ESIZAYO WIND ENERGY FACILITY NEAR LAINGSBURG, CENTRAL KAROO DISTRICT MUNICIPALITY, WESTERN CAPE: PALAEONTOLOGICAL HERITAGE ASSESSMENT

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EXECUTIVE SUMMARY

BioTherm Energy (Pty) Ltd is proposing to develop the Esizayo Wind Energy Facility with a total generation capacity of up to 140 MW on a site in the Klein-Roggeveld region of the Great Karoo. The site lies some 30 km to the northwest of Laingsburg in the Laingsburg District Municipality, Western Cape. The project area comprises the following land parcels: Farm Aanstoot 72 Portion 1 (762 ha), Farm Annex Joseph's Kraal 84 (913 ha) and Farm Aurora 285 (4385 ha).

The Esizayo WEF project area is underlain by deltaic and fluvial sediments of the Waterford Formation (Ecca Group) and Abrahamskraal Formation (Lower Beaufort Group) of Middle Permian age. Well-preserved fossil logs are recorded in Waterford Formation deltaic sediments just outside the study area. During the four-day palaeontological field assessment the small outcrop area of Waterford Formation bedrocks yielded very few fossils, however, apart from one conservation-worthy site featuring fragmentary, reworked vertebrate remains (possibly amphibian or fish) in association with simple invertebrate burrows. This site, situated on the steep banks of the Roggeveldrivier on the Farm Anstoot 72m, lies well away from the development footprint but should nevertheless be safeguarded by a 10 m–radius buffer zone (See satellite map Fig. 42 herein).

The lowermost portion of the Lower Beaufort Group succession in the SW Karoo is characterised by very rare tetrapod remains and vertebrate burrows of the *Eodicynodon* Assemblage Zone. No fossil vertebrates or petrified wood were recorded in the Abrahamskraal Formation within the present study area, however. The dense assemblages of reedy plant stem casts (probably horsetails) as well as small invertebrate burrows found here occur widely within the region and are therefore not considered to be of special conservation significance. It is concluded that the Middle Permian bedrocks in the Esizayo WEF study area are generally of low palaeontological sensitivity. The same applies to a range of Late Caenozoic superficial sediments (alluvium, colluvium, calcretes, soils, surface gravels *etc*) overlying the Palaeozoic bedrocks. These may contain reworked blocks of petrified wood in the Klein-Roggeveld region, but no fossils or this or any other sort were recorded within these younger deposits during the field assessment.

The overall impact significance of the construction phase of the proposed wind energy project 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 to the proposed layout for the wind turbines, laydown area, access and internal roads, on-site IPP substation and associated WEF infrastructure within the study area. A comparable low impact significance is inferred for all project infrastructure alternatives and layout options under consideration, including different options for routing of access and internal roads, turbine layouts and siting of the on-site substation. Significant further impacts during the operational and de-commissioning phases of the WEF are not anticipated. There are therefore no preferences on palaeontological heritage grounds for any particular layout among the various options under consideration. No significant further impacts on fossil heritage are anticipated during the planning,

operational and de-commissioning phases of the WEF. The no-go alternative (*i.e.* no WEF 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, are predicted to be low (negative), *provided that* the proposed monitoring and mitigation recommendations made for 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. *Without* mitigation, cumulative impacts resulting from the large number of WEF projects in the Klein-Roggeveld region are anticipated to be of medium significance.

There are no fatal flaws in the Esizayo WEF development proposal as far as fossil heritage is concerned. *Provided that* the recommendations for palaeontological monitoring and mitigation outlined below are followed through, there are no objections on palaeontological heritage grounds to authorisation of the Esizayo WEF project.

It is noted that borrow pit sites will only be identified if and when the proposed WEF wins preferred bidder status. In this case, a separate palaeontological assessment of all borrow pit sites will be necessary in the pre-construction phase.

With the exception of the one vertebrate fossil site in the Waterford Formation already mentioned, no highly sensitive “no-go” areas within the proposed Esizayo WEF study area have been identified in this study. 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 WEF development 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, turbine placements) 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 (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). 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 alternative energy project. 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 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 report is to provide an authoritative, reasoned assessment of the palaeontological heritage resources within the Esizayo Wind Energy Facility (WEF) project area near Laingsburg, Western Cape, based on desktop studies and a short field survey. Known fossil sites are mapped in relation to the proposed WEF infrastructure layout. The palaeontological sensitivity of the area and the inferred impact significance of the proposed WEF development are then assessed. Recommendations for any necessary palaeontological mitigation or management measures during the construction phase of the WEF are made.

1.2. Objectives of the report

The Esizayo WEF study area is located in a region that is underlain by potentially fossiliferous sedimentary rocks of Late Palaeozoic and younger, Late Tertiary or Quaternary, age (These are described in more detail in Section 3 of this report). The construction phase of the proposed WEF 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 WEF are unlikely to involve further adverse impacts on local palaeontological heritage.

A short desktop palaeontological heritage scoping phase report for the Esizayo WEF has been submitted previously by the author (Almond 2016d). The present combined desktop and field-based palaeontological heritage assessment of the Esizayo WEF project area has been commissioned as part of the EIA Phase for this 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).

1.3. Legislative Framework

The present palaeontological heritage assessment report contributes to the consolidated heritage assessment for the proposed ESizayoWEF and falls under the South African Heritage Resources Act (Act No. 25 of 1999). It will also inform the Environmental Management Programme (EMP) for this alternative energy 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; 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 combined desktop and field-based 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 regions between Sutherland and Matjiesfontein. These include palaeontological impact assessments (PIAs) for the Eskom Gamma – Omega 765 kV transmission line that runs just to the north of the study area (Almond 2010a) and

those for several alternative energy facilities in the Klein-Roggeveld and Sutherland regions (*e.g.* Almond 2010a-d, 2011, 2014, 2015a-g, Almond 2016b-e, Miller 2010).
4. A four-day palaeontological field assessment of the Esizayo WEF study area (February 2016) by the author and between one and three experienced field assistants;
5. The author's previous experience with the formations concerned and their palaeontological heritage (*cf* Almond & Pether 2008a-b and references listed above).

GPS data and brief descriptive notes for all numbered geological or palaeontological localities mentioned in the text are provided in the Appendix. Fossil localities that were recorded during fieldwork are shown in relation to relevant major components of the proposed development footprint on the satellite image provided in Figure 42. Pease note that this map does *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 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). The study area is very extensive and much of it is hilly or mountainous with few access roads, especially in rugged upland areas (Figs. 2 to 5). However, sufficient bedrock exposures were examined during the course of the four-day field study to assess the palaeontological heritage sensitivity of the main rock units represented within the study area (See Appendix for locality data). Comparatively few academic palaeontological studies have been carried out hitherto in the region, so any reliable new palaeontological data from field-based impact studies here are of scientific interest. Palaeontological and geological data from the recent field study is usefully supplemented by those from several other field-based fossil heritage impact studies carried out in the Klein-Roggeveldberge region by the author in recent years (See reference list). Confidence levels for this impact assessment are consequently rated as medium, despite the unavoidable constraints of limited exposure, time and access.

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.

John E. Almond

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. The project area comprises the following land parcels: Farm Aanstoot 72 Portion 1 (762 ha), Farm Annex Joseph's Kraal 84 (913 ha) and Farm Aurora 285 (4385 ha) (Fig. 1).

The main infrastructural components of the proposed WEF (Fig. 2) include:

- Up to 70 wind turbine generators with a generating capacity of between 2 and 4 MW each. The turbines will have a hub height of up to 120 m and rotor diameter of up to 150 m.
- Concrete foundations to support the turbines.
- An onsite 132/400 kV substation (IPP) with transformers for voltage step-up from medium voltage to high voltage. The IPP substation will occupy an area of 150 mx 150 m. Two locations for the on-site substation are under consideration (Fig 2. The site indicated here in blue is the preferred alternative). The IPP substation will occupy a common substation area together with an Eskom Substation that will connect to the grid *via* a 400 kV powerline (to be assessed separately).
- A medium voltage collector system consisting of underground 1 to 33 kV cables (except where technical assessment suggests that overhead lines are more suitable) connecting the turbines to the onsite substation.
- A laydown area (max. 4 ha) for the temporary storage of materials during construction.
- Temporary site compound for contractors,
- Sewage disposal facility and septic tanks.
- Borrow pits.
- Access roads and internal roads.
- Car park and security fencing
- Administration, control and warehouse buildings.
- Operations and Maintenance compound including O&M buildings, car park and storage area.

Borrow pit sites will only be identified if and when the proposed WEF wins preferred bidder status. In this case, a separate palaeontological assessment of all borrow pit sites will be necessary.

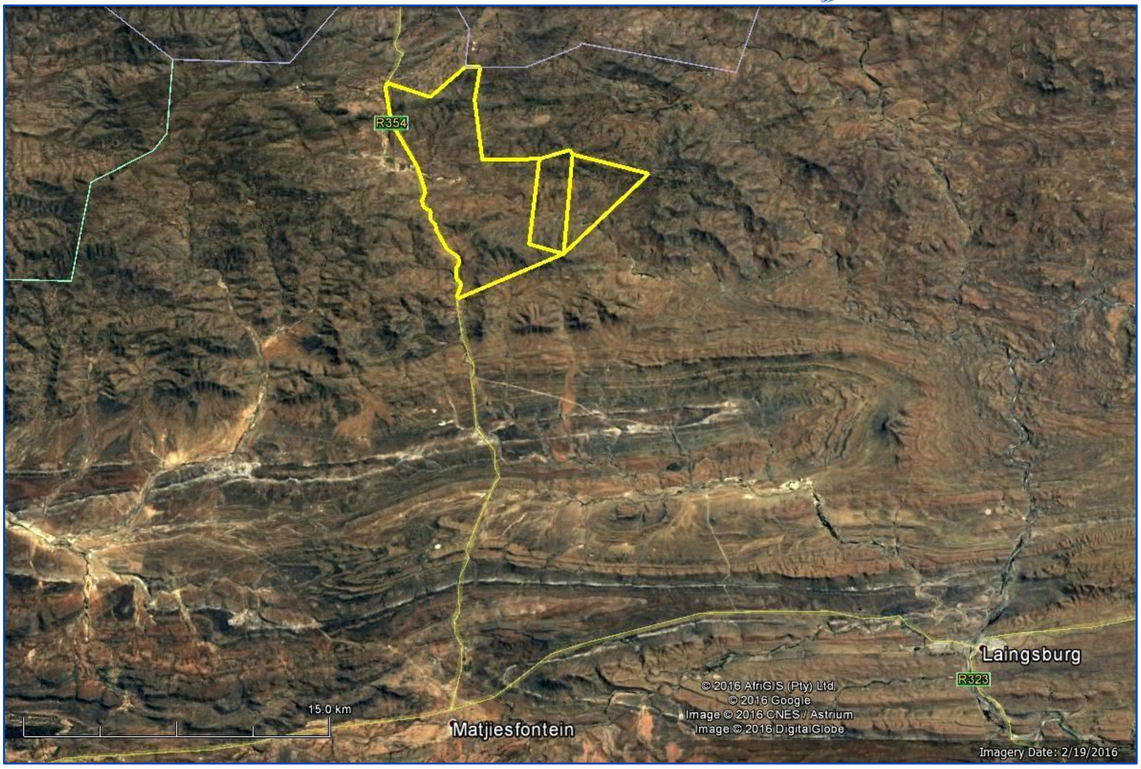

Figure 1: Google earth© satellite image of the SW Karoo showing the location of the proposed Esizayo WEF project area, situated on the eastern side of the R354 tar road, *c*. 30 km NW of Laingsburg, Western Cape (yellow polygon).

