PALAEONTOLOGICAL ASSESSMENT: COMBINED DESKTOP & FIELD-BASED ASSESSMENT

PROPOSED UPGRADE OF THE ACCESS ROAD TO THE AUTHORISED 140 MW RIETRUG WIND ENERGY FACILITY, SUTHERLAND MAGISTERIAL DISTRICT, NORTHERN CAPE

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EXECUTIVE SUMMARY

It is proposed to upgrade and widen the existing gravel access road from the R354 to the authorised Rietrug Wind Energy Facility (WEF) to a width of up to 7 m over a 10 km sector. The access road runs within a servitude over the Remainder of Lange Kuil 136 and Portion 1 of Nooitgedacht 148, located some 40 km ESE of Sutherland in the Roggeveld plateau region of the Northern Cape Province. The start and end points for the proposed upgrade are S32° 32' 02.5" E20° 58' 22.3" and S32° 36' 12.5" E21° 00' 38.2" respectively. From the southern end of the upgraded section the road will join the internal access roads for the authorised Rietrug WEF and proceed through that site to the Sutherland WEF site immediately to the south. Since the access road development has already been included in the Environmental Authorisations for the adjoining Sutherland and Rietrug WEFs and the route remains unchanged from the EIA phase, a Part 2 amendment application is being submitted for (1) the inclusion of the co-ordinates on the existing access road and (2) to assess the impacts associated with upgrading and widening of the access road.

The footprint of the short WEF access road sector to be upgraded is underlain by sedimentary rocks within the upper part of the Abrahamskraal Formation, Lower Beaufort Group (Karoo Supergroup) which are of Middle Permian Permian age. In the Main Karoo Basin this stratigraphic interval (*viz*. upper Moordenaars Member *plus* Karelskraal Member) is associated with impoverished tetrapod faunas of the upper *Diictodon* – *Styracocephalus* Assemblage Zone reflecting the Middle Permian global ecological crisis and resulting Mass Extinction Event on land. Only a few fossil sites - comprising fragmentary skeletal remains of dicynodont therapsids, tetrapod burrow casts, low diversity invertebrate trace fossil assemblages and scrappy plant remains - have been recorded in the vicinity of the access road, all of which lie *outside* the amended footprint. A high proportion of the access road project area is mantled by Late Caenozoic superficial deposits (alluvium, colluvium, surface gravels, soils) of low palaeosensitivity; no fossils have been recorded within them. (*N.B.* Sectors of the access road within the project areas of the authorised Sutherland and Rietrug Wind Energy Facilities have not yet been surveyed for palaeontological heritage. Since they traverse older Moordenaars Member bedrocks associated with diverse fossil biotas of the lower *Diictodon* – *Styracocephalus* Assemblage Zone, impacts here are potentially more significant).

The DFFE Screening Report for the proposed access road development provisionally assigns a VERY HIGH palaeosensitivity to the project area (Appendix 3). Due to the scarcity of well-preserved, scientifically important fossils here, based on desktop studies as well as fieldwork, it is inferred that the area is in fact largely of LOW PALAEONTOLOGICALLY SENSITIVITY, although sparse, and largely unpredictable sensitive fossil sites might also occur here. The results of the DFFE screening tool sensitivity are therefore *contested* here.

Given (1) the small footprint of the WEF access road upgrade and (2) the low palaeosensitivity of both the bedrocks and superficial sediments here, the impact significance of the proposed amendment for the construction phase is assessed as NEGATIVE LOW before and after mitigation. Negative residual impacts will be partially offset by an improved palaeontological data base and fossil collections (*positive* impacts). The No-Go alternative - *i.e*. no widening of the access road - would also have a NEGATIVE LOW impact on palaeontological heritage, with and without mitigation. Confidence levels for this assessment are Medium, given the paucity of palaeontological field data in the broader project region. Once constructed, the Operational and De-commissioning Phases of the access road will not involve further adverse impacts on palaeontological heritage so these are not assessed here.

Given the extensive outstanding palaeontological heritage field data in the south-eastern Roggeveld region relevant to this development, notably for the Sutherland and Rietrug WEF project areas, it is not feasible to meaningfully assess cumulative palaeontological impacts for the proposed WEF access road upgrade under consideration in this report. However, pending the outcome of the outstanding palaeontological field-based studies, it is *provisionally* concluded that the cumulative impact significance of the proposed access road upgrade in the context of road developments relating to renewable energy developments in the region is NEGATIVE MEDIUM without mitigation. This would fall to *NEGATIVE LOW provided that* the proposed palaeontological monitoring and mitigation recommendations made for *all* these various renewable energy projects are fully implemented.

The proposed access road upgrade project is not fatally flawed and there are no objections on palaeontological heritage grounds to authorisation of the proposed amendment, *provided that* the recommended mitigation measures for the construction phase outlined below and tabulated in Appendix 2 are included in the EMPr for the development and are fully implemented.

8.1. Recommended mitigation measures

In view of the low palaeosensitivity of the access road upgrade project area and the inferred low impact significance of the proposed development on palaeontological heritage resources, it is concluded that no further palaeontological heritage studies or specialist palaeontological mitigation are required for this project, pending the exposure of any substantial fossil remains (*e.g.* vertebrate bones and teeth, large blocks of petrified wood) before or during the construction phase. None of the fossil sites recorded in the vicinity lies within the project footprint and so they do not require mitigation in this regard.

In accordance with the EMPrs for the authorised Sutherland WEF and Rietrug WEF, sectors of the access road *within* the WEF project areas should be surveyed by a qualified palaeontological specialist, with recommendations for palaeontological mitigation (if any is necessary) to be submitted for comment to SAHRA.

The ECO / ESO responsible for the development should be alerted to the possibility of fossil remains being found on the surface or exposed by fresh excavations during construction. Should substantial fossil remains be discovered during construction, these should be safeguarded (preferably *in situ*) and the ECO / ESO should alert the 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). This is so that appropriate mitigation (*e.g.* recording, sampling or collection) can be taken by a qualified palaeontologist.

The palaeontological specialist involved would require a collection permit from SAHRA. Fossil material must be curated in an approved repository (*e.g.* museum or university collection) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA (2013).

These recommendations are summarized in Appendix 2 and must be incorporated into the EMPr for the amended WEF access road development as a condition accompanying environmental authorisation of the project.

Summary of palaeontological impact significance ratings for the amended WEF access road

Impact: Disturbance, damage or destruction of fossil heritage resources preserved at or beneath the ground surface within the project footprint		
Cause: Surface clearance or excavations		
	Without mitigation	***With mitigation***
Construction Phase	NEGATIVE LOW	NEGATIVE LOW
No-Go Option*	NEGATIVE LOW	NEGATIVE LOW
Cumulative impacts	NEGATIVE MEDIUM (provisional only)	NEGATIVE LOW (provisional only)

- ***i.e.*** **no widening of WEF access road**

1. INTRODUCTION & BRIEF

South Africa Mainstream Renewable Power Developments (Pty) Ltd has been granted an Environmental Authorisation (12/12/20/1782/1) for the 140MW Rietrug Wind Energy Facility (WEF). Access to the wind energy facility will be *via* a Secondary Road off the R354 (Fig. 1). Following receipt of the Environmental Authorisation for the adjoining Rietrug and Sutherland WEFs it was determined that the start, middle and end co-ordinates of the existing access road and its width had not been specified within the authorisations. The relevant EIA reports indicated that the impacts associated with internal access roads for the Sutherland and Rietrug WEFs had been considered in their assessments (*N.B.* This does *not* apply to potential impacts on palaeontological heritage since the necessary field studies required by SAHRA have not yet been undertaken). However, the upgrade of *external* roads fell outside the scope of the EIA.

It is now proposed to upgrade and widen the existing gravel access road to a width of 7 m over a 10 km sector to facilitate transportation of abnormal loads such as wind turbines during the construction phase. Since the activities concerned have already been included in the Environmental Authorisations for the WEFs and the route remains unchanged from the EIA phase, a Part 2 amendment application is being submitted for (1) the inclusion of the co-ordinates on the existing access road and (2) to assess the impacts associated with upgrading and widening of the access road.

The access road runs within a servitude over the Remainder of Lange Kuil 136 and Portion 1 of Nooitgedacht 148. The start and end points for the proposed upgrade are S32° 32’ 02.5”, E20° 58’ 22.3” and S32° 36’ 12.5”, E21° 00’ 38.2” respectively. From the southern end of the upgraded section the road will join the internal access roads for the authorised Rietrug WEF and proceed through that site to the Sutherland WEF site immediately to the south.

The access road project area is underlain by Middle Permian bedrocks of the Beaufort Group (Karoo Supergroup) that are potentially fossiliferous and provisionally rated as of High to Very High palaeosensitivity (SAHRIS palaeosensitivity map, DFFE Screening Tool) (Fig. A3.1 in Appendix 3). A reconnaissance-level field-based study of fossil sites along the secondary road off the R354 up to the boundary of the adjoining authorised Rietrug and Sutherland Wind Energy Facilities was undertaken by the author in 2016 while several further fossil sites in the wider region were recorded in the context of proposed electrical grid infrastructure to support the authorised Rietrug, Sutherland and Sutherland 2 Wind Energy Facilities (Almond 2017, 2019).

It is noted that the extensive original Mainstream Sutherland WEF project area (now split into the Sutherland, Sutherland 2 and Rietrug WEFs) has not yet been subjected to a full, field-based palaeontological heritage assessment. A pre-construction palaeontological field survey of all the land parcels involved was recommended in the original pre-scoping desktop assessment for the Mainstream Sutherland WEF (Almond 2010c). A pre-construction specialist palaeontological walk-down of the final project footprint of the Sutherland, Sutherland 2 and Rietrug WEFs was requested by the South African Heritage Resources Agency (SAHRA) (Case ID 9622, Interim Comment of 5 July 2016 and subsequent comments). These recommendations were not included within the relevant WEF Environmental Authorisations but have been incorporated in full into the EMPrs for these renewable energy developments. Sectors of the access road within the Sutherland WEF and Rietrug WEF project areas should then be palaeontologically surveyed with recommendations for palaeontological mitigation (if any) submitted to SAHRA for comment.

The present combined desktop and field-based PIA report contributes to the Part 2 Amendment process that is being undertaken to assess the proposed upgrading of the external access road to the authorised Rietrug WEF. The independent EAP for the project is Ms Arlene Singh of Nala Environmental Consultants (Address: Corner of Old Pretoria Main Road & Maxwell Drive, Waterfall, Johannesburg, 2090.Tel: +27 84 277 7074. E-mail: Arlene@veersgroup.com).

