PALAEONTOLOGICAL SPECIALIST STUDY: DESKTOP ASSESSMENT

Proposed Wind and Solar (Photovoltaic) Energy Facilities on Kangnas Farm near Springbok in the Northern Cape

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SUMMARY

South Africa Mainstream Renewable Power Developments (Pty) Ltd (Mainstream) is proposing to develop a 750 MW generating capacity wind energy facility as well as a 250 MW generating capacity photovoltaic (PV) and / or concentrated photovoltaic (CPV) solar energy facility on adjacent sites near Kangnas in the Bushmanland region of the Northern Cape (Nama Khoi Local Municipality). The study area is situated some 50 km east of Springbok and straddles the N14 tar road between Springbok and Pofadder. It comprises five portions of four farms: Kangnas Trust (Portion 3 and Remaining portion of Farm No. 77), Farm Koeris (Portion 1 of Farm No. 78), Farm Areb (remaining portion of Farm No. 75) and Farm Smorgenschaduwe (Portion 0 of Farm No. 127).

The Mainstream wind energy and solar energy facility project areas are largely underlain by ancient Precambrian metamorphic and igneous basement rocks of the Namaqua-Natal Metamorphic Province that crop out as low, rocky inselberge and are entirely unfossiliferous. In the intervening flatter, low-lying areas where the wind and solar energy facilities are likely to be constructed these older basement rocks are extensively mantled with geologically young superficial deposits (Quaternary to Recent sandy alluvium, colluvium, soils, wind-blown sand, calcrete hardpans *etc*) that are generally of low to very low palaeontological sensitivity.

Small but significant areas of older fossiliferous sediments have been recorded subsurface within the Kangnas study area and have yielded scientifically important vertebrate and plant fossil material. These include (1) rare dinosaur remains (*Kangnasaurus*), petrified woods and non-marine crustaceans (ostracods) from crater lake deposits of probable Late Cretaceous age at Goebees in the northeast, as well as (2) Late Tertiary (Miocene) three-toed horses (*Hipparion*) from palaeochannel river deposits at Areb in the north. Neither of these fossil sites is likely to be directly affected by the proposed developments. However, it is quite possible that further, hitherto undiscovered fossiliferous deposits of this nature lie buried beneath the superficial sediment cover elsewhere within the broader study area. Fossils exposed at the surface or underground may be damaged, disturbed or sealed-in during the construction phase of the proposed wind and solar energy facilities near Kangnas. However, these deposits are unlikely to be directly affected except by deeper excavations (> 3m) that penetrate the generally unfossiliferous superficial deposits overlying them. Both the proposed wind energy facility and solar energy facility developments are inferred to be of LOW overall impact significance in terms of palaeontological heritage resource conservation.

Given the low overall palaeontological sensitivity of the basement rocks and superficial deposits within the Kangnas study area, the successive or concurrent development here of the proposed

wind and solar energy facilities is not considered to pose a significant cumulative impact on local fossil heritage. Future changes in infrastructure layout for the wind or solar energy projects will not materially affect the conclusions and recommendations made in this palaeontological report.

In view of the overall low impact significance of the proposed developments on palaeontological heritage resources, it is concluded that no further palaeontological heritage studies or specialist mitigation are required for these alternative energy projects, *pending* the discovery or exposure of any substantial fossil remains (*e.g.* vertebrate bones and teeth, large blocks of petrified wood, fossil plant-rich horizons, buried laminated shales) during the construction phase. The Environmental Control Officer (ECO) responsible for these developments should be alerted to the two known fossil sites as well as the possibility of fossil remains being found either on the surface or exposed by fresh excavations during construction. Should fossil remains be discovered during construction, these should be safeguarded (preferably *in situ*) and the ECO should alert the South African Heritage Resources Authority (SAHRA) so that appropriate mitigation (*e.g.* recording, sampling or collection) can be undertaken by a professional palaeontologist.

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

These recommendations should be incorporated into the Environmental Management Programme (EMP) for the two Mainstream alternative energy developments near Kangnas.

1. INTRODUCTION & BRIEF

The company South Africa Mainstream Renewable Power Developments (Pty) Ltd (Mainstream) is proposing the development of (1) a 750 MW generating capacity wind energy facility as well as (2) a 250 MW generating capacity photovoltaic (PV) and / or concentrated photovoltaic (CPV) solar energy facility on adjacent sites near Kangnas in the Bushmanland region of the Northern Cape (Nama Khoi Local Municipality). The study area of about 46 535 hectares extent is situated some 48 km east of Springbok and straddles the N14 tar road between Springbok and Pofadder (Figs. 1 to 3). It comprises five portions of four farms that are currently zoned for agriculture and used for grazing (Fig. 2), namely:

- Kangnas Trust (Portion 3 and Remaining portion of Farm No. 77);
- Farm Koeris (Portion 1 of Farm No. 78);
- Farm Areb (Remaining portion of Farm No. 75);
- Farm Smorgenschaduwe (Remaining portion of Farm No. 127).

The main infrastructural components of the proposed wind energy facility of relevance to the present fossil heritage study are:

- 185 to 500 wind turbines of 1.5-4 MW capacity each, giving a total generation capacity of up to 750 MW. The turbine foundations would be approximately 20 m x 20 m and an average of 3 m deep;
- A permanent hard standing area for the crane of compacted gravel of approximately 20 m x 50 m adjacent to each turbine location;
- Gravel surface access roads of approximately 6-10 m width between each turbine;
- Underground cables connecting the turbines with each other and a new overhead transmission line. The underground cables will run next to the wind turbine connection roads as far as possible;
- Electricity distribution network consisting of up to four satellite substations, a main substation and a new 132 or 220 kV overhead transmission line connecting to the existing 220 kV Eskom power line that crosses the northern part of the study site (Fig. 3).

The preferred location for the wind turbines will be largely south of the N14.
The main infrastructural components of the proposed solar energy facility of relevance to the present fossil heritage study are:

- Numerous PV / CPV arrays of up to 250 MW total generation capacity combined as tables (*c*. 40 m x 5 m) mounted on racks that are fixed to the ground *via* concrete, screw or pile foundations. Tracking systems may also be installed;
- Gravel access roads of approximately 6 to 10 m width;
- Cables connecting the arrays with a single 220 kV overhead transmission line crossing the site to an onsite substation. This substation will connect to the existing 220 kV Eskom power line that crosses the northern part of the study site.

The total footprint of the solar energy facility will be approximately 1000 hectares. The preferred location is north of the N14 tar road near Areb (Se Fig. 3).

The present fossil heritage desktop assessment forms part of the combined EIA process for both the wind energy facility and solar energy facility at Kangnas that is being co-ordinated by Aurecon South Africa (Pty) Ltd, Cape Town (Aurecon project no: 108495**)** (DEA ref. no. 14/12/16/3/3/2/346 (Wind); NEAS ref. no. DEA/EIA/0001222/2012; DEA ref.no. 14/12/16/3/3/2/342 (PV); NEAS ref. no. DEAT/EIA/0001217/2012).

