PROPOSED 400 KV POWERLINE CONNECTION FOR THE ESIZAYO WIND ENERGY FACILITY NEAR LAINGSBURG, CENTRAL KAROO DISTRICT MUNICIPALITY, WESTERN CAPE: PALAEONTOLOGICAL HERITAGE BASIC ASSESSMENT

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EXECUTIVE SUMMARY

It is planned to connect the Biotherm Energy's proposed Esizayo Wind Energy Facility (WEF), situated in the Klein-Roggeveld region of the Great Karoo some 30 km to the northwest of Laingsburg, Western Cape, to the national electricity grid. The link will occur *via* the existing Eskom Komsberg Main Transmission Substation, situated to the north of the Esizayo WEF project area on Farm Standvastigheid 210, Northern Cape Province. It will involve the construction of an Eskom on-site substation (two sites under consideration) as well as a 400 kV powerline (two corridor options *per* substation under consideration).

Combined field-based and desktop palaeontological assessments covering all the potential substation and powerline footprints have already been submitted (Almond 2015b, 2015c, 2016f), as well as for several adjoining areas. The Klein-Roggeveld region is largely underlain by deltaic and continental (fluvial / lacustrine) sediments of the Waterford and Abrahamskraal Formations. These rocks belong to Ecca and Lower Beaufort Groups of the Karoo Supergroup and are of Middle Permian age. The Karoo bedrocks in this region have yielded scientifically-important fossils of petrified wood, tetrapod (terrestrial vertebrate) burrows and very rare skeletal remains of the *Eodicynodon* Assemblage Zone in this region, but well-preserved fossils are very sparsely distributed. There are no known fossil sites within any of the substation and powerline footprints under consideration. The sedimentary bedrocks are extensively covered by Late Caenozoic superficial sediments (*e.g.* scree, gravelly soils) that are usually unfossiliferous. The overall palaeontological sensitivity of the study area is rated as low.

The impact significance of the construction phase of the proposed on-site substation and powerline for the Esizayo WEF is assessed as LOW (negative) in terms of palaeontological heritage resources. This is a consequence of (1) the paucity of irreplaceable, unique or rare fossil remains within the study area as well as (2) the extensive superficial sediment cover overlying most potentially-fossiliferous bedrocks here. This assessment applies equally to the two substation sites and various associated powerline corridors under consideration here. Significant further impacts during the operational and de-commissioning phases of the electrical infrastructure are not anticipated. There are therefore no preferences on palaeontological heritage grounds for any particular layout among the various substation and powerline options under consideration. The no-go alternative (*i.e.* no development) will have a low (neutral) impact on palaeontological heritage.

Cumulative impacts on palaeontological heritage resources that are anticipated as a result of the numerous alternative energy developments currently proposed or authorised for the Klein-Roggeveldberge region, including the Esizayo WEF and its electrical infrastructure, are predicted to be low (negative), *provided that* the proposed monitoring and mitigation recommendations made for these various projects are followed through (Almond 2016f). Unavoidable residual negative impacts may be partially offset by the improved understanding of Karoo palaeontology resulting from appropriate professional mitigation. This is regarded as a *positive* impact for Karoo palaeontological

heritage. *Without* mitigation, cumulative impacts resulting from the large number of alternative projects in the Klein-Roggeveld region are anticipated to be of medium significance.

There are no fatal flaws in the Esizayo WEF grid connection infrastructure development proposals as far as fossil heritage is concerned. *Provided that* the recommendations for palaeontological monitoring and mitigation outlined below (See also Section 6 of this report) are followed through, there are no objections on palaeontological heritage grounds to authorisation of the proposed on-site substation and 400 kV powerline. Pending the potential discovery of substantial new fossil remains during construction, specialist palaeontological mitigation is not recommended for this project. The following general recommendations concerning conservation and management of palaeontological heritage resources apply.

The Environmental Control Officer (ECO) responsible for the Esizayo WEF grid connection developments should be made aware of the potential occurrence of scientifically-important fossil remains within the development footprint. During the construction phase all major clearance operations (*e.g.* for new access roads, pylon footings) and deeper (> 1 m) excavations should be monitored for fossil remains on an on-going basis by the ECO. Should substantial fossil remains - such as vertebrate bones and teeth, or petrified logs of fossil wood - be encountered at surface or exposed during construction, the ECO should safeguard these, preferably *in situ*. They should then alert the relevant provincial heritage management authority as soon as possible - *i.e.* Heritage Western Cape for the Western Cape (Contact details: Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 086-142 142. Fax: 021-483 9842. Email: hwc@pgwc.gov.za) and SAHRA for the Northern Cape (Contact details: Dr Ragna Redelstorff, SAHRA, P.O. Box 4637, Cape Town 8000. Tel: 021 202 8651. Email: rredelstorff@sahra.org.za). This is to ensure that appropriate action - *i.e.* recording, sampling or collection of fossils, recording of relevant geological data - can be taken by a professional palaeontologist at the developer's expense.

These mitigation recommendations should be incorporated into the Environmental Management Programme (EMPr) for the Esizayo WEF on-site substation and powerline projects. Please note that:

- All South African fossil heritage is protected by law (South African Heritage Resources Act, 1999) and fossils cannot be collected, damaged or disturbed without a permit from SAHRA or the relevant Provincial Heritage Resources Agency (in this case Heritage Western Cape);

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

- All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies developed by HWC (2016) and SAHRA (2013).

1. INTRODUCTION

1.1. Scope of Work

The brief for the present Basic Assessment report is to provide an authoritative, reasoned assessment of potential impacts on palaeontological heritage resources posed by the construction of an on-site substation and associated 400 kV powerline connection between the proposed Esizayo Wind Energy Facility (WEF) near Laingsburg, Western Cape, and the national grid *via* the existing Komsberg Main Transmission Substation on Farm Standvastigheid 210 near Sutherland, Northern Cape Province (Figures 1 & 2). The assessment is largely based on a desktop survey of several recent palaeontological field surveys within and adjoining the study region, most notably those by Almond (2015b), Almond (2015c), Almond (2016b), Almond (2016c) and - especially - Almond (2016f).

Recommendations for any necessary palaeontological mitigation or management measures during the construction phase of the powerline are also made.