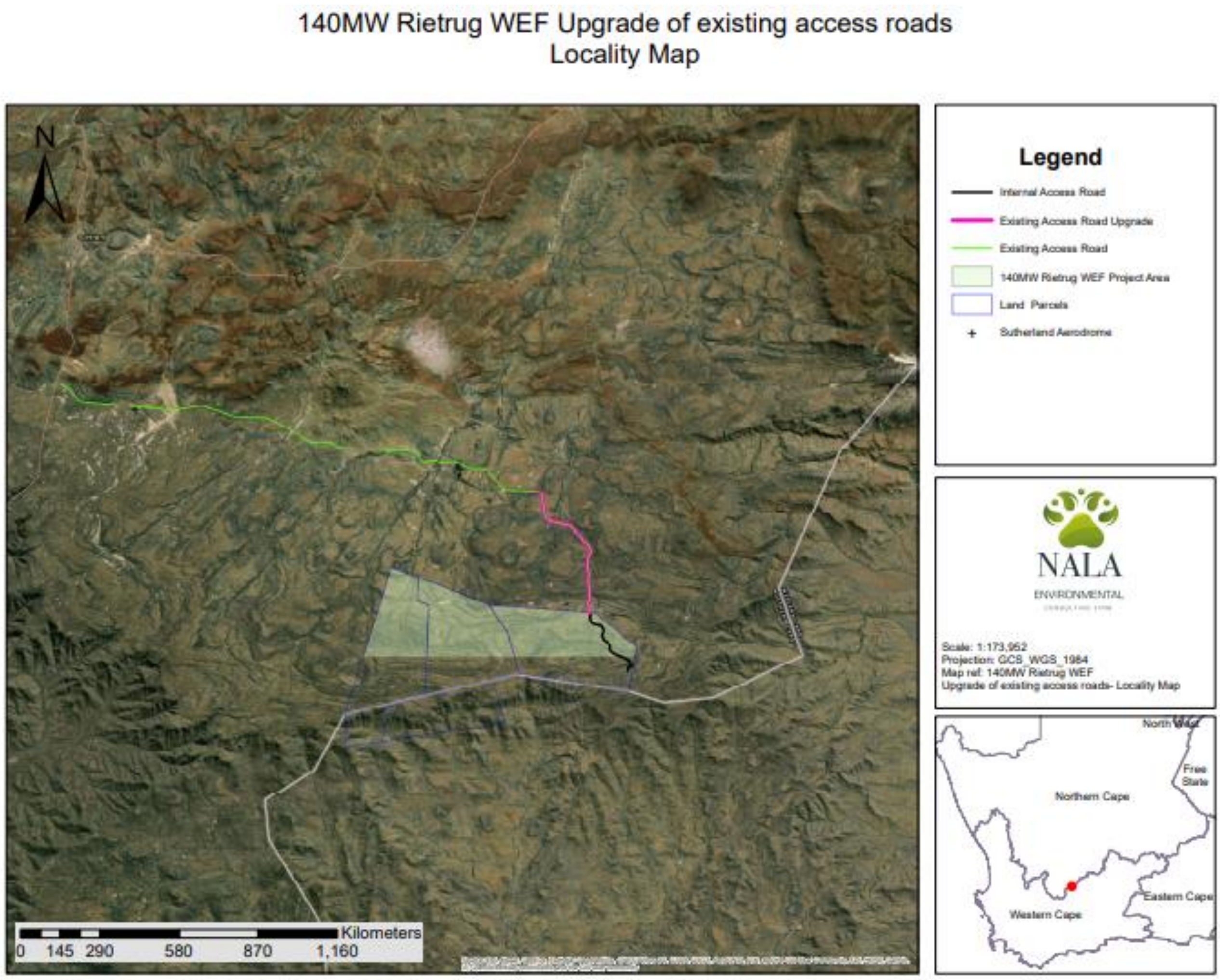

Figure 1: Satellite map of the Roggeveld region southeast of Sutherland showing the amended access road project area to the Rietrug WEF (pink line) (Image provided by Nala Environmental Consultants). Sectors crossing the Rietrug WEF and Sutherland WEF project areas have already been authorised. According to the EMPrs for these two WEFs, the infrastructure footprint here, including access roads, will be surveyed by a qualified palaeontologist in the pre-construction phase. See Figure 17 for a more detailed satellite image of the access road amendment project area.

2. LEGISLATIVE CONTEXT

The present combined desktop and field-based palaeontological heritage report falls under Sections 35 and 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999), and it will also inform the EMPr for this project.

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;
- 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) and by Heritage Western Cape (2021).

2.1. Legislative and Permit Requirements for potential specialist mitigation

Should professional palaeontological mitigation be necessary during the construction phase of the development (1) the palaeontologist concerned will need to apply for a Fossil Collection Permit from SAHRA (Contact details: 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) while (2) Palaeontological collection should comply with international best practice. (3) All fossil material collected must be deposited, together with key collection data, in an approved depository (museum / university), such as the Iziko Museums, Cape Town. (4) Palaeontological mitigation work including the ensuing Fossil Collection Reports should comply with the minimum standards specified by SAHRA (2013).

3. STUDY APPROACH

This combined desktop and field-based palaeontological heritage report provides an assessment of the observed or inferred palaeontological heritage within the amended WEF access road project area, with recommendations for any specialist palaeontological mitigation where this is considered necessary. GPS data for key localities mentioned by number in the text are given in Appendix 1 where they are mapped in the context of the amended project area (Fig. A1.1).

This report is based on:

- A desktop review of (a) the relevant 1:50 000 scale topographic and the 1:250 000 scale topographic map 3220 Sutherland and 1: 50 000 maps 3220DB Komsberg and 3221CA Besemgoedberg, (b) Google Earth© satellite imagery, (c) published geological and palaeontological literature, including 1:250 000 geological and metallogenic maps (3220 Sutherland) and relevant sheet explanations (Theron 1983, Cole & Vorster 1999) as well as (d) several previous desktop and field-based fossil heritage (PIA) assessments in the Roggeveld region to the southeast of Sutherland by the author and colleagues (See especially Almond 2010b, 2010c, 2015i, 2016h, 2017, 2019) .

- A several-day long field assessment by the author in 2016-2017 of portions of the access road from the R354 up until the boundary of the Rietrug WEF project area as well as portions of nearby terrain within WEF grid connection project areas.

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

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

4. ASSUMPTIONS & LIMITATIONS

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

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

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The

maps generally depict only significant (“mappable”) bedrock units as well as major areas of superficial “drift” deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

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

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

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

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:
(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or
(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous “drift” (soil, alluvium *etc*).
Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

This palaeontological heritage assessment report is largely based on a reconnaissance-level, field-based survey by the author in Nov-Dec 2016 of the WEF access road from the R354 to the border of the adjoining Rietrug WEF and Sutherland WEF project areas. The WEF project areas themselves – including sectors of the access road traversing them - have not been surveyed, substantially limiting the palaeontological database informing this study. Confidence levels for this assessment are therefore rated as Medium / Moderate, at most.

5. GEOLOGICAL CONTEXT

The access road project area on the Remainder of Lange Kuil 136 and Portion 1 of Nooitgedacht 148 (1: 50 000 maps 3220DB Komsberg, 3221CA Besemgoedberg) traverses rugged, semi-arid, hilly terrain mantled with karroid vegetation (Fig. 1). The area lies towards the south-eastern edge of the Roggeveld Plateau – part of the Great Escarpment - which is defined to the south and east by the Komsberg, Besemgoedberg, Lammerberg and Rooiberg ranges. The bedrocks here are deformed by a series of upright, large scale folds with W-E trending axes which exert a major control on topography, as well seen on satellite images (Fig. 17). The area is characterised by stepped hillslopes, controlled by thin, laterally-extensive and prominent-weathering sandstone packages with intervening gentler slopes (largely mantled by sandstone colluvium) underlain by more readily-weathering mudrocks. Upland areas include numerous small sandstone plateaux and ridges capped by rubbly sandstone eluvium and reaching elevations of 1500-1600 m amsl in this region. Away from the Escarpment edge - a major watershed - drainage is largely into the subcontinental interior *via* the Rietrivier and its numerous tributaries which are incised across the grain of the Cape Fold Belt.

The geology of the Roggeveld region to the southeast of Sutherland region is outlined on the 1: 250 000 scale geology sheet 3220 Sutherland (Theron 1983) (Fig. 3) as well as on the updated 1: 250 000 Sutherland metallogenic map that includes important new stratigraphic detail for the Lower Beaufort Group succession (Cole & Vorster 1999) (*cf* Fig. 4). The study area is entirely underlain by Middle Permian continental sediments of the **Lower Beaufort Group** (Adelaide Subgroup, Karoo Supergroup), and in particular the **Abrahamskraal Formation** (Pa) at the base of the Lower Beaufort Group succession (Johnson *et al.* 2006 and references cited below). No Karoo dolerite or younger (Cretaceous) intrusions are mapped within the present study region; major **Karoo Dolerite Suite** intrusions as well as younger Cretaceous igneous bodies of the **Sutherland Suite** (*e.g.* Salpeterkop) intrude the Lower Beaufort Group shortly (< 20 km) to the northeast, north and northwest. The Karoo bedrocks in the study area are extensively overlain by Late Caenozoic **superficial deposits** such as scree and other slope deposits (colluvium and hillwash), stream alluvium, down-wasted surface gravels, calcretes and various sandy to gravelly soils.

The **Abrahamskraal Formation** is a very thick (*c*. 2.5 km) succession of fluvial and lacustrine deposits that were laid down in the Main Karoo Basin by meandering rivers on an extensive, low-relief floodplain during the Middle Permian Period, some 266-260 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, laminated mudrocks, limestones, evaporites). A number of 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 reworked volcanic ash (tuffs, tuffites). A wide range of sedimentological and palaeontological observations point to deposition 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.

The Abrahamskraal Formation in the SW Karoo has been subdivided by various authors into a series of alternating sandstone- and mudrock-dominated packages, most recently by Day and Rubidge (2014) (Fig. 2). According to the 1: 250 000 metallogenic map of Cole and Vorster (1999) (Fig. 4) the majority of the access road study area on the Roggeveld Plateau to the southeast of Sutherland is underlain by a thick, channel sandstone-rich package known as the **Moordenaars Member** which appears pale brown on satellite images with darker stripes indicating intercalated mudrock-dominated intervals (Fig. 17). The channel sandstones are tabular, laterally extensive and closely spaced towards the west (near the 354 tar road) while the interleaved mudrock packages increase in thickness towards the east into the present study area.

