HERITAGE IMPACT ASSESSMENT

KAREEBOSCH WIND FARM (PHASE 2 OF ROGGEVELD WIND FARM)

(Assessment conducted under Section 38 (8) of the
National Heritage Resources Act as part of an EIA.)

Prepared for
SAVANNAH SA

On behalf of

Karreebosch Wind Farm (Pty) Ltd

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EXECUTIVE SUMMARY

ACO Associates CC have been appointed by Savannah Pty Ltd on behalf of the proponent, Karreebosch Wind Farm (Pty) Ltd to undertake a Heritage Impact Assessment, as part of the EIA process, for the establishment of a wind energy facility (WEF) on a site some 40 km south of Sutherland. The proposed facility lies in the Western Cape Province and Northern Cape Province. This is a renewed application for Phase 2 of a project (Roggeveld WEF) that was first assessed in 2010-2011.

The fieldwork for the original Roggeveld Wind Farm was completed in 2010. On the advice of the Department of Environment Affairs the project was broken down into three phases. The original fieldwork, which was comprehensive, remains relevant (see Hart and Webley 2010). It involved a walk and drive survey of many of the turbine positions and a broad overview of the entire development site for all phases proposed at the time. In 2013, a revised layout was proposed for phase 1 for the study area which has been subject to an environmental impact assessment. Phase 2, known as the Karreebosch Wind Farm, involves a further expansion phase (incorporating a further valley and ridgeline to the east, and development of further turbines to the north) is the subject of this report.

The findings of the heritage assessment have revealed that the study area is relatively austere in terms of pre-colonial heritage, however valley bottoms contain evidence of early *trekboer* cultural landscapes – ruins, graves and occasional middens. These consist of collections of ruined stone and mud buildings, threshing floors and kraals located exclusively in the valley areas between the high longitudinal ridges that characterise the study area. There are a number of existing farm houses that contain 19th century fabric, however very few of these have anything more than moderate heritage significance. Parts of the study area enjoy very high aesthetic qualities with the area known by locals as "Gods Window" having grade 2 aesthetic qualities, hence the significance of the study area lies mainly with its undeveloped wilderness qualities. Interestingly, pre-colonial or stone age heritage and archaeology is extremely scarce in the areas that were searched. Very few archaeological sites of these kinds were recorded despite the fact that overall 9 experienced archaeologists were involved in scouring the landscape.

While the geology of the study area is potentially palaeontologically sensitive, very few fossils were found by either Dr Duncan Miller or Dr John Almond in the study area. No further work in this respect is recommended, other than reporting of any finds during construction to the heritage authorities.

In our opinion, no significant heritage limitations were encountered during the survey, however it will be necessary for an archaeologist to be involved in reviewing and walking down some of the proposed road alignments, especially through the valleys which are the most sensitive areas as part of the EMP for the project

The area of greatest concern is the accumulative impact of a large amount of applications for wind energy development in the area which will impact the overall aesthetic qualities of the Roggeveld and plateaux.

Heritage Recommendations:

The Palaeontological Impact Assessment recommended:

Field inspection of borrow-pits, turbine footing excavations and cable tranches by the project ECO team and reporting of finds..
Mitigation normally involves recording and/or collection of any discovered fossil material of conservation value with a permit issued by SAHRA and/or Heritage Western Cape;
It seems unlikely that any infrastructure will have to be repositioned;
Selective monitoring of substantial excavations may be required.

The Pre-colonial and Colonial Archaeology:

No recommendations are made with respect to pre-colonial heritage.
The most important colonial archaeological sites in the study area are associated with Ekkraal Valley, the Rietfontein-Wilgebosch River valley and the Krans Kraal-Karrekraal valley. The valley bottoms are archaeologically sensitive and should be avoided wherever possible.

The Built Environment:

Re-use of empty farm houses is encouraged as long as renovations carried out are subject to the approval of the relevant heritage compliance authority. It is suggested that the services of a conservation architect is sought if any farm houses are to be altered for re-use.

Graves:

A number of cemeteries have been encountered in valley bottoms. The planning of widening of the valley bottom roads will need to be done with care to ensure that these are avoided. Consideration should be made to cordoning these cemeteries off. It is possible that unmarked graves may be encountered during trenching and excavations. In the event of this happening, work in the immediate area should cease and the finds reported to the heritage authority and an archaeologist. Human remains must not be removed from the find-site, but the area cordoned off until a formal exhumation and investigation can be put in place.

Cultural Landscape:

The proposed energy facility will not be visible from any major transport routes (N1) but there will be visibility from tertiary roads in the area and especially the R543 between Matjiesfontein and Sutherland, a scenic tourism route. This will affect the sense of wilderness of a large chunk of the region. Conservation-worthy buildings or places of celebrated heritage significance are limited. The presence of existing 400 kV lines and 765 kV as well as further planned 765 kV transmission lines are destined to lead to further industrial clutter.

The landscape grading of the study area ranges from Grade IIIA to Grade II. The visual impact of the turbine positions as been assessed by a separate Visual Impact Assessment with the finding that receptors in the study area including the regional roads will experience a significant impact.

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LIST OF DEFINITIONS AND ABBREVIATIONS

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

Brakdak huis: A flat roofed form of vernacular architecture.

Early Stone Age: The archaeology of the Stone Age between ~700 000 and ~300 000 years ago.

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

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

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

Kookskerm: A circular brush wood screen in which outdoor cooking is done. These are still used by people of Namaqualand.

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

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

National Estate: The collective heritage assets of the Nation.

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

SAHRA: South African Heritage Resources Agency – the compliance authority which protects national heritage.

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

Trapvloer: A circular open flat floor area surrounded by upright stones that was used for hand-threshing wheat.

Acronyms

BP	Before the Present
DEA	Department of Environmental Affairs
ESA	Early Stone Age
GPS	Global Positioning System
HIA	Heritage Impact Assessment
HWC	Heritage Western Cape
LSA	Late Stone Age
MSA	Middle Stone Age
NHRA	National Heritage Resources Act, No 25 of 1999
SAHRA	South African Heritage Resources Agency

1 INTRODUCTION

ACO Associates CC has been appointed by Savannah Environmental (pty) ltd on behalf of the applicant, Karreebosch Wind Farm (Pty) Ltd, to conduct a Heritage Impact Assessment for Phase 2 of the proposed Roggeveld Wind Energy Facility known as the Kareebosch Wind Farm. Karreebosch Wind Farm (Pty) Ltd proposes the establishment of a wind energy facility on a site located approximately 30km north of Matjiesfontein, and approximately 40 km south of Sutherland. The site falls within the Karoo Hoogland Local Municipality, Northern Cape and Laingsburg Local Municipality, Western Cape. The proposed facility would utilise wind turbines to generate electricity that will be fed into the National Power Grid. The project is part of an initial Environmental Impact Assessment (EIA) application for Roggeveld Wind Farm which, based on the recommendation of the Department of Environmental Affairs (DEA), is being developed in smaller Phases. This current EIA application for Karreebosch Wind Farm is Phase 2 of Roggeveld Wind Farm (previously assessed and approved by regional heritage authorities). Karreebosch Wind Farm will have an energy generation capacity of up to 140 MW, in line with the Department of Energy's requirement.

The R543, the regional road between Sutherland and Matjiesfontein runs along-side (3-1 km) east of the study area (figure 1).

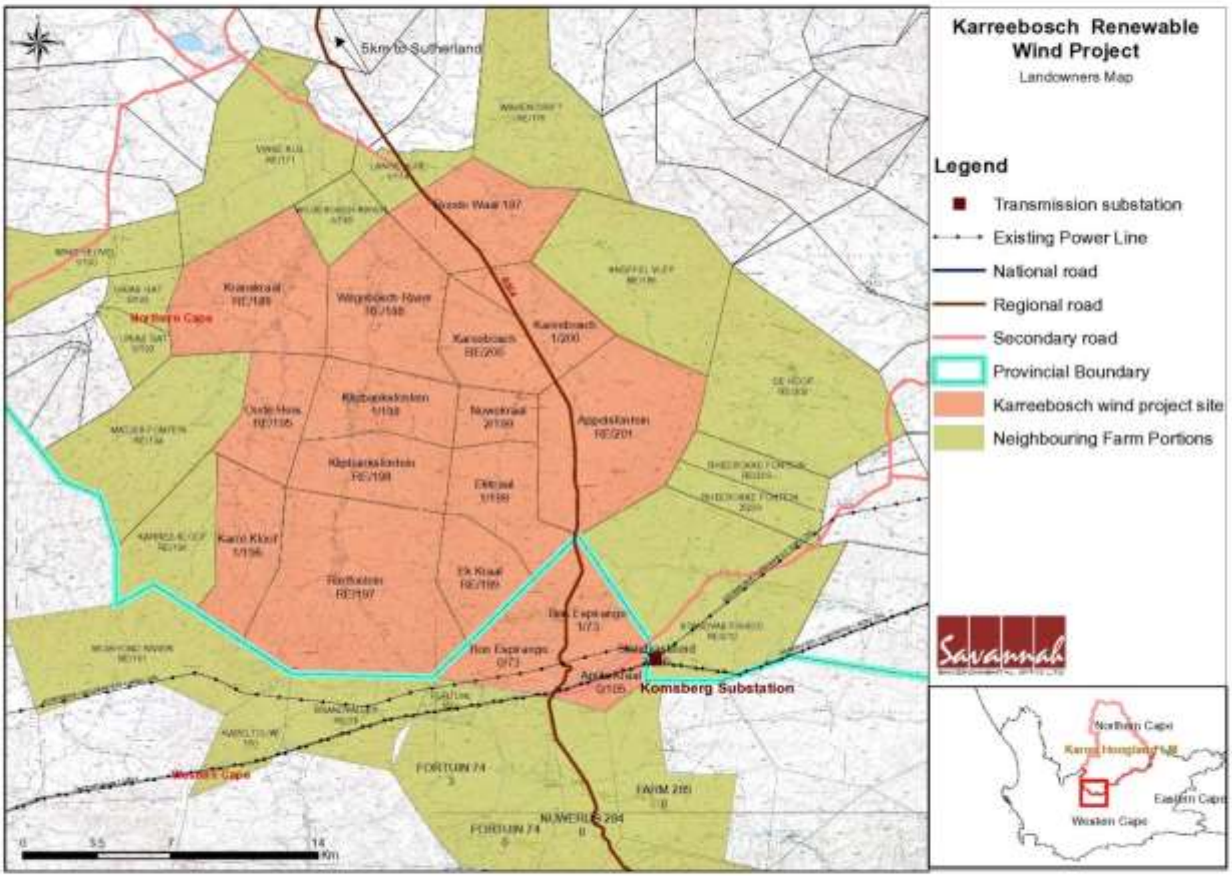

Figure 1. The proposed study area

1.1 Development Proposal

The renewed proposal for the Phase 2 Karreebosch Wind Energy Facility consists of the following:

The typical infrastructure required for the proposed wind farm includes wind turbines, electrical connections (power line and cables), on-site substation/s, access roads, borrow pits, wind monitoring masts, office and construction laydown areas.

The purpose of the proposed wind energy facility is to sell the electricity generated to Eskom under the Renewable Energy Independent Power Producers Procurement Programme (REIPPP). REIPPP has been introduced by the Department of Energy (DoE) to promote the development of renewable power generation facilities (derived from) by IPPs in South Africa.

Site (Property boundaries)

Farm Name	Farm No	Portion No	Local Municipality	Province
Ekkraal	199	2 Nuwekraal	Karoo Hoogland Municipality	Northern Cape
Wilgebosch Rivier	188	0	Karoo Hoogland Municipality	Northern Cape
Klipbanksfontein	198	0	Karoo Hoogland Municipality	Northern Cape
Klipbanksfontein	198	1	Karoo Hoogland Municipality	Northern Cape
Karreebosch	200	0	Karoo Hoogland Municipality	Northern Cape
Roode Wal	187	0	Karoo Hoogland Municipality	Northern Cape
Karreebosch	200	1	Karoo Hoogland Municipality	Northern Cape
Karreekloof	196	1	Karoo Hoogland Municipality	Northern Cape
Oude Huis	195	0	Karoo Hoogland Municipality	Northern Cape
Appelsfontein	201	0	Karoo Hoogland Municipality	Northern Cape
Rietfontein	197	0	Karoo Hoogland Municipality	Northern Cape
Bon Espirange	73	1	Laingsburg Municipality	Western Cape
Bon Espirange	73	0	Laingsburg Municipality	Western Cape

Farm Name	Farm No	Portion No	Local Municipality	Province
Ekkraal	199	0	Karoo Hoogland Municipality	Northern Cape
Ekkraal	199	1	Karoo Hoogland Municipality	Northern Cape
Standvastigheid	210	2 Komsberg	Karoo Hoogland Municipality	Northern Cape
Aprils Kraal	105	0	Laingsburg Municipality	Western Cape
Kranskraal	189	0	Karoo Hoogland Municipality	Northern Cape

1.1.1 Details of the infrastructure

- Up to 71 wind turbine generators
- Each wind turbine generator 2MW -3.3MW
- The hub height of each turbine will be up 100 metres, and the rotor diameter up to 140 metres
- The wind turbines will have a foundation of 25m in diameter and 4m in depth.
- Permanent compacted hardstanding areas / crane pads for each wind turbine (70x50m)
- Electrical turbine transformers (690V/33kV) at each turbine (2m x 2m typical but up to 10 x 10m at certain locations)
- Internal access roads up to 12 m wide.
- Approximately 25km of 33kV overhead power lines and approximately 25km of 132kV overhead power lines to Eskom's Komsberg substation.
- Up to two electrical substations (on-site 33/132 kV substation of 100m x 200m).
- An operations and maintenance building (O&M building) next to the smaller substation.
- Up to 4 x 100m tall wind measuring masts.
- Temporary infrastructure required during the construction phase includes construction lay down areas and a construction camp up to 9ha (300m x 300m).
- A borrow pit for locally sourcing aggregates required for construction (~3ha)

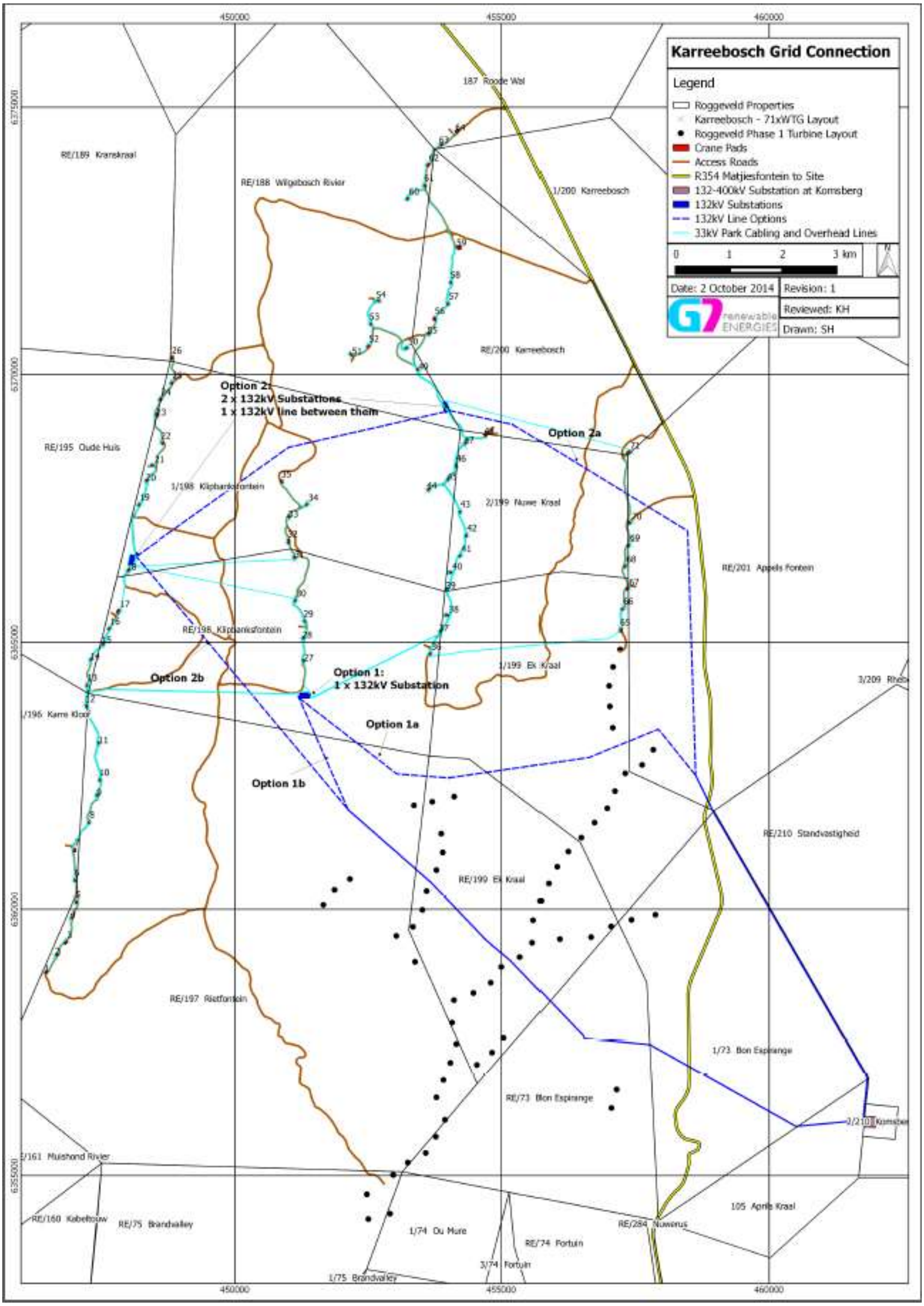

Figure 2. Plan showing the Phase 2 expansion area. The turbine positions are numbered, the first phase turbines are represented by un-numbered dots (HIA completed)

1.2 The heritage team

Mr Tim Hart is an independent specialist consultant who is in no way connected with the proponent, other than delivery of consulting services.

Ms Natalie Kendrick is an honours graduate of UCT and is employed as an intern with ACO Associates.

Tim Hart (MA) is an archaeologist with 28 years of working experience in heritage consultancy. He is accredited with Principal Investigator status with the Association of Professional Archaeologists of Southern Africa. Mr Hart serves on the Impact Assessment Review committee of Heritage Western Cape and on the Permit committee of SAHRA.

2 METHODOLOGY

This study has been commissioned as the heritage component of an EIA. It assesses the identified range of impacts in terms of accumulated knowledge of the area from previous field studies, published and unpublished material related to archaeological work and history of the region. A field survey of heritage resources has been conducted and heritage indicators (conservation-worthy buildings, archaeological sites and places celebrated as heritage) were identified and mapped where appropriate. Definitions of heritage and criteria for assessment of heritage are indicated in the National Heritage Resources Act (NHRA) while the Provincial Guidelines for assessing heritage in the Western Cape applies. Both the NHRA and Provincial Guidelines require that cultural landscapes and areas of particular aesthetic and/or cultural heritage significance are considered in the assessment.

Independent Visual assessments form part of the EIA process, and a separate report has been compiled by MetroGIS.

2.1 Assessing heritage in the context of wind energy developments

Wind energy facilities have grown exponentially throughout the world in response to the international energy crisis and climate change. Wind energy is relatively a new technology in South Africa, but is well tested in other parts of the world. Such facilities are not without controversy – while supported by many as a source of renewable clean energy, they can result to impacts by clusters of massive wind turbines on cultural landscape, which can be serious, both in physical terms and with respect to the intangible and aesthetic qualities of a given locality.

Wind energy facilities are often large developments. Turbines can be up to 100m high with blades up to 50m in radius. The structure has to be counterweighted by a concrete block (up to 2000 cubic metres or more) sunk deep into the ground. Each turbine location must be on an access road with gradients that can be negotiated by a heavy lift crane. Turbines can be visible from 10 km depending on the landscape. Indications are that they are perceived to be aesthetically more acceptable in agricultural or manicured landscapes than in natural environments (PGWC 2006).

The point at which a wind turbine may be perceived as being "intrusive", in terms of the aesthetics of an area, is a subjective judgment, but it can be anticipated that the presence of such facilities close to wilderness and heritage areas will impact on many of the intangible and aesthetic qualities for which those areas may be valued, or could be potentially be valued in the future. In some contexts however, the graceful shapes of the turbines and the sculptured twist of the blades is perceived to be aesthetically pleasing.

The degree of physical landscape disturbance caused during the construction process of a wind energy facility means that the destruction of archaeological and palaeontological and historical heritage is very likely if encountered. Impacts of wind energy facilities can therefore cause direct physical damage to heritage resources through the establishment of infrastructure, and by their presence can change the aesthetic and intangible values of the broader cultural landscapes in which the heritage resources exist.

2.2 The Site

The notional location of the proposed turbines and access roads were loaded onto handheld GPS receivers (set to the WGS84 datum) to facilitate the identification of the search area during the field work component of the study that was undertaken in October 2014. During this time the landscape in the Phase 2 area expansions were covered. Walk and drive paths, as well as site locations, were recorded with GPS as were locations of heritage resources. Heritage resources were photographed and assessed.

2.3 Limitations

There is little published archaeological information for the area. The remote location has meant that little development has occurred that required archaeological and heritage impact assessments, but additional proposals for other wind farms in the area has meant that some information has been accumulated. Dr Nigel Penn of Dept. of History at UCT has published on the early colonial history of the area and the clashes that colonists had with local indigenous groups. Prof Simon Hall of UCT currently has students working on Roggeveld historical archaeology.

The fieldwork for the proposed Phase 2 of development of the facility proved difficult. A number of gates had been wired tightly shut or locked -limiting accessibility. The study area is vast and the road infrastructure is appalling. The vast size of the area has precluded a detailed survey, however the ACO team responded to these conditions by sampling areas close to water sources, assessing the historical built environment (which are very sensitive to visual impacts) and spot-checking the tops of high ridges (turbine sites) in the few areas where these could be accessed. This is the third study that ACO has conducted in this area, therefore we have drawn on previous experience to inform our findings.

Budgetary constraints on Phase 2 of this project precluded a detailed foot survey of the study area (only two days were available), so the latest work has focussed primarily on those areas that could be reached by vehicle, that would be impacted by proposed infrastructure.

3 REGULATORY AND LEGISLATIVE OVERVIEW

The basis for all heritage impact assessment is the National Heritage Resources Act 25 (NHRA) of 1999, which in turn prescribes the manner in which heritage is assessed and managed. The National Heritage Resources Act 25 of 1999 has defined certain kinds of heritage as being worthy of protection, by either specific or general protection mechanisms. In South Africa the law is directed towards the protection of human made heritage, although places and objects of scientific importance are covered. The National Heritage Resources Act also protects intangible heritage such as traditional activities, oral histories and places where significant events happened. Generally protected heritage which must be considered in any heritage assessment includes:

Cultural landscapes (described below), buildings and structures (greater than 60 years of age), Archaeological sites (greater than 100 years of age), Palaeontological sites and specimens, shipwrecks and aircraft wrecks, graves and grave yards.

Section 38 of the NHRA requires that Heritage Impact Assessments (HIA's) are required for certain kinds of development such as rezoning of land greater than 10 000 sq m in extent or exceeding 3 or more sub-divisions, or for any activity that will alter the character of a site greater than 5000 sq m.

3.1 Cultural Landscapes

Section 3(3) of the NHRA, No 25 of 1999 defines the cultural significance of a place or objects with regard to the following criteria:

(a) its importance in the community or pattern of South Africa's history;
(b) its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;
(c) its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;
(d) its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects;
(e) its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
(f) its importance in demonstrating a high degree of creative or technical achievement at a particular period;
(g) its strong or special association with a particular community or cultural group for social cultural or spiritual reasons;

(h) its strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa; and
(i) sites of significance relating to the history of slavery in South Africa.

