PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

Proposed Bokpoort II Solar Power Facility on the Remaining Extent of Farm Bokpoort 390 near Groblershoop, Northern Cape Province

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1. EXECUTIVE SUMMARY

ACWA Power Energy Africa (Pty) Ltd is proposing to develop the Bokpoort II Solar Power Facility on the Remaining Extent (RE) of the Farm Bokpoort 390 near Groblershoop, Northern Cape. An associated, authorised water pipeline to the Orange River running along an existing servitude will also traverse the adjoining Farm Sand Draai 391. The combined power generation capacity of the Bokpoort II solar development will be up to 2000 MW that will be generated by ten x 200 MW photovoltaic (PV) facilities, two of which have already been authorised but are undergoing another Basic Assessment (BA) study for the battery storage energy system as well as the capacity increase from 75 to 200MW. The total size of the Bokpoort II Solar Power Facility is approximately 1 500 ha.

The proposed alternative energy developments are underlain by highly metamorphosed Precambrian basement rocks (schists, quartzites, gneisses) of the Namaqua-Natal Province that are entirely unfossiliferous. These are largely mantled by Late Caenozoic superficial sediments including Quaternary aeolian sands of the Gordonia Formation (Kalahari Group), calcrete pedocretes (soil limestones) and alluvium of the Orange River and its tributaries. These younger superficial sediments are generally of low palaeontological sensitivity. Potentially fossiliferous older alluvial gravels are not mapped along the banks of the Orange River close to Groblershoop where these are intersected by the proposed water pipeline.

No significant fossil heritage resources have been recorded within the Bokpoort II Solar Power Facility study area. The area is inferred to be of low sensitivity in terms of palaeontological heritage and no sensitive or no-go areas have been identified within it during the present desktop assessment. The proposed solar power facility is of LOW (negative) impact significance with respect to palaeontological heritage resources. This assessment applies to all the planned infrastructure within the project area – *including* the water pipeline to the Orange River (already authorised) as well as the short 132 kV overhead line connection to the existing Eskom Garona Substation - and applies equally to all PV plants under consideration for the Bokpoort II Solar Power Facility. Cumulative impacts associated with the ten alternative energy developments are probably low and there are no fatal flaws in the development proposal as far as fossil heritage is concerned. The no-go alternative is of neutral significance for palaeontology. Providing that the recommendations outlined below for palaeontological monitoring and mitigation are fully implemented, there are no objections on palaeontological heritage grounds to authorisation of this alternative energy project. Pending the potential discovery of significant new fossil remains during development - notably fossil vertebrate bones & teeth - no further specialist palaeontological studies or mitigation are considered necessary for this project.

In the case of any significant chance fossil finds during construction (*e.g.* vertebrate teeth, bones, burrows, petrified wood, shells), these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the South African Heritage Resources Agency, SAHRA (Contact

details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). This is so that appropriate mitigation by a professional palaeontologist can be considered. Such mitigation usually involves the judicious sampling, collection and recording of fossils as well as of relevant contextual data concerning the surrounding sedimentary matrix. The palaeontologist concerned would need to apply beforehand for a collection permit from SAHRA. A tabulated Chance Fossil Finds Procedure is appended to this report.

These recommendations should be incorporated into the Environmental Management Plan (EMP) for all the Bokpoort II alternative energy developments.

2. INTRODUCTION & BRIEF

The company ACWA Power Energy Africa (Pty) Ltd is proposing to develop a solar power facility – to be known as Bokpoort II - on the Remaining Extent (RE) of the Farm Bokpoort 390. An associated water pipeline to the Orange River running along an existing servitude will also traverse the adjoining Farm Sand Draai 391. The Bokpoort II project area is situated *c*. 20 km north of the town of Groblershoop within the !Kheis Local Municipality in the ZF Mgcawu District Municipality, Northern Cape Province (Fig. 1). In 2016 ACWA Power obtained three Environmental Authorisations (EAs) for two 75 MW PV facilities as well as a 150 MW CSP facility on the property. The water main pipeline to the Orange has also already been authorised. However, it is now being proposed that, instead of the CSP facility, eight additional PV plants are developed within the same footprint. The two authorised PV facilities are undergoing another BA study for the battery storage energy system as well as the capacity increase from 75 to 200MW. The combined power generation capacity of the entire Bokpoort II solar development will be up to 2000 MW that will be generated by ten x 200 MW photovoltaic (PV) facilities.

Each of the eight proposed additional 200 Megawatt (MW) Photovoltaic (PV) Solar Developments will cover approximately 150 hectares and will comprise the following infrastructure:

- Solar PV modules that will be able to deliver up to 200 MW to the Eskom National Grid;
- Inverters that convert direct current (DC) generated by the PV modules into alternating current (AC) to be exported to the electrical grid;
- A transformer that raises the system AC low voltage (LV) to medium voltage (MV). The transformer converts the voltage of the electricity generated by the PV panels to the correct voltage for delivery to Eskom;
- Transformer substation; and
- Instrumentation and Control consisting of hardware and software for remote plant monitoring and operation of the facility.