1.2. Objectives of the report

The Esizayo WEF on-site substation and powerline study areas are located in a region that is underlain by potentially fossiliferous sedimentary rocks of Late Palaeozoic and younger, Late Tertiary or Quaternary, age (See Section 3 of this report). The construction phase of the proposed substation, powerline and associated access roads will entail extensive surface clearance as well as excavations into the superficial sediment cover and underlying bedrock. The development may adversely affect legally-protected fossil heritage within the study area by 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 substation and powerline are unlikely to involve further adverse impacts on local palaeontological heritage.

A combined desktop and field-based palaeontological heritage assessment of the Esizayo WEF project area (Almond 2016f) has already been submitted as part of the EIA Phase for the WEF development that is being co-ordinated on behalf of Biotherm Energy (Pty) Ltd (Biotherm) by WSP | Parsons Brinckerhoff, Environment & Energy, Africa (Contact details: Ms Ashlea Strong. WSP | Parsons Brinckerhoff, Environment & Energy, Africa. WSP House, Bryanston Place, 199 Bryanston Drive, Bryanston, 2191, South Africa. Tel: +27 11 361 1392. Mob: +27 82 786 7819. Fax: +27 11 361 1381. E-mail: Ashlea.Strong@WSPGroup.co.za). Comparable palaeontological assessments for the adjoining Karusa WEF, Rietkloof WEF, Brandvalley WEF and the expanded Eskom Komsberg Substation have also been submitted by the author (Almond 2015c, 2015b, 2016b and 2016c respectively).

1.3. Legislative Framework

The present palaeontological heritage assessment report contributes to the consolidated heritage Basic Assessment for the proposed substation and 400 kV powerline and falls under the South African Heritage Resources Act (Act No. 25 of 1999). It will also inform the Environmental Management Programme (EMP) for these alternative energy projects.

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

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

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

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.
(2) All archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.
(4) No person may, without a permit issued by the responsible heritage resources authority—
    (a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
    (b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
    (c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
    (d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.
(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—
    (a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
    (b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
    (c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and
    (d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have been published by Heritage Western Cape, HWC (2016) and the South African Heritage Resources Agency, SAHRA (2013).

1.4. Study approach and methodology

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

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the planning, operational or de-commissioning phases. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authorities, *i.e.* SAHRA for the Northern Cape (Contact details: Dr Ragna Redelstorff. Heritage Officer Archaeology, Palaeontology & Meteorites Unit, SAHRA. 111 Harrington Street, Cape Town, 8001. Tel: +27 (0)21 202 8651. Fax: +27 (0)21 202 4509 E-mail:rredelstorff@sahra.org.za) and Heritage Western Cape for the Western Cape (Contact details: Heritage Western Cape. Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 086-142 142. Fax: 021-483 9842. Email: hwc@pgwc.gov.za). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

In summary, the approach to a Phase 1 palaeontological heritage study is as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and relevant geological sheet explanations as well as satellite images. Known fossil heritage in each rock unit is inventoried from scientific literature, previous palaeontological assessments of the broader study region, and the author's field experience and palaeontological database. Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed in this case using the methodology selected by WSP | Parsons Brinckerhoff, Environment & Energy, Africa. Recommendations for any further palaeontological studies or mitigation considered necessary are specified.

The present desktop PIA study was undertaken in line with the HWC (2016) and SAHRA (2013) Minimum Standards for the palaeontological component of heritage impact assessment. It was largely based on the following sources of information:

1. A brief project outline, maps and kmz files provided by WSP | Parsons Brinckerhoff, Environment & Energy, Africa;
2. Relevant geological maps and sheet explanations (*e.g.* Theron 1983, Theron *et al.* 1991, Cole & Vorster 1999) as well as Google earth© satellite imagery;
3. Several palaeontological heritage assessment reports by the present author for proposed developments in the Klein-Roggeveldberge region between Sutherland and Matjiesfontein. They include palaeontological assessments for the Esizayo WEF, Karusa WEF, Rietklof WEF, Brandvalley WEF and the expanded Eskom Komsberg Substation (Almond 2016f, 2015c, 2015b, 2016b and 2016c respectively).
4. The author's previous experience with the formations concerned and their palaeontological heritage (*cf* Almond & Pether 2008a-b and references listed above).

Fossil localities that were recorded during fieldwork for the Esizayo WEF (See Almond 2016f for details) are shown in relation to the powerline corridors and substation sites under consideration on the satellite images provided in Figures 1 and 2. Please note that these maps do *not* show all fossils that are present at surface within the study area. Additional, unrecorded fossil occurrences (the majority) are to be expected in the subsurface, where they may be impacted during the construction phase of the development. Areas on the map that do not contain known fossil sites are therefore not necessarily fossil-free or palaeontologically insensitive.

1.5. Assumptions

Since most fossils are buried beneath the surface, their nature and distribution cannot be directly assessed during field surveys of the development footprint. Palaeontological assessments therefore rely on extrapolating palaeontological sensitivities within the footprint from desktop data and field surveys of well-exposed sedimentary rocks, mostly from sites *outside,* and often well away from, the footprint itself. This approach assumes that the rock exposures seen are representative - in palaeontological terms - of the rock units (formations, members *etc*) that will be impacted by the proposed development.

1.6. Limitations of this study

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

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

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

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

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

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

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

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

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

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

In the case of the Esizayo WEF substation and powerline study area near Laingsburg in the Western Cape, preservation of potentially fossiliferous bedrocks is favoured by the semi-arid climate and sparse vegetation. However, bedrock exposure is highly constrained by extensive superficial deposits, especially in areas of low relief, as well as pervasive Karoo *bossieveld* vegetation (Central Mountain Shale Renosterveld, Koedoesberg – Moordenaars Karoo, Tanqua Wash Riviere). Much of the study area is is hilly or mountainous with few access roads, especially in rugged upland areas (*cf* Figures 3 to 10). However, sufficient bedrock exposures were examined during the course of the several previous field studies in the region to assess the palaeontological heritage sensitivity of the main rock units represented within the study area (See reference list). Confidence levels for this impact assessment are consequently rated as medium.

