SiVEST SA (PTY) LTD

PROPOSED CONSTRUCTION OF THE KAREE WIND ENERGY FACILITY, BATTERY ENERGY STORAGE SYSTEM (BESS) AND ASSOCIATED GRID INFRASTRUCTURE, NEAR TOUWSRIVIER, WESTERN CAPE PROVINCE, SOUTH AFRICA

Palaeontological Heritage Report

DFFE Reference:	**TBA**
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PROPOSED CONSTRUCTION OF THE KAREE WIND ENERGY FACILITY, BATTERY ENERGY STORAGE SYSTEM (BESS) AND ASSOCIATED GRID INFRASTRUCTURE, NEAR CERES, WESTERN CAPE PROVINCE, SOUTH AFRICA

PALAEONTOLOGICAL HERITAGE REPORT

EXECUTIVE SUMMARY

South Africa Mainstream Renewable Power Developments (Pty) Ltd is proposing to develop the Karee WindEnergy Facility (WEF), Battery Energy Storage System (BESS) and associated grid infrastructure on a site in the Ceres Karoo located approximately 18km north of Touwsrivier in the in the Cape Winelands District Municipality, Western Cape Province. The WEF will comprise up to twenty seven (27) wind turbines with a maximum total energy generation capacity of up to approximately 140MWac. The electricity generated will be fed into the national grid *via* a 132kV overhead power line to the existing Kappa Substation in the Ceres Karoo. The Karee WEF, BESS and grid connection project areas lie within the Komsberg Renewable Energy Development Zone (REDZ 2).

The Karee WEF and grid connection project areas are underlain by several basinal to shallow marine sedimentary formations of the Witteberg Group (Cape Supergroup), Dwyka Group and Ecca Group (Karoo Supergroup) of Mid to Late Palaeozoic age. All these units are potentially fossiliferous but only two – the Early Carboniferous Waaipoort Formation and the Early Permian Whitehill Formation – are generally regarded as of high palaeosensitivity due to their record of well-preserved fish, mesosaurid reptiles, crustaceans and plant fossils in the Tanqua - Ceres Karoo region and elsewhere. A recent two-day palaeontological field survey shows that the Waaipoort Formation is very poorly exposed within the WEF project area, although potentially fossiliferous phosphatic carbonate concretions do occur here, while the uppermost several meters of the Whitehill Formation are intensely weathered. The only fossil remains recorded within the WEF and grid connection project areas comprise (1) sparse diagenetic concretions within the Waaiport Formation containing poorly-preserved fish and plant remains, (2) occasional stromatolitic carbonate erratic clasts within the Dwyka Group and (3) low-diversity, poorly-preserved trace fossil assemblages in the Collingham Formation. These fossils occur widely within the outcrop areas of the formations concerned and, given their poor preservation, are not of high scientific interest or conservation value. Desktop reviews of several previous palaeontological assessment reports relevant to the grid connection project area (*e.g.* Almond 2010b, 2016e) show that the Dwyka Group bedrocks here are likewise of low palaeosensitivity with no significant fossil sites recorded within the two grid corridors under consideration.

As a consequence of (1) the paucity of irreplaceable, unique or rare fossil remains within the WEF and grid connection project areas, as well as (2) the extensive superficial sediment cover overlying most potentially-fossiliferous bedrocks here, the overall impact significance of the construction phase of the proposed Karee WEF, BESS and grid connection regarding legally-protected palaeontological heritage resources is assessed as ***LOW*** (*negative status*), both with and without mitigation. This assessment applies equally to all layout alternatives and grid connection options under consideration. There is therefore no preference on palaeontological heritage grounds for any specific layout (*e.g.,* location of on-site substation, construction laydown area, grid connection corridor) among those under consideration. No significant further impacts on fossil heritage are anticipated during the operational and decommissioning phases of the renewable energy developments. The No-Go alternative (*i.e.,* no WEF / grid development) would probably have a neutral impact on palaeontological heritage.

No palaeontological High Sensitivity or No-Go areas have been identified within the WEF, BESS and grid connection project areas. None of the recorded fossil sites lies within the development footprint as currently defined. Pending the potential discovery of significant new fossil material here during the construction phase, no specialist palaeontological monitoring or mitigation is recommended for these developments.

Inevitable loss of some fossil heritage during the construction phase may be - at least partially - offset by an improved understanding of local palaeontological heritage through professional recording and mitigation of any significant new fossil finds (This may be considered as a *positive* impact).

Due to the generally low palaeosensitivity of the Ceres Karoo as a whole, anticipated cumulative impacts of the known renewable energy projects proposed or authorised in the region are assessed as ***LOW*** *(negative)* with and without mitigation. It is concluded that, as far as fossil heritage resources are concerned, the proposed Karee WEF, BESS and grid connection projects, whether considered individually or together, will not result in any unacceptable loss or impact considering all the renewable energy projects proposed in the area. This analysis only applies *provided that* all the proposed monitoring and mitigation recommendations made for the other renewable energy projects proposed or authorised in the Ceres Karoo are fully and consistently implemented.

Recommended mitigation:

(1) The Environmental Site Officer (ESO) should be made aware of the possibility of important fossil remains (bones, teeth, fish, petrified wood, plant-rich horizons *etc*) being found or unearthed during the construction phase of the development.
(2) Monitoring for fossil material of all major surface clearance and deeper (> 1m) excavations by the Environmental Site Officer on an on-going basis during the construction phase is therefore recommended.

(3) Significant fossil finds should be safeguarded and reported at the earliest opportunity to Heritage Western Cape for recording and sampling by a professional palaeontologist.
(4) A protocol for Chance Fossil Finds is appended to this report (Appendix 3). These recommendations must be included within the Environmental Management Programmes (EMPrs) for the Karee WEF, BESS and grid connection developments.

Conclusion

There are no fatal flaws in the Karee WEF, BESS and grid development proposals as far as fossil heritage is concerned. Provided that the recommended palaeontological monitoring and mitigation measures are followed through, residual impacts for the Karee WEF, BESS and grid projects are rated as **LOW***.* There are no objections on palaeontological heritage grounds to authorization of the proposed Karee WEF and the associated grid connection.

This palaeontological impact assessment - including the tables provided in Sections 6 and 7 of the report – together with recommendations for the Environmental Management Programme apply to the final proposed layouts of the Karee WEF (with refined buildable areas as shown in Figure 51 at the end of this report) and the associated Grid Connection.

NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (ACT NO. 107 OF 1998) AND ENVIRONMENTAL IMPACT REGULATIONS, 2014 (AS AMENDED) - REQUIREMENTS FOR SPECIALIST REPORTS (APPENDIX 6)

Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	Section of Report
1. (1) A specialist report prepared in terms of these Regulations must contain- a) details of- i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	**1.2 & Appendix 1**
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	**Appendix 5**
c) an indication of the scope of, and the purpose for which, the report was prepared;	**1.1**
(cA) an indication of the quality and age of base data used for the specialist report;	**1.3.1.**
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	**5**
d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	**1.3.1.**
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	**1.3.1.**
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	**3.2 & 6**
g) an identification of any areas to be avoided, including buffers;	n/a
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	**Error! Reference source not found.** Appendix 4
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	**2**
j) a description of the findings and potential implications of such findings on the impact of the proposed activity, (including identified alternatives on the environment) or activities;	**5,6, & 7**

k) any mitigation measures for inclusion in the EMPr;	**8 & Appendix 3**
l) any conditions for inclusion in the environmental authorisation;	**8**
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	**8 & Appendix 3**
n) a reasoned opinion- i. (as to) whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	**9**
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	**n/a**
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	**n/a**
q) any other information requested by the competent authority.	None to date
2) Where a government notice *gazetted* by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	-

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PALAEONTOLOGICAL HERITAGE REPORT

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List of Abbreviations

amsl	above mean sea level
DFFE	Department of Forestry, Fisheries and the Environment
ECO	Environmental Control Officer
EMPr	Environmental Management Programme
ESO	Environmental Site Officer
HWC	Heritage Western Cape
Ma	millions of years ago
PIA	palaeontological heritage impact assessment
SAHRA	South African Heritage Resources Agency
SAHRIS	South African Heritage Resources Information System

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PALAEONTOLOGICAL HERITAGE REPORT

1. INTRODUCTION

South Africa Mainstream Renewable Power Developments (Pty) Ltd (hereafter referred to as “Mainstream”), has appointed SiVEST SA (Pty) Ltd (hereafter referred to as “SiVEST”) to undertake the required Basic Assessment (BA) Processes for the proposed construction of the 140MWac Karee Wind Energy Facility (WEF), Battery Energy Storage System (BESS), Grid Connection and associated infrastructure near Touwsrivier in the Witzenberg Local Municipality (Cape Winelands District), Western Cape Province.

The overall objective of the development is to generate electricity by means of renewable energy technology capturing wind energy to feed into the National Grid.

It is anticipated that the proposed Karee WEF will comprise twenty seven (27) wind turbines with a maximum total energy generation capacity of up to approximately 140MWac. The electricity generated by the proposed WEF development will be fed into the national grid *via* a 132kV overhead power line.

In terms of the Environmental Impact Assessment (EIA) Regulations, which were published on 04 December 2014 [GNR 982, 983, 984 and 985) and amended on 07 April 2017 [promulgated in Government Gazette 40772 and Government Notice (GN) R326, R327, R325 and R324 on 7 April 2017], various aspects of the proposed development are considered listed activities under GNR 327 and GNR 324 which may have an impact on the environment and therefore require authorisation from the National Competent Authority (CA), namely the Department of Forestry, Fisheries and the Environment (DFFE), prior to the commencement of such activities. Specialist studies have been commissioned to assess and verify the project under the new Gazetted specialist protocols.

The proposed WEF, BESS and associated grid infrastructure is located within the Komsberg Renewable Energy Development Zone (REDZ 2), as published in terms of Section 24(5) of the National Environmental Management Act, 1998 (NEMA) in GN R114 of 16 February 2018. A BA process as contemplated in terms of regulation 19 and 20 of the EIA Regulations, 2014, is required for the authorization of this large scale WEF. Accordingly, a BA process as contemplated in terms of the EIA Regulations (2014, as amended) is being undertaken in respect of the proposed WEF project.

Grid connection infrastructure for the WEF will be subject to a separate BA Process as contemplated in terms of regulation 19 and 20 of the Environmental Impact Assessment Regulations, 2014, which is currently being undertaken in parallel to the WEF BA process.

1.1 Terms of Reference

The present combined desktop and field-based Palaeontological Impact Assessment (PIA) report assesses potential impacts to palaeontological heritage resources that may result from the proposed Karee WEF, BESS and its associated grid connection. It will contribute to the over-arching Heritage Impact Assessments, co-ordinated by PGS Heritage and SiVEST Environmental Division, as part of the two separate BA processes that are being conducted for these developments as well as to the relevant Environmental Management Programmes (EMPrs).

1.2 Specialist Credentials

The author, Dr John Almond, is a specialist palaeontologist who has over 40 years of experience in palaeontological research and teaching in Europe, South Africa and elsewhere. He also has more than 20 years of experience in the palaeontological heritage impact assessment world in the RSA and has been involved with numerous PIAs in the Ceres Karoo region and elsewhere (Please see Appendix 1 for a short Specialist CV).

1.3 Assessment Methodology

1.3.1 Information sources

The desktop and field-based palaeontological heritage study of the Karee WEF, BESS and associated grid connection project areas was based on the following information resources:

1. A detailed project outline, kmz files, screening report and maps provided by SiVEST Environmental Division and PGS Heritage;

2. A desktop review of:
   (a) the relevant 1:50 000 scale topographic maps (3319BB Inverdoorn, 3320 AA Brewelsfontein) and the 1:250 000 scale topographic maps 3220 Ladismith and 3319 Worcester),
   (b) Google Earth© satellite imagery,
   (c) published geological and palaeontological literature, including 1:250 000 geological maps (3220 Ladismith, 3319 Worcester) and relevant sheet explanations (Theron *et al.* 1991, Gresse & Theron 1992) as well as

(d) several previous and fossil heritage (PIA) assessments for renewable energy and transmission line projects in the Ceres Karoo region near Touwsrivier by the author and colleagues (*e.g.,* Almond 2010a-c, 2015, 2016a-b, 2018, 2020a-d, Almond 2022, Butler 2018).

3. The author's field experience with the formations concerned and their palaeontological heritage (*cf* Almond & Pether 2008 and PIA reports listed in the References); and

4. A two-day field assessment of the Karee WEF project area, including portions of all land parcels involved, by the author and an experienced field assistant (Ms Madelon Tusenius, *Natura Viva* cc), during the period 4 to 9 December 2020. Sectors of the Grid Connection project area lying outside the WEF project area itself were *not* re-surveyed but are treated here on a desktop level. This is because the areas concerned have already been well-covered by previous field-based palaeontological heritage studies for earlier renewable energy and transmission line projects (see References under Almond and Butler, especially Almond 2010b, 2016e) and are therefore considered to be well-understood as well as generally of low palaeosensitivity.

The season in which the site visit took place has no critical bearing on the palaeontological study.

1.3.2 Study approach

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

The focus of palaeontological field assessment is not simply to survey the development footprint or even the development area as a whole (e.g., farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present

(N.B. Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, fresh (*i.e.,* unweathered) and include a large fraction of the stratigraphic unit concerned (e.g., formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Consolidated as well as uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the field study where they are well-represented in the study area. It is occasional practice for impact palaeontologists to collect representative, well-localised (*e.g.,* GPS and stratigraphic data) samples of fossil material during field assessment studies. In order to do so, a fossil collection permit from Heritage Western Cape (HWC) is required and all fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

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

Given 1) the large project areas concerned with the Karee WEF project and (2) the extensive superficial sediment cover in this region of the Ceres Karoo, the palaeontological heritage field study largely entailed the examination of selected, representative, potentially fossiliferous sites with good bedrock exposure – especially along drainage lines as well as steeper hillslopes and erosion gullies. A representative selection of good exposures and sections through Late Caenozoic alluvial deposits were also examined. It is emphasized that it is simply not practicable to record all, or even a major portion, of fossil sites within such a large area within the course of a few days' fieldwork, and that the occurrence of fossils at surface in the Ceres Karoo has a large element of unpredictability. Several fossil sites were discovered simply by chance. It is therefore inevitable that the recent site visit can only hope to locate a representative subsample of surface fossil sites present within the WEF project areas. The absence of recorded sites within an area does *not* therefore mean that palaeontologically significant material is not present there, either on or beneath the ground surface.

2. ASSUMPTIONS AND LIMITATIONS

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

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

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

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, as in the case of the present study.

In the case of the Karoo WEF project area bedrock exposure may be good in highly-dissected, hilly regions (mostly outside and south of the project footprint, *e.g.* Bontberg range) but is highly constrained by extensive superficial deposits in the areas of low relief that make up most of the project area, as well as, to a lesser extent, by shrubby karroid vegetation. The project area is very extensive (*c*. 11 841ha) and with comparatively few access roads. Unavoidably, only a small fraction of the entire project area could be surveyed on foot within the time available (two days).

Nevertheless, sufficient bedrock exposures – including a few of excellent quality - were examined during the course of the two-day field study to assess the palaeontological heritage sensitivity of the main rock units represented within the Karee WEF, BESS and grid connection study area. As previously noted, sectors of the grid connection project area lying outside the WEF project area are treated at a desktop level in the present report since this area and the rock units concerned have already been well-covered by previous PIA reports by the author and colleagues (See References). Confidence levels for this impact assessment are accordingly rated as *medium*.

3. TECHNICAL DESCRIPTION

3.1 Project Location

The proposed Karee WEF, BESS and associated grid infrastructure project areas are located approximately 18km north and 60 km east-northeast respectively of Ceres and Touwsrivier in the Western Cape Province and lie within the Witzenberg Local Municipality, in the Cape Winelands District Municipality (Figure 1).

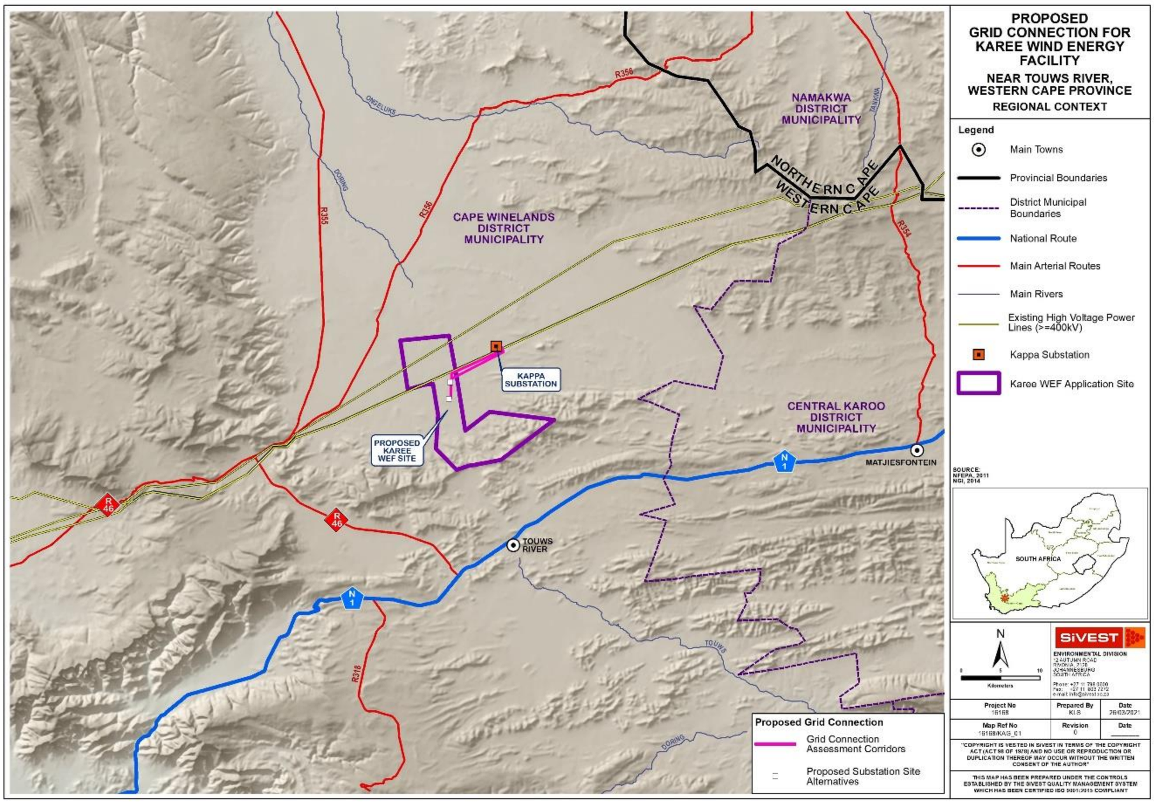

Figure 1: Regional Context Map for the proposed Karee WEF and associated grid connection near Touwsrivier, Western Cape.

