg Ridge with thicker sandstone packages towards crest (possible Grootfontein Member).
008	S32° 53' 04.1" E20° 18' 43.7"	Oliviers Berg 159. View SW from UItkyk Pass towards *possible* tectonic reduplication (thrust fault) of channel sandstone package.
010	S32° 52' 46.6" E20° 18' 32.2"	Oliviers Berg 159. Substation 1 site adjacent to Uitkyk Pass. Flat terrain mantled in coarse colluvial sandstone angular to subrounded gravels, bossieveld vegetation. No bedrock exposure. Views to NW of central turbine ridge with flat-lying thicker sandstone packages towards crest, in core of anticline (possible Grootfontein Member). Southern slopes of ridge show S-dipping sandstone bedding plane exposure in stream beds.
011	S32° 51' 51.8" E20° 18' 57.0"	Oliviers Berg 159. Crest of Central Ridge at top of Uitkyk Pass and near wind mast. Views along ridge crest. Views N into Amandelboom 158 –thick lower sandstone packages (Combrinkskraal Mb) close to N foot of ridge.
012	S32° 51' 46.6" E20° 17' 48.0"	Oliviers Berg 159. Views from crest of Central Ridge along ridge – upper sandstone package (Grootfontein Member).
013	S32° 51' 40.3" E20° 17' 36.5"	Oliviers Berg 159. Western end of track along crest. Views along ridge of Grootfontein Mb sandstone package.
014	S32° 51' 46.5" E20° 17' 52.5"	Oliviers Berg 159. Crest of Central Ridge. Carpet of downwasted, well-rounded to subrounded, poorly-sorted sandstone / wacke corestones (pebble to boulder-sized) overlying thin brown gravelly soil or sandstone channel body at depth.
016	S32° 51' 51.3" E20° 18' 33.0"	Oliviers Berg 159. Crest of Central Ridge Patch of crumbly blue-grey overbank mudrocks overlying channel sandstone with horiozns of sparse, small

Loc	GPS data	Comments
		palaeocalcrete nodules, silicified gypsum pseudomorphs, intermittent lenses of irregular to lenticular ferruginous carbonate concretions (up to few dm across) along strike.
017	S32° 52' 24.2" E20° 18' 40.0"	Oliviers Berg 159. Steep N-facing section through Abrahamskraal Fm in stream valley close to Uitkyk Pass. Good exposure of tabular grey-green mudrocks interbedded with tabular single-storey sandstones (m- to few m scale) – possibly crevasse splays. Lower part of succession with coarsening-upwards packages of few m thickness from (1) grey-green, crumbly claystones mudrocks with occasional horizons of ferruginous carbonate concretions through (2) laminated siltstones, (3) thin-bedded sandstones / heterolithic packages to (4) medium-bedded sandstones / wackes, last with gradational bases and sharp tops. Possible infills of interdistributary bays on delta platform / top. Upper part of exposure with sharp-based sandstones (1-few m thick) and more typical fluvial style. Cleaner-washed pale sandstones towards top of succession. *i.e.* Possible shoreline transition between deltaic and fluvial deposition on delta platform. Views SSSE towards Oliviersberg showing fault-displaced (or slumped) thick channel sandstone body (c. 750 m west of Substation 2 site, 32 53 04 S, 20 19 44.4 E). Possibly represent major distributary or fluvial channels on delta platform. Contrast with numerous, thin, highly tabular sandstone ridges above.
018	S32° 53' 11.0" E20° 18' 42.1"	Oliviers Berg 159. West-facing hillslope showing thick lenticular multi-storey channel sandstone with thinner spaced tabular sandstones on either side. Possible locus of channel development on delta platform.
020	S32° 53' 11.8" E20° 18' 55.5"	Oliviers Berg 159. Gentle hillslope exposures of grey-green mudrocks near Uitkyk Pass track. Surface gravels dominated by spheroidal gypsum rose pseudomorphs up to c. 6 cm diameter with radiating crystals internally, small lenticular crystals visible on exterior. Indicates / evaporative arid period on floodplain overlying delta platform. Poorly sorted surface gravels also comprise well-rounded wacke corestones, occasional fine-grained wacke flaked artefacts, downwasted ferruginous carbonate concretionary material.
021	S32° 53' 26.4" E20° 19' 25.6"	Oliviers Berg 159. East-facing riverbank section through major tabular to lenticular, well-jointed, multi-storey, grey-green wacke package at low elevation (valley floor). Probably Combrinkskraal Mb. Sharp erosive base with local gullying. Beds pinch and swell along strike. Thin (few dm) to thick (few m) lenticular horizons of mudflake intraclast breccio-conglomerates (sometimes ferruginized; no reworked palaeocalcrete nodules or plant material / wood seen) between thick-bedded massive to horizontally-laminated to low angle current cross-bedded channel wacke packages. Underlying succession upward-coarsening from dark hackly massive mudrocks into thin-bedded, locally slickesided siltstone facies. Major erosive sandstone sole surfaces show well-developed current crescents and sandstone-infilled mudcracks; *i.e*. subaerial deposition.
