PROPOSED GEMSBOK SOLAR PV1 SOLAR ENERGY FACILITY NEAR KENHARDT, NORTHERN CAPE PROVINCE

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Executive Summary

Mulilo Renewable Project Developments (PTY) LTD is proposing to develop the Gemsbok Solar PV1 75 MW solar energy facility on the farm Gemsbok Bult (Remaining Extent of Portion 3 of 120), located *c*. 30 km northeast of Kenhardt, Northern Cape. The study area is underlain at depth by Precambrian basement rocks (*c*. 1-2 billion years old) assigned to the Namaqua-Natal Province. These ancient igneous and high-grade metamorphic rocks - mainly granites and gneisses of the Keimoes Suite and Korannaland Group - crop out at surface as small patches and are entirely unfossiliferous. A large proportion of the basement rocks are mantled by a range of superficial sediments of Late Caenozoic age that may contain fossil remains. These predominantly thin, unconsolidated deposits include small patches of calcretes, gravelly to sandy river alluvium, pan sediments, surface gravels, colluvium (scree) as well as Pleistocene wind-blown sands of the Gordonia Formation (Kalahari Group). Most of these younger rock units are of widespread occurrence and low palaeontological sensitivity. Scientifically important vertebrate fossil remains (*e.g.* Pleistocene mammalian bones and teeth) have been recorded within older stratified pan and river sediments in the Bushmanland region where they are often associated with stone artefacts, while a limited range of trace fossils (*e.g.* plant root casts, termitaria and other invertebrate burrows) may be found within calcrete horizons.

No previously recorded areas or sites of exceptional fossil heritage sensitivity or significance have been identified within the study area. Due to the inferred scarcity of fossil remains within the study area, the overall impact significance of the construction phase of the proposed solar energy project is assessed as LOW. This applies equally to all the site options under consideration. No significant further impacts on fossil heritage are anticipated during the operational and decommissioning phases of the solar energy facility. There are no fatal flaws in the proposed development proposal as far as fossil heritage is concerned. The potentially fossiliferous sedimentary rock units represented within the study area (*e.g.* Gordonia sands, calcrete) are of widespread occurrence and this is also likely to apply to most of the fossils they contain. It concluded that the cumulative impacts on fossil heritage resource posed by the known solar energy developments in the region is low.

Given the low palaeontological sensitivity of the broader Nieuwehoop Solar Development study area, as determined from desktop analysis, as well as the inferred very low impact significance of the Gemsbok Solar PV1 alternative energy project for fossil heritage conservation, no specialist palaeontological mitigation is recommended here, pending the discovery of substantial new fossil remains during construction. During the construction phase all substantial bedrock excavations should be monitored for fossil material by the responsible ECO. Should substantial fossil remains - such as vertebrate bones and teeth, plant-rich fossil lenses, petrified wood or dense fossil burrow assemblages - be exposed during construction, the responsible Environmental Control Officer should safeguard these, preferably *in situ*. SAHRA, *i.e.* The South African Heritage Resources Authority, should be alerted as soon as possible (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za) so that appropriate action can be taken by a professional palaeontologist, at the developer's expense. Mitigation would normally involve the scientific recording and judicious sampling

or collection of fossil material as well as associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy) by a professional palaeontologist.

1. Introduction

1.1. Project outline

The company Mulilo Renewable Project Developments (PTY) LTD (Mulilo) is proposing to develop three separate Solar PV power generation projects, each of 75 MW generation capacity, on the farms Gemsbok Bult (Remaining Extent of Portion 3 of 120) and Boven Rugzeer (Remaining Extent of 169) located *c*. 30 km to the northeast of the town of Kenhardt in the Northern Cape, South Africa. Two of the projects will be located on the farm Gemsbok Bult (Remaining Extent Portion 3 of 120) and one on Boven Rugzeer (Remaining Extent 169). These all form part of the proposed Nieuwehoop Solar Development.

Each project will occupy less than 300 hectares and will comprise of a Solar Field, Inverter Stations, Cabling, Operations Office, Substation, Substation Building, Laydown Area, 132KV Overhead Distribution Line, Access Road, Water Pipeline, Borehole, Fence, and Guard Cabin. Each project will connect to the recently approved Eskom Nieuwehoop Substation, to be located on the farm Gemsbok Bult (Remaining Extent of Portion 3 of 120), *via* a 132 kV overhead line. Depending on the location of the on-site substation, the length of the proposed overhead line connecting the on-site substation to the Nieuwehoop Substation could range from 1 km to 7 km.