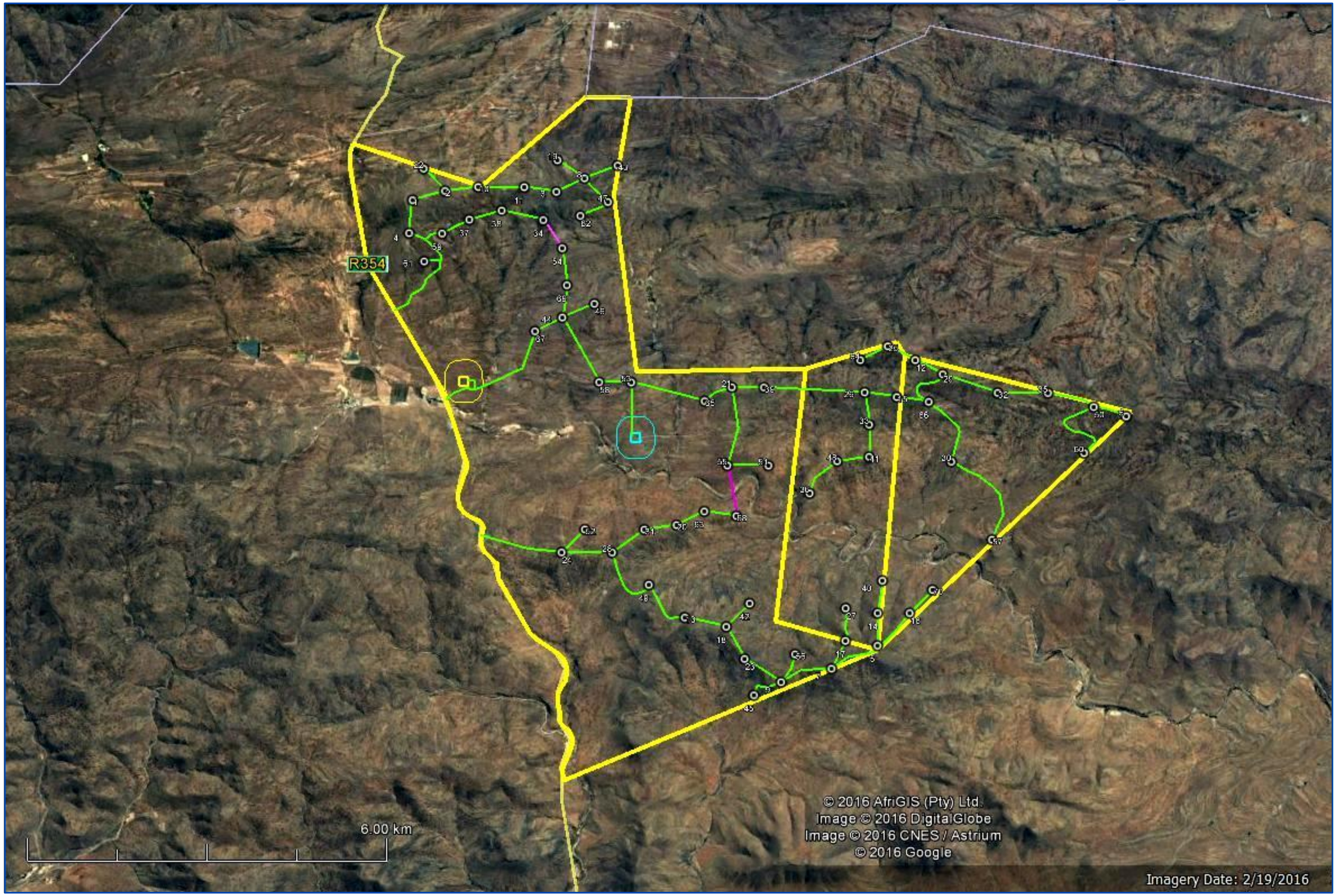

Figure 2: Google earth© satellite image of the Esizayo WEF project area showing the dissected, mountainous terrain in the Klein-Roggeveld region and the land parcels making up the area (yellow polygons). Also shown here are the 70 proposed wind turbine sites (white dots), internal roads (green), overhead cables (purple) as well as alternative sites for the on-site IPP substation (blue – preferred; yellow – alternative).

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

In this section of the report a short description of the physical geography of the Esizayo WEF project area is followed by an illustrated outline of the geological context for the palaeontological findings that are outlined in Section 4 below.

3.1. Esizayo WEF study area – general description

The Esizayo WEF 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 (Figs. 1 & 2). West-east trending uplands reach elevations of *c*. 1390 m above mean sea level (amsl) in the north (Skaapberg) and1155 m amsl in the south. 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).

Figure 3. View southwards from the crest of Skaapberg across the northern and central sectors of the Esizayo WEF study area.

Figure 4. View eastwards along the Roggeveldrivier towards De Bron homestead, eastern sector of the Esizayo WEF study area (Annex Josephs Kraal 84)

Figure 5. View southwards towards uplands on southern margins of the Esizayo WEF study area with gulley exposure of grey-green Abrahamskraal Formation mudrocks in the foreground (Loc. 253).

3.2. Geological context

The geology of the Esizayo WEF study area is outlined on the two adjoining 1: 250 000 geology sheets 3320 Ladismith and 3220 Sutherland (Council for Geoscience, Pretoria; Theron 1983, Theron *et al.* 1991, Cole & Vorster 1999) (Fig. 6). 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. Small outcrop areas are present in low-lying central, south-western and north-western parts of the study area (Pw dark brown / Pwa orange in Fig. 6). A major west-east anticlinal core of Waterford rocks lies just south of and outside the study area (Spitskop – Ramkop – Droeberg line).

- 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 study area, including beneath almost all proposed wind turbine positions (Pa, pale green in Fig. 6).

- 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 in the southern portion of the study area (Jd, red lines in Fig. 6).

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. 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.

Illustrated descriptions of Waterford, Lower Beaufort and Karoo dolerite bedrocks as well as various superficial sediments have been given in previous PIAs by the author for the Klein-Roggeveld region (see References). The following account is in part based on recent PIA reports by Almond (2016b-c) which deal with WEF study areas on the western border of the Esizayo WEF project.

Figure 6. 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). 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.

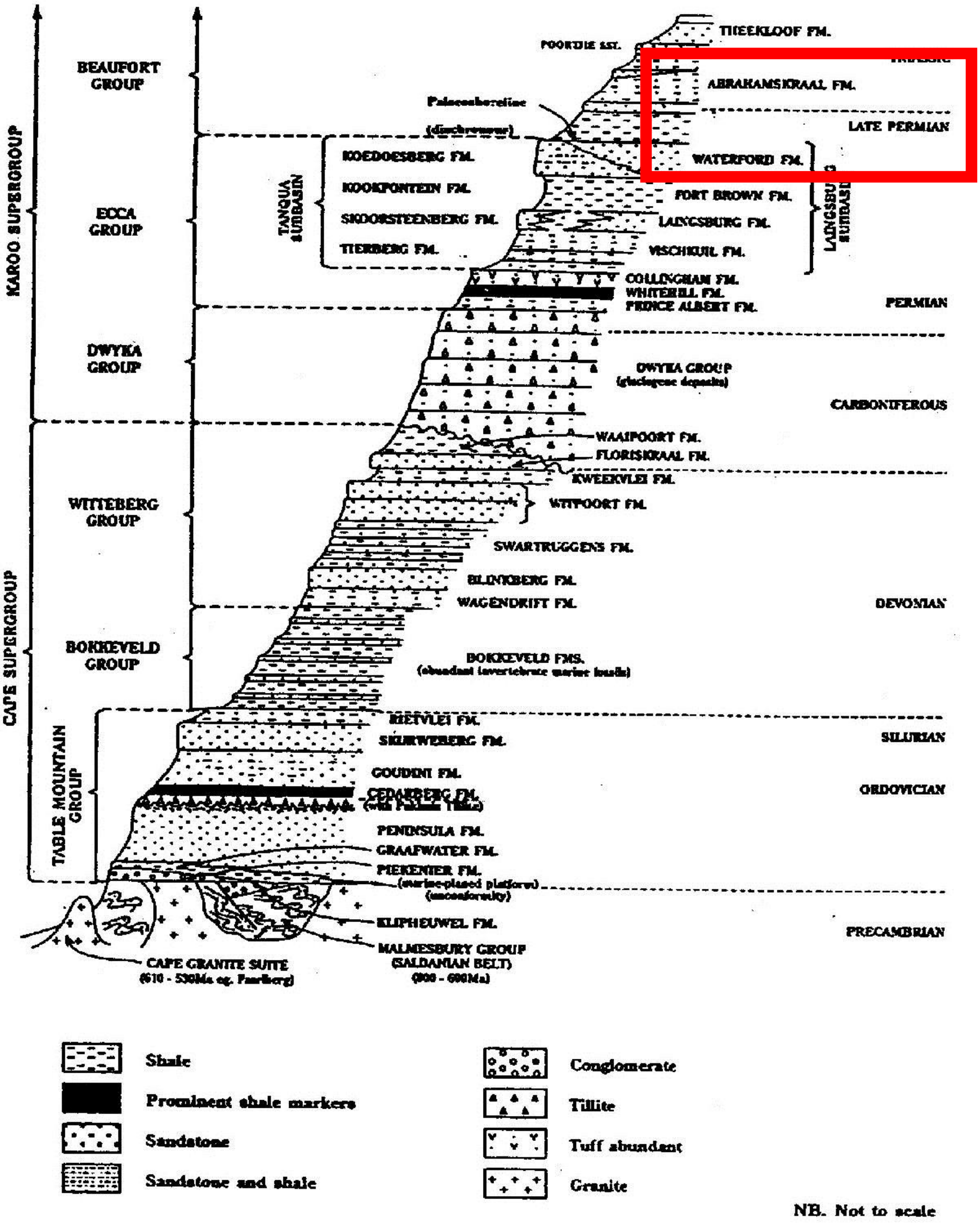

Figure 7. Schematic stratigraphic column for the Western Cape, the red box indicating the position of the various Late Palaeozoic sedimentary formations that crop out within the Esizayo WEF study area (Modified from original figure by H. de V. Wickens). *N.B.* The sedimentary bedrocks within the study area are all Middle Permian in age, in contrast to the time scale shown here.

3.2.1. Waterford Formation

The Waterford Formation (Pw) ("Upper Ecca") is a thick (*c*. 500-770 m), easterly- and northerly-thinning wedge of fine-grained deltaic deposits of Middle Permian age that represent the last phase of infilling of the Ecca Basin before the onset of continental sedimentation of the Lower Beaufort Group. Dominant lithologies include fine greyish to khaki, massive lithofeldspathic sandstones or wackes (often speckled) and dark grey mudrocks (often including thin-bedded rhythmitites) that are structured into sharp-topped, broadly coarsening-upwards prograding cycles. Shallow water prodelta and delta platform sandstones capping the cycles typically show well-developed wave-rippled bedding planes and extensive evidence of soft-sediment deformation including spectacular ball-and-pillow load structures and chaotic slump facies. Large, ovoid ferruginous carbonate concretions of diagenetic origin (*koffieklip*) are common. Theron (1983) provides a short account of the Waterford Formation in the Sutherland 1: 250 000 sheet where it thins northwards from 75 m just south of the map area. A recent account of the Waterford Formation in the Eastern Cape has been given by Rubidge *et al.* (2012) while Rubidge *et al.* (2000) describe Waterford sediments and fossils along the south-western Karoo margin. New radiometric dates for tuffs within the lowermost Abrahamskraal Formation (Lanci *et al.* 2013) imply a Roadian (early Guadalupian, Middle Permian) age for the Waterford Formation, *i.e.* around 270 Ma.

Thick-bedded, massive wackes within the upper part of the Waterford Formation succession are exposed along stream cuttings through the Skaapberg ridge (Fig. 8). The best exposures of older Waterford Formation bedrocks in the study area are seen along the banks of the Roggeveldrivier where the river has dissected the core region of a gentle anticline (Fig. 9). Dark grey, mudrock-dominated, thin-bedded, markedly tabular prodeltaic facies are overlain by higher-energy delta top wackes (Fig. 10). The latter locally show well-developed soft-sediment deformation, including spectacular chaotic-bedded slump deposits (Fig. 11).

Figure 8. Thick package of Waterford Formation delta top wackes exposed in the core of the Skaapberg anticline on the eastern side of the R354 (Loc. 338).

Figure 9. Incised meander of the Roggeveldrivier with extensive riverbank exposures of the Waterford Formation, Aanstoot 72 (Loc. 255).

Figure 10. Tabular-bedded, dark grey prodeltaic mudrocks of the Waterford Formation overlain by a thick package of delta-top wackes (Loc. 255).

Figure 11. Chaotic bedding with large foundered blocks of wacke, Waterford Formation along the Roggeveldrivier, Aanstoot 72 (Loc. 257).

3.2.2. Abrahamskraal Formation

The Abrahamskraal Formation is a very thick (*c*. 2.5 km) succession of fluvial deposits laid down in the Main Karoo Basin by meandering rivers on an extensive, low-relief floodplain during the Middle Permian Period, some 266-260 million years ago (Rossouw & De Villiers 1952, Johnson & Keyser 1979, Turner 1981, Theron 1983, Smith 1979, 1980, 1990, 1993a, 1993b, Smith & Keyser 1995a, Loock *et al*., 1994, Cole & Vorster 1999, McCarthy & Rubidge 2005, Johnson *et al*., 2006, Day 2013a, Day & Rubidge 2014, Wilson *et al.* 2014). These sediments include (a) lenticular to sheet-like channel sandstones, often associated with thin, impersistent intraformational breccio-conglomerates (larger clasts mainly of reworked mudflakes, calcrete nodules, *plus* sparse rolled bones, teeth, petrified wood), (b) well-bedded to laminated, grey-green, blue-grey to purple-brown floodplain mudrocks with sparse to common pedocrete horizons (calcrete nodules formed in ancient soils), (c) thin, sheet-like crevasse-splay sandstones, as well as more (d) localized playa lake deposits (*e.g.* wave-rippled sandstones, laminated mudrocks, limestones, evaporites). A number of greenish- to reddish-weathering, silica-rich “chert” horizons are also found. Many of these appear to be secondarily silicified mudrocks or limestones but at least some contain subaerial or reworked volcanic ash (tuffs, tuffites). Thin, fine-grained tuffs with a pale greenish, cherty appearance also occur here and are of value for radiometric dating (Lanci *et al.* 2013). A wide range of sedimentological and palaeontological observations point to deposition of the Abrahamskraal sediments under seasonally arid climates. These include, for example, the abundance of pedogenic calcretes and evaporites (silicified gypsum pseudomorphs or “desert roses”), reddened mudrocks, sun-cracked muds, “flashy” river systems, sun-baked fossil bones, well-developed seasonal growth rings in fossil wood, rarity of fauna, and little evidence for substantial bioturbation or vegetation cover (*e.g.* root casts) on floodplains away from the river banks.