Associated infrastructure (Figs. 2 & 3) includes:

- Mounting structures for the solar panels;
- Cabling between the structures, to be lain underground where practical;
- A new 132kV overhead powerline which will connect the facility to the National Grid via Eskom's existing Garona Substation. The powerlines vary in length and will be located within a servitude spanning 15.5m meters on both sides. The powerline towers will be 35m high;
- Battery Energy Storage System (BESS) - battery Power at Point of Connection: 150MW, area required: 16ha; the BESS will store approximately 4500m^3 of hazardous substance.;
- Internal access roads (4 – 6 m wide roads will be constructed but existing roads will be used as far as possible) and fencing (approximately 3 m in height); and
- Shared infrastructure consisting of buildings, including a workshop area for maintenance, storage (i.e. fuel tanks, etc.), laydown area, parking, warehouse, and offices (previously approved).

Since fossils preserved within the sedimentary rocks represented within the project area might be disturbed, damaged or destroyed during the construction phase of the proposed Bokpoort II development (*e.g.* during excavations or surface clearance) a desktop palaeontological heritage assessment was originally requested for this development by SAHRA (Case IDs 9659, 9699 and 9702; three letters of 27 June 2016). The present palaeontological heritage desktop study covering the entire Bokpoort II project area has accordingly been commissioned on the proponent's behalf by Royal HaskoningDHV (Pty) Ltd, Woodmead, Gauteng. The present palaeontological report contributes to a Basic Assessment process that covers:

- Eight additional 200 MW PV developments on the originally authorised CSP site.
- Two BESS sites to be included within the footprint of the approved PV 1 (Ndebele) and PV 2 (Xhosa) plants with a combined dangerous good storage volume of approximately 4500 m^3 for each additional BESS site as well as the capacity increase up to 200MW.

It is noted that:

(1) Two PV plants of 75 MW each (*i.e.* Ndebele and Xhosa) have already been authorised. These two PV plants will be subject to their own BA, for the proposed new BESS sites and capacity upgrade from 75 to 200MW. Basic Assessment processes for each of the proposed PV plants are being co-ordinated by Royal HaskoningDHV (Pty) Ltd. (Contact details: Ms Seshni Govender. Royal HaskoningDHV (Pty) Ltd. Address: Building No. 5 Country Club Estate, 21 Woodlands Drive, Woodmead, 2191. PO Box 867, Gallo Manor, 2052, Gauteng, South Africa. Tel: 087 352 1592. Mobile: 072 442 0086. E-mail: seshni.govender@rhdhv.com).

(2) The Bokpoort II site is within one of South Africa's eight Renewable Energy Development Zones (RED7 Upington area *cf* Heritage review by Fourie *et al.* 2014), and has therefore been identified as one of the most suitable areas in the country for renewable energy development, in terms of a number of environmental impact, economic and infrastructural factors.

2.1. Legislative context for palaeontological assessment studies

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

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

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

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

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

(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 Agency, or to the nearest local Agency offices or museum, which must immediately notify such heritage resources Agency.

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

(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 Agency 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 Agency 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 SAHRA (2013).