3.1.1 WEF

The WEF application site as shown on the locality map below (**Figure 2**) is approximately 11 841 hectares (ha) in extent and incorporates the following farm portions:

- Farm Sadawa No 239[1]
- Farm Tierberg No 258; and
- Farm Voetpads Kloof No 253.

[1] *Note whilst Mainstream will no longer be proceeding with turbines on Sadawa 239 (northernmost land parcel), it will remain part of the Development Area / Envelop but not the Development Footprint.*

A smaller buildable area (1753.1 ha) has, however, been identified as a result of a preliminary suitability assessment undertaken by Mainstream and this area is likely to be further refined with the exclusion of sensitive areas determined through various specialist studies being conducted as part of the BA process (**Figure 2**).

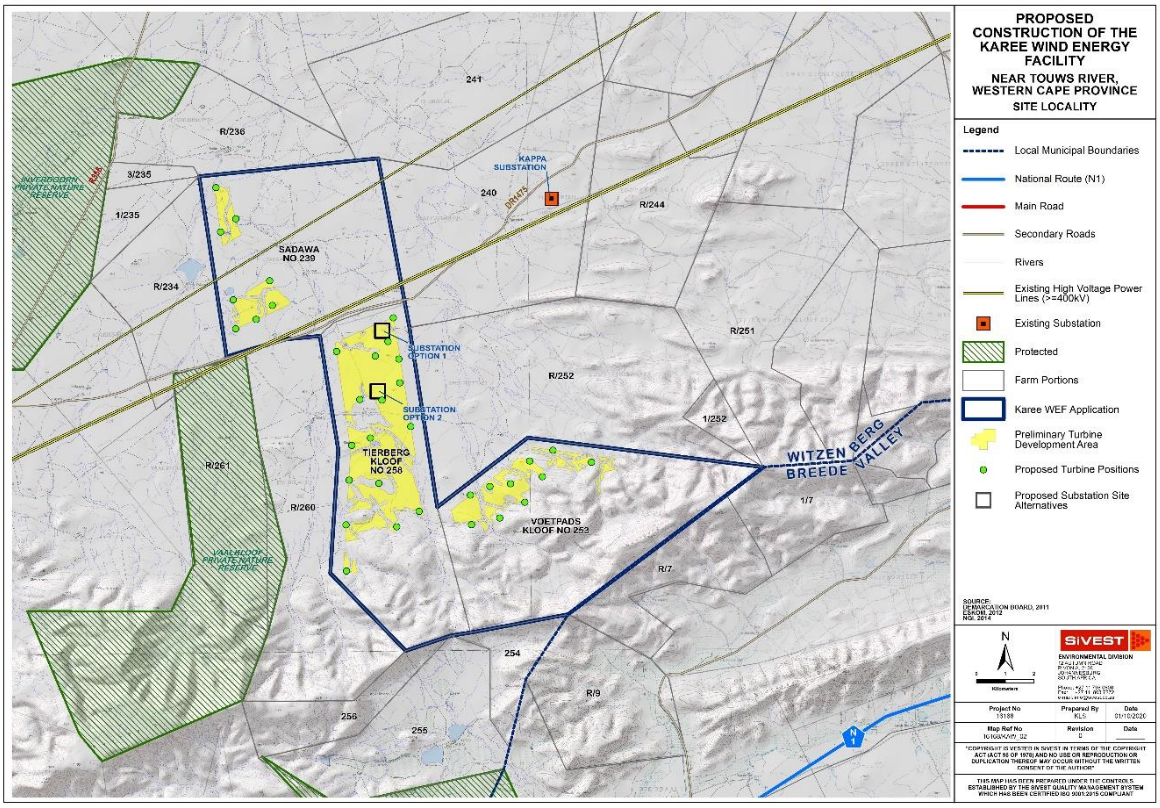

Figure 2: Karee WEF Site Locality in the Ceres Karoo region near Touwsrivier, Western Cape.

3.1.2 Grid Connection

At this stage, it is proposed that the 132kV power lines will connect the Karee WEF on-site substation to the national grid *via* the existing Kappa Substation situated approximately 5 km due east of the WEF project area (**Figure 3**).

The grid incorporates the following properties:

- Farm Sadawa No 239;
- Farm Tierberg No 258;
- Farm Voetpads Kloof No 253; and
- Farm Platfontein No 240.

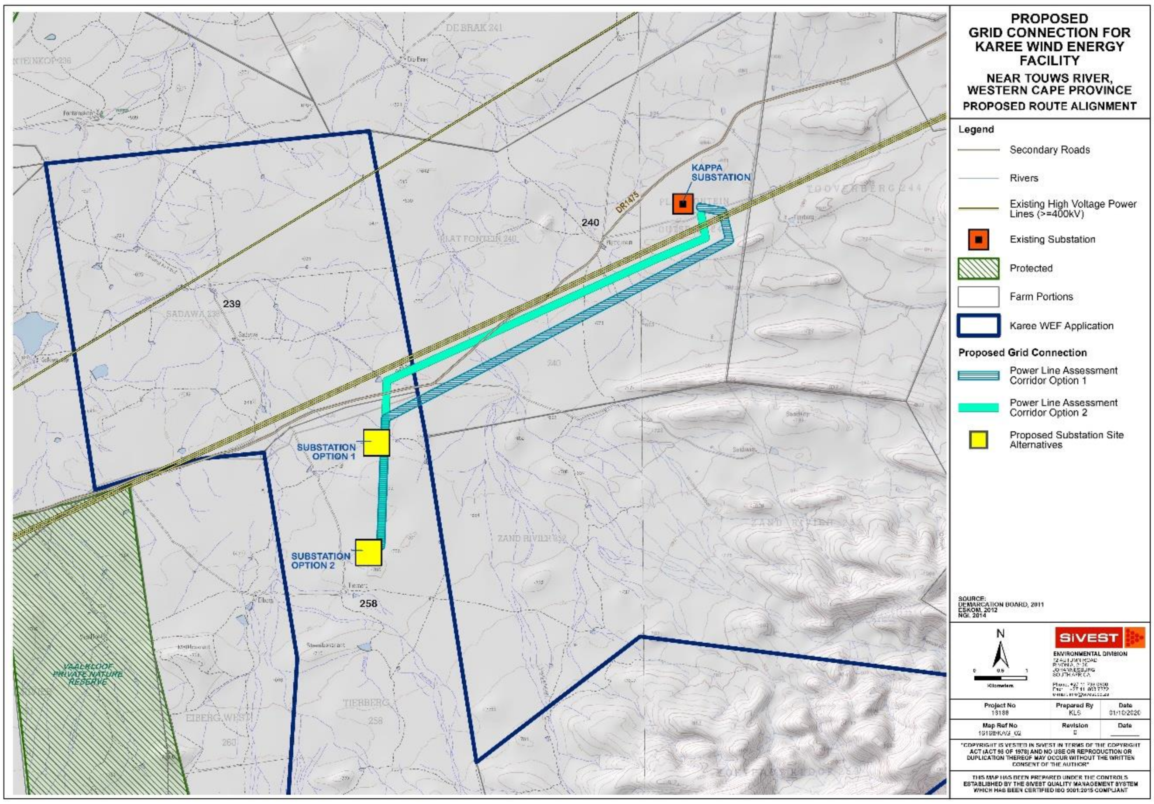

Figure 3: Alternative 132kV Power Line Route Alignments to the existing Kappa Substation from the proposed Karee WEF.

3.2 Project Description

At this stage it is anticipated that the proposed Karee WEF will comprise up to twenty seven (27) wind turbines with a maximum total energy generation capacity of up to approximately 140MWac. The electricity generated by the proposed WEF development will be fed into the national grid *via* a 132kV overhead power line. The 132kV overhead power line will however require a separate EA and is subject to a separate BA process, which is currently being undertaken in parallel to the WEF BA process.

3.2.1 Wind Farm Components

In summary, the proposed Karee WEF will include the following components:

- Up to 27 wind turbines, with a maximum export capacity of approximately 140MW. The final number of turbines and layout of the WEF will, however, be dependent on the outcome of the Specialist Studies conducted during the BA process;
- Each wind turbine will have a hub height of between 120m and 200m and rotor diameter of up to approximately 200m;

- Permanent compacted hardstanding areas / platforms (also known as crane pads) of approximately 100m x 100m (total footprint of approx. 10000m^2) per turbine during construction and for on-going maintenance purposes for the lifetime of the proposed development;
- Each wind turbine will consist of a foundation of up to approximately 30m in diameter. In addition, the foundations will be up to approximately 3m in depth;
- Electrical transformers (690V/33kV) adjacent to each wind turbine (typical footprint of up to approximately 2m x 2m) to step up the voltage to between 11kV and 33kV;
- One (1) new 11kV - 33/132kV on-site substation consisting of two (2) portions: IPP portion / yard (33kv portion of the shared 33kv/132kv portion) and an Eskom portion (132kv portion of the shared 33kv/132kv portion) including associated equipment and infrastructure, occupying a total area of approximately 25ha (i.e., 250 000m2) i.e., 15.5 ha for the IPP Portion and 15.5 ha for the Eskom Portion. The Eskom portion will be ceded over to Eskom once the IPP has constructed the onsite substation. The necessary Transfer of Rights will be lodged with DFFE when required;
- A Battery Energy Storage System (BESS) will be located next to the IPP portion / yard of the shared onsite 33/132kV substation and will be included as part of the 15.5ha. The storage capacity and type of technology would be determined at a later stage during the development phase, but most likely comprise an array of containers, outdoor cabinets and/or storage tanks;
- The wind turbines will be connected to the proposed substation *via* 11 to 33kV underground cabling and overhead power lines.
- Road servitude of 8m and a 20m underground cable or overhead line servitude.
- Internal roads with a width of up to approximately 5m wide will provide access to each wind turbine. Existing site roads will be used wherever possible, although new site roads will be constructed where necessary. Turns will have a radius of up to 50m for abnormal loads (especially turbine blades) to access the various wind turbine positions. It should be noted that the proposed application site will be accessed via the DR1475 District Road and DR1475, MR316 and MR319 WCG provincial Roads;
- One construction laydown / staging area of up to approximately 3ha to be located on the site identified for the substation. It should be noted that no construction camps will be required in order to house workers overnight as all workers will be accommodated in the nearby town;
- Operation and Maintenance (O&M) buildings, including offices, a guard house, operational control centre, O&M area / warehouse / workshop and ablution facilities to be located on the site identified for the substation. This will be included in the 33kv portion/yard of the substation area i.e.,15.5 ha of the IPP portion of the onsite substation
- A wind measuring lattice (approximately 120m in height) mast has already been strategically placed within the wind farm application site in order to collect data on wind conditions;
- No new fencing is envisaged at this stage. Current fencing is standard farm fence approximately 1-1.5m in height. Fencing might be upgraded (if required) to be up to approximately 2m in height; and
- Water will either be sourced from existing boreholes located within the application site or will be trucked in, should the boreholes located within the application site be limited.
- Optic fibre overhead or underground line from the Adamskraal Substation to the proposed on-site substation.

3.2.2 Grid Connection Components

Two (2) options have been identified for the 33kv portion/yard of the shared 33/132kV onsite substation:

- **Option 1:** The location of the 33kv portion/yard of the shared 33/132kV onsite substation is located near an existing gravel road, making access to the onsite substation easier. (Preferred).
- **Option 2:** The location of the 33kv portion/yard of the shared 33/132kV onsite substation is located central to the land parcel, thereby reducing the energy loss associated with the wind turbines.

Two (2) grid corridors have been identified for the 132kv overhead line and 132kv portion/yard of the shared 33kv/132kv onsite substation – these applications will be prepared and assessed under separate BA application processes.

- **Option 1:** The line from the 132kv portion/yard of the 33/132kv onsite substation moves in a north easterly direction for about 7.5 km, then turns sharply in a north north westerly directly for about 0.5km and then turns left for about 0.5km in a west north westerly direction before terminating at the Kappa MTS. The associated grid connection route to the Kappa Main Transmission Substation is shorter i.e., approximately 8.5km – 10.5km in length (Preferred).
- **Option 2:** The line from the 132kv portion/yard of the 33/132kv onsite substation moves in a northerly direction for about 3.2km, turning right in a north easterly direction for about 6.7 km and then left for about 0.5km in a northerly direction before terminating at the Kappa MTS. The associated grid connection route to the Kappa Main Transmission Substation is slightly longer i.e., approximately 10.4km to 11.4km in length.

3.3 WEF BA ALTERNATIVES

3.3.1 Location Alternatives

Several key aspects played a role in determining the location of the proposed Karee WEF, BESS and shared 33/132kV on-site substation (this application) and associated 132kV Power Line development. These include resource, grid availability and capacity, environmental, competition, topography and access.

The Project Sites are micro-sited in terms of environmental sensitivities and a suitable development area identified. Thus, the development area proposed avoids sensitive environmental areas ensuring the development has the least possible impact on the land on which it will be built.

Only one Project Site was identified, however, within the development area itself, two (2) locations of the proposed 33/132kv shared on-site substation are considered. The on-site substation will be a step-up substation and will include an Independent Power Producer (IPP) portion (33kv portion/yard of the shared 33/132kv onsite substation) and an Eskom portion (132kv portion/yard of the shared 33kv/132kv onsite substation – this portion will be ceded to Eskom once the onsite substation is constructed and the necessary transfer of rights undertaken), hence the IPP portion (33kv portion/yard of the shared 33/132kv onsite substation) has been included in the WEF BA process (i.e. this application) and the Eskom portion (132kv portion/yard of the shared 33kv/132kv onsite substation) and associated 132kv overhead line, included in grid connection infrastructure BA process. This will facilitate an ease of transfer over to Eskom once the onsite substation is constructed.

3.3.2 Technology Alternatives

The choice of technology selected for the Karee WEF is based on environmental constraints and technical and economic considerations. No other technology alternatives are being considered as wind energy facilities are more suitable for the site than other forms of renewable energy due to the high wind resource.

The size of the wind turbines will depend on the development area and the total generation capacity that can be produced as a result. The choice of turbine to be used will ultimately be determined by technological and economic factors at a later stage.

3.3.3 Layout Alternatives

Layout alternatives have been considered and assessed as part of the BA process. The alternatives which have been considered and assessed as part of the grid connection infrastructure application include two (2) substation site alternatives (as discussed above) and two (2) power line corridor route alignment alternatives. All alternatives have been comparatively assessed by the respective specialists and assessed against the 'no-go' alternative (i.e., status quo).

3.3.4 No-Go Alternative

The 'no-go' alternative is the option of not undertaking the proposed WEF infrastructure project. Hence, if the 'no-go' option is implemented, there would be no development. This alternative would result in no environmental impacts from the proposed project on the site or surrounding local area. It provides the baseline against which other alternatives are compared and will be considered throughout the report.

3.4 GRID CONNECTION BA ALTERNATIVES

The grid connection infrastructure proposals include two substation site alternatives, each of which are 25 hectares in extent, and two power line route alignment alternatives (**Figure 3**). These alternatives will be considered and assessed as part of the BA process and will be amended or refined to avoid identified environmental sensitivities.

3.4.1 Route Alternatives

All power line route alignments will be assessed within a 150m wide assessment corridor (75m on either side of power line).

Two (2) grid corridors have been identified for the 132kv overhead line and 132kv portion/yard of the shared 33kv/132kv onsite substation. These are being assessed in a separate Grid Infrastructure BA Process:

- Option 1: The line from the 132kv portion/yard of the 33/132kv onsite substation moves in a north easterly direction for about 7.5 km, then turns sharply in a north north westerly directly for about 0.5km and then turns left for about 0.5km in a west north westerly direction before terminating at the Kappa MTS. The associated grid connection route to the Kappa Main Transmission Substation is shorter i.e., approximately 8.5km – 10.5km in length (Preferred).
- Option 2: The line from the 132kv portion/yard of the 33/132kv onsite substation moves in a northerly direction for about 3.2km, turning right in a north easterly direction for about 6.7 km and then left for about 0.5km in a northerly direction before terminating at the Kappa MTS. The associated grid connection route to the Kappa Main Transmission Substation is slightly longer i.e., approximately 10.4km to 11.4km in length.

Power line corridors are being assessed to allow flexibility when determining the final route alignment. As mentioned, the power line corridors which are being assessed are up to approximately 300m wide (150m on either side of power line) to allow for flexibility to route the power line within the assessed corridor. Based on the specialist assessments, a few potentially sensitive and/or 'no-go' areas have been identified within the application site. These areas were used to inform the development area for the substation within the application site as well as the routing of the power line corridors. The identified sensitive / 'no-go' areas were also used to perform a comparison of substation site alternatives and the route alternatives. The substation site alternatives and power line route alternatives and results of the comparative assessment of alternatives have been discussed in more detail below.

3.4.2 No-Go Alternative

The 'no-go' alternative is the option of not undertaking the proposed grid connection infrastructure projects. Hence, if the 'no-go' option is implemented, there would be no development. This alternative would result in no environmental impacts from the proposed project on the site or surrounding local area. It provides the baseline against which other alternatives are compared and will be considered throughout the report.

4. LEGAL REQUIREMENT AND GUIDELINES

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

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

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

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

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

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

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

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

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

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

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

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

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

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

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

Where Preconstruction of Construction Phase mitigation, comprising palaeontological recording and collection of fossil material and associated geological data, is required as a condition of Environmental Authorization, this must be carried out by a suitably qualified professional palaeontologist under a Fossil Collection Permit issued by the relevant Heritage Resources Management Agency (in the present case, a

Work Plan would be required by Heritage Western Cape, Cape Town). The fossil material collected must be curated in an approved repository (museum / university collection). Standards for palaeontological reporting and mitigation in the RSA have been established by Heritage Western Cape (2016, 2021) and SAHRA (2013). A tabulated Chance Fossil Finds Protocol which must be implemented throughout the Construction Phase of the WEF, and grid connection infrastructure projects is provided in Appendix 3 to this report.

5. DESCRIPTION OF THE RECEIVING ENVIRONMENT

This section of the PIA presents a short, illustrated overview of the geology and palaeontological heritage encountered within the Karee WEF project area, including the associated grid connection project area.