3.2 Scenic Routes

While not specifically mentioned in the NHRA (Act 25 of 1999), "scenic routes" are recognised by DEA&DP as a category of heritage resource. In the DEA&DP Guidelines for involving heritage specialists in the EIA process, Baumann & Winter (2005) comment that the visual intrusion of development on a scenic route should be considered a heritage issue. This is also given recognition in the Notice of Intent to Develop (NID) application which is used by Heritage Western Cape.

3.3 Heritage Grading

Heritage resources are graded following the system established by Winter and Baumann (2005) in the guidelines for involving heritage practitioners in EIA's (Table 1).

Table 2: Grading of heritage resources (Source: Winter & Baumann 2005: Box 5).

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

3.3.1 Landscape grading

Heritage Western Cape requires the grading of landscapes as the National Heritage Resources Act protects areas that are considered aesthetically important to a community. The process for the grading of landscapes is as follows:

Landscapes are heritage resources of national or regional or local importance in terms of rarity and representivity. The UNESCO Operational Guidelines for the World Heritage Convention (1995) identified three main types of cultural landscapes derived from the following characteristics:

(i) The clearly defined landscape designed and created intentionally. This embraces garden and parkland landscapes constructed for aesthetic reasons
(ii) The organically evolved landscape. This results from an initial social, economic, administrative, and/or religious imperative and has developed its present form by association with and in response to its natural environment. Such landscapes reflect that process of evolution in their form and component features. They fall into two sub-categories:
• a relict (or fossil) landscape is one in which an evolutionary process came to an end at some time in the past, either abruptly or over a period. Its significant distinguishing features are, however, still visible in material form.
• a continuing landscape is one which retains an active social role in contemporary society closely associated with the traditional way of life, and in which the evolutionary process is still in progress. At the same time it exhibits significant material evidence of its evolution over time.
(iii) The associative cultural landscape included by virtue of the powerful religious, artistic or cultural associations of the natural element rather than material cultural evidence which may be insignificant or even absent. (Extract from paragraph 39 of the Landscape Operational Guidelines for the Implementation of the World Heritage Convention)

Also criteria that have been considered (Baumann, Winter, Aikman 2005) locally are:

- Design quality. The landscape should represent a particular artistic or creative achievement or represent a particular approach to landscape design
- Scenic quality. The landscape should be of high scenic quality, with pleasing, dramatic or vivid patterns and combinations of landscape features, and important aesthetic or intangible qualities (vividness, intactness, unity)
- Unspoilt character/authenticity/integrity. The landscape should be unspoilt, without visually intrusive urban, agricultural or industrial development or infrastructure. It should thus reveal a degree of integrity and intactness
- Sense of place. The landscape should have a distinctive and representative character, including topographic and visual unity and harmony
- Harmony with nature. The landscape should demonstrate a good example of the harmonious interaction between people and nature, based on sustainable land use practices
- Cultural tradition. The landscape should bear testimony to a cultural tradition which might have disappeared or which illustrates a significant stage in history or which is a good example of traditional human settlement or land use which is representative of a culture/s
- Living traditions. The landscape should be directly and tangibly associated with events or living traditions with ideas or with beliefs, with artistic and literary works of high significance.

4 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The study area is situated towards the southern margin of the Main Karoo basin almost immediately west of the Sutherland – Matjiesfontein road (R354). To the south, rocks of the Cape Supergroup make up the Cape Fold Belt mountains. Folding due to the tectonic forces which gave rise to the Cape Fold Belt is also present in the study area, but it is much more subdued. This has given rise to more or less parallel gentle anticlines (∩-shaped) and synclines (U-shaped), with their axes orientated approximately north-south. The entire area is underlain by rocks of the Karoo Supergroup rocks of the Abrahamskraal Formation and the Permian Beaufort Group. In the south there are scattered outcrops of the slightly older Waterford Formation of the Ecca Group, and also outcrops of the Tierberg and Fort Brown Formations in the extreme south (Theron, 1983). The Abrahamskraal Formation underlies all of the northern area and makes up the ridges on which the planned wind turbines are to be erected. The hilltops and hill slopes expose horizons of resistant channel-fill sandstones, with intervening layers of shales, representing former muddy flats and flood splays from broken river banks.

It is a semi-arid region with rainfall mainly in the form of summer thunderstorms in recent years, some snow and precipitation in winter. The vegetation is characteristic of the Succulent Karoo biome. The northern parts of the "site" straddles the foot hills (Kleinroggeveldberge) below the great escarpment. This area is characterised by a series of very high and long ridges with valleys in-between (anticlines and synclines). These contain acacia thickets in places, a number of farm buildings and local roads. The high ridges are windswept, dry, inhospitable and un-developed (apart from dirt tracks).

The area is sparsely populated being limited to a number of farms, most of which have absentee landlords. Farmers that were resident on site complained bitterly about un-predictable weather patterns, climate change and an increase in the number of predators which was making the main activity in the area (sheep farming) very difficult to sustain. Many farm buildings contains elements that area greater than 60 years of age and fall with the general protection of the NHRA.

There are a number of farm tracks which cross the study area to service fenced stock camps and associated small dams and their accompanying wind pumps. Despite human intervention related to farming, the site remains predominantly natural and, in places inaccessible and isolated.

Figure 4. Typical topography of the study area - valleys and ridges

Figure 3. The turbines are to be located on the high ridges, farming has historically taken place on the valley floors.

4.1 Palaeontological heritage of the area

A palaeontological impact assessment (PIA) of the site was commissioned and undertaken by Dr Duncan Miller with further comment kindly provided by Dr John Almond who has prepared a second report as appendix 2 with that of Dr Miller (both reports overlap in coverage) The findings are integrated into this report. This area of the Karoo is known for a variety of fossils of early mammal-like reptiles and trace fossils.

4.2 Pre-colonial Heritage of the area

Little was known of the archaeology of the study area until recently and in fact no heritage impact assessments are listed on the SAHRA database for this area (at least up to 2009). Despite the official record, there has been some limited research work around Sutherland (for example: Lloyd Evans et al. 1985; Hart 2005). Lloyd Evans et al. (1985) excavated a small rock shelter on the grounds of the South African Astronomical Observatory in Sutherland. It contained a Later Stone Age assemblage with a relatively high proportion of small convex scrapers and thin-walled potsherds of indigenous manufacture, ostrich eggshell and some *Nassarius kraussianus* (a type of marine shell) beads. They comment (1985: 108) that the presence of the shell beads points to cultural ties with people along the Cape coast while the small scrapers can be assigned to the Wilton industry, distinct from the large elongated scrapers typically associated with the interior sites along the Orange River as described by Sampson (et al. 1989).

Hart (2005) undertook a survey for a golf course to the south of the Sutherland urban edge. The most significant find was a complex of 13 stone enclosures which are typical of the Khoekhoen kraals that were mapped and described by the author in the eastern Karoo (Hart 1989, Sampson 2008). A single highly dispersed artefact scatter consisting of mainly waste material (flakes made from hornfels or indurated shale) was also found. Hart (2005) reported finding a dense artefact scatter associated with a shallow rock shelter outside the study area indicating that archaeological sites may be found in areas that were sheltered from the wind (an important consideration given Sutherland's extreme temperature ranges).

Recent work on another wind farm to the east, the so-called Suurplaat WEF (Hart et al 2010) as well as archaeological specialist studies of the Gamma-Omega 765 kV powerline passing to the south of the escarpment (Patrick 2009) has overcome the information vacuum to a degree. The Zuurplaats project is of particular relevance given that it occupies a similar geographical position to the facility under discussion here, whereas the linearity of the power line and its context make the archaeological observations moderately less useful.

Hart (et al's 2010:22-23) observations, included below:

Pre-colonial archaeological material: As expected includes Early Stone Age (ESA), Middle Stone Age (MSA) and Later Stone Age (LSA) artefact scatters. Open sites are extremely sparse. The most common raw materials are hornfels, quartzite, chert, and also quartz and Karoo shale. Occasional flakes were noted randomly on the landscape, lie scattered on the land surface, which represents the "litter" of the Stone Age. On the ridge tops where the turbines are to be built, even incidental artefacts were very scarce.

Stone kraals: The most common form of pre-colonial site on the upper plateau were stone kraals or kraal clusters, which according to Sampson's (2008) figures from the Eastern Karoo, could be between 300 and just over 1000 years of age. The kraal complexes (which are distinctly different from colonial period stock kraals) tend to be found along the leeward slopes of low ridges (or where minimal wind affects the area). These typically consist of dry stone piled wall enclosures in a roughly circular configuration, sometimes interlocking but not more than half a meter high, and ranging from 3 - 4 meters to 9 m in diameter. In the past they are likely to have been associated with reed mat huts or brush shelter/s), probably erected a few meters away from the main 'kraal' where small stock such as fat tailed sheep and goats were kept. Often found in proximity to the larger 'kraals' are lammerkraals (lambs' kraasl), which are much smaller (about 1m in diameter) and a bit higher (usually a few more layers of stones added to the wall) than the adjoining larger 'kraal'. These small kraals are known to have been used to keep new born lambs or goats separate from their mothers so that the milk could be used rather by the people (Webley 1986). It was noted that kraals are arranged in complexes of up to 13 interlocking enclosures with adjoining lammerkraals.

Below the escarpment another form of archaeological site has been identified on previous projects. These are what we interpret to be open Khoekhoen encampments situated among the Kameeldoring trees along the dry river beds in the bottom of valleys. The sites are typically quite large (60 – 80m in diameter), artefactually rich with very fine thin walled and burnished Cape Coastal pottery noted. There are numerous stone features, informal stone artefacts, grinding surfaces as well as a number of graves, some of which have broken grinding stones placed on top. Also evident were discreet ash middens and animal bone. On two of the sites there is evidence of European goods (19th century glass and ceramics) which may indicate some form of continuous use of the sites by Khoekhoen herders into the colonial period.

Halkett and Webley (2011) conducted a study just south of the Suurplaats site which revealed that the area had a rich and previously un-described heritage such as evidence of proto-historic herder communities that were residing in the valley bottoms.

4.3 Colonial Heritage

Schoeman (1986) has described the early settlement of the Roggeveld and Sutherland area which commenced around 1750. The early farmers found the escarpment, which enjoys the highest rainfall, particularly suitable for small stock farming during the summer months but they moved down into the valleys and plains of the Karoo to escape the extreme winters. In addition, the escarpment seems to have been where most of the springs were found, and from there they were able to exploit the vegetation of both the Onder Karoo as well as the Sak River region in Bushmanland. Each Trekboer usually had in addition to a loan farm on the plateaux, a farm in the Karoo known as a legplaats (outpost). Initially, the population of the area remained small, because many of the early loan farms were merely "stock posts" and the owners lived elsewhere. Drought, poor grazing and attacks by the San caused many farms to be abandoned. Disputes over farm boundaries were intense. According to Penn (2005), in the 18th century there were numerous independent Khoekhoen kraals located amongst the Trekboer farms in the Roggeveld.

The first recorded loan farms in the Roggeveld date to 1743, and by 1750 there were 31 registrations (Penn 2005). Robert Jacob Gordon travelled through the Roggeveld in 1786 and he mentions farms belonging to the Van Wyks and the Louws (both are families who have lived in the area for generations) as well as a farm on the edge of the "Comsberg" (sic) that belonged to a Cloete (in Schoeman 1986). Many farmers seem to have had more than one loan farm.

Resistance to the Trekboers in the Roggeveld came initially from the San who resisted fiercely throughout the great Karoo, at times beating back the vanguard of Trekboer farmers. In 1754, attacks from the Khoisan are reported to have increased and flocks of sheep and herds of cattle belonging to the Trekboers were driven out of the area. This increased to the extent that it is described by Schoeman as a type of guerrilla warfare. Livestock was stolen, Khoisan herders and slaves killed, and Trekboer farms attacked. The colonists fought back by establishing the Kommando system – and leading to the officially sanctioned "hunting" of San in 1777 (Adhikari 2011, Dooling 2007). In some instances, bounties were obtainable from the local landdrost. There was apparently a massacre of 186 San in the Roggeveld in 1765. The only confirmation of this is from the farm Oorlogskloof near Sutherland. There are a great many graves, some 30, laid out in three groups, with piles of rocks above them. There is also a separate gravestone with the date 1768. Both Penn and Schoeman refer to another mass grave on the farm Gunsfontein (to the west of Schietfontein (Scholtzenhof) - and now part of a private nature reserve), possibly dating to the rebellion of the 1770's. According to Penn (pers comm.), somewhere in the valleys of the escarpment is a large cave or shelter where some of the few surviving San made their last stand against the kommando's.

The Khoisan were gradually driven from the Roggeveld northward to the extent that by 1809 there is reported to have been only one settled "Bushmen" kraal left in the area.

Settlement became more permanent from the beginning of the 19th century. The farmers' main source of income was small stock, since wheat could only be grown with great difficulty in isolated and protected valleys when conditions permitted. There was very little grazing and standing water for cattle.

Schoeman (1986) notes that during the early years of settlement in the Roggeveld, many of the Trekboers lived in grass huts or Matjieshuise (mat covered houses), and in tents and some travellers found farmers living in Matjieshuise as late as 1839. Attempts at constructing more permanent structures were inhibited by the lack of suitable wood for roofs. The generic house comprised a "small oblong low hut" built of slabs of leiklip piled on top of each other, unplastered, with a reed roof. A single window was covered with white linen and a doorway covered with panel of reeds. The floor was of clay smeared with dung. Generally houses comprised two rooms, with an entrance into living room/kitchen and a second room serving as a communal sleeping/storeroom. Some had a free standing kookhuis. Associated farm buildings also included the houses of the workers.

There were also a number of kraals, with seven to eight not uncommon. A number of farm workers were slaves, brought by their owners from the Cape, but also included local Khoisan (Busmen and Khoekhoen) who for one reason or another were no longer pursuing their traditional lifestyles – some of these people were captured as children by Kommando units and enslaved as farm labour.

During the South African War, the threat of Boer incursions led British forces to build fortifications at a number of strategic passes through the Roggeveld. A stone redoubt was constructed on the farm Gunsfontein (adjoining the proposed wef) at the top of the Brandkloof and Maleishoek passes. With the Boer leader Manie Maritz active in the Calvinia District, many young men from the Roggeveld joined the Boer cause. One of the followers was Jan Fourie of Welgemoed (Schoeman 1986:98). There appears to have been some skirmishes in the vicinity of Skietfontein (Komsberg) in 1901. One of the stone structures located on Beerenvallei during the survey may relate to the Anglo Boer war. In a recent study Orton and Halkett (2011) identified a previously un-documented British complex of fortifications – redoubts and gun platforms situated on a farm 10 km south of Sutherland.

5 FINDINGS

5.1 Palaeontology

The full report is included in Appendix 2. The stratigraphy, lithology and palaeoenvironments of the rocks of the northern areas are summarised in the following Table 3.

Table 3 Summary of stratigraphy and lithology.

AGE	GROUP	FORMATION	LITHOLOGY	PALAEOENVIRONMENT
Permian	Beaufort	Abrahamskraal	sandstone channel + crevasse splay deposits, interbedded mudstones	subaerial upper delta plain, aerially exposed mudflats, backswamps,
Permian	Ecca	Waterford	sandstone, greywacke, shale	shallow water, delta-front
Permian	Ecca	Fort Brown	mudstone, minor sandstone	prodelta and delta-front
Permian	Ecca	Tierberg	dark shale, mudstone	settling from suspension in deep water, shallowing towards the top

Table 4.1.1. Stratigraphy, Lithology and Palaeoenvironments of the Rocks Exposed in the Study Area (modified from Johnson et al., 2006)

The outcrops of the Waterford Formation in the south were not searched, but trace fossils in the form of burrows, trails and tubes are common in this formation, with rare bivalves and fragmentary fish remains (Thamm & Johnson, 2006; Johnson et al., 2006). Plant fragments (Glossopteris) are also reported to be common and in places pieces of stem fragments of the tree genus Dadoxylon occur (Theron et al., 1991).

The only fossils found in the rocks of the Abrahamskraal Formation were trace fossils in the form of sand-filled vertical burrows in sandstone (Figure 4.2.1). These were in a loose block adjacent to a packed stone ruin in the Ekkraal valley) and may have been transported from elsewhere as building material (Figure 5).

Figure 5. Trace Fossils Consisting of Sand-filled Vertical Burrows in Sandstone, from Ekkraal Farm (width of rock ca. 200 mm)

The Abrahamskraal Formation contains terrestrial vertebrate fossils, fish remains, non-marine molluscs and silicified wood (Johnson et al., 2006). The lowest biozone of the Beaufort Group is the Eodicynodon Assemblage Zone, recently recognised in the southwestern part of the Karoo basin by Bruce Rubidge. This zone is characterised by fossils of Eodicynodon, a small primitive tetrapod reptile. Fossils of other primitive reptiles are also found in this biozone (MacRae, 1999). These are extremely important fossils documenting the rise of reptiles and evolution of mammal-like reptiles (therapsids), for which the Karoo is the pre-eminent locality.

The Eodicynodon Assemblage Zone is not recorded in this area and the Study Area lies within the Tapinocephalus Assemblage Zone. The zone is named after a therapsid (the mammal-like reptile Tapinocephalus atherstonei) restricted to this zone. Fossils of a wide variety of other tetrapods, both herbivores and carnivores, including early precursors to the line that gave rise to mammals, have been found in this zone (MacRae, 1999). There are very few records of vertebrate fossils in the part of the Tapinocephalus Assemblage Zone covered by the Study Area, and what has been found is sparse but diverse, so anything found would be of considerable significance (J. Almond pers. comm.). Surveys within the study area by both Almond and Miller have revealed that although the mudstones of Abrahamskraal formation are fossilifierous, finds within the study area are very rare and thus the project area is not particularly sensitive. However if fossils were found, these may be very important and should be reported.

5.2 Pre-colonial Archaeology

5.2.1 Stone age artefactual material

The actual turbine sites are situated on the tops of very high ridges where the wind conditions are optimal. Within the study area the ridges are devoid of rock shelters, rock outcrops but are covered in stones and low shrubs. They are extremely in-hospitable in that they contain no foci where people could shelter from the elements. Rock shelters in this area are entirely absent, and water sources are scarce. These harsh conditions were evidently experienced in the pre-colonial past as almost no evidence of any archaeological material at all was located. Even Middle Stone Age material with is normally ubiquitous throughout the Karoo was almost entirely absent. These observations are not the result of a thin search pattern over a vast area, as half of the turbine sites were easily accessible by off-road vehicle. Very large tracts of the country were traversed. As has been demonstrated by other recent studies in the area, pre-colonial heritage tends to occur in the valley bottoms close to watercourses and springs which may explain why the high ridges of the study contains so little evidence for pre-colonial occupation.

Figure 6. Typical landscape of the study area.

5.2.2 Other pre-colonial indicators

Co-ordinates and details of observations are presented in Appendix 1.

There are very few caves or shelters within the study area that could have supported occupation (few exhibited any form of sediment trap), and those that do exist, are generally formed in soft rock strata resulting in constant exfoliation. Two small rock shelters were inspected, however these contained no habitable floors or archaeological deposits.

5.3 Graves

A collection of stone piles were recorded in the Ekkraal Valley (figure 7) while similar and more defined examples which are almost certainly graves have been identified in the Rietfontein and Karrekraal areas. Many of these are not far from the valley bottom raods which means they could be impacted if roads are to be widened.

A large informal cemetery was located in the Wilgebosch-Rietfontein area, while further collections of likely graves were found in the Kranskraal-Karrekraal area.

Figure 7 Stone pile (possible grave) near Ekkraal.

5.4 Built Environment and colonial heritage

The built environment of the study area is limited to farms, farm houses, stone walls, walled kraals and secondary roads. Given the remoteness of this area, even these are sparsely distributed. Virtually all farm infra-structure is situated in the low lying areas between the ridges. Most are several kilometres from proposed turbine locations which mean that direct impacts are not expected. Characteristically, locales of colonial settlement seem to be concentrated in the valley bottoms – namely the farm known as Ou Mure, the Ekkraal Valley and the Hartjieskraal-Barendskraal valley somewhat south of the study area, and within the study area at Karrekraal.

5.5 The Valleys

Ekkraal:

The most significant collection of heritage resources in the entire area is confined to a single remote valley at the entrance to which lies the farm Ekkraal. The valley forms a geographically delineable cultural landscape consisting of ruined 19th century farms, stone walled kraals, fragments of stone walling. The shallow Ekkraal valley lies between two of the large longitudinal ridges which form the main turbine rows. Along the gently sloping valley floor the team recorded some 16 occurrences of historical material, all evidently dating to the 19th century (figure 8). The rivulet which runs down the valley bottom was evidently a wetland which attracted trekboer agriculture. The presence of at least two trapvloers (threshing floors) and remnant of disturbed landscapes and ruined stone and mud-brick homesteads indicate that the area produced some harvests of wheat (figures 8-14). Today there is very little evidence of any fields in this essentially wilderness landscape.

The existing Ekkraal Farm (absentee owner) is a humble corrugated iron roofed building which dates from the 19th century. It is probably worthy of Grade IIIC status. The structure is not under threat and evidently well maintained (figures 12-14). The closest turbines are well in excess of 1 km distant, which means that no direct impacts will result from the turbines themselves. Others elements of the built environment consist of dams, kraals and two out-buildings, one of which is built from stone and has a Dutch hearth. The existing vehicle track up the valley will be upgraded and widened to allow heavy vehicles to pass. Since many of the ruined features lie very close to this track, impacts could occur

The significance of Ekkraal valley lies in the intactness of the archaeological signature of early colonial occupation. The pattern of kraals, farm buildings, artefact scatters and walling remains highly legible. The area can be considered to be archaeologically sensitive and worthy of preserving in terms of its research potential. The heritage of the valley is not a tourism resource, and not well known to anyone other than the local populous. In these terms it does not constitute visually sensitive heritage. The revised layout for Phase 1 is more sympathetic to the heritage qualities of the Ekraal Valley in terms of both visual impacts and physical impacts as the valley has been largely left free of infrastructure or access roads.

Figure 8 Artefacts of the mid-late 19th century found associated with ruins near Ekkraal.