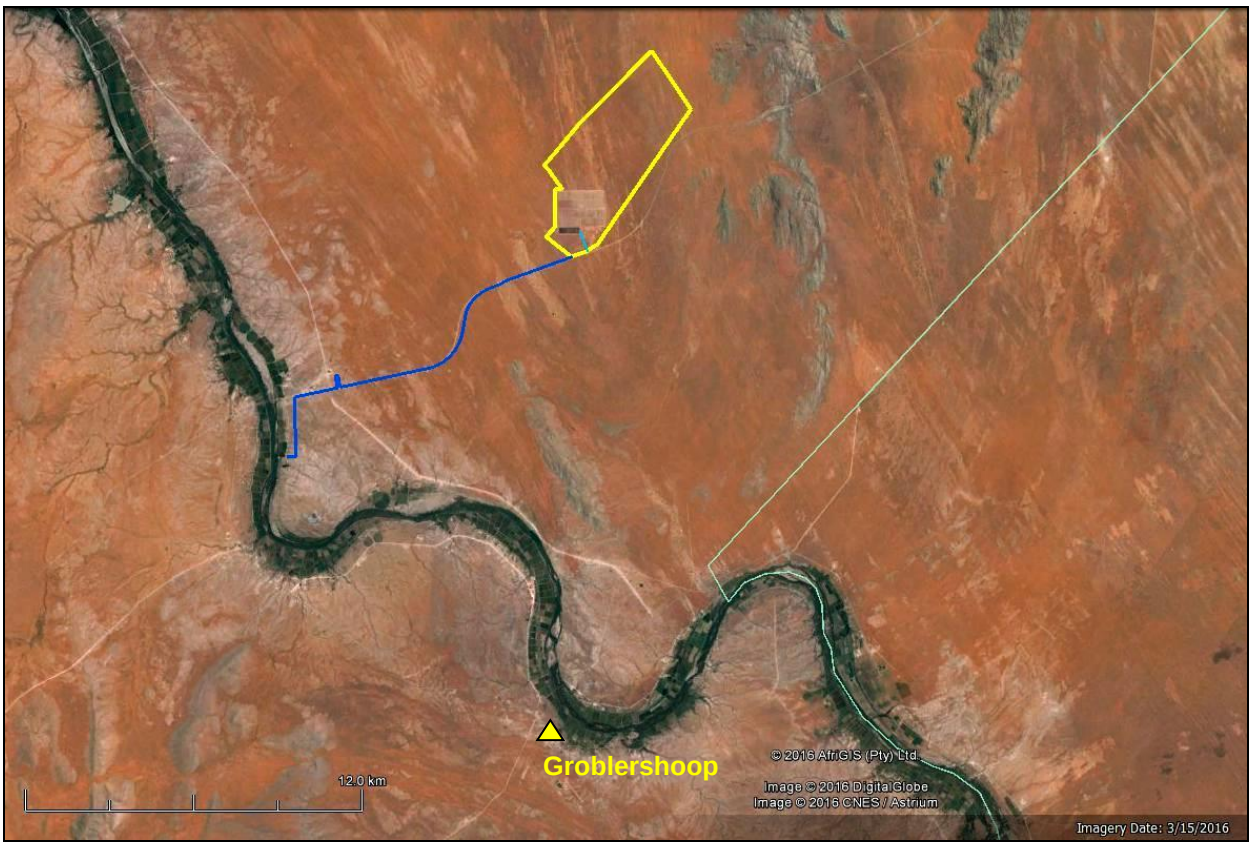

Figure 1: Google earth© satellite image showing the location of the Bokpoort II Solar Power Facility project area (yellow polygon) situated *c*. 20 km north of Groblershoop, Gordonia District, Northern Cape. The associated water pipeline to the Orange River (already authorised) is indicated by the blue line. N is towards the top of the image. Scale bar = 12 km.