The present report is a desktop palaeontological heritage assessment for the alternative energy project called **Gemsbok Solar PV1** (DEA reference number: 14/12/16/3/3/2/710) which is to be situated in the southwestern corner of farm Gemsbok Bult (Remaining Extent of Portion 3 of 120) (approximate location 29° 7'53.29" S 21°19'12.42" E) (Figs. 1 & 2).

The Gemsbok Solar PV1 solar energy facility study area is underlain in part by potentially fossiliferous sediments of Late Caenozoic age. The proposed development may have impacts on fossil heritage preserved at or beneath the surface that is protected by law (National Heritage Resources Act, 1999). The present palaeontological desktop assessment of the Gemsbok Solar PV1 solar energy facility study area has therefore been commissioned as part of a broad-based Heritage and Environmental Impact Assessment that is being co-ordinated by CSIR - Environmental Management Services (Contact details: Ms Surina Brink. CSIR -Environmental Management Services. PO Box 320. Stellenbosch 7599. Tel: 021 888 2490. Cell: 082 468 0962. Fax: 021 888 2693. E-mail: sbrink1@csir.co.za).

1.2. Terms of Reference

The Terms of Reference for this palaeontological assessment, as defined by the CSIR, are to determine the environmental risks posed by the proposed development, assess the identified impacts, highlight any potential fatal flaws that may be found in accordance with the requirements of the EIA Regulations for specialist studies and associated guidelines.

The report must include, *inter alia*:

- a declaration of independence;
- details of the scope of work;
- impact assessment methodology (CSIR template provided);
- baseline information;
- impact assessment, including cumulative impact assessment of existing solar PV facility or proposed projects in the area (including the Nieuwehoop Solar Development projects);

- impacts identified and management and mitigation measures to be included in the Environmental Management Programme.