022	S32° 53' 22.3" E20° 19' 26.7"	Oliviers Berg 159. Riverbank sections through coarse boulder alluvium dominated by angular to subrounded cobbles and boulders of wacke / sandstone, clast-supported, with poorly-developed imbrication of platy clasts. Overlain by thin sandy alluvium and gravels. Coarse alluvial conglomerates wedge out along strike to interbedded semi-consolidated brown sandy and poorly-sorted gravelly alluvial deposits.
023	S32° 52' 39.8" E20° 20' 09.4"	Oliviers Berg 159. River bed and bank exposure of Combrinkskraal Mb wackes and grey-green as well as mottled purple-brown overbank mudrocks. Sandstones lenticular, v. fine-grained, massive with gradational, upward-coarsening bases. Small-scale wave ripples preserved at several horizons within grey-green, fine-grained wackes. Well-exposed packages of upward-coarsening purple-brown and grey-green siltstones and fine wackes with sharp tops – small spectrum of grain size variation. Riverbank sections through pale brown, rubbly, massive diamictites (probably debrites) with subrounded sandstone clasts within sandy matrix.
024	S32° 52' 35.3" E20° 20' 23.5"	Oliviers Berg 159. Good riverbank sections through several m-thick coarse alluvial and colluvial gravels with massive wacke boulders suspended in a sandy matrix. Basal horizon is a matrix-supported debrite diamictite with a gritty matrix while upper parts of succession include imbricated, clast-supported alluvial conglomerates. Coarse succession capped by sandy alluvium with minor gravels.
025	S32° 52' 37.3" E20° 20' 24.5"	Oliviers Berg 159. Stream bank and bed exposures of massive to well-bedded, hackly-weathering, purple-brown and grey green mudrocks grading up into

Loc	GPS data	Comments
		tabular, laterally-extensive, thin wackes with possible local slumping or collapse of wacke blocks into soupy mudrocks. Combrinkskraal Member.
026	S32° 52' 35.4" E20° 20' 43.7"	Oliviers Berg 159. Deeply-incised, meandering “dry” river valley below channel sandstone capping, downstream of dry waterfall. Extensive dark grey to purple-brown overbank mudrock exposure in banks and bed of river valley.
027	S32° 52' 33.7" E20° 20' 48.7"	Oliviers Berg 159. Bed of dry river valley with grey-green wackes sharply overlain by purple-brown mudrocks, upward-coarsening mudrock to wacke packages, Late Caenozoic coarse, crudely imbricated alluvial rubble overlies bedrocks.
028	S32° 52' 34.0" E20° 20' 50.4"	Oliviers Berg 159. Extensive riverbank exposure of Combrinkskraal Member overbank mudrocks and channel sandstones. Latter fine-grained, massive, gradational (towards base of succession) to sharp and erosive-based (higher in succession), undulose-topped, but locally show evidence of loading into soupy mudrocks Possibly multiple transitions across deltaic – fluvial boundary within Combrinkskraal Member.
029	S32° 52' 30.6" E20° 20' 56.3"	Oliviers Berg 159. Steep gully bank exposure of Combrinkskraal succession – massive to thinly-bedded purple-brown mudrock facies well represented, with subordinate thin sandstone interbeds. No calcrete palaeosols observed, but occasional possible gypsum pseudomorphs. Capped by thick, cliff-forming, well-jointed, tabular channel sandstone package.
029a	S32° 52' 31.0" E20° 21' 04.9"	Oliviers Berg 159. Float blocks below base of main channel sandstone showing poorly-preserved, backfilled cylindrical burrows of the *Scoyenia* Ichnofacies (Proposed Field Rating IIIC: Local Resource. No mitigation required).
029b	S32° 52' 35.9" E20° 20' 41.8"	Oliviers Berg 159. Small roadside exposure of a sandstone palaeosurface (possibly crevasse splay sandstone) bearing *possible* tetrapod tracks associated with small scale, linear-crested wave ripples. (Proposed Field Rating IIIB: Local Resource. Site should be recorded if disturbance is expected here during development. Site lies outside proposed development footprint).
030	S32° 53' 03.8" E20° 21' 02.4"	Oliviers Berg 159. Gullied hillslope exposures of thin- to medium-bedded grey-green and purple-brown overbank mudrocks, thin (dm-scale) sandstone interbeds – probably crevasse splays (stratigraphically between major sandstone packages). Cobble-sized ferruginous carbonate concretions.
031	S32° 53' 04.3" E20° 21' 04.1"	Oliviers Berg 159. Low hillslope step or *kranz* of thin-bedded purple-brown mudrocks grading upwards to sandstones. Cobble-sized ferruginous carbonate concretions in lower mudrocks.