In accordance with the National Heritage Resources Act, 1999, a palaeontological heritage assessment is required as part of a Heritage Impact Assessment for these projects since important fossil material (Cretaceous dinosaurs and Tertiary mammals) has previously been recorded in the Kangnas area. The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act include, among others:

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

The Terms of Reference for the present palaeontological heritage draft scoping report, as specified by Aurecon South Africa (Pty) Ltd, are briefly to undertake a Paleontological Impact Assessment in relation to the proposed wind and solar energy facilities, Kangnas, near Springbok in the Northern Cape. A desk top study should be conducted to determine the likelihood and need for detailed paleontological assessment.

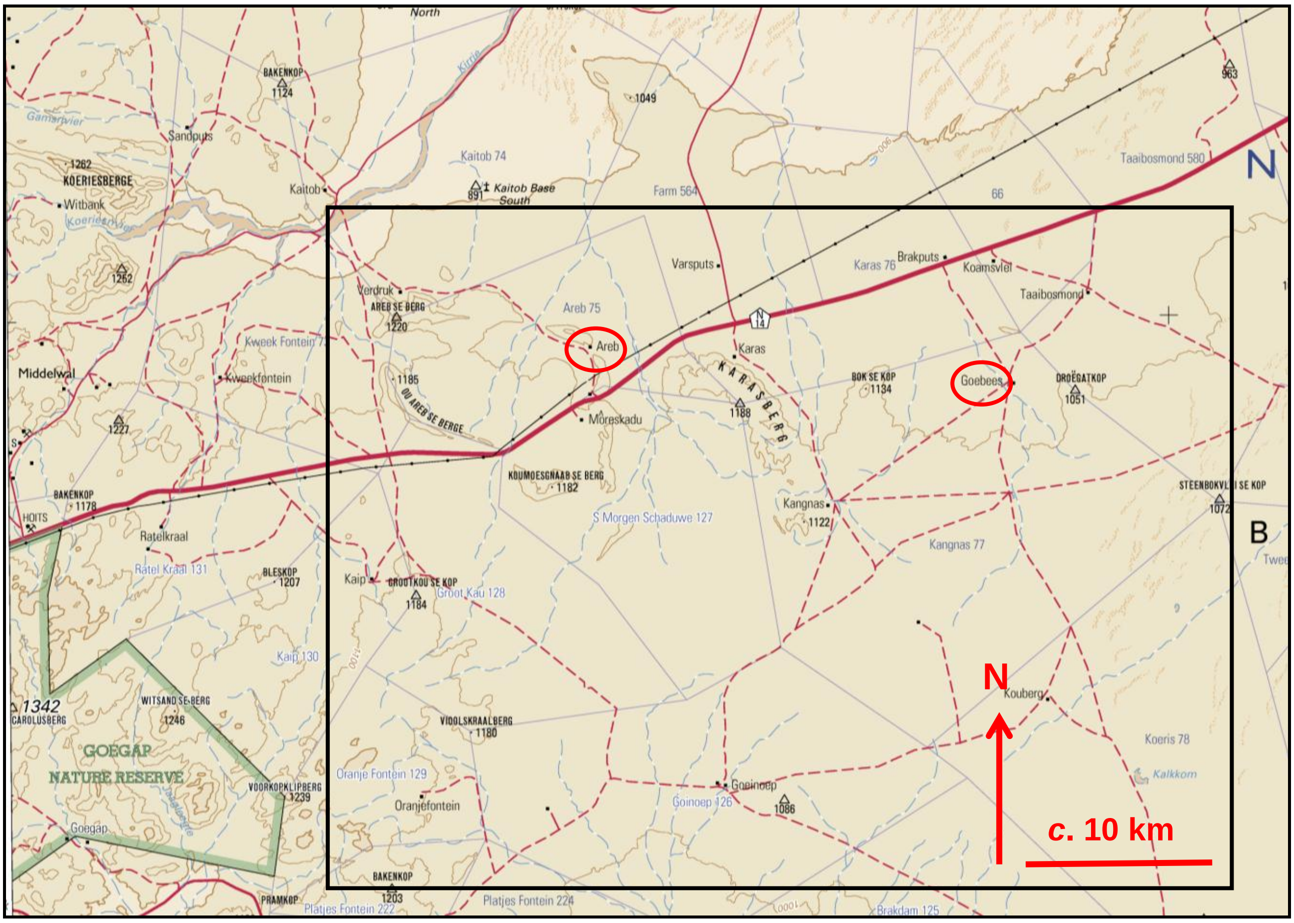

Fig. 1. Extract from 1: 250 000 topographical sheet 2918 Pofadder showing the *approximate* location (black rectangle) of the proposed wind and solar energy facilities near Kangnas, approximately 50 km east of Springbok and close to the eastern edge of the Goegap Nature Reserve, Northern Province (Courtesy of the Chief Directorate: National Geospatial Information, Mowbray). Important vertebrate fossil sites at Areb (Miocene river deposits) and Goebees (Late Cretaceous crater lake sediments) are circled.