1.7. Declaration of independence

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

Dr John E. Almond
(**Palaeontologist**, ***Natura Viva*** **cc)**

2. DESCRIPTION OF THE PROJECT

The company BioTherm Energy (Pty) Ltd (BioTherm) is proposing to develop a wind energy facility (WEF) with a total generation capacity of up to 140 MW, to be known as the Esizayo WEF, on a site located some 30 km to the northwest of Laingsburg, Laingsburg District Municipality, Western Cape. A separate combined desktop and field-based palaeontological heritage assessment for the Esizayo WEF has been submitted previously by Almond (2016f) as part of the EIA for this project. It is planned to connect the Esizayo WEF to the national electricity grid *via* the existing Eskom Komsberg Main Transmission Substation situated to the north of the Esizayo WEF project area on Farm Standvastigheid 210, Northern Cape Province. The present report provides a brief Basic Assessment of anticipated palaeontological heritage impacts of electrical infrastructure relating to the connection of the Esizayo WEF to the national grid, *viz*, the Eskom on-site substation and associated 400 kV powerline.

The following main infrastructural components will be involved:

- An Eskom on-site substation (The two site options under consideration are shown in green and red in Figs. 2 and 3, with the former being the preferred option).
- A double-circuit 400 kV powerline between the chosen Eskom on-site substation and the Komsberg Main Transmission Substation (See Figures 1 and 2 for optional western and eastern powerline routes, showing the 500-m wide corridor assessed here. The western corridor running along the R354 tar road between Matjiesfontein and Sutherland is the preferred option).
- An operations and maintenance (OM) building at each Eskom on-site substation;
- Roads and cables.

Land parcels potentially affected by the proposed 400 kV powerline, depending on the final route chosen, include: Farm 72 (Portion 2) Anstoot, Remainder of Farm 73 Bon Espirange, Portion 1 of Farm 73 Bon Espirange, Remainder of Farm 74 Fortuin, Remainder of Farm 105 Oskop (April's Kraal), Remainder of Farm 284 Nuwerus and Remainder of Farm 285 Aurora.

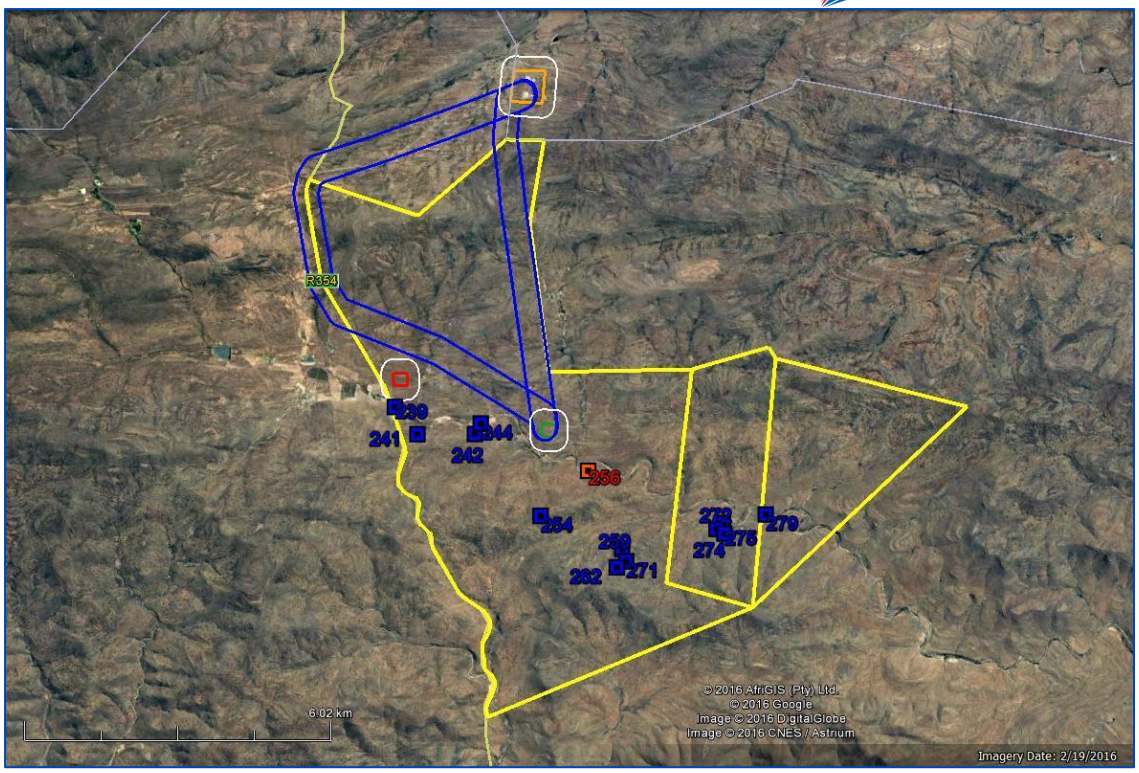

Figure 1: Google earth© satellite image of the Esizayo WEF project area (yellow polygon) near Laingsburg, Western Cape, showing two site options for the on-site Eskom substation (green – preferred; red – alternative) and two route options for the 400 kV powerline corridor connecting the preferred Eskom on-site substation with the existing Komsberg Main Transmission Substation to the northeast (orange). Numbered fossil sites in red and blue are from Almond (2016f). White lines show buffer zones around the substation sites.