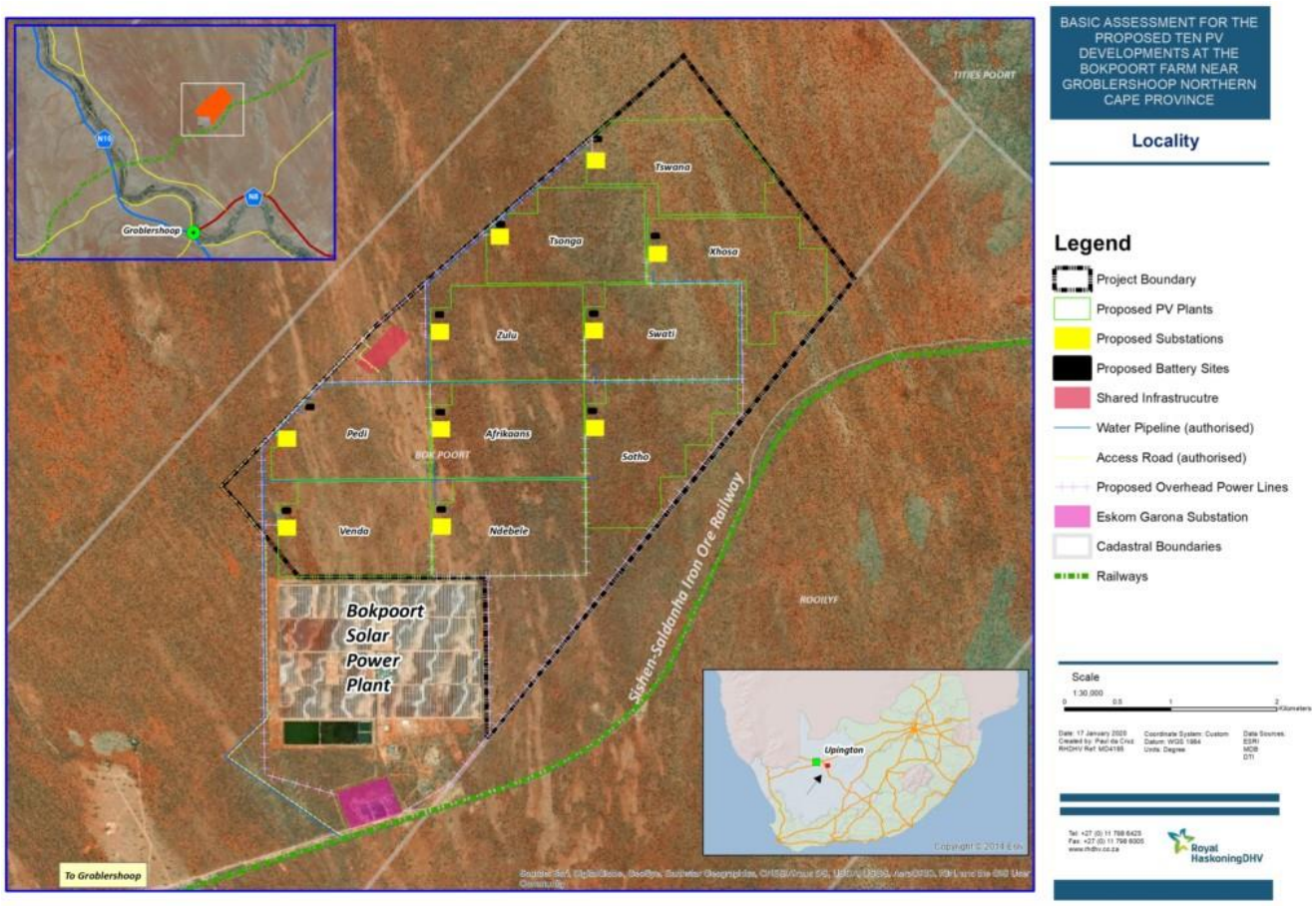

Figure 2: Google earth© satellite image of the Bokpoort II Solar Power Facility project area on the Remaining Extent (RE) of the Farm Bokpoort 390. Shown here are the project boundary (black dashed lines), 10 x PV plants (green) each with a battery site (black) and on-site substation (yellow), the existing Eskom Garona Substation (lilac), main access road (yellow) and shared infrastructure (red). The cleared area for the existing Bokpoort Solar Power Plant can be clearly seen.

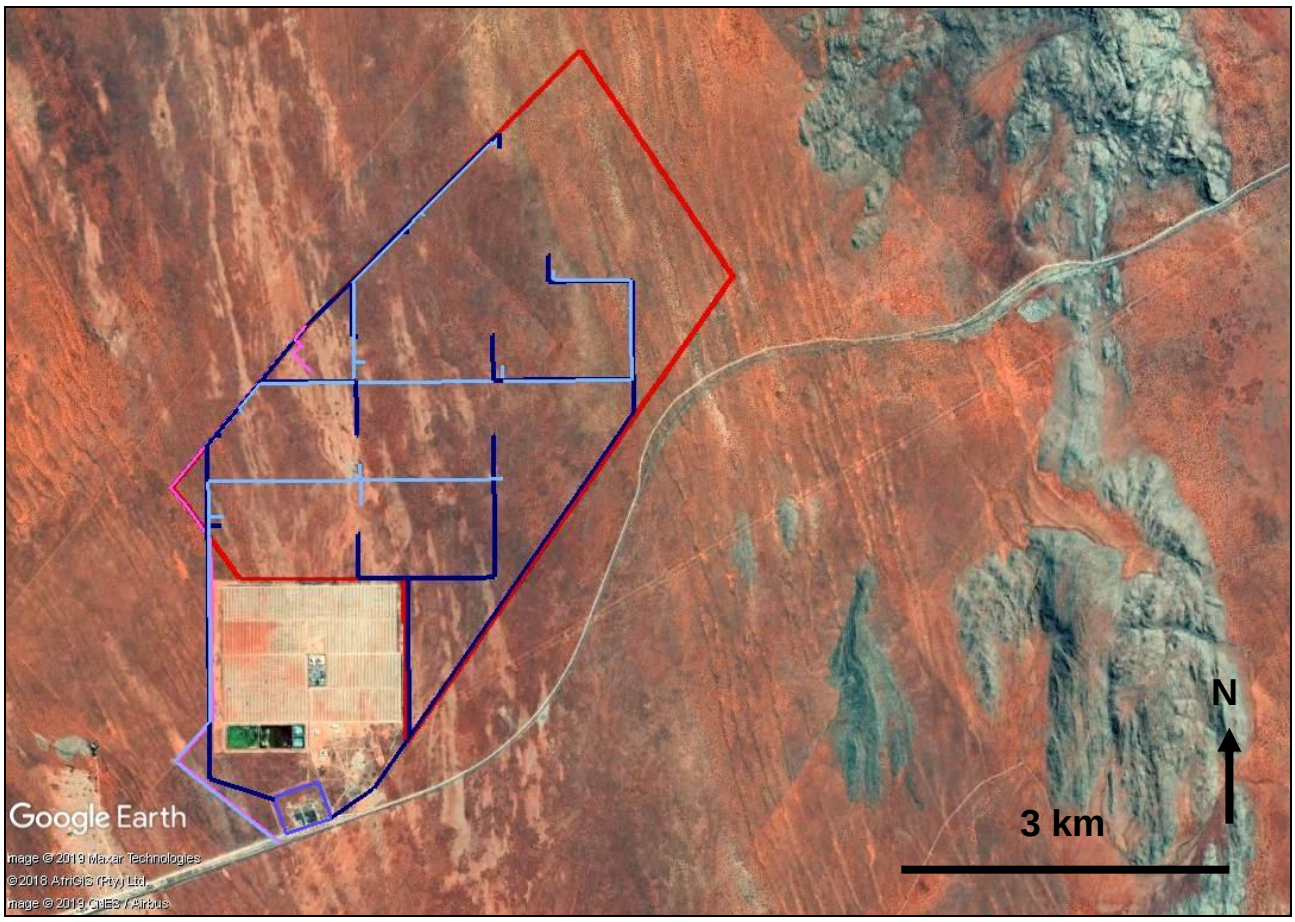

Figure 3: Google earth© satellite image of the Bokpoort II Solar Power Facility project area on the Remaining Extent (RE) of the Farm Bokpoort 390. Shown here are the project boundary (red), overhead powerlines (dark blue), water pipelines, main access road (pink) and the existing Eskom Garona Substation (lilac).