The sharply overlying **Karelskraal Member**, the youngest subunit of the Abrahamskraal Formation, comprises a series of thin, heavily mudrock-dominated cycles with thin crevasse-splay sandstone horizons but few channel sandstones, some of which are lenticular rather than tabular in geometry. The Karelskraal mudrocks appear as a finely-striped, dark grey-brown zone on satellite images (Fig. 17). A major, highly dissected and hence well-exposed area of the Karelskraal Member crops out to the west of the access road project area in the core of a syncline, with occasional dark mudrock road cuttings along the road itself.

A short, illustrated account of the Abrahamskraal Formation bedrocks to the southeast of Sutherland has been provided by Almond (2017, 2019). The **Moordenaars Member** here is a 300-350 m – thick, sandstone-rich succession of continental fluvial rocks characterized by stacked sheet sandstones with intervening, more recessive-weathering mudrocks (Stear 1980, Le Roux 1985, Loock *et al.* 1994, Cole & Vorster 1999). The prominent, laterally-persistent sandstone ledges generate a distinctive terraced topography on hill slopes in the Sutherland area. The sheet sandstones are generally pale-weathering (enhanced by epilithic lichens), fine-grained, and structured by horizontal lamination (flaggy, with primary current lineation) or tabular to trough cross-bedding. The tabular-laminated units often contain numerous dark, very thin, laterally persistent laminae composed of heavy minerals that suggest density sorting during high energy sheet-flow conditions. The lower contacts of the channel sandstones are erosive, with lenticular basal breccias that may infill small-scale erosive gullies. The breccias, which may also occur within the body of the channel sandstone unit, are composed of reworked mudflake intraclasts, small rounded to irregular calcrete glaebules or nodules as well as occasional rolled vertebrate bones, teeth and local concentrations of plant debris. Some of the originally more organic-rich breccias are associated with secondary iron / manganese-rich carbonate lenses ('*koffieklip*") and uranium ore mineralization (Cole & Vorster 1999). Rare clusters of pebble- to cobble-sized lonestones of exotic (extra-basinal) rock types such as igneous rocks are of note (*e.g.* on Nooitgedagt 148); they were possibly transported into the Karoo Basin on the roots of floating logs or by floating river ice during winter (*cf* Almond 2017, 2019).

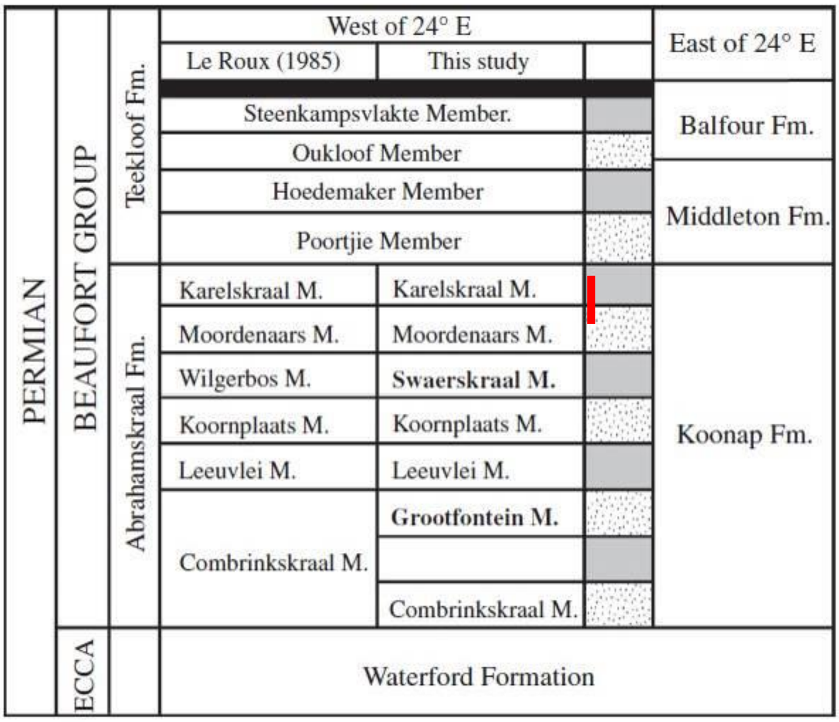

Figure 2: Revised stratigraphic subdivision of the Abrahamskraal and Teekloof Formations of Day and Rubidge (2014). The red bar indicates lithostratigraphic members that are represented within the WEF access road study area. Mudrock-dominated units are indicated in grey and sandstone packages by stippling.

The northern sector of the access road project area (Langekuil 136) transects a thick grey-green, blue-green to (especially abundant) purple-brown mudrock package within the uppermost part of the Moordenaars Member succession which displays sedimentological evidence for aridification (and possibly also for intervening pluvial intervals) on the Middle Permian floodplain of the Main Karoo Basin (Fig. 5). These fluctuating climates may be associated with the end-Capitanian global ecological crisis and accompanying Mass Extinction Event. Thin sandstone interbeds have erosive, gullied bases associated with mudflake intraclast brecias and sand-infilled mudcracks. Calcrete pedocretes marking arid climate palaeosols are well-developed and often rusty brown. Pluvial intervals with flooding of the distal floodplain and the development of shallow playa lakes are suggested by wave-rippled sandstone bed tops, occasional horizons rich in pseudomorphed gypsum roses as well as lake margin sandstones with damp substrate trace fossil (*Scoyenia* ichnofacies) and casts or moulds of reedy plant stems (probably equisetalean ferns). A curious horizon of very pale, rubbly to friable material containing abundant mudflakes (Fig. 6) *might* be a minor intrusion of the Sutherland Suite (*cf* carbonatites) or Permian tuffite (mixed sediment and volcanic ash), but this requires further investigation.

The rubbly sandstone plateau on the southern portion of Langkuil 136 (Fig. 8) probably lies along the upper contact of the Moordenaars Member, though this is not always easy to trace in the field. The scenic sandstone cliffs along the Rietrivier Valley at Swaelkranse on Nooitgedacht 148 (Fig. 7) probably lie along the same stratigraphic level. Overlying smooth slopes on the lower eastern slopes of the Rietrivier Valley suggest the lower Karelskraal Member here contains very little sandstone indeed. In contrast, the upper Karelskraal Member here comprises a series of very thin sandstone and mudrock packages leading up to the base of the Poortjie Member. This last unit is defined by much thicker sandstone packages, appears reddish-brown on satellite images (Fig. 17). It does not crop out within the access road project area itself but caps small relictual sandstone plateaux to the west and east (Figs. 7 & 9).

A stepped scarp of Karelskraal Member mudrocks within only minor, thin sandstone interbeds overlies the uppermost Moordenaars Member sandstone plateau to the west (Figs. 9 & 10); this area provides several excellent gullied exposures of the Karelskraal mudrocks that are ideal for palaeontological surveying. Hillslope, gulley and occasional borrow pit exposures of the Karelskraal Member in this area show well-developed lenses of rusty-brown *koffieklip* (Fig. 11) and palaeosols marked with ferruginous calcrete concretions (Fig. 12). Thin crevasse-splay sandstones (possibly extending out into playa lakes) and siltstones locally display high levels of soft-sediment deformation (loading, convolute lamination) (Fig. 13), microbial mat textures, equisetalean stem impressions and narrow horizontal burrows (perhaps undermat miners) (Figs. 22 & 23). Another interesting facies is half meter-thick packages of mottled grey-green and purple-brown mudrocks composed of a dense slurry of mudflakes. These may represent debrites (debris flow deposits) associated with high levels of floodplain degradation typical of major pluvial events in arid settings with little protective vegetation cover.

Extensive access road cuttings through the Karelskraal Member near Swaelkranse feature distal floodplain, and possibly lacustrine, facies (Fig. 16). Thin, upward-coarsening packages (possible lake infills) of dark grey mudrocks are capped by a closely-spaced series of thin-bedded, laterally-persistent sandstones, locally showing loading, with occasional small, lenticular sandstone bodies above. In contrast, road cuttings further south near Skerphoek are incised into massive, hackly, purple-brown and grey-green siltstones of the distal floodplain (Fig. 15).

Apart from the ubiquitous sandstone colluvium on hillslopes and sandstone-dominated surface gravels, the main other Late Caenozoic superficial deposits encountered within the access road project area are various species of alluvium exposed in the banks of shallow incised stream. These comprise up to several meters of greyish to brownish, fine gravelly alluvium (mainly flaky mudrock clasts) or thinner horizons of rubbly sandstone breccio-conglomerates, often partially cemented by calcrete, overlying bedrock. Relict patches of High Level Gravels, composed of well-rounded pebbly to cobbly (and occasionally boulder-sized) sandstone clasts, are associated with the ancient Rietrivier.