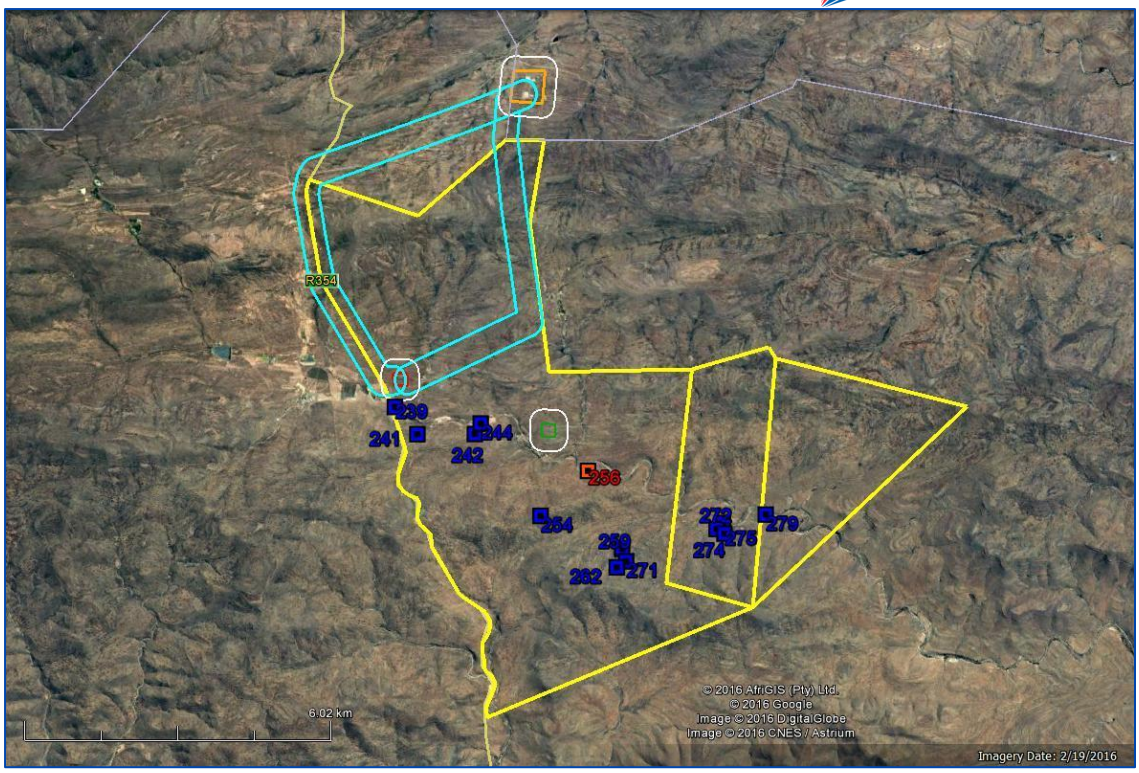

Figure 2: Google earth© satellite image of the Esizayo WEF project area (yellow polygon) near Laingsburg, Western Cape, showing two site options for the on-site Eskom substation (green – preferred; red – alternative) and two route options for the 400 kV powerline corridor connecting the alternative Eskom on-site substation with the existing Komsberg Main Transmission Substation to the northeast (orange). Numbered fossil sites in red and blue are from Almond (2016f). White lines show buffer zones around the substation sites.

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

The Esizayo WEF powerline project area is situated in semi-arid, hilly to mountainous terrain of the Klein-Roggeveldberge region in the south-western part of the Great Karoo. It lies on the eastern side of the R354 Matjiesfontein to Sutherland tar road and some 30 km northwest of Laingsburg, Western Cape (Figures 1 & 2). West-east trending uplands reach elevations of *c*. 1390 m above mean sea level (amsl) in the north of the WEF study area (Skaapberg). The northern and central portions of the area are drained by the SE-flowing Roggeveldrivier (itself a tributary of the Buffelsrivier) and its various small tributaries. The south-western and southern portions are drained by tributaries of the Wilgerhoutrivier which also eventually drains into the Buffelsrivier near Laingsburg. The level of bedrock exposure in the study region is highly constrained by extensive superficial deposits, especially in areas of low relief, as well as pervasive Karoo *bossieveld* vegetation (Central Mountain Shale Renosterveld, Koedoesberg – Moordenaars Karoo, Tanqua Wash Riviere).

Representative views of the geology and topography in the present study area are given in Figures 3 to 10 below. Further details on local geology and provided by Almond (2016f).

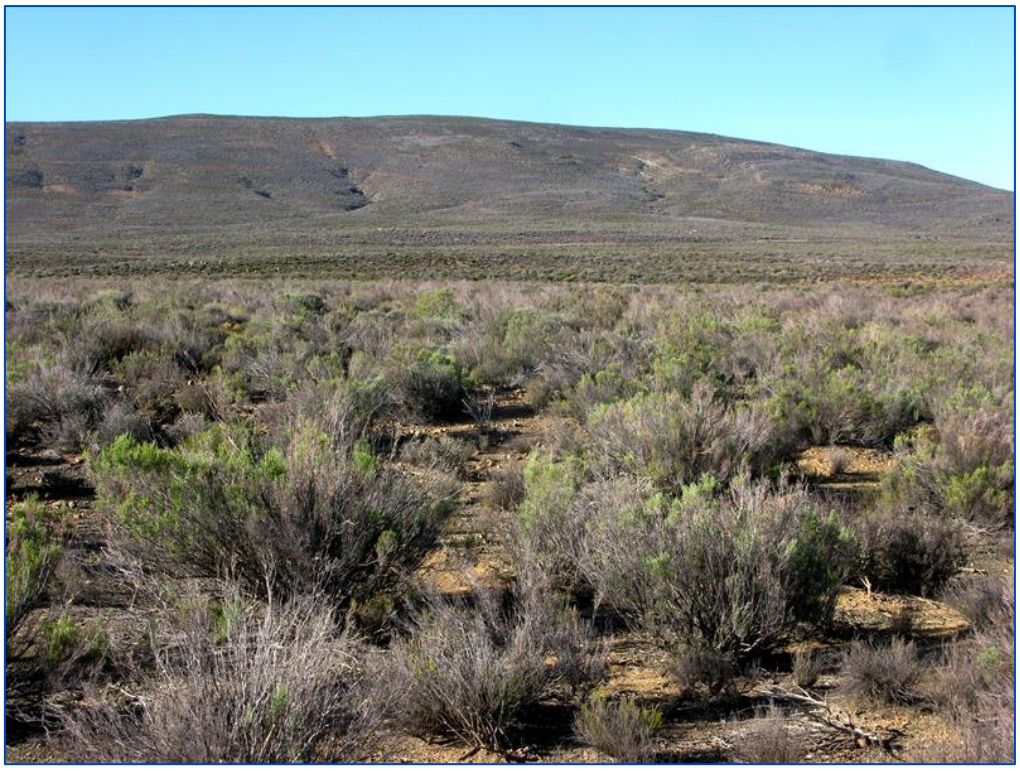

Figure 3. View of the northern slopes of the west-east trending Skaapberg ridge that runs between the Esizayo WEF project area and the existing Komsberg Substation (April's Kraal 105). Note gentle slopes and lack of bedrocks exposure outside stream gullies.