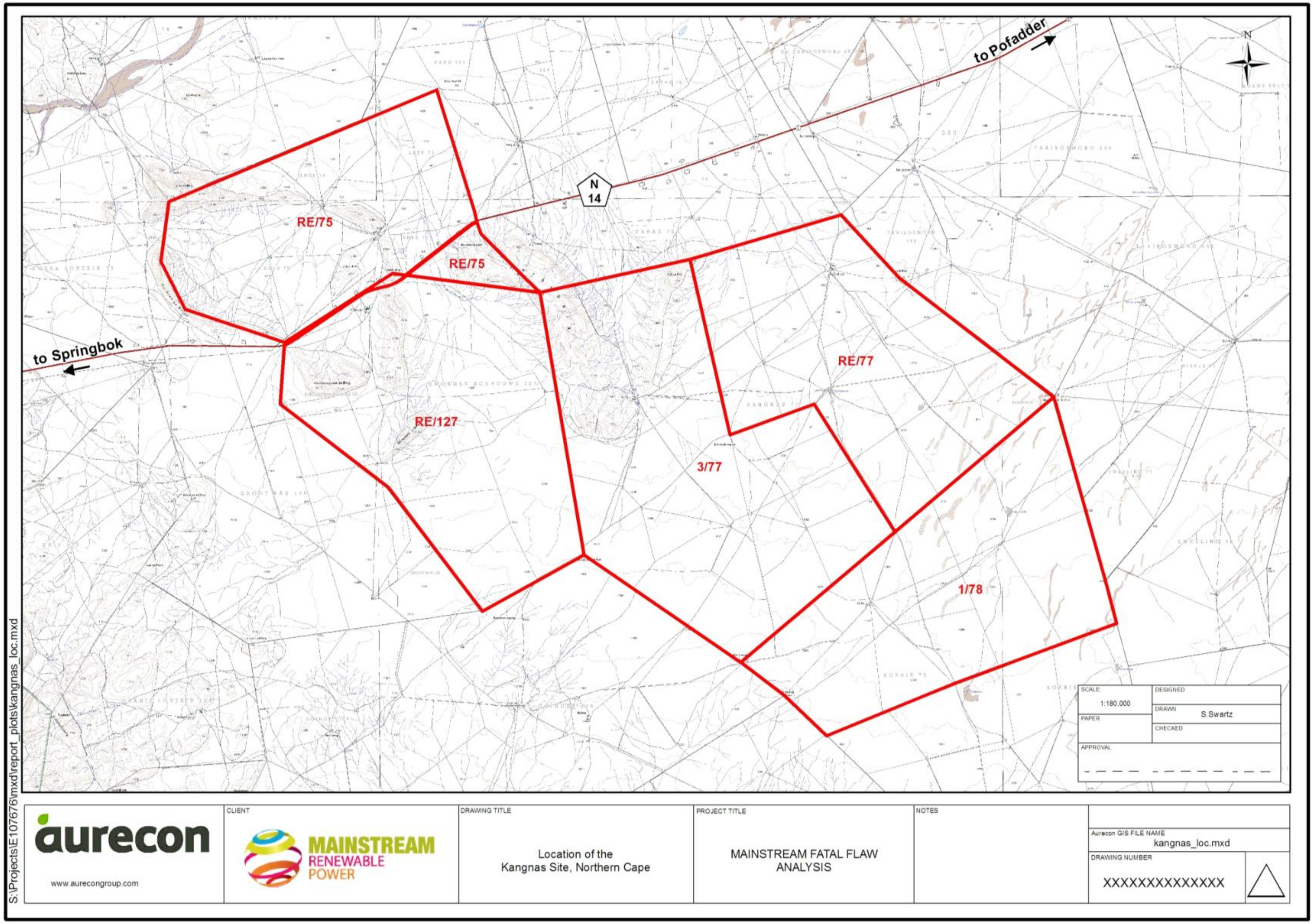

Fig. 2. Map showing the land parcels concerned in the proposed wind energy and solar energy facilities near Kangnas, Northern Cape (Image kindly provided by Aurecon South Africa (Pty) Ltd).

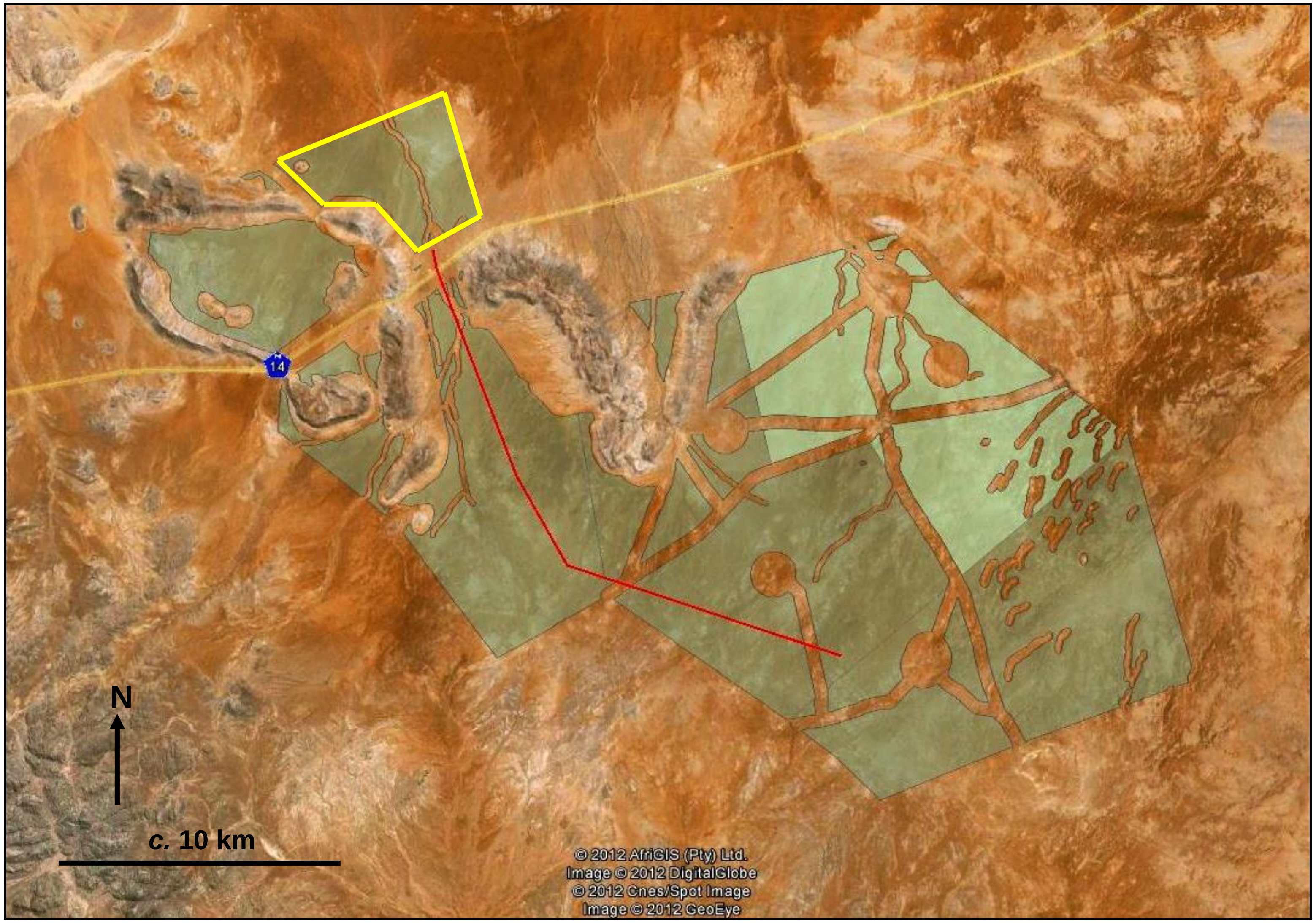

Fig. 3. Google Earth© satellite image of the Kangnas study area straddling the N14 tar road between Springbok and Pofadder. The flatter-lying buildable areas are shown in grey-green. The preferred route for the new overhead transmission line is indicated by the red line. The focus area for the proposed solar energy facility is outlined in yellow. The focus area for the WEF lies south of the N14.

1.1 Approach used for this specialist palaeontological study

This palaeontological report provides an assessment of the recorded or inferred palaeontological heritage within the Kangnas wind and solar energy facility study areas, with recommendations for specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, including a palaeontological assessment for a wind farm project near Springbok (Almond 2010); (2) published geological maps and accompanying sheet explanations, and (3) relevant geological data provided in the Draft Scoping Report for these projects produced by Aurecon (Report No. 6205, June 2012) including a useful report on a geological site visit by Professor Chris Harris of UCT.

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

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

1.2 Assumptions & limitations

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

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

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

influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

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

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

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

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

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

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

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

In the case of palaeontological field studies in the Springbok region, the main limitations are the high levels of bedrock cover by alluvial and colluvial soils as well as extensive calcrete hardpans. These younger sandy and gravelly deposits may conceal scientifically important buried fossiliferous sediments associated with ancient (Tertiary) drainage courses and volcano crater lake deposits (Late Cretaceous), such as have been described near Kangnas and elsewhere in the Bushmanland region.