The precise stratigraphic range of the Lower Beaufort Group beds represented within the Esizayo WEF study area has not been determined here with any confidence. On the basis of their proximity to the Ecca – Beaufort boundary and the paucity of maroon-hued overbank mudrocks it is concluded that much or most of the succession here belongs to the **Combrinkskraal Member** *sensu lato* of Loock *et al.* (1994) (The black dashed line running roughly W-E just to the north of the study area in Fig. 6 indicates the approximate incoming of maroon mudrocks within the Abrahamskraal Formation within the upper part of the Combinkskraal Member *s.l.* However, this is not regarded as a reliable stratigraphic marker since maroon mudrocks occur along the very close to the mapped Ecca – Beaufort boundary elsewhere in the region; *cf* Almond 2016c). The revised lithostratigraphic scheme for the Abrahamskraal Formation of Day and Rubidge (2014) recognizes two sandstone packages separated by an unnamed mudrock-dominated interval below the Leeuvlei Member. These *might* be equated successively with the sandstones overlying the Waterford wackes along the Roggeveldrivier, the thick mudrock exposures on the N-facing hillslopes towards the southern edge of Aanstoot 72 (Fig. 12), and the higher-lying sandstones building the upland ridges in the southernmost part of the study area. However, further detailed mapping is required to confirm these tentative correlations.

The sedimentology of the Combrinkskraal Member *sensu lato* in the Klein-Roggeveld region has been outlined in a recent PIA by Almond (2016c). Here only brief mention of some of the most informative exposures and interesting features will be given, as illustrated below and summarized in the Appendix. The best exposures occur along the banks of the Roggeveldrivier (Fig. 13) as well as on the gullied, N-facing slopes on the southern margins of Aanstoot 72 (Fig. 12). Sandstone facies within the lowermost Abrahamskraal Formation are generally well-sorted, fine-grained, laterally-persistent and markedly tabular-bedded with well-developed jointing (Fig. 15). However, a few small-scale, erosive-based, lenticular channel sandstone bodies occur towards the base of the succession (Fig. 14). Extensive exposures of channel sandstone tops are seen, for example on the slopes of

Skaapberg, but are often weathered and rubble-strewn (Fig. 23). Well-preserved, rippled sandstone palaeosurfaces – often of interest for trace fossils such as tetrapod trackways - were only rarely encountered (*e.g.* Loc. 265). Sandstone bases are usually sharp and not markedly gullied, although exceptions do occur in association with modest basal breccias composed mainly of reworked calcrete and mudrock clasts (often secondarily ferruginised). An anomalous 1 m-thick breccia bed encountered on Aanstoot 72 (Figs. 20 & 21) is not obviously associated with the base of a prominent-weathering sandstone body. Well-developed intraclast breccia units, associated with episodes of erosional incision of the floodplain, are uncommon this low down in the Abrahamskraal succession. This bed (marked at Loc. 254 in satellite map Fig. 42) is potentially fossiliferous, although no fossils have been here to date.

Overbank mudrocks are mainly thin- to medium-bedded, tabular, almost exclusively dark grey to grey-green or blue-grey, hackly-weathering, with frequent horizons of large, oblate to irregular ferruginous carbonate concretions (Figs. 16-19). The dark mudrocks and orange-hued concretions may be related to episodes of high water tables on the ancient Karoo floodplain. Other horizons featuring much smaller, sphaeroidal to irregular palaeocalcrete nodules also occur, but are not as frequent; secondary ferriginisation of the pale to dark grey calcrete to a rusty-brown material is common. These calcrete palaeosols reflect semi-arid climatic periods, while locally prolific, silicified pseudomorphs of gypsum roses record episodes of intense evaporation, perhaps from salty floodplain ponds (Fig. 22)..

Figure 12. Extensive hillslope and gulley exposures of the lower Abrahamskraal Formation on the southern margins of Aanstoot 72 (Loc. 260).

Figure 13. Excellent exposure of gently-dipping, blue-grey overbank mudrocks of the lowermost Abrahamskraal Formation along the Roggeveldrivier, Annex Josephs Kraal 84 (Loc. 279).

Figure 14. Good vertical section through the lowermost Abrahamskraal Formation showing erosive-based, lenticular channel sandstone below and tabular sandstone on the horizon, Aanstoot 72 (Loc. 287).

Figure 15. Well-jointed, pale brown Abrahamskraal channel sandstone overlain by gently-dipping overbank mudrocks, Aanstoot 72 (Loc. 248).

Figure 16. Some of the best exposures of the Abrahamskraal Formation are seen in north-facing stream gullies, waterfalls and hillslopes on the southern side of the Roggeveldrivier, Aanstoot 72 (Loc. 266).

Figure 17. Thin-bedded, dark blue-grey siltstone and fine-sandstone facies of the lower Abrahamskraal Formation, capped by a tabular channel sandstone, Aanstoot 72 (Loc. 266).

Figure 18. Extensive, gentle hillslope exposures of the Abrahamskraal Formation overbank mudrocks in the southern sector of the study area, Aanstoot 72 (Loc. 260). Such areas are prime hunting grounds for vertebrate palaeontologists.

Figure 19. Well-developed horizon of large, rusty-brown, ferruginous carbonate concretions probably reflecting waterlogged floodplain soils in lower Abrahamskraal Formation times, Aanstoot 72 (Loc. 276).

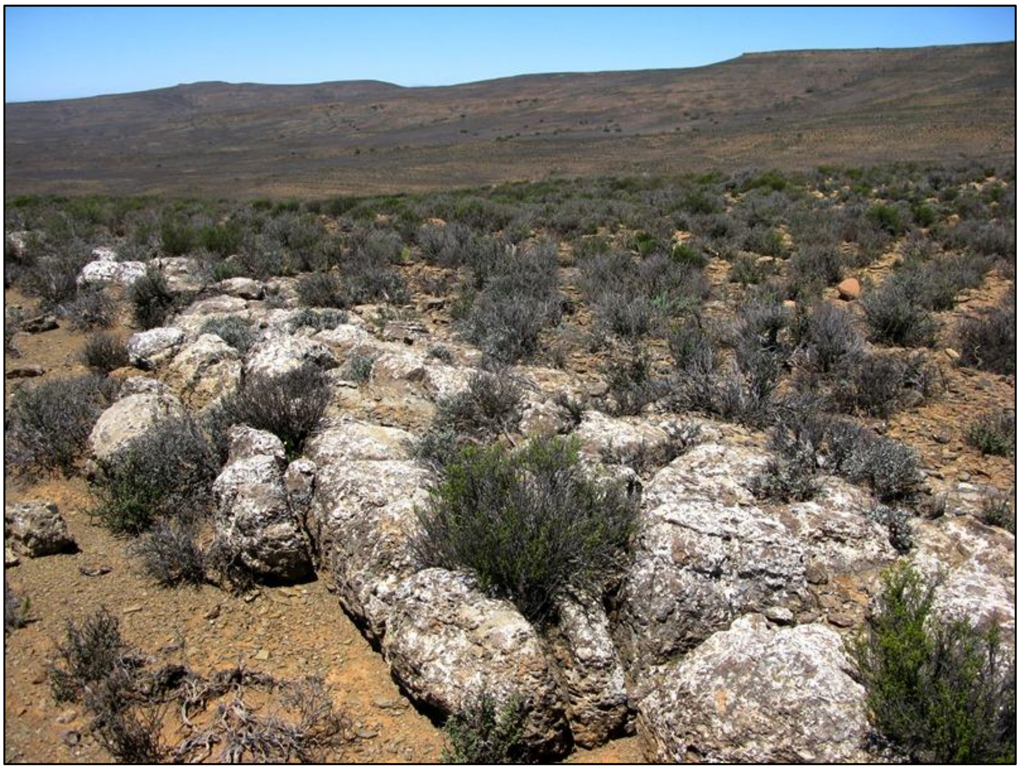

Figure 20. Exceptionally extensive intraclast breccio-conglomerate weathering-out as a pale grey, lichen-covered ridge on Aanstoot 72 (Loc. 254). This bed is potentially fossiliferous. See also satellite map Fig. 42.

Figure 21. Close-up of the ferruginised breccio-conglomerate seen in the previous figure showing intraclasts of calcrete and calcretised sediment in a brown sandy matrix (Loc 254) (Scale in cm and mm). Such conglomerates might contain transported vertebrate remains.

Figure 22. Silicified pseudomorphs of gypsum desert roses weathered out as float overlying the Abrahamskraal Formation, Aanstoot 72 (Loc. 287) (Scale in cm).

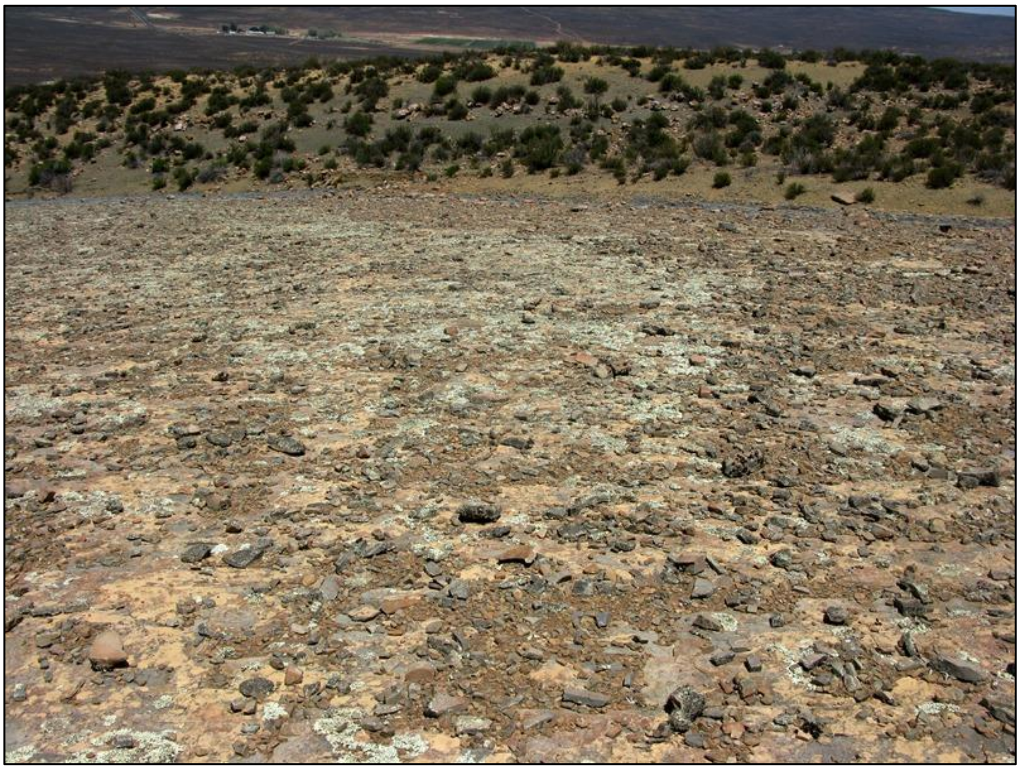

Figure 23. Extensive exposure of a tabular sandstone top overlain by weathered overbank mudrocks, gulley on the southern slopes of Skaapberg, Aanstoot 72 (Loc. 295).

3.2.3. Karoo Dolerite Suite

A series of narrow, WNW-ESE orientated dolerite dykes is mapped intruding Lower Beaufort Group country rocks in the southern portion of the study area, for example on Anstoot 72 (Fig. 6, thin red lines). These Early Jurassic dykes are associated with a swarm of linear fractures that are clearly seen on satellite images of the region, for example near quarry areas along the R354 on Fortuin 74. Examples of similar fracture-associated dykes from the Karusa WEF study area to the north of the Isizayo WEF project area have been illustrated by Almond (2015c). The only dolerite dykes encountered during recent fieldwork were small exposures of jointed grey-green rocks seen along and close to stream beds on the northern portion of Aurora 285, where they have not been mapped (Fig. 24). Since these rocks are of no palaeontological interest, they will not be treated further here.

Figure 24. Streambed exposure of a narrow, dark grey, well-jointed dolerite dyke on Aanstoot 72 (Loc. 280) (Hammer = 30 cm).