Figure 4. View southwards from the crest of Skaapberg across the northern and central sectors of the Esizayo WEF study area (From Almond 2016f). The Skaapberg ridge will be traversed by the proposed 400 kV powerline to the Komsberg Substation. Hillslopes here are extensively mantled by sandstone colluvium (scree, gravelly soil).

Figure 5. Stream gulley and waterfall exposure of dark grey overbank mudrocks of the lower Abrahamskraal Formation, northern slopes of Skaapberg, Aanstoot 72, Esizayo WEF project area.

Figure 6. Broad stream gully exposure of lower Abrahamskraal Formation bedrocks, including fine-grained sandstones and dark grey mudrocks with ferruginous carbonate concretions, on the southern slopes of Skaapberg, Aanstoot 72, Esizayo WEF project area.

Figure 7. View eastwards along the crest of Skaapberg showing mantle of coarse sandstone colluvium and sandy soils with very limited solid bedrock exposure, Aanstoot 72.

Figure 8. Thick gravelly to sandy alluvium and soils overlying Abrahamskraal Formation mudrocks exposed in a deep donga on the southern footslopes of the Skaapberg (From Almond 2016f). Much of the proposed 400 kV powerline corridor would traverse similar poorly-fossiliferous superficial deposits.

Figure 9. Bare sandy patches of alluvial soils with patches of dispersed surface gravels modified by sheetwash, Aanstoot 72 (From Almond 2016f).

Figure 10. Thick package of Waterford Formation delta top wackes exposed in the core of the Skaapberg anticline on the eastern side of the R354, Fortuin 74 (From Almond 2016f).

3.1. Geological context

The geology of the Esizayo WEF powerline study area is outlined on the 1: 250 000 geology sheet 3220 Sutherland (Council for Geoscience, Pretoria; Theron 1983, Cole & Vorster 1999) (Figure 11) and illustrated in Figures 3 to 10 below. Geologically it lies on the gently-folded northern margin of the Permo-Triassic Cape Fold Belt (CFB) and is dominated by bedrocks of the Karoo Supergroup within the Main Karoo Basin (Johnson *et al.* 2006). Gentle folding along west-east trending fold axes of both uppermost Ecca Group and Lower Beaufort Group bedrocks is apparent within the study area. In general bedding dips are not high, however (15 to 25 degrees on geological map), and levels of tectonic deformation are usually low with little cleavage development. Several WNW-ESE trending faults cutting the Lower Beaufort Group succession can be picked out on satellite images by bush clumps and sharp bedding discontinuities but these are not shown on the geological map. These narrow lines may be locally associated with narrow dolerite dykes.

Only three mappable bedrock units or formations are represented within the study area. These are:

- Sandstone-dominated deltaic sediments of the **Waterford Formation** (**upper Ecca Group**) of Middle Permian age that crop out in the cores of west-east trending anticlines. A small outcrop area of Waterford bedrocks is present in the core of the Skaapberg anticline, as seen along the R354 (Figure 10) (Pw dark brown / Pwa orange in Figure 11).

- Fluvial and lacustrine mudrocks and sandstones of the **Abrahamskraal Formation** (**Lower Beaufort Group / Adelaide Subgroup**) of Middle Permian age. These beds crop out over the great majority of the powerline study area (Pa, pale green in Figure 11). However, exposure levels of these older sedimentary bedrocks are generally very low and mainly confined to stream gullies (Figs. 3 to 6), as well as a borrow pit along the R354.

- Narrow dykes of the **Karoo Dolerite Suite** of Early Jurassic age that are intruded into the Lower Beaufort Group beds along WNW-ESE trending fracture zones. They are only mapped in the southern portion of the Esizayo WEF study area (Jd, red lines in Figure 11) but were also recorded in streambed exposures further north by Almond (2016f).

- Levels of bedrock exposure in the Klein-Roggeveldberge region are generally very low due to the pervasive mantle of **Late Caenozoic superficial deposits** such as alluvium, colluvium (scree, hillwash), surface gravels, pedocretes (*e.g.* calcrete) and soils, as well as karroid bossiveld vegetation (Figs. 7 to 9). Most of these deposits are of Quaternary to Holocene age. They have not been mapped at 1: 250 000 scale within the Esizayo project area. The majority of powerline pylon foundations are likely to be excavated into relatively unfossiliferous superficial sediments rather than the underlying Beaufort Group bedrocks.

Illustrated descriptions of Waterford, Lower Beaufort and Karoo dolerite bedrocks as well as various superficial sediments within the Esizayo WEF and powerline study area have been given by Almond (2016f). The area to the north is covered by previous PIA studies for the Komsberg Substation and Karusa WEF by Almond (2015b, 2015c).

Figure 11. Extracts from adjoining 1: 250 000 scale geology sheets 3320 Ladismith (below) and 3220 Sutherland (above) showing the location of the proposed Esizayo WEF study area, *c*. 30 km northwest of Langsburg, Western Cape Province (yellow polygon) (Abstracted from geological maps published by Council for Geoscience, Pretoria). Optional sites for the Eskom on-site substation are shown in green (preferred) and red (alternative). The two 400 kV powerline corridors to the existing Komsberg Main Transmission Substation (orange) under consideration for each on-site substation are shown in pale or dark blue. In each case the western corridors along the R354 tar road are preferred.

The main mappable rock units (fm = formation) represented within the study area are:

ECCA GROUP	**Waterford Fm (Pwa, orange / Pw, dark brown)**
LOWER BEAUFORT GROUP	**Abrahamskraal Fm (Pa, pale green)**
KAROO DOLERITE SUITE	**Karoo dolerite (Jd, red lines)**

Various Late Caenozoic superficial deposits that are not mapped at 1: 250 000 scale include alluvium, colluvium (scree deposits, hillwash), downwasted surface gravels, pedocretes (calcretes) and soils.