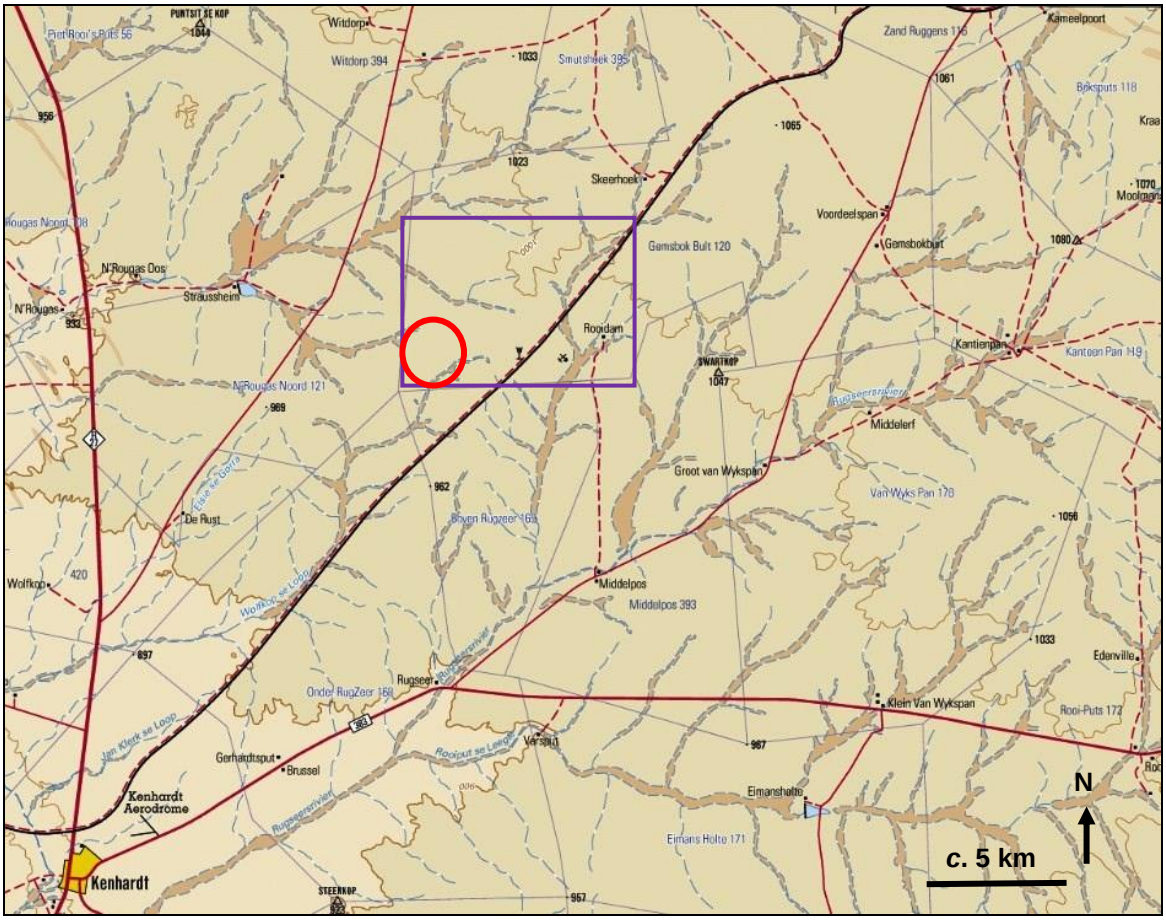

Figure 1. Extract from 1: 250 000 topographical sheet 2920 Kenhardt showing the *approximate* location (purple rectangle) of the Gemsbok PV 1 study area situated *c.* 30 km to the northeast of the town of Kenhardt, Northern Cape Province (Courtesy of the Chief Directorate of Surveys and Mapping, Mowbray). The red ellipse indicates the preferred PV1 development area in the southwestern corner of Farm Gemsbok Bult (Remaining Extent of Portion 3 of120) (See satellite image, Fig. 2 below).