032	S32° 52' 23.9" E20° 22' 20.0"	Matjes Fontein 194. Nek in Pad de Hoek pass – patches of grey-green mudrock exposure on lower hillslopes. Views of NE end of Central Ridge.
033	S32° 52' 15.3" E20° 22' 29.7"	Matjes Fontein 194. Pad se Hoek pass below wind mast. Extensive gullied hillslope exposure of crumbly, weathered, grey-green, massive to laminated overbank mudrocks as well as S-dipping highly-weathered, pale brown sandstone packages. Views towards west show gentle anticlinal fold in Abrahamskraal Fm.
034	S32° 51' 27.6" E20° 22' 43.3"	Matjes Fontein 194. Views west from Pad se Hoek pass showing stream gullies at eastern end of Central Ridge with exposure of channel sandstone *kranzes* and some mudrocks on steeper gully slopes. Local lenticular thickening of multi-storey channel sandstones associated with major water falls, exposed grey-green mudrocks beneath. Carpet of lichen-covered sandstone colluvium on gentler hillslopes.
035	S32° 50' 54.6" E20° 22' 49.7"	Matjes Fontein 194. Gulley exposures of low-elevation, poorly-sorted colluvial sands and gravels. Dominated by brown-patinated, well-rounded to angular wackes with minor vein quartz. Possible debrite diamictite facies with suspended large sandstone clasts in sandy matrix. Fine-grained sandstones show conchoidal fracture.
036	S32° 50' 23.0" E20° 22' 57.7"	Matjes Fontein 194. Modern boulder to cobbly alluvial gravels in shallow stream bed. Views of N turbine ridge from SE showing gently folding of Abrahamskraal Fm succession on N flanks of ridge. River bank exposure of hackly grey-green mudrocks (some laminated distal floodplain, possibly lacustrine packages, horizons with sphaeroidal to irregular, cobble-sized ferruginous carbonate concretions) with thin (< 1m), sharp-based crevasse splay sandstones. Sandstone bed tops with dispersed rounded casts of reedy plant stems – probably sphenophyte ferns. (Proposed Field Rating IIIC: Local Resource. No mitigation required).
037	S32° 50' 01.6" E20° 23' 50.7"	Matjes Fontein 194. Extensive channel sandstone bedrock exposure just downstream of Matjiesfontein homestead. Low angle cross-lamination in medium-

Loc	GPS data	Comments
		to coarse grained, medium- to thick-bedded, grey-green sandstone. Stream bank exposure of grey-green mudrocks with lenticular, ferruginous carbonate concretions, sharp-based, gradational-topped, fine-grained tabular sandstones SE of homestead.
038	S32° 49' 50.2" E20° 24' 03.6"	Matjes Fontein 194. Good riverine exposures of Abrahamskraal Fm sandstones and mudrocks *c*. 0.5 km NE of homestead. Upward-thickening succession grading up into base of thin-bedded sandstone packages. Hackly mudrocks v. dark grey, massive, thin-bedded to laminated – possibly lacustrine facies. Laterally-persistent horizons of ferruginous carbonate concretions (several dm thick). Small-scale (sev. m across) channel cut-and-fill feature overlying, and incising, dark grey thin-bedded facies.Abrahasmkral Fm bedrocks capped by several meters of semi-consolidated, rubbly, poorly-sported High Level Gravels (mainly sandstone clasts, up to boulder-sized)
039	S32° 49' 47.6" E20° 24' 04.9"	Matjes Fontein 194. Upper bedding plane of loaded, gradational-based, current ripple cross-laminated wacke with thin concentration of plant debris impressions. Casts of *in situ* stems and radiating, longitudinally-ridged, strap-like leaves of *Schizoneura africana* and *S. gondwanensis* as well as an undecribed new sphenophyte. Setting possibly a playa lake margin. Soft substrates indicated by loading, dewatering flame structures. Intermittent exposure indicated by small-scale cracking of muddy veneers on current-rippled surfaces. Overlying mudrocks with flame structures, then sandstone packages showing upward-thinning, sharp bases. (Proposed Field Rating IIIA: Local Resource. Site lies well outside WEF footprint so should be protected from disturbance or damage during construction. No mitigation recommended).
041	S32° 49' 47.2" E20° 24' 05.0"	Matjes Fontein 194. Unidentified reworked vascular plant debris – including sphenophytes and long-leaved lycopods - at same site, in part enclosed within dark grey, fine-grained wacke and showing low-relief 3d preservation (pale grey to rusty-brown, mineralised, not simply carbonaceous compressions). Associated large-scale mudcracks, ferruginous carbonate concretions, overlain by thin loaded wacked within grey-green mudrocks (Proposed Field Rating IIIA: Local Resource. Site lies well outside WEF footprint so should be protected from disturbance or damage during construction. No mitigation recommended). *N.B.* stream gully to east of nearby farm track was not checked for possible extension of fossiliferous horizon beneath capping sandstones.