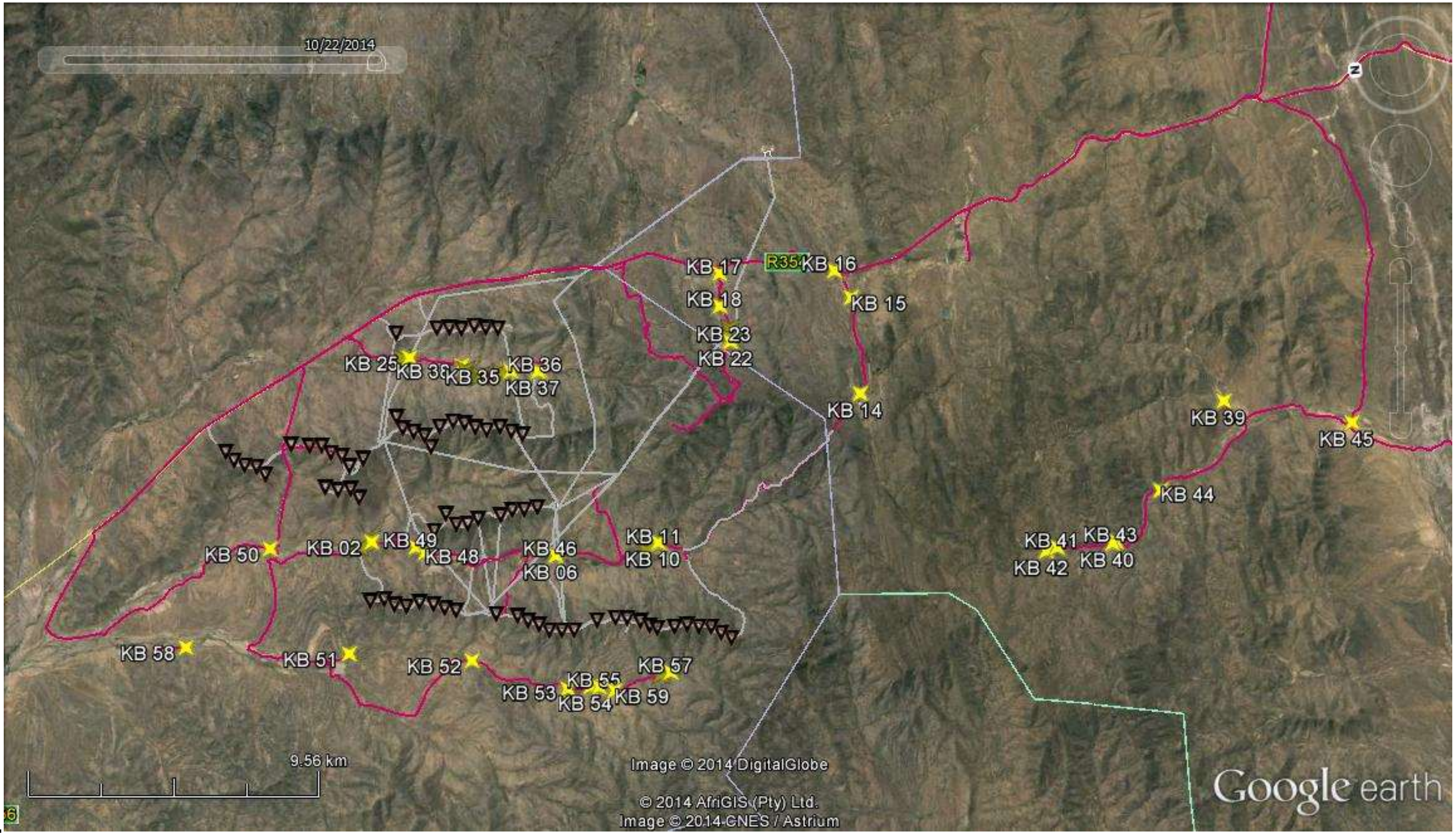

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Figure 9 .Recorded tracks and waypoints from both the 2010 Phase 1, and the 2014 Phase 2 surveys (tracks are in magenta and the waypoints are the numbered stars). The Karreebosch layout is in grey (powerlines and roads) while the turbine positions are indicated as black triangles.

Figure 10. Large stone kraal, Ekkraal.

Figure 6. 19th century ruins, Ekkraal

Figure 12. Remnants of a threshing floor (trapvloer) associated with ruins in Figure 10.

Figure 7. Existing structure, Ekkraal.

Figure 14. Existing Farm House, Ekkraal.

Rietfontein – Wilgebosch:

This area reflects the clear pattern of historic settlement in the valley bottoms. A number of historic ruins and graves were recorded, and highlight the need to treat the valley bottoms as conservatively as possible when designing infrastructure. Widening of the Valley Road may impact these elements.

Kranskraal-Karrekraal:

No infrastructure is planned for this valley bottom. This highly isolated area contains numerous historic ruins, and particularly to the south at Karrekraal a rare *brakdak* huis (19th century) with a traditional kookskerm, a rare heritage feature which is seldom seen these days. There are also a number of graves, both informal and with headstones. It is fortunate that infrastructure is not planned for this area as it is sensitive in terms of historical archaeology.

5.6 Cultural Landscape

In overall terms the study area represents a remote wilderness landscape, which even in prehistoric times appears to have been marginally inhabited. Colonial occupation of the area was also sparse, having been limited to valley bottoms. The predominant presence is that of open wilderness. While the area is highly scenic, within the project boundary there are no major tourism enterprises and is very seldom visited by persons other than those directly involved in farming.

Visual impacts, which are addressed in a separate independent report, are a concern as the proposed facility will be visible from the R543.

5.7 Landscape grading

The NHRA requires the grading of all heritage resources including the grading of a landscape for its aesthetic qualities. This has been implemented in the Western Cape but has yet to be implemented in other provinces.

The study area lies within a continuously evolving landscape that is predominantly natural and of considerable time depth. It is extremely remote, sparsely inhabited and seldom visited by anyone apart from landowners and possibly occasional tourists. In terms of its aesthetics it has all the wide open qualities for which the central Karoo is cherished.

Suggested grading: lllA with views down the valleys from the southern ridges reaching grade ll significance.

6 Assessment of Impacts

6.1 Turbines

The areas selected for the proposed construction of turbines are the tops of the large longitudinal ridges that are generally orientated north-south through the study area. These wind-swept mountain tops are generally remote, exposed and inhospitable. During the course of this study many kilometres of ridge top landscape were traversed and found to be largely sterile of any form of human made heritage material.

There are some 16 turbines within 3 km of the R354 which will be highly visible from the R354 between Sutherland and Majiesfontein occupying some 14 linear km of landscape on the western side of the road. This means that together with Phase 1 of the Roggeveld project almost 30 km of the R354 will be subject to direct landscape impacts.

While the R354 is not a heritage resource as such, it does link two heritage rich communities which are strongly contextually linked with the Karoo experience, hence the proposed development could impact the sense of place associated with both towns. The degree to which this potential impact will be perceived by people depends on the perceptions and aesthetic inclinations of the user of the R543. The historic pass to Sutherland via Karoopoort lies about 18km to the east of the closest turbine row. The impact to this heritage resource and scenic route will be minimal as the turbines will only be marginally visible under the clearest of conditions.

The study area has little amenity or intrinsic active tourism value at the present time (although it is highly scenic), which means that assigning a high degree of impact in terms of sense of place is unjustified. On the other hand, it is these very qualities that impart the area its wilderness value. It must be noted that the development proposal will potentially sterilise the area in terms of any future development of wild life experiences or outdoors orientated tourism, while the visual impact from the R543 will change the experience of people using the route to Sutherland, a locality that has become a popular tourist destination on account of SALT (South African Large Telescope).

The area is fossiliferous which means that palaeontological material may be impacted by excavation of footings for turbines. Provided that suitable mitigation is carried out, this is not necessarily a negative impact as gains in terms of contributions to scientific knowledge may result from any new observations made. If mitigation is not carried out, negative impacts will result as potentially significant scientific evidence will be lost.

6.2 Substations

Indications are that physical impacts will be minimal.

6.3 Connecting electrical lines

The intention to use above ground connecting lines between turbines and transformers presents a new vertical intrusion in the landscape which will add further to the industrialised character presented by the proposed facility in general. In terms of physical heritage the use of above ground lines will decrease the potential impact on both archaeology and palaeontology.

In terms of options, no particular power line option is preferred. This is a visual impact which should be addressed from that discipline.

Final layouts must be assessed during the Environmental Management Plan (EMP).

6.4 Access Roads

Indications are that the proposed access roads will have a low impact on physical heritage, however any widening of the roads down the valley bottoms must avoid impacting historical sites and graves.

6.5 Borrow pits

The location of proposed borrow pits appears satisfactory.

Table 4: The potential impact of construction of turbines, substation, access roads and power line/s on the palaeontological heritage of the study area.

<table>
<tr><td colspan="3">NATURE OF IMPACT: Direct impacts caused by breaking, crushing or discarding of fossil material during excavation for turbines bases, road cuttings or any other deep excavation.</td></tr>
<tr><td></td><td>Without mitigation</td><td>With mitigation</td></tr>
<tr><td>EXTENT</td><td>Local</td><td>Local</td></tr>
<tr><td>DURATION</td><td>Long term</td><td>Long term</td></tr>
<tr><td>MAGINITUDE</td><td>Moderate</td><td>Low</td></tr>
<tr><td>PROBABILITY</td><td>Probable</td><td>Possible</td></tr>
<tr><td>SIGNIFICANCE</td><td>Low</td><td>Low</td></tr>
<tr><td>STATUS</td><td>Negative</td><td>Neutral - positive</td></tr>
<tr><td>REVERSIBILITY</td><td>Non-Reversible</td><td>Reversible</td></tr>
<tr><td>IRREPLACEABLE LOSS OF RESOURCES?</td><td>Yes</td><td>No</td></tr>
<tr><td>CAN IMPACTS BE MITIGATED?</td><td>Yes</td><td></td></tr>
<tr><td colspan="3">MITIGATION: Mitigation of palaeontological heritage can be achieved by ensuring that trenches and deep rock excavations are checked by the project ECO. The collection of new scientific information is a positive impact.</td></tr>
<tr><td colspan="3">CUMULATIVE IMPACTS: Given that several other large WEFs are planned for the region, there is a possibility of cumulative impacts, although this is likely to be relatively insignificant.</td></tr>
<tr><td colspan="3">RESIDUAL IMPACTS: Residual impacts are likely to be low.</td></tr>
</table>

Table 5: The potential impact of the construction of the turbines, substations, access roads and power line/s on the pre-colonial and colonial archaeology of the study area.

NATURE OF IMPACT: Direct impacts caused by physical destruction of archaeological material.		
	Without mitigation	With mitigation
EXTENT	Local	Local
DURATION	Long term	Long term
MAGINITUDE	Low	Low
PROBABILITY	Possible	Possible
SIGNIFICANCE	Low	Negligible
STATUS	Neutral	Neutral
REVERSIBILITY	Non-Reversible	Non-Reversible
IRREPLACEABLE LOSS OF RESOURCES?	Yes	No
CAN IMPACTS BE MITIGATED?	Yes	
MITIGATION: Final infra-structure positions must be field proofed by an archaeologist prior to construction.		
CUMULATIVE IMPACTS: Cumulative impacts are unlikely		
RESIDUAL IMPACTS: Residual impacts are likely to be low.		

Table 6: The potential impact of the construction of the turbines, substation, access roads and power line/s on the built environment of the study area

NATURE OF IMPACT: Direct impacts caused by physical destruction of buildings, un-authorised demolition, theft of fabric and fixtures or neglect.		
	Without mitigation	With mitigation
EXTENT	Local	Local
DURATION	Long term	Long term
MAGINITUDE	Low	Low
PROBABILITY	Probable	Possible
SIGNIFICANCE	Low	Low
STATUS	Negative	Positive
REVERSIBILITY	Non-Reversible	Non-Reversible
IRREPLACEABLE LOSS OF RESOURCES?	Yes	No
CAN IMPACTS BE MITIGATED?	Yes	
MITIGATION: Mitigation of the built environment should involve micro siting turbine positions and associated infrastructure during the EMP to avoid placing turbines or infrastructure directly over built environment features and buildings or bisecting coherent		

settlement complexes. The sensitive reuse of vacant buildings is encouraged (as long as advice is sort on heritage sensitivities) as this will help sustain them.
CUMULATIVE IMPACTS: Cumulative impacts are unlikely
RESIDUAL IMPACTS: Residual impacts are likely to be low.

Table 7: The potential impact of the construction of the turbines, substation, access roads and power line/s on the Cultural Landscape of the Study Area.

NATURE OF IMPACT: Direct impacts caused by physical destruction and massive visual intrusion, impacts to sense of wilderness and country..		
	Without mitigation	With mitigation
EXTENT	Local	Local
DURATION	Long term	Long term
MAGINITUDE	High	High
PROBABILITY	Likely	Likely
SIGNIFICANCE	Major	Major
STATUS	Negative	Negative
REVERSIBILITY	Non-Reversible	Non-Reversible
IRREPLACEABLE LOSS OF RESOURCES?	Yes	Yes
CAN IMPACTS BE MITIGATED?	No	
MITIGATION: The size of the turbines and their massed presence will impact the quality of the Karoo landscape. Good rehabilitation of construction roads and cuttings may mitigate to a small degree.		
CUMULATIVE IMPACTS: Cumulative impacts are likely. There are at least a further 6 facilities planned for the area. If all of these transpire there will be a clear change in the sense of place of the region and a sense of industrialisation of a rural landscape. This may have further impacts to sustainability of local tourism. The heritage grading of the landscape is likely to be affected causing a shift from Grade IIIA to Grade IIIC or ungraded.		
RESIDUAL IMPACTS: Residual impacts are likely to be present – road cuttings and landscape scars.		

7 ACCUMULATIVE IMPACTS

Accumulative impacts are becoming an increasing concern as progressively greater expanses of Karoo landscape are subject to industrial development for renewable energy purposes. The Sutherland area and the Great Escarpment and foothills have attracted some twenty proposals (https://dea.maps.arcgis.com/apps/webappviewer) within this highly scenic landscape, which up to now has a wilderness landscape character. The accumulative impact will involve significant sterilisation of the aesthetic qualities of the landscape, the Karoo heritage and its character and sense of place. The nation's open landscapes and wilderness qualities are unique, the Karoo as a landform and a landscape is unequalled and a quintessential aspect of the nation's character. The accumulative impact of massed adjoining renewable energy facilities is of deep concern given that the National Heritage Resources Act 25 of 1999 clearly protects places of aesthetic significance.

It is expected that the cumulative impact on the central Karoo as a physical and scenic heritage resource will be significant and negative. The proposed Kareebosch Wind Energy Facility is but a moderate contributor to what is becoming an alarming erosion of landscape quality in many areas of the country.

8 CONCLUSION AND RECOMMENDATIONS

8.1 Palaeontology

All the geological horizons in the Study Area are potentially fossiliferous. Consequently, all excavations, whether for road cuttings or foundations, may reveal fresh fossiliferous rock. There is a low but significant likelihood of important new discoveries in the Abrahamskraal Formation.

The likelihood of encountering Cenozoic fossils in valley fill sediments is considered to be low, but if excavations for infrastructure take place in the Ekkraal or Wilgebosrivier valleys, there is a possibility of fossil mammalian bones being encountered. In this case the South African Heritage Resources Agency will have to be notified immediately.

Road cuttings, particularly into hill slopes for access roads to the ridge tops where wind turbines would be located, should be investigated by a suitably qualified and experienced Karoo palaeontologist. Any substantial excavation exposing fresh bedrock, like borrow pits, similarly should be monitored by the project ECO for palaeontological materials of conservation value.

If fossil material is encountered, a palaeontologist must be appointed and given sufficient time, access and resources to recover a scientifically representative sample for further study. If it cannot be studied immediately, the costs of housing the material should be borne by the developers. If this recommendation is followed, then from a palaeontological point of view, the development of the proposed Roggeveld wind farm will constitute a positive intervention, providing greater insight into the palaeontological heritage of South Africa.

8.2 Archaeology

The pre-colonial heritage of the area as manifested by archaeological traces is extremely sparse. Very little material was identified and no particular mitigation is suggested.

The colonial archaeological heritage of the study is confined to areas along river banks, and valleys which appear to have been the focus of settlement during the last two centuries (see Appendix 1).

If any of the valley bottoms are to be impacted or the valley bottom roads widened, then this area will need to be thoroughly surveyed and all heritage sites recorded and mapped on the landscape. Sensitive areas must be flagged so that these can be protected from construction related activities.

8.3 Graves

Graves tend to be located close to settlements. In addition to the identified ones with typical surface identifiers such as cairns and/or head stones, there are likely to be others that never had any, or which have been lost over time.

If human remains/burials are uncovered during the construction phase, work in the specific location should cease, and HWC/SAHRA should be notified. They would in all likelihood request an archaeologist to investigate and implement mitigation, in the form of exhumation. The mitigation of human remains from the colonial period requires a permit to be issued by the SAHRA Burials Unit.

8.4 Buildings

It is acceptable to utilise farm buildings for the project, however if renovation or changes to structures is envisaged, a heritage professional with experience in historical structures should be consulted to assist with sensitive re-adaptation or restoration. Kraals, walls, stone features and ruins must be left in-tact on the landscape.

The built environment of the study area is limited and sparse. Although virtually every farm has generally protected material in its confines, none of these have anything beyond moderate local heritage significance. Direct impacts to any structures are expected to be very limited (the best example of a Karoo historical house lies well outside the study area some 5 km to the south).

The greatest negative impact is on the landscape. This is the industrialisation of a very large expanse of natural landscape adjacent to the R534 which is considered a scenic route. Combined with the impact of up to 5 other similar facilities planned in the general area, the natural amenity qualities of the region will be negatively impacted. The grading of the scenic route between Sutherland and Matjiesfontein will be affected and in all likelihood decrease from Grade lllA to Grade lllc or ungraded. Apart from moving the turbines beyond visual range of the route, no mitigation is possible.

Conclusion

On physical heritage alone, there is no justifiable reason for not supporting the proposal. However the accumulative impacts on the Karoo landscape and its archetypical South African scenery are of deep concern. The proliferations of renewable energy facilities that sterilise vast tracts of landscape will in time alter the economy of the Karoo, and change its identity in the Southern African context.

Project component/s	The renewed proposal for Phase 2 involves some 71 turbines. Each turbine has a 100m hub height and a maximum 117m rotor diameter. Each turbine has a foundation up to 20m x 20m underground and backfilled with a with maxim area of 5m x 5m protruding above ground, adjacent to each turbine a crane pad or hard standing

	area of a maximum of 2500 m2 to facilitate construction and maintenance. Access roads are up to 12m wide. Site layout (turbine locations, substation, access roads etc.) Additional infrastructure (office and storage building, met masts, temporary laydown area, borrow pits). One main 200x200m substation next to existing Eskom Komsberg series capacitor station and up to two smaller substations closer to the turbines of 100x200m with smaller transformers closer to the turbines collecting capacity from the turbines. The smaller substations would be connected to the main one via 132kV overhead lines. Approx. 10.6km of 33kV overhead lines and 5.8km of 400kV transmission lines Underground cabling between turbines.
Potential Impact	Physical destruction of both palaeontological and human made heritage.
Activity/risk source	Construction of roads, turbines bases, transmission lines and substations, intentional/unintentional neglect of historic buildings
Mitigation: Target/Objective	The conservation of human made heritage, the collection of palaeontological samples from excavation sites, conservation of protected buildings, retention of landscape qualities.

Mitigation: Action/control	Responsibility	Timeframe
Final walk-down of turbine sites as needed, checking of substation sites and power line routes, roads. Paleontological monitoring of cuttings into bedrock, foundations,	Contracted archaeologist. Contracted Palaeontologist	Prior to construction as part of EMP. Prior to and during construction.

Performance Indicator	Retain archaeological sites in un-impacted condition, heritage buildings and farms cared for and re-used, scientific contribution through palaeontological research.
Monitoring	Periodic site inspection during and after construction, photographic recording of impacts, much can be done by a well-trained Environmental Control Officer (ECO).

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9 Appendix 1: Heritage sites recorded during the 2010 survey

No.	Location	Character	Description
KB 01	S32 48 09.0 E20 28 20.7	Historical	Scatter of historical ceramics, glass, metal, rubber. A few other bits also scatter for some 50m to the south.
KB 02	S32 48 21.3 E20 28 26.0	Historical	Scatter of historical ceramics, glass, metal, rubber, leather. More present under tree to the east.
KB 03	S32 48 21.1 E20 28 28.7	Ruin	Stone enclosures and ruined cottage with dumps, artefacts etc. Also a small stone circle (?oven) of ~1m diameter. Bucket toilet in wooden shelter to the east. Coke and Fanta bottle fragments. Probably occupied quite recently, ?less than 100 years ago?
KB 03	as above	Ruin	Small ruin and trapvloer of c.10 m diameter, also a feeding trough. This site lies just south of 18 and is part of same 'complex'.
KB 04	S32 49 07.4 E20 28 13.9	Ruin	Small house ruin.
KB 05	S32 51 07.1 E20 27 57.0	House	House.
KB 06	S32 51 33.3 E20 27 43.8	Ruin	Two ruins, one on either side of road. Mud brick ruin has stone foundations and platforms reaching within 1.5m of road edge. Ruin is 3 x 6 m. Platforms on at least 2 sides. Some historical artefacts lying around. Also a hand plough. Other ruin is mostly stone but with portions in mud bricks. It is about 6 x 12 m and seems built in phases. Various stone ?alignments around the area and many historical artefacts around.
KB 07 KB 08 KB 09	S32 53 08.5 E20 27 35.6 S32 53 08.3 E20 27 38.0 S32 53 09.4 E20 27 37.1	?graves	6 piles of rocks on east side of road. Not in any order but one group of three and other three more widely spread. Two gps points for the ends (E+W).
KB 10 KB 11 KB 12 KB 13	S32 53 22.3 E20 27 46.3 S32 53 23.3 E20 27 45.3 S32 53 23.0 E20 27 44.0 S32 53 21.6 E20 27 44.0	Cairns	Many stone piles with mostly small cobbles, perhaps 30 - 40 of them. Spread around a large area. Cairns on hard ground surface with nothing beneath them. 4 gps points delimit area.
KB 14	S32 57 09.5 E20 30 23.9	Farm	Ou Mure farm complex.
KB 15	S32 57 11.3 E20 32 23.8	Building	Small white building south of the road.
KB 16	S32 56 57.1 E20 32 59.5	Ruin	Stone ruin and kraal just off main tar road.
KB 17	S32 54 57.3 E20 33 12.0	Farm	Bon Esperance farm complex.
KB 18	S32 54 54.0 E20 32 31.5	Kraal	Stone kraal 30m north of road. Two enclosures, smaller may not be for stock?
KB 19	S32 55 01.5 E20 32 02.4	Trapvloer	Trapvloer 15 m from road.
KB 20	S32 55 02.0 E20 31 57.6	House	Farmhouse. Original part (running east-west) was built in 1929 but the addition is newer.
KB 21	S32 55 02.3 E20 31 50.1	Kraal	Stone kraal.
KB 22	S32 55 01.1 E20 31 45.7	Kraal	Stone kraal.
KB 23	S32 54 59.9 E20 31 46.8	Ruin	Stone house with probable external hearth. About 4 x 12 m. Many historical artefacts and bones lying around outside.
KB 24	S32 49 14.6 E20 32 10.8	Kraal	Stone kraal 100m west of road.
KB 25	S32 49 22.7 E20 32 10.6	Kraal	Stone kraal next to cottage.

KB 26	S32 50 20.3 E20 31 47.3	Kraal	Stone kraal alongside river.
KB 27	S32 50 35.3 E20 31 38.1	Leiwater	Small double skin and rubble fill dam/leiwater to catch water and lead out of stream bed to wheat fields.
KB 28	S32 50 34.1 E20 31 38.2	Leiwater	More of above
KB 29	S32 50 33.2 E20 31 38.3	Leiwater	End of visible stone alignment.
KB 30	S32 50 34.8 E20 31 37.1	Ruin	Long house with very large hearth. Double skin and rubbble fill. Also small round feature outside to southeast. 14 m long with 2m deep hearth on end. Original part (10 m long) had north and south room with hearth on north end and a small stoep on east side of south room. A third room (4m long) was added to the south end. Ceramics found next to house
KB 31	S32 50 57.8 E20 31 36.3	Ruin	Stone and mud-brick house ruin and outbuilding with a small brick feature (?oven) on east sde of road.
KB 32	S32 50 57.1 E20 31 36.4	?graves	Two mounds of rocks, biggish ones. Also a stone line along the very edge of the road.
KB 33	S32 50 57.3 E20 31 39.2	Trapvloer	Trapvloer of 9m diameter with two small circles inside it. Various glass and ceramic frags around about including some fanta bottle fragments.
KB 34	S32 50 58.9 E20 31 35.3	Dam	Small earthen dam of 4 m x 12 m, very shallow, just behind house at 039.
KB 35	S32 51 07.9 E20 31 39.7	?	Stone feature in eroding area.
KB 36	S32 51 38.5 E20 31 35.4	Ruin	Very long stone walling above river. L-shape with foot at 90 degrees to river about 6m long. GPS at both ends.
KB 37	S32 51 36.4 E20 31 35.8		
KB 38	S32 50 16.8 E20 31 53.6	Dam	Earthen dam with stone lining in river, breached.
KB 39	S33 03 29.2 E20 29 24.7	Farm	Hartjies Kraal Farm Complex.
KB 40	S33 01 16.0 E20 26 43.3	Ruin	Stone ruin 0.5m from road and a few metres from river.
KB 41	S33 00 17.5 E20 26 46.0	Kraal	Stone kraal. A second one occurs 200m east and a third 250m northwest.
KB 42	S33 00 05.9 E20 26 42.9	Graveyard (Barendskraal)	Graveyard in two halves with elaborate graves to south and others to north. Graves bear names Groenewald and Marais . One grave has lots of marine shell on it (argenvillei, oculus, granatina, 1 exotic shell). Less formal graves may be workers graves – these are recently celebrated, covered with decorations, flowers, shells in jars, etc. One has a wooden sign on it with K. Maritz.
KB 43	S33 01 19.8 E20 26 45.1	Trapvloer	Trapvloer 8m diametre with 1.5x2m 'room' on one side.
KB 44	S33 02 12.7 E20 27 42.3	Farm	De Libanon. Interesting farm house with early 20th C additions. .
KB 45	S33 05 41.1 E20 28 40.2	Farm	Volstruisfontein farm complex.