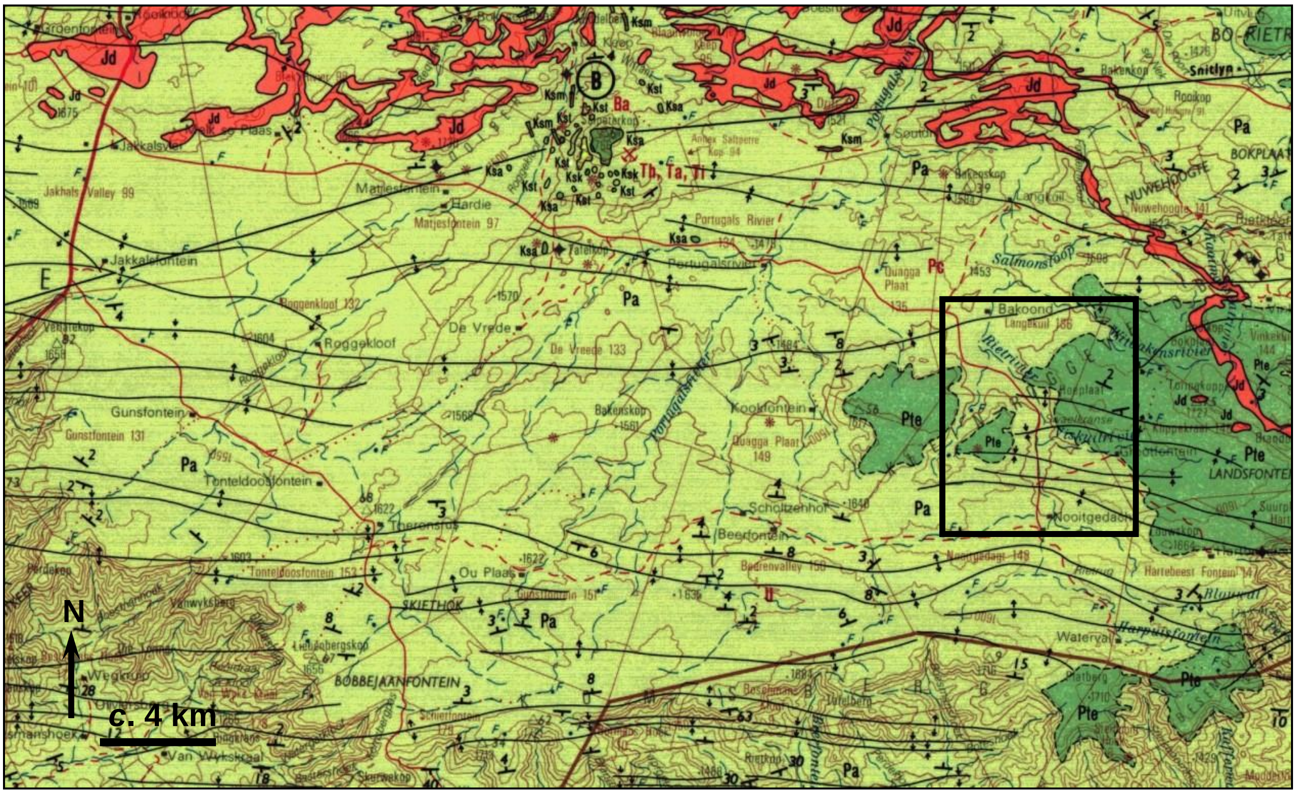

Figure 3: Extract from 1: 250 000 geological sheet 3220 Sutherland (Council for Geoscience, Pretoria) showing the approximate location of the WEF access road upgrade project area (black rectangle) to the north of the Great Escarpment in the Roggeveld Plateau region to the southeast of Sutherland. No historical fossil sites are mapped here. The main bedrock units represented in the broader study region include:
Pa (pale green) = Abrahamskraal Formation (Lower Beaufort Group) – Moordenarskaroo and Karelskraal Members
Pte (dark green) = Teekloof Formation (Lower Beaufort Group) – Poortjie Member
Jd (red) = Karoo Dolerite Suite
***N.B.* Late Caenozoic superficial deposits that are not mapped at 1: 250 000 scale also occur here, including alluvium, colluvium, surface gravels, soils and calcrete.**

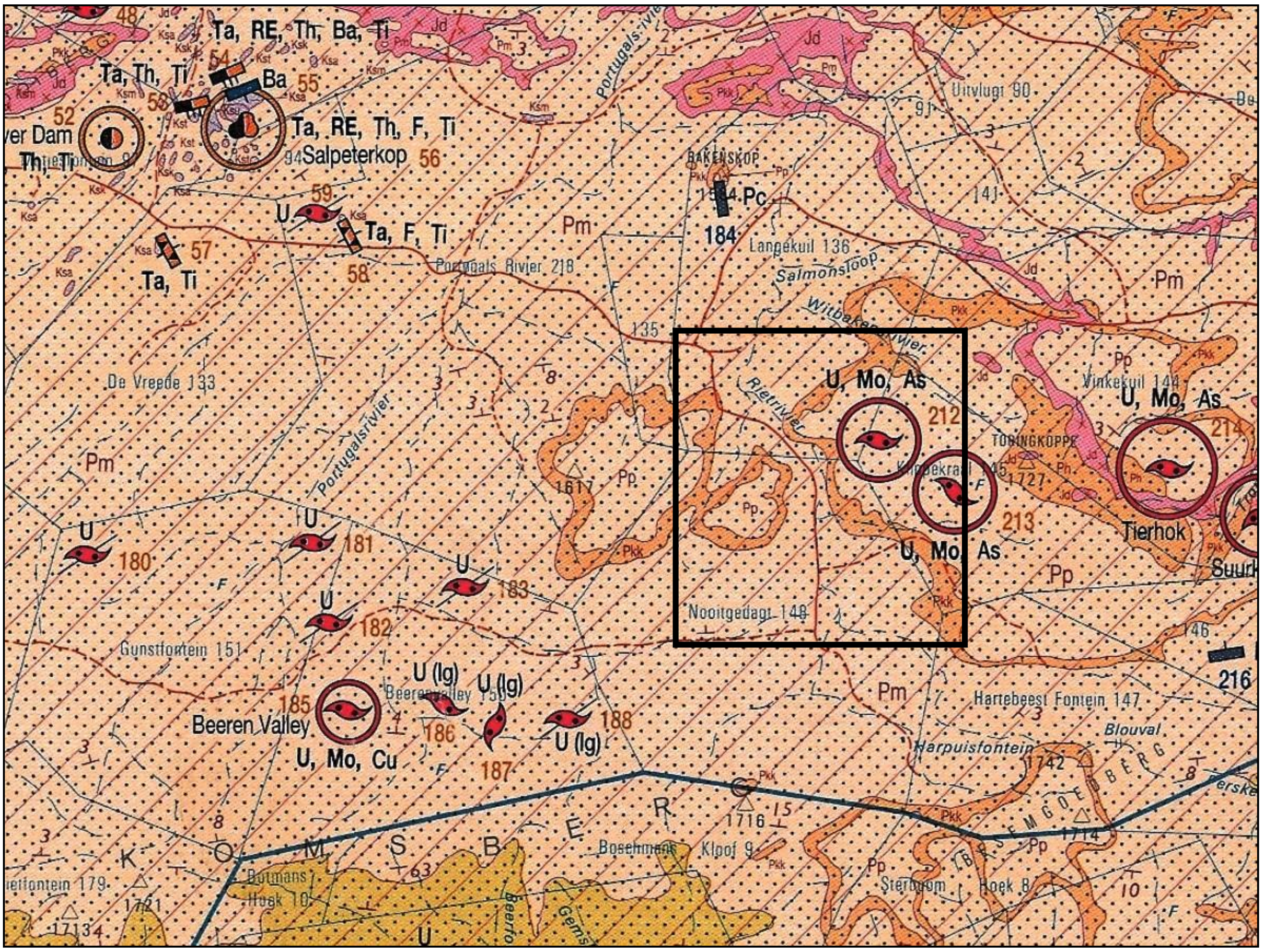

Figure 4: Extract from the 1: 250 000 Sutherland metallogenic map (Cole & Vorster 1999) which differentiates between the various members of the Abrahamskraal and Teekloof Formations in the broader access road project area (black rectangle), *viz*: Moordaars Member (Pm with stipple, pale orange), Karelskraal Member (Pkk, dark orange with stipple) and Poortjie Member (Pp, pale orange with stipple). According to the map, the access road project footprint is almost entirely restricted to the Moordenaars Member.

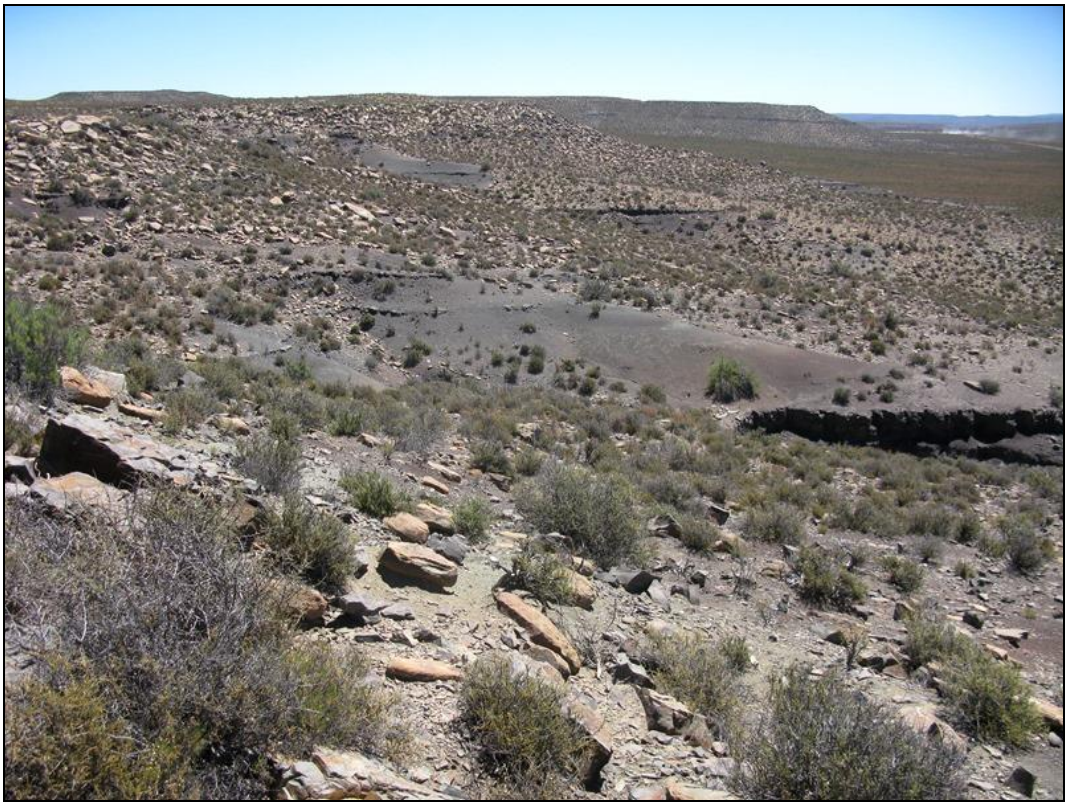

Figure 5: Dissected, N-facing scarp on Langekuil 136, south of the WEF access road, showing a thick mudrock package within the upper Moordenaars Member. View towards the west.

Figure 6: Curious pale, rubbly-weathering horizon within a mudrock package of the upper Moordenaars Member – *possibly* a tuffite or intrusion of the Sutherland Suite.

Figure 7: Swaelkranse – a major lenticular channel sandstone body at the top of the Moordenaars Member along the Rietrivier Valley to the east of the WEF access road on Nooitgedacht 148. The valley slopes behind are built of Karelskraal Member mudrocks capped by thick sandstones of the Poortjie Member.

Figure 8: Plateau on top of the Moordenaars Member mantled by eluvial sandstone rubble with the Karelskraal Member capped by Poortjie sandstones in the background, Nooitgedacht 148.

Figure 9: Extensive hillslope exposures of Karelskraal Member grey mudrocks west of the WEF access road on Nooitgedacht 148 with thin sandstone interbeds higher up, capped by a *krans* of Poortjie Member sandstones.