3.2.4. Late Caenozoic superficial sediments

A broad spectrum of Late Caenozoic superficial deposits mantle the Karoo Supergroup bedrocks and dolerite intrusions in the Esizayo WEF study area. Most of these younger sediments are unconsolidated to partially consolidated and probably of Quaternary to Recent age. Among the oldest deposits recognised here are thick, calcretised, rubbly alluvial conglomerates on the banks of the Roggeveldrivier on Annex Josephs Kraal 84 (Figs. 25 & 26); the base of the calcretised "High Level Gravels" lies several meters above modern riverbed level. A wide range of well-bedded, semi-consolidated, sandy to gravelly alluvial deposits are exposed in river bank sections (Fig. 28), while unconsolidated sandy to bouldery alluvium, the latter dominated by clasts of Karoo wackes, lines modern water courses (Fig. 27). Lowland areas are largely covered by sandy and gravelly soils that are up to several meters thick and mainly of alluvial origin; they are well-exposed in the walls of erosion gullies or dongas (Fig. 29). Sheetwash processes have concentrated thin gravels at the soil surface (Fig. 30). Upland slopes and plateau – where most of the wind turbine infrastructure will be placed - are generally covered with sandy and rubbly colluvial deposits that are principally composed of downwasted Beaufort Group sandstones and wackes (Fig. 31).

Figure 25. Overbank mudrocks of the Abrahamskraal Formation overlain by a thick package of calcretised ancient alluvial and colluvial breccio-conglomerates of probable Quaternary age, river bank on Annex Josephs Kraal 84 ("High Level Gravels") (Loc. 297).

Figure 26. Close-up of heavily-calcretised, rubbly "High Level Gravels" seen in the previous figure (Loc. 297) (Hammer = 30 cm).

Figure 27. Poorly-sorted modern alluvial gravels along the Roggeveldrivier, Aanstoot 72 (Loc. 273).

Figure 28. Good exposures of thick, gravely to sandy alluvial deposits along the banks of the Roggeveldrivier, Aanstoot 72 (Loc. 277).

Figure 29. Thick gravelly to sandy alluvium and soils overlying Abrahamskraal Formation mudrocks exposed in a deep donga on the southern footslopes of the Skaapberg (Loc. 290).

Figure 30. Bare sandy patches of alluvial soils with patches of dispersed surface gravels modified by sheetwash, Aanstoot 72 (Loc. 283).

Figure 31. View westwards along the crest of Skaapberg showing mantle of coarse sandstone colluvium and sandy soils, Aanstoot 72 (Loc. 294).

4. PALAEONTOLOGICAL FINDINGS

In this section of the report the principal palaeontological heritage findings within the Esizayo WEF project area are outlined and illustrated. Gps co-ordinates and associated field data for each of the numbered geological and palaeontological sites are given in the Appendix. The principal fossil sites recorded are indicated on the satellite image of the project area in Fig. 42. Please note that this is *not* a distribution map 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 development. 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. One notable exceptional site (Loc. 256, indicated in red on satellite map Fig. 42) is considered worthy of special protection.

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 (MacRae 1999, McCarthy & Rubidge 2005). 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).

4.1. Fossils in the Waterford Formation

The body fossil record of the deltaic facies of the Waterford Formation (*i.e.* western outcrop area, including the previously recognised Koedoesberg Formation) is sparse, but this may in part reflect comparative neglect by palaeontologists. Rare fragments of poorly-preserved tetrapod bone are recorded in channel lags within the upper Waterford Formation in the Williston sheet area (Viljoen 1989) and the southern Great Karoo. These probably belong to aquatic temnospondyl amphibians ("labyrinthodonts") but large fish and terrestrial therapsids might also be represented. Scattered palaeoniscoid fish scales and fish coprolites are common in the Waterford Formation, and several genera of non-marine bivalves have been described from the southern Karoo (Bender *et al*. 1991, Cooper & Kensley 1984).

Upper delta platform facies of the Waterford Formation contain abundant, low diversity trace assemblages of the *Scoyenia* ichnofacies. They are dominated by the rope-like, horizontal and oblique burrows of the ichnogenus *Scoyenia* that has been attributed to small arthropods (possibly insects) and / or earthworms. These tubular, meniscate back-filled scratch burrows characterise intermittently moist, firm substrates such as channel and pond margins on the upper delta platform (Smith & Almond 1998, Buatois & Mángano 2004, 2007). Good examples, often associated with wave-rippled surfaces, are recorded from Waterford thin-bedded sandstones and siltstones in the Roggeveld Escarpment zone by Wickens (1984, 1996) and Viljoen (1989). Offshore delta platform facies of the Waterford Formation have very impoverished, poorly-preserved ichnofaunas due to rapid sedimentation rates with abundant soft-sediment deformation and perhaps also to fluctuating salinities. Contrasting ichnoassemblages of the *Cruziana* ichnofacies are recorded from wave-dominated siliclastic shoreline facies of the Waterford Formation in the Northern Cape (previously known as the Carnarvon Formation) (Siebrits 1989, Rust *et al.* 1991, Almond 2016a). Elements of such assemblages – including rusophycids, bivalve burrows and *Palaeophycus striatus* - have also been found in the Klein-Roggeveld region (Almond 2016b).

Petrified wood and other plant material of the *Glossopteris* Flora (*e.g. Glossopteris, Phyllotheca*) occurs widely in the Waterford Formation and is often reworked into associated pediment or downwasted surface gravels (Theron 1983, Anderson & Anderson 1985, Viljoen 1989, Wickens 1984, 1996, Theron *et al.* 1991, Rubidge *et al*. 2000, Almond 2016b). Leaves and stems of arthrophytes (horsetails) such as *Schizoneura* have been observed in vertical life position. Substantial fossil logs (so-called "*Dadoxylon*") showing clearly developed seasonal growth rings are mostly permineralised with silica but partially or completely calcified material is also known (Viljoen 1989). At least two different genera of gymnospermous woods, *Prototaxoxylon* and *Australoxylon,* have been identified from the Waterford Formation so far (Bamford 1999, 2004). Petrified fossil wood material has been widely recorded within the Waterford Formation – including the previously separate Koedoesberg Formation – in the Ladismith and Sutherland 1: 250 000 sheet areas (Theron 1983, Theron *et al.* 1991). Some of the best examples of well-preserved petrified logs from the Waterford succession occur on the slopes of Kranskop, just southwest of the present study area. Tool marks made by current-entrained logs are also known from sandstone palaeosurfaces in the broader region; these have occasionally been mistaken for the actual fossil impressions or moulds of logs (Theron 1983, p. 8; Almond 2010a).

The only fossils recorded within the upper part of the Waterford Formation in the Esizayo WEF study area comprise a mixed assemblage of trace fossils and transported, fragmentary body fossils exposed on the planar upper surface of a brown-weathering wacke that forms part of a heterolithic, medium-bedded package (Fig. 32). The trace fossils are simple horizontal, cylindrical burrows preserved as positive epichnia and showing a wide range in diameter (*c*. 5-10 mm). The body fossils include a couple of complex reticulate or pitted structures as well as a concentration of elongate elements, some with longitudinal ridges (Figs. 32 to 34). The body fossils are tentatively interpreted as sandstone moulds and casts of disarticulated vertebrate remains, such as dermal scutes and endoskeletal elements (possibly cartilaginous). They may have belonged to large bony fish or alternatively to temnospondyl amphibians (*cf* Viljoen 1989). It is noted that multiple trackways as well as skeletal fragments of possible temnospondyls (or similar-sized amphibious tetrapods) are recorded from younger Karoo beds (Abrahamskraal Formation) in the Klein-Roggeveld region some 35 km NE of the present study area as well as from the outskirts of Sutherland (Almond 2016e). The Waterford vertebrate fossil site recorded here is considered to be of significant scientific interest and conservation value. The site (Loc. 256, marked red in Fig. 42) lies on the steep banks of the Roggeveldrivier on Farm Anstoot 72 and is unlikely to be directly impacted by the Esizayo WEF development. However, a protective buffer zone of 10 m radius is proposed to safeguard it during construction.

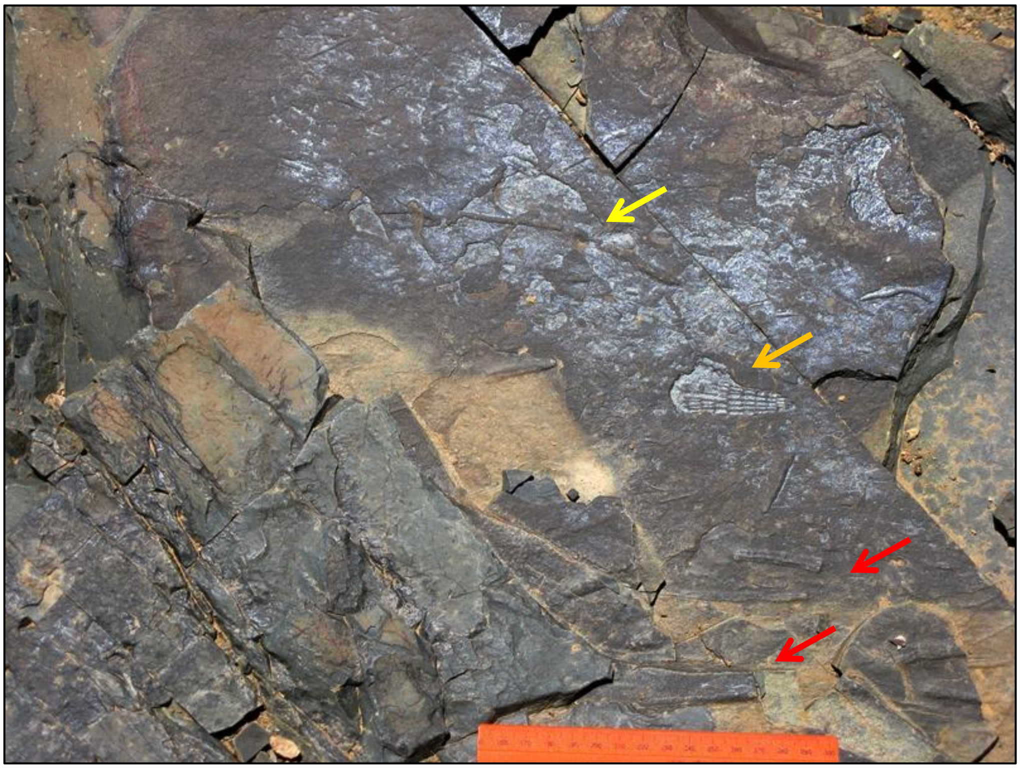

Figure 32. Flat upper bedding plane of Waterford Formation wacke with horizontal burrows (yellow arrow), problematic reticulate mould (orange arrow) and elongate, ribbed sandstone structures (red arrows), Aanstoot 72 (Loc. 256) (Scale in cm). See also two following figures.

Figure 33. Close-up of problematic subparallel, elongate, ridged sandstone structures seen in previous figure – *possibly* casts of vertebrate skeletal structures (*e.g.* fish or amphibian) (Loc. 256) (Scale in cm).

Figure 34. Detail of another problematic pitted structure – possibly the mould of a temnospondyl amphibian dermal scute - exposed on the same bedding plane seen in Fig. 32 above (Loc. 256) (Scale in cm and mm).

4.2. Fossils in the Abrahamskraal Formation

These earliest terrestrial vertebrate faunas of the Main Karoo Basin are assigned to the *Eodicynodon* Assemblage Zone of *c*. 268-265 million years ago (Rubidge 1995, Smith *et al.* 2012). The Combrinkskraal Member *sensu lato* (including the Combrinkskraal and Grootfontein Members of Day & Rubidge 2014) are assigned to the *Eodicynodon* AZ (*ibid*, Jinnah & Rubidge 2007). Only a few fossil tetrapod (*i.e.* four-limbed vertebrate) remains have been discovered from the lowermost Abrahamskraal Formation beds along the southern and south-western margins of the Great Karoo. They are dominated by small dicynodont therapsids (mammal-like reptiles) as well as extremely rare, large-bodied dinocephalians (Fig. 35). Sparse, disarticulated skeletal remains and sizeable burrows of small-bodied tetrapods – probably the dicynodont *Eodicynodon* itself - have recently been recorded from lower Abrahamskraal Formation beds in the Klein-Roggeveld region at a site less than 20 km west of the Esizayo WEF project area (Almond 2016c). Other interesting fossils from the lowermost Abrahamskraal Formation include well-preserved, reedy swamp plants (horsetail ferns) and probable lungfish burrows (*cf* Almond 2010a, Hasiotis *et al.* 1993, Odendaal & Loock 2015).