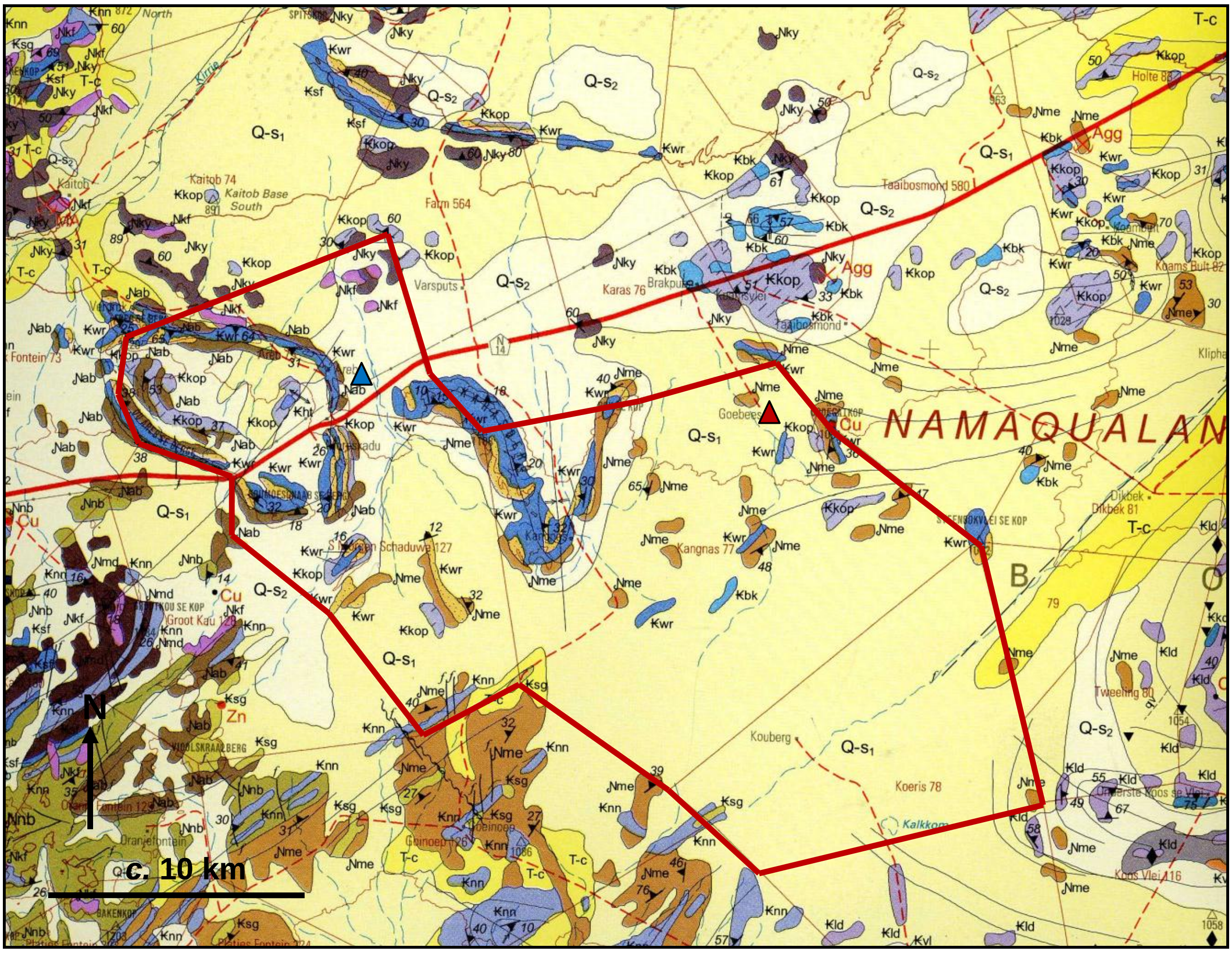

Fig. 4. Geological map of the Kangnas region *c.* 50 km east of Springbok, Northern Cape, showing the outcrop areas of the main rock units represented within the wind energy facility and solar energy facility study areas, outlined in dark red (Map abstracted from 1: 250 000 geology sheet 2918 Pofadder, Council for Geoscience, Pretoria). The red triangle indicates the site of the *Kangnasaurus* Cretaceous dinosaur fossil site at the Goebees farmstead and the blue triangle the Miocene fossil horse locality at Areb (approximate position only).

The following rock units are mapped at surface within the Kangas study area:
Precambrian metamorphic and intrusive igneous rocks of the Namaqua-Natal Metamorphic Province:
Ksg, Kwr, Kkop, Kld = Mid Proterozoic (Mokolian / Kheisian) metamorphic rocks of the Bushmanland Group and Gladkop Metamorphic Suite
Nml, Nky, Nab, Nkf – Early to Mid Proterozoic (Mokolian / Namaquan) metamorphic and intrusive igneous rocks of the Little Namaqualand Suite, Korridor Suite
T-c (yellow) = Tertiary / Quaternary calcrete (pedogenic limestone)
Q-s1 (pale yellow) = Quaternary aeolian (wind-blown) sands, probably equivalent to the Gordonia Formation (Kalahari Group)
Q-s2 (v. pale yellow) = Quaternary sand, scree, rubble, sandy soils of alluvial and colluvial origin
small black diamond symbol (K-k) = kimberlite volcanic pipe
small black triangular symbol (K-om) = olivine melilitite volcanic pipe
Grey area in bottom RHS corner = Permo-carboniferous Mbizane Formation (Dwyka Group, Pmb).

2. GEOLOGICAL BACKGROUND

The Kangnas study area is situated within the arid Bushmanland region between Springbok and Pofadder (Fig. 3). The rugged mountainous terrain of the Namaqualand klipkoppe (*e.g.* Goegap Nature Reserve) lies some ten km to the west. Much flatter-lying, sandy terrain predominates around Kangnas, where the ground slopes northwards from around 1100m amsl in the south down to c. 900m amsl in the north. Numerous small koppies and ridges of ancient basement rocks (gneisses, granites *etc*) emerge abruptly above the sand cover as isolated *Inselberge*, reaching elevations of some 1200m amsl or slightly more (*e.g.* Karasberg, Areb se Berg, Koumoesgnaab se Berg). The flatter areas feature several shallow, intermittent-flowing drainage channels; many of these trend southwest in the southern part of the study area and northwards in the northern part of the area. There are also numerous depressions or pans, the most prominent among which are Steenbok Pan and Kalkom pan, the latter situated towards the southern margin of the area (Draft Scoping Report 2012, Aurecon Report No. 6205, geological site report by Harris 2012) (Fig. 4). These pans, often associated with thick development of calcrete (pedogenic limestone), are variously related to depressions in the underlying basement rocks as well as possible buried ancient water courses and volcanic pipes.