042	S32° 49' 31.4" E20° 24' 16.5"	Matjes Fontein 194. Roadside stream gulley exposure of Abrahamskraal sediments. *Possible* vertebrate burrow cast *c*. 30 cm wide (requires confirmation). (Proposed Field Rating IIIB: Local Resource. No mitigation required).
043	S32° 49' 32.6" E20° 24' 19.1"	Matjes Fontein 194. Stream gulley exposure of Abrahamskraal sediments. Thin, possibly upward-fining packages of grey-green, laminated to thin-bedded siltstone beneath package of fine-grained channel sandstones. *Possible* subcylindrical vertebrate burrow cast *c*. 30-40 cm wide of grey-green wacke enclosed in crumbly mudrock, overlies top of channel sandstone (requires confirmation). (Proposed Field Rating IIIB: Local Resource. No mitigation required).
044	S32° 47' 56.9" E20° 25' 02.2"	Krans Kraal 189. Stream bank exposure of single-storey fine-grained channel wacke.
045	S32° 48' 52.6" E20° 24' 37.7"	Matjes Fontein 194. Stream gulley exposure of dark grey-green Abrahamskraal Fm mudrocks, pale grey calcrete nodules, gradational-based sandstone interbeds, loaded into underlying mudrocks.
046	S32° 51' 05.1" E20° 22' 43.1"	Matjes Fontein 194. Hillslope and roadside exposure of crumbly-weathering purple-brown and grey-green mudrocks.
047	S32° 51' 16.7" E20° 22' 26.1"	Matjes Fontein 194. Deeply-incised stream kloof exposure of Abrahamskraal Fm. Series of upward-coarsening packages capped by tabular, upward-coarsening wackes, sharply overlain by grey-green mudrocks with ferruginous carbonate horizons.
048	S32° 51' 16.7" E20° 22' 23.5"	Matjes Fontein 194. Waterfall in stream kloof formed by upward-coarsening, prograding package. Massive to laminated grey-green mudrocks – heterolithic, thin bedded facies – medium to thick-bedded, sharp-based, fine-grained, yellow-brown wackes. Heterolithic package beneath main channel sandstones is extensively loaded. Resembles Waterford deltaic facies spectrum.
049	S32° 51' 27.9" E20° 22' 02.5"	Matjes Fontein 194. Major sandstone dry waterfall and overhang in stream *kloof*. Two closely-spaced major channel sandstone packages, clear lenticular bedding, internal channel features (high relief reactivation surfaces). Very dark grey

Loc	GPS data	Comments
		wackes, thin- to thick-bedded. Upper thick package with sharp erosive base into recessive-weathering, darker underlying silty wackes or sandy silstones. Mudflake intraclasts on bedding plane surfaces.
049a	S32° 51' 28.8" E20° 22' 09.6"	Matjes Fontein 194. Stream section showing Waterford-like upward-coarsening packages, loading into dark grey mudrocks beneath major sandstone units, horizons of rusty-brown ferrugunous carbonate concretions, speckled diamictite-like immature sediments with dispersed small angular mudclasts suspended in silty wacke matrix. Thick, rubbly, immature alluvium towards base of stream gulley.
050	S32° 52' 04.5" E20° 20' 04.3"	Oliviers Berg 159. Obvious large overhang at base of laterally-persistent, tabular –bedded channel sandstone package. Scree of large sandstone blocks on underlying slopes.
051	S32° 46' 52.1" E20° 18' 31.7"	Wind Heuwel 190. View SE into northern sector of WEF study area (Urias Gat 193).
052	S32° 48' 14.2" E20° 21' 03.7"	Urias Gat 193. Stream bed and bank exposure of Abrahamskraal Fm channel sandstone, interbedded sandstone and mudrock. Small-scale, slightly sinuous crested wave ripples on upper bedding surfaces (shallow pond / playa lake setting). Coarse modern bouldery to sandy alluvium along stream banks. Possible vertical plant stem casts (*e.g.* sphenophyte reeds). (Proposed Field Rating IIIC: Local Resource. No mitigation required).
053	S32° 48' 14.9" E20° 21' 15.0"	Urias Gat 193. Gentle hillslope exposure of crumbly to hackly grey-green mudrocks. Well-developed horizons of rusty-brown ferruginous carbonate concretions – prhaps reflect high water tables on swampy floodplain.
054	S32° 48' 45.1" E20° 21' 31.6"	Urias Gat 193. Hillslope gulley exposure of weathered, khaki to grey overbank mudrocks, thin sandstones with gradational bases. Horizons of oblate sandstone load casts – suggests soupy substrates, rapid deposition.