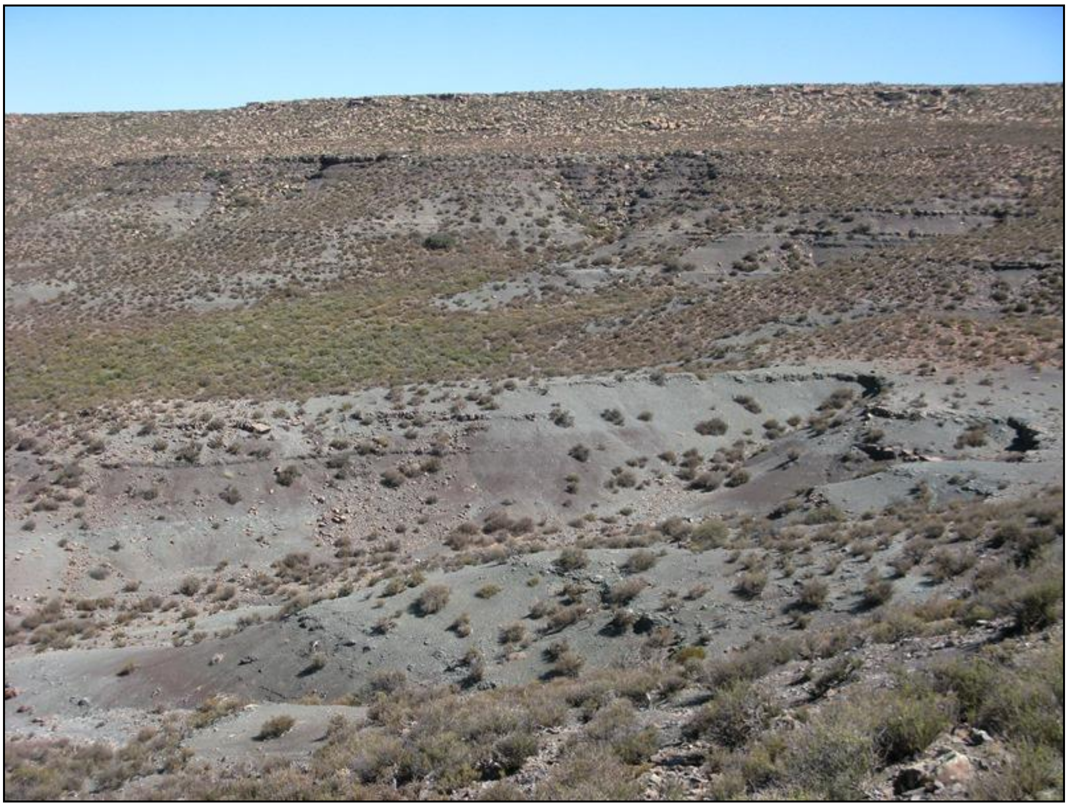

Figure 10: Gullied foothills on Nooitgedacht 148 provide ideal terrain for palaeontological surveys within the Karelskraal Member. However, these uppermost Abrahamskraal Formation beds appear to be largely unfossiliferous.

Figure 11: Rusty-brown lenses of *koffieklip* (ferruginous diagenetic carbonate) within the lower part of the Karelskraal Member close to the WEF access road on Nooitgedacht 148.

Figure 12: Brownish concretions of pedogenic calcrete scattered through 1-2 m thickness of floodplain mudrocks, Karelskraal Member, Nooitgedacht 148 (Hammer = 30 cm).

Figure 13: Convolute lamination of fine-grained, brownish sandstones within the lower part of the Karelskraal Member, Nooitgedacht 148 (Hammer = 30 cm).

Figure 14: Possible debrite deposit (slurry) of reworked mudrock clasts beneath a thin crevasse-splay sandstone within the lower part of the Karelskraal Member, Nooitgedacht 148 (Hammer = 30 cm).

Figure 15: Massive purple-brown siltstones with occasional thin sandstone interbeds of the lowermost Karelskraal Member exposed in a WEF access road cutting near Skerphoek, Nooitgedacht 148 (Hammer = 30 cm).

Figure 16: Thin, upward-coarsening packages of grey mudrock passing into thin-bedded sandstone (locally loaded) – possible lake-infill deposits within the lower Karelskraal Member, WEF access road cutting near Swaelkranse, Nooitgedacht 148 (Hammer = 30 cm).

Figure 17: Google Earth© satellite image of the Roggeveld Plateau region to the SE of Sutherland showing the Rietrug WEF project area (yellow polygon) and external access road to be upgraded (red line). Numbered fossil sites in the region (yellow) were recorded by Almond in 2016 (See Appendix 1 for details) (*N.B.* The access road sector within the Rietrug WEF project area has already been authorised but have not yet been palaeontologically surveyed). Members of the Abrahamskraal and Teekloof Formations represented in the study region can be clearly differentiated in satellite images and include: Moordenaars Member – sandstone-dominated with thin mudrock packages (Pmm, pale brown with dark stripes); Karelskraal Member – dominated by mudrocks with very little sandstone (Pkk, dark grey-brown); Poortjie Member - sandstone-dominated with thin mudrock packages (Pp, reddish brown). Rusty-brown areas to the N and NW are underlain by intrusive dolerite.

6. PALAEONTOLOGICAL HERITAGE

The overall palaeontological sensitivity of the Beaufort Group sediments is High to Very High (Almond & Pether 2008, SAHRIS website, DFFE Screening Tool). These continental sediments have yielded one of the richest fossil records of land-dwelling plants and animals of Permo-Triassic age anywhere in the world (MacRae 1999, Rubidge 2005, McCarthy & Rubidge 2005, Smith *et al.* 2012, 2020). Bones and teeth of Late Permian tetrapods have been collected in the western Great Karoo region since at least the 1820s and this area remains a major focus of palaeontological research in South Africa.

A chronological series of mappable fossil biozones or assemblage zones (AZ), defined mainly on their characteristic tetrapod faunas, has been established for the Main Karoo Basin of South Africa (Rubidge 1995, 2005, Van der Walt *et al.* 2010, Smith *et al.* 2020). Maps showing the distribution of the Beaufort Group assemblage zones within the Main Karoo Basin have been provided by Keyser and Smith (1979), Rubidge (1995, 2005), Nicolas (2007), Van der Walt *et al.* (2010) and, most recently, by Smith *et al.* (2020). The assemblage zone represented within the present study area is the late Middle Permian (Capitanian) ***Tapinocephalus* Assemblage Zone** (AZ) (Theron 1983, Rubidge 1995, Day & Rubidge 2020). More specifically, the upper part of the Abrahamskraal succession, including the Moordenaars and Karelskraal Members, is characterised by fossil biotas of the recently defined *Diictodon* – *Styracocephalus* Subzone – which extends into the lower part of the Poortjie Member and has an estimated age of 262-260 Ma, *i.e.* late Capitanian (Day & Rubidge 2020). Impoverishment of fossil assemblages, notably with few dinocephalians, within the upper part of the subzone are associated with the catastrophic, global end-Capitanian ecological crisis and Mass Extinction Event (*cf* Day *et al.* 2015).

The main categories of fossils recorded within the *Tapinocephalus* fossil biozone (Keyser & Smith 1977-78, Anderson & Anderson 1985, Smith & Keyser 1995a, MacRae 1999, Rubidge 2005, Nicolas 2007, Almond 2010a, Smith *et al.* 2012, Day 2013a, Day 2013b, Day *et al.* 2015b, Marchetti *et al.* 2019, Day & Rubidge 2020) include:

- isolated petrified bones as well as rare articulated skeletons of tetrapods (*i.e.* air-breathing terrestrial vertebrates) such as true **reptiles** (notably large herbivorous pareiasaurs like *Bradysaurus*, small insectivorous millerettids, the tortoise-like *Eunotosaurus*), rare pelycosaurs, and diverse **therapsids** or "mammal-like reptiles" (*e.g.* numerous genera of large-bodied dinocephalians, herbivorous dicynodonts, flesh-eating biarmosuchians, gorgonopsians and therocephalians);

- aquatic vertebrates such as large **temnospondyl amphibians** (*Rhinesuchus*, usually disarticulated), and **palaeoniscoid bony fish** (*Atherstonia*, *Namaichthys*, often represented by scattered scales rather than intact fish);

- freshwater **bivalves** (*Palaeomutela*);

- **trace fossils** such as tracks and burrows of worms, arthropods, lungfishes and tetrapods, coprolites (fossil droppings) and plant stem or root casts;

- **vascular plant remains** (usually sparse and fragmentary), including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora, especially glossopterid trees and arthrophytes (horsetail ferns) with rare lycopods.

Fossils recorded from the *Tapinocephalus* AZ in the southeastern Roggeveld Plateau region during recent palaeontological assessment studies by Almond and colleagues – including a number of solar and wind renewable energy projects - have been outlined by Almond (2017, 2019). Palaeontological surveys for the authorised Sutherland, Sutherland 2 and Rietrug WEFs – including access roads within their project areas - have not yet been conducted. However, a number of fossil sites within their project areas have been identified during the course of related grid connection and access road impact studies in the region (Almond 2017, 2019). Several of these are indicated on satellite map Figure 17 and tabulated in Appendix 1 while selected examples most relevant to the present access road study are illustrated here in Figures 18 to 24. The great majority of the records come from mudrock or sandstone intervals within the Moordenaars Member (*i.e.* lower *Diictodon* – *Styracocephalus* AZ). They include several occurrences of substantial post-cranial remains of large-bodied tetrapods (pareiasaurs or tetrapods), often disarticulated and weathered (*e.g.* sun-cracked) and mostly found in float. Lacustrine intervals are characterised by vertical, cylindrical sandstone casts of lungfish burrows, as well seen some 4 km west of the present study area (Fig. 18).

A marked impoverishment of fossil biotas in terms of abundance and variety characterises the mudrock-rich Karelskraal Member, even where this is ideally exposed for palaeontological recording (Fig. 10). This equates with the fossil-poor upper portion of the *Diictodon* – *Styracocephalus* AZ which is associated with the end Capitanian ecological crisis. Sedimentological evidence for unstable, arid to pluvial / lacustrine climatic extremes during the crisis is shown by beds of the uppermost Moordenaars Member and succeeding Karelskraal Member in the present study region. The only fossils recorded from the Karelskraal Member beds during the 2016-2017 palaeontological field studies include:

(1) local concentrations of medium-sized tetrapod burrow casts, possibly constructed by small dicynodonts (Figs. 19 & 20) (*N.B.* some, but certainly *not* all, of these casts are equivocal and require confirmation);
(2) very rare therapsid skeletal remains (*e.g.* incomplete skull of a small dicynodont, Fig. 19);
(3) poorly-preserved equisetalean (scouring fern) stems (Fig. 22) associated with
(4) fine horizontal burrows which were probably made by small invertebrates such as insects feeding on microbial mats along damp pond margins (Fig. 22), and
(5) traces of fine vermicular burrows or plant rootlets preserved within ferruginised pedogenic calcrete concretions (Fig. 24).