The geology of the Kangnas study area is shown on 1: 250 000 geology sheet 2912 Pofadder (Council for Geoscience, Pretoria; Fig. 4) and described in the accompanying sheet explanation by Agenbacht (2007). Also relevant are the explanations to the adjoining Springbok and Loeriesfontein sheets by Marias *et al.* (2001) and Macey *et al.* (2011) respectively since the terrain and rocks concerned show a high level of overlap. Most of the study area is mantled by unconsolidated **Quaternary to Recent superficial sediments**. These include a range of quartz-rich **alluvial sands and gravels, skeletal soils, colluvial deposits** such as bouldery or blocky scree, sandy, arkosic (feldspar-rich) and gravelly sheet wash and slope deposits derived from weathering of the surrounding granite-gneiss terrain) (**Q-s2**), and **wind-blown (aeolian) sands** (**Q-s1**). These last may probably be equated with the Quaternary Gordonia Formation of the Kalahari Group whose main outcrop area lies to the north of the Pofadder sheet area. Pans and water courses are often associated with thick developments of calcrete (pedogenic limestone). **Calcrete hardpans** (**T-c**) of probable Late Tertiary (Neogene) to Quaternary or Recent age also occur subsurface and extensive surface exposures are mapped at the south-eastern and south-western edges of the study area. Calcrete thicknesses of 10m are apparently typical for the study area but a succession up to 80m thick occurs in association with the Kalkkom pan in the south (Van Niekerk, pers. comm. *in* Harris 2012).

Relict patches of ancient **Tertiary alluvial sediments** dating back to at least the Neogene (Late Tertiary), and possibly older, are preserved in the Bushmanland interior, as shown by sparse fossil mammal and petrified wood evidence (Section 4; see review in Macey *et al.* 2011). The best known is the Koa River Valley, a defunct south bank tributary of the Orange River situated some 50 km northeast of the Kangnas study area, that enters the main Orange River valley at Henkries (De Wit 1990, 1993, 1999, De Wit *et al.* 2000) (Figs. 5, 6.1). Rogers (1915) postulated the existence within the study area of a western tributary of this palaeo-drainage system termed the Kangnas Valley, but this has been largely discounted by more recent work (De Wit *et al*., 1992).

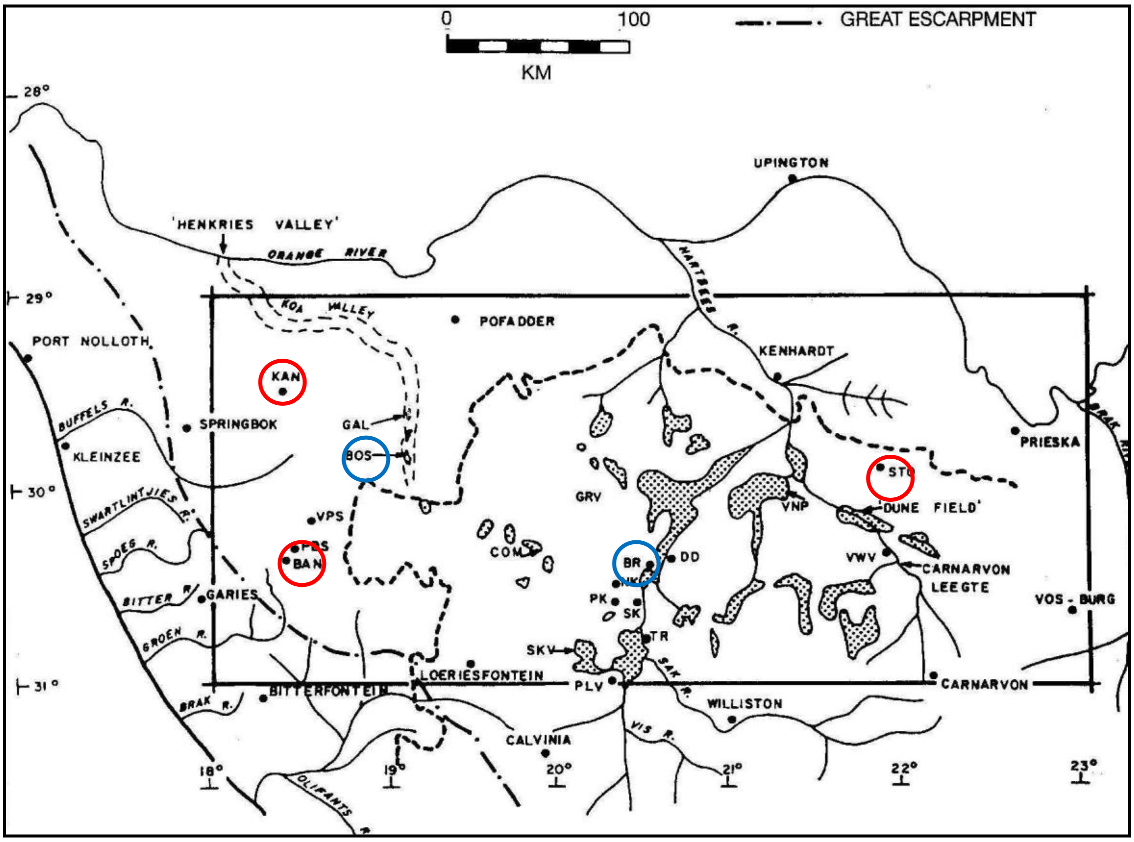

Fig. 5. Traces of post-Gondwana drainage systems in the Namaqualand – Bushmanland region (modified from De Wit 1999). Note the extinct Koa Valley palaeodrainage system draining into the Orange River between Pofadder and Springbok, north and east of Kangnas. Important crater lake fossil sites in the Northern Cape (red circles) include Late Cretaceous assemblages at Kangnas (KAN) and Stompoor (STO) and the Late Cretaceous / early Palaeocene assemblage at Banke (BAN). Miocene vertebrate remains and petrified woods are recorded from Bosluis Pan (BOS) and Brandvlei (BR) (blue circles).

Several **kimberlite and olivine melilitite volcanic pipes** of Cretaceous age are mapped just to the east of the Kangnas study area (black triangle and diamond symbols on geological map Fig. 4). The melilitite pipes belong to the “Bushmanland pipe swarm” of the Gamoep Melilitite Suite, dated 59 to 77 Ma (Late Cretaceous Period) (Verwoerd & De Beer 2006). Some of these pipes are still associated with fossiliferous crater lake deposits whose preservation reflects the low levels of landscape denudation since Late Cretaceous times in the Bushmanland region. Of particular interest for the present fossil heritage study is the buried double feeder pipe olivine-melilitite system with a footprint of some one to two hectares that has been inferred on geophysical as well as geological grounds at Goebees in the north-eastern portion of the study area (red triangle in Fig. 4, also Figs. 6.1, 6.2) (De Wit *et al.* 1992). Here melilitite-rich volcaniclastic breccias are associated with laminated fossiliferous mudrocks that are interpreted respectively as debris flow and lacustrine deposits within a crater lake of probable Late Cretaceous age. It is quite possible that other potentially-fossiliferous crater lake deposits are hidden beneath the Late Caenozoic superficial sediments elsewhere within the Kangnas study area (*e.g.* calcrete-capped pans), but these are difficult to detect without geomagnetic surveys or borehole coring. For example, the Kalkkom pan on the southern margin of the study area may also overlie an olivine melilitite pipe, although there is currently no convincing geological data to confirm this (Harris 2012).

Beneath the superficial sediment cover the study area is almost entirely underlain by Mid Proterozoic (Mokolian) basement rocks of the **Namaqua-Natal Metamorphic Province**. The basement rocks build the numerous isolated inselberge and ridges scattered across the Bushmanland landscape (Fig. 3). These rocks, primarily highly metamorphosed sediments and volcanic rocks (*e.g.* gneisses, schists, quartzites, amphibolites) *plus* major granitic and gabbroic (norite) intrusions, are dated between 2050 and 1000 Ma (million years ago; Cornell *et al*., 2006). They have been assigned to several rock successions such as the intrusive Korridor Suite and Little Namaqualand Suite as well as the metamorphic crustal rocks of the Gladkop Metamorphic Suite and Bushmanland Group. Since these ancient Precambrian rocks are entirely unfossiliferous, they will not be treated further here.