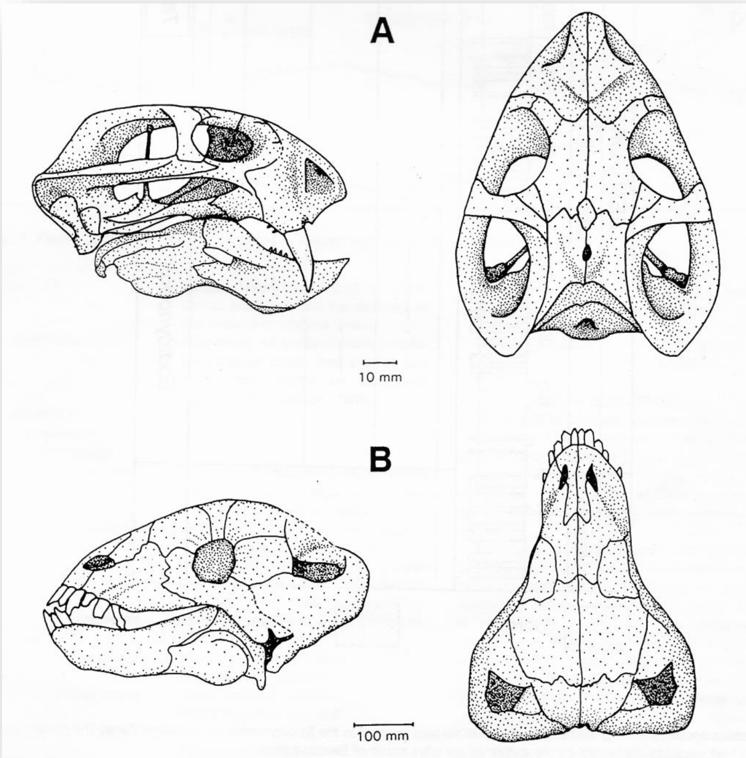

Figure 35. Skulls of two key fossil therapsids from the Middle Permian *Eodicynodon* Assemblage Zone which is represented in Esizayo WEF study area: A – the small dicynodont *Eodicynodon*; B – the rhino-sized dinocephalian *Tapinocaninus* (From Rubidge 1995).

No tetrapod skeletal fossils or traces (*e.g.* burrows, trackways) were recorded from the Abrahamskraal Formation in the Esizayo WEF study area, despite a careful search of good exposures showing well-developed palaeosols as well as of the infrequent calcrete-dominated breccio-conglomerates that elsewhere in the Karoo may contain reworked disarticulated bones and teeth. The extensive breccio-conglomerate bed at Loc. 254 is potentially fossiliferous (*cf* Turner 1981), although no fossils have been recorded here to date (See Figs. 20 & 21 as well as satellite map Fig. 42).

Invertebrate trace fossils recorded from the Esizayo WEF study area include several occurences of small (*c*. 8mm wide) meniscate back-filled burrows assigned to the ichnogenus *Scoyenia* and characteristic of damp substrates, such as the sandy margins of ponds and rivers (Fig. 36). Very narrow, sinuous to scribbly burrows preserved as positive epichnia in association with puckered microbial mat textures are referred to the *Helminthopsis* ichnoguild that commonly occurs in association with microbial mats in marine and freshwater settings (Fig. 37). These narrow traces are associated with thin-bedded rhythmitites that were probably deposited in a pond or lacustrine setting.

Mudrock and sandstone bedding planes with dense assemblages of narrow, vertical, subcylindrical structures are commonly seen in the Abrahamskral Formation (Fig. 38) They are interpreted as the sand-infilled moulds of reedy plants - probably sphenophyte ferns (horsetails) - that colonised comparable swampy settings along river banks and floodplain lakes. Finely-ridged, segmented stem compressions and moulds of sphenophyte stems occur abundantly in some mudrock horizons. Unusually wide (up to 6 cm diam.) *in situ* plant stem casts as well as closely-associated, collapsed or transported stem compressions of comparable dimensions were recorded, for example, on Aanstoot 72 (Figs. 39 to 41). No petrified wood occurrences were noted in the study area.

Figure 36. Sandstone bed bioturbated by cylindrical, meniscate back-filled invertebrate burrows (*c*. 6-8 mm wide) – probably *Scoyenia*, Abrahamskraal Formation, Aanstoot 72 (Loc. 242).

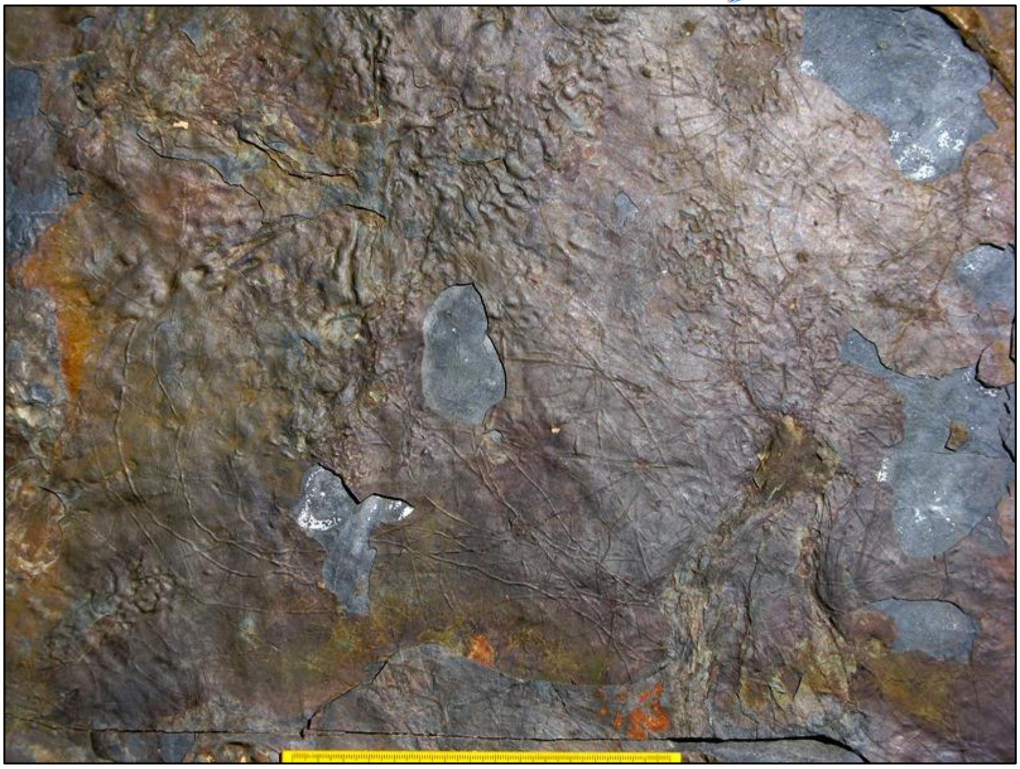

Figure 37. Abrahamskraal Formation sandstone bedding surface showing fine-scale puckering as well as a network of very thin horizontal burrows (*Helminthopsis* ichnoguild) that may reflect the presence of microbial mats, Aanstoot 72 (Loc. 274) (Scale in cm).

Figure 38. Bedding plane of dark grey laminated siltstone showing dense assemblage of round sandy casts of reedy plant stems (Loc. 259) (Scale in cm).

Figure 39. ***In situ*** **cylindrical sandstone casts of sizeable plant stems embedded within dark grey-green Abrahamskraal Formation overbank mudrocks, Aanstoot 72 (Loc. 272) (Scale *c*. 15 cm long). The stems are up to 6 cm wide. See also following figure.**

Figure 40. Weathered-out subcylindrical sandstone cast of a longitudinally-ridged plant stem - probably a sphenophyte fern – Abrahamskraal Formation, Aanstoot 72 (Loc. 271) (Scale in cm and mm).

Figure 41. Mould of a sizeable reworked or collapsed plant stem (*c*. 3 cm wide), probably sphenophyte, preserved within mudrocks and associated with the sandstone stem casts seen in Fig. 39 above (Loc. 271).

4.3. Fossils in the Karoo Dolerite Suite

The **Karoo dolerites** are igneous in origin and do not contain fossils.

4.4. Fossils in the Late Caenozoic superficial sediments

The wide spectrum of Late Caenozoic superficial sediments overlying the Palaeozoic and Mesozoic bedrocks in the study area are generally fossil-poor. Important occurrences of bones, teeth and horn cores may occasionally be found in better-consolidated Quaternary alluvial deposits, while finer-grained sediments and calcretes may contain fossilised burrows (*e.g.* termitaria), freshwater molluscs and plant root casts (*e.g*. Skead 1980, Klein 1984, Bousman *et al.* 1988, Brink & Rossouw 2000, Churchill *et al.* 2000, Cole *et al.* 2004, Rossouw 2006). Surface gravels on the footslopes of the Klein-Roggeveld escarpment some 10 km to the southwest of the present study area as well as in nearby valleys contain locally common blocks of silicified wood that have probably been reworked from petrified logs within the Waterford Formation outcrop area (Almond 2016b, 2016c).

No reworked blocks of petrified wood or other fossils were recorded from the superficial sediments in the Esizayo WEF study area, however.

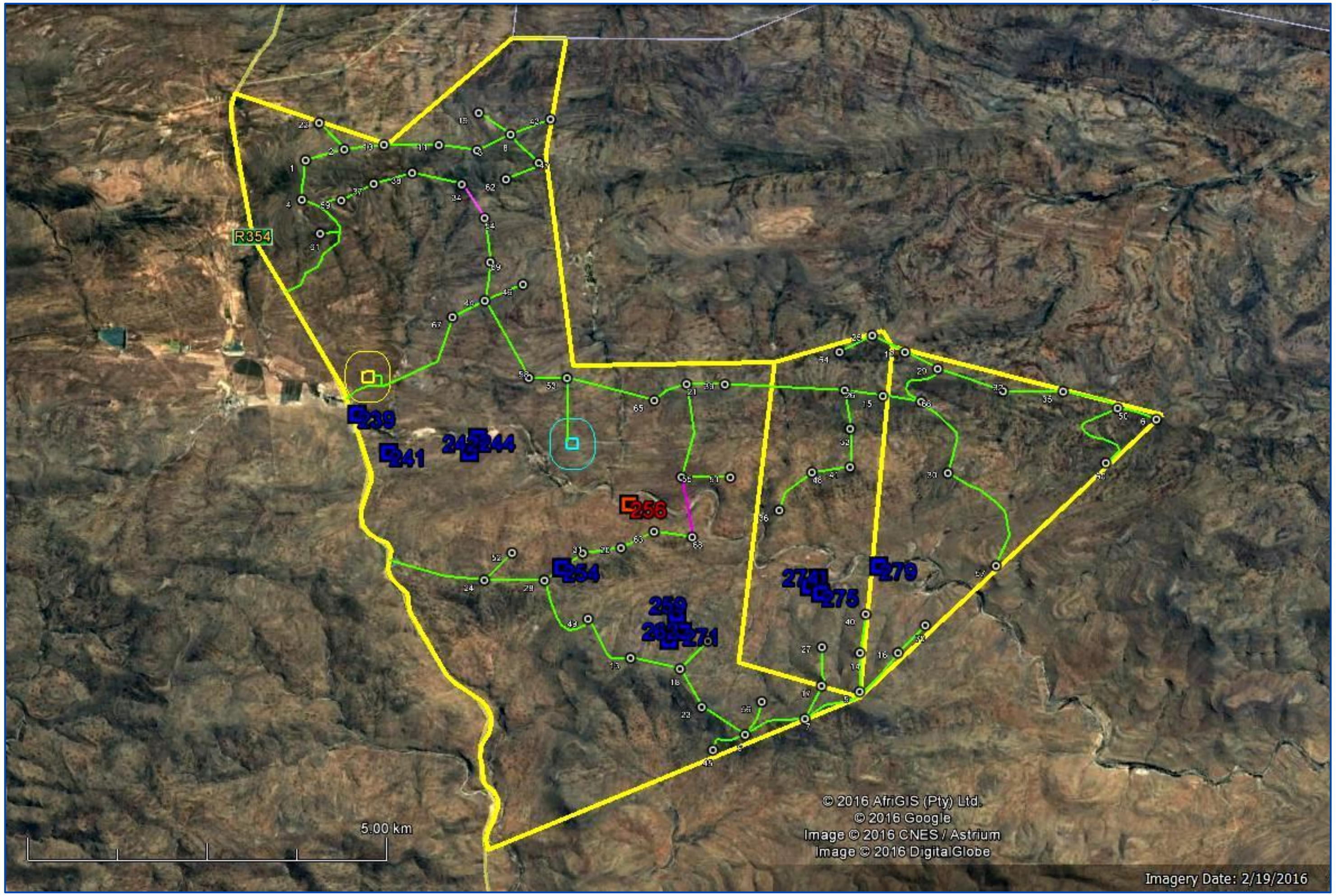

Figure 42: Distribution of recorded fossil sites within the Esizayo WEF project area (See Appendix for details). Sites marked in blue are not considered to be of special conservation significance. Site 256 along the banks of the Roggeveldrivier (marked in red) features vertebrate remains in the Waterford Formation that are of special scientific interest and should be safeguarded by a 10 m-radius buffer. Site 254 features an extensive *potentially*-fossiliferous breccio-conglomerate bed, but no fossils recorded here so far. *N.B*. *This is* not *a comprehensive map of fossil distribution within the project area.*

5. Assessment of impacts

This assessment applies to the entire Esizayo WEF project area, including access roads and on-site IPP substation, but not to the 400 kV powerline and Eskom substation that are the subject of a separate Basic Assessment process.