2.2. General approach used for this palaeontological impact study

This PIA report provides an assessment of the observed or inferred palaeontological heritage within the broader study area, 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 previous palaeontological impact assessments in the area (*e.g.* Almond 2012, 2013a, 2013b, Bamford 2016), (2) published geological maps and accompanying sheet explanations (*e.g.* Moen 2007), as well as (3) the author's extensive field experience with the formations concerned and their palaeontological heritage (*e.g.* Almond & Pether 2008).

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 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 assessment study by a professional palaeontologist is usually warranted.

The focus of palaeontological field assessment is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present (*N.B.* Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the field study where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localized (*e.g.* GPS and stratigraphic data) samples of fossil material during field assessment studies. In order to do so, a fossil collection permit from SAHRA is required and all fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

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

On the basis of the desktop and field 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 and taphonomic data) – is usually most effective 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 Agency, *i.e.* the South African Heritage Resources Agency, SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.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.

2.3. Assumptions and limitations

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

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

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

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

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

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

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

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

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

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

In the case of the present study area near Groblershoop in the Northern Cape preservation of potentially fossiliferous bedrocks is favoured by the arid climate but bedrock exposure is very limited indeed due to cover by extensive superficial deposits (*e.g.* alluvium, sandy soils, surface gravels), especially in areas of low relief, as well as by Kalahari vegetation. Very few previous palaeontological heritage assessments have been carried out in the study region (*cf* SAHRIS website; Bamford 2016).

3. GEOLOGICAL CONTEXT

The Bokpoort II Solar Power Facility study area on the Remaining Extent (RE) of the Farm Bokpoort 390 comprises arid, low relief terrain in the Gordonia region on the north-eastern side of the Orange River some 20 km north of Groblershoop, Northern Cape (Fig. 1). The terrain within the solar facility study area slopes broadly southwards from *c*. 1010 m amsl in the north to c. 950 m amsl in the south. As clearly seen in satellite images (Figs. 1 to 3) bedrock exposure is good close to the river and along some sectors of the river bank, while away from the river the bedrocks are largely mantled with orange-brown Kalahari sands. NNW to SSE trending linear sand dunes here surround occasional emergent rocky Inselberge of basement rocks. Bedrock exposures in the vicinity are dissected by the dendritic drainage courses of small, intermittently-flowing streams.

The geology of the study area near Groblershoop is shown on the adjoining 1: 250 000 geological maps 2820 Upington and 2822 Postmasburg (Council for Geoscience, Pretoria; Fig. 4 herein). A comprehensive sheet explanation for the Upington map has been published by Moen (2007) while only a very brief explanation for the Postmasburg area is printed on the map itself. The entire study area is underlain at depth by ancient Precambrian igneous and metamorphic rocks that belong to the **Namaqua-Natal Province** of Mid Proterozoic (Mokolian) age (Cornell *et al.* 2006, Moen 2007). These metamorphosed basement rocks are approximately two to one billion years old and are entirely unfossiliferous (Almond & Pether 2008); they are only represented at surface by small bouldery outcrops (*cf* Dreyer 2015). They include a range of schistose and quartzitic units assigned to the **Brulpan Group** (*e.g.* **Groblershoop Formation** and **Prynnsburg Formation**), details of which are given by Moen (2007) as well as Cornell *et al.* (2006). Outside the present study area the Brulpan rocks are locally intruded by the **Kalkwerf Granite-gniess**, likewise unfossiliferous.

The Precambrian basement rocks within the study area are to a great extent mantled with a spectrum of coarse- to fine-grained **superficial deposits** such as rocky soils, downwasted surface gravels, colluvium (slope deposits), sheet wash, calcrete hardpans, aeolian sands and alluvium of intermittently-flowing streams. These younger deposits are generally young (Quaternary to Recent) and are largely unfossiliferous. Field photos of the study area (*e.g.* Dreyer 2015) show orange-brown Kalahari sands, exhumed calcrete hardpans and dispersed, surface gravels dominated by reworked or downwasted calcrete with minor basement quartzite and cherty clasts (these last probably derived from alluvial gravels of the Orange River).

Small patches of Late Tertiary to Quaternary **calcretes** or pedogenic limestones (T, darker yellow in Fig. 4) are mapped between the solar facility study area and the Orange River; some of these are traversed by the water pipeline servitude. Some of these calcretes may be correlated with the Pleistocene or Late Pliocene **Mokalanen Formation** of the **Kalahari Group**, while others may be of younger age (Partridge *et al.* 2006, Moen 2007). They include horizons of layered to structureless or nodular calcretes overlying basement rocks that are usually less than 3 m thick and often partially covered by wind-blown sands.