Glacial tillites of Permo-Carboniferous age (**Dwyka Group**) crop out extensively in the eastern half of the Pofadder sheet area. Small Dwyka Group inliers (**Mbizane Formation, Pmb**) are mapped just to the southeast of the Kangnas study area (bottom right corner of map Fig. 4), but none are recorded within the study area itself (*pace* the Draft Scoping Report by Aurecon 2012). Downwasted and reworked weathering products of pre-existing Dwyka sediments, such as erratic boulders of various exotic lithologies, might be represented in local surface or subsurface gravels.

Figure 6 (following page): Late Cretaceous dinosaur fossils from Kangnas, Bushmanland.

6.1. Location of fossil site at farmstead Goebees on Farm Kangnas 77, c. 50 km east of Springbok, Northern Cape (From De Wit *et al.* 1992).

6.2. Inferred double volcanic pipe overlain by fossliferous crater lake deposits at Goebees (From De Wit *et al.* 1992).

6.3. Sketch plan of fossil site at Goebees farmstead (From De Wit *et al.* 1992).

6.4. Right femur of *Kangnasaurus* (From Cooper 1985).

6.5. Vertebrae (centra) of *Kangnasaurus* (From Cooper 1985).

6.6. Tooth of *Kangnasaurus* – this is the holotype specimen, *c*. 18 mm long (From Cooper 1985).

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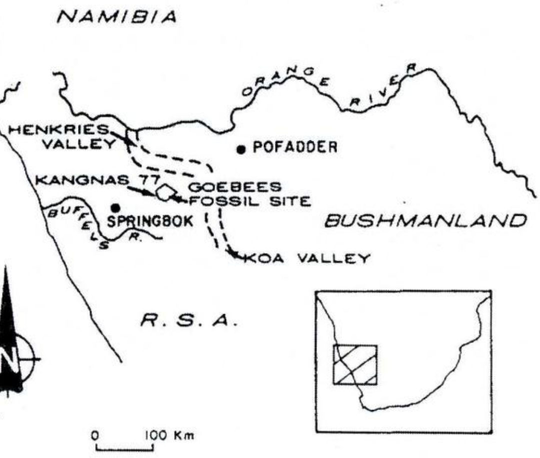

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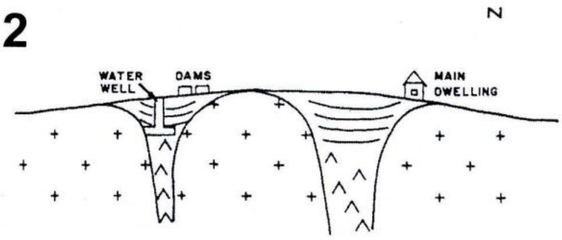

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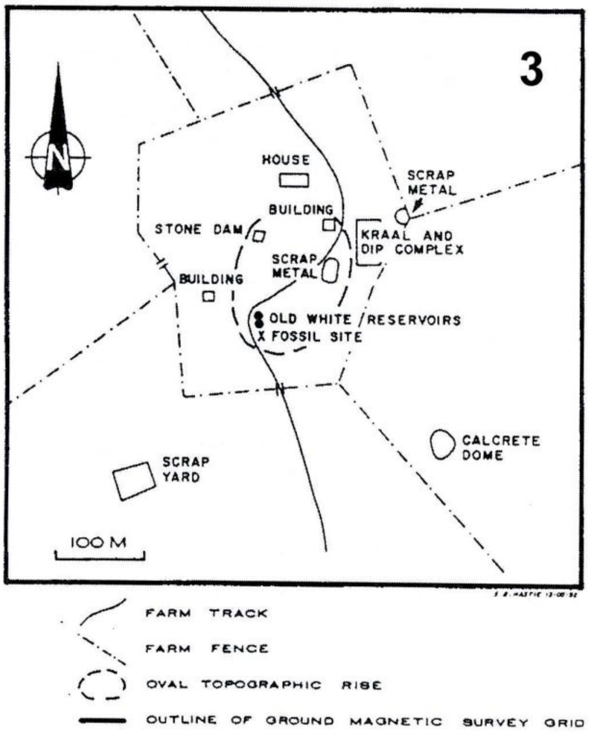

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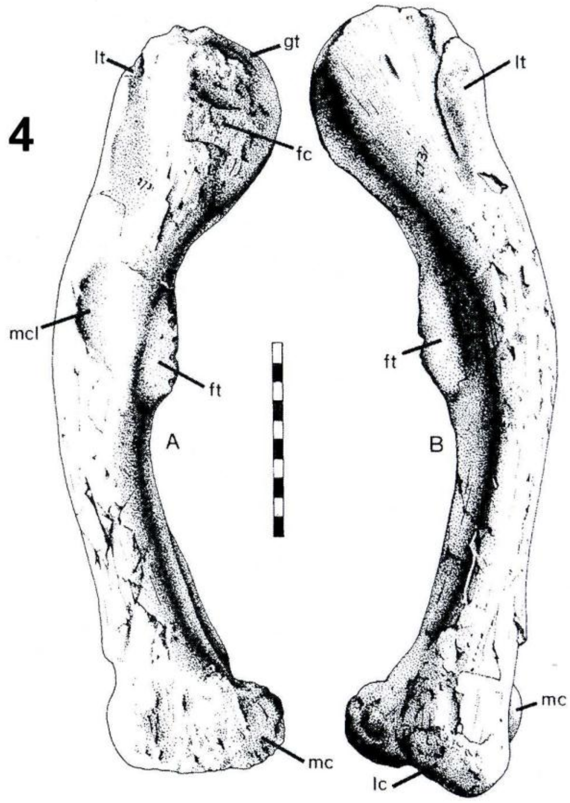

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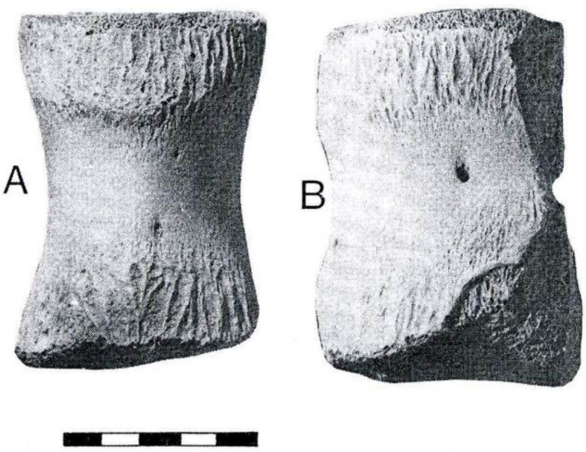

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Kangnasaurus

3. PALAEONTOLOGICAL HERITAGE

3.1 Precambrian basement rocks

The ancient Precambrian basement rocks underlying the entire Kangnas study area at depth are entirely unfossiliferous (highly metamorphosed sediments, igneous intrusions) and are therefore not of palaeontological heritage significance (Almond & Pether 2008). They are therefore not considered further here.