In terms of the palaeontological sensitivity of the rock units represented within the Esizayo WEF project area the outcrop area of the Waterford Formation is generally rated as medium but locally high (*e.g.* fossil logs) while the Lower Beaufort Group is generally considered to be high to very high sensitivity because of its rich record of Permian vertebrates and plants (MacRae 1999, McCarthy & Rubidge 2005, Almond & Pether 2008a, 2008b, Smith *et al.* 2012, SAHRIS website). The Karoo dolerites are unfossiliferous (zero sensitivity), while the Late Caenozoic superficial deposits (alluvium *etc*) are generally of low sensitivity but may also be locally high (*e.g.* fossil mammals). Fieldwork in the Klein-Roggeveld region backed-up by desktop analysis indicates that fossil material such as vascular plants, vertebrate skeletal material (bones, teeth) and trace fossils are present within the Karoo Supergroup here (See References under Almond). However, well-preserved specimens of special scientific interest and conservation significance are very rare indeed. With one important exception, no vertebrate bones, teeth or tetrapod trace fossils (trackways, burrows), nor any petrified wood, were found during the field study of the Esizayo project area. The fossils seen here – predominantly invertebrate traces, reedy plant remains - consist almost entirely of taxa that occur widely within the region and that are therefore not of exceptional conservation significance.

One notable exception is the small concentration of fragmentary vertebrate remains recorded in the Waterford Formation along the banks of the Roggeveldrivier on Aanstoot 72 (Loc. 256, Figs. 32 to 34). This riverine fossil site, which is also of geoscientific value for the excellent exposures of Waterford Formation sediments seen here (Figs. 9 to 11), lies outside the provisional development footprint (Fig. 42, site marked in red). It is nevertheless designated here as a no-go area with a 50 m-radius buffer zone as a precautionary measure.

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 WEF will entail extensive surface clearance as well as excavations into the superficial sediment cover and underlying bedrock. 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 WEF 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 Esizayo WEF project area during the construction phase, mainly due to surface clearance and excavation activities. 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 study area and this lies outside the development footprint (Fig. 42, 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 of the Esizayo WEF *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 Esizayo WEF development. Given the overall low impact significance of the 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 layout, including wind turbine sites, access and internal roads and associated infrastructure. Likewise, there is no preference for one or other of the two sites under consideration for the on-site IPP substation. Once identified, any borrow pit sites will require separate palaeontological heritage assessment before excavation commences.

Confidence levels for this assessment are rated as medium, given the necessarily superficial nature of the short field assessment counterbalanced by the number of palaeontological field studies recently carried out within the broader Klein-Roggeveld study region (See Cumulative Impacts, Section 5.2).

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 (construction phase)

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 assessed here 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 (Fig. 43). Relevant published palaeontological literature for the region has also been taken into account (*e.g.* Loock *et al.* 1994, Day & Rubidge 2014). This assessment applies only to the construction phases of the WEF developments, since significant additional impacts on palaeontological heritage during the operational and de-commissioning phases are not anticipated.

It should be emphasized that, in the case of palaeontological heritage, it only makes sense to consider cumulative impacts on *comparable fossil assemblages* present in the same formations that are represented in the present study area as well as in the broader study region. For example, impacts on Permian aquatic fossil invertebrates in the Whitehill Formation (Ecca Group) that crops out in WEF project areas to the southwest of the Esizayo WEF study area are not directly relevant to impacts on fossil assemblages of terrestrial vertebrates in the Lower Beaufort Group as represented in the latter area. The analysis in Table 2 is therefore restricted to considering cumulative impacts on fossil heritage preserved within rock units and fossil assemblages that are represented in the Esizayo WEF study area as well as in nearby project areas – specifically the Waterford Formation and lowermost Abrahamskraal Formation (*Eodicynodon* Assemblage Zone – See Section 4). WEF projects in the SW Karoo that share fossil assemblages in the Waterford Formation and lowermost Abrahamskraal Formation include the following: Kareebosch WEF (Almond 2014), Karusa WEF (Almond 2015c), Rietkloof WEF (Almond 2016b) and Brandvalley WEF (Almond 2016c). Further PIAs (palaeontological impact assessments) of relevance include those for the Eskom Gamma-Omega 765kV transmission line (Almond 2010a) and the Komsberg Substation (Almond 2015b).

Other WEF projects in the wider region, such as the Perdekraal East WEF (Almond 2015a), Soetwater WEF (Almond 2015d), Gunsfontein WEF (Almond 2015g), Komsberg West WEF (Almond 2015f), Komsberg East WEF (Almond 2015e), Sutherland WEF (Almond 2010c), Suurplaat WEF (Almond 2010b), Maralla West and Maralla East WEFs (Almond 2016e) and the Great Karoo WEF (for which no field-based palaeontological study was done) are underlain by younger rocks within the Lower Beaufort Group, or by much older Dwyka Group and Ecca Group rocks. These successions contain different fossil assemblages and so are not relevant to the present cumulative impact assessment. This also applies to further alternative energy facilities within the Cape Fold Belt near Touwsrivier and Laingsburg, such as the Konstabel WEF (Almond 2010d) and Witberg WEF (Miller 2010), that are underlain by older bedrocks and to solar energy facilities above the Great Escarpment near Sutherland that overlie younger portions of the Abrahamskraal Formation.

In all the strictly *relevant* field-based palaeontological studies listed above the palaeontological sensitivity of the project area and the palaeontological heritage impact significance for the developments concerned has been rated as low. In all cases it was concluded by the author that, despite the undoubted occurrence of scientifically-important fossil remains (notably fossil vertebrates, vertebrate trackways and burrows, petrified wood), 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 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 Esizayo WEF 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*.

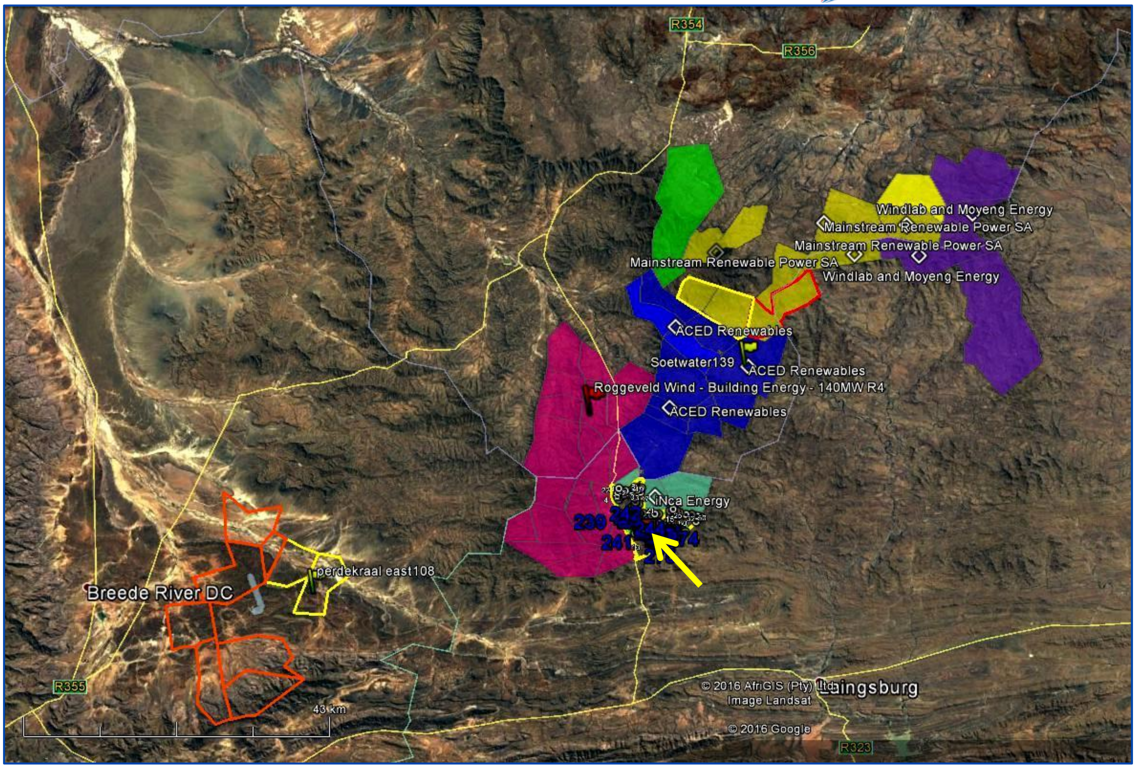

Figure 43: Google earth© satellite image of SW Karoo showing the large number of WEF projects that have been proposed or already approved in the region. The Esizayo WEF project area is indicated by the yellow arrow.

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 in the context of numerous other alternative developments in the region (construction phase).

6. Mitigation and Management Measures

The vertebrate and trace fossil site at Loc. 256 on the banks of the Roggeveldrivier on Aanstoot 72 (33º 00’ 01.8” S, 20º 36’ 26.0” E, marked in red in satellite map Fig. 42) is of special scientific interest and should be safeguarded by a 10 m-radius buffer, although it lies well away from the development footprint in an area that is unlikely to be impacted by the WEF.

Given the scarcity of scientifically-important, unique fossil heritage recorded within the 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. There are no suggested modifications on palaeontological heritage grounds to the proposed layout, including wind turbine sites, access and internal roads, IPP substation and associated infrastructure,

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).

- 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 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 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 WEF 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 WEF and also included as conditions for authorisation of the development project.

Table 3 (following pages) : 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
Design of final WEF layout	Safeguard fossil site Loc. 256 (33 00 01.8 S 20 36 26.0 E) on banks of Roggeveldrivier with 10 m–radius buffer.	Developer & ECO	Planning & construction	Yes	ECO to ensure fossil site is safeguarded from disturbance.
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).	ECO	Construction	Yes	Define and secure fossil site with security tape. Report finds at earliest opportunity to HWC
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 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.	Professional palaeontologist	Construction	Yes	Following Phase 2 palaeontological mitigation

Activity	Mitigation and Management Measure	Responsible Person	Applicable Development Phase	Include as Condition of Authorisation	Monitoring requirements
Development of borrow pits	Separate palaeontological heritage assessment for each proposed borrow pit	Professional palaeontologist	Pre-construction	Yes	To be specified by palaeontologist and HWC on submission of palaeontological assessment reports

7. STAKEHOLDER CONSULTATION

7.1. Stakeholder Consultation Process

Public participation is a requirement of the S&EIR process; it consists of a series of inclusive and culturally appropriate interactions aimed at providing stakeholders with opportunities to express their views, so that these can be considered and incorporated into the S&EIR decision-making process. Effective public participation requires the prior disclosure of relevant and adequate project information to enable stakeholders to understand the risks, impacts, and opportunities of the Proposed Project.

A comprehensive stakeholder consultation process was undertaken during the scoping phase. Stakeholders were identified through existing databases, site notices, newspaper adverts and meetings. All stakeholders identified to date have been registered on the project database. All concerns, comments, viewpoints and questions (collectively referred to as 'issues') received to date have been documented and responded to in a Comment and Response Report.

There will be ongoing communication between WSP | Parsons Brinckerhoff and stakeholders throughout the S&EIR process.

The following stakeholder comments and responses on the Draft Scoping Report for the proposed Esizayo WEF have been reviewed with respect to palaeontological heritage issues for this EIA phase report:

- Letter from Cape Nature (Ref: 14/2/6/1/5/2_LAIN/ Esizayo_2016/CF023), dated 17 October 2016;
- E-mail from the Department of Environmental Affairs, dated 14 October 2016;
- DEA&DP comment on Draft Scoping report (undated).

7.2. Stakeholder Comments and Response

Only one comment regarding palaeontological heritage was submitted during the stakeholder consultation process. This comment, together with the corresponding specialist response, are provided in the table below.

STAKEHOLDER DETAILS	COMMENT	SPECIALIST RESPONSE
DEA&DP	4.9 Paleontological impact and mitigation 4.9.1 The final WEF layout must be subjected to an intensive paleontological impact assessment, as per the specialist recommendations. All resulting micro-siting mitigation measures identified must be reported on in the Draft EIA Report.	A four-day palaeontological field study of the Esizayo WEF study area has been carried out by J. Almond and assistants (February, 2016), as recommended in the Scoping report (Almond 2016d). Given the large size of the study area and low level of bedrock exposure, the survey focused mainly on good bedrock exposures in riverbanks, erosion gulleys and steeper hillslopes, rather than on the development footprint. It was concluded that the

STAKEHOLDER DETAILS	COMMENT	SPECIALIST RESPONSE
		bedrocks within the WEF study area are only sparsely fossiliferous and the proposed WEF layout is unlikely to compromise unique, scientifically-important fossil heritage in EIA report. Accordingly, no recommendations for changes to the proposed layout have been made.

8. CONCLUSIONS

BioTherm Energy (Pty) Ltd is proposing to develop the Esizayo Wind Energy Facility with a total generation capacity of up to 140 MW on a site in the Klein-Roggeveld region of the Great Karoo. The site lies some 30 km to the northwest of Laingsburg in the Laingsburg District Municipality, Western Cape. The project area comprises the following land parcels: Farm Aanstoot 72 Portion 1 (762 ha), Farm Annex Joseph's Kraal 84 (913 ha) and Farm Aurora 285 (4385 ha).