4. PALAEONTOLOGICAL HERITAGE

The Great Karoo is world-famous for its rich record of terrestrial vertebrates and other fossils from the Permian, Triassic and Early Jurassic Periods in Gondwana (Rubidge 1995, MacRae 1999, Rubidge 2005, McCarthy & Rubidge 2005, Smith *et al.* 2012). The fossil record of the Klein-Roggeveld region is very poorly known by Karoo standards but our knowledge has been improved in recent years through several palaeontological impact assessments in the area (See References).

The principal fossil sites recorded during the recent field study for the Esizayo WEF are indicated on the satellite image of the project area in Figures 1 and 2. The fossil database has been abstracted from Almond (2016f) where the fossil material is illustrated and briefly described, while detailed locality data has been tabulated in the Appendix to that report. Please note that these are *not* distribution maps of *all* fossil occurrences within the project area – most of which are not exposed at the surface – but only a representative sample of the better-preserved fossils encountered during the field assessment. Further, unrecorded fossil occurrences are to be expected elsewhere at the ground surface or in the subsurface (the majority), where they may be impacted during the construction phase of the powerline. Areas on the map that do not contain known fossil sites are therefore not necessarily fossil-free or palaeontologically-insensitive. The great majority of the fossils observed are of widely-occurring forms and are not considered to be of exceptional scientific or conservation value.

The only fossils recorded from the Waterford Formation in the Esizayo WEF project area are local concentrations of simple horizontal burrows plus disarticulated moulds of bony and / or cartilaginous skeletal elements of probable fish or amphibian affinity (Almond 2016f). Well-preserved silicified wood – including fragments of large logs – as well as low-diversity trace fossil assemblages have been recorded from the Rietkloof and Brandvalley WEF study areas, just to the southwest and west of the Esizayo WEF study area (Almond 2016b, 2016c). No fossils are known from the Waterford beds along the R354 whose outcrop lies close to the western Esizayo powerline corridor (Figure 10).

Sparse fossil remains recorded from the Lower Beaufort Group in the Esizayo WEF study area include low-diversity trace fossil assemblages (invertebrate burrows, casts of reedy plant stems) and plant compressions, casts and moulds that are probably attributable to horsetail ferns (Almond 2016f). None of the known fossil sites lies within the footprints of the 400 kV powerline and on-site substation sites under consideration (Figures 1 and 2); direct impacts on these sites are therefore not anticipated. It is notable that no well-preserved petrified wood or terrestrial vertebrate remains have been recorded from these lowermost beds of the Abrahamskraal Formation in the Esizayo, Karusa and Komsberg Substation study areas. These beds probably belong to the Middle Permian *Eodicynodon* Assemblage Zone within which vertebrate remains are notoriously rare (Rubidge 2005, Smith *et al.* 2012). It is therefore of scientific interest that very occasional tetrapod burrows, and even disarticulated skeletal remains, are in fact recorded from this stratigraphic level in the Brandvalley WEF study area (Almond 2016c).

No fossil remains are recorded from the pervasive Late Caenozoic superficial sediments mantling the Karoo Supergroup bedrocks in the broader study region, while the minor dolerite intrusions are unfossiliferous. It is concluded that the overall palaeontological sensitivity of the 400 kV powerline and on-site substation study areas for the Esizayo WEF development is low.

5. ASSESSMENT OF IMPACTS

Given the very uniform underlying geology (and hence expected palaeontological resources), this assessment applies equally to all the on-site substation sites and 400 kV powerline corridors under consideration.

All South African fossil heritage is protected by law (South African Heritage Resources Act, 1999) and fossils may not be collected, damaged or disturbed without a permit from the relevant Provincial Heritage Resources Agency (in this case Heritage Western Cape) (See Section 1.3). The construction

phase of the proposed on-site substation and 400 kV powerline will entail extensive surface clearance (notably for access roads, pylon footings) as well as excavations into the superficial sediment cover and possibly also into the underlying bedrock, albeit to a limited extent (*e.g. for* pylon footings). The development may adversely affect potential fossil heritage within the study area by destroying, damaging, 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 operational and de-commissioning phases of the substation and powerline are very unlikely to involve further adverse impacts on local palaeontological heritage and are therefore not separately assessed here.

5.1. Impact assessment for the construction phase

This assessment (See Table 1) refers to impacts on fossil heritage preserved at or beneath the ground surface within the footprint of the on-site substation and associated 400 kV powerline during the construction phase, mainly due to surface clearance and excavation activities. It is noted that surface clearance for lengthy access roads associated with new powerlines is likely to have greater impact on fossil heritage than the intermittent, shallow excavations for pylon footings. Such impacts on fossil heritage are *limited to the site* (development footprint) and are generally *direct*, *negative* and of *permanent* effect (non-reversible). While fossils of some sort (including microfossils, invertebrate trace fossils and plant debris) are of widespread occurrence within the project area, unique or scientifically-important fossils are very scarce indeed here, even where bedrock exposure levels are locally high. Only one highly-sensitive no-go area has been identified within the broader Esizayo WEF study area and this lies well outside the substation and 400 kV powerline development footprint (Figures 1 & 2, site marked in red). It is concluded that impacts on scientifically important palaeontological heritage resources are *improbable* and of *minor magnitude* since (1) significant fossil sites are unlikely to be affected and (2) in many cases these impacts can be mitigated. The overall impact significance during the construction phase of the substation and powerline infrastructure *without mitigation* is rated as LOW in terms of palaeontological heritage resources. Should the proposed mitigation measures outlined in Section 6 below be fully implemented, the impact significance would remain low. However, residual negative impacts such as the inevitable loss of fossil heritage would be partially offset by an improved understanding of Karoo fossil heritage which is considered a *positive* impact.

There are no objections on palaeontological heritage grounds to authorisation of the proposed on-site substation and associated 400 kV powerline developments. Given the overall low impact significance of the broader Esizayo WEF project area, and the paucity of high-sensitivity fossil sites recorded here, there are no suggested modifications on palaeontological heritage grounds to the proposed siting of the Eskom on-site substation and associated 400 kV powerline. Likewise, there is no preference on palaeontological grounds for one or other of the two sites under consideration for the on-site Eskom substation, or for the western or eastern powerline corridors associated with each substation site.

Confidence levels for this assessment are rated as medium, given the number of palaeontological field studies recently carried out within the broader Klein-Roggeveld study region, including the Esizayo WEF study area (See References).