5.1 Geological context

The Karee WEF study area is located on the southern margins of a low-lying, semi-arid sector of the Great Karoo region known as the Ceres Karoo or southern Tanqua Karoo. It extends from the foot of the rugged, highly dissected Bontberg mountain range in the south (up to *c*. 1360 m amsl) - a component of the Cape Fold Mountains - into gently hilly terrain and gravelly vlaktes of the Ceres Karoo to the north, spanning the unpaved road from Karooport to Matjiesfontein. Away from the Bontberg range, topographic relief is generally moderate to low (Figures 4, 5-8), with elevations between 600 and 700 m amsl (above mean sea level). This northern area is largely underlain by readily-weathered, clay-rich sedimentary bedrocks and has experienced extensive, protracted denudation by post-Gondwana river systems during the Caenozoic Era. These rivers include tributaries of the Kolkies and Karee Rivers which feed into the Doringrivier further to the north. These drainage systems flow only intermittently today and are themselves tributaries of the ancient Tanqua River network that runs through the Tanqua Karoo to the northwest. Levels of bedrock exposure within the development footprint are generally poor, except along larger water courses and steeper hillslopes, because in most areas there is extensive cover by alluvial, eluvial and colluvial deposits (e.g., river conglomerates, grits and sands as well as surface gravels, soils) and by karroid bossieveld vegetation - Tanqua Karoo and Koedoesberg-Moordenaarskaroo bossieveld *plus* Tanqua Wash Riviere along drainage channels.

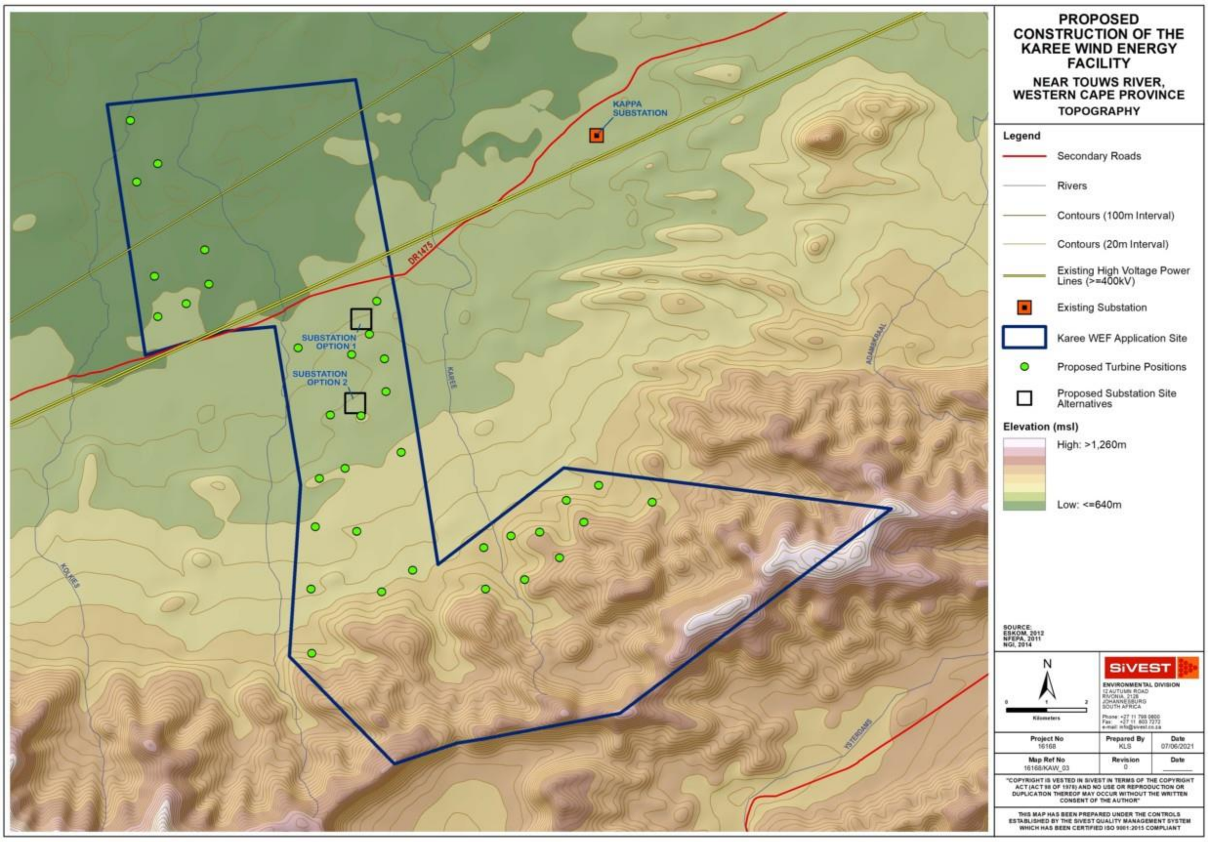

Figure 4: Topographic relief map of the Karee WEF project area.

The geology of the Karee WEF, BESS and grid connection project area is outlined on two adjoining 1: 250 000 geology sheets Worcester 3319 and Ladismith 3320 (Council for Geoscience, Pretoria) (Figure 9). In geological terms the Karee WEF study area straddles the boundary between Palaeozoic sediments of the Cape Supergroup (Thamm & Johnson 2006) and unconformably overlying Karoo Supergroup sediments along the south-western margin of the Main Karoo Basin of South Africa (Johnson *et al.* 2006) (Fig. 10). The bedrocks here have been deformed during the Permo-Triassic Cape Orogeny (mountain building event) and thus lie within, and towards the northern margin of, the Cape Fold Belt (CFB), just to the east of the Cape syntaxis (*i.e.,* junction of the N-S and E-W branches of the CFB). A total of sixteen or so mappable sedimentary rock units (*e.g.,* formations) are represented within the entire study area. However, only half of these will be directly impacted by the proposed WEF, since the development footprint will not extend into the main massif of older folded rocks within the core of the Bontberg range itself. Only those potentially fossil-bearing rock units that will be directly impacted by the WEF will be considered further in this report. The geology of these rock successions has been summarized in several previous illustrated PIA reports for the Ceres Karoo region such as Almond (2010b, 2010c, 2010d, 2015a, 2016a-e, 2018, 2020a-d, 2022, Butler 2018).

The rocky uplands of the Bonteberg range along the southern margins of the Karee WEF study area are built of several successive sedimentary formations of Middle to Late Devonian age that are assigned to the **Upper Bokkeveld Group** (Bidouw Subgroup) and the **Witteberg Group**. These rocks are strongly folded along

WSW-ENE axes and overturned towards the northwest (Figure 7). The northern flanks of the Bontberg range are deeply incised by several stream valleys or *klowe* including Windhoek, Seekoeigat se Kloof and Groothoek. Access to these upland areas, which will not be directly impacted by the proposed WEF development, is only on foot. The outcrops here of potentially-fossiliferous mudrock units within the Klipbokkop, Karoopoort and Wagen Drift Formations here appear on satellite images to be largely or entirely blanketed by quartzitic scree. Thick, shallow marine quartzites of the Late Devonian **Witpoort Formation** build the rugged, NW-facing flanks of the Bontberg range on Tierberg 258 and Voetpads Kloof 253 as well as several whale-backed WSW-ENE anticlinal ridges to the north of the mountain front. Many of the turbine positions in the southern sector of the WEF overlie this prominent-weathering rock unit. No horizons or lenses of Witpoort dark lagoonal mudrock facies were observed here; they are generally very poorly exposed. The gleaming white, ultra-quartzose **Perdepoort Member** of the Witpoort Formation is represented along the mountain front, locally showing well-developed karstic (solution) weathering features (Figure 8, Figure 12). Relicts of gently north-sloping, low elevation, gravel-strewn pediment surfaces can be seen planed across folded Witpoort Formation bedrocks (Figure 11). On the eastern portion of Zand Rivier 252 (*outside* and NE of the present project area) the Witpoort Formation quartzites are locally overlain by lenses of distinctive, massive-weathering, "dirty" sandstones (wackes) of the informally named "**Potdeksel Member"** (Figure 14). This facies has been interpreted as debris flow deposits (debrites) related to Late Devonian glacial episodes on Gondwana (*cf* Almond *et al.* 2002, 2022). The Potdeksel Member occurrences on Zand Rivier 252 are unusually extensive, apparently forming part of a single debris flow of lenticular cross-section that was well over 2 km wide. This special Witpoort facies is not well represented within the Karee WEF project area, however. Nevertheless, there are occurrences at the top of the Perdepoort Member succession here of greyish, impure quartzites with a peculiar wood-like foliated fabric - probably generated by soft-sediment deformation processes (and possibly by subglacial deformation) – which typically underlie Potdeksel Member debrites (Figure 13).

Non-marine sandstones and mudrocks of the upper Witteberg Group (**Lake Mentz Subgroup** of Early Carboniferous age) underlie much of the terrain between the Bontberg range and the dust road between Karoopoort and Matjiesfontein. The recessive-weathering, post-glacial mudrocks of the basal **Kweekvlei Formation** are almost nowhere seen at surface, except for thin-bedded, shoaling heterolithic packages exposed in stream banks just below the upper contact with the Floriskraal Formation. Good exposures of stacked upward-shallowing packages of the sandstone-dominated **Floriskraal Formation** are seen in the north-eastern part of Zand Rivier 252 (outside the project area) with poorer occurrences building low whaleback ridges further to the south on Tierberg 258 and on the northern margins of Voetpads Kloof 253 (Figure 15, Figure 16). The brown-weathering sandstones are tabular cross-bedded (palaeocurrents towards the NW) to horizontally laminated with occasional fine pebbly horizons and storm-generated hummocky or swaley cross-stratification towards the base. The mudrock-dominated **Waaipoort Formation** at the top of the Witteberg succession is mapped in small adjoining areas of Tierberg 258 and the neighbouring farm Zand Rivier 252 (Almond 2022, See Figure 17, Figure 18). These outcrop areas show very low relief with occasional low ridges of prominent-weathering, brownish-weathering wackes but almost no mudrock exposure. Most of the outcrop is mantled by sandy soils and sparse eluvial gravels of brownish wacke and fragments of greyish to black phosphatic carbonate concretions as well as by low *bossieveld* vegetation.

Permo-Carboniferous sediments of the **Karoo Supergroup** in the northern portion of the Karee WEF and grid study area are deformed into large-scale folds with SSW-NNE trending axes and show evidence of smaller-scale folds as well. However, compared with the older Cape Supergroup rocks to the south, levels of tectonic deformation are generally low, with gentle bedding dips of 5º to 20°. A tectonic cleavage may be well-developed within finer-grained mudrocks, especially towards the Bontberg range. No intrusions of the Karoo Dolerite suite are mapped within the study area.

Much of the northern and central portions of Sadawa 238 as well as hills on the northern part of Tierberg 258 are underlain by Late Carboniferous to Early Permian glacial-related sediments of the **Dwyka Group** (**C-Pd**) assigned to the **Elandsvlei Formation** (Figures 19 to 24). The Dwyka rocks here are often poorly exposed, with the exception of good outcrops of grey, clast-poor to clast-rich Dwyka tillite seen along major water courses such as the Eierberg se Kloof on Sadawa 238. Sphaeroidal, cannon-ball sized concretions of rusty-brown diagenetic corbonate are common in some horizons. The massive tillites often display well-developed tombstone weathering, possibly enhanced by karstification, which clearly developed before deposition of the overlying pervasive mantle of gravelly to sandy alluvial sediments, as well as local exfoliation with relict corestones. The alternation of late glacial and interglacial facies of the Dwyka Group can be picked out locally by contrasting shading on satellite images but thin-bedded, mudrock-rich interglacial beds are not well-exposed at surface here. Low hills and ridges of Dwyka rocks within the study area probably represent the coarser basal portion of several deglaciation cycles. Local accumulations of downwasted outsized erratics on Sadawa 238 include some spectacular faceted and striated boulders representing a wide range of exotic rock types (**Figure 21**, **Figure 22**). Sparse, elongate, quartz-veined lenses or irregular bodies of stratified, gritty to well-sorted, cross-bedded sandstones and quartzites with minor pebbly horizons embedded within the Dwyka tillites represent eskers or glacial outwash fans. They are often rimmed with an apron of downwasted quartzitic rubble (**Figure 23**).

The south-western corner of Sadawa 238 is underlain by basinal sediments of the Early Permian **Ecca Group** building a small elliptical outlier in the core of a syncline. Post-glacial mudrocks of the **Prince Albert Formation** generally form low-lying terrain of little relief that is blanketed in alluvial soils and fine surface gravels. The only reasonably good exposures encountered are of open-folded, silicified or ferruginised mudrocks and well-jointed cherty lenses and horizons (some possibly tuffitic) in the vicinity of Sadawa homestead (**Figure 25**, **Figure 26**). The overlying, pale-grey mudrocks of the **Whitehill Formation** are highly-weathered and very poorly exposed indeed; the outcrop area is almost entirely mantled by fine soils and surface gravels (**Figure 27**). No fresh mudrocks – which are typically highly carbonaceous and very dark grey to black – are observed at surface. It is noted that extensive deposits of secondary gypsum within the Whitehill Formation are commercially exploited on the farm Kolkies Rivier 234 adjoining Sadawa 238 on the western side. The lower Ecca Group synclinal core is occupied by greyish, resistant-weathering, silicified or cherty, highly tabular beds of the **Collingham Formation** (**Figure 28**). Blocky colluvial / eluvial gravels of grey, silicified mudrock here show up clearly as pale zones on satellite images and also cover most of the underlying Whitehill Formation outcrop.

As is apparent in satellite images, and also in the field, the Palaeozoic sedimentary bedrocks in the Ceres Karoo region are extensively blanketed by superficial deposits comprising colluvium (slope deposits such as scree and hillwash), eluvium (downwasted rock material), sheetwash and alluvial (river) sediments as well as silty, sandy and gravelly / rocky soils of mainly Quaternary to Recent age. Of these younger sediments, most are too thin to be mapped separately at 1: 250 000 scale.

A wide range of **Late Caenozoic alluvial deposits** are represented within the Karee WEF study area, especially in the central portion of Tierberg 258. Here large, coalescent alluvial fans were deposited by ancient drainage networks issuing from the Bontberg range – probably during more pluvial intervals in Late Tertiary and Quaternary times. Satellite images show relict pediment surfaces in this zone on Vaal Kloof Rivier 261, 6 km west of the WEF project area, as well as within the area on Voetpads Kloof 253 where a pediment surface cutting across the folded Witpoort Formation extends well to the north of the main Bontberg range (**Figure 11**). These surfaces are now intensely karstified and capped by coarse, rubbly, ferricretised downwasted pediment gravels (**Figure 12**, **Figure 33**). The Bontberg pediments may have also been originally capped by silcrete pedocretes, at least locally, since in some cases they appear on satellite images to be bordered by pale saprolite (*in situ* weathered bedrock). Comparable pediment surfaces capped by well-developed silcretes - since completely denuded - were probably also present on the northern portion of Tierberg 258. This would account for the extensive cobbly, subrounded, grey, ochreous and pale brown **silcrete gravels** recorded here, both at surface and eroding out from beneath cover sands, where they show abundant evidence of anthropogenic flaking, including probable ESA and MSA artefacts (**Figure 29**, **Figure 30**). These silcrete gravel occurrences (also including ferricretised and subordinate grey quartzite clasts) are of geological interest in so far as silcretes are not currently mapped along the southern margins of the Ceres Karoo.

Thick (several m) **alluvial fan deposits** on Tierberg 258 and Voetpands Kloof 253, where a substantial portion of the WEF infrastructure will be sited, are exposed in the banks of incised stream gullies bordering the Bontberg. They comprise coarse, poorly-sorted, semi-consolidated to unconsolidated gravels dominated by Witteberg Group quartzites and sandstones (often ferruginised) as well as alluvial sands (**Figure 31**, **Figure 32**). The semi-consolidated older gravels are locally very coarse and bouldery, suggesting very powerful stream flow in past times. Well-developed ochreous to khaki **ferricretes**, sometimes closely associated with calcretes, developed in regions of high water tables along water courses. Good examples are seen overlying Witpoort quartzites along Seekoiegat se Kloof (**Figure 34**). Streambed exposures of massive, semi-consolidated, orange-hued, gritty sands with dispersed “floating” gravel clasts and a distinctive polygonal cracking pattern *might* be debrites or inundates influenced by Pleistocene permafrost action (**Figure 37**, **Figure 38**). Thick, massive, unconsolidated sandy to silty sediments with dispersed gravels and subtle polygonal cracks might also be flood deposits dissected by more recent (Holocene) stream erosion. The younger fine-grained alluvium has been partially reworked by wind into orange-hued **aeolian dunes**, currently stabilised by vegetation and is often capped by fine eluvial gravels with abundant ferricrete clasts (**Figure 39**, **Figure 40**). Evenly-spaced, rounded *heuweltjies* feature prominently here on satellite images and are often secondarily calcretised at depth. The aeolian sands mantle the surface of the alluvial fans and have been blown northwards onto prominent rocky ridges. A wide range of downwasted (eluvial) and sheetwashed **surface gravels** as well as alluvial gravels are represented within the Karee WEF study area, a major control being bedrock geology (**Figure 41**, **Figure 42**). Some of the gravel clasts show polishing due to sand-blasting as well as dark, ferromagnesian desert varnish. Surface gravels overlying the Dwyka Group outcrop area vary from pebbles to boulders in size are typically highly polymict (many different lithologies - cherts, carbonates, quartzites, lavas, granites *etc*) reflecting the diverse origins of ice-transported glacial erratics with an admixture of clasts from the CFB (*e.g.,* pale grey quartzites, often flaked). Thin but extensive sheets of fine pebbly gravels overlying the Lower Ecca Group outcrop area are dominated by ferruginised (often desert varnished) and silicified mudrocks, cherts, vein quartz with rare blocks of silicified wood (or deceptively similar-looking quartz mineral lineation). Blocky quartzitic **colluvial gravels** (scree) of pale grey to orange-brown, ferruginised rubble overlie the Witpoort and Floriskraal Formations while silicified greyish mudrock blocks characterise much of the Collingham Formation outcrop area.

The grid connection project area (both corridor alternatives), extending from the on-site substation site within the Karee WEF eastwards to Kappa Substation, has been treated in several previous PIA reports by the author (e.g., Almond 2010b, 2016e) and is therefore only covered at desktop level in this report. The corridor traverses largely low-relief, gravelly to rocky terrain underlain by Dwyka Group bedrocks in addition to gravelly to sandy Late Caenozoic alluvial deposits on Zand Rivier 252 (see geological map **Figure 9**). Low, stepped rocky hillslopes in the SE corner of Sadawa 238 successive reflect deglaciation cycles within the Elandsfontein Formation (Dwyka Group). Good exposures of recessive-weathering, mudrock-dominated interglacial deposits are not well-exposed within the grid connection corridor. However, intermittent small exposures of post-glacial dropstone laminites are seen in roadside drainage gullies in the SW corner of Sadawa 238 (**Figure 24**) (Almond 2020c).