The great majority of the study area, including the water pipeline corridor, is covered by fine-grained aeolian (wind-blown) sands of the **Gordonia Formation** (**Qg**, pale yellow in Fig. 4), the youngest, Pleistocene to Recent, subunit of the Kalahari Group. Prominent NNW-SSE trending linear dunes of orange-hued sands are clearly visible on satellite images of the study area (Figs. 1 to 3). The geology of the Late Cretaceous to Recent Kalahari Group is reviewed by Thomas (1981), Dingle *et al.* (1983), Thomas & Shaw 1991, Haddon (2000) and Partridge *et al.* (2006). The Gordonia dune sands are considered to range in age from the Late Pliocene / Early Pleistocene to Recent, dated in part from enclosed Middle to Later Stone Age stone tools (Dingle *et al*., 1983, p. 291). Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8 Ma back to 2.588 Ma would place the Gordonia Formation almost entirely within the Pleistocene Epoch.

According to Moen (2007) **older river terrace gravels** of possible Late Tertiary to Pleistocene age occur “all along the [Orange] river” within 2 km of the present banks and at elevations of up to 45 m (rarely as high as 85m) above the present flood plain. These older river gravels are frequently calcretised. Small patches of older terrace gravels are mapped along the eastern banks of the River Orange some 25 km north of Groblershoop but they are not indicated within the present study area. They may either be completely absent here or too small to map at 1: 250 000 scale. Field photos of the river bank where this is intersected by the existing pipeline show the presence here of disturbed, fine-grained younger alluvium.

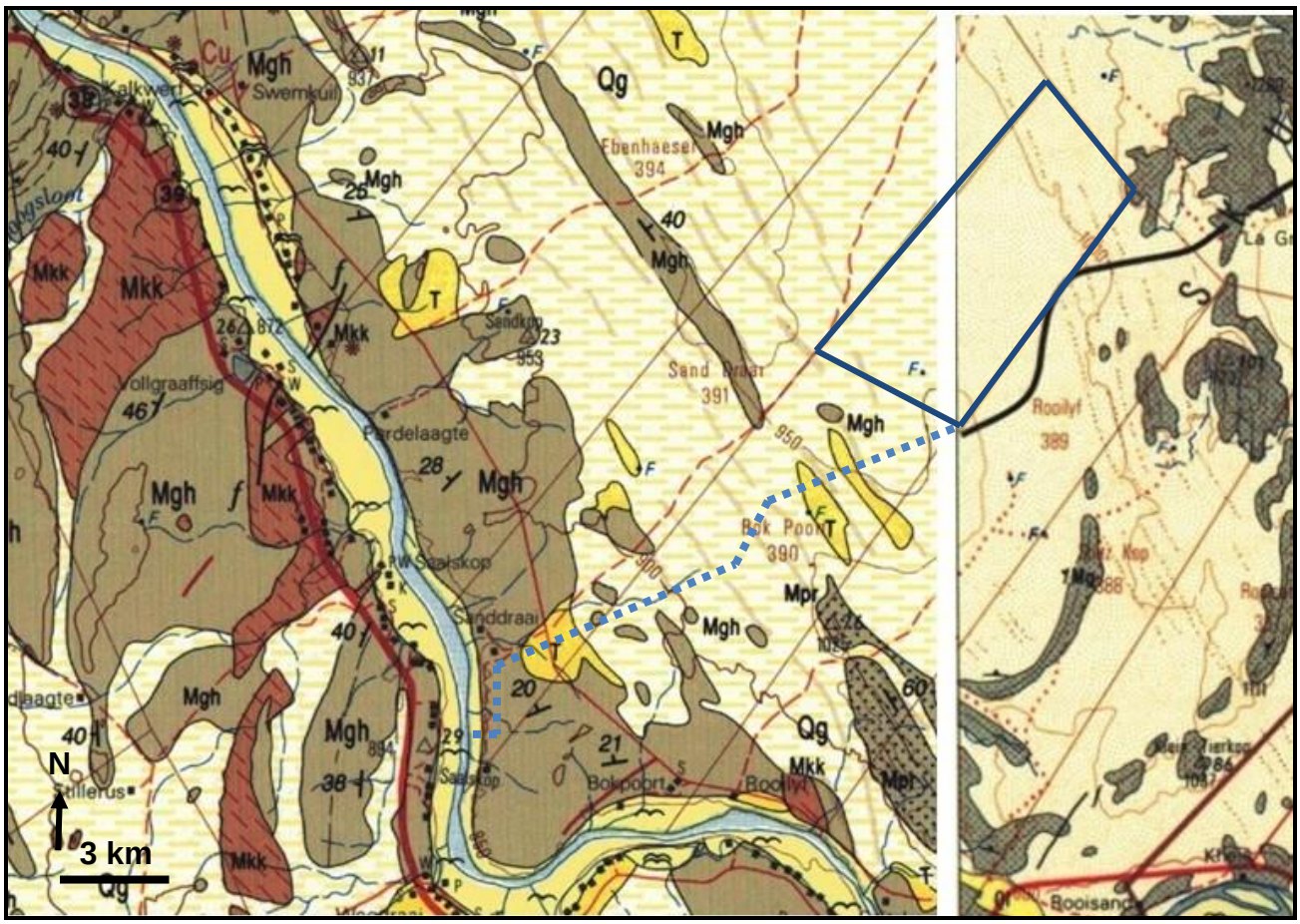

Figure 4: Extract from the adjoining 1: 250 000 geological maps 2820 Upington and 2822 Postmasburg (Council for Geoscience, Pretoria) showing the approximate location of the study area for the Bokpoort II Solar Power Facility on Farm Bokpoort 390 (dark blue polygon). The paler blue dotted line indicates the *approximate* course of the water pipeline to the Orange River.