055	S32° 48' 45.6" E20° 21' 37.4"	Urias Gat 193. Long hillslope gulley exposure of thin-bedded grey-green overbankj mudrocks passing up into thinly-interlaminated / striped, fine-grained, micaceous sandstone-siltstone facies. Overlain by dark grey, thin-bedded siltstone with subordinate thin sandstones showing undulose bed tops. Upward increase in bed thickness with extensive development of large (m-scale) oblate, ferruginous carbonate nodules, heterolithic facies where fine-grained wackes have gradational bases and tops. Upper part of exposed succession with small grey palaeocalcrete concretions as well as ferruginous carbonate concretions, *c.*2 m-thick, sharp-, erosive-based, medium-grained wacke.
056	S32° 49' 13.1" E20° 21' 52.8"	Urias Gat 193. Relict patch of weathered grey-green to khaki mudrock showing sparse gypsum pseudomorphs near to wind mast. Bedrocks of grey-green wacke. Views southwards towards N turbine ridge – tabular sandstone packages building plateau, Great Escarpment to NE beyond Windheuwel. View westwards towards alternative WEF access road ridge to N turbine ridge. Prism of brownish-hued, thick, sandy to gravelly colluvium at base of slope to N.
057	S32° 47' 20.0" E20° 21' 18.1"	Urias Gat 193. Stream bank exposure of medium-bedded, tabular grey-green wackes and siltstones near old farmstead. Lenticles of ferruginous carbonate concretions up to 30 cm thick.
058	S32° 46' 18.4" E20° 21' 43.5"	Urias Gat 193. Gullied roadside exposure of thick (sev. m) pale brown sandy alluvium on valley floor. Sparse gravels of well-rounded to angular wacke, vein quartz, with some flaked artefacts of greyish wacke. Local development of creamy calcrete glaebules. Downwasted surface gravels on alluvial plains mainly composed of wacke.
059	S32° 45' 11.2" E20° 21' 46.1"	Urias Gat 193. Deep trenches near Windheuwel farmstead exposing several meters of coarse gravelly to sandy alluvium of Uriasgatrivier. Older alluvium richer in coarse wacke clasts.
101	S32° 54' 16.9" E20° 20' 47.1"	Oliviers Berg 159. Long riverine exposure of Abrahamskraal Fm purple-brown and greenish-blue hackly mudrocks and laterally-persistent, tabular, sharp-based sandstones, overlain by coarse alluvial gravels. Gypsum pseudomorphs, pale greyish palaeocalcrete nodules in mudrocks. Tops of thin sandstone beds with round casts of reedy plants (*e.g.* sphenophytes) (Proposed Field Rating IIIC: Local Resource. No mitigation required).
102	S32° 54' 12.9" E20° 20' 49.6"	Oliviers Berg 159. Riverine cliff section through interbedded tabular to lenticular, medium-bedded wackes and mudrocks of Abrahamskraal Fm. Close spacing of wacke units seen here (upward-coarsening mudrock – wacke cycles only a few m thick). Thick (*c.* 2 m) massive, well-sorted, fine-grained, erosive-based wacke

Loc	GPS data	Comments
		towards base of succession builds prominent step. Mudrocks mottled purple and greenish-blue, with slickensides. Pale calcareous flowstone developed over part of cliff face, locally forming stalactites beneath overhangs.
103	S32° 54' 14.8" E20° 20' 49.1"	Oliviers Berg 159. Small-scale linear to sinuous-crested wave ripples towards top of major sandstone unit. Rippled surfaces locally show poorly-preserved, arcuate horizontal burrows (*c.* 3-5 mm wide) as well as round casts of plant stems. Possible *Scoyenia* Ichnofacies traces. Mudrock horizons with mudcrack infills. Probably crevasse-splay ichnoassemblages. (Proposed Field Rating IIIC: Local Resource. No mitigation required). Succession of sharp-based tabular wackes overlying purple-brown to blue-green mudrocks exposed on lower valley slopes upstream.
104	S32° 54' 13.0" E20° 21' 06.9"	Oliviers Berg 159. View along valley to ESE showing thick, sharp-based channel sandstone at river level overlying blue-grey and purple-brown overbank mudrocks.
105	S32° 54' 24.2" E20° 21' 17.2"	Oliviers Berg 159. Views towards southern turbine ridge (Koedoesberge) show major channel sandstone underlying plateau along crest. Coarse colluvial gravels of wacke mantling hillslopes. Almost no mudrock exposure.
106	S32° 54' 46.9" E20° 21' 18.1"	Oliviers Berg 159. Viewpoint westwards along Koedoesberge ridge. Regular banding of hillslopes reflects underlying tabular-bedded Abrahamskraal Fm bedrocks. Views towards sandstone capping of Koedoesberge to SE show possible upward- and laterally-stepping successive channel sandstones, reflecting lateral channel migration through time..
107	S32° 55' 04.7" E20° 21' 08.2"	Muishond Rivier 161. Patch of crumbly- to hackly-weathering grey-green mudrocks along crest of Koedoesberge ridge. Khaki-hued where highkly weathered. Downwasted pebble-sized, greyish to brownish palaeocalcrete concretions.