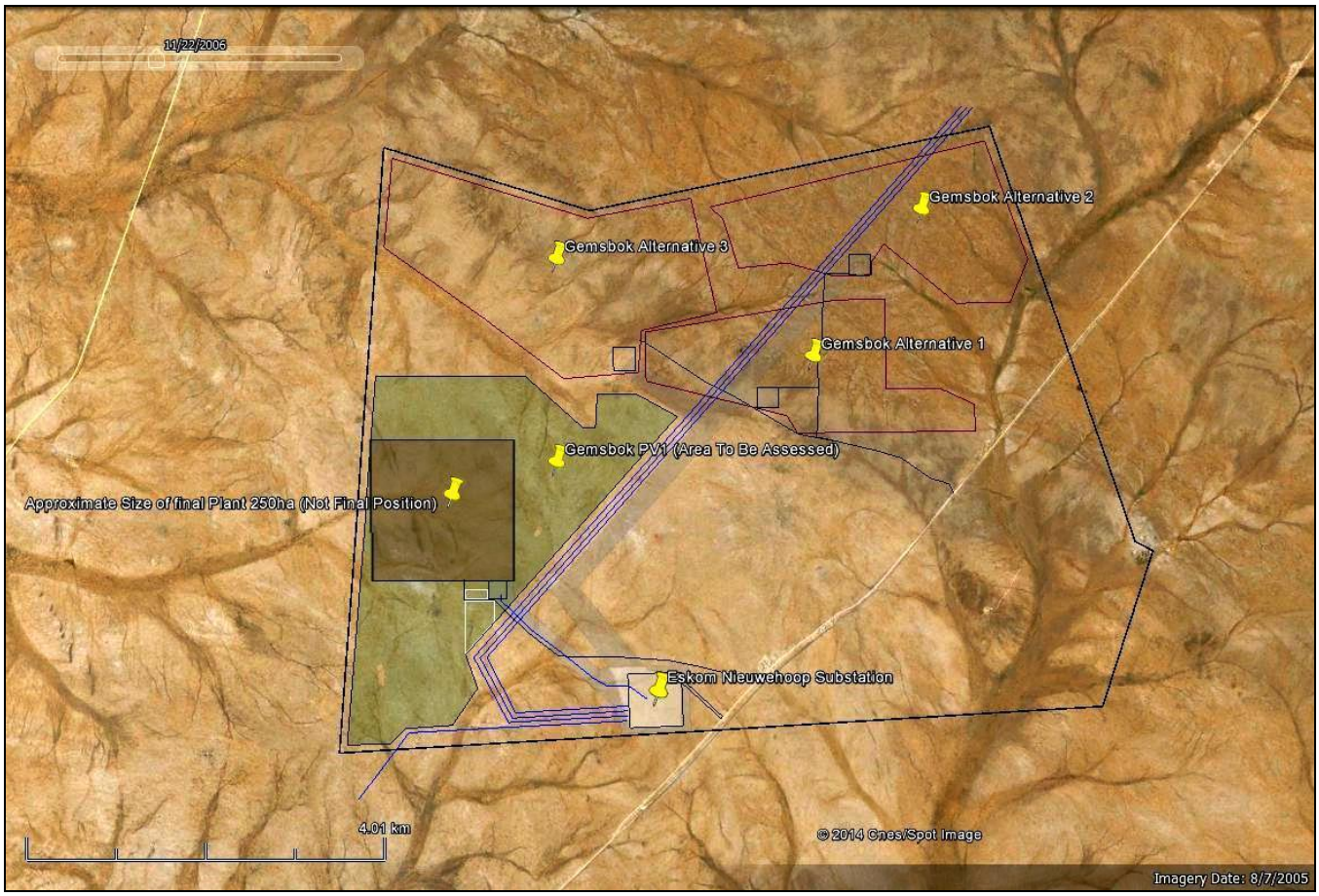

Figure 2. Google earth© satellite image of the Gemsbok Solar PV1 study area on the Farm Gemsbok Bult (Remaining Extent of Portion 3 of120) , *c*. 30 km to the northeast of Kenhardt, Northern Cape (green polygon) and 3 km NW of the Eskom Nieuwehoop Substation. Three alternative locations for the Gemsbok Solar facility are also shown by the brown polygons.

1.3. 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 authority.
(2) All archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage

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

1.4. 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 the present study area in the Kenhardt region of the Northern Cape exposure of potentially fossiliferous bedrocks is favoured by the semi-arid climate and sparse vegetation but may be compromised by extensive superficial deposits in areas of low relief. Comparatively few academic palaeontological studies or field-based fossil heritage impact have been carried out in the region, so any new data from impact studies here are of scientific interest.

1.5. Information sources

The information used in this desktop study was based on the following sources:
1. A brief project outline kindly supplied by CSIR - Environmental Management Services;
2. Previous desktop palaeontological assessment reports for study areas in the Kenhardt region by the author (Almond 2011, 2014);
3. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations (*e.g.* Slabbert *et al.* 1999);
4. The author's previous field experience with the formations concerned and their palaeontological heritage (*cf* Almond & Pether 2008).

2. Approach and Methodology for the Palaeontological Heritage Study

The objective of the present desktop study is (1) to assess the significance of fossil heritage resources that may be present within the Gemsbok Solar PV1 study area near Kenhardt, (2) to identify potential impacts on fossil heritage posed by the proposed development and their significance, (3) to highlight any potential fatal flaws in the proposed development in terms of palaeontological heritage, and (4) to recommend appropriate management and mitigation measures for the Environmental Management Programme for the development.

The following brief account of the geology and palaeontology of the entire Nieuwehoop Solar Development study area has previously (June 2014) been provided by the author for the Scoping Phase of the environmental assessment process:

The study area for the Nieuwehoop Solar Development, located *c*. 28 km northeast of Kenhardt, Northern Cape, lies within the semi-arid Bushmanland region between 900 to 1000 m amsl, with a general slope towards the south. It is drained by a dendritic network of shallow, southwest-flowing tributary streams of the Hartbeesrivier, such as the Rugseersrivier. The entire area is underlain at depth by a variety of Precambrian basement rocks (*c*. 2 billion years old) assigned to the Namaqua-Natal Province. These ancient igneous and high-grade metamorphic rocks (mainly granites and gneisses) crop out at surface as small patches and are entirely unfossiliferous. The Precambrian crustal rocks are

transected by a major NW-SE trending fault zone, the Boven Rugzeer Shear Zone. A large proportion (probably over 50 %) of the basement rocks are mantled by a range of superficial sediments of Late Caenozoic age, some of which are included within the Kalahari Group. These predominantly thin, unconsolidated deposits include small patches of calcretes (soil limestones), gravelly to sandy river alluvium, pan sediments along certain watercourses, surface gravels, colluvium (scree) as well as wind-blown sands of the Gordonia Formation. Most of these younger rock units are of widespread occurrence and low palaeontological sensitivity. Scientifically important vertebrate fossil remains (*e.g.* Pleistocene mammalian bones and teeth) have been recorded within older stratified pan and river sediments in the Bushmanland region where they are often associated with stone artefacts, while a limited range of trace fossils (*e.g.* plant root casts, termitaria and other invertebrate burrows) may be found within calcrete horizons. A palaeontological heritage desktop study for the Nieuwehoop Solar Development has been commissioned for the EIA phase.