No fossil remains were recorded from the Late Caenozoic superficial deposits within the project area.

Figure 18: Road cutting through interbedded thin sandstones and overbank mudrocks of the Moordenaars Member showing several cylindrical lungfish burrow casts up to 10 cm in diameter (arrowed), Portugals Rivier 218 (Loc. 512, *c*. 4km west of the access road project area) (Image from Almond 2017, 2019).

Figure 19: Partial disarticulated skull of small tetrapod with a boat-shaped lower jaw (probably a small-bodied dicynodont) embedded in a pedocrete horizon, Karelskraal Member on Farm Nooigedagt 148 (Loc. 550) (jaw is 3.5 cm across, as seen here).

Figure 20: *Possible* but equivocal vertebrate burrow casts (*c*. 30 cm wide) (Requires confirmation), Karelskraal Member on Farm Nooigedagt 148 (Loc 548) (Hammer = 30 cm).

Figure 21: One of several moderately large (*c*. 15 cm wide), gently inclined, subcylindrical tetrapod burrow casts embedded in maroon overbank mudrocks, here showing well-developed scratch marks on the ventrolateral surface (arrows). These are among the youngest recorded tetrapod burrows within the Abrahamskraal Formation and were possibly constructed by dicynodonts. Karelskraal Member, Farm Nooigedagt 148 (Loc. 521).

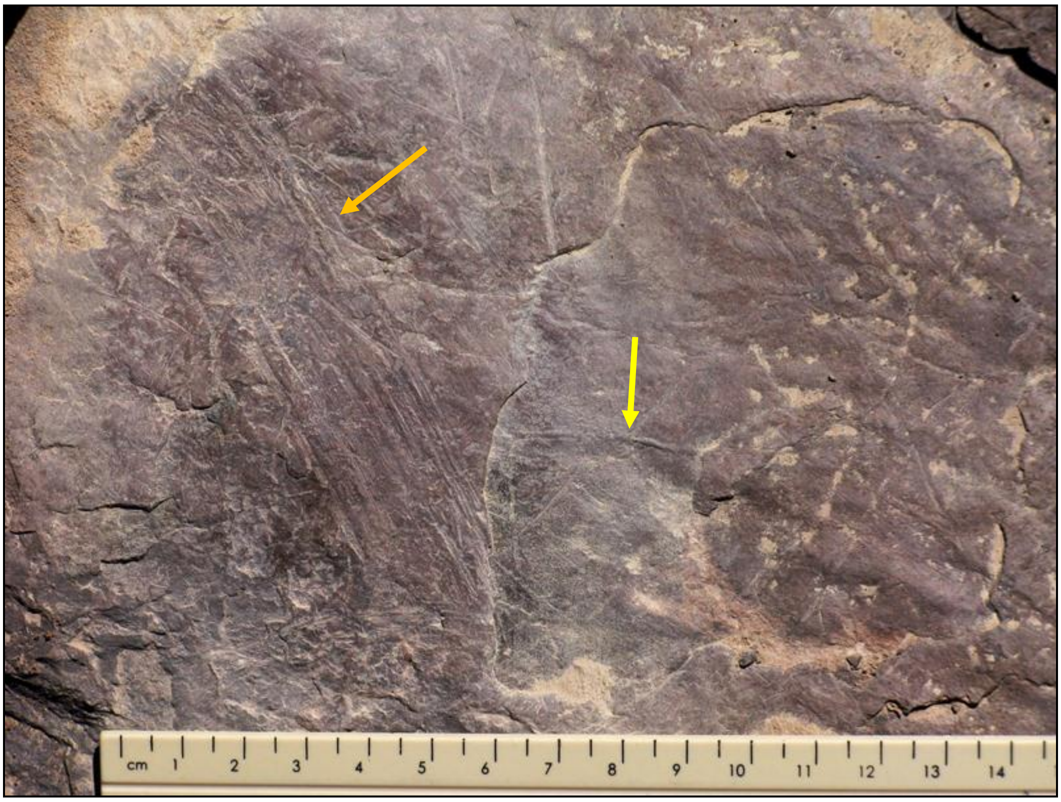

Figure 22: Poorly-preserved impressions of equisetalean ferns (orange arrow) associated with narrow horizontal burrows of probable undermat miners (yellow arrow), borrow pit on Nooitgedacht 148 (Scale in cm).

Figure 23: Laminated channel sandstone showing primary current lineation and small, round casts of reedy plant stems, upper Moordenaars Member on Annex Bakover 135/1, just west of access road project area (Loc. 515) (Scale = 15 cm).

Figure 24: Ferruginous pedogenic calcrete concretion containing fine, pale impressions of burrows or plant rootlets, Karelskraal Member on Farm Nooigedagt 148 near Skerpkrans (Loc. 548) (Scale in cm and mm).

7. ASSESSMENT OF IMPACT SIGNIFICANCE

The proposed widening of the Rietrug WEF access road will entail excavations into the superficial sediment cover (soils, surface gravels, alluvium *etc*) and also into the underlying, potentially fossiliferous Beaufort Group bedrocks during the construction phase. The development may adversely affect potential legally protected and scientifically important fossil heritage within the project footprint by destroying, damaging, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good.

The uppermost Abrahamskraal Formation bedrocks that will be directly impacted by the proposed access road upgrade belong to parts of the succession (uppermost Moordenaars Member and Karelskraal Member) are characterised by a very sparse fossil record which nevertheless may include rare, scientifically important specimens of unpredictable occurrence. None of the few fossil sites recorded here within the Moordenaars and Karelskraal Member lie within the footprint of the access road upgrading project or are threatened by the project (Fig. 17), so no mitigation is required in regard to them. The bedrocks within most of the access road project footprint are mantled with Late Caenozoic colluvial, eluvial and alluvial deposits and gravely soils that are usually palaeontologically insensitive in most of the Roggeveld Plateau region. Rare fossil mammalian remains might potentially occur within older, calcretised alluvium but none have been recorded here so far.

The significance of anticipated impacts on fossil heritage resources within the WEF access road project footprint as a consequence of the proposed upgrading activities (*viz*. road widening) is assessed for the **Construction Phase** in Table 1, both with and without mitigation. It is concluded that the proposed development will have a NEGATIVE LOW impact significance without mitigation, decreasing but still remaining NEGATIVE LOW following full implementation of the proposed mitigation measures (See Section 8). Negative residual impacts during the construction phase will be partially offset by an improved palaeontological data base and fossil collections due to mitigation (*positive* impacts). Confidence levels for this assessment are Medium at most, given (1) the reasonably good bedrock exposure levels encountered in the broader project area but (2) the inadequate palaeontological database for the Rietrug WEF and Sutherland WEF project areas.

Once constructed, the **Operational Phase** of the access road will not involve further adverse impacts on palaeontological heritage, so these are not assessed here.

In the case of the **No-Go Option** - *i.e.* no upgrading of the WEF access road – impacts before and after mitigation are rated as NEGATIVE LOW (Table 2). Mitigation here would involve implementation of the Chance Fossil Finds Protocol which applies to all components of the WEF development (See Appendix 2).

Given the low significance of anticipated impacts on palaeontological heritage, professional palaeontological mitigation would only be triggered if substantial fossil remains (*e.g.* assemblages of fossil vertebrate remains, vertebrate burrow casts, petrified wood) were encountered or freshly exposed during the construction phase of development. In this case the ECO / ESO should safeguard the fossil material, preferably *in situ*, and alert the South African Heritage Resources Agency, SAHRA (Address: 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) as soon as possible. This is so that appropriate action (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist. If triggered, these mitigation actions to conserve legally-protected fossil heritage are considered to be essential.

It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

Table 1. Assessment of impacts on fossil heritage resources of the proposed upgrading of the WEF access road (Construction Phase)

Nature: Disturbance, damage or destruction of legally protected, scientifically valuable fossil heritage resources preserved at or beneath the ground surface through surface clearance and excavations within the project footprint		
	Without mitigation	With mitigation
Extent	Low (1)	Low (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	V. small (1)	V. small (1)
Probability	Improbable (2)	Very improbable (1)
Significance	Low (14)	Low (7)
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	
Mitigation: On-going Construction Phase monitoring for fossils of surface clearance and excavations by ECO / ESO. Application of Chance Fossil Finds Protocol during construction phase with recording and collection of significant new finds by qualified palaeontologist.		
Residual Impacts: Small residual impacts may be off-set by improved palaeontological database following mitigation.		

Table 2. Assessment of impacts on fossil heritage resources of the No-Go Option (*i.e.*no upgrading of access road)

Nature: Disturbance, damage or destruction of legally protected, scientifically valuable fossil heritage resources preserved at or beneath the ground surface through surface clearance and excavations within the project footprint		
	Without mitigation	With mitigation
Extent	Low (1)	Low (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Minor (2)	V. small (1)
Probability	Improbable (2)	Very improbable (1)
Significance	Low (16)	Low (7)
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	
Mitigation: On-going Construction Phase monitoring for fossils of surface clearance and excavations by ECO / ESO. Application of Chance Fossil Finds Protocol during construction phase with recording and collection of significant new finds by qualified palaeontologist.		
Residual Impacts: Small residual impacts may be off-set by improved palaeontological database following mitigation.		

7.1. Cumulative impacts

As shown by the DFFE Renewable Energy EIA Applications Database (REEA) for the first quarter of 2021, a considerable number of renewable energy facilities (notably wind farms) have been authorised are proposed for the Roggeveld region to the southeast of Sutherland. Of these, several have been the subject of combined desktop and field-based palaeontological heritage impact studies (PIAs) by the author and others (See References). However, as already noted in Section 1 of this report, only desktop level PIAs have been submitted for the Sutherland , Sutherland 2 and Rietrug WEFs (Almond 2010b) as well as for the Suurplaat WEF to the east (Almond 2010b).