108	S32° 55' 05.0" E20° 20' 52.0"	Muishond Rivier 161. Pale yellowish-green to grey-green, speckled, angular surface gravels near wind mast represent fine-grained tuff (volcanic ash) horizon (probably < 10 cm thick) that crops out in this area (possibly traceable along strike to west as pale areas on satellite images). Tuff horizon lies below level of highest channel sandstone body seen capping ridge to the west. Crest of ridge otherwise dominated by extensive, coarse, poorly-sorted surface gravels of Abrahamskraal wacke and gravely to sandy soils with very little mudrock exposure.
110	S32° 53' 55.1" E20° 20' 10.9"	Oliviers Berg 159. Extensive riverine exposure of thick successions of tabular-, thin-bedded to massive, crumbly, greyish as well as minor purple-brown mudrock facies of Abrahamskraal Fm (*i.e.* succession between major sandstone packages). Thin crevasse splay sandstone interbeds. Laterally-persistent horizons of rusty-brown ferruginous carbonate concretions as well as palaeosols marked by smaller (cobble-sized), pale grey to ferruginous palaeocalcrete nodules. Upper part of succession with several thin upward-coarsening cycles ending with laminated sandstone or thin channel sandstone (dm scale). Extensive bedding plane exposure of channel wackes in stream bed – massive, fine-grained, well-jointed. Distal floodplain facies, possibly with repeated packages of lacustrine infill. Occasional horizons of loading.
111	S32° 53' 55.4" E20° 20' 12.2"	Oliviers Berg 159. Several m-thick upward fining package (fine single storey sandstone, possibly crevasse-splay – thin-bedded purple-brown siltstone – grey-green thin-bedded to massive siltstone to claystone sharply capped by thick channel sandstone package). Good examples of several m-thick upward coarsening packages with thin-bedded wackes capped by medium-bedded wackes.
112	S32° 53' 42.2" E20° 18' 09.9"	Oliviers Berg 159. View eastwards from old stone kraal towards low hillslopes featuring repeated thin (few m), S-dipping upward-coarsening, sandstone-capped cycles. Well-developed calcrete hardpan beneath colluvial gravels of brown-patinated wacke.
113	S32° 53' 29.5" E20° 17' 25.2"	Gats Rivier 156. Vertically stacked, lenticular, thick-bedded channel sandstone bodies, increasing successively in width/thickness ratio over time. Core channel bodies overlie dipping, convex-downard, thinner-bedded, heterolithic zone incised into flat-bedded, mudrock-rich Abrahamskraal succession.
115	S32° 57' 15.8" E20° 17' 03.4"	Klip Banks Fontein 395. Long riverbank exposure through NE-dipping lower Abrahamskraal Fm succession of numerous successive sandstone-mudrock packages. Change in dip within succession may reflect episodic basinward collapse of sediment prism. At western (lower) end of exposed succession,

Loc	GPS data	Comments
		massive grey-green and purple-brown siltstones with horizons of large ferruginous carbonate concretions, overlain by crumbly claystones with gypsum pseudomorphs (subaerial deposition). Well-jointed thin (<1m) sandstones higher up succession are lenticular, often mottled, fine-grained wackes with gradational bases. May cap upward-coarsening packages.
116	S32° 57' 14.9" E20° 17' 09.8"	Klip Banks Fontein 395. Same riverine exposure as above. Thick mudrock package with well-developed ferruginous carbonate concretions towards the base. Purple-brown and grey-green siltstones coarsen upwards via thin-bedded zone into thin sandstone capping.
117	S32° 57' 13.8" E20° 17' 10.8"	Klip Banks Fontein 395. Same riverine exposure as above. Thick (>1m) fine-grained tabular sandstone with gradational, loaded base. Overlying heterolithic zone with undulating bedding planes, perhaps due to small-scale channeling and sediment prism subsidence. Sizeable (sev. dm-scale) sandstone loadcasts within overlying mudrocks. Thick package of thin-bedded purple-brown and blue-green mudrocks towards top of exposed succession.
118	S32° 55' 18.1" E20° 16' 24.9"	Klip Banks Fontein 395. Small stream gulley and hillslope exposures of heterolithic purple brown or grey-green siltstone / fine sandstone succession. Mudcrack infills.
119	S32° 55' 21.7" E20° 16' 34.3"	Klip Banks Fontein 395. Coarse colluvial gravels, angular to subrounded, with abundant ferruginous palaeocalcrete clasts as well as Abrahamskraal wacke clasts. Views eastwards along Koedoesberge ridge shoing largely flat-lying stratigraphy, paucity of bedrock exposure.