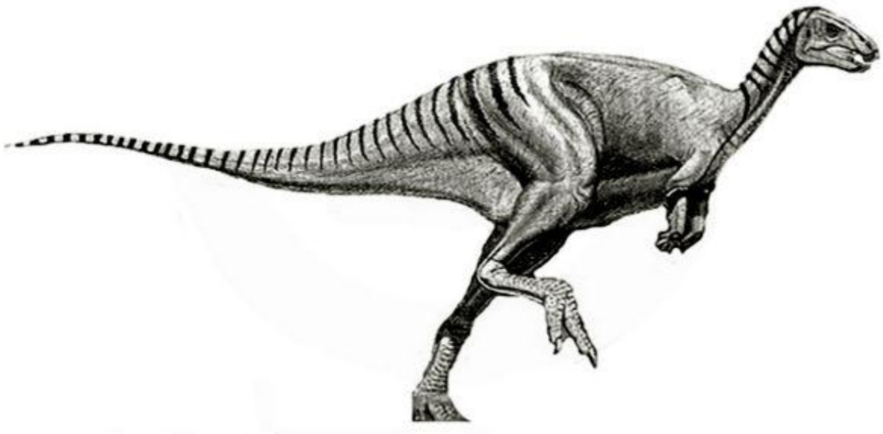

Fig. 7. Reconstruction of a bipedal iguanodontian dinosaur similar to *Kangnasaurus* from the Late Cretaceous Bushmanland

3.2 Cretaceous crater lake deposits

The Kangnas area of Bushmanland is of special geological and palaeontological interest because sediments and fossils of probable Late Cretaceous age have been recorded here, representing some of the oldest remnants of post-Gondwana rocks and fossils from South Africa (De Wit *et al.* 1992). The fossil material largely comprises the teeth and disarticulated post-cranial skeletal elements (leg bones, vertebrae, ribs) of the ornithischian dinosaur *Kangnasaurus* (Figs. 6.4 to 6.6). Associated fossils include calcified and silicified wood, lignite, leaf fragments and aquatic ostracods (microscopic seed shrimps) (Rogers 1915, De Wit *et al.* 1992). The dinosaur remains were first recorded from quartzofeldspathic grits, breccias and laminated calcareous mudrocks in a well and associated spoil heap at Goebees farmstead (Farm Kangnas 77) at a depth of some 34m by Rogers (1915) and were described in some detail by Haughton (1915) (Figs. 6.1 & 6.2). The dinosaur material was subsequently revised by Cooper (1985), who considers the remains to belong to a single individual, but to the author's knowledge the fossil wood remains unstudied (*N.B.* The locality map of Cooper (1985, his. Fig. 1), placing the Kangnas fossil site near Goodhouse on the River Orange, is incorrect). Nevertheless, the taxonomic validity, age and systematic position of *Kangnasaurus* remain uncertain, with some workers regarding the genus as of dubious status. According to the most recent review, it was probably a basal bipedal, herbivorous iguanodontian related to *Dryosaurus* (Ruiz-Omeñaca *et al.* 2007) (Fig. 7).

Rogers (1915) interpreted the fossiliferous sediments at Goebees as infilling a buried palaeochannel (Kangnas Valley) that formed a tributary of the Koa River system (Figs. 5, 6.1). However, the fossil bones show no evidence of transport and subsequent geological and palaeomagnetic studies have demonstrated the presence of paired olivine melilitite (volcanic) feeder pipes at Goebees overlain by bedded sediments (Fig. 6.2; De Wit *et al.* 1992). The fossil vertebrate and plant remains are therefore considered to lie within a crater lake infill comparable to those described at Stompoor and Banke elsewhere in Bushmanland and Namaqualand respectively (Fig. 6.2; Haughton 1931, De Villiers 1999, Smith 1986a, 1986b, 1988, 1995, Macey *et al.* 2011 and refs. therein). Cooper (1985) suggests a Early Cretaceous age for *Kangnasaurus*, while De Wit *et al.* (1992) prefer a younger, Late Cretaceous age based on that of other olivine melilitite pipes in the region (*cf* Verwoerd & De Beer 2006).

There is a significant possibility that other small patches of fossiliferous crater lake sediments lie buried beneath the superficial sediment cover (sands, calcrete *etc*) within the Kangnas study area (See discussion on Kalkom Pan in Harris 2012). Any such sediments are only likely to be intersected by deeper excavations – *i.e.* those exceeding a few meters below surface (*cf* 35m depth for material from the well at Goebees, 80m thickness for calcretes at Kalkkom).

3.3 Late Tertiary to Recent superficial deposits

The overall palaeontological sensitivity of the sandy and calcretised superficial deposits in the Bushmanland region is low. The predominantly porous, sandy superficial deposits in the study area, including the Quaternary alluvial and aeolian sands and gravels, are unlikely to contain substantial fossil remains (De Beer *et al*., 2002, Almond & Pether 2008, Almond *in* Macey *et al.* 2008). Fossil land snails have been recorded from yellowish to reddish terrestrial sands and overlying calcretes in the Springbok sheet area (Marais *et al.,* 2001, p70). Among the limited range of other fossils that might be encountered within Late Caenozoic surface sediments in the study area are calcretized rhizoliths (root casts), termitaria and other burrows, freshwater molluscs, ostrich egg shells, sparse bones, teeth and horn cores of mammals, and tortoise remains. Finer-grained river and pan sediments may contain fossils of fish, frogs, molluscs, crustaceans (crabs, ostracods, phyllopods such as conchostracans) as well as microfossils such as diatoms, palynomorphs and macroplant remains (*e.g.* wood, peats).

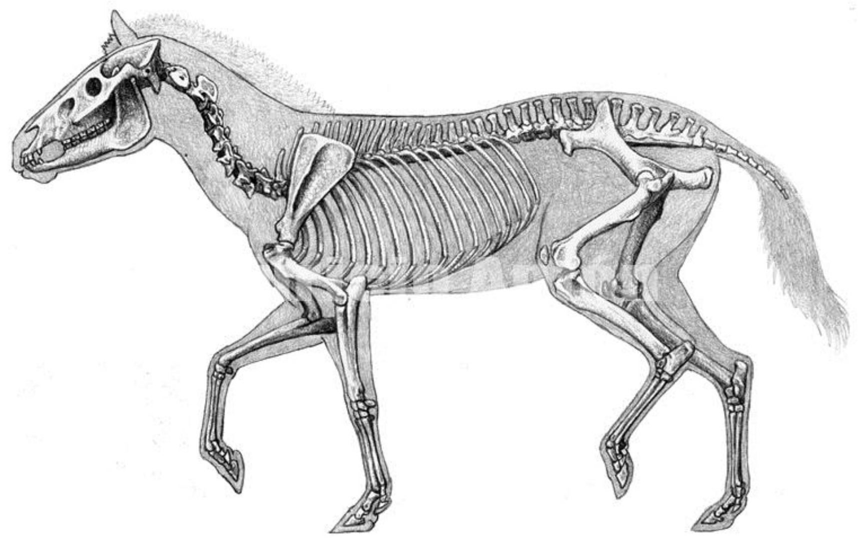

Fig. 8. Reconstruction of an extinct Miocene three-toed horse, *Hipparion*. Fossil remains or related fossil horses are recorded from Areb in Bushmanland (Northern Cape) as well as Langebaanweg (West Coast Fossil Park, W. Cape).