Illustrations of representative exposures of the various rock units represented within the Karee WEF, BESS and grid connection project areas are provided in **Figure 11 to Figure 42** below, together with explanatory figure legends. Several of these figures have been abstracted from a PIA report on an earlier version of the Karee WEF project area by Almond (2016d) supplemented by additional photos from the 2020 palaeontological site visit.

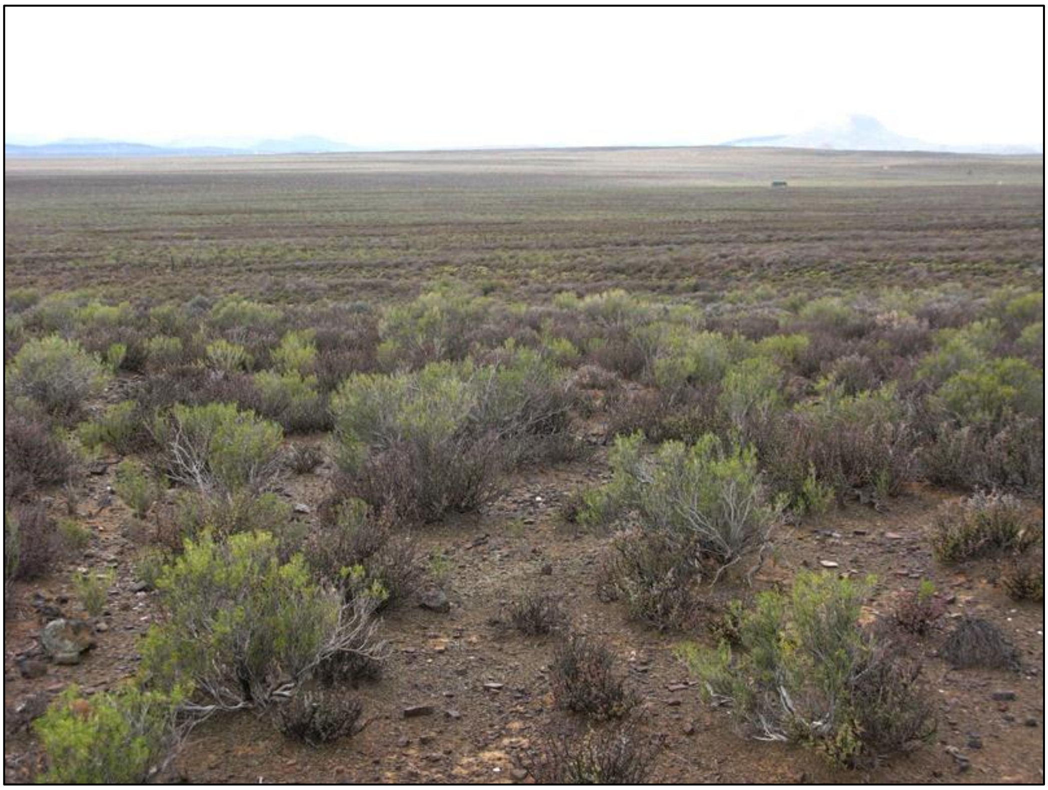

Figure 5: Low-relief terrain underlain by Karoo Supergroup sediments (Prince Albert Formation, Ecca Group) with cover by karroid bossieveld and skeletal gravelly soils in the northern portion of the Karee WEF project area (Sadawa 238).

Figure 6: Sandy to gravelly alluvial outwash sediments in the southern portion of the Karee WEF project area (Tierberg 258), looking southwards towards the rugged fold mountains of the Bontberg range.

Figure 7: Intensely folded Middle to Late Devonian sediments of the Witteberg Group exposed in Oranjekloof (Tierberg 258). Rock units stratigraphically below the Witpoort Formation (pale quartzites in middle ground) will not be impacted by the proposed WEF development.

Figure 8: View eastwards along the northern edge of the Bontberg on Voetpads Kloof 253. WEF infrastructure will be sited here on low, incised pediment surfaces planed across intensely folded pale Witpoort Formation quartzites.

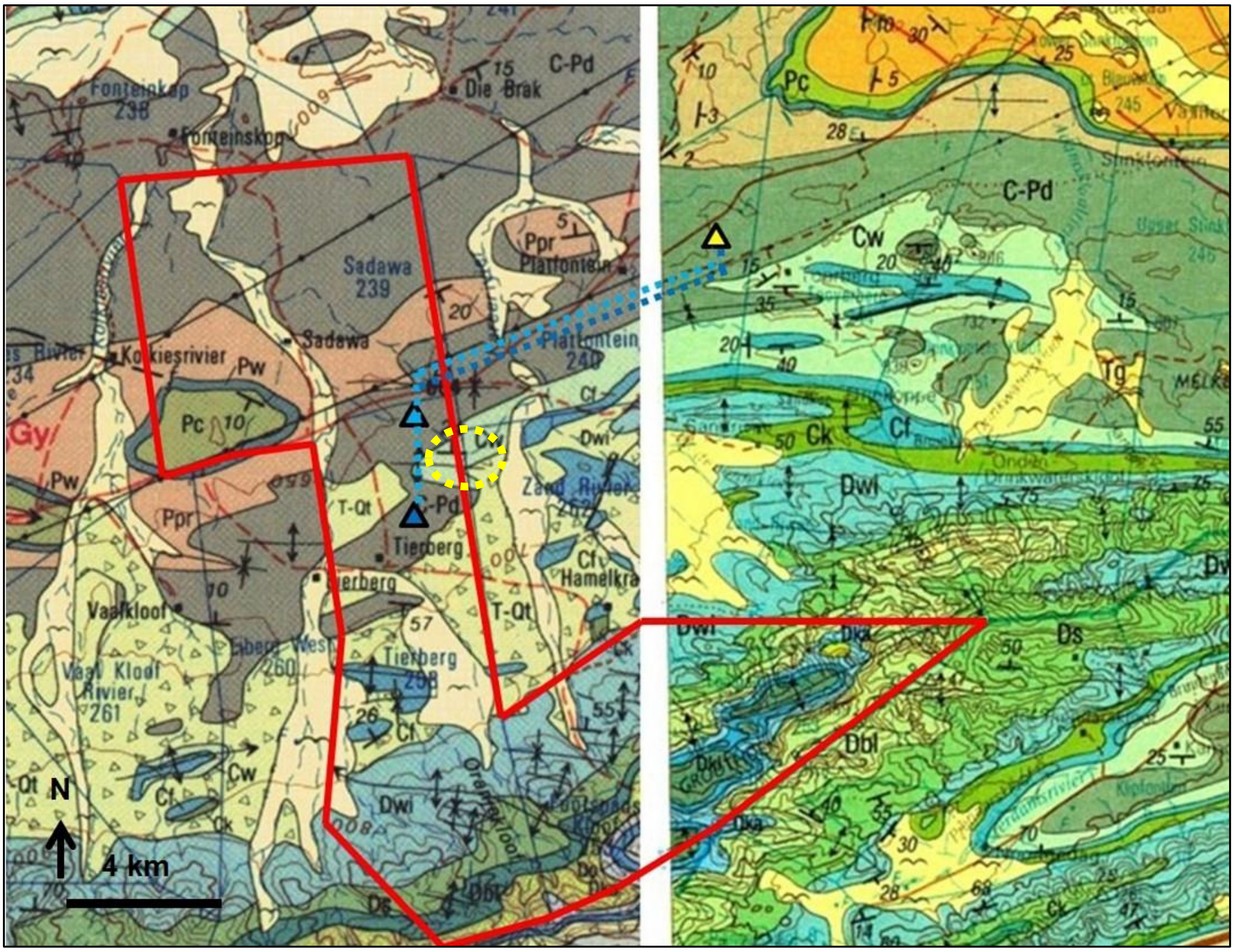

Figure 9: Extract from adjoining 1: 250 000 geology sheets 3319 Worcester and 3320 Ladismith (Council for Geoscience, Pretoria) showing the project area for the proposed Karee WEF near Touwsrivier, Western Cape spanning the contact of the Cape and Karoo Supergroups in the Ceres Karoo region of the Western Cape (red polygon). The two 132 kV grid connection options under consideration between the on-site substation (2 options, blue triangles) and the existing Kappa Substation (yellow triangle) are schematically indicated by the blue dotted lines (compare Figure 3 for key to grid options).

The main sedimentary rock units mapped here (not all of which will be impacted by the proposed WEF developments) include:

- **WITTEBERG GROUP: Dbl (blue-green) = Blinkberg Formation; Ds (middle green) = Swartruggens Formation; Dwi (pale blue) = Witpoort Formation; Ck (grey green) = Kweekvlei Formation; Cf (middle blue) = Floriskraal Formation; Cw (v. pale blue-green) = Waaipoort Formation. Fossiliferous concretions within the Waaipoort Formation on Tierberg 258 and Zand Rivier 252, inside and outside the present project area, are outlined by the yellow dotted ellipse.**

- **DWYKA GROUP: C-Pd (grey / blue-grey) = Elandsvlei Formation**

- **ECCA GROUP: Pp (pale brown) = Prince Albert Formation; Pw (dark blue) = Whitehill Formation; Pc (pale green) = Collingham Formation; Pt (orange) = Tierberg Formation.**

- **SUPERFICIAL DEPOSITS: Tg (dark yellow with double flying bird symbol) = older pediment gravels (possibly Neogene / Pleistocene in age); pale yellow or white with single flying bird symbol = Quaternary to Recent alluvium; T-Qt (pale green) = Neogene gritty sands, colluvial and eluvial gravel.**

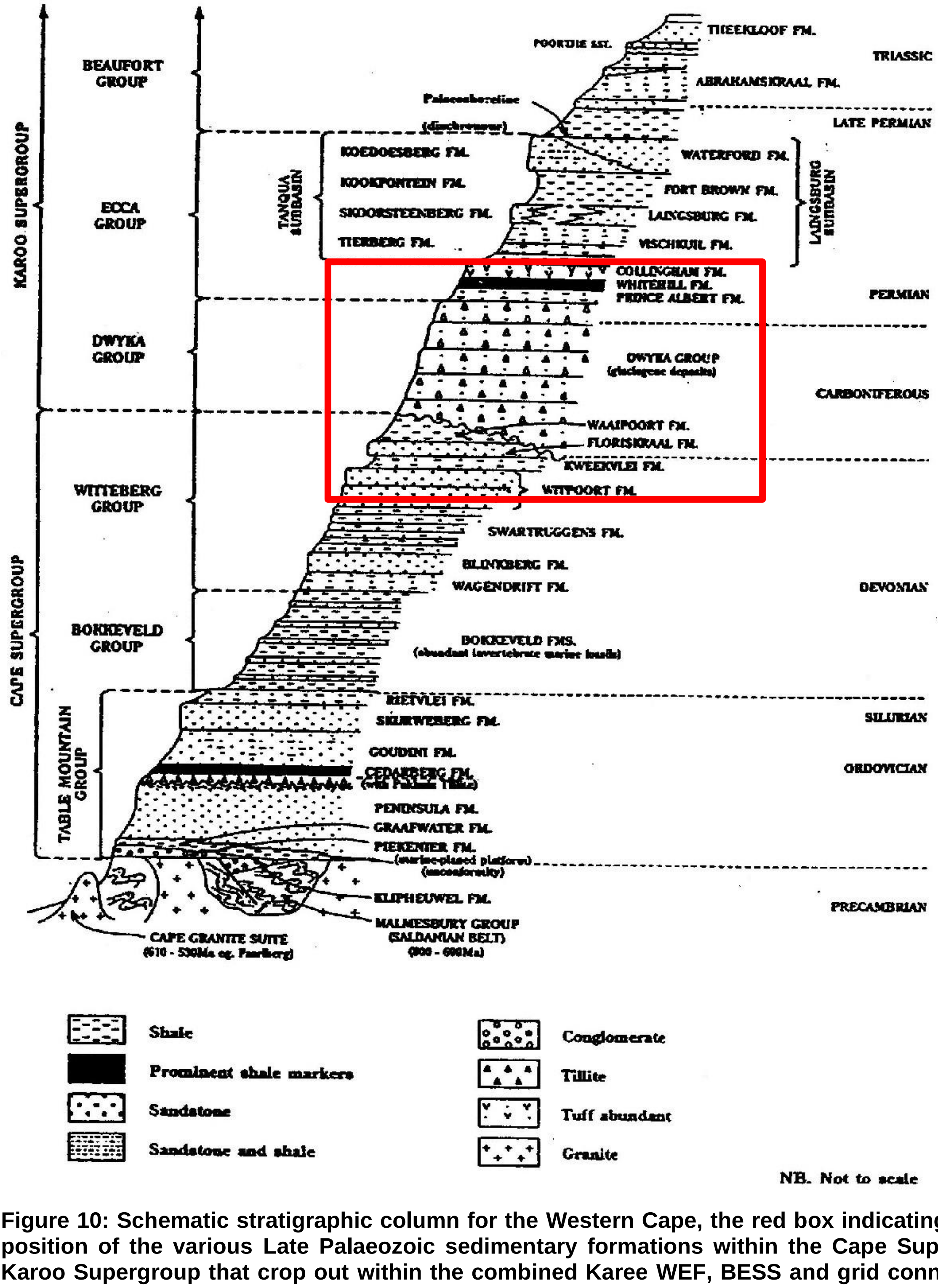

Figure 10: Schematic stratigraphic column for the Western Cape, the red box indicating the relative position of the various Late Palaeozoic sedimentary formations within the Cape Supergroup and Karoo Supergroup that crop out within the combined Karee WEF, BESS and grid connection study area (Modified from original figure by H. de V. Wickens).

Figure 11: Flat-topped pediment surface incised across intensely folded Witpoort Formation arenites, seen here on Voetpads Kloof 253.

Figure 12: Pale, ultra-quartzose sediments of the Perdepoort Member (Witpoort Formation) along the Bontberg mountain front on Voetpands Kloof 253 show extensive evidence of karstic (solution) weathering – such as the widening of steeply inclined joint fractures see here.

Figure 13: Distinctive wood-like secondary fabrics developed at the top of the Perdepoort Member (beneath hammer, 30 cm long) are attributed to soft-sediment deformation associated with latest Devonian debrite deposition or subglacial processes.

Figure 14: Unusually thick lens of massive, tombstone-weathering, dirty-brown sandstones of the "Potdeksel Member" (Witpoort Formation) – probably debris flow deposits related to a latest Devonian glacial interval on Gondwana (Zand Rivier 252, just outside the WEF project area).

Figure 15: Low ridge of Floriskraal Formation rocks on the northern edge of Voetpads Kloof 253 showing at least three sandstone-capped, upward-coarsening cycles.

Figure 16: Low krans of tabular, massive to cross-bedded arenites with minor pebble horizons of the Floriskraal Formation (same locality as previous illustration).

Figure 17: Low relief terrain mantled by gravelly to sandy soils which is typically seen in the outcrop area of the mudrock-dominated Waaipoort Formation, here in the NE corner of Tierberg 258.

Figure 18: Low ridges of impure sandstone (wacke), as seen in the foreground here, define bedding within Waaipoort Formation outcrop area, Tierberg 258 (hammer = 30 cm).

Figure 19: Low ridge of massive, greyish, clast-poor tillites of the Elandsvlei Formation (Dwyka Group) in the northern sector of Sadawa 238.

Figure 20: Typical joint-controlled tombstone weathering style of massive Dwyka tillites building a rocky ridge on the north-eastern margins of Tierberg 258.

Figure 21: Boulder-sized erratics weathering out of the Dwyka Group on Sadawa 238 comprise a range of exotic rock types – here a well-cemented, quartzose pebbly conglomerate of possible Precambrian age (scale = 15 cm).

Figure 22: Excellent example of a glacially facetted and striated erratic boulder from the Dwyka Group on Sadawa 238 composed of grey-brown quartzite (hammer = 30 cm).

Figure 23: Elongate body of pale, sparely pebbly quartzite embedded within Dwyka Group diamictites in the northern sector of Tierberg 258. Such bodies probably represent glacial outwash fans and are typically surrounded by an apron of eluvial rock rubble.

Figure 24: Conical dropstone ("plonsteen") embedded with its long axis vertical within bedded interglacial mudrocks of the Dwyka Group exposed in a roadside gulley on Sadawa 238 (scale = 15 cm).

Figure 25: Gently-folded, prominent-weathering, dark, ferruginised mudrocks of the Prince Albert Formation (lowermost Ecca Group) in the vicinity of the homestead on Sadawa 238.

Figure 26: Well-jointed Prince Albert Formation wackes exposed on the margins of a small synclinal structure in the SW sector of Sadawa 238 (hammer = 30 cm).

Figure 27: Outliers of pale grey-weathering, potentially fossiliferous basinal mudrocks of the Whitehill Formation (Ecca Group) cropping out in the SW portion of Sadawa 238 are highly weathered near-surface and poorly exposed due to the pervasive cover by silty soils and colluvial gravels of the overlying Collingham Formation.

Figure 28: Blocky-jointed, siliceous mudrocks and cherts of the Collingham Formation in the core of a small syncline of Lower Ecca bedrocks in the SW corner of Sadawa 238.

Figure 29: Extensive carpet of cobbly silcrete gravels close to the northern edge of Tierberg 258, west of on-site substation site Option 1. These are probably the downwasted, fluvially reworked remains of a pre-existing, silcrete-capped pediment surface (possibly Tertiary).

Figure 30: Close-up of grey and pale-brown sandy, gritty, and finely-gravelly silcretes seen in the previous figure (Scale in cm and mm). Note many of the clasts are anthropogenically flaked.

Figure 31: Very coarse, poorly-sorted, semi-consolidated alluvial fan deposits exposed in incised stream banks at the foot of the Bontberg range (Voetpads Kloof 253).

Figure 32: Rubbly, semi-consolidated alluvium overlying a dark, khaki-hued ferricrete zone with patches of pale grey calcrete, stream bank exposure on Voetpads Kloof 253 (Hammer = 30 cm).

Figure 33: Cover of sands and pebbly ferricretised gravels capping the karstified pediment surface on Voetpads Kloof 253. It is notable that no eluvial silcrete gravels were observed in such settings.

Figure 34: Bouldery, quartzitic alluvial gravels ("High Level Gravels") capping a pediment surface on the western margins of Tierberg 258. Note extensive, purple-brown secondary ferruginization of the underlying beds (hammer = 30 cm).