Oberservations Phase 2 Kareebosch 2014 survey.

Please note that site numbers are identifiers only and are not necessarily chronological

No.	Location		Character	Description
KB 47	-32.8520	20.4657	Farm	Small stone cottage. Corrugated pitched roof. Vegetation around quite developed (hasn't been used in some time.) 2 side garages/barns. There is no ceiling inside in the cottage. Ungraded.
KB 48	-32.8213	20.4682	Graves	Collection of up to 40 stone cairns, possibly graves, in river flood plain.
KB 49	-32.8187	20.4704	Ruin	Stone ruin with 2 rooms, approx. 7m x 3 with 2 m small. Kraals one side (one might be bread oven)
KB 50	-32.7758	20.4754	LSA	Late Stone Age - Large grind stone, on donga close to small sandstone cliff. Some hornfels chunks
KB 51	-32.7956	20.4359	Graves	6-8 graves. Some historic ceramics and a Stone Age core (opposed platform, Late Stone Age).
KB 52	-32.8314	20.4290	Ruin	Mud brick ruin on stone foundation and with stone room attached. Some coarse porcelain observed 18th-early 19th century. West of the house is river has washed some features away- including impacting a stone feature (oven?) and ash heap/midden.
KB 53	-32.8584	20.4157	Historical	Historic kraal situated on river bank beneath/ against cliff. No artefacts, has been impacted by flooding, however walls still in reasonable condition
KB 54	-32.8652	20.4156	Graves	Cemetery. At least four graves (three still have head stones). One has been fenced off, and has large chunks of quartz on the grave.
KB 55	-32.8677	20.4151	Farm	Vernacular brakdak huis. Has been altered but core appears intact. Associated kookskerm and outbuildings. A conservation-worthy structure.
KB 56	-32.8860	20.4171	Grave	Single grave next to the river.
KB 57	-32.8890	20.4176	Ruin/Farm	Small ruined vernacular stone house. Hearth has a clay brick chimney. Very careful stonework construction. House is situated on the bend of the river. Located close to the house is a kookskerm that has subsequently grown into a significantly sized tree which seems to shelter the remainder of the original thatched walls. The kookskerm contains a stone hearth and oven. The !Naa (poles used in Khoikhoi tradition for hanging pots and utensils) poles are still standing on the edge of the skerm. There is some indistinguishable porcelain on the site and there were a few stone artefacts including flakes and a thumbnail scraper indicating that the area was also occupied in the Late Stone Age, however the area is fairly covered with brush. Sites may be associated with shepherds of khoikhoi origin.
KB 58	-32.7478	20.4443	Grave	Single grave, just outside boundary, but close to the road.
KB 59	-32.8721	20.4133	Ruin	Ruin seen from the road, however we were unable to reach it at the time.

Tracks of both the 2010 survey and the 2014 survey in pink. The recorded waypoints are indicated by yellow stars.

10 APPENDIX 2 PALAEONTOLOGICAL ASSESSMENT

PALAEONTOLOGICAL HERITAGE ASSESSMENT: COMBINED DESKTOP & FIELD-BASED STUDY

PROPOSED KARREEBOSCH WIND FARM (ROGGEVELD PHASE 2) NEAR SUTHERLAND, NORTHERN CAPE PROVINCE

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10.1.1.1 October 2014

10.2 EXECUTIVE SUMMARY

Karreebosch Wind Farm (Pty) Ltd proposes to develop a wind energy facility on a site located approximately 30 km north of Matjiesfontein and about 40 km south of Sutherland (Karoo Hoogland Local Municipality, Northern Cape and Laingsburg Local Municipality, Western Cape). The proposed facility, representing Phase 2 of the Roggeveld Wind Farm, will have a contracted energy generation capacity of up to 140 MW and be connected to the existing Eskom Komsberg Substation to the southeast of the main study area.

The fluvial Abrahamskraal Formation (Lower Beaufort Group, Karoo Supergroup) that underlies almost the entire wind farm study area is known for its diverse fauna of Permian fossil vertebrates - notably various small- to large-bodied therapsids and reptiles - as well as fossil plants of the *Glossopteris* Flora and low diversity trace fossil assemblages. However, desktop analysis of known fossil distribution within the Main Karoo Basin shows a marked paucity of fossil localities in the study region between Matjiesfontein and Sutherland where sediments belonging only to the lower part of the thick Abrahamskraal Formation succession are represented. Bedrock exposure levels in the Karreebosch Wind Farm study area are generally very poor due to the pervasive cover by superficial sediments (colluvium, alluvium, soils, calcrete) and vegetation. Nevertheless, a sufficiently large outcrop area of Abrahamskraal Formation sediments, exposed in stream and riverbanks, borrow pits, erosion gullies as well as road cuttings along the R354, has been examined during the present fieldwork to infer that macroscopic fossil remains of any sort are very rare indeed here. Exceptions include common trace fossil assemblages (invertebrate burrows) and occasional fragmentary plant remains (horsetail ferns). Levels of tectonic deformation of the bedrocks are generally low and baking by dolerite intrusions (Early Jurassic Karoo Dolerite Suite) is very minor. It is concluded that the Lower Beaufort Group bedrocks in the study area are generally of low palaeontological sensitivity and this also applies to the overlying Late Caenozoic superficial sediments (colluvium, alluvium, calcrete, soils *etc*).

No areas or sites of exceptional fossil heritage sensitivity or significance have been identified within the Karreebosch Wind Farm study area. The majority of fossil sites recorded in the study region lie outside the anticipated development footprint. The common trace fossil assemblages identified in this study are of widespread occurrence within the Abrahamskraal Formation (*i.e.* not unique to the study area). Construction of the Karreebosch Wind Farm and associated infrastructure is therefore unlikely to entail significant impacts on local fossil heritage resources; *i.e.* the impact significance of the wind farm project is assessed as MINOR. The impact significance of both transmission line route options to Komsberg Substation is likewise assessed as MINOR and there is no marked preference for either route option on palaeontological grounds. Irreplaceable loss of fossil heritage is not anticipated, although it should be highlighted that any new vertebrate fossil finds made during construction (*e.g.* exposed in new bedrock excavations) would be of considerable scientific interest, given their rarity. The operational and decommissioning phases of the wind energy facility and transmission lines are very unlikely to involve further adverse impacts on local palaeontological heritage.

Given the low impact significance of the proposed Karreebosch Wind Farm near Sutherland (including alternative transmission line corridors to Komsberg Substation) as far as palaeontological heritage is concerned, no further specialist palaeontological heritage studies or mitigation are considered necessary for this project, pending the discovery or exposure of substantial new fossil remains during development. This recommendation applies provided that no substantial infrastructure, apart from the proposed transmission lines and associated access roads, is constructed within the portion of the study area east of the R354 which has not been directly assessed through fieldwork.

During the construction phase all deeper (> 1 m) bedrock excavations should be monitored for fossil remains by the responsible ECO. Should substantial fossil remains such as vertebrate bones and teeth, plant-rich fossil lenses, fossil wood or dense fossil burrow assemblages be exposed during construction, the responsible Environmental Control Officer should safeguard these, preferably *in situ*, and alert SAHRA, *i.e.* The South African Heritage Resources Authority, as soon as possible (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za) so that appropriate action can be taken by a professional palaeontologist, at the developer's expense. Mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy) by a professional palaeontologist.

These mitigation recommendations should be incorporated into the Environmental Management Plan (EMP) for the Karreebosch Wind Farm and associated transmission line development.

1. INTRODUCTION & BRIEF

1.1. Project outline

Karreebosch Wind Farm (Pty) Ltd proposes the establishment of a wind energy facility on a site located approximately 30 km north of Matjiesfontein, and approximately 40 km south of Sutherland (Figs. 1 & 2). The site falls within the Karoo Hoogland Local Municipality, Northern

Cape and Laingsburg Local Municipality, Western Cape. The proposed facility would utilise wind turbines to generate electricity that will be fed into the National Power Grid. The project is part of an initial Environmental Impact Assessment (EIA) application for the Roggeveld Wind Farm which, based on the recommendation of the Department of Environmental Affairs (DEA), is being developed in smaller phases. This current EIA application for Karreebosch Wind Farm represents Phase 2 of the Roggeveld Wind Farm. Karreebosch Wind Farm will have an energy generation capacity of up to 140 MW in line with the Department of Energy's requirement.

The typical infrastructure required for the proposed wind farm includes wind turbines, electrical connections (overhead power line and underground cables), on-site substation/s, access roads, borrow pits, wind monitoring masts, office and construction laydown areas.

The purpose of the proposed wind energy facility is to sell the electricity generated to Eskom under the Renewable Energy Independent Power Producers Procurement Programme (REIPPP). REIPPP has been introduced by the Department of Energy (DoE) to promote the development of renewable power generation facilities (derived from) by IPPs in South Africa.

Land portions that are concerned in the proposed Karreebosch Wind Farm are listed below in Table 1.

Table 1: List of properties concerned in the proposed Karreebosch Wind Farm

Farm Name	Farm No	Portion No	Local Municipality	Province
Ekkraal	199	2 (Nuwekraal)	Karoo Hoogland Municipality	Northern Cape
Wilgebosch Rivier	188	0	Karoo Hoogland Municipality	Northern Cape
Klipbanksfontein	198	0	Karoo Hoogland Municipality	Northern Cape
Klipbanksfontein	198	1	Karoo Hoogland Municipality	Northern Cape
Karreebosch	200	0	Karoo Hoogland Municipality	Northern Cape
Roode Wal	187	0	Karoo Hoogland Municipality	Northern Cape
Karreebosch	200	1	Karoo Hoogland Municipality	Northern Cape
Karreekloof	196	1	Karoo Hoogland Municipality	Northern Cape
Oude Huis	195	0	Karoo Hoogland Municipality	Northern Cape
Appelsfontein	201	0	Karoo Hoogland Municipality	Northern Cape
Rietfontein	197	0	Karoo Hoogland Municipality	Northern Cape
Bon Espirange	73	1	Laingsburg Municipality	Western Cape
Bon Espirange	73	0	Laingsburg	Western

Farm Name	Farm No	Portion No	Local Municipality	Province
			Municipality	Cape
Ekkraal	199	0	Karoo Hoogland Municipality	Northern Cape
Ekkraal	199	1	Karoo Hoogland Municipality	Northern Cape
Standvastigheid	210	2 (Komsberg)	Karoo Hoogland Municipality	Northern Cape
Aprils Kraal	105	0	Laingsburg Municipality	Western Cape
Kranskraal	189	0	Karoo Hoogland Municipality	Northern Cape

The Karreebosch Wind Farm development will involve the following main infrastructural components:

- Up to 71 **wind turbine generators** of 2 to 3.3 MW generation capacity. The hub height of each turbine will be up 100 metres, and the rotor diameter up to 140 metres. The wind turbines will have a foundation of 25 m in diameter and 4 m in depth.
- Permanent compacted **hardstanding areas** / crane pads for each wind turbine (70 x 50 m).
- **Electrical turbine transformers** (690 V/ 33 kV) at each turbine (typically 2 m x 2 m but up to 10 m x 10 m at certain locations).
- **Internal access roads** up to 12 m wide.
- Approximately 25 km of 33 kV **overhead power lines** and approximately 25 km of 132 kV overhead power lines to Eskom's Komsberg substation.
- Up to two **electrical substations** (on-site 33/132 kV substation of 100 m x 200 m) next to the existing Eskom Komsberg substation.
- An **operations and maintenance building** (O&M building) next to the smaller substation.
- Up to 4 x 100 m-tall **wind measuring masts**.
- Temporary infrastructure required during the construction phase, including **construction lay down areas** and a **construction camp** up to 9 ha (300 m x 300 m) in area.
- A **borrow pit** for locally sourcing aggregates required for construction (~3 ha).

The present palaeontological heritage assessment of the Karreebosch Wind Farm study area has been commissioned as part of the broad-based Heritage and Environmental Impact Assessment that is being co-ordinated by Savannah Environmental (Pty) Ltd, Woodmead (Contact details: Ms Azrah Essop. Savannah Environmental (Pty) Ltd. 1st Floor, Block 2, 5 Woodlands Drive Office Park, Woodlands Drive, Woodmead, 2191. Tel: +27 11 656 3237. Fax: +27 86 684 0547. Cell: +27 71 871 0179 . Email: azrah@savannahsa.com. Postal address: P.O. Box 148, Sunninghill, 2157).

1.2. Legislative context for palaeontological assessment studies

The Karreebosch Wind Farm project area is located in an area that is underlain by potentially fossiliferous sedimentary rocks of Late Palaeozoic and younger, Late Tertiary or Quaternary, age (Sections 2 & 3). The construction phase of the proposed wind farm development will entail substantial excavations into the superficial sediment cover and locally into the underlying bedrock as well. These include, for example, excavations for the wind turbine foundations, hardstanding areas, internal access roads, transmission line pylon footings, electrical substations, operations and maintenance building, construction laydown areas, construction camp and borrow pit. All these developments may adversely affect potential fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils at or beneath the surface of the ground that are then no longer available for scientific research or other public good. The operational and decommissioning phases of the wind energy facility are unlikely to involve further adverse impacts on local palaeontological heritage, however.

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 Environmental Management Plan 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 recently been published by SAHRA (2013).

1.3. Approach to the palaeontological heritage study

The approach to a Phase 1 palaeontological heritage study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images. Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database. Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

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 field assessment 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, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has 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 authorities, *i.e.* SAHRA for the Northern Cape (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za) and Heritage Western Cape for the Western Cape (Contact details: Heritage Western Cape. 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). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

1.4. 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.

In the case of the present Karreebosch Wind Farm study area near Sutherland in the Northern Cape preservation of potentially fossiliferous bedrocks is favoured by the semi-arid climate and sparse vegetation but bedrock exposure is largely compromised by extensive superficial deposits, especially in areas of low relief, as well as pervasive bossieveld vegetation (Koedeoesberge – Moordenaars Karoo). Comparatively few academic palaeontological studies or field-based fossil heritage impact have been carried out in the region, so any new data from impact studies here are of scientific interest.

1.5. Information sources

The present combined desktop and field-based palaeontological study was largely based on the following sources of information:

1. A brief project outline kindly supplied by Savannah Environmental (Pty) Ltd;

2. A previous short palaeontological assessment report covering the central portions of the present study area by Dr D. Miller compiled for ACO Associates, St James (Miller 2011).

3. Several palaeontological heritage assessment reports by the present author for proposed developments in the Karoo region to the south of Sutherland, including the Eskom Gamma – Omega 765 kV transmission line that runs just to the south (Almond 2010a) and several alternative energy facilities (Almond 2010b, 2010c, 2011);

3. A four-day field assessment of the western and central portions of the Karreebosch study area during October 2014 (*N.B.* The eastern portions, on the eastern side of the R354, on which no infrastructure is planned apart from transmission line pylons and access roads, are only covered at desktop level here due to access constraints during fieldwork);

5. The author's previous field experience with the formations concerned and their palaeontological heritage (*cf* Almond & Pether 2008 and references listed above).

GPS data for all numbered localities mentioned in the text are provided in the Appendix.

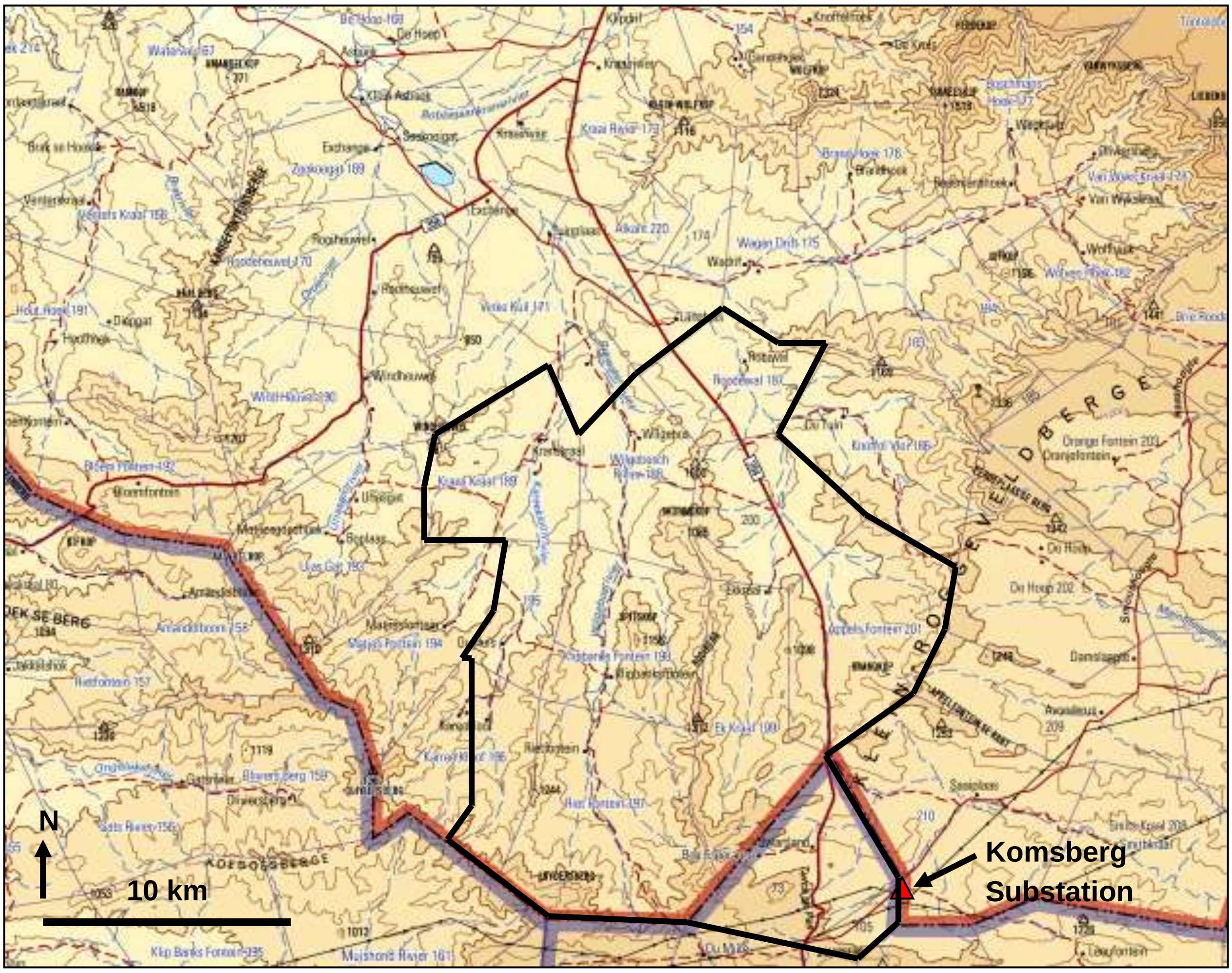

Figure 1. Extract from 1: 250 000 topographical sheet 3220 Sutherland showing the outline of the Karreebosch Wind Farm study area (black polygon) situated on the eastern side of the Klein-Roggeveldberge and *c*. 40 km south of Sutherland, Northern Cape Province and Western Cape (Courtesy of the Chief Directorate of Surveys and Mapping, Mowbray). Note the existing Gamma-Omega transmission line that runs just to the south of the study area and the existing Eskom Komsberg Substation (red triangle). The study area is transected by the R354 tar road between Matjiesfontein and Sutherland.

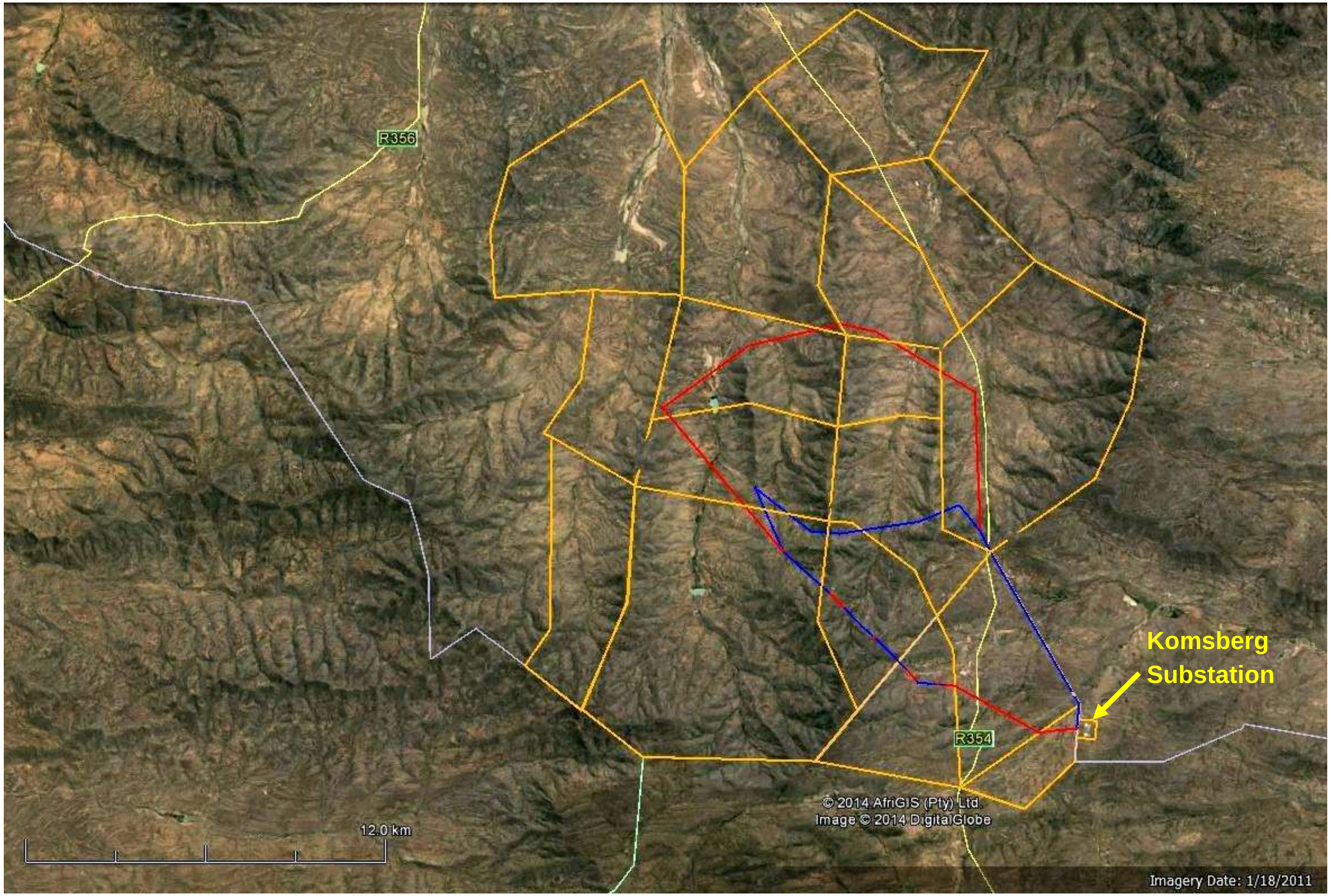

Figure 2. Google earth© satellite image of the Karoo region *c.* 40 km south of Sutherland showing the outline of the Karreebosch Wind Farm study area (land parcels shown by orange polygons) as well as 132 kV transmission line route options to the existing Komsberg Substation (red and blue lines).