The impact assessment for the **No-Go Option** considers future impacts on local fossil heritage that are likely to occur in the absence of WEF development, using the present status of fossil heritage in the area as a baseline. Destruction of near-surface or surface fossil material by natural bedrock weathering and erosion will be partially counterbalanced by on-going exposure of fresh fossil material by erosion. Improvements in our understanding of palaeontology of the area (a possible positive impact) will depend on whether or not field-based academic or impact studies are carried out here, which is inherently unpredictable (There is an on-going research project on the palaeontology of the SW Karoo by Wits University).

Potential Impact		Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
	Nature of impact:	Disturbance, damage or destruction of fossils (direct, negative impacts) preserved at or beneath the ground surface within the development footprint during the construction phase, mainly due to surface clearance or excavation activities.							
	Without Mitigation	1	5	2	2	16	Low	-	Medium
	degree to which impact can be reversed:	Irreversible							
	degree of impact on irreplaceable resources:	Minor							
	Mitigation Measures	• Monitoring of all surface clearance and substantial excavations (>1 m deep) by the ECO for fossil material (e.g. bones, teeth, fossil wood) on an on-going basis during the construction phase. • Safeguarding of chance fossil finds (preferably in situ) during the construction phase by the responsible ECO, followed by reporting of finds to Heritage Western Cape. • Recording and judicious sampling of significant chance fossil finds by a qualified palaeontologist, together with pertinent contextual data (stratigraphy, sedimentology, taphonomy). • Curation of fossil material within an approved repository (museum / university fossil collection) by a qualified palaeontologist.							
	With Mitigation								Medium

Table 1: Assessment of anticipated impacts on palaeontological heritage resources for the proposed Esizayo WEF Eskom on-site substation and associated 400 kV powerline (construction phase). This assessment applies equally to both substation sites as well as the alternative western and eastern powerline corridors under consideration.

5.2. Assessment of cumulative impacts (construction phase)

Cumulative impacts inferred for the various alternative energy developments in the Klein-Roggeveld region between Matjiesfontein and Sutherland have been previously assessed by Almond (2016f) on the basis of desktop and field-based palaeontological impact assessment reports for these projects, the great majority of which were submitted by the present author (See references provided below and SAHRIS website). The projects concerned lie within a radius of some 50-70 km of the Esizayo WEF project area. Relevant published palaeontological literature for the region has also been taken into account (*e.g.* Loock *et al.* 1994). This assessment applies only to the construction phases of the WEF developments, since significant additional impacts on palaeontological heritage during the operational and de-commissioning phases are not anticipated.

In all the strictly *relevant* field-based palaeontological studies in the Klein-Roggeveld region the palaeontological sensitivity of the project area and the palaeontological heritage impact significance for the developments concerned has been rated as low. In all cases it was concluded by the author that, despite the undoubted occurrence of scientifically-important fossil remains (notably fossil vertebrates, vertebrate trackways and burrows, petrified wood), 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 some of the formations present, they tend to be sparse – especially as far as fossil vertebrates are concerned - while the great majority represent common forms that occur widely within the outcrop areas of the rock units concerned. Important exceptions include (1) local concentrations of exceptionally well-preserved fossil logs in the Waterford Formation and (2) vertebrate burrows attributed to small therapsids, and possibly also to lungfish (Almond 2016b, Almond 2016c). Well-preserved vertebrate trackways made by temnospondyl amphibians or other, unidentified tetrapods found *c*. 35 km north of the Esizayo WEF project area (Almond 2016e) are not really relevant here because they occur within significantly younger sediments of the Lower Beaufort Group.

Cumulative impacts for the Esizayo WEF Eskom on-site substation and associated 400 kV powerline in the context of comparable alternative energy projects proposed or authorised in the Klein-Roggeveld region are assessed in Table 2. It is concluded that the cumulative impact significance of the proposed new developments and other regional projects is *low* (*negative*), *provided* that the proposed monitoring and mitigation recommendations made for all these various projects are followed

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

Potential Impact		Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
	Nature of impact:	Disturbance, damage or destruction of fossils (direct, negative impacts) preserved at or beneath the ground surface within the development footprint during the construction phase, mainly due to surface clearance or excavation activities.							
	Without Mitigation	3	5	4	3	36	Medium	-	Medium
	degree to which impact can be reversed:	Irreversible							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	• Monitoring of all surface clearance and substantial excavations (>1 m deep) by the ECO for fossil material (e.g. bones, teeth, fossil wood) on an on-going basis during the construction phase. • Safeguarding of chance fossil finds (preferably in situ) during the construction phase by the responsible ECO, followed by reporting of finds to Heritage Western Cape (HWC). • Recording and judicious sampling of significant chance fossil finds by a qualified palaeontologist, together with pertinent contextual data (stratigraphy, sedimentology, taphonomy). • Curation of fossil material within an approved repository (museum / university fossil collection) by a qualified palaeontologist.							
	With Mitigation	3	5	2	2	20	Low	-	Medium

Table 2: Assessment of anticipated cumulative impacts on palaeontological heritage resources for the proposed Esizayo WEF Eskom on-site substation and associated 400 kV powerline in the context of numerous other alternative developments in the region (construction phase).

6. MITIGATION AND MANAGEMENT MEASURES

Given the scarcity of scientifically-important, unique fossil heritage recorded within the on-site substation and powerline study area, no further specialist palaeontological studies or mitigation are recommended for this development, pending the potential discovery of significant new fossils before or during the construction phase.

The following general palaeontological mitigation measures apply to the construction phase (See Table 3):

- Monitoring of all surface clearance and substantial excavations (>1 m deep) by the ECO for fossil material (*e.g.* bones, teeth, fossil wood) on an on-going basis during the construction phase.

- Safeguarding of chance fossil finds (preferably *in situ*) during the construction phase by the responsible ECO, followed by reporting of finds to Heritage Western Cape (HWC) / SAHRA.

- Recording and judicious sampling of significant chance fossil finds by a qualified palaeontologist, together with pertinent contextual data (stratigraphy, sedimentology, taphonomy) (Phase 2 mitigation).