Figure 35: Unconsolidated coarse gravelly and overlying sandy alluvial deposits of Holocene age exposed along a drainage line in the central sector of Tierberg 258.

Figure 36: Oligomict pebbly to cobbly alluvial gravels (mainly quartzite) overlying Dwyka Group bedrocks on Sadawa 238 (hammer = 30 cm).

Figure 37: Shallow stream bed incised into hackly-weathering Dwyka Group bedrocks overlain by semi-consolidated, polygonally-jointed gritty sands, central sector of Tierberg 258.

Figure 38: Close-up of the polygonally-cracked or -jointed gritty sands seen above. These deposits might be of debris flow or flood origin and Pleistocene in age (hammer = 30 cm).

Figure 39: Degraded relicts of sandy flood deposits and downwasted fine ferricrete surface gravels on the southern portion of Tierberg 258. This region shows numerous rounded heuweltjies on satellite images.

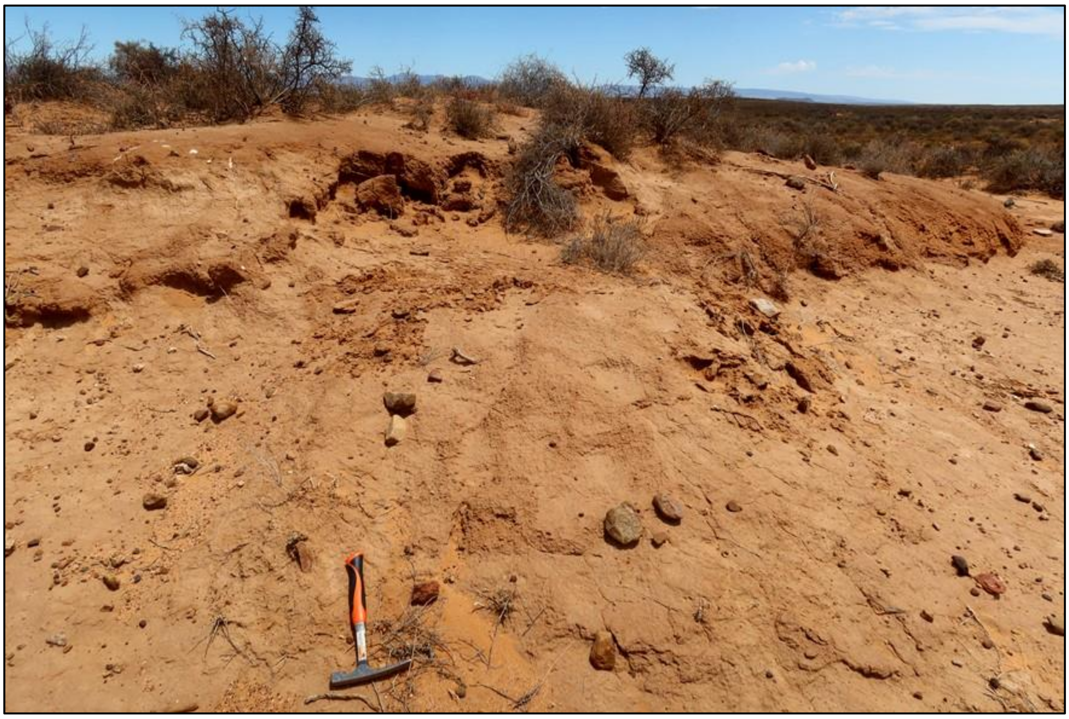

Figure 40: Close-up of massive, polygonally jointed sandy deposits seen in the previous illustration (hammer = 30 cm).

Figure 41: Extensive patch of fine sheetwash gravels overlying alluvial soils in the Prince Albert Formation outcrop area, southern margins of Zadawa 238. These gravels comprise ferruginous, rusty-brown mudrock, grey-green chert, white vein quartz, occasional pale brown silcretes and very sparse blocks of reworked petrified wood.

Figure 42: Polymict eluvial to sheetwashed surface gravels overlying the Dwyka Group outcrop area (here on Sadawa 238) comprise a wide range of clasts weathered out of the underlying tillites with an admixture of locally derived alluvial material (quartzite, silcrete etc).

5.2 Palaeontological heritage context and findings

The fossil record of the main sedimentary units represented within the Karee WEF and grid connection project areas is outlined in Table 1 (based largely on Almond & Pether 2008). It has been discussed in more detail, with extensive references to the academic literature, in several previous field-based PIA reports for the Ceres Karoo and the Matjiesfontein – Laingsburg regions of the southern Great Karoo by Almond (*e.g.* 2010a-d, 2015a, 1016a-e, 2018, 2019a-d, 2020a-d, 2022). Palaeontological heritage within the Komsberg Renewable Energy Development Zone (REDZ 2) has been reviewed by Almond in Fourie *et al.* (2015). The inferred sensitivity of the project areas in terms of palaeontological heritage is mapped in Figure 49 which is based on the web-based SAHRIS palaeosensitivity map / DFFE Screening Tool. It is noted, however, that the SAHRIS palaeosensitivity mapping requires extensive revision (*e.g.* under-estimated sensitivity of the Waaipoort Formation). The two most potentially sensitive bedrock units within the WEF, BESS and grid connection project areas are (1) the Early Carboniferous Lake Mentz Subgroup at the top of the Witteberg Group (especially the Waaipoort Formation) and (2) the Early Permian Whitehill Formation. Bokkeveld and Witteberg Group formations stratigraphically below the Witpoort Formation that crop out in the folded core of the Bontberg Range will not be directly impacted by the proposed development and so are not treated further here.

- **Witpoort Formation**

Very few fossils have been recorded so far from the Witpoort Formation in the Western Cape (Gresse & Theron 1992, Almond 2008b). They include a few vascular plants (*e.g.,* the lycopod *Haplostigma*), sparse low diversity trace fossils, including *Spirophyton*, and undescribed Fammenian palynomorphs. In contrast, an extraordinarily rich high latitude biota of Late Devonian fish, arthropods, vascular plants, algae and trace fossils has been described from dark lagoonal mudrocks within the upper Witpoort near Grahamstown in the Eastern Cape Province (*e.g.,* Anderson *et al.* 1994, 1999, Gess & Hiller 1995, Gess 2002). Lenticles of dark laminated siltstones with fragmentary kaolinitized plant remains that are reminiscent of the Grahamstown fossils have also been found in the Western Cape (J. Almond & F. Evans, pers. obs.) but these potentially fossiliferous mudrocks are very rarely exposed. Latest Devonian, lenticular, massive sandy debrites of the informally named Potdeksel Member intercalated between the Perdepoort Member quartzites of the Witpoort Formation and the basinal mudrocks of Kweekvlei Formation are generally unfossiliferous. Only occasional reworked axes of vascular plants have been recorded from this unit (Almond, pers. obs).

- **Lake Mentz Subgroup**

The basal **Kweekvlei Formation** mudrocks are not well exposed along the Bontberg mountain front in the present study arrea. It can be expected that they are generally deeply-weathered beneath pediment gravels here. No trace or body fossils were recorded from this rock unit or from the overlying Floriskraal Formation sandstones during the recent site visit. The **Waaipoort Formation** outcrop area is generally poorly exposed where it is mapped in low-relief terrain in the north-eastern sector of Tierberg 258 (See potentially fossilferous beds outlined by yellow dotted ellipse on geological map in **Figure 9**). In the Ceres Karoo region (*e.g.* near Fonteinskop) pale grey-weathering, phosphatic carbonate concretions within the lower part of the Waaipoort succession contain reworked vascular plant debris as well as a range of articulated remains of various fish subgroups including palaeoniscoids, sharks and acanthodians) (*cf* Evans 1997 and later papers, Almond 2016b). Low diversity ichnoassemblages have also been recorded from mudrock and wacke facies within this formation in the Ceres Karoo (*e.g.* Almond 2022). Impressive fish death assemblages are known from rippled Waaipoort sandstone facies near Matjiesfontein. Sparse early diagenetic concretions previously recorded within the Waaipoort Formation outcrop area in the north-eastern sector of Tierberg 258 as well as the adjoining portion of Zand Rivier 252 (*outside* the WEF project area) contain poorly preserved paaleoniscoids and vascular plants (Almond 2016d) (**Figure 43, Figure 44**).

- **Dwyka Group fossils**

The Elansfontein Formation (Dwyka Group) tillites are for the most part unfossiliferous, with the exception of rare fossiliferous carbonate erratics containing small Precambrian stromatolites, such as those enclosed within partially silicified dolomite previously recorded from the Sadawa 238 in the Ceres Karoo (Almond 2016b, 2022 (**Figure 45**). They are probably sourced from the Late Archaean / Early Proterozoic Transvaal Supergroup carbonates cropping out in the northern part of the RSA but it is noted that fossiliferous carbonate erratics of Early Cambrian age with remains of archaeocyathid sponges and small trilobites are also recorded within the Dwyka Group beds along the southern Karoo Basin margin (Cooper & Oosthuizen 1974, Oosthuizen 1981). Poorly-preserved vascular plant remains have been recorded from esker / outwash fan sandstones embedded within the Dwyka succession (Du Toit 1921), but no such occurrences were noted in the Karee WEF project area. Where (rarely) exposed, potentially fossiliferous, thin-bedded interglacial to early post-glacial mudrocks are generally weathered to crumbly saprolite in the study area and unlikely to be fossiliferous.

- **Ecca Group fossils**

The **Prince Albert Formation** exposures examined in the Karee WEF project area were generally too weathered, secondarily mineralised and cleaved to contain well-preserved fossil remains. Occasional phosphatic lenses and beds within this formation have been reported to contain microfossils, such as the siliceous tests of radiolarians, elsewhere in the Laingsburg region (Strydom 1950). Diagenetic nodules containing the remains of palaeoniscoids (primitive bony fish), sharks, spiral bromalites (coprolites, spiral gut infills *etc* attributable to sharks or temnospondyl amphibians) and petrified wood have been found in the Ceres Karoo (Almond 2008b, 2010b and refs. therein). Rare shark remains (*Dwykaselachus*) are recorded near Prince Albert on the southern margin of the Great Karoo (Oelofsen 1986). Microfossil remains in this formation include sponge spicules, foraminiferal and radiolarian protozoans, acritarchs and miospores.

The **Whitehill Formation**, well-known for its exquisitely preserved skeletal remains of crustaceans, fish and mesosaurid reptiles (Oelofsen 1981, 1987), is poorly-exposed and very deeply weathered in the study area (**Figure 27**) with extensive secondary gypsum deposits known in the wider region. Fossil remains near-surface are therefore not expected here; poorly-preserved, low-diversity trace fossil assemblages have been recorded within these beds elsewhere in the Ceres Karoo. No crustacean fossils were identified within occasional laminated concretions of diagenetic dolomite within the Whitehill Formation outcrop. The **Collingham Formation** is best known in the SW Karoo for its eurypterid (water scorpion) trackways and other trace fossils as well as occasional well-preserved petrified wood. Good exposures are rare and the only fossils recorded from this rock unit during the field survey comprise low diversity ichnoassemblages on siltstone bedding planes and possibly also simple, hollow intrastratal invertebrate burrows (**Figure 47** and **Figure 48**).

- **Late Caenozoic fossils**

Several occurrences of calcretised large, sphaeroidal termite nests of possible Pleistocene age have been observed embedded within saprolite or alluvial deposits the Ceres Karoo by the present author (Almond 2020d). They have sometimes been mistaken for fossil corals or elephant teeth in the past. Silicified wood reworked from Ecca bedrocks may be locally abundant within surface gravels in the Ceres Karoo (*cf* Almond 2020d). However, apart from occasional small blocks of reworked silicified wood among surface gravels **(Figure 46),** no fossil remains were recorded from the various Late Caenozoic superficial sediments (colluvium, alluvium *etc*) within the Karee WEF project area.

The sparse fossil material recorded within the Karee WEF and grid connection project area is illustrated in **Figure 43** to **Figure 48** below and mapped on a satellite image in Appendix 4.

Figure 43: Greyish-weathering phosphatic carbonate concretion with the vague outline of a palaeoniscoid fish fossil (scale in cm and mm), Waaipoort Formation, Tierberg 258 (From Almond 2016d). [33 09 07.9 S, 19 57 21.5 E. See F1 on satellite map in Appendix 4]

Figure 44: Fragments of diagenetic concretions weathered out from the Waaipoort Formation on Tierberg 258. They contain poorly-preserved vascular plant debris (Scale in cm and mm). [33 09 07.9 S, 19 57 21.5 E. See F1 on satellite map in Appendix 4]

Figure 45: Close-up of a laminated, partially silicified carbonate erratic of Precambrian age from the Dwyka tillites on Sadawa 238, here showing a small dome-shaped stromatolite c. 10 cm wide (specimen collected by landowner, precise locality unknown) (Almond 2016d). [No locality data: found and collected by landowner]

Figure 46: Small block of silicified fossil wood from sheetwash surface gravels overlying the Prince Albert Formation, southern portion of Sadawa 238 (scale in cm) (Almond 2016d). [33 08 44.3 S, 19 55 12.2 E. See F2 on satellite map in Appendix 4]

Figure 47: Dense monospecific assemblage of small-scale invertebrate burrows ("Chondrites") covering a bedding plane in the Collingham Formation, Sadawa 238 (scale in mm) (Almond 2016d). [33 08 29.6 S, 19 53 52.3 E. See F3 on satellite map in Appendix 4]

Figure 48: Joint blocks of Collingham Formation greyish wacke containing assemblages of hollow vermiform invertebrate burrows (scale in cm and mm) (33.142689 S, 19.887692 E. See F4 on satellite map in Appendix 4]

Table 1: Sedimentary rock units mapped within the Karee WEF and grid connection project areas and their fossil records *(provisional palaeosensitivity rating: red – high; green – medium; blue – low).*

LATE CAENOZOIC FLUVIAL, LACUSTRINE & TERRESTRIAL DEPOSITS OF INTERIOR ***e.g.,* Grahamstown Fm (Tg) (*N.B.* Most occurrences too small to be indicated on 1: 250 000 geological maps)** **Miocene to Holocene**		Fluvial, pan, lake and terrestrial sediments, including diatomite (diatom deposits), pedocretes (silcrete, ferricrete, calcrete), spring tufa / travertine, cave deposits, peats, colluvium	Bones and teeth of wide range of mammals (*e.g.,* proboscideans, rhinos, bovids, horses, micromammals, hominins), reptiles (crocodiles, tortoises), ostrich egg shells, fish, freshwater and terrestrial molluscs (unionid bivalves, gastropods), crabs, trace fossils (*e.g.,* termitaria, horizontal invertebrate burrows, stone artefacts), reworked blocks of petrified wood, leaves, rhizoliths, diatom floras, peats and palynomorphs.
ECCA GROUP Early – Middle Permian (290 – 266 Ma)	**Tierberg Fm (Pt)**	Offshore non-marine mudrocks with distal turbidite beds, prodeltaic sediments	Disarticulated microvertebrate remains (*e.g.,* fish teeth, scales), sponge spicules, spare vascular plants (leaves, petrified wood), moderate diversity trace fossil assemblages (as below *plus* variety of additional taxa such as large ribbed pellet burrows, arthropod scratch burrows, *Siphonichnus etc*)
	Collingham Fm (Pc)	Offshore non-marine mudrocks with numerous volcanic ashes, subordinate turbidites	Low diversity but locally abundant ichnofaunas (horizontal "worm" burrows, arthropod trackways including giant eurypterids), vascular plant remains (petrified and compressed wood, twigs, leaves *etc*).
	Whitehill Fm (Pw)	Carbonaceous offshore non-marine mudrocks within minor volcanic ashes, dolomite nodules	Mesosaurid reptiles, rare cephalochordates, variety of palaeoniscoid fish, small eocarid crustaceans, insects, low diversity of trace fossils (*e.g.,* king crab trackways, possible shark coprolites), palynomorphs, petrified wood and other sparse vascular plant remains (*Glossopteris* leaves, lycopods *etc*)
	Prince Albert Fm (Pp)	Marine to hyposaline basin plain mudrocks, minor volcanic ashes, phosphates and ironstones, post-glacial mudrocks at base	Low diversity marine invertebrates (bivalves, nautiloids, brachiopods), palaeoniscoid fish, sharks, fish coprolites, protozoans (foraminiferans, radiolarians), petrified wood, palynomorphs (spores, acritarchs), non-marine trace fossils (especially arthropods, fish, also various "worm" burrows), possible stromatolites, oolites
DWYKA GROUP (C-Pd) Late Carboniferous – Early Permian *c.* 320-290 Ma	**Elandsvlei Fm** Late Carboniferous – Early Permian	Predominantly massive tillites, with interglacial mudrocks at intervals	Interglacial mudrocks occasionally with low diversity marine fauna of invertebrates (molluscs, starfish, brachiopods, coprolites *etc*), palaeoniscoid fish, petrified wood, leaves (rare) and palynomorphs of *Glossopteris* Flora. Well-preserved non-marine ichnofauna (traces of fish, arthropods) in laminated mudrocks. Possible stromatolites, oolites at top of succession. Occasional Cambrian limestone erratics with archaeocyathid sponges, trilobites.
WITTEBERG GROUP	**Lake Mentz Subgroup**	lacustrine / lagoonal / coastal mudrocks, sandstones, minor conglomerates	Non-marine fish fauna (palaeoniscoids, sharks, acanthodians), vascular plants (*e.g.* lycopods), freshwater bivalves, traces, organic-walled microfossils

	Waaipoort Fm (Cw) **Floriskraal Fm (Cf)** **Kweekvlei Fm (Ck)**	Early Carboniferous	
	Witpoort Formation **(Dw)**	shallow marine sandstones, quartzites with minor lagoonal mudrocks, glacial sediments Late Devonian	Diverse lagoonal biota of fish (placoderms, acanthodians, sharks, several subgroups of bony fish, lampreys *etc*), arthropods (*e.g.,* eurypterids), rich vascular plant flora (lycopods, progymnosperms *etc*), seaweeds, charophytes, low diversity trace assemblages, including *Spirophyton*

6. IDENTIFICATION AND ASSESSMENT OF IMPACTS

The potential impact of the proposed Karee WEF development, BESS and the associated grid connection on legally-protected local fossil heritage resources is evaluated in this section of the report and summarized in **Table 3** to **Table 8** below. This assessment applies only to the *construction phase* of the developments since further significant impacts on fossil heritage during the planning, operational and decommissioning phases of the facility are not anticipated. The first assessment (**Table 3**) applies to all the key infrastructure described in Section 3 that will be situated within the WEF and grid connection project areas (*i.e.* wind turbine foundations, access roads, on-site substation, pylons, underground cables, as well as the construction camp, laydown areas and operational and maintenance buildings, BESS, overhead powerlines *etc*). Impacts of the two grid connection options under consideration (See **Figure 3**) are separately assessed in **Table 4**. Potential impacts here refer mainly to any associated new access roads, which may entail substantial surface disturbance or clearance, since bedrock excavations for the pylon footings are generally small.