120	S32° 55' 13.9" E20° 16' 41.4"	Klip Banks Fontein 395. Low exposures of yellowish-brown weathering, crumbly ("biscuit-like") sandstones, parallel-laminated, with darker brown m-scale corestones.
121	S32° 55' 11.5" E20° 16' 52.3"	Klip Banks Fontein 395. Several low Abrahamskraal Fm hillslope and gulley exposures across crest of ridge. Crumbly, blue-grey overbank mudrocks, wacke surface gravels.
122	S32° 55' 09.2" E20° 16' 51.6"	Klip Banks Fontein 395. Gulley exposure of thin-bedded Abrahamskraal blue-grey mudrocks with ferruginous carbonate concretions capped by thin crevasse splay sandstone.
123	S32° 55' 09.1" E20° 16' 54.5"	Klip Banks Fontein 395. Low hillslope exposures of blue-grey Abrahamskraal Fm mudrocks with occasional thin sandstone interbeds. Small (few cm diam.) flattened to sphaeroidal, pinkish-grey calcrete nodules and occasional gypsum pseudomorphs within mudrocks – calcrete forms common component of downwasted gravels in stream gullies.
124	S32° 54' 58.4" E20° 17' 25.9"	Klip Banks Fontein 395. Thick (several m) tabular channel sandstone at ridge crest forming well-jointed *kranz* with skirt of coarse scree. Uppermost and thickest of series of prominent-weathering tabular sandstone units Gypsum pseudomorphs common in poorly-exposed interbedded mudrocks.
125	S32° 55' 00.2" E20° 17' 40.1"	Klip Banks Fontein 395. Hillslope exposure of crumbly purple-brown mudrocks. Numerous pebble to cobble-sized palaeocalcrete concretions weathering out at surface Concretions weather pale grey and show septarian (shrinkage) cracking internally.
126	S32° 54' 59.2" E20° 17' 46.7"	Klip Banks Fontein 395. Hillslope exposures of Abrahamskraal tabular-bedded sediments. Low *kranz* of greyish wacke interbedded grey-green and purple-brown siltstone with laterally-persistent horizon of ferruginous carbonate concretions.
127	S32° 54' 57.5" E20° 17' 44.8"	Oliviers Berg 159. Stream gulley exposure of thin-bedded overbank siltstones and highly-jointed tabular wackes building upward-coarsening packages.
128	S32° 55' 19.4" E20° 17' 41.4"	Klip Banks Fontein 395. Major local thickening of channel sandstones (vertical amalgamation) exposed in stream gulley waterfall. Pattern repeated instream gully to the west.
129	S32° 55' 26.2" E20° 17' 51.9"	Klip Banks Fontein 395. Coarse, subrounded wacke corestones building colluvial gravels mantling hillslopes. Occasional flaked weathered MSA artefacts of brown-patinated wacke recorded here. Stepped hillslopes in region display lichen-covered stable gravels overlying sandstone bedrock.
130	S32° 55' 19.1" E20° 18' 19.7"	Klip Banks Fontein 395. Hillslope and gulley exposure of massive grey mudrocks with horizons of grey to rusty-brown calcrete concretions. Overlain by finely-laminated to cross-laminated thin sandstone and then speckled diamictite facies with development of small-scale load balls beneath. Mudrocks with wide (2-3 cm) polygonal desiccation crack infills extending for several dm into mudrocks – suggests period of protracted aridity on floodplain. Possible playa lake bed

Loc	GPS data	Comments
		succession.
131	S32° 57' 31.6" E20° 16' 22.2"	Klip Banks Fontein 395. Road cutting near Klipbanksfontein farmstead showing several meters of heterolithic, gey-green, interbedded wacke and siltstone. Isolated, vertical, upwards-tapering wacke plug (*c*. 25 cm across towards exposed base, circular cross-section) piercing and deforming strata may be a dewatering pipe.
132	S32° 52' 39.5" E20° 16' 16.8"	Gats Rivier 156. Viewpoint on southern slopes of central turbine ridge. S-sloping sandstone surfaces mantled with colluvial rubble. Mudrock exposure limited to several stream gullies, steeper hillslope patches. Sandstone package along ridge crest also represented close to river in valley due to steep regional dip to the south.
133	S32° 52' 02.1" E20° 16' 03.8"	Gats Rivier 156. Gentle hillslope exposures of crumbly grey-green mudrocks with thin sandstone capping close to ridge crest. Ferruginous carbonate concretions.
134	S32° 52' 00.8" E20° 16' 04.7"	Gats Rivier 156. Long gulley-side cliff exposure through dark grey, thin-bedded siltstones, massive siltstones with horizon of large (boulder-sized) ferruginous carbonate concretions, laterally-persistent ferruginised, speckled sandstone bed with gradational base, thin crevasse-splay sandstone capping.