The Esizayo WEF project area is underlain by deltaic and fluvial sediments of the Waterford Formation (Ecca Group) and Abrahamskraal Formation (Lower Beaufort Group) of Middle Permian age. Well-preserved fossil logs are recorded in Waterford Formation deltaic sediments just outside the study area. During the four-day palaeontological field assessment the small outcrop area of Waterford Formation bedrocks yielded very few fossils, however, apart from one conservation-worthy site featuring fragmentary, reworked vertebrate remains (possibly amphibian or fish) in association with simple invertebrate burrows. This site, situated on the steep banks of the Roggeveldrivier on the Farm Anstoot 72m, lies well away from the development footprint but should nevertheless be safeguarded by a 10 m–radius buffer zone (See satellite map Fig. 42 herein).

The lowermost portion of the Lower Beaufort Group succession in the SW Karoo is characterised by very rare tetrapod remains and vertebrate burrows of the *Eodicynodon* Assemblage Zone. No fossil vertebrates or petrified wood were recorded in the Abrahamskraal Formation within the present study area, however. The dense assemblages of reedy plant stem casts (probably horsetails) as well as small invertebrate burrows found here occur widely within the region and are therefore not considered to be of special conservation significance. It is concluded that the Middle Permian bedrocks in the Esizayo WEF study area are generally of low palaeontological sensitivity. The same applies to a range of Late Caenozoic superficial sediments (alluvium, colluvium, calcretes, soils, surface gravels *etc*) overlying the Palaeozoic bedrocks. These may contain reworked blocks of petrified wood in the Klein-Roggeveld region, but no fossils or this or any other sort were recorded within these younger deposits during the field assessment.

The overall impact significance of the construction phase of the proposed wind energy project 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 to the proposed layout for the wind turbines, laydown area, access and internal roads, on-site IPP substation and associated WEF infrastructure within the study area. A comparable low impact significance is inferred for all project infrastructure alternatives and layout options under consideration, including different options for routing of access and internal roads, turbine layouts and siting of the on-site substation. Significant further impacts during the operational and de-commissioning phases of the WEF are not anticipated. There are therefore no preferences on palaeontological heritage grounds for any particular layout among the various options under consideration. No significant further impacts on fossil heritage are anticipated during the planning, operational and de-commissioning phases of the WEF. The no-go alternative (*i.e.* no WEF 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, are predicted to be low (negative), *provided that* the proposed monitoring and mitigation recommendations made for 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. *Without* mitigation, cumulative impacts resulting from the large number of WEF projects in the Klein-Roggeveld region are anticipated to be of medium significance.

There are no fatal flaws in the Esizayo WEF development proposal as far as fossil heritage is concerned. *Provided that* the recommendations for palaeontological monitoring and mitigation outlined below are followed through, there are no objections on palaeontological heritage grounds to authorisation of the Esizayo WEF project.

It is noted that borrow pit sites will only be identified if and when the proposed WEF wins preferred bidder status. In this case, a separate palaeontological assessment of all borrow pit sites will be necessary in the pre-construction phase.

With the exception of the one vertebrate fossil site in the Waterford Formation already mentioned, no highly sensitive “no-go” areas within the proposed Esizayo WEF study area have been identified in this study. 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 WEF development 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, turbine placements) 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 (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). 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 alternative energy project. 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 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).

9. ACKNOWLEDGEMENTS

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10. REFERENCES

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

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

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

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

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

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

ALMOND, J.E. 2010d. Proposed Mainstream wind farm at Konstabel near Touwsrivier, Laingsburg Magisterial District, Western Cape. Palaeontological impact assessment: pre-scoping desktop study, 19 pp. Natura Viva cc, Cape Town.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ALMOND, J.E. & PETHER, J. 2008b. Palaeontological heritage of the Northern Cape. Interim SAHRA technical report, 124 pp. Natura Viva cc., Cape Town.

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

HERITAGE WESTERN CAPE (2016). Guide for minimum standards for archaeology and palaeontology reports submitted to Heritage Western Cape, 5pp. Approved: HWC Council June 2016.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

MILLER, D. 2010. Palaeontological potential of proposed Witberg Wind Farm. Heritage impact assessment prepared for ACO, Cape Town, 8 pp.

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

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

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

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

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

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

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

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

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

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

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

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

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

RUBIDGE, B.S. (Ed.) 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Biostratigraphy, Biostratigraphic Series No. 1., 46 pp. Council for Geoscience, Pretoria.

RUBIDGE, B.S. 1995. Biostratigraphy of the *Eodicynodon* Assemblage Zone. Pp. 3 to 7 *in* Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Biostratigraphy, Biostratigraphic Series No. 1., 46 pp. Council for Geoscience, Pretoria.

RUBIDGE, B.S. 2005. Re-uniting lost continents – fossil reptiles from the ancient Karoo and their wanderlust. 27th Du Toit Memorial Lecture. South African Journal of Geology 108, 135-172.

RUBIDGE, B.S. & OELOFSEN, B.W. 1981. Reptilian fauna from Ecca rocks near Prince Albert, South Africa. South African Journal of Science 77, 425-426.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

VILJOEN, J.H.A. 1989. Die geologie van die gebied Williston. Explanation to geology sheet 3120 Williston, 30 pp. Council for Geoscience, Pretoria.

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

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

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

APPENDIX

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84. Land parcel names used in the table refer to those shown on the relevant 1: 50 000 maps 3320BA Matjiesfontein and 322DC Swartland (Published by the Chief Directorate: National Geo-spatial Information, Mowbray).

N.B. Fossil locality data is not for general release to the public (e.g. through publication on open access websites) for conservation reasons.

Fossil localities that were recorded during fieldwork are shown in relation to relevant major components of the proposed development footprint on the satellite image provided in Figure 42. Please note that this map does *not* show all fossils that are present at surface within the study area, and further, unrecorded fossil occurrences (the majority) are to be expected at the surface or 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.

Loc.	GPS data	Comments
239	32 59 21.7 S 20 34 01.6 E	Fortuin 74. Bed & banks of Roggeveldrivier nr Nuwerus farmstead & R354. Medium to thick-bedded, fine-grained, grey-green channel sandstones of Abrahamskraal Fm. Current-rippled bed tops, thin mudflake breccio-conglomerates, flaggy bedding with primary current lineation. Poorly-preserved *Scoyenia* ichnofacies trace fossils (backfilled horizontal burrows, *c*. 8 mm wide).
240	32 59 22.1 S 20 34 04.9 E	Fortuin 74. Downwasted alluvial surface gravels along banks of Roggeveldrivier. Medium- to coarse, angular to subangular, composed of Abrahamskraal wackes, minor vein quartz. Corroded clasts perhaps related to salt precipitation.
241	32 59 38.8 S 20 34 18.5 E	Fortuin 74. Gulley exposure of hackly-weathering, grey-green, silty overbank mudrocks and thin crevasse-splay sandstones of Abrahamskraal Fm. Common impressions of sphenophyte fern stems within mudrocks as well as thin-bedded upward-fining packages beneath crevasse splay sandstones (proximal floodplain deposits). Thin, laterally-extensive horizons of small, grey calcrete nodules (palaeosols) beneath plant-bearing beds. Nearby stream bed with thin-bedded, fine-grained flaggy sandstones with vague horizontal burrows preserved as negative epichnia.
242	32 59 38.7 S 20 35 01.3 E	Aanstoot 72. Streambank exposure of Abrahamskraal Fm grey-green mudrocks and package of thin-bedded, fine-grained sandstones (possibly loaded) near Aurora farmstead. Pale grey calcrete nodules. Bedding plane assemblages of sphenophyte plant debris. Poorly-preserved, meniscate-backfilled horizontal burrows (positive epichnia and endichnia, probably *Scoyenia*), dense assemblages of narrow (1 cm or less diameter, variable) cylindrical sandstone casts on mud-draped bed tops of fine-grained sandstone – probably casts of reedy plant stems (*e.g.* sphenophytes). Large lenticular concretions of ferruginous carbonate up to several dm across.
243	32 59 36.3 S 20 35 01.47 E	Aanstoot 72. Stream bank vertical section through thick (2-3m), buff, silty alluvium with coarse, subangular basal gravels (poorly-sorted, locally cross-bedded, mainly Abrahamskraal wackes with minor vein quartz) and thin internal gravels lenses.
244	32 59 32.1 S 20 35 05.7 E	Aanstoot 72. Stream bed close to Aurora homestead. Stream bank sections through modern gravelly and silty alluvium (as above). Good Abrahamskraal Fm exposures in banks of Roggeveldrivier. Hackly-weathering grey-green to olive-green overbank mudrocks at base overlain by very thin-bedded, greenish-brown, flaggy siltstones that are in turn sharply overlain by buff, tabular, thin- to thick-bedded channel sandstones. Narrow straight to gently curved horizontal burrows preserved as positive and negative epichnia within flaggy siltstone facies (possibly algal mat-related).
245	32 59 43.1 S 20 35 27.7 E	Aanstoot 72. Hillslope and erosion gulley exposure of Abrahamskraal Fm grey-green mudrocks, thin horizontally-laminated to medium-bedded channel sandstones (cut by numerous narrowly-spaced joints). Extensive pedocretes of secondarily ferruginised calcrete

		concretions (probably due to dolerite intrusion)
246	32 59 46.8 S 20 35 32.6 E	Aanstoot 72. Erosion gulley and stream bank exposures of buff alluvial sands (up to 3 m) and fine gravelly alluvium overlying well-jointed Abrahamskraal Fm channel sandstones. "High Level Gravels" up to *c*. 3 m above modern stream bed – unconsolidated coarse, poorly sorted clasts of Abrahamskraal wackes with minor vein quartz and reworked calcrete.
247	32 59 59.3 S 20 35 55.0 E	Aanstoot 72. Hillslope exposures of Abrahamskraal Fm mudrocks and sandstones with horizons of ferruginised calcrete nodules, jointed lenses of loaded sandstone.
248	33 00 01.3 S 20 35 49.6 E	Aanstoot 72. Extensive exposure of gently-dipping, dark blue-grey Abrahamskraal Fm mudrocks with horizons of dark grey calcrete nodules, boulder-sized pale buff diagenetic carbonate concretions with shrinkage cracks. Scree of rubbly, angular to subrounded pale brown Abrahamskraal sandstone clasts.
249	33 00 22.5 S 20 36 13.7 E	Aanstoot 72. Wind mast area with downwasted rubbly sandstone colluvium and sandy soils.
251	33 00 37.1 S 20 36 00.2 E	Aanstoot 72. Extensive dipping strike exposure of Abrahamskraal Fm grey-green mudrocks with large ferruginous calcrete concretions, capped by tabular, densely-jointed crevasse-splay sandstone.
252	33 00 37.0 S 20 35 57.4 E	Aanstoot 72. Zone of large (sev. m diameter) concretions of dark rusty-brown ferruginous carbonate (*koffieklip*) concretions.
253	33 00 35.8 S 20 35 52.8 E	Aanstoot 72. Extensive dipping strike exposure of Abrahamskraal Fm grey-green mudrocks with *koffieklip* concretion horizon towards base. Numerous dispersed small grey calcrete nodules and fragments of sphenophyte ferns within mudrocks. Nearby sandstone upper bedding surfaces with small-scale linear wave ripples.
254	33 00 29.9 S 20 35 50.8 E	Aanstoot 72. Prominent-weathering, dyke-like, laterally-persistent ridge of south-dipping, pebbly breccio-conglomerate *c*. 1-1.5 m thick and striking at c. 120º. Pale grey colour due to saxicolous lichen cover. Breccia composed of subrounded to platy clasts of reworked calcrete (including laminated calcretised sandstone) in a sandy ferruginous carbonate matrix. No clasts of reworked fossil bone / teeth / petrified wood observed, but these may well be present (much of breccia is obscured by lichen cover).
255	33 00 02.7 S 20 36 24.1 E	Aanstoot 72. Good exposures of upper Waterford Fm in steep banks of incised meander of the Roggeveldrivier. Upward-coarsening package with massive dark green-grey siltstones, thinly-interbedded siltstone and wackes gradationally overlain by thick-bedded to massive, well-sorted brownish distributary channel wackes (locally speckled). Abundant loaded horizons (soft-sediment deformation, load balls and pillows *etc*), wave-rippled bedding surfaces (contrasting azimuths of ripple crests).
256	33 00 01.8 S 20 36 26.0 E	Aanstoot 72. Same Waterford Fm cliff exposure as above. Upper bedding plane of flat-laminated, brown-weathering wacke with abundant straight short grooves (probably trace fossils), positive epichnial horizontal burrows, problematic reticulate-ornamented moulds (possibly disarticulated temnospondyl amphibian scutes), elongate, longitudinally-ridged sandstone structures (possibly casts of cartilaginous or bony skeletal debris). Wackes on northern banks extensively covered with greyish saxicolous lichens.
257	33 00 06.9 S 20 37 11.6 E	Aanstoot 72. Good exposures of pale brown, tabular-bedded, massive to laminated Waterford Fm distributary channel wackes incised into massive to thin-bedded prodeltaic mudrocks seen in steep banks of incised meander of the Roggeveldrivier. Packages of thin-bedded rhythmitites. Zones of pervasive soft-sediment deformation with small- to large-scale load balls, large (several m) foundered blocks of wacke, deformed and chaotic bedding. Base of thick wackes erosionally incised and loaded, showing mudrock flame structures. Local development of interference wave-rippled as well as linear wave- and current-rippled bed tops. Several progradational deltaic cycles probably represented within upper Waterford Fm.
258	33 00 02.2 S 20 35 57.9 E	Aanstoot 72. Along-strike exposure of dark grey-green Abrahamskraal Fm mudrocks and sharp-based, medium-bedded sandstones. Partially ferruginised calcrete nodules with calcite-infilled shrinkage cracks. Thick gravelly to sandy along river banks.
259	33 00 50.8 S 20 36 51.5 E	Aanstoot 72. Stream gulley exposure of dark blue-grey Abrahamskraal Fm mudrocks with dense concentrations of vertical reedy plant stem casts (6 mm or less in diam.) infilled with sandstone. Rippled siltstone bed tops with low-diversity horizontal burrows (possibly *Scoyenia*).
260	33 00 56.2 S 20 36 50.8 E	Aanstoot 72. Extensive hillslope and gulley exposures of grey-green and olive-green, hackly to crumbly Abrahamskraal Fm mudrocks (locally with pencil cleavage), thin sandstones (ripple topped, densely jointed). Heterolithic, thin-bedded packets of fine-grained sandstone and siltstone. Abundant ferruginous carbonate nodules and lenses (*koffieklip*) ranging up to boulder-sized, some with septarian cracking pattern, rugose exterior surface; probably indicate high water table during deposition. Colluvium dominated by koffieklip and fine-grained quartzitic sandstone or wacke.
261	33 01 00.0 S 20 36 46.0 E	Aanstoot 72. Stream gulley and waterfall exposures of Abrahamskraal Fm. Sandstones / grey wackes finely jointed. Thin-bedded heterolithic packages with dark grey sphaeroidal calcrete