6.1. Palaeontological sensitivity mapping of the project area

According to the provisional palaeosensitivity map based on the DFFE Screening Tool, the Karee WEF and grid connection project areas includes outcrop areas of Low to Very High palaeosensitivity (**Figure 49**). It is noted that, in the author's opinion, the palaeosensitivity of many of the formations concerned has been incorrectly coded in the DFFE database (*e.g.* the palaeontological sensitivity of the Witpoort Formation is exaggerated, while that of the Waaipoort Formation is underestimated).

- **Palaeosensitivity of the WEF project area**

Only a handful of fossil sites have been recorded within the WEF project area during previous and recent palaeontological heritage site visits. Waaipoort Formation fossiliferous concretions are reported in the small area outlined by the yellow dotted ellipse in **Figure 9** but the specimens found here so far are of limited scientific value. (*N.B.* GPS locality detail for some of the material illustrated by Almond 2016d is not currently available). None of these sparse fossil remains are rare or of significant scientific or conservation value. They represent forms that occur widely within the outcrop areas of the sedimentary formations concerned. Most of the Cape Supergroup and Karoo Supergroup rock units represented within the study area are generally of low to (at most) medium palaeosensitivity (**Table 1**). Important fossil biotas are known elsewhere in the Western Cape from fresh exposures of the Early Carboniferous Waaipoort and Early Permian Whitehill Formations (Section 5.2) but in the Karee WEF, BESS and grid connection project area these units are both very poorly exposed and often deeply weathered so their palaeosensitivity here is now low. Similar conclusions have been reached by the author and others in several previous palaeontological heritage reports for the Ceres Karoo region (*e.g.* Almond 2010a-c, 2015, 2016a-b, 2018, 2020a-d, Almond 2022, Butler 2018).

The overall palaeontological sensitivity of the Karee WEF project area is inferred to be generally **LOW** due to (1) poor sedimentary bedrock exposure, (2) high levels of tectonic cleavage development and (3) deep chemical weathering of mudrock facies. No high sensitivity fossil sites or palaeontological heritage No-Go areas were identified here during the present field survey.

The provisional palaeosensitivity mapping shown by the DFFE Screening Tool is therefore *contested* here.

- **Palaeosensitivity of grid connection corridors**

Similar conclusions apply equally to the palaeosensitivity of the alternative grid connection corridors under consideration to link the Karee WEF to the national grid (see **Figure 3**) which are only treated here at desktop level. The corridors traverse portions of the Ceres Karoo that are underlain by the same stratigraphic units as those studied within the WEF project area (**Figure 9**) – *viz*. bedrocks of the Dwyka Group, Late Caenozoic surface gravels and alluvium - and that have, for the most part, already been surveyed for previous electrical infrastructure and renewable energy projects (See PIA reports listed in the References for the Gamma-Omega 765 kV transmission line, Kappa Substation as well as the Perdekloof East, Kolkies, Karee and Pienaarspoort WEFs, especially Almond 2010b, 2016e). Based on these previous PIA studies a general LOW palaeosensitivity for both corridor alternatives is inferred, with no high sensitivity fossil sites reported within them (Note that the only area where fossiliferous Waaipoort concretions have been recorded (Almond 2016b) lies east of and *outside* the Karee WEF, BESS and grid connection corridor project area; see yellow dotted ellipse in geological map **Figure 9**). There is therefore no preference on palaeontological heritage grounds for either grid connection, with the proviso that shorter corridors are likely to have less impact than longer ones.

The provisional palaeosensitivity mapping of the grid connection project area shown by the DFFE Screening Tool is *contested* here.

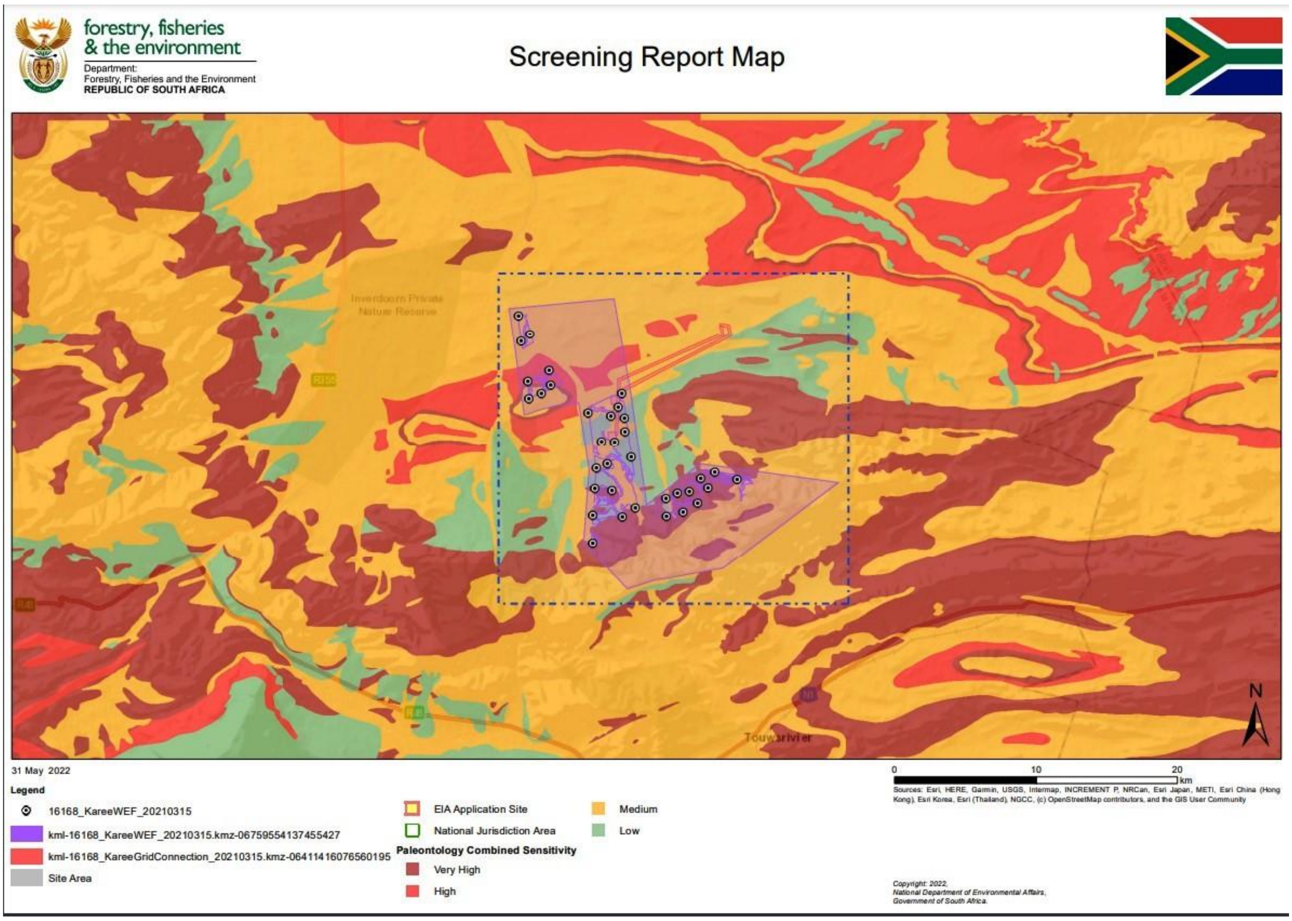

Figure 49: Paleontological sensitivity map for the Karee WEF, BESS and associated grid connection project areas. The sensitivity ratings for many of the rock units involved are erroneous, in the author's view. Due to the scarcity of well-preserved, scientifically important fossils over the great majority of this region, based on several desktop studies and recent palaeontological fieldwork, it is inferred that the WEF and grid connection project areas are in practice of LOW palaeontological sensitivity.

6.2. Identification of Potential Impacts

The construction phase of the proposed WEF, BESS and grid connection will entail extensive surface clearance as well as excavations into the superficial sediment cover and underlying bedrock (*e.g.,* for widened or new access roads, wind turbine foundations, hardstanding areas, on-site substation, underground cables, construction laydown area, O&M building, overhead power lines, BESS *etc*). Construction of the facility may adversely affect potential fossil heritage within the development footprint by damaging, destroying, disturbing or permanently sealing-in fossils preserved at or beneath the surface of the ground that are then no longer available for scientific research or other public good. The planning, operational and de-commissioning phases of the facility are unlikely to involve further adverse impacts on local palaeontological heritage and are therefore not separately assessed in this report. The potential palaeontological heritage resource impacts identified during the PIA assessment can be briefly summarized as follows:

- ***Planning / Pre-construction Phase***

No significant impacts on palaeontological heritage anticipated.

- ***Construction Phase***

Potential Impact 1: Disturbance, damage or destruction of fossil heritage resources preserved at or below the ground due to surface clearance and excavations (especially into sedimentary bedrock).

- ***Operational Phase***

No significant impacts on palaeontological heritage anticipated.

- ***Decommissioning Phase***

No significant impacts on palaeontological heritage anticipated

- ***Cumulative impacts***

No significant cumulative impacts on palaeontological heritage anticipated as a consequence of multiple renewable energy developments (wind, solar and grid connections) in the region.

6.3. Assessment of WEF and grid connection project impacts

Current impacts on palaeontological heritage within the Karee WEF, BESS and grid connection project areas include ongoing destruction of fossils by natural weathering and erosion processes *plus* very minor impacts due to agricultural activities. Loss of fossils due to illegal collection is probably negligible.

Potential impacts of the construction phase of the proposed Karee WEF, BESS and associated grid connection on local fossil heritage resources, with and without mitigation, are assessed below in **Table 3** and **Table 4** respectively, according to the Environmental Impact Assessment (EIA) Methodology developed by SiVEST. Further significant impacts on fossil heritage during the planning, operational and decommissioning phases of the facility are not anticipated.

Given the closely comparable geology of the WEF and grid connection project areas, the inferred impact ratings are the same in both cases.

6.3.1. Construction Phase: Disturbance, damage or destruction of fossils

The destruction, damage or disturbance out of context of legally-protected, scientifically-important fossils preserved at the ground surface or below ground that may occur during construction of the WEF, BESS / grid connection entail *direct negative* impacts to palaeontological heritage resources that are confined to the development footprint (*site*). These impacts can often be mitigated but cannot be fully rectified (*i.e.,* they are *irreversible*). All the sedimentary formations represented within the study area contain fossils of *some* sort, so impacts at some level on fossil heritage are definite. However, the majority of the fossils recorded are of widespread occurrence and low scientific or conservation value while sedimentary bedrock exposure levels are low to very low. Impacts on rare, well-preserved fossils of high scientific / conservation significance are therefore *unlikely*. Since most (but *not* all) of the fossils concerned are probably of widespread occurrence elsewhere within the outcrop areas of the formations concerned, the potential loss of irreplaceable fossil resources without mitigation is therefore rated as *marginal*. Such impacts are of *permanent* duration. Their intensity / magnitude during the construction phase is rated as *low* without mitigation. Without mitigation, a NEGATIVE LOW impact significance is accordingly inferred for both the WEF, BESS and grid connection projects. The assessment applies equally to all grid connection options under consideration.

Potential negative impacts can be reduced through implementation of the Chance Fossil Finds Procedure during the construction phase. With mitigation, the impact significance of the proposed WEF / grid connection project remains NEGATIVE LOW but potential improvements to the palaeontological database through professional mitigation can be regarded as a positive impact.

Confidence levels of this assessment are HIGH because it is supported by several previous palaeontological field assessments undertaken in the broader Ceres Karoo / Tanqua Karoo region by the author and colleagues (See References and discussion on cumulative impacts below).

6.3.2. No-Go Option impacts

In the case of the No-Go Alternative (*i.e.* no WEF, BESS / grid development), the possible loss of local heritage resources through construction activities (negative impact) would be avoided while potential improvements in palaeontological understanding through professional mitigation - *i.e.* recording and collection of palaeontological material and data (positive impacts) - would be lost. The slow destruction of fossils exposed at the surface through natural weathering and erosion would continue (with very minor negative impacts attributable to agricultural activities or illegal fossil collection), but at the same time new fossils are revealed for scientific study. On balance, it is concluded that No-Go alternative would have a *neutral* impact on palaeontological heritage.

6.4. Cumulative impacts

Cumulative impacts addressed here principally concern the *potential* loss of a significant fraction of scientifically valuable and legally-protected fossil heritage preserved within the Witpoort Formation, Lake Mentz Group (upper Witteberg Group), Dwyka Group, lower Ecca Group and older alluvial deposits in the Ceres Karoo region of the Western Cape through multiple alternative energy developments in the region (**Figure 50** and **Table 2**). Project areas which are underlain by quite different stratigraphic units with very different fossil assemblages - such as the Bokkeveld Group or Beaufort Group - are not considered to be strictly relevant for the present cumulative impact analysis (*e.g.,* Kudusberg WEF, Oya Energy Facility, Brandvallei WEF, Montague Road Solar and Touwsrivier Solar Facilities). Since potentially fossiliferous, consolidated Late Caenozoic alluvial deposits will normally not be impacted in WEF developments because they usually lie along well-buffered drainage lines they are not considered for the purpose of this analysis.

Several existing, proposed or authorised renewable energy projects within a 35 km radius of the Karee WEF and grid connection project areas are mapped in **Figure 50** below (No comprehensive data is available for any other large-scale industrial developments in the region). PIA reports for the majority of these projects have been submitted by the present author (see References) who has also undertaken studies for additional renewable energy projects in the region which are not shown on the map (*viz*. Perdekraal West WEF, Pienaarspoort 1 and 2 WEFs, Veroniva Solar, Sadawa Solar, Kolkies Solar projects,). PIA reports are also available for the Tooverberg WEF by Butler (2018) and for the Witberge WEF by Hart and Miller (2011).

The cumulative impacts analysis shown in **Table *5*** is based on the Environmental Impact Assessment (EIA) Methodology developed by SiVEST. This cumulative impact assessment applies only to the construction phases of the renewable energy developments, since significant additional impacts on palaeontological heritage during the planning, operational and de-commissioning phases are not anticipated.

In all the strictly *relevant* field-based palaeontological studies in the Ceres Karoo listed above the palaeontological sensitivity of the project area and the palaeontological heritage impact significance for the developments concerned has been rated as *low*. In all cases it was concluded by the author that, despite the potential occurrence of scientifically-important fossil remains (notably fossil vertebrates, petrified wood), the overall impact significance of the proposed developments was low because the probability of significant impacts on *scientifically important, unique or rare fossils* was slight. While fossils do indeed occur within most of the formations present, they tend to be sparse – especially as far as fossil vertebrates are concerned **-** while the great majority represent common forms that occur widely within the outcrop areas of the rock units concerned. Important exceptions include well-articulated skeletal remains of palaeoniscoid fish and mesosaurid reptiles in the Waaipoort and Whitehill Formations.

Anticipated cumulative impacts of the known renewable energy projects proposed or authorised for the margins of the Ceres Karoo region– *including* the associated grid connection **-** are assessed as *NEGATIVE LOW* without mitigation. The overall impact significance remains NEGATIVE LOW with full mitigation but impacts will then occur at a lower intensity and will be partially offset by valuable new scientific data. The analysis only applies *provided that* all the proposed monitoring and mitigation recommendations made for all these various renewable energy projects are followed through (*N.B.* This is inherently unpredictable, and, sadly, unlikely). Unavoidable residual negative impacts may be partially offset by the improved understanding of Ceres Karoo palaeontology resulting from appropriate professional mitigation. This is regarded as a *positive* impact for Karoo palaeontological heritage.

In conclusion, the cumulative impacts on local fossil heritage anticipated for the various renewable energy projects in the Ceres Karoo region of the Western Cape – including the proposed Karee Wind Energy Facility and its associated grid connection – fall within acceptable limits, *provided that* all recommended mitigation recommendations for these projects are followed through.

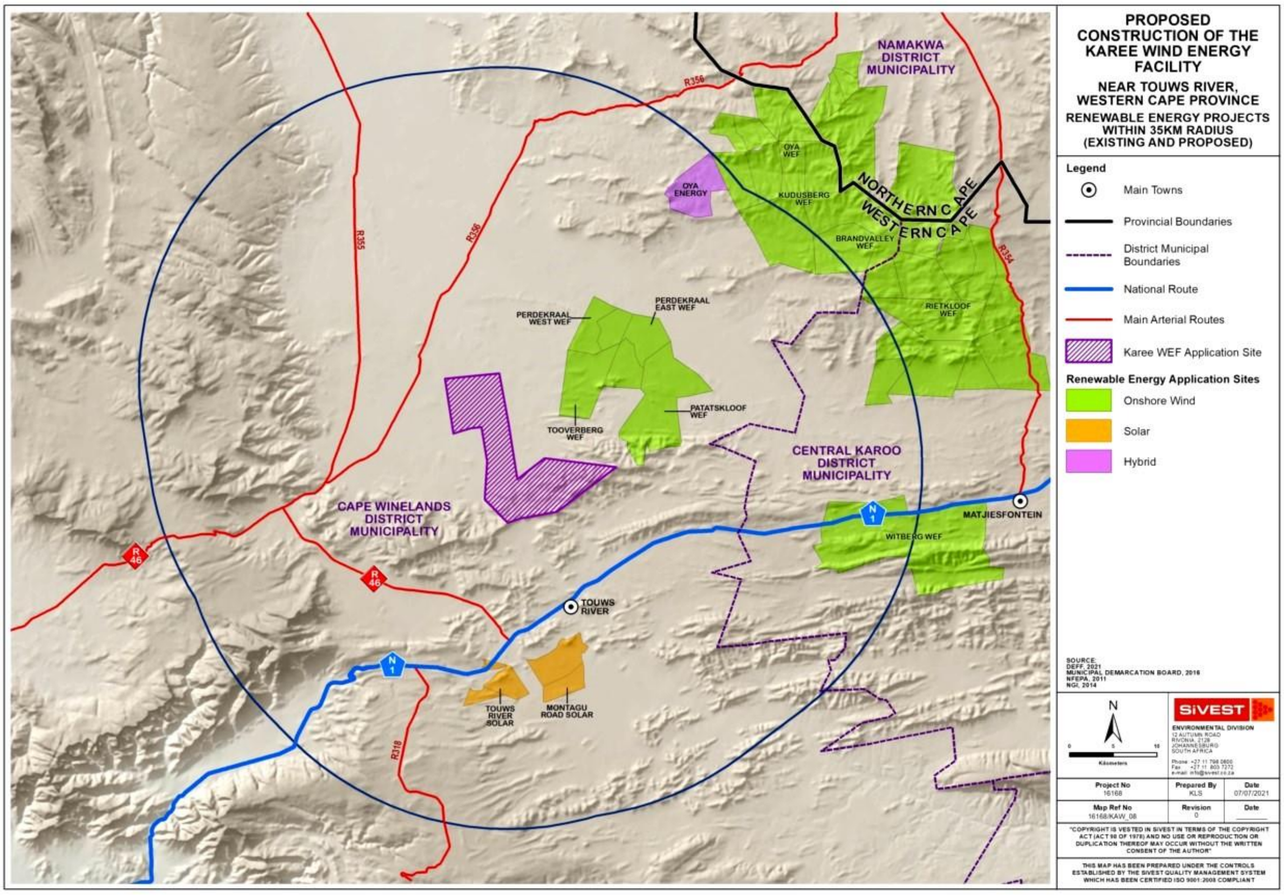

Figure 50: Map showing project areas for authorized and proposed renewable energy projects within a 35 km radius of the Karee WEF, BESS and grid connection project areas (Image provided by SiVEST). Additional unmapped renewable energy projects and PIA reports based in the broader Ceres Karoo region have also been taken into consideration here (e.g., Pienaarspoort 1 and 2 WEFs, Veroniva Solar, Sadawa Solar, Kolkies Solar, Patatskloof WEF) and are listed in the References.