- Curation of fossil material within an approved repository (museum / university fossil collection) and submission of a Phase 2 palaeontological heritage report to HWC / SAHRA by a qualified palaeontologist.

Mitigation of significant chance fossil finds reported by the ECO would involve the recording, sampling and / or collection of fossil material and associated geological data by a professional palaeontologist during the construction phase of the development. The palaeontologist concerned with potential mitigation work (Phase 2) would need a valid fossil collection permit from Heritage Western Cape (W. Cape) or SAHRA (N. Cape) and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection). All palaeontological fieldwork and reporting should meet the minimum standards outlined by HWC (2016) and SAHRA (2013).

Significant further impacts on palaeontological heritage resources are not anticipated during the planning, operational, decommissioning and rehabilitation phases of the substation and powerline so no further mitigation or management measures in this respect are proposed here.

These monitoring and mitigation requirements should be incorporated into the Environmental Management Programme (EMPr) for the proposed electrical infrastructure and also included as conditions for authorisation of the development projects.

Table 3 (following page) : Recommended mitigation and management measures concerning palaeontological heritage for the Esizayo WEF

ACTIVITY	MITIGATION AND MANAGEMENT MEASURE	RESPONSIBLE PERSON	APPLICABLE DEVELOPMENT PHASE	INCLUDE AS CONDITION OF AUTHORISATION	MONITORING REQUIREMENTS
Surface clearance & substantial excavations (> 1 m deep)	Monitoring of all surface clearance and substantial excavations (>1 m deep) for fossil material (*e.g.* bones, teeth, fossil wood)	ECO	Construction	Yes	Inspect cleared ground and excavations for fossil remains. On-going, throughout construction phase
Surface clearance & substantial excavations (> 1 m deep)	Safeguarding of chance fossil finds (preferably *in situ*), followed by reporting of finds to Heritage Western Cape (HWC) / SAHRA.	ECO	Construction	Yes	Define and secure fossil site with security tape. Report finds at earliest opportunity to HWC / SAHRA
Surface clearance & substantial excavations (> 1 m deep)	Recording and judicious sampling of significant chance fossil finds by a qualified palaeontologist, together with pertinent contextual data (stratigraphy, sedimentology, taphonomy).	Professional palaeontologist	Construction	Yes	Following consultation over chance fossil finds with HWC / SAHRA and professional palaeontologist
Surface clearance & substantial excavations (> 1 m deep)	Curation of fossil material within an approved repository (museum / university fossil collection). Submission of Phase 2 palaeontological heritage report to HWC / SAHRA.	Professional palaeontologist	Construction	Yes	Following Phase 2 palaeontological mitigation

7. CONCLUSIONS

The Middle Permian sedimentary Karoo bedrocks in the Klein-Roggeveld study region have yielded scientifically-important fossils of petrified wood, tetrapod (terrestrial vertebrate) burrows and very rare skeletal remains of the *Eodicynodon* Assemblage Zone, but well-preserved fossils are very sparsely distributed. There are no known fossil sites within any of the Esizayo on-site substation sites and 400 kV powerline corridors under consideration. The sedimentary bedrocks are extensively covered by Late Caenozoic superficial sediments (*e.g.* scree, gravelly soils) that are usually unfossiliferous. The palaeontological sensitivity of the study area is rated as low.

The impact significance of the construction phase of the proposed on-site substation and powerline for the Esizayo WEF is assessed as LOW (negative) in terms of palaeontological heritage resources. This is a consequence of (1) the paucity of irreplaceable, unique or rare fossil remains within the study area as well as (2) the extensive superficial sediment cover overlying most potentially-fossiliferous bedrocks here. This assessment applies equally to the two substation sites and various associated powerline corridors under consideration here. Significant further impacts during the operational and de-commissioning phases of the electrical infrastructure are not anticipated. There are therefore no preferences on palaeontological heritage grounds for any particular layout among the various substation and powerline options under consideration. The no-go alternative (*i.e.* no development) will have a low (neutral) impact on palaeontological heritage.

Cumulative impacts on palaeontological heritage resources that are anticipated as a result of the numerous alternative energy developments currently proposed or authorised for the Klein-Roggeveldberge region, including the Esizayo WEF and its electrical infrastructure, are predicted to be low (negative), *provided that* the proposed monitoring and mitigation recommendations made for these various projects are followed through (Almond 2016f). *Without* mitigation, cumulative impacts resulting from the large number of alternative projects in the Klein-Roggeveld region are anticipated to be of medium significance.

There are no fatal flaws in the Esizayo WEF grid connection infrastructure development proposals as far as fossil heritage is concerned. *Provided that* the recommendations for palaeontological monitoring and mitigation outlined below (See also Section 6 of this report) are followed through, there are no objections on palaeontological heritage grounds to authorisation of the proposed on-site substation and 400 kV powerline. Pending the potential discovery of substantial new fossil remains during construction, specialist palaeontological mitigation is not recommended for this project. The following general recommendations concerning conservation and management of palaeontological heritage resources apply.

The Environmental Control Officer (ECO) responsible for the Esizayo WEF grid connection developments should be made aware of the potential occurrence of scientifically-important fossil remains within the development footprint. During the construction phase all major clearance operations (*e.g.* for new access roads, pylon footings) and deeper (> 1 m) excavations should be monitored for fossil remains on an on-going basis by the ECO. Should substantial fossil remains - such as vertebrate bones and teeth, or petrified logs of fossil wood - be encountered at surface or exposed during construction, the ECO should safeguard these, preferably *in situ*. They should then alert the relevant provincial heritage management authority as soon as possible - *i.e.* Heritage Western Cape for the Western Cape (Contact details: Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 086-142 142. Fax: 021-483 9842. Email: hwc@pgwc.gov.za) and SAHRA for the Northern Cape (Contact details: Dr Ragna Redelstorff, SAHRA, P.O. Box 4637, Cape Town 8000. Tel: 021 202 8651. Email: rredelstorff@sahra.org.za). This is to ensure that appropriate action (*i.e.* recording, sampling or collection of fossils, recording of relevant geological data) can be taken by a professional palaeontologist at the developer's expense. These mitigation recommendations should be incorporated into the Environmental Management Programme (EMPr) for the Esizayo WEF on-site substation and powerline projects.

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