2. GEOLOGICAL BACKGROUND

The Karreebosch Wind Farm study area is situated within hilly to mountainous terrain to the south of Sutherland and the Great Escarpment (Roggeveldberge) and just west of the main Klein-Roggeveldberge range (Figs. 1 & 2). An upland plateau to the south (*e.g.* Snyderberg at 1440 m amsl) passes northwards into a series of north-south trending mountain ridges at *c*. 1000-1300 along which the main wind farm infrastructure will be located. The ridges are separated by the valleys of north-flowing, intermittently active tributaries of the Tanqua River drainage system, such as the Appelfontein se Rivier, Wilgebosrivier and Kareekloofrivier that are associated with fairly wide alluvial plains in their downstream sectors (Figs. 4 to 9). The gentle, distinctly stepped mountain slopes are cut by small, usually dry side streams. Levels of bedrock exposure are generally very low due to the pervasive cover by gravelly colluvium, alluvium, soils and karroid *bossieveld* vegetation. Isolated mudrock exposures occur along the stream beds and banks, in steeper gorges or *klowe*, around farm dams, in borrow pits as well as in several excellent road cuttings along the R354 Majiesfontein to Sutherland tar road that transects the study area from south to north.

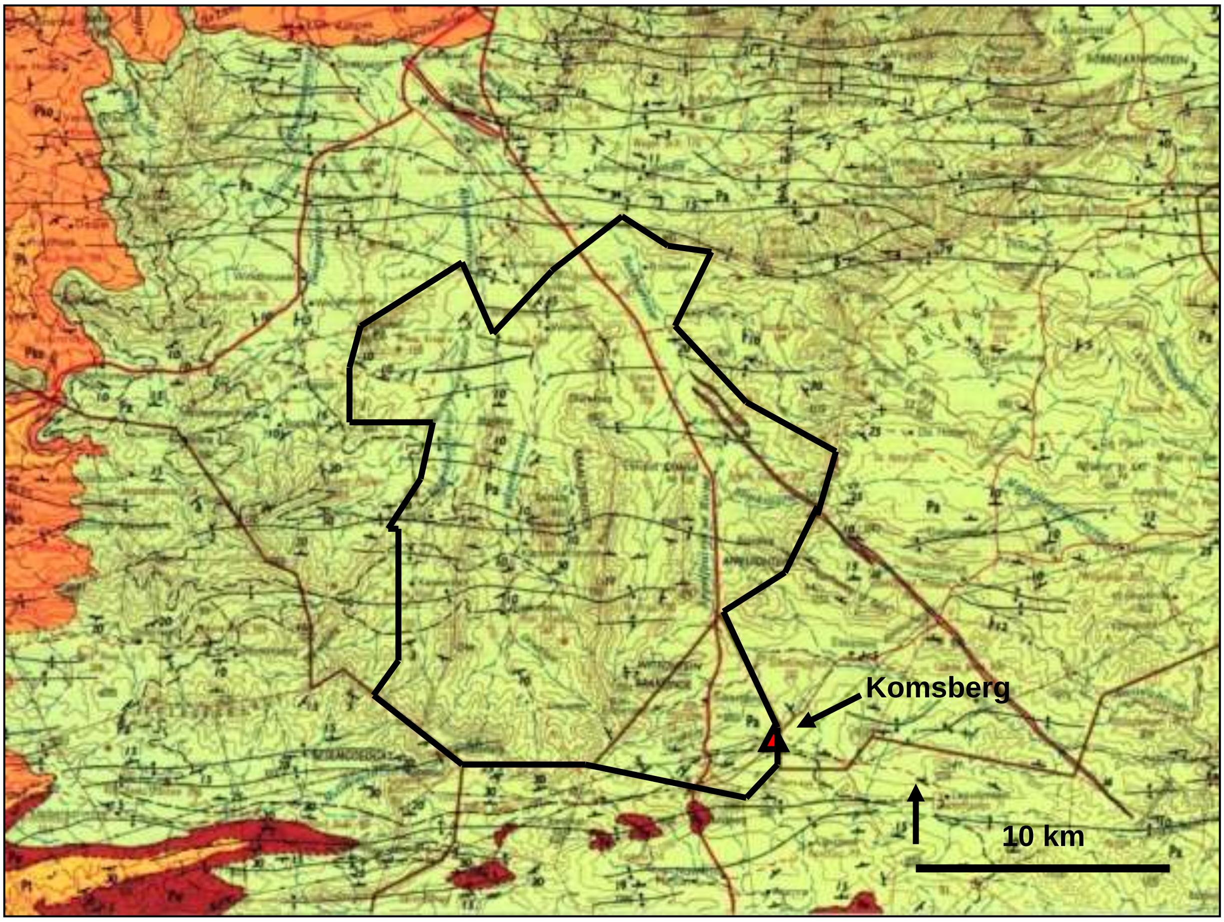

Figure 3. Extract from the 1: 250 000 scale geology sheet 3220 Sutherland (Council for Geoscience, Pretoria, 1999) showing the location of the proposed Karreebosch Wind Farm study area *c*. 40 km south of Sutherland, Northern Cape Province (black polygon). The study area is entirely underlain by Middle Permian sediments of the Abrahamskraal Formation, Lower Beaufort Group (Pa, pale green). A narrow NW-SE trending Early Jurassic dolerite dyke of the Karoo Dolerite Suite (Jd, pink) crosses the eastern portion of the area. The black dashed line marks the incoming of maroon mudrocks within the Abrahamskraal Formation. Note also several W-E trending fold axes as well as a fault line (f-f) mapped within the study area.

3.1. Geological setting

The geology of the Sutherland region is outlined on the 1: 250 000 scale geology sheet 3220 Sutherland (Theron 1983) as well as the updated 1: 250 000 Sutherland metallogenic map that includes important new stratigraphic detail for the Beaufort Group succession (Cole & Vorster 1999) (Fig. 3). The study area is almost 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 Beaufort Group succession (Johnson *et al.* 2006 and references cited below). In the Sutherland area, situated just north of the Great Escarpment, the Lower Beaufort Group sediments have been extensively intruded and thermally metamorphosed (baked) by dolerite sills and dykes of the **Karoo Dolerite Suite** of Early Jurassic age (*c*. 182 Ma = million years ago; Duncan & Marsh 2006). These igneous rocks were intruded during an interval of crustal uplift and stretching that preceded the break-up of the supercontinent Gondwana. They show up on satellite images as rusty-brown areas. In the present study area to the south of the Great Escarpment the only major dolerite intrusions are a set of laterally persistent, NW-SE trending dykes that transect the eastern portion of the area and can be well seen in road cuttings along the R354 (Jd, pink in Fig. 3). The Karoo dolerites are entirely unfossiliferous and will therefore only be very briefly treated in this report. The Palaeozoic and Mesozoic bedrocks in the study area are very 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 soils. These geologically youthful sediments are generally of low palaeontological sensitivity.

Figure 4. View NNW into the Karreebosch Wind Farm study area from a viewpoint towards southern edge of Riet Fontein 197. Kareekloofrivier Valley in background, Wilgebosrivier Valley in foreground.

Figure 5. View northwards towards the eastern section of the Karreebosch Wind Farm study area, east of the R354 and Appelfontein se Rivier. Roggeveld Escarpment in the background.

Figure 6. Stepped or striped hill slopes typifying the lower Abrahamskraal Formation outcrop area underlying the Karreebosch Wind Farm, exemplified here on the southern slopes of Windheuwel on Krans Kraal 189.

Figure 7. View northwards along the eastern flank of the Wilgebosrivier Valley showing gently northward-dipping, prominent-weathering channel sandstones of the Abrahamskraal Formation. The intervening mudrocks are very poorly exposed.

Figure 8. View eastwards towards the Klein-Roggeveldberge Escarpment (Appels Fontein 201) showing package of closely-spaced, thick channel sandstones along the escarpment edge.

Figure 9. Package of thick, prominent-weathering sandstones building the higher ground in the south-western portion of Riet Fontein 197, viewed from the east.

3.1.1. Lower Beaufort Group (Adelaide Subgroup)

A useful recent overview of the Beaufort Group continental succession has been given by Johnson *et al.* (2006). Geological and palaeoenvironmental analyses of the Lower Beaufort Group sediments in the western Great Karoo region have been conducted by a number of workers. Key references within an extensive scientific literature include various papers by Roger Smith (*e.g.* Smith 1979, 1980, 1986, 1987a, 1987b, 1988, 1989, 1990, 1993a, 1993b) and Stear (1978, 1980a, 1980b), as well as several informative field guides (*e.g.* Cole *et al.* 1990, Cole & Smith 2008) and two geological sheet explanations for the Sutherland area (Theron 1983, Cole & Vorster 1999). In brief, the thick Beaufort Group successions of clastic sediments were laid down by a series of large, meandering rivers within a subsiding basin over a period of some ten or more million years, largely within the Middle to Late Permian Period (*c.* 266-251 Ma). Sinuous sandstone bodies of lenticular cross-section represent ancient channel infills, while thin (<1.5m), laterally-extensive sandstone beds were deposited by crevasse splays during occasional overbank floods. The bulk of the Beaufort sediments are greyish-green to reddish-brown or purplish mudrocks ("mudstones" = fine-grained claystones and slightly coarser siltstones) that were deposited over the floodplains during major floods. Thin-bedded, fine-grained playa lake deposits also accumulated locally where water ponded-up in floodplain depressions and are associated with distinctive fossil assemblages (*e.g.* fish, amphibians, coprolites or fossil droppings, arthropod, vertebrate and other trace fossils, plant fossils).

Frequent development of fine-grained pedogenic (soil) limestone or calcrete as nodules and more continuous banks indicates that semi-arid, highly seasonal climates prevailed in the Middle Permian Karoo. This is also indicated by the common occurrence of sand-infilled mudcracks and silicified gypsum "desert roses" (Smith 1980, 1990, 1993a, 1993b, Almond 2010a). Highly continental climates can be expected from the palaeogeographic setting of the Karoo Basin at the time – embedded deep within the interior of the Supercontinent Pangaea and in the rainshadow of the developing Gondwanide Mountain Belt. Fluctuating water tables and redox processes in the alluvial plain soil and subsoil are indicated by interbedded mudrock horizons of contrasting colours. Reddish-brown to purplish mudrocks probably developed during drier, more oxidising conditions associated with lowered water tables, while greenish-grey mudrocks reflect reducing conditions in waterlogged soils during periods of raised water tables. However, diagenetic (post-burial) processes also greatly influence predominant mudrock colour (Smith 1990).

3.1.1.2. Abrahamskraal Formation

The Abrahamskraal Formation is a very thick (*c*. 2.5km) succession of fluvial deposits laid down in the Main Karoo Basin by meandering rivers on an extensive, low-relief floodplain during the Mid 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, McCarthy & Rubidge 2005, Johnson *et al*., 2006, Almond 2010a). 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). 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 1: 250 000 Sutherland geological sheet 3220 (Theron 1983) shows a large area of undifferentiated Abrahamskraal Formation beds in the Sutherland area (Fig. 3). There have since been a number of attempts, only partially successful, to subdivide the very thick Abrahamskraal Formation succession in both lithostratigraphic (rock layering) and biostratigraphic (fossil) terms. Among the most recent and relevant of these was the study by Loock *et al.* (1994) in the Moordenaarskaroo area north of Laingsburg. Detailed geological mapping here led to the identification of six lithologically-defined members within the Abrahamskraal Formation (Fig. 10). Several of these members have since been mapped in the Sutherland area by Cole and Vorster (1999) but not in the Karreebosch study area. Based on (1) the proximity of the Lower Beaufort Group rocks in the study area to the Ecca / Beaufort boundary (Fig. 3) as well as (2) the common occurrence of maroon mudrocks within the study area and (3) the apparent scarcity of vertebrate fossils here (as determined during the present field study), it is inferred that the bedrocks represented in the study area belong to the the upper part of the **Combrinkskraal Member** and lower part of the **Leeuvlei Member** (See red bar in Fig. 10). They lie stratigraphically above and below the dashed black line representing the incoming of maroon mudrocks that is shown on the 1: 250 000 geological map (Fig. 3). Very brief descriptions of these two members are given by Loock *et al.* (1994) but the interested reader should refer to earlier works by Le Roux (1985) and Jordaan (1990) for detailed sedimentological data that is beyond the scope of the present palaeontological heritage study. Closely-spaced, thick channel sandstone bodies appear to underlie the higher ground along the Klein-Roggeveld Escarpment within and to the east of the study area (*e.g.* eastern margins of Appels Fontein 201) as well as along the ridge running along the boundary between Riet Fontein 197 and Karee Kloof 196)(Figs. 8 & 9). This sandstone-rich succession might constitute a separate member of the Abrahamskraal Formation, or perhaps represent the upper portion of the Leeuvlei Member. These beds were not examined during the present field study due to access constraints; their stratigraphic position and palaeontology remain undetermined.

Although bedrock exposure is generally poor within the wind farm study area, especially on valley floors (Figs. 4 to 9), a sufficient number of rocky outcrops in stream beds and banks, erosion gullies, dam areas, borrow pits and road cuttings were available for to allow a fair assessment of the sedimentology and palaeontology of the Abrahamskraal Formation here. GPS data for over forty exposures of Abrahamskraal beds examined during the present field study are presented in the Appendix.

The Abrahamskraal Formation in the study area is a succession of continental fluvial rocks characterized by numerous lenticular to sheet-like sandstones with intervening, more recessive-weathering mudrocks (Stear 1980, Le Roux 1985, Loock *et al.* 1994, Cole & Vorster 1999). The channel sandstone units are up to several (5 m) meters thick and vary in geometry from extensive, subtabular sheets to single-storey lenticles or multi-storey channel bodies with several partially superimposed, cross-cutting lenticular subunits, often demarcated at the base by thin mudrocks and / or basal breccio-conglomerates (Figs. 13 to 22). Obliquely side-steeping, successively higher channel bodies of laterally-migrating river systems are also seen within some intervals. The prominent, laterally-persistent sandstone ledges generate a distinctive stepped or terraced topography on hill slopes in the area (Fig. 6). 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), thin flaggy bedding, or tabular to trough cross-bedding. Greyish hues of some freshly broken sandstone surfaces suggest an "impure" clay-rich mineralogy (*i.e.* wackes) (Fig. 23). Current ripple cross-lamination is common towards the tops of the sandstone beds which may also feature undulose bars and swales. The lower contacts of the channel sandstones are erosive on a small scale, and only occasionally associated with lenticular basal breccias that may infill small-scale erosive gullies (Fig. 20). The breccias, which may also occur within the body of the channel sandstone unit, are almost entirely composed of reworked mudflake intraclasts. Reworked small calcrete nodules, rolled vertebrate bones, teeth and plant debris, as seen in basal breccias higher within the Abrahamskraal Formation, were not observed in the Kareeebosch Wind Farm study area. Heterolithic, thinly-interbedded sandstone and mudrock packages associated with some channel sandstone may represent delta-like levee deposits (Figs. 13 & 14). An interesting feature of some of the finer-grained, homogeneous channel sandstones and darker grey, impure wackes is their tendency to be very well-jointed and show exfoliation weathering, leading to the formation of sphaeroidal corestones in a rather dolerite-like manner (Fig. 23). These well-rounded sandstone corestones of cobble to boulder size form an important component of local colluvial and downwasted surface gravels (Fig. 38).

The Abrahamskraal overbank mudrocks vary from grey-green, blue-grey to maroon in hue and are variously massive, medium- to thin-bedded or laminated and hackly-weathering. Occasional horizons of large (several dm diameter) ferruginous carbonate nodules and meter-scale lenticles occur within the mudrocks, as do small (1-10 cm diameter) rounded, pale to dark greyish calcrete nodules (Figs. 27-28), but these are not as abundant as they are higher up within the Abrahamskraal Formation. Pseudomorphs after gypsum roses were not recognized within the study area but several examples of desiccation-cracked overbank mudrocks were seen. Occasional examples of possible loading of fine-grained sandstones into the underlying mudrocks (Figs. 15 & 16) are suggestive of local swampy conditions on the floodplain.

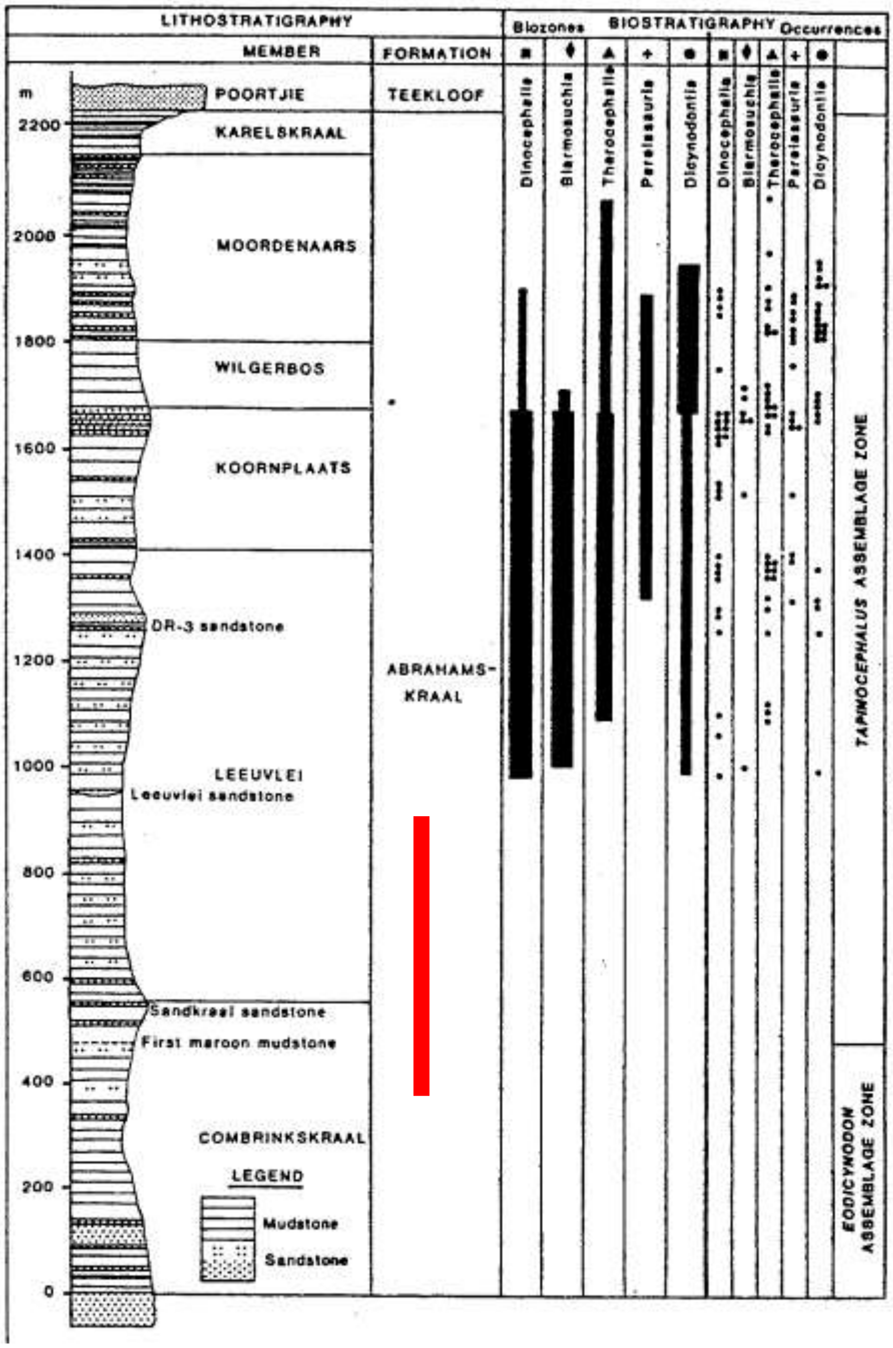

Figure 10. Chart showing the subdivision of the Abrahamskraal Formation in the western Karoo region with stratigraphic distribution of the major fossil vertebrate

groups (Loock *et al*. 1994). The Karreebosch Wind Farm study area is probably underlain by sediments within the upper portion of the Combrinkskraal Member and lower portion of the Leeuvlei Member (red bar), both below and above the first appearance of maroon mudstones but below the incoming of abundant vertebrate fossils.

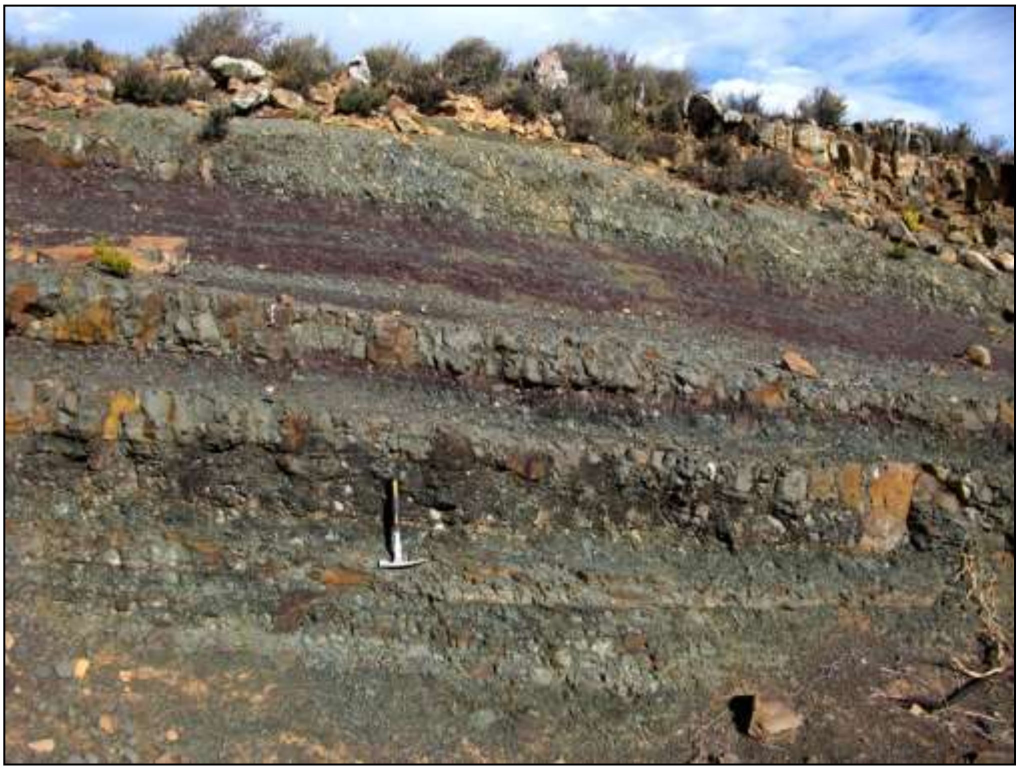

Figure 11. Riverbank exposure of maroon and grey-green overbank mudrocks of the Abrahamskraal Formation, Karee Kloof 196 (Loc. 041) (Hammer = 30 cm).

Figure 12. Thin-bedded, laminated and massive, hackly-weathering siltstones of the Abrahamskraal Formation showing contrasting maroon and grey-green hues, gulley exposure on Riet Fontein 197 (Loc. 034) (Hammer = 30 cm).

Figure 13. Multi-hued mudrocks, channel sandstones and thin-bedded heterolithic package of interbedded sandstones and siltstones, Abrahamskraal Formation, R354 road cutting, Ek Kraal 199 (Hammer = 30 cm).

Figure 14. Overbank mudrocks overlain by thin-bedded package (possible levee deposits) and then buff-weathering channel sandstone, R354 road cutting through Abrahamskraal Formation, Roodewal 187 (Loc. 043).

Figure 15. Detail of Abrahamskraal Formation exposure seen in the previous figure showing loading of channel sandstone base into the underlying mudrocks (pale rounded blobs) (Loc. 043).