Table 2: Renewable energy developments proposed within a 35km radius of the Karee WEF application site

Applicant	Project	Technology	Capacity	Status of Application / Development
Oya Energy (Pty) Ltd	Oya Energy Facility	Hybrid (Solar / Fuel-Based)	305MW	EIA Process underway
Brandvalley Wind Farm (Pty) Ltd	Brandvalley WEF	Wind	140MW	Approved
Kudusberg Wind Farm (Pty) Ltd	Kudusberg WEF	Wind	325W	Approved
South Africa Mainstream Renewable Power Perdekraal West (Pty) Ltd	Perdekraal West WEF & Associated Grid Connection Infrastructure	Wind	150M	Approved
South Africa Mainstream Renewable Power Perdekraal East (Pty) Ltd	Perdekraal East WEF & Associated Grid Connection Infrastructure	Wind	110MW	Operational
South Africa Mainstream Renewable Power Developments (Pty) Ltd	Patatskloof WEF	Wind	140MW	EIA Process underway
Rietkloof Wind Farm (Pty) Ltd	Rietkloof WEF	Wind	186MW	Approved
ENERTRAG SA (Pty) Ltd	Tooverberg WEF & Associated Grid Connection Infrastructure	Wind	140MW	Approved
Witberg Wind Power (Pty) Ltd	Witberg WEF	Wind	120MW	Approved
Montagu Road Solar (Pty) Ltd	Montagu Road Solar	Solar PV	75MW	Approved
Touwsrivier Solar	Touwsrivier Solar	Solar PV	36MW	Approved

N.B. Several of these projects are not strictly relevant for the present analysis while a number of additional renewable energy projects have recently been proposed in the area. A PIA report for the Montagu Road Solar project was not available at the time of writing.

Table 3: Assessment of paleontological heritage impacts for the proposed Karee Wind Energy Facility (Construction Phase)

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Construction Phase																				
Fossil heritage resources	Disturbance, damage or destruction of fossils at or beneath the ground surface due to surface clearance and bedrock excavations	1	1	4	2	4	1	12	_	L	Application of Chance Fossil Finds Procedure during construction phase	1	1	4	2	4	1	12	_	L

Table 4: Assessment of paleontological heritage impacts for the proposed Karee Wind Energy Facility grid connection (Construction Phase) (This assessment applies equally to both corridor options under consideration)

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Construction Phase																				
Fossil heritage resources	Disturbance, damage or destruction of fossils at or beneath the ground surface due to surface clearance and bedrock excavations	1	1	4	2	4	1	12	_	L	Application of Chance Fossil Finds Procedure during construction phase	1	1	4	2	4	1	12	_	L

Table 5: Assessment of cumulative impacts for the Karee WEF, BESS plus grid connection and other renewable energy developments in the region.

Fossil heritage resources	Disturbance, damage or destruction of fossils at or beneath the ground surface due to surface clearance and bedrock excavations	3	2	4	2	4	1	15	_	L	Application of Chance Fossil Finds Procedure during construction phase	3	2	4	2	4	1	15	_	L

6.5. Overall Impact Rating

Overall impact ratings for the Karee WEF, BESS and associated grid connection projects – including all phases of the developments - are provided in **Table 6** and **Table 7** below (These are essentially the same as the impact tables for the Construction Phase since further significant impacts during the Operational and De-commissioning Phases are not anticipated). The significance of relevant cumulative impacts is assessed in **Table 8**. Recommended monitoring and mitigation measures for these developments – *viz*. the application of a Chance Fossil Finds Procedure during the Construction Phase - are outlined in more detail in **Section 8** of this report.

Table 6: Overall impact rating for the Karee WEF project

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Construction Phase																				
Fossil heritage resources	Disturbance, damage or destruction of fossils at or beneath the ground surface due to surface clearance and bedrock excavations	1	1	4	2	4	1	12	_	L	Application of Chance Fossil Finds Procedure during construction phase	1	1	4	2	4	1	12	_	L

Table 7: Overall impact rating for the Karee WEF grid connection project (applies equally to all options under consideration)

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Construction Phase																				
Fossil heritage resources	Disturbance, damage or destruction of fossils at or beneath the ground surface due to surface clearance and bedrock excavations	1	1	4	2	4	1	12	_	L	Application of Chance Fossil Finds Procedure during construction phase	1	1	4	2	4	1	12	_	L

Table 8: Overall cumulative impact rating for the Karee WEF and grid connection project in the context of other authorized renewable energy developments in the Ceres Karoo region

Fossil heritage resources	Disturbance, damage or destruction of fossils at or beneath the ground surface due to surface clearance and bedrock excavations	3	2	4	2	4	1	15	_	L	Application of Chance Fossil Finds Procedure during construction phase	3	2	4	2	4	1	15	_	L

7. COMPARATIVE ASSESSMENT OF ALTERNATIVES

7.1 Karee WEF

A comparable NEGATIVE LOW impact significance (without mitigation), as assessed in **Table 3**, applies equally to all Karee WEF project infrastructure alternatives and layout options under consideration that are outlined in Section 3.3 of this report. This includes the various site options for the on-site substation and construction laydown area. Given their very similar geological - and hence palaeontological – contexts and anticipated low impact significance, there are no preferences on palaeontological heritage grounds for any particular layout among the various site options under consideration.

Key

PREFERRED	The alternative will result in a low impact / reduce the impact / result in a positive impact
FAVOURABLE	The impact will be relatively insignificant
LEAST PREFERRED	The alternative will result in a high impact / increase the impact
NO PREFERENCE	The alternative will result in equal impacts

Table 9: Comparative assessment of Karee WEF layout options

Alternative	Preference	Reasons (incl. potential issues)
SUBSTATION SITE ALTERNATIVES		
Substation Option 1	None	Similar geological / palaeontological context (low sensitivity)
Substation Option 2	None	
CONSTRUCTION LAYDOWN AREA SITE ALTERNATIVES		
Construction Laydown Area Option 1	None	Similar geological / palaeontological context (low sensitivity)
Construction Laydown Area Option 2	None	

7.2 Karee WEF grid connection

As shown in geological map **Figure 9**, alternative Grid Connection Options 1 and 2 both traverse terrain of closely comparable geology and inferred low palaeosensitivity. T*here is no marked preference on palaeontological heritage grounds between either of the two connection options, given their very similar geological and palaeontological context, length and anticipated low impact significance.*

Table 10: Comparative assessment of Karee WEF grid connection options

Alternative	Preference	Reasons (incl. potential issues)
GRID CONNECTION ALTERNATIVES		
Power Line Corridor Option 1 (Sub 1 or 2)	No Preference	Both options have similar impact significance due to similar geological context, length.
Power Line Corridor Option 2 (Sub 1 or 2)		

8. PROPOSED MONITORING AND MITIGATION: INPUT TO EMPR

A very small number of fossil sites have been previously recorded within the Karee WEF project area (Section **5**). All the known fossil sites lie well away from the proposed WEF infrastructure footprints, including the buildable areas and alternative grid connection corridors, while all the sites are rated as being of low scientific or conservation significance (Proposed Field Rating IIIC Local Resource). ***The distribution of recorded fossil sites therefore has no influence on the proposed layout of the WEF or associated grid connection.***

During the construction phase the Chance Fossil Finds Protocol summarized in Appendix 4 should be fully implemented (See also summary of monitoring and mitigation recommendations in Table 11 below). The Environmental Control Officer (ECO) / Environmental Site Officer (ESO) responsible for the development should be made aware of the possibility of important fossil remains (vertebrate bones, teeth, petrified wood, plant-rich horizons *etc.*) being found or unearthed during the construction phase of the development. Monitoring for fossil material of all major surface clearance and deeper (>1m) excavations by the Environmental Site Officer on an on-going basis during the construction phase is therefore recommended. Significant fossil finds should be safeguarded and reported at the earliest opportunity to Heritage Western Cape for recording and sampling by a professional palaeontologist (Contact details: Heritage Western Cape. 3rd Floor Protea Assurance Building, 142 Longmarket Street, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 021 483 5959 Email: ceoheritage@westerncape.gov.za).

The palaeontologist responsible for any mitigation work will be required to submit a Work Plan to Heritage Western Cape (HWC) and a Mitigation Report must be submitted to HWC for consideration. All fieldwork and reporting should meet the standards of international best practice as well as those developed for PIA reports by SAHRA (2013) and Heritage Western Cape (2021). Fossil material collected must be safeguarded and curated within an approved palaeontological repository (*e.g.* museum or university collection) with full collection data. **These recommendations must be included within the EMPrs for the Karee WEF and associated grid connection developments.**

Table 11: Tabulated summary of monitoring and mitigation recommendations regarding Palaeontological Heritage for the Construction Phase of the Karee WEF and grid connection

PALAEONTOLOGICAL HERITAGE: CONSTRUCTION PHASE					
Impact/Aspect	**Mitigation/Management Actions**	***Responsibility***	***Methodology***	**Mitigation/Management Objectives and Outcomes**	***Frequency***
Disturbance, damage or destruction of fossil remains preserved at or below the ground surface through site clearance of bedrock excavations.	Monitoring of substantial, deeper excavations (> 1m)	ECO / ESO	Visual inspection of excavations Application of Chance Fossil Finds Protocol Safeguarding newly exposed fossils - *in situ*, if feasible – pending mitigation.	Reporting and safeguarding of significant new fossil finds (*e.g.* vertebrate bones, teeth, petrified wood, shells) to Heritage Western Cape for potential mitigation.	Ongoing throughout Construction Phase
	Submission of Work Plan to / application for Fossil Collection permit from responsible Heritage Resources Agency (PHRA) Recording and sampling / collection of significant new fossil finds that have been reported by ECO / ESO	Specialist palaeontologist appointed by developer	Recording of fossil material as well as associated geological data. Professional sampling / collection of fossils. Curation of fossils and site data within an approved repository (museum / university palaeontological collection)	Conservation and recording of new fossil material of scientific / conservation value within project area	Triggered by alert from ECO / ESO / PHRA
	Palaeontological mitigation reporting to responsible Heritage Resources Agency (PRHA)	Specialist palaeontologist appointed by developer	Submission of Fossil Collection Report to responsible Heritage Resources Agency (PRHA)	Conservation and recording of new fossil material of scientific / conservation value within project area	Following specialist palaeontological mitigation

N.B

- A more detailed Chance Fossil Finds Protocol is appended to the PIA report
- Palaeontological mitigation is normally only needed in the Construction Phase

9. SUMMARY & CONCLUSIONS

9.1 Summary of Findings.

The Karee WEF, BESS and grid connection project areas are underlain by several basinal to shallow marine sedimentary formations of the Witteberg Group (Cape Supergroup), Dwyka Group and Ecca Group (Karoo Supergroup) of Mid to Late Palaeozoic age. All these units are potentially fossiliferous but only two – the Early Carboniferous Waaipoort Formation and the Early Permian Whitehill Formation – are generally regarded as of high palaeosensitivity in the Tanqua - Ceres Karoo region and elsewhere due to their record of well-preserved fish, mesosaurid reptiles, crustaceans and plant fossils. A recent 2-day palaeontological field survey shows that the Waaipoort Formation is very poorly exposed within the WEF project area, although potentially fossiliferous phosphatic carbonate concretions do occur here, while the uppermost several meters of the Whitehill Formation are intensely weathered. The only fossil remains recorded during the site visit comprise (1) sparse diagenetic concretions within the Waaiport Formation containing poorly-preserved fish and plant remains, (2) occasional stromatolitic carbonate erratics within the Dwyka Group and (3) low-diversity, poorly-preserved trace fossil assemblages in the Collingham Formation. These fossils occur widely within the outcrop areas of the formations concerned and, given their poor preservation, are not of high scientific interest or conservation value. Desktop reviews of several previous palaeontological assessment reports relevant to the grid connection project area (*e.g.,* Almond 2010b, 2016e) show that the Dwyka Group bedrocks and Late Caenozoic superficial deposits here are likewise of low palaeosensitivity with no significant fossil sites recorded within the two grid corridors under consideration.

As a consequence of (1) the paucity of irreplaceable, unique or rare fossil remains within the WEF and grid connection project areas, as well as (2) the extensive superficial sediment cover overlying most potentially-fossiliferous bedrocks here, the overall impact significance of the construction phase of the proposed Karee WEF and grid connection regarding legally-protected palaeontological heritage resources is assessed as LOW (negative status), with and without mitigation. This assessment applies equally to all layout alternatives and grid connection options under consideration. There is therefore no preference on palaeontological heritage grounds for any specific layout (*e.g.,* location of on-site substation, construction laydown area, grid connection corridor) among those that have been proposed. No significant further impacts on fossil heritage are anticipated during the operational and decommissioning phases of the renewable energy developments. The No-Go alternative (*i.e.,* no WEF / grid development) would probably have a neutral impact on palaeontological heritage.

No palaeontological High Sensitivity or No-Go areas have been identified within the WEF and grid connection project areas. None of the recorded fossil sites lies within the development footprint as currently defined. Pending the potential discovery of significant new fossil material here during the construction phase, no specialist palaeontological monitoring or mitigation is recommended for these developments. The Environmental Site Officer (ESO) should be made aware of the possibility of important fossil remains (bones, teeth, fish, petrified wood, plant-rich horizons etc) being found or unearthed during the construction phase of the development. Monitoring for fossil material of all major surface clearance and deeper (> 1m) excavations by the Environmental Site Officer on an on-going basis during the construction phase is therefore recommended. Significant fossil finds should be safeguarded and reported at the earliest opportunity to Heritage Western Cape for recording and sampling by a professional palaeontologist. A protocol for Chance

Fossil Finds is appended to this report (Appendix 4). These recommendations must be included within the EMPrs for the Karee WEF and grid connection developments.

Provided that these monitoring and mitigation measures are followed through, residual impacts for the Karee WEF and grid projects are rated as LOW. Inevitable loss of some fossil heritage during the construction phase may be - at least partially - offset by an improved understanding of local palaeontological heritage through professional recording and mitigation of any significant new fossil finds (This may be considered as a positive impact).

Due to the generally low palaeosensitivity of the Ceres Karoo as a whole, anticipated cumulative impacts of the known renewable energy projects proposed or authorized in the region are assessed as LOW (negative) with and without mitigation. It is concluded that, as far as fossil heritage resources are concerned, the proposed Karee WEF, BESS and grid connection projects, whether considered individually or together, will not result in any unacceptable loss or impact considering all the renewable energy projects proposed in the area. This analysis only applies provided that all the proposed monitoring and mitigation recommendations made for the other renewable energy projects proposed or authorized in the Ceres Karoo are fully and consistently implemented.

There are no fatal flaws in the Karee WEF, BESS and grid development proposals as far as fossil heritage is concerned. Provided that the proposed recommendations for palaeontological monitoring and mitigation are fully implemented, there are no objections on palaeontological heritage grounds to authorization of these renewable energy developments.

9.2 Conclusions and Impact Statement

In terms of palaeontological heritage resources, the proposed Karee WEF. BESS and associated grid connection are assigned a similar overall impact significance rating (Construction Phase) of NEGATIVE LOW without mitigation and NEGATIVE LOW following mitigation. No significant further impacts on fossil heritage resources are anticipated in the planning, operational and decommissioning phases. The No-Go Option is likely to have a neutral impact significance. All layout options under consideration have a similar impact significance and there is therefore no preference on palaeontological heritage grounds for a specific design option (*e.g.*, on-site substation location, grid connection corridor). Anticipated cumulative impacts in the context of several planned or authorized renewable energy projects in the Ceres Karoo region are assessed as NEGATIVE LOW with and without mitigation and therefore fall within acceptable limits.

The proposed Karee WEF and grid connection developments are not fatally flawed and, on condition that the recommended mitigation measures are included within the EMPr and implemented in full, there are no objections on palaeontological heritage grounds to their authorization.

This palaeontological impact assessment - including the tables provided in Sections 6 and 7 of the report – together with recommendations for the Environmental Management Programme apply to the final proposed layouts of the Karee WEF (with refined buildable areas as shown in Figure 51 at the end of this report) and the associated Grid Connection.