Given the extensive outstanding palaeontological heritage field data in the south-eastern Roggeveld region relevant to this development, and following Almond (2019), it is concluded that it is not yet feasible to meaningfully assess cumulative palaeontological impacts for the proposed WEF access road upgrade under consideration in this report. However, pending the outcome of these and several other outstanding palaeontological field-based studies for WEF projects in the Sutherland – Merweville region, it is *provisionally* concluded that the cumulative impact significance of the proposed access road upgrade in the context of road developments relating to renewable energy developments in the region is NEGATIVE MEDIUM without mitigation (Table 3). This would fall to *NEGATIVE LOW provided that* the proposed monitoring and mitigation recommendations made for *all* these various renewable energy projects are fully implemented (which is doubtful).

These anticipated cumulative impacts following mitigation lie within acceptable limits. 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.

Table 3. Assessment of cumulative impacts on fossil heritage resources of the proposed WEF access road upgrade in the context of other road developments for renewable energy and other developments in the region

Nature: **Disturbance, damage or destruction of legally protected, scientifically valuable fossil heritage resources preserved at or beneath the ground surface through surface clearance and excavations within the project footprint**		
	Without mitigation	**With mitigation**
Extent	**Low (1)**	**Low (1)**
Duration	**Permanent (5)**	**Permanent (5)**
Magnitude	**Moderate (6)**	**Low (4)**
Probability	**Definite (5)**	**Probable (3)**
Significance	**Medium (60)**	**Low (30)**
Status (positive or negative)	**Negative**	**Negative**
Reversibility	**Low**	**Low**
Irreplaceable loss of resources?	**Yes**	**No**
Can impacts be mitigated?	**Yes**	
Mitigation: **Specialist palaeontological walk-downs of project footprints in the pre-construction phase in cases where no field-based palaeontological study has yet been conducted.** **On-going Construction Phase monitoring for fossils of surface clearance and excavations by ECO / ESO.** **Application of Chance Fossil Finds Protocol during construction phase with recording and collection of significant new finds by qualified palaeontologist.**		
Residual Impacts: **Residual impacts may be off-set by improved palaeontological database following mitigation.**		

8. CONCLUSIONS & RECOMMENDATIONS

The footprint of the short WEF access road sector to be upgraded is underlain at depth by sedimentary rocks within the upper part of the Abrahamskraal Formation, Lower Beaufort Group (Karoo Supergroup) which are of Middle Permian Permian age. In the Main Karoo Basin this stratigraphic interval (*viz*. upper Moordenaars Member *plus* Karelskraal Member) is associated with impoverished tetrapod faunas of the upper *Diictodon* – *Styracocephalus* Assemblage Zone reflecting the Middle Permian global ecological crisis and resulting Mass Extinction Event on land. Only a few fossil sites - comprising fragmentary skeletal remains of dicynodont therapsids, tetrapod burrow casts, low diversity invertebrate trace fossil assemblages and scrappy plant remains - have been recorded in the vicinity of the access road, all of which lie *outside* the amended footprint. A high proportion of the access road project area is mantled by Late Caenozoic superficial deposits (alluvium, colluvium, surface gravels, soils) of low palaeosensitivity and no fossils are recorded within them here (*N.B.* Sectors of the access road within the project areas of the authorised Sutherland and Rietrug Wind Energy Facilities have not yet been surveyed for palaeontological heritage. Since they traverse older Moordenaars Member bedrocks associated with diverse fossil biotas of the lower *Diictodon* – *Styracocephalus* Assemblage Zone, impacts here are potentially more significant).

The DFFE Screening Report for the proposed WEF access road development provisionally assigns a VERY HIGH palaeosensitivity to the project area (Appendix 3). Due to the scarcity of well-preserved, scientifically important fossils here, based on desktop studies as well as fieldwork, it is inferred that the area is in fact largely of LOW PALAEONTOLOGICALLY SENSITIVITY, although sparse, and largely unpredictable fossil sites of high sensitivity might also occur here. The results of the DFFE screening tool sensitivity are therefore *contested* here.

Given (1) the small footprint of the road upgrade and (2) the low palaeosensitivity of both the bedrocks and superficial sediments here, the impact significance of the proposed amendment for the construction phase is assessed as NEGATIVE LOW before and after mitigation. Negative residual impacts will be partially offset by an improved palaeontological data base and fossil collections (*positive* impacts). The No-Go alternative - *i.e*. no widening of the access road - would also have a NEGATIVE LOW impact on palaeontological heritage, with and without mitigation. Confidence levels for this assessment are Medium, given the paucity of palaeontological field data in the broader project region. Once constructed, the Operational and De-commissioning Phases of the access road will not involve further adverse impacts on palaeontological heritage so these are not assessed here.

Given the extensive outstanding palaeontological heritage field data in the south-eastern Roggeveld region relevant to this development, notably for the Sutherland and Rietrug WEF project areas, it is not feasible to meaningfully assess cumulative palaeontological impacts for the proposed WEF access road upgrade under consideration in this report. However, pending the outcome of the outstanding palaeontological field-based studies, it is *provisionally* concluded that the cumulative impact significance of the proposed access road upgrade in the context of road developments relating to renewable energy developments in the region is NEGATIVE MEDIUM without mitigation. This would fall to *NEGATIVE LOW provided that* the proposed palaeontological monitoring and mitigation recommendations made for *all* these various renewable energy projects are fully implemented.

The proposed access road upgrade project is not fatally flawed and there are no objections on palaeontological heritage grounds to authorisation of the proposed amendment, *provided that* the recommended mitigation measures for the construction phase outlined below and tabulated in Appendix 2 are included in the EMPr for the development and are fully implemented.

8.1. Recommended mitigation measures

In view of the low palaeosensitivity of the access road upgrade project area and the inferred low impact significance of the proposed development on palaeontological heritage resources, it is concluded that no further palaeontological heritage studies or specialist palaeontological mitigation are required for this project, pending the exposure of any substantial fossil remains (*e.g.* vertebrate bones and teeth, large blocks of petrified wood) before or during the construction phase. None of fossil sites recorded in the vicinity lies within the project footprint and so they do not require mitigation in this regard.

In accordance with the EMPrs for the authorised Sutherland WEF and Rietrug WEF, sectors of the access road *within* the WEF project areas should be surveyed by a qualified palaeontological specialist, with recommendations for palaeontological mitigation (if any is necessary) to be submitted for comment to SAHRA.

The ECO / ESO responsible for the development should be alerted to the possibility of fossil remains being found on the surface or exposed by fresh excavations during construction. Should substantial fossil remains be discovered during construction, these should be safeguarded (preferably *in situ*) and the ECO / ESO should alert the 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). This is so that appropriate mitigation (*e.g.* recording, sampling or collection) can be taken by a qualified palaeontologist.

The palaeontological specialist involved would require a collection permit from SAHRA. Fossil material must be curated in an approved repository (*e.g.* museum or university collection) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA (2013).

These recommendations are summarized in Appendix 2 and must be incorporated into the EMPr for the amended WEF access road development as a condition accompanying environmental authorisation of the project.

9. ACKNOWLEDGEMENTS

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11. QUALIFICATIONS & EXPERIENCE OF SPECIALIST

The author, Dr John Almond, is a specialist palaeontologist who has over 40 years of experience in palaeontological research and teaching in Europe, South Africa and elsewhere. He also has more than 20 years of experience in the palaeontological heritage impact assessment world in the RSA and has been involved with numerous PIAs in the Karoo region and elsewhere.

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 the University of Tübingen in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa and Madagascar. 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 numerous palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape, Limpopo, Northwest Province, Mpumalanga, Gauteng, KwaZulu-Natal and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has served as a 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).

Declaration of Independence

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

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

APPENDIX 1: GPS LOCALITY DATA FOR FOSSIL SITES LISTED IN TEXT

All GPS readings were taken in the field using a hand-held Garmin GPSmap 64s instrument. The datum used is WGS 84. Please note that:

- Locality data for South African fossil sites in *not* for public release, due to conservation concerns.
- The table does *not* represent all potential fossil sites within the project area but only those sites recorded during the 2016-2017 field survey. The absence of recorded fossil sites in any area therefore does *not* mean that no fossils are present there.

See Text Figure 17 for mapping of fossil sites on a satellite image.

NEW FOSSIL SITES FROM SUTHERLAND WEF ROAD & POWERLINE PROJECT Nov 2016- Feb 2017		
Loc. No.	**GPS data**	**Comments**
494	S32° 29' 26.3" E20° 46' 38.5"	Farm Matjesfontein 92. End of very robust limb bone (dinocephalian / pareiasaur) – partially embedded in soil. Proposed Field Rating IIIB.
495	S32° 29' 29.2" E20° 46' 41.1"	Farm Matjesfontein 92. Highly weathered, worn postcranial bone fragment in float. Proposed Field Rating IIIC.
496	S32° 29' 29.8" E20° 46' 41.4"	Farm Matjesfontein 92. Cluster of several highly weathered, worn postcranial bone fragments in float. Proposed Field Rating IIIC.
502	S32° 30' 38.3" E20° 52' 28.5"	Farm Portugals Rivier 218. Dykes of well-exposed ferruginised pyroclastic breccia of the Sutherland Suite.
509	S32° 31' 04.4" E20° 54' 47.2"	Farm Portugals Rivier 218. Well-developed channel breccias containing several disarticulated and worn tetrapod postcranial bone fragments. Ferruginised oblique burrow (*c.* 5.5 cm wide) excavated through breccia bed. Proposed Field Rating IIIB.
512	S32° 31' 16.4" E20° 56' 11.0"	Farm Portugals Rivier 218. Horizon with numerous subvertical lungfish burrow casts excavated into maroon overbank mudrocks exposed in cutting on southern side of dust road. Proposed Field Rating IIIB.
513	S32° 31' 42.6" E20° 56' 51.9"	Farm Portugals Rivier 218. Blocks of greyish-purple wacke with assemblage of narrow vertical sand-infilled cylinders – probably casts of reedy plant stems (*e.g.* sphenophytes or "horsetails"). Proposed Field Rating IIIC.
515	S32° 32' 06.1" E20° 58' 03.4"	Farm Annex Bakoven 135/1. Flaggy sandstone blocks with plant stem casts, small invertebrate traces of the *Scoyenia* ichnofacies. Proposed Field Rating IIIC. No mitigation necessary (outside project footprint).
521	S32° 33' 48.5" E21° 00' 14.1"	Farm Nooigedagt 148. Karelskraal Member. Several large, gently inclined, subcylindrical tetrapod burrow casts (*c*. 15 cm wide) of sandstone embedded in maroon overbank mudrocks. The best example shows well-developed scratch marks on the ventrolateral surface. These are among the youngest recorded tetrapod burrows within the Abrahamskraal Formation and were possibly constructed by dicynodonts. Proposed Field Rating IIIB. No mitigation necessary (outside project footprint).
530	S32° 36' 32.6" E20° 52' 19.0"	Farm Beeren Valley 150. Bioturbated swaley channel sandstone palaeosurface with poorly-preserved horizontal burrows and other ill-defined traces. Proposed Field Rating IIIC.
532	S32° 36' 27.6" E20° 54' 24.5"	Farm Beeren Valley 150. Two isolated pieces of highly-weathered postcranial bones in surface float. Proposed Field Rating IIIC.
535	S32° 36' 36.9" E20° 55' 29.2"	Farm Beeren Valley 150. Articulated partial postcranial skeleton of a large tetrapod embedded in grey-green overbank mudrocks. This specimen is conservation-worthy and should be protected by a buffer zone of 30 m radius. Proposed Field Rating IIIB.
539	S32° 36' 53.5" E20° 57' 34.1"	Farm Nooigedagt 148. Disarticulated limb bone of large tetrapod embedded in maroon mudrocks, showing sun-dried surface texture. Proposed Field Rating IIIB.
540	S32° 36' 53.6" E20° 57' 33.9"	Farm Nooigedagt 148. Fragment of long bone in surface float. Discrete cluster of several pebble- to cobble-sized exotic clasts ("lonestones") embedded within maroon overbank mudrocks. The larger cobbles are of a greenish-grey igneous rock (possibly andesite) and are subrounded. They are among the largest exotic clasts recorded from the Lower Beaufort Group in the SW Karoo. The conglomeratic lens also contains weathered, dark-grey tillite-like material, suggesting a Dwyka Group provenance for the pebbles which may have been brought into the Mid Permian Karoo Basin by floating tree roots or ice floes. Proposed Field Rating IIIB.