Relict patches of Neogene (Late Tertiary) river, pan and lake sediments in the Northern Cape interior, including Bushmanland, have yielded a small range of terrestrial and freshwater vertebrates (fish, reptiles, mammals) as well as freshwater molluscs, petrified wood and trace fossils from localities such as Bosluis Pan and Brandvlei (See review in Macey *et al.* 2011 and references therein, including De Beer *et al.,* 2002, Agenbacht 2007). Skeletal remains of a Pliocene three-toed horse, *Hipparion*, have been recorded from a well at Areb, 65km east of Springbok and within the northern part of the present study area, close to the proposed solar energy facility development area (Haughton 1932, Hendey 1984) (Figs. 1, 4, 5 and 8). The rare vertebrate fossils are probably associated with buried Late Tertiary river deposits comparable to those in the Koa River palaeochannel to the east. These deposits are likely to be narrow, linear, perhaps branching, in geometry and may well occur elsewhere within the Kangnas study area, as originally suggested by Rogers (1915).

4. ASSESSMENT OF SIGNIFICANCE OF PALAEONTOLOGICAL HERITAGE IMPACTS

The construction phase of the Kangnas alternative energy developments will entail numerous, but mostly shallow (< 3m), excavations into the superficial sediment cover and in some areas into the underlying bedrock as well. These include, for example, excavations for the wind turbine and solar panel foundations, underground cables, new electricity transmission line pylons and substations, as well as new gravel access roads and any control / administrative buildings. In addition, substantial areas of bedrock will be sealed-in or sterilized by infrastructure such as lay-down and standing areas for the wind turbines as well as new access roads. All these developments may adversely affect fossil heritage within the development footprint by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good.

The significance of expected impacts on palaeontological heritage resources within the combined wind energy and solar energy facility study areas at Kangnas are assessed together for the construction phase in Table 1 below, according to the scheme specified by Aurecon. Given the uncertainties concerning the patchy distribution of buried fossil heritage, predicted impacts for the wind and solar energy facilities are not significantly different, and are considered unsure. Please note that:

- the operational and decommissioning phases of the wind and solar energy facilities will not involve further significant adverse or other impacts on palaeontological heritage;
- impacts from the construction of associated new road infrastructure and transmission lines is treated as part of the overall impact of each PV development, and have not been considered separately.

Table 1: Evaluation of impacts of the proposed Kangnas Wind Energy Facility and Solar Energy Facility on fossil heritage resources (construction phase)

CRITERIA	CATEGORY	COMMENTS
Extent	Site specific	Limited to development footprint
Magnitude	Generally low (but locally high)	Most surface rocks within study area are unfossiliferous but highly significant fossil material (*e.g.* dinosaur and mammal remains) occurs at small, localized sites (buried crater lake and alluvial deposits) within the study area.
Duration	Long term	Loss of fossils and contextual geological data is generally permanent.
Significance	Generally low (but locally high)	Specialist monitoring or mitigation measures therefore not proposed for this project *unless* new fossil sites are encountered during development.
Probability	Unlikely	Buried fossiliferous deposits probably occupy only a small fraction of the study area.
Confidence	Unsure	Limited by low levels of fossiliferous rock exposure within the study area (Covered by extensive mantle of unfossiliferous superficial sediments)
Reversibility	Irreversible	Loss of fossil heritage is generally permanent.

6. CONCLUSIONS & RECOMMENDATIONS

The proposed Mainstream wind energy and solar energy facility project areas near Kangnas, Bushmanland, are largely underlain by ancient Precambrian metamorphic and igneous basement rocks of the Namaqua-Natal Metamorphic Province that crop out as low, rocky inselberge and are entirely unfossiliferous. In the intervening flatter, low-lying areas where the wind and solar energy facilities are likely to be constructed these older basement rocks are extensively mantled with geologically young superficial deposits (Quaternary to Recent sandy alluvium, soils, wind-blown sand, calcrete hardpans *etc*) that are generally of low to very low palaeontological sensitivity. However, small but significant areas of older fossiliferous sediments have been recorded subsurface within the Kangnas study area since the early twentieth century and have yielded scientifically important vertebrate and plant fossil material. These include (1) rare dinosaur remains (*Kangnasaurus*), petrified woods and non-marine crustaceans (ostracods) from crater lake deposits of probable Late Cretaceous age at Goebees in the northeast, as well as (2) Late Tertiary (Miocene) three-toed horses (*Hipparion*) from palaeochannel river deposits near Areb in the north. Both these fossil sites are unlikely to be directly affected by the proposed developments. It is quite possible that further, hitherto undiscovered fossiliferous deposits of this nature lie buried beneath the surface elsewhere within the broader study area. Fossils exposed at the surface or underground may be damaged, disturbed or sealed-in during the construction phase of the proposed wind and solar energy facilities near Kangnas. However, these deposits are unlikely to be directly affected except by deeper excavations (> 3m) that penetrate the generally unfossiliferous superficial deposits overlying them. Both the proposed wind energy facility and solar energy facility developments are inferred to be of LOW overall impact significance in terms of palaeontological heritage resource conservation.

Given the low overall palaeontological sensitivity of the basement rocks and superficial deposits within the Kangnas study area, the successive or concurrent development here of the proposed wind and energy energy facilities is not considered to pose a significant cumulative impact on local fossil heritage. Future changes in infrastructure layout for the wind or solar energy projects will not materially affect the conclusions and recommendations made in this palaeontological report.

In view of the overall low significance of the proposed developments on palaeontological heritage resources, it is concluded that no further palaeontological heritage studies or specialist mitigation are required for these alternative projects, *pending* the discovery or exposure of any substantial fossil remains (*e.g.* vertebrate bones and teeth, large blocks of petrified wood, fossil plant-rich horizons, buried laminated shales) during the construction phase. The ECO responsible for these developments should be alerted to the two known fossil sites within the study area as well as possibility of fossil remains being found either on the surface or exposed by fresh excavations during construction. Should fossil remains be discovered during construction, these should be safeguarded (preferably *in situ*) and the ECO should alert SAHRA so that appropriate mitigation (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist.

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

These recommendations should be incorporated into the EMP for the two Mainstream alternative energy developments near Kangnas.

7. ACKNOWLEDGEMENTS

Ms Cornelia Steyn of Aurecon South Africa (Pty) Ltd and and her colleagues Tanya Farber and Louise Corbett are thanked for commissioning this desktop study, for commenting on the draft report, and for providing the necessary background information.

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9. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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

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

Declaration of Independence

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

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

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	12/12/20/
NEAS Reference Number:	DEAT/EIA/
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

Proposed wind and solar (photovoltaic) energy facilities near Springbok, Northern Cape

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4.2 The specialist appointed in terms of the Regulations_

I, John E. Almond, declare that

- I act as the independent specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

John E. Almond

Signature of the specialist:

Name of company (if applicable):

Natura Viva cc

Date:
1 August 2012