The approach to a Phase 1 palaeontological heritage study is briefly as follows. Fossil-bearing rock units occurring within the broader study area are determined from geological maps and satellite images. Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database. Based on this data as well as, where warranted, field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

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

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority, *i.e.* SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@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.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have recently been published by SAHRA (2013).

3. Potential Impacts of Proposed Project on Fossil Heritage Resources

The Nieuwehoop Solar Development project area near Kenhardt is located in an area that is underlain by potentially fossiliferous sedimentary rocks of Late Tertiary or Quaternary age as well as by unfossiliferous basement rocks (Section 4). The construction phase of the proposed developments will entail substantial excavations into the superficial sediment cover and locally into the underlying bedrock as well. These include, for example, excavations for the solar panel foundations, energy storage facility, underground cables, internal access roads, 132 kV transmission line towers, on-site substation, laydown areas, water pipeline and foundations for buildings. All these developments may adversely affect potential, legally protected fossil heritage resources within the study area by destroying, disturbing or permanently sealing-in fossils at or beneath the surface of the ground that are then no longer available for scientific research or other public good.

The operational and decommissioning phases of the solar energy facilities are very unlikely to involve further adverse impacts on local palaeontological heritage, however.

4. Geology and Palaeontology of the Study Area

4.1. Geological context

The study area for the Nieuwehoop Solar Development, located *c*. 30 km northeast of Kenhardt, Northern Cape, lies within the semi-arid Bushmanland region. It comprises flat to gently undulating, semi-arid veld at an elevation of around 1000 m amsl. The area is drained by a dendritic network of shallow, southwest-flowing tributary streams of the Hartbeesrivier, such as the Rugseersrivier and Wolfkop se Loop. The geology of the study area is shown on 1: 250 000 geology sheet 2920 Kenhardt (Council for Geoscience, Pretoria) (Slabbert *et al.* 1999) and consists essentially of a range of Precambrian basement rocks overlain over large areas by Late Caenozoic superficial sediments (Fig. 3).

According to the 1: 250 000 geological map, the main rock units represented within the preferred Gemsbok Solar PV1 study area are (1) basement banded and migmatitic gneisses of the Jacomynpan Group (Mja, blue) and (2) aeolian sands of the Gordonia Formation (Kalahari Group) (Qg, yellow with red stipple). The various alternative sites (Fig. 2) are underlain by very similar geology, but with a wider range of basement rock units.

4.1.1. Precambrian basement rocks

The entire Nieuwehoop Solar Development area is underlain at depth by a variety of Precambrian basement rocks (*c*. 1 billion years old or more = Mid Proterozoic or Mokolian age) assigned to the **Namaqua-Natal Province**. These ancient igneous and high-grade metamorphic rocks - mainly granites and gneisses of the **Keimoes Suite** (granitoids) and **Korannaland Group** (high grade metasediments) - crop out at surface as small patches where the superficial sediments are thinly developed or absent. They are listed in the legend to the geological map (Fig. 3). The various basement rock units are described in the Kenhardt 1: 250 000 sheet explanation by Slabbert *et al.* (1999) and placed in the context of the Namaqua-Natal Province by Cornell *et al.* (2006). However, they are entirely unfossiliferous and so will not be treated further here. The Precambrian crustal rocks are transected by a major NW-SE trending fault zone, the Boven Rugzeer Shear Zone, which separates two major crustal blocks in Bushmanland known as the Kakamas Terrane and Areachap Terrane (Cornell *et al.* 2006, their fig. 18).

4.1.2. Late Caenozoic superficial sediments

A large proportion (probably over 50 %) of the basement rocks in the Nieuwehoop Solar Development area are mantled by a range of superficial sediments of Late Caenozoic age. These predominantly thin, unconsolidated deposits include small patches of **calcretes** or soil limestone (dark yellow patches on geological map, perhaps associated with ancient pans), gravelly to sandy **alluvium** along intermittently flowing water courses, pan sediments along certain larger watercourses, downwasted surface gravels, colluvium (scree) as well as Quaternary wind-blown sands of the **Gordonia Formation** (**Kalahari Group**) (Qg, pale yellow with red stipple on geological map).