Figure 16. Possible loading of fine-grained sandstone units into plastic, water-rich underlying mudrocks, Abrahamskraal Formation, Riet Fontein 197 (Loc. 031) (Hammer = 30 cm).

Figure 17. Probable N-S longitudinal section through extensive, tabular channel sandstone of the Abrahamskraal Formation, Riet Fontein 197. Note gentle overlying slopes woth exposures of grey-green overbank mudrocks.

Figure 18. Massive, fine-grained channel sandstone with an erosive base but no obvious basal breccio-conglomerates, R354 road cutting through Abrahamskraal Formation, Roode Wal 187 (Loc. 028) (Hammer = 30 cm).

Figure 19. ***Krans*** **of thin-bedded, flaggy channel sandstones of the Abrahamskraal Formation, Wilgebosch Rivier 188 (Loc. 16a) (Hammer = 30 cm).**

Figure 20. Multi-storey channel sandstone package within the Abrahamskraal Formation showing lenticular channel bodies separated by thin mudflake breccio-conglomerates (*e.g.* at level of hammer), R354 road cutting, Karee Bosch 200 (Loc. 15a) (Hammer = 30 cm).

Figure 21. Wide, lenticular single-storey channel sandstone of the Abrahamskraal Formation showing erosive base, Krans Kraal 189 (Loc. 010).

Figure 22. Tapering edges of dark- and pale-weathering channel sandstones on the margin of a multi-storey sandstone package, river cutting on Karee Kloof 196 (Loc. 042).

Figure 23. Corestone formation within a deeply-weathered channel sandstone, Abrahamskraal Formation, R354 road cutting, Appels Fontein 201 (Loc. 014) (Hammer = 30 cm). Note dark grey, dolerite-like appearance of fresh sandstone.

Figure 24. Thick succession of maroon and blue-grey overbank mudrocks interbedded with thin crevasse-splay sandstones, Abrahamskraal Formation, stream gulley exposure on Wilgebosch Rivier 188 (Loc. 019).

Figure 25. Extensive riverbed and bank exposure of dark grey overbank mudrocks of the Abrahamskraal Formation, Krans Kraal 189 (Loc. 038a). The apparent absence of vertebrate remains at such well-exposed localities suggests that they are very rare or even absent at this stratigraphic level.

Figure 26. Contrasting massive (below) and thin-bedded overbank siltstones beneath a flat-based channel sandstone, Abrahamskraal Formation, Riet Fontein 197 (Loc. 035) (Hammer = 30 cm).

Figure 27. Horizon of abundant, small, pale grey palaeocalcrete nodules marking a palaeosol horizon within overbank mudrocks, Abrahamskraal Formation, Wilgebosch Rivier 188 (Loc. 018) (Hammer = 30 cm). Such fossil soil horizons are a primary target for vertebrate fossil hunting.

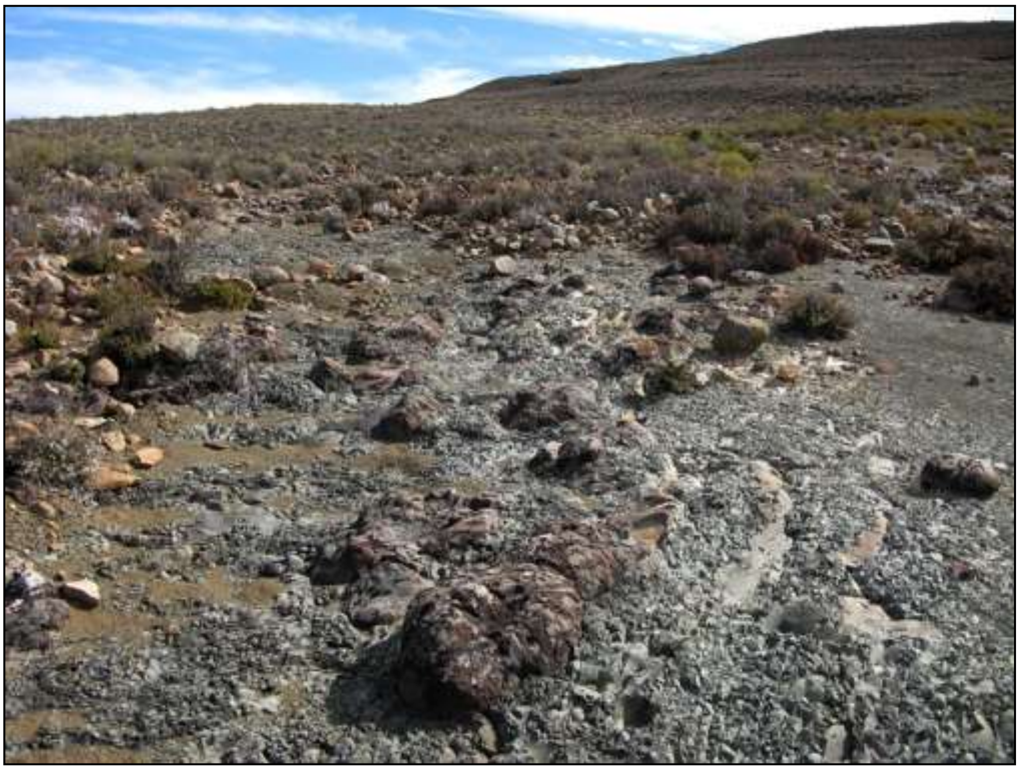

Figure 28. Grey mudrock horizon with abundant large (several dm diameter) ferruginous carbonate nodules of probable pedocrete origin, Abrahamskraal Formation, Oude Huis 195 (Loc. 012).

3.1.2. Karoo Dolerite Suite

The only dolerite intrusion mapped within the study area is an elongate set of dykes, one of which is well exposed in a R354 road cutting on Roodewal 187 (Fig. 29). The highly weathered greenish-brown dolerite shows well-developed exfoliation (onionskin weathering) with the development of sphaeroidal corestones and calcrete veining. Adjacent mudrocks and sandstones have been baked to hornfels and metaquartzite respectively.

Figure 29. Onionskin weathering, corestone development and calcite veining within a deeply-weathered dolerite dyke, R354 road cutting on Roodewal 187 (Loc. 044) (Hammer = 30 cm).

3.1.3. Late Caenozoic Superficial Deposits

Superficial deposits examined for fossil material within the Karreebosch Wind Farm study area include calcretised alluvial silts and older alluvial gravels ("terrace gravels") (Figs. 32 & 33), unconsolidated silty, sandy and coarse, poorly-sorted, cobbly to bouldery modern alluvium dominated by sandstone clasts with very minor reworked vein quartz and calcrete (Figs. 34, 36 & 37), sandy to peaty *vlei* deposits, blocky sandstone colluvium (Fig. 30), downwasted surface and colluvial gravels dominated by well-rounded sandstone corestones with minor vein quartz and weathered-out calcrete concretions (Fig. 38), as well as sheetwash sands and silts (hill wash) (Fig. 35). The extensive sheets of braided river alluvium associated with the larger river systems (*e.g.* Wilgeboschrivier, Kareekloofrivier) may reflect more pluvial climates during cooler, wetter intervals of the Quaternary Period. Where the unconsolidated superficial deposits have been stripped off by flood action (*e.g.* dam overflow area, Krans Kraal 189) the bedrocks can be seen to be extensively mantled in calcretised sediments (Fig. 31).

Fig. 30. Stream exposure of dark Abrahamskraal mudrocks showing thick mantle of poorly-sorted, rubbly colluvial and alluvial deposits, Wilgebosch Rivier 188 (Loc. 023).

Fig. 31. Extensive exposure of gently dipping Abrahamskraal bedrocks where the superficial sediment cover has been scoured away within a dam overflow channel,

Krans Kraal 189 (Loc. 038a). Note frequent development of pale calcrete directly overlying the bedrocks.

Figure 32. Calcretised coarse alluvial gravels at an elevation of *c*. 2 m above the present river bed, Krans Kraal 189 (Loc. 038a) (Same locality as Figure 25).

Figure 33. Calcretised alluvial sands and silts, Krans Kraal 189 (Loc. 038a) (Same locality as Figure 25) (Hammer = 30 cm). Note unconsolidated silty alluvium in the background.

Figure 34. Thick, buff, silty to sandy alluvial deposits of the Wilgebosrivier drainage system exposed by gulley erosion, Wilgebosch Rivier 188 (Loc. 016b).

Figure 35. Sheetwash surface gravels (including common flaked sandstone artefacts) overlying buff sandy alluvial deposits at an elevation of several meters above the present valley floor (seen in previous figure), Wilgebosch Rivier 188 (Loc. 016a).

Figure 36. Older, calcretised, poorly-sorted bouldery alluvial gravels overlain by unconsolidated sandy alluvium with coarse gravel lenticles, banks of the Kleinpoortsrivier, Farm 220 (Loc. 004).

Figure 37. Poorly-sorted, coarse, subrounded to angular sandstone gravels of the Wilgebosrivier overlain by younger sandy to silty alluvium, Riet Fontein 197 (Loc. 036).

Figure 38. Colluvial gravels composed largely of cobble- to boulder-sized sandstone corestones, Oude Huis 195 (Loc. 011).

In situ tuff (volcanic ash) layers were not recorded in the study area but a float block of pale greyish-green, well-consolidated fine tuff was collected in a stream bed on the southern flanks of Windheuwel (Krans Kraal 189, Loc. 009) (Fig. 39). This block is angular and fresh-looking, suggesting a local origin. It appears to be derived from a tuff bed or lenticle that is at least 10 cm thick. While a number of tuff units from the Lower Beaufort Group have recently been radiometrically dated (Rubidge *et al.* 2013), to the author's knowledge there are no dated tuffs within the lower portion of the Abrahamskraal Formation of the Western Cape. The location, sampling and radiometric dating of the source tuff bed for the Krans Kraal float block may therefore be of considerable scientific interest.

According to the 1: 250 000 Sutherland sheet the Lower Beaufort Group rocks in the study area have been gently folded along east-west or WNW-ESE fold axes, forming the northern margin of the Permo-Triassic Cape Fold Belt (Fig. 3). The beds are generally fairly flat-lying or show gentle to moderate dips (Figs. 40 & 41) and levels of tectonic deformation are generally low. However, in some areas bedding dips are high (Fig. 43) and features such as abundant quartz veining (*e.g.* tension gashes, mineral lineation), well-jointed sandstones, small normal and reverse faults associated with fault breccia zones (Fig. 44) and even local cleavage development within mudrocks (Fig. 42) indicate higher levels of tectonic deformation in some areas that might have locally compromised fossil preservation.

Figure 39. Fractured float block of fine-grained, pale greenish-grey tuff (volcanic ash) probably of local provenance within the lower part of the Abrahamskraal Formation, stream gulley on Krans Kraal 189 (Loc. 009) (Scale in cm.).

Figure 40. Laterally persistent N-S sandstone units of the Abrahamskraal Formation showing a gentle southerly dip, eastern side of Tanqua River, Roode Wal 187.

Figure 41. Pronounced northerly dip shown by the Abrahamskraal Formation near Snydersberg, Riet Fontein 197, looking towards the west.

Figure 42. Well-developed pencil cleavage within thick-bedded, grey-green overbank mudrocks of the Abrahamskraal Formation, Klipbanks Fontein 198 (Loc. 037) (Hammer = 30 cm).

Figure 43. Steeply-dipping folded beds of the Abrahamskraal Formation on the western margin of Riet Fontein 197, west of Rietfontein homestead.

Figure 44. Disturbed bedding either side of a fault zone marked by massive fault breccia (arrow), R354 road cutting, Roode Wal 187 (Loc. 028).

3. PALAEONTOLOGICAL HERITAGE

In this section of the report the fossil heritage recorded elsewhere within the main rock units that are represented within the Karreebosch Wind Farm study area, together with fossils observed here during the present field assessment, are outlined.

3.2.1. Fossil biotas of the Lower Beaufort Group (Adelaide Subgroup)

The overall palaeontological sensitivity of the Beaufort Group sediments is high to very high (Almond & Pether 2008). 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). 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 the 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). Maps showing the distribution of the Beaufort Group assemblage zones within the Main Karoo Basin have been provided by Keyser and Smith (1979, Fig. 45 herein) and Rubidge (1995, 2005). A recently updated version is now available (Nicolas 2007, Van der Walt *et al.* 2010). The only assemblage zone represented within the Karreebosch Wind Farm study area is the Middle Permian ***Tapinocephalus* Assemblage Zone** (Theron 1983, Rubidge 1995).

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) 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* (Fig. 47), small insectivorous millerettids), rare pelycosaurs, and diverse **therapsids** or "mammal-like reptiles" (*e.g.* numerous genera of large-bodied dinocephalians (Figs. 47 & 48), 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 worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings) and plant 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 (horsetails).

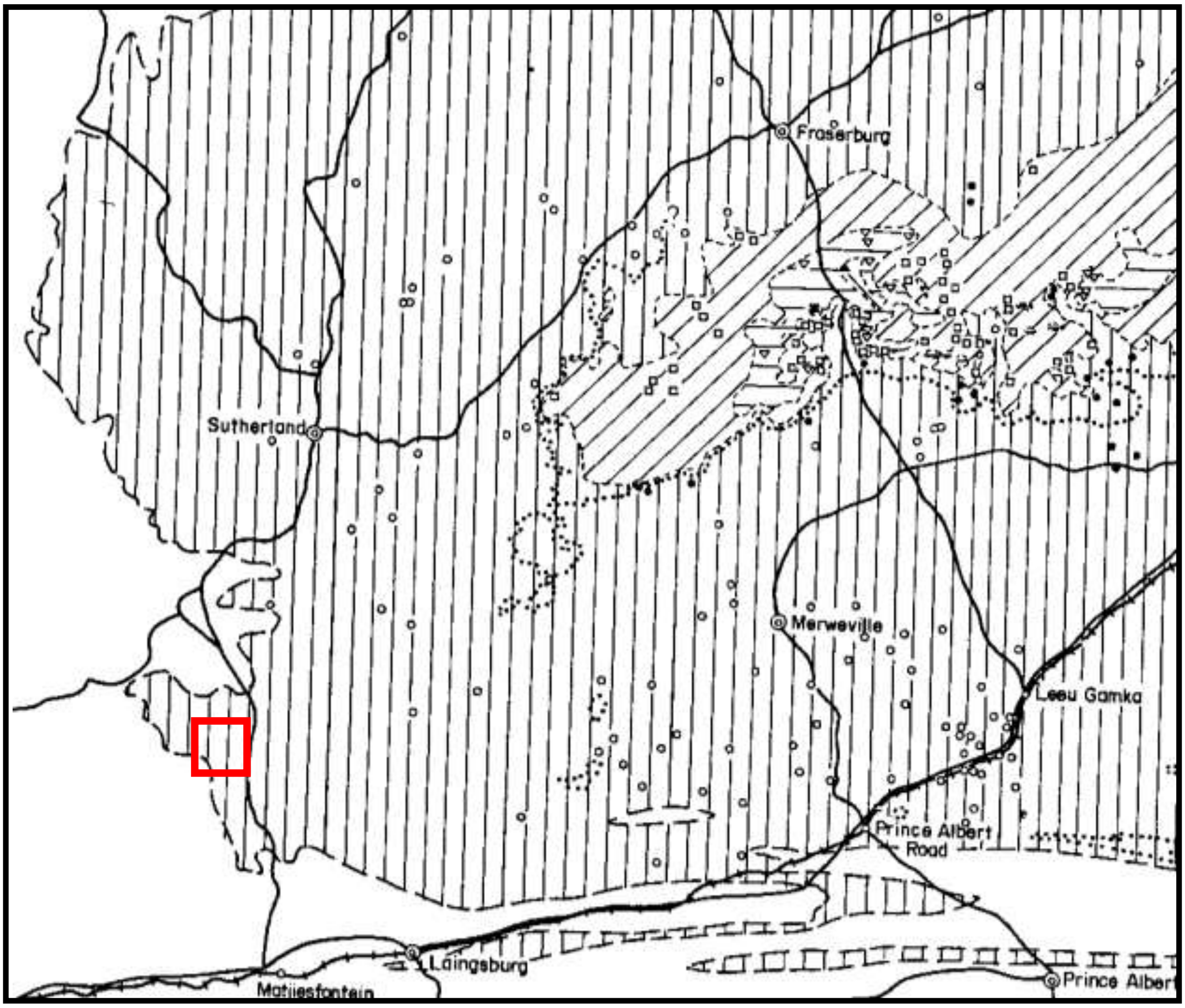

Figure 45. Vertebrate fossil localities within the Lower Beaufort Group in the southwestern Karoo region (Map abstracted from Keyser & Smith 1977-78). Outcrop areas with a vertical lined ornament are assigned to the Middle Permian *Tapinocephalus* Assemblage Zone. Note the absence of fossil records from the lower part of the Abrahamskraal Formation in the Karreebosch Wind Farm study area to the southeast of Sutherland (red rectangle).

In general, tetrapod fossil assemblages in the *Tapinocephalus* Assemblage Zone are dominated by a wide range of dinocephalian genera and small therocephalians *plus* pareiasaurs while relatively few dicynodonts can be expected (Day & Rubidge 2010, Jirah & Rubidge 2010 and refs. therein). Vertebrate fossils in this zone are generally much rarer than seen in younger assemblage zones of the Lower Beaufort Group, with almost no fossils to be found in the lowermost beds (Loock *et al.* 1994) (Fig. 10).

Despite their comparative rarity, there has been a long history of productive fossil collection from the *Tapinocephalus* Assemblage Zone in the western and central Great Karoo area, as summarized by Rossouw and De Villiers (1952) and Boonstra (1969). Numerous fossil sites recorded in the region are marked on the published 1: 250 000 Sutherland geology sheet

3220, Beaufort West sheet 3222, and on the map in Keyser and Smith (1977-78; Fig. 45). Vertebrate fossils found in the Sutherland sheet area are also listed by Kitching (1977) as well as Theron (1983). They include forms such as the pareiasaur *Bradysaurus*, tapinocephalid and titanosuchid dinocephalians *plus* rarer dicynodonts, gorgonopsians and therocephalians (*e.g.* pristerognathids, *Lycosuchus*) as well as land plant remains (*e.g.* stems and leaves). Numerous fossil sites were recorded along the eastern edge of the Moordenaarskaroo in the key biostratigraphic study of the Abrahamskraal Formation by Loock *et al.* (1994) (Fig. 10). A recent palaeontological heritage study was carried out by the author within the Abrahamskraal Formation of the Moordenaarskaroo (Almond 2010a). This fieldwork yielded locally abundant dinocephalian and other therapsid skeletal remains, large, cylindrical vertical burrows or plant stem casts, *Scoyenia* ichnofacies trace fossil assemblages and sphenophytes (horsetail ferns) associated with probable playa lake deposits, as well as locally abundant petrified wood.

Fossils in the *Tapinocephalus* Assemblage Zone occur in association with both mudrocks and sandstones, most notably in thin intraformational conglomerates (*beenbreksie*) at the base of channel sandstones (Rossouw & De Villiers 1952, Turner 1981, Smith & Keyser 1995a). Tetrapod bones actually occur in a wide range of taphonomic settings in the *Tapinocephalus* Assemblage Zone (2010a). For example they are recorded as:

1. Disarticulated bones within thin intraformational conglomerates at the base of shallow (unistorey) channel sandstones. The bones are often impregnated with secondary iron and manganese minerals (coffee brown and black respectively). They vary from highly-weathered and rounded fragments to intact and well-preserved specimens. Bones occur at the base of, within, or floating at the top of the conglomerates in association with calcrete nodules, mudflakes, petrified wood and gypsum pseudomorphs. Bones in these channel lags were variously eroded out of riverbanks or washed into drainage channels from upland areas, riverine areas and floodplains during floods or episodes of landscape denudation.

2. Disarticulated bones within or at the top of channel sandstones.

3. Bones coated with calcrete or embedded within calcrete nodules associated with arid climate palaeosols (ancient soils). These bones are often suncracked, showing that lay exposed on the land surface for a long time before burial.

4. Isolated bones or articulated skeletons (possible mummies) embedded within levee or floodplain mudrocks.

5. Well-articulated skeletons preserved within fossil burrows (Botha-Brink & Modesto, 2007).

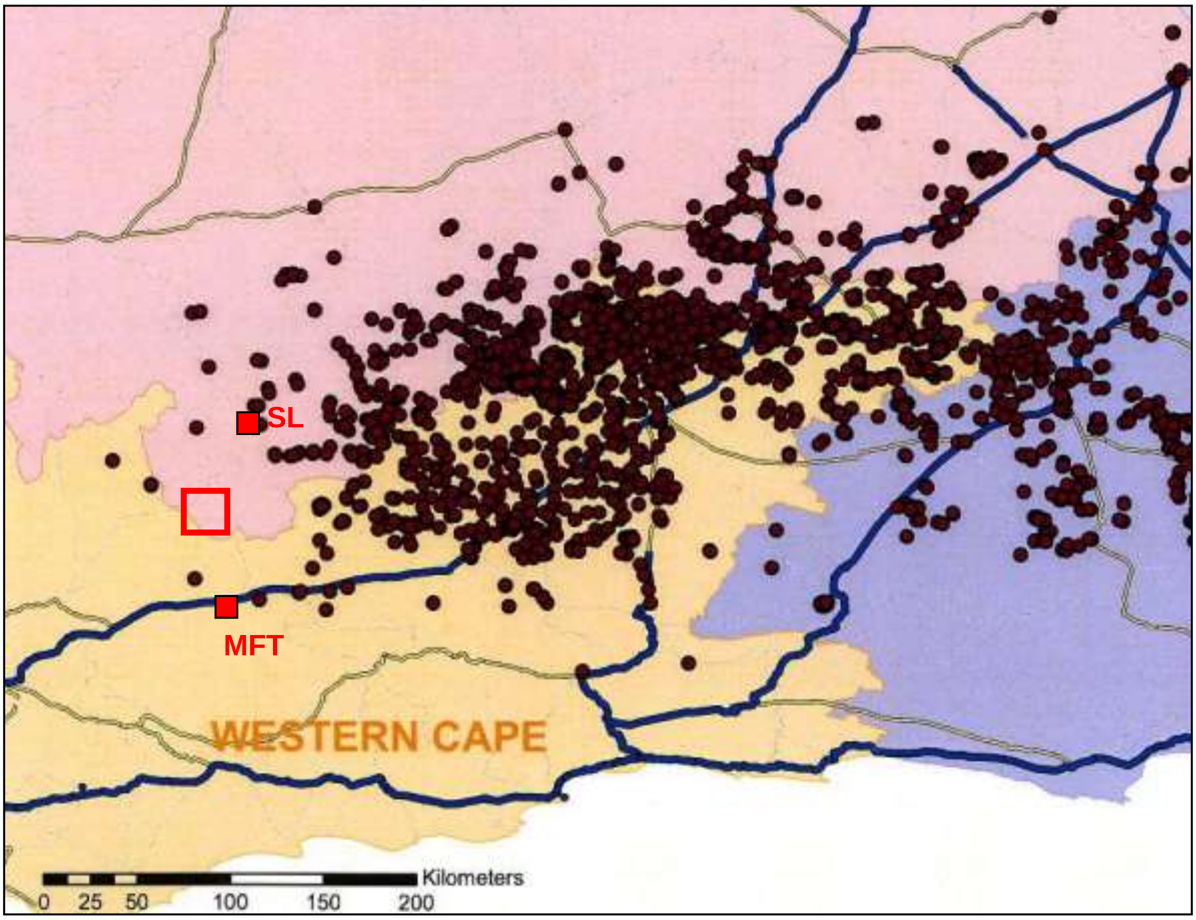

Figure 46. Distribution of recorded vertebrate fossil sites within the south-western portion of the Main Karoo Basin (modified from Nicolas 2007). The approximate location of the Karreebosch Wind Farm study area is indicated by the red rectangle. SL = Sutherland. MFT = Matjiesfontein.