135	S32° 52' 00.7" E20° 16' 04.9"	Gats Rivier 156. Same exposure as above. Zone c. 1 m –thick of sparse to closely-spaced, vertical, cylindrical lungfish burrow casts (6-8 cm diameter) extending downwards from base of thin ferruginised sandstone marker bed into thin-bedded dark grey mudrocks – probable playa lake facies. Sandstone casts fracture into discs, show vague vertical ridges and grooves. Occur sporadically along strike. (Proposed Field Rating IIIA: Local Resource. Site lies well outside (> 50 m) WEF footprint so no mitigation recommended).
136	S32° 52' 07.2" E20° 15' 25.0"	Gats Rivier 156. Low exposure of crumbly grey-green mudrocks near central turbine ridge crest.
137	S32° 52' 15.8" E20° 15' 33.2"	Gats Rivier 156. Thick package of grey-green, massive to laminated mudrocks exposed on N-facing gulley slopes, thin sandstone interbeds (crevasse-splays), succession capped by thin-bedded greyish wackes and then sharp-based, , yellowish crumbly channel sandstone. Ferruginous carbonate concretions common within mudrocks. Isolated blobs of greyish wacke embedded in mudrock – possibly pillows, or vertebrate burrow casts (no specific evidence for latter interpretation). Possible evidence for large-scale slumping of channel sandstone bodies lower down in succession, with rapid changes in dip and strike of medium-bedded sandstones.
139	S32° 52' 25.0" E20° 16' 11.9"	Gats Rivier 156. S-sloping channel sandstone top showing exfoliation weathering, surface scatter of sandstone rubble.
140	S32° 52' 42.5" E20° 16' 11.3"	Gats Rivier 156. Long stream bank dip section through Abrahamskraal grey-green mudrocks and thin sandstones, overlying major channel sandstone body. Informative section for Lower Abrahamskraal Fm sedimentology. Massive and thin-bedded overbank mudrock facies with horizons of ferruginous carbonate concretions. Coarsening-up top of section with thin-bedded and then medium-bedded wackes.
141	S32° 52' 44.5" E20° 16' 09.1"	Gats Rivier 156. Downstream part of same panel section showing pale laminated sandstone (*c*. 10 cm thick) containing darker, vertical to oblique burrows with circular cross-section (*c*. 5 mm wide). Speckled texture of burrow infill possibly reflected faecal pellets or may be diagenetic effect. Pale bed might be tuffaceous (unconfirmed).
142	S32° 52' 57.2" E20° 16' 19.0"	Gats Rivier 156. Riverine bank section through khaki, medium- to thin-bedded, markedly tabular sandstones Beds mottled / speckled, crumbly (“biscuit” texture), parallel-laminated to massive (*cf* Koornplaats Member of Abrahamskraal Fm).
143	S32° 53' 08.0" E20° 15' 38.4"	Gats Rivier 156. W-facing stream *kloof* section through thin- to thick-bedded, tabular, khaki-hued Abrahamskraal sandstones interbedded with thin laminated siltstone facies. Some sandstone beds loaded at base and secondarily ferruginised, others with wave-rippled bed tops. *In situ* sandstone bedding planes and broken surfaces of fallen blocks with abundant, dispersed, fragmentary plant remains (*e.g.* finely-striated stem axes preserved as ferruginised compressions - probably sphenophytes, ferruginised moulds of woody material). Reworked plant material also associated with intraclast breccias of reworked mudrock. . (Proposed Field Rating IIIC: Local Resource. No mitigation required).

<table>
<tr><th colspan="3">Appendix 2: CHANCE FOSSIL FINDS PROTOCOL:
KUDUSBERG WEF between Matjiesfontein and Sutherland</th></tr>
<tr><td>Province & region:</td><td colspan="2">Western Cape (Cape Winelands District Municipality) and Northern Cape (Namakwa District Municipality)</td></tr>
<tr><td>Responsible Heritage Management Authority</td><td colspan="2">Heritage Western Cape for the Western Cape (Contact details: Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 086-142 142. Fax: 021-483 9842. Email: hwc@pgwc.gov.za) and SAHRA for the Northern Cape (Contact details: South African Heritage Resources Agency. 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel : 021 462 4502).</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Abrahamskraal Formation (Lower Beaufort Group), Late Caenozoic alluvium</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Fossil vertebrate bones, teeth, large burrows, trackways, petrified wood, plant-rich beds in the Abrahamskraal Fm bedrocks. Fossil mammal bones, teeth, horncores, freshwater molluscs, plant material in Late Caenozoic alluvium.</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
• Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
• Context – describe position of fossils within stratigraphy (rock layering), depth below surface
• Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
• Alert Heritage Management Authority and project palaeontologist (if any) who will advise on any necessary mitigation
• Ensure fossil site remains safeguarded until clearance is given by the Heritage Management Authority for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
• Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
• Photograph fossils against a plain, level background, with scale
• Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
• Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
• Alert Heritage Management Authority and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Management Authority, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Management Authority</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Management Authority minimum standards.</td></tr>
</table>