545	S32° 33' 10.2" E20° 54' 13.0"	Farm Portugals Rivier 218. Several highly weathered postcranial bones in surface float, showing sun-cracked surface textures. Proposed Field Rating IIIB.
546	S32° 33' 11.2" E20° 54' 16.1"	Farm Portugals Rivier 218. Scatter of numerous disarticulated, weathered bones of a large tetrapod (dinocephalian / pareiasaur) among sandstone scree. Proposed Field Rating IIIB.
548	S32° 34' 35.1" E21° 00' 29.7"	Farm Nooigedagt 148. Kareskraal Member. *Possible* vertebrate burrow casts (*c*. 30 cm wide). Require confirmation. Proposed Field Rating IIIC. No mitigation necessary (outside project footprint).
550	S32° 34' 40.0" E21° 00' 27.4"	Farm Nooigedagt 148. Karelskraal Member. Partial disarticulated skull of small tetrapod with a boat-shaped lower jaw (probably dicynodont) embedded in pedocrete horizon. Proposed Field Rating IIIB. No mitigation necessary (outside project footprint).
555	S32° 38' 21.2" E20° 59' 33.7"	Farm Nooigedagt 148. Possible sandstone cast of vertebrate burrow (*c*. 15 cm wide) within maroon overbank mudrocks (requires confirmation). Proposed Field Rating IIIC.
556/557	S32° 37' 16.3" E20° 58' 47.9"	Farm Nooigedagt 148. Moordenaars Member. Two highly-weathered post-cranial bones of a large tetrapod in surface float. Proposed Field Rating IIIB.

APPENDIX 2: CHANCE FOSSIL FINDS PROTOCOL

<table>
<tr><td colspan="3">Access road upgrade for the Rietrug WEF near Sutherland</td></tr>
<tr><td>Province & region:</td><td colspan="2">Northern Cape: Sutherland Magisterial District</td></tr>
<tr><td>Responsible Heritage Resources Agency</td><td colspan="2">SAHRA: 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</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, trace fossils, trackways, petrified wood, plant-rich beds in the Lower Beaufort Group bedrocks.
Fossil mammal bones, teeth, horn cores, 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 Resources Agency and project palaeontologist (if any who will advise on any necessary mitigation
• Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Agency 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 Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Agency, 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 Resources Agency</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 Agency. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Agency minimum standards.</td></tr>
</table>

APPENDIX 3: SITE SENSITIVITY VERIFICATION

In accordance with Appendix 6 of the National Environmental Management Act (Act 107 of 1998, as amended) (NEMA) Environmental Impact Assessment (EIA) Regulations of 2014, a site sensitivity verification has been undertaken in order to confirm the current land use and environmental sensitivity of the proposed WEF access road upgrade project area on the Remainder of Lange Kuil 136 and Portion 1 of Nooitgedacht 148 as identified by the National Web-Based Environmental Screening Tool. Key references are listed in the main body of the PIA report.

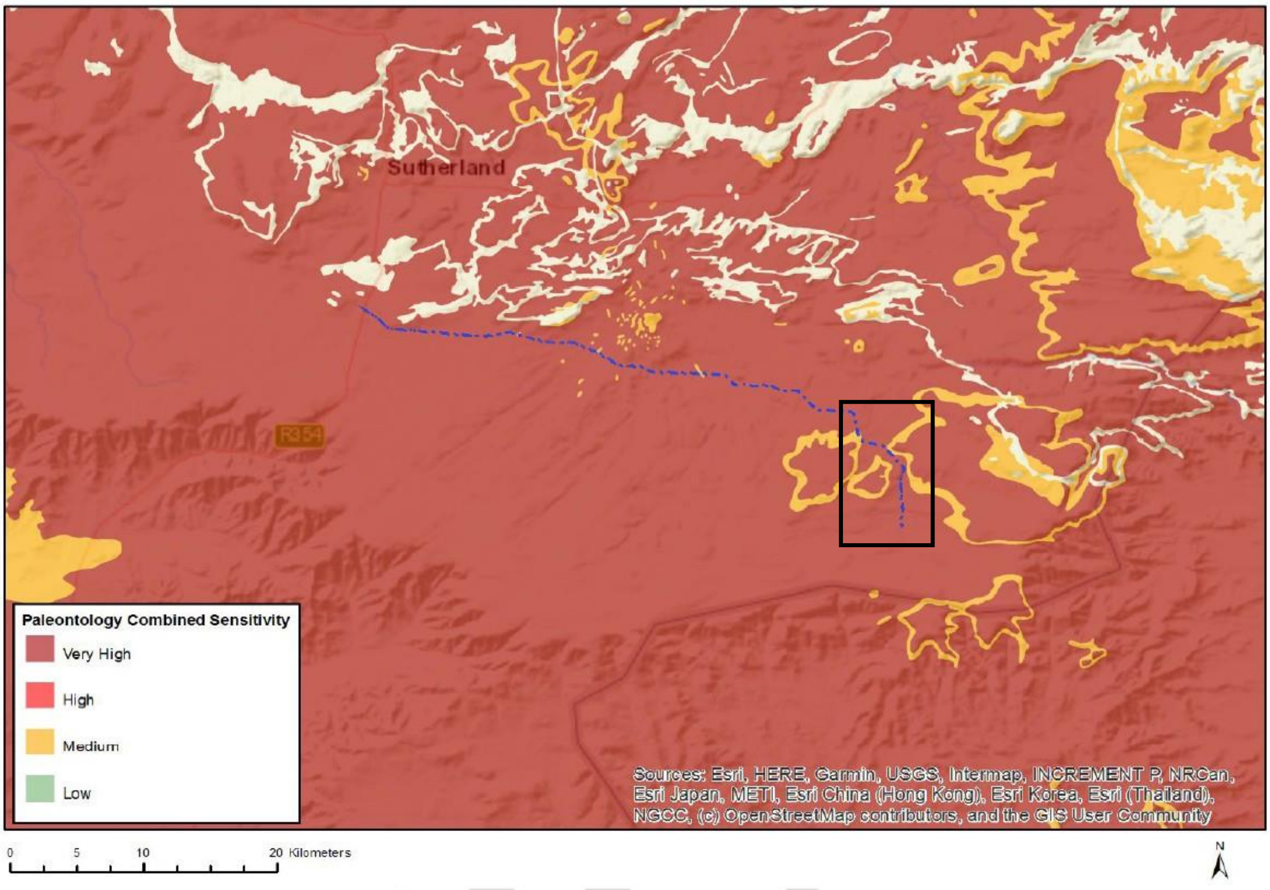

Figure A3.1. Paleontological sensitivity map for the secondary road from the R354 that will be used to access the authorised Sutherland and Rietrug WEFs from the R354 to the west, Northern Cape. The project area for the present access road upgrade report is outlined by the black rectangle. Image abstracted from the DFFE Screening Report for an environmental authorization prepared by Nala Environmental (May 2021). Due to the scarcity of well-preserved, scientifically important fossils in this region, based on desktop studies and fieldwork, it is inferred herein that the project area is in fact largely of LOW palaeontological sensitivity with small, sparse and largely unpredictable fossil sites of High Sensitivity.

The DFFE Screening Report for the proposed development provisionally assigns a VERY HIGH palaeosensitivity to the project area (Fig. A3.1).

The site sensitivity verification of the proposed access road upgrade project is based on:

- A desktop review of (a) the relevant 1:50 000 scale topographic and the 1:250 000 scale topographic map 3220 Sutherland and 1: 50 000 maps 3220DB Komsberg and 3221CA Besemgoedberg, (b) Google Earth© satellite imagery, (c) published geological and palaeontological literature, including 1:250 000 geological and metallogenic maps (3220 Sutherland) and relevant sheet explanations (Theron 1983, Cole & Vorster 1999) as well as (d) several previous desktop and field-based fossil heritage (PIA) assessments in the

Roggeveld region to the southeast of Sutherland by the author and colleagues (See especially Almond 2017, 2019) .

- A several-day long field assessment by the author in 2016-2017 of portions of the access road from the R354 up until the boundary of the Rietrug WEF project area as well as portions of nearby terrain within WEF grid connection project areas.

3. Outcome and Conclusions

Due to (1) the scarcity of well-preserved, scientifically important fossils within the WEF access road project area as well as (2) the low sensitivity of the Late Caenozoic superficial sediments present here (alluvial soils, eluvial surface gravels *etc*), based on desktop studies as well as fieldwork, it is inferred that the project area is in fact largely of LOW PALAEONTOLOGICALLY SENSITIVITY. However, sparse, and largely unpredictable fossil sites of high sensitivity might occur here.

The results of the DFFE screening tool sensitivity (Figure A3.1) are therefore *contested*.