Intensive fossil collection within the middle part of the Abrahamskraal Formation succession has suggested that a significant faunal turnover event may have occurred at or towards the top of the sandstone-rich Koornplaats Member, with the replacement of a more archaic, dinocephalian-dominated fauna (with primitive therapsids like the biarmosuchians) by a more advanced, dicynodont-dominated one at this level (Loock *et al.* 1994; Fig. ** herein). This is the "faunal reversal" previously noted by Boonstra (1969) as well as Rossouw and De Villiers (1953). Other fossil groups such as therocephalians and pareiasaurs do not seem to have been equally affected. Problems have arisen in trying to correlate the lithologically-defined members recognized within the Abrahamskraal Formation by different authors across the whole outcrop area, with evidence for complex lateral interdigitation of the sandstone-dominated packages (D. Cole, pers. com., 2009). A research project is currently underway to subdivide the Abrahamskraal Formation on a biostratigraphic basis, emphasizing the range zones of various genera of small dicynodonts such as *Eodicynodon, Robertia* and *Diictodon* (Day & Rubidge 2010, Jirah & Rubidge 2010, 2014).

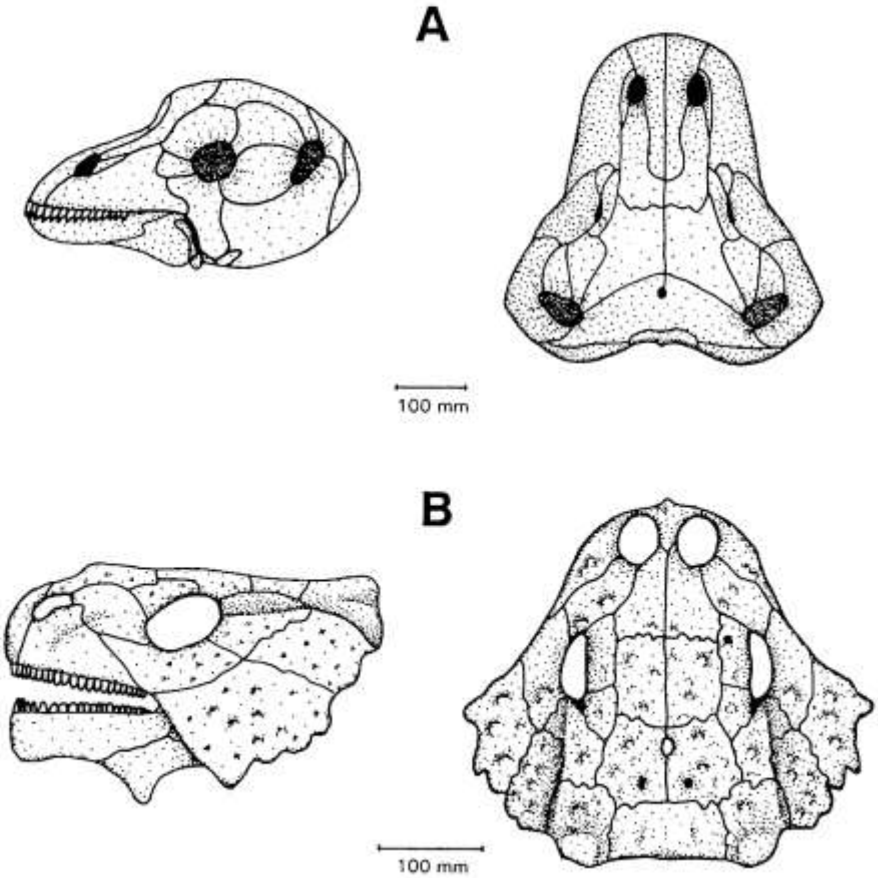

Figure 47. Skulls of two key tetrapods of the *Tapinocephalus* Assemblage Zone: A – the dinocephalian therapsid *Tapinocephalus*; B – the pareiasaur *Bradysaurus* (From Smith & Keyser 1995b).

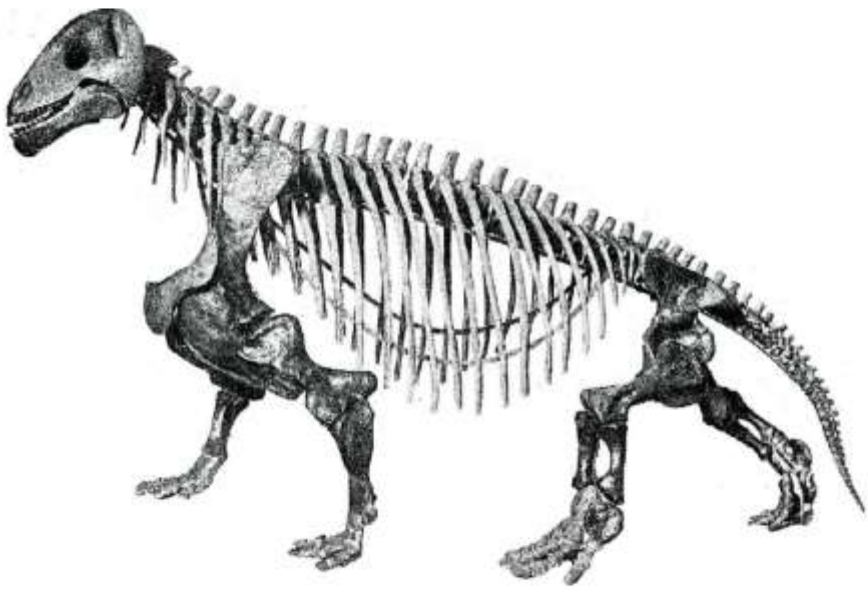

Figure 48. Skeleton of the tapinocephalid (thick-skulled) dinocephalian *Moschops*, a rhino-sized herbivorous therapsid that reached lengths of 2.5 to 3 m and may have lived in small herds.

Selected fossil sites recorded within the *Tapinocephalus* Assemblage Zones in the Sutherland region are indicated on outline maps by Kitching (1977), Keyser and Smith (1977-78) (Fig. 45) and Nicolas (2007) (Fig. 46). Several fossil sites near Sutherland are also shown on the 1: 250 000 geological sheet 3220 Sutherland published by the Council for Geoscience, Pretoria. In addition Kitching (1977) provides palaeofaunal lists for specific localities within the Great Karoo region. It is notable that these works suggest a profound paucity of vertebrate fossil finds in the present study area to the south of Sutherland, although a few localities are indicated in stratigraphically lower-lying beds of the Lower Beaufort Group to the west and south of the study area. This palaeontological impoverishment seems to apply even to the excellent exposures of Abrahamskraal Formation sediments within the Verlatekloof Pass near Sutherland. The reasons for the lack of fossils even here - despite appropriate facies and good bedrock exposure - is currently unresolved and may have a palaeoenvironmental component. A previous palaeontological field assessment of Mordenaars Member rocks on the outskirts of Sutherland by Almond (2005) yielded only transported plant remains (arthrophytes including *Phyllotheca*, glossopterid and other, more strap-shaped leaves, possible wood tool marks), sparse trace fossil assemblages of the damp-ground *Scoyenia* ichnofacies, and rare fragments of rolled bone. Reworked silicified wood from surface gravels, scattered, fragmentary plant remains associated with channel sandstones and rare disarticulated bones were reported from a Moordenaars Member study site *c*. 1 km south of Sutherland by Almond (2011). A traverse through the Combrinkskraal and Leeuvlei Members along the Gamma – Omega 765 kV transmission line corridor just south of the Karreebosch Wind Farm study area did not yield fossil vertebrate remains in this area, although locally abundant plant material (*e.g.* sphenophytes, possible floating log tool marks) and sizeable vertical burrows were seen, mainly further to the east in the Moordenaarskaroo region (Almond 2010a).

The only fossil remains recorded from the Abrahamskraal Formation within the Karreebosch Wind Farm study area include rare, fragmentary remains of vascular plants - notably disarticulated sphenophyte (horsetail fern) stems embedded within massive siltstones (Fig. 49) – as well as wisely occurring, low-diversity trace fossil assemblages. Fine-grained channel sandstone and siltstone bedding surfaces often feature abundant small-scale (≤ 10 mm diameter) horizontal, oblique and vertical invertebrate burrows that are probably referable to the genus *Scoyenia* of the *Scoyenia* softground ichnofacies that has been attributed to earthworms and / or insect larvae (*cf* Seilacher 2007) (*e.g.* Locs. 001, 002, 018, 019, 031 *etc.,* Figs. 10 to 12). These low-diversity ichnoassemblages are responsible for marked colour-mottling of some beds and are sometimes associated with V-shaped epichnial grooves. Larger scale (5 to 10 mm diameter) vertebrate burrows ("*Skolithos*") also occur locally within fine-grained sandstone facies (Miller 2011) (Fig. 51). At Loc. 018 (Karee Bosch 200) networks of apparently interconnected burrows of circular cross-section occur within grey siltstone (Fig. 52). They are reminiscent of fossil burrow systems reported from the Abrahamskraal Formation near Kanolfontein, to the west of Sutherland, that have been compared (probably erroneously) with the ichnogenus *Hormosiroidea* (Cole *et al.* 1990, p, 36).

Figure 49. Fragment of the longitudinally-striated stem of a sphenophyte fern embedded in Abrahamskraal grey-green mudrocks, Wilgebosch Rivier 188 (Loc. 017) (Scale in mm).

Figure 50. Siltstone bedding plane of the Abrahamskraal Formation riddled with small-scale burrows of the *Scoyenia* Ichnofacies, Wilgebosch Rivier 188 (Loc. 018) (Scale in cm).

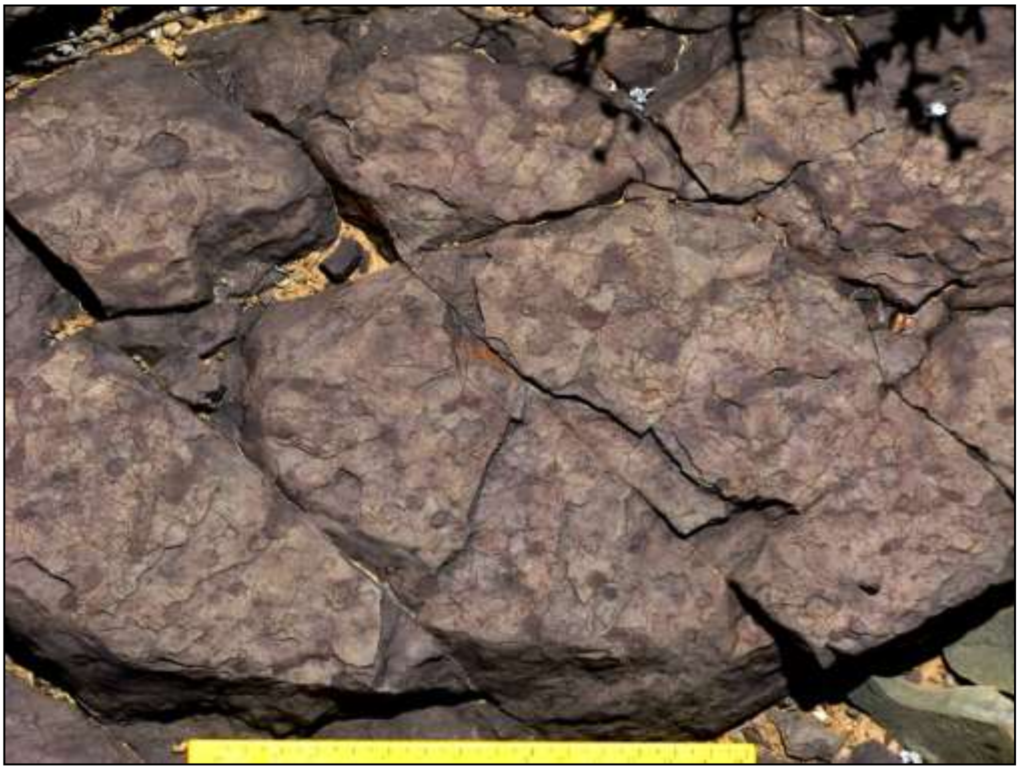

Figure 51. Low-diversity assemblage of small (5-10 mm diameter) backfilled horizontal to vertical burrows within a fine-grained sandstone bed, Abrahamskraal Formation, Wilgebosch Rivier 188 (Loc. 018) (Scale in cm).

Figure 52. Linear arrays of cylindrical vertical burrows (*cf "Hormosiroidea"*) within overbank mudrocks, Abrahamskraal Formation, Karee Bosch 200 (Loc. 021) (Scale in cm).

3.3. Fossils within the superficial deposits

The diverse 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). 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 fossils were observed within the various superficial deposits represented within the Karreebosch Wind Farm study area. Locally abundant fragments of quartz mineral lineation superficially resemble petrified wood but are actually pseudofossils (Fig. 53). Sandstone clasts within some sheetwash and hillwash gravels occasionally include flaked Stone Age artefacts (*e.g.* Loc. 016a).

Figure 53. Quartz mineral lineation blocks weathered out of fault or fracture zones in bedrocks and reworked within sheetwash gravels, Wilgebosch Rivier 188 (Loc. 016a) (Scale in cm)(See also Fig. 35). Such iron-stained, fibrous quartz vein material is sometimes mistaken for fossil wood (*i.e.* they are technically *pseudofossils*).

4. ASSESSMENT OF IMPACTS ON FOSSIL HERITAGE

In this section of the report the anticipated impacts of the proposed wind farm on local palaeontological heritage resources within the Karreebosch Wind Farm study area, as outlined in Figs. 1 and 2, is first assessed. In Section 4.2. impacts specifically associated with the alternative transmission line corridors are briefly considered.

4.1. Impacts within the Karreebosch Wind Farm project area

The Karreebosch Wind Farm project area is located in an area that is underlain by potentially fossiliferous sedimentary rocks of Late Palaeozoic and younger, Late Tertiary or Quaternary, age (Sections 2 & 3). The construction phase of the proposed wind farm development will entail substantial excavations into the superficial sediment cover and locally into the underlying bedrock as well. These include, for example, excavations for the wind turbine foundations, hard standing areas, internal access roads, transmission line pylon footings, electrical substations, operations and maintenance building, construction laydown areas, construction camp and borrow pit. All these developments may adversely affect potential fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils at or beneath the surface of the ground that are then no longer available for scientific research or other public good. The operational and decommissioning phases of the wind energy facility are unlikely to involve further adverse impacts on local palaeontological heritage, however.

The fluvial Abrahamskraal Formation (Lower Beaufort Group, Karoo Supergroup) that underlies almost the entire wind farm study area is known for its diverse fauna of Permian fossil vertebrates - notably various small- to large-bodied therapsids and reptiles - as well as fossil plants of the *Glossopteris* Flora and low diversity trace fossil assemblages. However, desktop analysis of known fossil distribution within the Main Karoo Basin shows a marked paucity of fossil localities in the study region between Matjiesfontein and Sutherland where sediments belonging only to the lower part of the thick Abrahamskraal Formation succession are represented. Bedrock exposure levels in the Karreebosch Wind Farm study area are generally very poor due to the pervasive cover by superficial sediments (colluvium, alluvium, soils, calcrete) and vegetation. Nevertheless, a sufficiently large outcrop area of Abrahamskraal Formation sediments, exposed in stream and riverbanks, borrow pits, erosion gullies as well as road cuttings along the R354, has been examined during the present fieldwork (See Appendix) to infer that macroscopic fossil remains of any sort are very rare indeed here. Exceptions include common trace fossil assemblages (invertebrate burrows) and occasional fragmentary plant remains (horsetail ferns). Levels of bedrock tectonic deformation are generally low, although folding, faulting and cleavage development associated with the Cape Fold Belt are locally apparent, and baking by Early Jurassic dolerite intrusions is very minor. It is concluded that the Lower Beaufort Group bedrocks in the study area are generally of low palaeontological sensitivity and this also applies to the overlying Late Caenozoic superficial sediments (colluvium, alluvium, calcrete, soils *etc*).

Due to access limitations it was not possible to confirm that this low sensitivity applies as equally to the ridge crests where the wind turbines will be sited as it does to the lower hill slopes and valley floors where most of the bedrock exposures examined during fieldwork are located, but this seems very probable. Likewise, it was not possible to examine sizeable land parcels within the study area to the east of the R354 where the only infrastructure currently proposed comprises short sections of transmission line. Given the very similar geology to the western and central sectors of the study area that were studied in some detail, palaeontologically sensitive rock units are not expected here. The sandstone-rich succession along the western edge of the Klein-Roggeveldberge escarpment (*e.g.* eastern margin of Appels Fontein 201) might prove more fossiliferous but access is difficult and the anticipated infrastructural footprint is very small.

Construction of the Karreebosch Wind Farm and associated infrastructure, including proposed new overhead transmission lines to the Komsberg Substation, is therefore unlikely to entail significant impacts on local fossil heritage resources. Due to the general great scarcity of fossil remains as well as the extensive superficial sediment cover observed within the entire study area, the overall impact significance of the construction phase of the proposed wind farm is assessed as MINOR. The operational and decommissioning phases of the wind energy facility are very unlikely to involve further adverse impacts on local palaeontological heritage.

The inferred impact of the proposed wind energy development on local fossil heritage resources is analysed in Table 1 below, based on the system developed by Environmental Resource Management. This assessment applies only to the construction phase of the development since further impacts on fossil heritage during the operational and decommissioning phases of the facility are not anticipated. There are no fatal flaws in the Karreebosch Wind Farm development proposal as far as fossil heritage is concerned.

In general, the destruction, damage or disturbance out of context of fossils preserved at the ground surface or below ground that may occur during construction represents a *direct*, *negative* impact that is limited to the development footprint (*on-site*). Such impacts can usually be mitigated but cannot be fully rectified or reversed (*i.e. permanent, irreversible*). Most of the sedimentary formations represented within the study area contain fossils of some sort, so impact on fossil heritage are *likely*. However, because of the generally very sparse occurrence of fossils within all of the bedrock formations concerned here, as well as within the overlying superficial sediments (soil, alluvium, colluvium *etc*), the magnitude of these impacts is conservatively rated as *low*. Likely impacts of low magnitude are considered to be of MINOR significance.

No areas or sites of exceptional fossil heritage sensitivity or significance have been identified within the Karreebosch Wind Farm study area. The majority of fossil sites recorded in the study region lie outside the anticipated development footprint. The common trace fossil assemblages identified in this study are of widespread occurrence within the Abrahamskraal Formation (*i.e.* not unique to the study area). Irreplaceable loss of fossil heritage is therefore not anticipated, although it should be highlighted that any new vertebrate fossil finds made during construction (e.g. exposed in new bedrock excavations) would be of considerable scientific interest, given their rarity. Should fossil remains be impacted by the proposed development, these impacts can be partially mitigated, as outlined in Table 2 and the following section of the report.

It should be noted that should new fossil remains be discovered before or during construction and reported by the responsible ECO to the responsible heritage management authority (SAHRA) for professional recording and collection, as recommended here, the overall impact significance of the project would remain MINOR. Residual negative impacts from loss of fossil heritage are likely to be *minor* and would be partially offset by an improved palaeontological database for the study region as a direct result of appropriate mitigation. This is a *positive* outcome because any new, well-recorded and suitably curated fossil material from this palaeontologically under-recorded region would constitute a useful addition to our scientific understanding of the fossil heritage here.

In the absence of comprehensive palaeontological data on further alternative energy or other developments in the broader study region, it is impossible to realistically assess cumulative impacts on fossil heritage resources. Given the scarcity of significant fossil remains in the region, cumulative impacts are likely to be low.

Because of the generally low levels of bedrock exposure within the study area, confidence levels for this palaeontological heritage assessment are only MEDIUM following the field assessment of representative rock exposures.

4.2. Impacts within the transmission line corridors

Connection of the proposed Karreebosch Wind Farm to the Eskom grid will involve approximately 25 km of 33 kV overhead power lines and about 25 km of 132 kV overhead power lines feeding into the existing Komsberg substation. Two route options for the 132 kV transmission line are under consideration:

- a smaller loop (Option 1) that runs from Komsberg Substation into the south-eastern sector of the wind farm study area (blue in Fig. 2);
- a larger loop (Option 2) that runs from Komsberg Substation across the central as well as eastern sectors of the wind farm study area (red in Fig. 2).

Both route options are underlain by very similar geology and no sensitive fossil sites have been identified along or close to the transmission line corridors. A previous palaeontological assessment (Almond 2010a) of the Eskom Gamma-Omega 765 kV transmission line corridor that runs to the south of the Karreebosch Wind Farm project area and that includes the area around the Komsberg Substation did not identify any palaeontologically sensitive sites.

Due to the general great scarcity of fossil remains as well as the extensive superficial sediment cover observed within the study area, the overall impact significance of the construction phase of the proposed transmission lines is assessed as MINOR (Table 2).

Impacts on fossil heritage due to disturbance of potentially fossiliferous bedrocks (excavations for pylon footings, access roads) are likely to be marginally greater in the case of the longer transmission line route (Option 2). However, the impact significance of both transmission line route options is MINOR (as assessed in Table 2) and there is no marked preference for either route option on palaeontological grounds.

Table 2: Assessment of impacts of the proposed Karreebosch Wind Farm on fossil heritage resources during the construction phase of the development *(N.B. Significant impacts are not anticipated during the operational and decommissioning phases). This table applies equally to the wind farm study area as well as the alternative transmission line corridors.*

Nature & type of impact: Negative & direct *viz*. Disturbance, damage, destruction or sealing-in of fossil remains preserved at or beneath the ground surface within the development area, most notably by bedrock excavations during the construction phase of the wind energy facility and associated transmission lines.		
	Without mitigation	**With mitigation**
Extent	On-site	On-site
Duration	Permanent	Permanent
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
SIGNIFICANCE	**MINOR**	**MINOR**
Degree of confidence	Medium	Medium
Mitigation Measures: Monitoring of all substantial bedrock excavations for fossil remains (notably vertebrate bones and teeth) by ECO, with reporting of substantial new palaeontological finds to SAHRA for possible specialist mitigation.		
Residual Impacts: Likely to be minor. Negative impacts due to loss of local fossil heritage will be partially offset by *positive* impacts resulting from mitigation (*i.e.* improved palaeontological database).		

5. RECOMMENDED MITIGATION AND MANAGEMENT ACTIONS

Given the low impact significance of the proposed Karreebosch Wind Farm near Sutherland (including alternative transmission line corridors to Komsberg Substation) as far as palaeontological heritage is concerned, no further specialist palaeontological heritage studies or mitigation are considered necessary for this project, pending the discovery or exposure of substantial new fossil remains during development. This recommendation applies provided that no substantial infrastructure, apart from the proposed transmission lines and associated access roads, is constructed within the portion of the study area east of the R354 which has not been directly assessed through fieldwork.

During the construction phase all deeper (> 1 m) bedrock excavations should be monitored for fossil remains by the responsible ECO. Should substantial fossil remains such as vertebrate bones and teeth, plant-rich fossil lenses, fossil wood or dense fossil burrow assemblages be exposed during construction, the responsible Environmental Control Officer should safeguard these, preferably *in situ*, and alert SAHRA, *i.e.* The South African Heritage Resources Authority, as soon as possible (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za) so that appropriate action can be taken by a professional palaeontologist, at the developer's expense. Mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy) by a professional palaeontologist.

These mitigation recommendations should be incorporated into the Environmental Management Plan (EMP) for the Karreebosch Wind Farm and associated transmission lines.

Provided that the recommended mitigation measures are carried through, it is likely that any potentially negative impacts of the proposed transmission line development on local fossil resources will be substantially reduced. Furthermore, they will be partially offset by the *positive* impact represented by increased understanding of the palaeontological heritage of the broader study region.

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;

- The palaeontologist concerned with mitigation work will need a valid fossil collection permit from SAHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection);

- All palaeontological specialist work would have to 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 recently developed by SAHRA (2013).