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 thickness of the unconsolidated Kalahari sands in the Bushmanland area is variable and often uncertain. The Gordonia dune sands are considered to range in age from the Late Pliocene / Early Pleistocene, dated in part from enclosed Middle to Late Stone Age stone tools (Dingle *et al*., 1983, p. 291). Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8Ma back to 2.588 Ma would place the Gordonia Formation entirely within the Pleistocene Epoch. A number of older Kalahari formations underlie the young wind-blown surface sands in the main Kalahari depository to the north of the study area. However, at the latitude of the study area near Kenhardt (*c*. 29° S) Gordonia Formation sands less than 30m thick are likely to be the main or perhaps only Kalahari sediments present (*cf* isopach map of the Kalahari Group, fig. 6 *in* Partridge *et al*., 2006). These unconsolidated sands will be locally underlain by thin subsurface gravels along the buried palaeosurface and perhaps by calcretes of Pleistocene or younger age (*cf* Mokalanen Formation).

4.2. Palaeontological heritage

In this section of the report the known or potential fossil heritage recoded within each of the major rock units represented within the study area is briefly outlined (See summary in Table 1).

Table 1: Fossil heritage recorded from the major rock units that represented within the broader Nieuwehoop Solar Development study area near Kenhardt

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY
LATE CAENOZOIC SUPERFICIAL SEDIMENTS, **especially** **ALLUVIAL & PAN SEDIMENTS**	**fluvial, pan, lake and terrestrial sediments, including diatomite (diatom deposits), pedocretes (*e.g.* calcrete), colluvium (slope deposits such as scree), aeolian sands (Gordonia Formation, Kalahari Group)** **LATE TERTIARY, PLEISTOCENE TO RECENT**	**bones and teeth of wide range of mammals (*e.g.* mastodont proboscideans, rhinos, bovids, horses, micromammals), fish, reptiles (crocodiles, tortoises), ostrich egg shells, fish, freshwater and terrestrial molluscs (unionid bivalves, gastropods), crabs, trace fossils (*e.g.* calcretised termitaria, horizontal invertebrate burrows, stone artefacts), petrified wood, leaves, rhizoliths, stromatolites, diatom floras, peats and palynomorphs.**	**GENERALLY LOW BUT LOCALLY HIGH** **(*e.g.* Tertiary alluvium associated with old river courses)**
Basement granites & gneisses **NAMAQUA-NATAL PROVINCE**	**highly metamorphosed sediments, intrusive granites** **MID-PROTEROZOIC (*c*.1- 2 billion yrs old)**	**none**	**ZERO**