The study area is underlain at depth by unfossiliferous Precambrian (Middle Proterozoic / Mokolian) basement rocks of the Namaqua-Natal Metamorphic Province (Mgh, Mg, Mpr *etc*, grey or grey-brown) that are assigned to the Brulpan Group and are intruded outside the study area by granite gneisses (Mkk, orange = Kalkwerf Gneiss). Superficial sediments of Late Caenozoic age include calcretes (T, bright yellow), reddish aeolian sands of the Gordonia Formation, Kalahari Group (Qg, pale yellow, with or without dashes), and alluvium of the Orange River (pale yellow with "flying bird" symbol). Small patches of older (Tertiary) terrace gravels are mapped on the eastern bank of the Orange River *c*. 25 km NW of Groblershoop, but *not* within the present study area.

4. PALAEONTOLOGICAL HERITAGE

The Precambrian metamorphic and igneous basement rocks of **the Namaqua-Natal Metamorphic Province** in the study area are entirely unfossiliferous (Almond & Pether 2008) and will therefore not be treated further here.

Late Caenozoic calcretes of the **Kalahari Group** may contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings) may be occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient alluvial gravels and pans (*cf* Almond 2008a). However, these fossil assemblages are generally sparse, low in diversity, and occur over a wide geographic area, so the

palaeontological sensitivity of the calcretes within the study region is rated as low. This applies equally to the thin veneer of other surface deposits (rocky scree, stream alluvium *etc*) within this highly-arid region.

Alluvial gravels of the Orange River of Miocene and younger age are locally highly fossiliferous (*e.g.* Hendy 1984, Schneider & Marias 2004, Almond 2008a, 2009 and extensive references therein) but, as argued above, these are *not* mapped within the study area. Younger silty alluvial deposits may contain a range of terrestrial and freshwater fossils and subfossils. Freshwater snails are mentioned in particular by Moen (2007, p. 150). Stream gravels close to the west bank of the Orange River in the Groblershoop area were examined without success for palaeontological remains by Almond (2012).

5. PALAEONTOLOGICAL HERITAGE IMPACT ASSESSMENT

The Precambrian metamorphic bedrocks underling the study area at depth are unfossiliferous while the overlying Late Caenozoic superficial sediments are generally fossil-poor. As a consequence of the paucity of irreplaceable, unique or rare fossil remains within the development footprint the overall impact significance of the construction phase of the proposed solar energy project is assessed as LOW (negative) without mitigation, and VERY LOW (negative) after mitigation (See summary presented in Table 1). This assessment applies to all the planned infrastructure within the project area – *including* the water pipeline to the Orange River as well as the 132 kV overhead line connection to the Eskom Garona Substation - and applies equally to all PV plants under consideration for the Bokpoort II Solar Power Facility. There are no preferences on palaeontological heritage grounds for any particular infrastructure layout or technology alternative among the various options under consideration.

No significant further impacts on fossil heritage are anticipated during the planning, operational and decommissioning phases of the solar power facility. The no-go alternative (*i.e.* no development) would have a neutral impact on palaeontological heritage.

There are no fatal flaws in the present development proposal as far as fossil heritage is concerned. Providing that the proposed recommendations for palaeontological monitoring and mitigation outlined below are followed through, there are no objections on palaeontological heritage grounds to authorisation of this alternative energy project.

Confidence levels for this palaeontological heritage assessment are high. These conclusions are supported by previous palaeontological field assessments undertaken in the broader Kalahari study region (*e.g.* Almond 2012).

- **Cumulative impacts**

Given the low impact significance assessed for all solar energy developments concerned which are all underlain by very similar geology, it is likely that cumulative impacts associated with the Bokpoort II solar power facility are LOW. Very few palaeontological impact assessments for other developments in the wider project area near Groblershoop have been undertaken (SAHRIS website); one exception - for solar projects on the farm Sand Draai by Bamford (2016) - also concluded that the palaeontological sensitivity of the region is low.

Table 1: Assessment of impacts of the proposed Bokpoort II Solar Power Facility on fossil heritage resources within the development footprint during the construction phase of the development (*N.B.* Significant impacts are not anticipated during the operational and decommissioning phases).