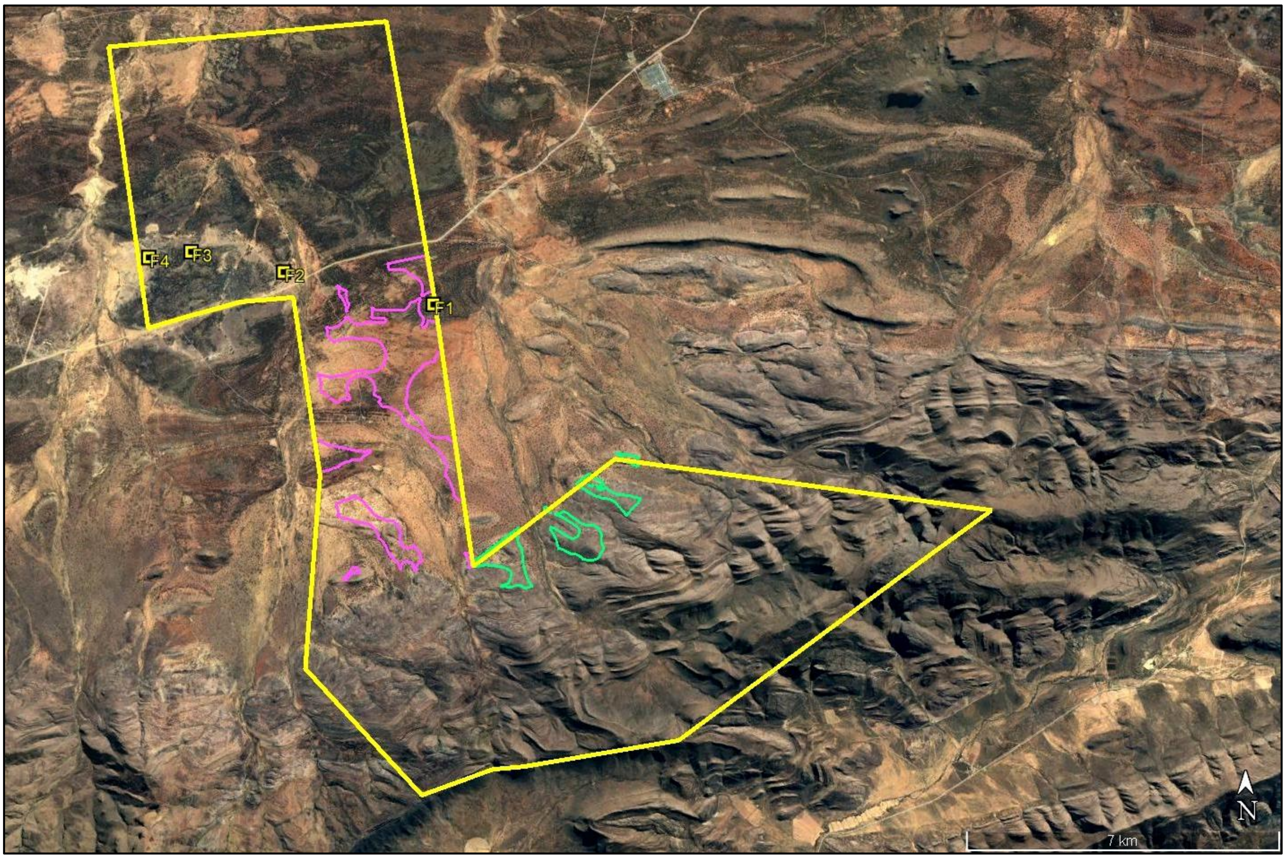

Figure 51: Google Earth© satellite showing recorded fossils sites in the context of the Karee WEF project area (yellow polygon) and refined buildable areas (green and pink polygons). Note than none of the fossil sites falls within the buildable areas.

10. REFERENCES

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APPENDIX 1: JOHN ALMOND SHORT CV

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge

University and the University of Tübingen in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa and Madagascar. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

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

APPENDIX 2: SITE SENSITIVITY VERIFICATION (IN TERMS OF PART A OF THE ASSESSMENT PROTOCOLS PUBLISHED IN GN 320 ON 20 MARCH 2020

3.1. Introduction

It is proposed to develop the Karee WEF and associated grid infrastructure on a site in the Ceres Karoo located approximately 18km north of Touwsrivier in the Cape Winelands District Municipality, Western Cape Province. The WEF will comprise up to thirty-five wind turbines with a maximum total energy generation capacity of up to approximately 140MW. The electricity generated will be fed into the national grid *via* a 132kV overhead power line to the existing Kappa Substation in the Ceres Karoo.

In accordance with Appendix 6 of the National Environmental Management Act (Act 107 of 1998, as amended) (NEMA) Environmental Impact Assessment (EIA) Regulations of 2014, a site sensitivity verification has been undertaken in order to confirm the current land use and environmental sensitivity of the proposed project area as identified by the National Web-Based Environmental Screening Tool (Screening Tool).

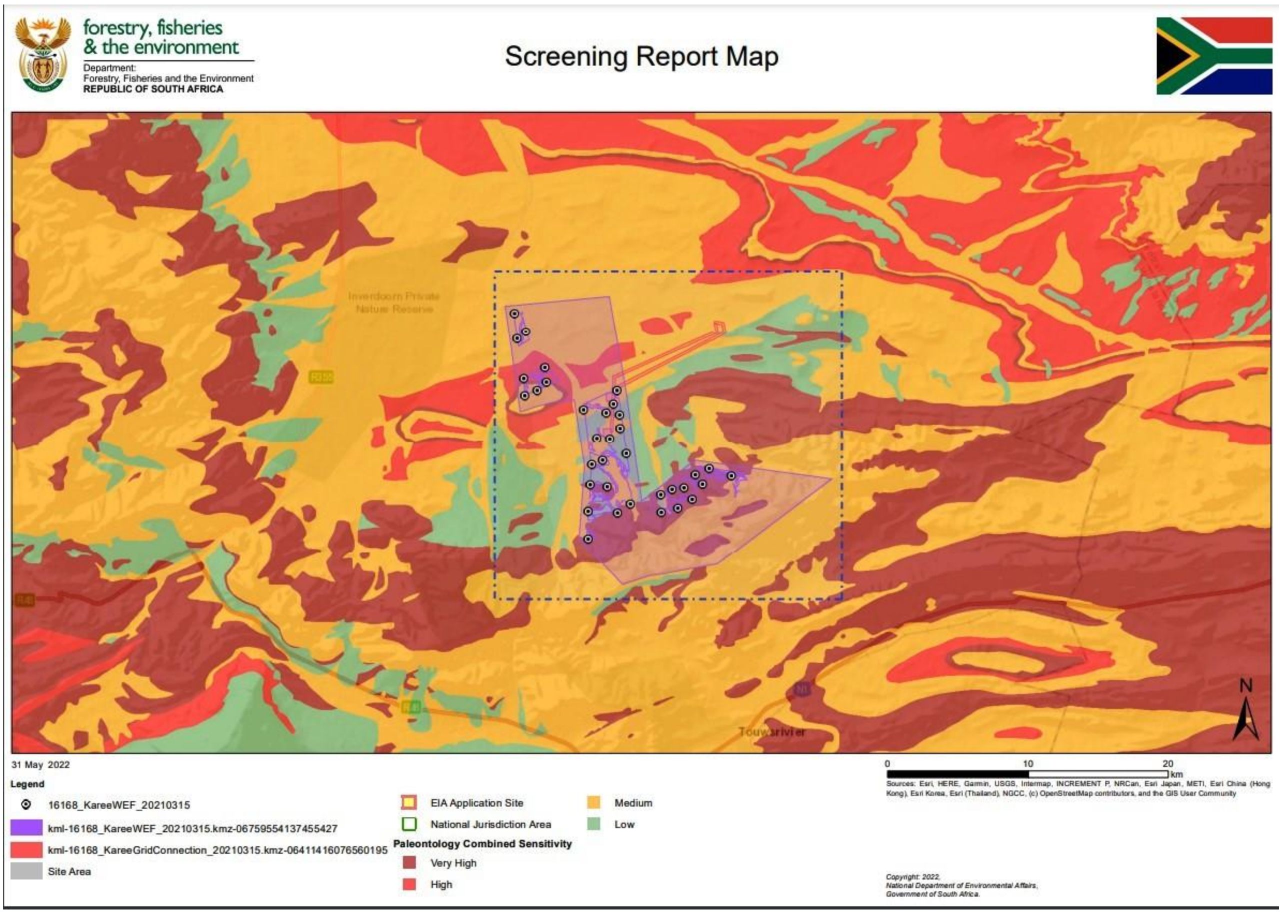


Figure A2.1: Paleontological sensitivity map for the Karee WEF and grid connection project areas. The sensitivity ratings for many of the rock units involved are erroneous, in the author's view. Due to the scarcity of well-preserved, scientifically important fossils over the great majority of this region, based on several desktop studies and recent palaeontological fieldwork, it is inferred that the WEF and grid connection project areas are in practice of LOW palaeontologically sensitivity.

3.2. National environmental screening tool

According to the provisional palaeosensitivity map based on the DFFE Screening Tool, the Karee WEF and grid connection project areas includes outcrop areas of Low to Very High palaeosensitivity (Figure A2.1). It is noted that, in the author's opinion, the palaeosensitivity of many of the formations concerned has been incorrectly coded in the DFFE database.

3.3. Site sensitivity verification

The desktop and field-based palaeontological heritage Site Sensitivity Verification of the Karee WEF and grid connection project areas was based on the following information resources:

1. A detailed project outline, kmz files, screening report and maps provided by SiVEST Environmental Division and PGS Heritage.
2. A desktop review of: (a) the relevant 1:50 000 scale topographic maps, (b) Google Earth© satellite imagery, (c) published geological and palaeontological literature, including 1:250 000 geological maps (3220 Ladismith, 3319 Worcester) and relevant sheet explanations as well as (d) several previous and fossil heritage (PIA) assessments for renewable energy and transmission line projects in the Ceres Karoo region near Touwsrivier by the author and colleagues.
3. The author's field experience with the formations concerned and their palaeontological record; and
4. A two-day field assessment of the Karee WEF project area, including portions of all land parcels involved, by the author and an experienced field assistant during the period 4 to 9 December 2020. Sectors of the Grid Connection project area lying outside the WEF project area itself were *not* re-surveyed but are treated here on a desktop level 9cf Almond 2010b). This is because the areas concerned have already been well-covered by previous field-based palaeontological heritage studies for earlier renewable energy and transmission line projects and are therefore considered to be well-understood as well as generally of low palaeosensitivity.

3.4. Outcome of site sensitivity verification

- **Palaeosensitivity of the WEF project area**

Only a handful of fossil sites has been recorded within the Karee WEF project area during the recent palaeontological heritage site visit. None of these sparse fossil remains are rare or of significant scientific or conservation value. They represent forms that occur widely within the outcrop areas of the sedimentary formations concerned. Most of the Cape Supergroup and Karoo Supergroup rock units represented within the study area are generally of low to (at most) medium palaeosensitivity. Important fossil biotas are known elsewhere in the Western Cape from fresh exposures of the Early Carboniferous Waaipoort and Early Permian Whitehill Formations but in the Karee WEF and grid connection project area these units are both very poorly exposed and often deeply weathered so their palaeosensitivity here is now low. Similar conclusions have been reached by the author and others in several previous palaeontological heritage reports for the Ceres Karoo region.

The overall palaeontological sensitivity of the Karee WEF project area is inferred to be generally LOW due to (1) poor sedimentary bedrock exposure, (2) local tectonic cleavage development and (3) deep chemical weathering of mudrock facies. No high sensitivity fossil sites or palaeontological heritage significance or No-Go areas were identified here during the present field survey.

The palaeosensitivity mapping shown by the DFFE Screening Tool is therefore *contested* here,

- **Palaeosensitivity of grid connection corridors**

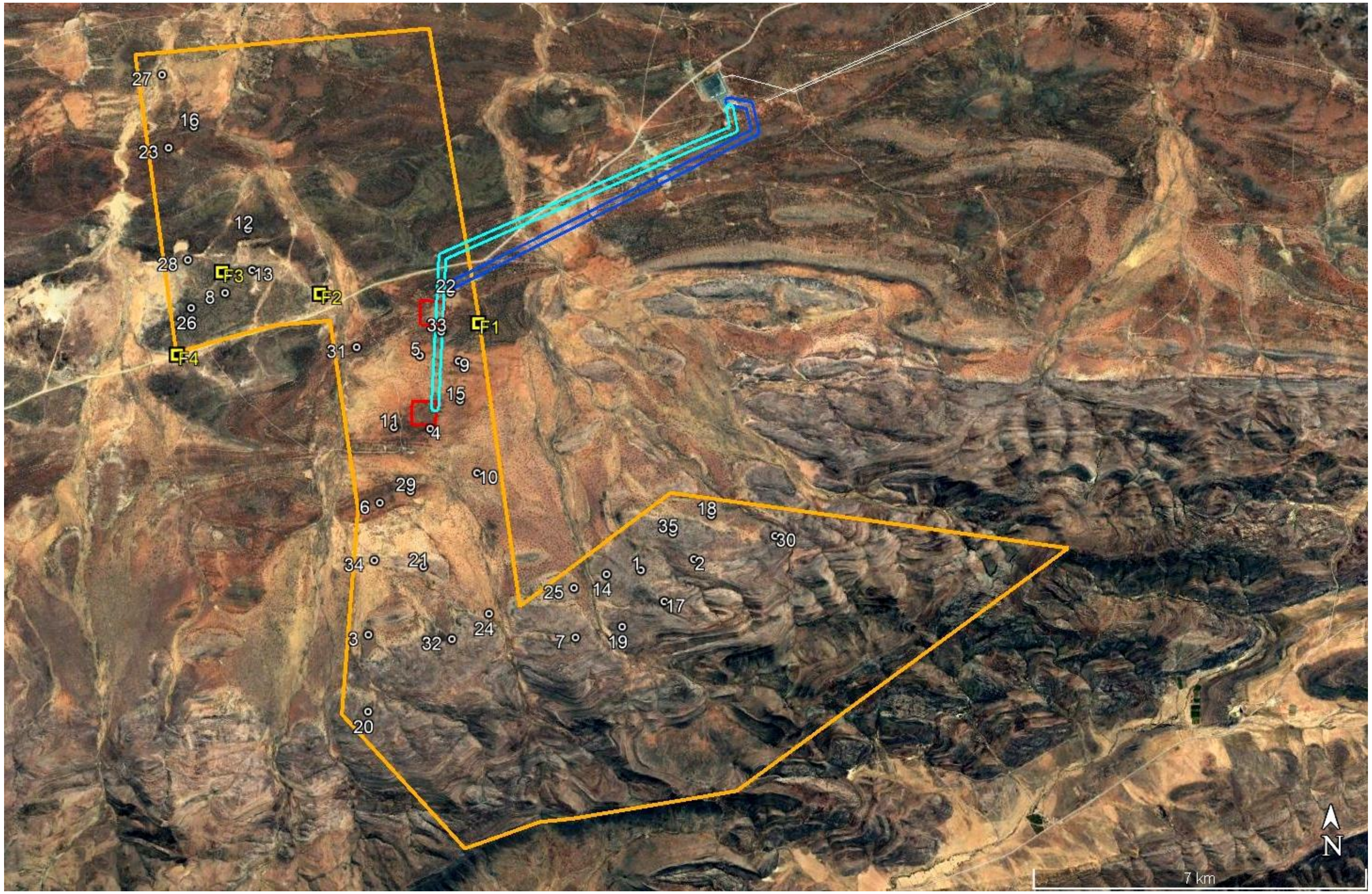
Similar conclusions apply equally to the palaeosensitivity of the alternative grid connection corridors under consideration to link the Karee WEF to the national grid. The corridors traverse portions of the Ceres Karoo that are underlain by the same stratigraphic units as those studied within the WEF project area and that have, for the most part, already been surveyed for previous electrical infrastructure and renewable energy projects (*e.g.,* Almond 2010b, 2016e). Based on these previous PIA studies a general LOW palaeosensitivity for all the various corridors is inferred, with no high sensitivity fossil sites reported within them

The palaeosensitivity mapping shown by the DFFE Screening Tool is *contested* here.

3.5. Conclusion

On the basis of both desktop and field data, the Karee WEF and grid connection project areas in the Ceres Karoo, Western Cape are inferred to be generally of Low Palaeosensitivity in practice. **The provisional Low to Very High Palaeosensitivities proposed by the DFFE Screening Tool for these areas are therefore contested.**

<table>
<tr><td colspan="3">APPENDIX 3: CHANCE FOSSIL FINDS PROCEDURE: Karee WEF and grid connection, Ceres Karoo near Touwsrivier</td></tr>
<tr><td>Province & region:</td><td colspan="2">Western Cape: Cape Winelands District Municipality / Witzenberg Local Municipality</td></tr>
<tr><td>Responsible Heritage Resources Agency</td><td colspan="2">HERITAGE WESTERN CAPE (Contact details: Heritage Western Cape. 3rd Floor Protea Assurance Building, 142 Longmarket Street, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 021 483 5959 Email: ceoheritage@westerncape.gov.za)</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Witteberg Group (Witpoort, Kweekvlei, Floriskraal & Waaipoort Fms), Dwyka Group, Ecca Group (Prince Albert, Whitehill, Collingham Formations), Late Caenozoic colluvium and alluvium.</td></tr>
<tr><td>Potential fossils</td><td colspan="2">In bedrocks: fossil fish, mesosaurid reptiles, shelly invertebrates, vascular plants (incl. petrified wood), trace fossil assemblages. In colluvium and alluvium: teeth, bones and horn cores of mammals, non-marine molluscs, calcretised trace fossils (e.g., termitaria), reworked fossil wood.</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
Context – describe position of fossils within stratigraphy (rock layering), depth below surface
Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g., rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation
Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Agency for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g., entire block of fossiliferous rock)
Photograph fossils against a plain, level background, with scale
Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Agency, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Resources Agency</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g., museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Agency. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Agency minimum standards.</td></tr>
</table>



Appendix 4. Satellite image showing the location of fossil sites recorded within the Karee WEF and grid connection project area (numbered yellow squares). None of these sites lies within the currently defined development footprint or is of significant scientific or conservation value, so no mitigation is proposed here in regard to them. Please see Table A4.1 and text Figures 43 to 48 for details of each fossil occurrence. See Figure 51 for map of fossil sites in relation to refined buildable areas (November 2022).

Table A4.1: Fossil sites recorded within the Karee WEF and grid connection project area

LOC.	GPS data	Comments
F1	33 09 07.9 S 19 57 21.5 E	Tierberg 258 Waaipoort Formation Greyish-weathering phosphatic carbonate concretions with poorly preserved palaeoniscoid fish fossils, vascular plant debris. Proposed Field Rating IIIB. No mitigation recommended.
F2	33 08 44.3 S 19 55 12.2 E	Sadawa 238 Sheetwash surface gravels overlying the Prince Albert Formation. Small block of silicified fossil wood. Proposed Field Rating IIIC. No mitigation recommended.
F3	33 08 29.6 S 19 53 52.3 E	Sadawa 238 Collingham Formation Dense monospecific assemblage of small-scale invertebrate burrows (“Chondrites”) covering a bedding plane. Proposed Field Rating IIIC. No mitigation recommended.
F4	33.142689S 19.887692 E	Collingham Formation greyish wacke Assemblages of hollow vermiform invertebrate burrows. Proposed Field Rating IIIC. No mitigation recommended.