6. RECOMMENDATIONS FOR THE DRAFT ENVIRONMENTAL MANAGEMENT PLAN

The following measures for inclusion in the Environmental Management Plan for the proposed Karreebosch Wind Farm and associated transmission lines near Sutherland are outlined below (following page), according to the scheme developed by Savannah Environmental (Pty) Ltd.

Specialist palaeontological mitigation is only triggered should significant new fossil remains be exposed during the construction phase.

Note that the operational and decommissioning phases of the developments are unlikely to have significant impacts on palaeontological heritage and no further recommendations are made in this regard.

7. ACKNOWLEDGEMENTS

Ms Azrah Essop of Savannah Environmental (Pty) Ltd, Woodmead as well as Mr Methuli Mbanjwa of G7 Renewable Energies (Pty) Ltd, Cape Town, are both thanked for commissioning this study and for kindly providing all the necessary background information. I am grateful to Ms Madelon Tusenius for companionship and logistical assistance in the field. The opportunity to work alongside archaeological colleagues Tim Hart and Natalie Kendrick of ACO Associates, Cape Town was also appreciated.

OBJECTIVE: Safeguarding, recording and sampling of any important fossil material exposed.

Project component/s	Construction phase of the wind farm.
Potential Impact	Disturbance, damage, destruction or sealing-in of scientifically valuable fossil material embedded within bedrock or weathered-out at ground surface
Activity/risk source	Extensive bedrock excavations and surface disturbance (*e.g.* wind turbine foundations, hard standing areas, internal access roads, transmission line pylon footings, electrical substations, operations and maintenance building, construction laydown areas, construction camp and borrow pit).
Mitigation: Target/Objective	Recording, judicious sampling and curation of any important fossil heritage exposed during construction within the wind farm development area.

Mitigation: Action/control	**Responsibility**	**Timeframe**
1. Monitoring of all bedrock excavations for fossil remains. Fossil finds to be safeguarded and reported to SAHRA for possible mitigation.	ECO	Construction phase
2. Recording and judicious sampling of representative as well as any exceptional fossil material from the development footprint.	Professional palaeontologist assisted by ECOs	Construction phase
3. Curation of fossil specimens at an approved repository (*e.g.* museum).	Professional palaeontologist	Following mitigation
4. Final technical report on palaeontological heritage within study area	Professional palaeontologist	Following mitigation and preliminary analysis of fossil finds

Performance Indicator	Identification of any new palaeontological hotspots within broader development footprint by ECO. Cumulative acquisition of geographically and stratigraphically well-localised fossil records, samples and relevant geological data from successive subsections of the development area. Submission of interim and final technical reports to SAHRA by palaeontologist involved with any mitigation work.
Monitoring	Monitoring during construction phase of fresh bedrock exposures within development footprint by ECO and, if necessary, by professional palaeontologist.

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15 QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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

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

John E. Almond

Dr John E. Almond
Palaeontologist
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APPENDIX: GPS LOCALITY DATA

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

Locality Number	South	East	Comments
001	S32 52 50.7	E20 33 34.6	R354 road cutting through Abrahamskraal Fm, Ek Kraaal 199. Minor folds & faulting. *Scoyenia* ichnofacies trace fossils.
002	S32 52 48.2	E20 33 36.4	Shallow roadside borrow pit east of R354, Appels Fontein 201.
003	S32 43 29.0	E20 27 01.3	Cobbly and silty alluvium, reedy *vlei* deposits, Kleinpoortsrivier, Farm 220.
004	S32 43 33.3	E20 26 51.3	Calcretised older alluvial gravels, younger gravels and silty alluvium, Kleinpoortsrivier, Farm 220.
005	S32 45 04.9	E20 26 38.0	Stream bed exposure of Abrahamskraal Fm, desiccation cracks. Sandstone gravel colluvium. Krans Kraal 189.
006	S32 45 50.9	E20 26 14.0	Stream bed exposure of Abrahamskraal Fm near Kranskraal homestead, Krans Kraal 189.
007	S32 47 19.2	E20 25 00.0	Stream bed exposure of Abrahamskraal Fm, Krans Kraal 189.
008	S32 47 04.2	E20 24 07.4	Stream bed exposure of Abrahamskraal Fm and overlying colluvium, Krans Kraal 189.
009	S32 46 58.4	E20 23 26.5	Stream gulley exposure of Abrahamskraal Fm, float block of pale greenish-grey tuff, weathered-out ferruginous calcrete nodules, Krans Kraal 189.
010	S32 47 56.6	E20 25 02.2	Stream gulley exposure of Abrahamskraal Fm channel sandstones, mudrocks with large ferruginous carbonate concretions, Krans Kraal 189.
011	S32 49 00.8	E20 25 09.7	Bouldery colluvium (sandstone corestones), quartz veins, Oude Huis 195.
012	S32 49 39.5	E20 25 41.8	Extensive stream bed exposure of Abrahamskraal Fm, Oude Huis 195. Horizons of large ferruginous carbonate concretions.
013	S32 49 49.8	E20 25 29.2	Steep gulley exposure of Abramaskraal Fm mudrocks, blocky stream alluvium Oude Huis 195.
014	S32 51 51.6	E20 33 39.1	R354 roadcutting showing sandstone corestone formation in Abrahamskraal Fm, Appels Fontein 201.
015a	S32 46 41.6	E20 31 48.0	R354 roadcutting through multi-story channels sandstones of Abrahamskraal Fm, basal mudrock intraclast breccias, Karee Bosch 200.

015b	S32 46 18.3	E20 31 34.0	R354 roadcutting through thick overbank mudrocks and thin, cross-bedded channel sandstones of the Abrahamskraal Fm,Karee Bosch 200 (= Loc. 029).
016a	S32 46 31.1	E20 28 33.0	*Krans* of thin-bedded channel sandstone, Abrahamskraal Fm, overlain by silty to gravelly colluvial deposits, sheet wash gravels including common flaked sandstone artefacts, Wilgebosch Rivier 188.
016b	S32 46 32.4	E20 28 31.3	Gulley erosion into silty Late Caenozoic alluvium, sandstone artefacts including a lower grindstone, Wilgebosch Rivier 188.
017	S32 46 44.9	E20 28 54.8	Stream bed exposure of Abrahamskraal Fm, Wilgebosch Rivier 188. Sparse reworked fragments of arthrophyte stems within mudrocks.
018	S32 46 55.5	E20 29 36.4	Extensive stream bed and bank exposure of Abrahamskraal Fm, Wilgebosch Rivier 188. Abundant *Scoyenia* ichnofacies trace fossil assemblages.
019	S32 47 04.9	E20 29 50.4	Good gulley and hillslope exposures of Abrahamskraal Fm, Wilgebosch Rivier 188. *Scoyenia* ichnofacies trace fossils.
020	S32 47 17.7	E20 31 27.2	Extensive stream bed exposure of Abrahamskraal Fm, Karee Bosch 200.
021	S32 47 23.4	E20 31 50.6	Stream bed and bank exposure of Abrahamskraal Fm, Karee Bosch 200. Rows of vertical burrows *cf Hormosiroidea.*
022	S32 47 35.5	E20 32 08.1	Small hillslope and gulley exposures of Abrahamskraal Fm, Karee Bosch 200.
023	S32 46 59.8	E20 29 46.9	Stream bank exposure of Abrahamskraal Fm with overlying thick colluvial gravels, Wilgebosch Rivier 188.
028	S32 45 31.6	E20 31 05.7	R354 road cutting through lenticular channel sandstones, Roode Wal 187. Fault zone with associated breccia.
029	S32 46 20.3	E20 31 35.5	R354 roadcutting through thick overbank mudrocks and thin, cross-bedded channel sandstones, hereolithic packages of the Abrahamskraal Fm, Karee Bosch 200 (= Loc. 15b).
030	S32 56 34.7	E20 29 40.2	Viewpoints into study area (*e.g.* Snydersberg), southern margin of Riet Fontein 197.
031	S32 56 25.2	E20 29 26.3	Hill slope exposure of Abrahamskraal Fm mudrocks, Riet Fontein 197. Possible soft-sediment deformation of fine -grained sandstones.
032	S32 55 51.1	E20 28 51.5	Hill slope exposure of Abrahamskraal Fm mudrocks, Riet Fontein 197.
034	S32 55 26.2	E20 28 40.0	Narrow gulley exposure of Abrahamskral mudrocks

			and heterolithic packages, Riet Fontein 197.
035	S32 54 53.8	E20 28 20.4	Extensive stream bank exposures of massive and thin-bedded grey-green mudrocks, Abrahamskraal Fm, Riet Fontein 197.
036	S32 54 14.3	E20 27 45.3	Alluvial gravels and silts of the Wilgebosrivier, Rietfontein 197.
037	S32 50 47.0	E20 27 16.2	Thick gulley exposure of grey-green, cleaved overbank mudrocks, Abrahamskraal Fm, Klipbanks Fontein 198.
038a	S32 47 14.8	E20 26 01.1	Extensive stream bed exposure of Abrahamskraal grey-green mudrocks, calcretised alluvial gravels and calcretes, tributary of Kareekloofrivier, Krans Kraal 189.
038b	S32 47 21.2	E20 25 47.7	Exposure of Abrahamskraal Fm bedrocks in overflow channel of large dam, Krans Kraal 189.
039	S32 50 40.8	E20 25 15.4	Stream bank exposure of tabular-bedded Abrahamskraal Fm, Oude Huis 195.
040	S32 51 31.5	E20 24 55.9	Stream bed exposure of Abrahamskraal Fm channel sandstone, overlying Caenozoic alluvial deposits, Karee Kloof 196.
041	S32 53 10.6	E20 25 03.3	Riverbank and bed exposures of Abrahamskraal Fm, Karee Kloof 196.
042	S32 52 29.9	E20 24 56.9	Excellent river bank exposures of Abrahamskraal channel sandstones, Karee Kloof 196.
043	S32 45 58.1	E20 31 22.4	Extensive R354 road cutting through the Abrahamskraal Formation, Roodewal 187.
044	S32 43 58.1	E20 29 36.8	R354 road cutting through weathered dolerite dyke, Roodewal 187.
045	S32 45 21.9	E20 30 55.9	Long stream bank cliff exposing Abrahamskraal Fm, Roodewal 187.
047	S32 50 15.0	E20 31 50.6	Riverbank exposure of Abrahamskraal Fm near breached earthwall dam, Ek Kraal 199.

ROGGEVELD WIND FARM

PALAEONTOLOGY STUDY

Duncan Miller

1. Introduction

Karreebosch Wind Farm (Pty) proposes to establish a wind energy facility between Matjiesfontein and Sutherland in the Western and Northern Cape. The proposed project will straddle the provincial boundary, although most of the planned infrastructure is on the Northern Cape farms. The site is located to the west of the R354, approximately 40 km south of Sutherland and approximately 20 km north of Matjiesfontein. Environmental Resources Management (ERM) has commissioned a heritage assessment of this area from the Archaeology Contracts Office, University of Cape Town, for whom this palaeontological assessment has been done by Dr Duncan Miller.

Dr Miller is a research scientist with PhDs in both Materials Engineering and Archaeological Science. He has published over 50 peer-reviewed scientific papers on various topics, including the palaeontology of elevated beach deposits on the West Coast of South Africa, as well as producing numerous technical reports.

2. Methodology

The study commenced with the collection of literature, including the 1:250 000 Geological Map (Sheet 3220 Sutherland). Given the very limited timeframe for its generation, this report relies on general reference works. The geological formations and strata underlying the study area were identified and a field trip was conducted to the study area, with two days spent inspecting road cuttings, borrow pits, and erosional exposures for fossils. This was undertaken in conjunction with the archaeological heritage survey of the northern area, and details of the tracks covered are available in the relevant archaeological report. The southern area was not visited for the purposes of this palaeontological report, which for this area relies on published sources.

3. Regulatory and Legislative Overview

In terms of the National Heritage Resources Act No. 25 of 1999, all palaeontological material is protected. In terms of the Act, "palaeontological means any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or trace". The Act stipulates that:

"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".

Control over palaeontological resources resides with the relevant provincial heritage authority, where such exists, otherwise with the national South African Heritage Resources Agency. Both Heritage Western Cape and the South African Heritage Resources Agency are responsible heritage authorities for this project. The provisions of the Act are complex, and the Act should be referred to directly for details about applications to collect or destroy palaeontological material.

4. Description of the Affected Environment

4.1 Local Geology

The Study Area is situated towards the southern margin of the Main Karoo basin. To the south, rocks of the Cape Supergroup make up the Cape Fold Belt mountains. Folding due to the tectonic forces which gave rise to the Cape Fold Belt is also present in the Study Area, but it is much more subdued. This has given rise to more or less parallel gentle anticlines (∩-shaped) and synclines (U-shaped), with their axes orientated approximately SSW-NNE, over most of the Study Area. The entire area is underlain by rocks of the Karoo Supergroup. Most of the area is underlain by rocks of the Abrahamskraal Formation of the Permian Beaufort Group (Figure 4.1.1). The hilltops and hill slopes expose horizons of resistant channel-fill sandstones, with intervening layers of shales, representing former muddy flats and flood splays from broken river banks (Figure 4.1.2). In the south there are scattered outcrops of the slightly older Waterford Formation of the Ecca Group, and also outcrops of the Tierberg and Fort Brown Formations in the extreme south (Theron, 1983).

Bedrock exposures are few, except on the crests of hills and a few marginal cliffs. Erosion gullies reveal that scree and valley fill deposits tend to be very thin, typically less than 1 metre, except in the central Wilgebosrivier valley in the north. Here the valley fill deposits, including river gravels exposed in the river bed in places, are of unknown thickness.

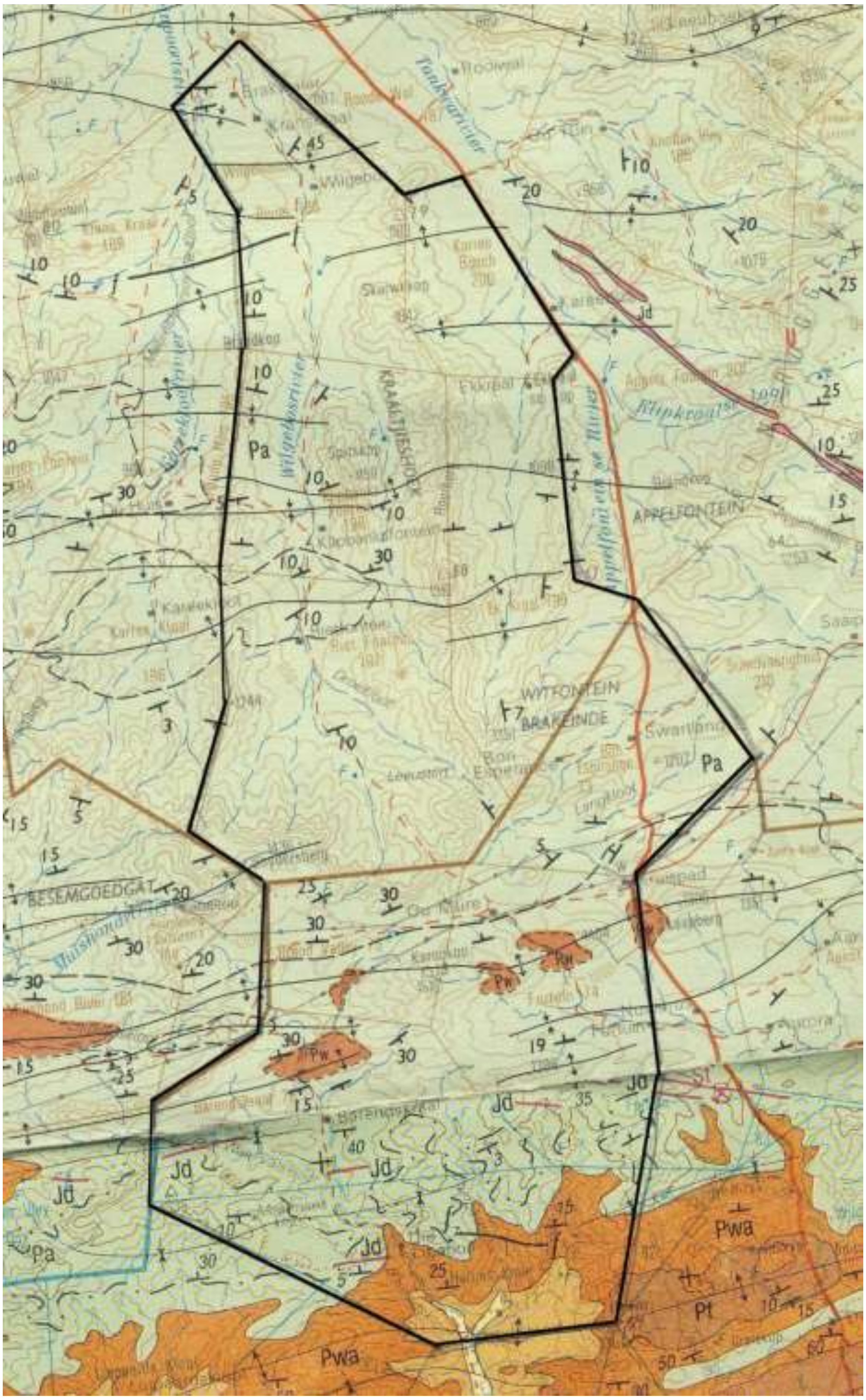

Figure 4.1.1 Geological Map of the Farms Enclosing the Proposed Wind Farm Area (from Sheet 3220 Sutherland and 3320 Ladismith) Pa = Abramskraal Formation; Pwa & Pw = Waterford Formation; Pt (yellow, unlabelled) = Tierberg Fm; Pf = Fort Brown Fm; Jd = dolerite

Figure 4.1.2 Typical Landscape of the Northern Area, Showing Ridges Supported by Resistant Sandstone Layers in the Abrahamskraal Formation (Looking North, Ekkraal Valley to the Right). Note the low bedrock exposure on the hillslopes.

The stratigraphy, lithology and palaeoenvironments of the rocks of the northern areas are summarised in the following table.

AGE	GROUP	FORMATION	LITHOLOGY	PALAEOENVIRONMENT
Permian	Beaufort	Abrahamskraal	sandstone channel + crevasse splay deposits, interbedded mudstones	subaerial upper delta plain, aerially exposed mudflats, backswamps,
Permian	Ecca	Waterford	sandstone, greywacke, shale	shallow water, delta-front
Permian	Ecca	Fort Brown	mudstone, minor sandstone	prodelta and delta-front
Permian	Ecca	Tierberg	dark shale, mudstone	settling from suspension in deep water, shallowing towards the top

Table 4.1.1 Stratigraphy, Lithology and Palaeoenvironments of the Rocks Exposed in the Study Area (modified from Johnson et al., 2006)

4.2 Palaeontology

The outcrops of the Waterford Formation in the south were not searched, but trace fossils in the form of burrows, trails and tubes are common in this formation, with rare bivalves and fragmentary fish remains (Thamm & Johnson, 2006; Johnson et al., 2006). Plant fragments (Glossopteris) are also reported to be common and in places pieces of stem fragments of the tree genus Dadoxylon occur (Theron et al., 1991).

The only fossils found in the rocks of the Abrahamskraal Formation were trace fossils in the form of sand-filled vertical burrows in sandstone (Figure 4.2.1). These were in a loose block adjacent to a packed stone ruin in the Ekkraal valley (Tim, please provide co-ordinates – it was at the ruin with the long wall adjacent to the river and the possible aqueduct/dam), and may have been transported from elsewhere as building material.

Figure 4.2.1 Trace Fossils Consisting of Sand-filled Vertical Burrows in Sandstone, from Ekkraal Farm (width of rock ca. 200 mm)

The Abrahamskraal Formation contains terrestrial vertebrate fossils, fish remains, non-marine molluscs and silicified wood (Johnson et al., 2006). The lowest biozone of the Beaufort Group is the Eodicynodon Assemblage Zone, recently recognised in the southwestern part of the Karoo basin by Bruce Rubidge. This zone is characterised by fossils of Eodicynodon, a small primitive tetrapod reptile. Fossils of other primitive reptiles are also found in this biozone (MacRae, 1999). These are extremely important fossils documenting the rise of reptiles and evolution of mammal-like reptiles (therapsids), for which the Karoo is the pre-eminent locality.

The Eodicynodon Assemblage Zone is not recorded in the Study Area and this area lies within the Tapinocephalus Assemblage Zone. The zone is named after a therapsid (the mammal-like reptile Tapinocephalus atherstonei) restricted to this zone. Fossils of a wide variety of other tetrapods, both herbivores and carnivores, including early precursors to the line that gave rise to mammals, have been found in this zone (MacRae, 1999). There are very few records of vertebrate fossils in the part of the Tapinocephalus Assemblage Zone covered by the Study Area, and what has been found is sparse but diverse, so anything found would be of great interest (J. Almond pers. comm.).

5. Impact Identification and Assessment

Infrastructure development, particularly new road cuttings and excavations for foundations, provides a positive opportunity for palaeontology by exposing fresh rock. This constitutes a positive, direct impact if the proposals for mitigation are followed.

5.1 Waterford, Tierberg and Fort Brown Formations (Ecca Group)

The Waterford Formation crops out only in a hilly area in the south. Excavations into these sandstones and shales may expose fresh slabs with trace fossils and plant remains. The magnitude of the impact is expected to be low as these characteristic fossils are plentiful elsewhere in this formation. This is true also for more the more spatially limited outcrops of the Tierberg and Fort Brown Formations even further south. The overall significance for these formations is thus expected to be minor to negligible.

5.2 Abrahamskraal Formation (Beaufort Group)

The Abrahamskraal Formation underlies most of the Study Area. New road cuttings and any excavations for foundations or road metal will produce fresh rock, any of which may contain important fossils, particularly terrestrial vertebrates. It is not possible to predict the locations of such fossils, which to date have been few (Theron, 1983). Some localities at which vertebrate fossils have been found are marked on the 1:250 000 Geological Map (Sheet 3220 Sutherland), but these are north east of the Study Area. Given that the base of the Beaufort Group has been redefined relatively recently (MacRae, 1999), the lower horizons of the Abrahamskraal Formation are a potential source of scientifically very important fossils. This gives rise to a paradoxical situation in which the likelihood of finding fossils appears to be low, but the importance if they are found through specialist mitigation would be high to very high.

6. Mitigation of Potential Impacts

All the geological horizons in the Study Area are potentially fossiliferous. Consequently, all excavations, whether for road cuttings or foundations, may reveal fresh fossiliferous rock. There is a low but significant likelihood of important new discoveries in the Abrahamskraal Formation. Road cuttings, particularly into hill slopes for access roads to the hill tops where wind turbines would be located, should be investigated by a suitably qualified and experienced Karoo palaeontologist. Any substantial excavation exposing fresh bedrock, like borrow pits, similarly should be investigated palaeontologically.

The likelihood of encountering Cenozoic fossils in valley fill sediments is considered to be low, but if excavations for infrastructure take place in the Ekkraal or Wilgebosrivier valleys, there is a possibility of fossil mammalian bones being encountered. In this case the South African Heritage Resources Agency will have to be notified immediately. The developers, site managers, and any operators of excavation equipment, need to be alerted to this possibility.

If any fossil material is encountered, the palaeontologist must be given sufficient time and access to resources to recover at least a scientifically representative sample for further study. If it cannot be studied immediately, the costs of housing the material should be borne by the developers.

7. Conclusion and Recommendations

All the geological horizons in the Study Area are potentially fossiliferous, and hence ideally all excavations for whatever purpose should be checked by a suitably qualified palaeontologist. If this is unfeasible, then at least all road cuttings and borrow pits should be investigated for fossil material. If fossil material is encountered, the palaeontologist must be given sufficient time and access to resources to recover a scientifically representative sample for further study. If this recommendation is followed, then from a palaeontological point of view, the development of the proposed Roggeveld wind farm will constitute a positive intervention, providing greater insight into the palaeontological heritage of South Africa.

8. References

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