Nature of impact: Disturbance, damage, destruction or sealing-in of *scientifically important* fossil remains preserved at or beneath the ground surface within the development area, most notably by surface clearance and bedrock excavations during the construction phase of the solar power facility.		
	Without mitigation	**With mitigation**
Scale	Site only (1)	Site only (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Minor (2)	Minor (2)
Probability	Low (2)	Improbable (1)
Significance	**Negative Low (16)**	**Negative Very Low (8)**
Status	Negative	Negative (loss of fossils) & positive (improved fossil database following mitigation)
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources	No, since the limited fossil resources concerned are also represented outside the development area (*i.e.* not unique)	No, since the limited fossil resources concerned are also represented outside the development area (*i.e.* not unique)
Can impacts be mitigated?	Yes	Yes.
Mitigation: Monitoring of all substantial bedrock excavations for fossil remains by ECO on an ongoing basis during construction phase, with reporting of any substantial new palaeontological finds (notably fossil vertebrate bones & teeth) to SAHRA for possible specialist mitigation.		
Cumulative impacts: Low, given the very similar geology of the entire Bokpoort II study region.		
Residual impacts: Negative impacts due to loss of local fossil heritage will be partially offset by *positive* impacts resulting from mitigation (*i.e.* improved palaeontological database).		

6. SUMMARY & RECOMMENDATIONS

The project areas for the proposed Bokpoort II alternative energy developments on the Remaining Extent (RE) of the Farm Bokpoort 390 near Groblershoop are underlain, at or below the surface, by highly metamorphosed Precambrian basement rocks (schists, quartzites, gneisses) of the Namaqua-Natal Province that are entirely unfossiliferous. These are largely mantled by Late Caenozoic superficial sediments including Quaternary aeolian sands of the Gordonia Formation (Kalahari Group), calcrete pedocretes and alluvium of the Orange River and its tributaries. These younger superficial sediments are generally of low palaeontological sensitivity. Potentially fossiliferous older alluvial gravels are not mapped along the banks of the Orange River close to Groblershoop where these are intersected by the proposed water pipeline.

No significant fossil heritage resources have been recorded within the Bokpoort II solar power facility study area. The area is inferred to be of low sensitivity in terms of palaeontological heritage and no sensitive or no-go areas have been identified within it during the present desktop assessment. The proposed solar power facility is of LOW (negative) impact significance before mitigation with respect to palaeontological heritage resources. This assessment applies to all the planned infrastructure within the project area – *including* the water pipeline to the Orange River (already authorised) as well as the 132 kV overhead line connection to the Eskom Garona Substation - and applies equally to all PV plants under consideration for the Bokpoort II Solar Power Facility. Cumulative impacts associated with the ten PV solar energy developments are probably low, given the similar regional geology, and there are no fatal flaws in the development

proposal as far as fossil heritage is concerned. The no-go alternative is of neutral significance for palaeontology. Providing that the recommendations outlined below for palaeontological monitoring and mitigation are followed through, there are no objections on palaeontological heritage grounds to authorisation of this alternative energy project.

Pending the potential discovery of significant new fossil remains during development - notably fossil vertebrate bones & teeth - no further specialist palaeontological studies or mitigation are considered necessary for this project.

6.1. Recommended monitoring and mitigation

In the case of any significant chance fossil finds during construction (*e.g.* vertebrate teeth, bones, burrows, petrified wood, shells), these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the South African Heritage Resources Agency, SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). This is so that appropriate mitigation by a professional palaeontologist can be considered. Such mitigation usually involves the judicious sampling, collection and recording of fossils as well as of relevant contextual data concerning the surrounding sedimentary matrix. The palaeontologist concerned would need to apply beforehand for a collection permit from SAHRA. A tabulated Chance Fossil Finds Procedure is provided in Appendix 1 to this report.

These recommendations should be incorporated into the Environmental Management Plan (EMP) for each alternative energy development.

7. ACKNOWLEDGEMENTS

I am grateful to Ms Seshni Govender of Royal HaskoningDHV, Woodmead, for commissioning this study as well as for providing the necessary background information. The original cultural heritage assessment for this project by Dreyer (2015) provided a very useful resource for evaluating surface geology in the study area.

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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, Limpopo, Northwest, KwaZulu-Natal, Mpumalanga and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has served as 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 project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

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

<table>
<tr><td colspan="3">Appendix 1: CHANCE FOSSIL FINDS PROCEDURE: BOKPOORT II SOLAR POWER FACILITY ON THE REMAINING EXTENT OF FARM BOKPOORT 390 NEAR GROBLERSHOOP</td></tr>
<tr><td>Province & region:</td><td colspan="2">Northern Cape, ZF Mgcawu District Municipality.</td></tr>
<tr><td>Responsible Heritage Management Agency</td><td colspan="2">SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa.
Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Precambrian Namaqua-Natal basement rocks. Kalahari Group aeolian sands, calcretes, Late Caenozoic alluvium.</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Mammalian bones, teeth and horn cores, freshwater molluscs, trace fossils in older alluvial deposits, calcrete hardpans.</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
Context – describe position of fossils within stratigraphy (rock layering), depth below surface
Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation
Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Agency for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
Photograph fossils against a plain, level background, with scale
Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Agency, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Resources Agency</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Agency. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Agency minimum standards.</td></tr>
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