		and rusty-brown ferruginous carbonate concretions beneath major channel sandstone body. Scree of angular sandstone clasts.
262	33 01 02.2 S 20 36 47.7 E	Aanstoot 72. Sharp basal contact of thick, fine-grained, tabular-bedded Abrahamskraal channel sandstone with no basal breccia. Underlying thin sandstones show pinch-and-swell along strike – possibly due to channel abandonment. Mudrocks beneath contain large ferruginous carbonate concretions as well as dense mottled calcrete horizon. Dense assemblages of intrastratal burrows preserved as washed-out casts on sole surface of channel sandstone.
263	33 01 01.1 S 20 36 42.3 E	Aanstoot 72. Gulley exposure of thin (few dm) upward-coarsening, grey siltstone / fine sandstone cycles within Abrahamskraal Fm.
264	33 01 00.1 S 20 36 37.1 E	Gulley exposure of Abrahamskraal Fm. Abundant downwasted *koffieklip* debris.
265	33 01 00.9 S 20 36 36.2 E	Aanstoot 72. Sandstone bed top with sloping pond margin, marginal falling water marks, rills.
266	33 01 04.1 S 20 36 38.4 E	Aanstoot 72. Gulley exposure through thin-bedded heterolithic facies of Abrahamskraal Fm leading up to channel sandstone body.
267	33 01 08.6 S 20 36 45.0 E	Aanstoot 72. Steep gulley exposure through Abrahamskraal Fm mudrocks and sandstones. Pedocrete nodules scarce.
268	33 01 08.1 S 20 36 49.3 E	Aanstoot 72. Extensive gulley and hillslope exposure of weathered Abrahamskraal Fm pale grey-green to greenish-brown mudrocks (with sparse calcrete nodules, often ferruginised) and medium-bedded sandstones. Thick colluvial sandstone mantle over bedrocks on gentle hillslopes.
269	33 01 12.3 S 20 36 50.1 E	As above.
270	33 01 03.0 S 20 36 57.4 E	Aanstoot 72. Thick cliff or krans of tabular-bedded, buff channel sandstones at head of stream gulley. Impersistent, thin (≤ 30 cm) fine gravelly basal breccia of mudflake intraclasts and calcrete clasts at lower contact.
271	33 00 58.5 S 20 36 54.6 E	Aanstoot 72. Stream bed exposure of hackly-weathering grey-green siltstones with *in situ* vertical sandstone casts of sphenophyte fern stems as well as bedding-parallel plant stems with nodes (*c*. 3 cm wide).
272	33 00 34.7 S 20 38 06.9 E	Aanstoot 72. Riverbank exposure of thin-bedded grey-green fine Abrahamskraal sandstone showing dense assemblages of reedy plant stem casts (≤ 6 cm) on successive bedding planes. Thick, pale brown silty modern alluvium.
273	33 00 39.4 S 20 38 03.2 E	Aanstoot 72. Excellent steep riverbank exposures of tabular-bedded Abrahamskraal Fm along the Roggeveldrivier. Rhythmic, small-scale upward-coarsening cycles, tabular, sharp-based, fine-grained channel sandstones.
274	33 00 38.5 S 20 38 02.1 E	Same locality as above. Sole surfaces of sandstones from thin-bedded “rhythmitite facies” showing wrinkle textures and narrow horizontal burrows that were probably associated with microbial mats (*cf Helminthoidichnites*). Medium-bedded sandstones (sometimes speckled) with horizontal lamination towards base, current ripple lamination at top. Horizons of large rusty-brown ferruginous carbonate concretions. Beds with abundant, dense reedy plant stem casts.
275	33 00 41.4 S 20 38 08.0 E	Same locality as above. Extensive sandstone bedding planes showing *Scoyenia* ichnofacies horizontal and oblique back-filled burrows (*c*. 5 mm wide), casts of reedy plant stems. Thick sandy to gravelly alluvial and colluvial cover over Abrahamskraal Fm bedrocks along river banks.
276	33 00 28.6 S 20 38 12.8 E	Aanstoot 72. Hillslope exposure of Abrahamskraal Fm mudrocks with horizon of well-developed, rusty-brown ferruginous carbonate concretions (suggesting high palao-water table on floodplain). Small greyish calcrete nodules also present. Good gentle hillslope exposures of grey-green mudrocks, thin crevasse-splay sandstones on distal floodplain.
277	33 00 32.7 S 20 38 23.7 E	Aanstoot 72. Good exposures of Abrahamskraal Fm grey-green hackly mudrocks and overlying thick Late Caenozoic alluvium along Roggeveldrivier. Alluvium well-bedded with angular basal gravels (mainly Abrahamskraal wackes), pale orange-brown silty sands above with darker brown modern alluvial silts above.
278	33 00 36.1 S 20 39 07.0 E	Annex Josephs Kraal 84. Extensive riverine exposure of Abrahamskraal Fm sandstones and mudrocks near De Bron homestead. Sharp-based, fine-grained, tabular-bedded channel sandstone (no basal breccia) incised into thin-bedded heterolithic package (possible levee deposits). Ferruginous carbonate concretion horizons. Major fracture zone cuts channel sandstone associated with ferruginous mineralisation, dense vertical jointing.
279	33 00 29.4 S 20 38 39.0 E	Annex Josephs Kraal 84, Renosterrivier NW of De Bron homestead. Good, thick riverine exposures of Abrahamskraal Fm including hackly blue-grey overbank mudrocks with ferruginous carbonate concretions, tabular channel and crevasse splay sandstones with well-developed ripple cross-lamination. Possible mudrock slurry deposits (small debris flows). Dispersed arthrophyte plant debris, gypsum pseudomorphs.
280	32 59 01.3 S	Aanstoot 72. Subvertical dyke (*c*. 5 m wide) of well-jointed, dark grey-green, brownish-

	20 34 24.7 E	weathering dolerite exposed in stream bed.
281	32 59 00.3 S 20 34 24.6 E	Aanstoot 72. Wide (several 10s m), brownish, prominent-weathering dolerite dyke exposed in *vlaktes* and along strike in stream bed. Sugary texture (medium-grained). Strike *c*. 100º.
282	32 58 58.1 S 20 34 23.8 E	Aanstoot 72. Coarse, poorly-sorted, unconsolidated to poorly-consolidated alluvial pediment gravels 4-5 meters above modern stream bed level. Clasts subangular to well-rounded, mainly Abrahamskraal wackes with minor dolerite. Surface gravels in area subrounded due to exfoliation more than transport. Occasional reworked calcrete clasts. Modern alluvium exposed in stream banks silty to sandy, pale brown, gravel-rich and incipiently calcretised towards base (especially in areas with dolerite bedrocks).
283	32 59 02.8 S 20 34 23.2 E	Aanstoot 72. Bare sandy patches among bossieveld vegetation with cover of dispersed surface gravels modified by sheetwash. Clasts angular, mainly Abrahamskraal wackes and dolerite with minor vein quartz (*e.g.* mineral lineation). No reworked fossil bones or petrified wood seen. Subsurface alluvium calcretised (nodular hardpan).
284	32 59 06.1 S 20 34 22.0 E	Aanstoot 72. Poorly-consolidated, ill-sorted thin older alluvial gravels (dolerite and wacke clasts) with calcrete cement.
285	32 59 07.7 S 20 34 30.6 E	Aanstoot 72. Extensive Abrahamskraal Fm mudrock exposure on low hill. Abundant ferruginous carbonate concretions fmarking palaeosol horizons. Mudrocks locally weathered to pale olive-brown hue. Frequent float blocks of vein quartz, quartz mineral lineation reflect local faulting and resemble fossil wood (pseudofossils).
286	32 58 12.9 S 20 35 33.8 E	Aanstoot 72. Extensive hillslope and gulley exposures of Abrahamskraal Fm hackly-weathering, grey-green mudrocks, thin, tabular, fine-grained crevasse-splay and channel sandstones.
287	32 58 19.7 S 20 35 28.8 E	Aanstoot 72. As above. Very abundant siliceous pseudomorphs of gypsum roses indicating arid palaeoclimates on floodplain (mainly weathering out as float). Palaosol horizons marked by ferruginous carbonate concretions.
288	32 58 14.7 S 20 35 29.8 E	Aanstoot 72. Deep stream gulley exposure of Abrahamskraal Fm dark grey mudrocks, Abundant gypsum rose pseudomorphs and zones of quartz mineral lineation.
289	32 58 08.3 S 20 35 35.0 E	Aanstoot 72. Area of extensive donga incision through thick gravelly to sandy alluvial and colluvial sediment cover (*c*. 2-3 m thick), with limited, weathered Abrahamskraal Fm bedrock exposure. Lenticles of poorly-sorted coarse gravels (wacke, vein quartz) at base or forming stone line within superficial sediment cover. Rubbly, angular modern alluvial gravels in stream bed.
290	32 58 06.6 S 20 35 32.6 E	Aanstoot 72. As above.
291	32 57 53.8 S 20 33 58.8 E	Aanstoot 72. Network of shallow streams on southern slopes of Skaapberg exposing dark blue-grey Abrahamskraal Fm mudrocks mantled with rubbly sandstone colluvium.
292	32 57 36.8 S 20 34 02.4 E	Aanstoot 72, Skaapberg. Extensive exposure of dark, well-indurated Abrahamskraal Fm mudrocks (blue-grey, splintery) with ferruginous carbonate concretions, thin-bedded sandstones.
293	32 57 32.8 S 20 34 02.0 E	Aanstoot 72, Skaapberg. Stream bed exposure of thin-bedded hackly-weathering, blue-grey Abrahamskral Fm mudrocks and well-jointed fine-grained sandstones.
294	32 57 27.9 S 20 33 49.1 E	Aanstoot 72, crest of Skaapberg. Surface exposure of well-jointed Abrahamskraal Fm sandstones and minor weathered mudrocks. Rubbly float of sandstone and ferruginous carbonate concretions. Occasional large relict blocks of fine-grained channel sandstone.
295	32 57 52.1 S 20 33 32.8 E	Aanstoot 72. Extensive dip surface exposure of well-jointed, Abrahamskraal Fm sandstones on southern flanks of Skaapberg, overlain by weathered overbank mudrocks with ferruginous carbonate concretions.
296	32 58 47.3 S 20 33 39.8E	Aanstoot 72. Large roadside borrow pit on east side of R354 excavated into Abrahamskraal Fm mudrocks overlain by friable, weathered channel sandstones.
297	33 00 25.9 S 20 38 55.5 E	Annex Josephs Kraal 84. Excellent, extensive riverine exposures of Abrahamskraal Fm sandstones and mudrocks NE of De Bron homestead. Thin to thick, unistorey, lenticular channel sandstones seen in section. Palaeosol horizons within overbank mudrocks. Small scale wave ripples on siltstone bed tops. Several meters of poorly-sorted, calcretised High Level Gravels (angular pediment gravels in pale brown calcretised matrix) elevated well above modern streambed.
338	32 57 55.8 S 20 33 06.0 E	Aanstoot 72. Steep cliff section on east side of R354 through thick package of tabular-bedded, well-sorted Waterford Formation channel wackes (core of anticline).