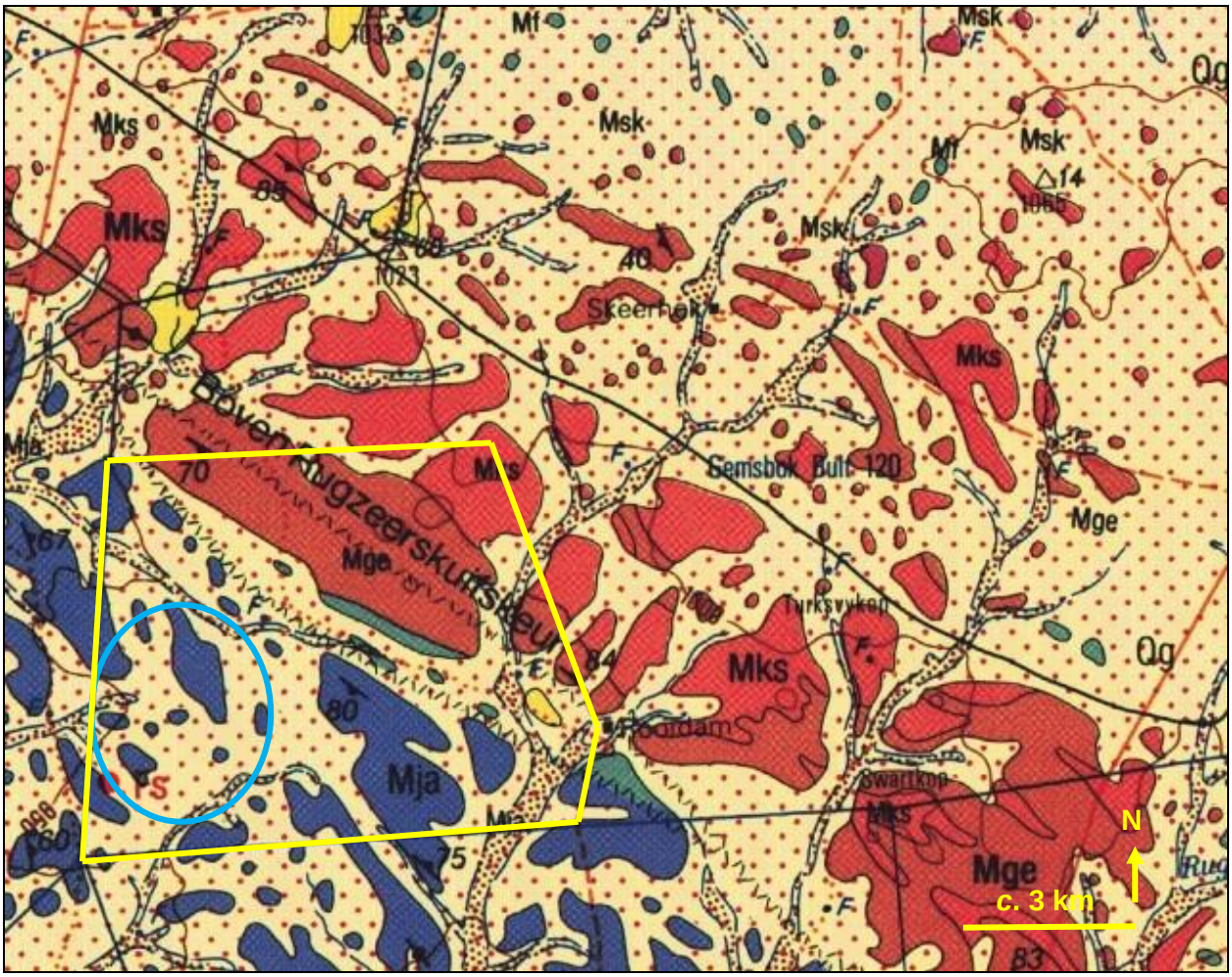

Figure 3. Extract from 1: 250 000 geological map 2920 Kenhardt (Council for Geoscience, Pretoria) showing the approximate outline of the Gemsbok Solar PV1 solar energy facility study area on Gemsbok Bult (Remaining exten of Portion 3) (yellow polygon). The preferred development site is roughly indicated by the blue ellipse. The main geological units represented within the study area include:

PRECAMBRIAN BASEMENT ROCKS

- **KEIMOES SUITE**
  - Brown (Mge) = Gemsbokbult Granite
  - Red (Mks) = Klipkoppies Granite
  - Blue-green (Mf) =Friersdale Charnockite

- **KORANNALAND SUPERGROUP**
  - Dark blue (Mja) = Jacomynpan Group

LATE CAENOZOIC SUPERFICIAL SEDIMENTS

- Pale yellow with sparse red stipple (Qg) = aeolian sands of the Gordonia Formation (Kalahari Group)
- Pale yellow with dense black stipple = alluvial and pan sediments
- Dark yellow (Tec) = calcrete

4.2.1. Fossils in Precambrian basement rocks

The Precambrian basement rocks represented within the study area are igneous granitoids of high grade metamorphic rocks that were last metamorphosed some 1 billion years ago and are entirely unfossiliferous. The sparse fossil record of Late Caenozoic superficial sediments in the region are briefly reviewed here.

4.2.2. Fossils in Late Caenozoic superficial sediments

The diverse superficial deposits within the South African interior, including Bushmanland, have been comparatively neglected in palaeontological terms. However, sediments associated with ancient drainage systems, springs and pans may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises (*e.g.* Skead 1980, Klein 1984b, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al*. 1995, MacRae 1999, Meadows & Watkeys 1999, Churchill *et al*. 2000, Partridge & Scott 2000, Brink & Rossouw 2000, Rossouw 2006, Almond *in* Macey *et al.* 2011). Other late Caenozoic fossil biotas that may occur within these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites, invertebrate burrows, rhizocretions), and plant material such as peats or palynomorphs (pollens) in organic-rich alluvial horizons (Scott 2000) and diatoms in pan sediments. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest (*e.g.* Smith 1999 and refs. therein). Ancient solution hollows within extensive calcrete hardpans may have acted as animal traps in the past. As with coastal and interior limestones, they might occasionally contain mammalian bones and teeth (perhaps associated with hyaena dens) or invertebrate remains such as snail shells.

Diverse fossils associated with the ancient Tertiary drainage systems of the Karoo and Bushmanland region have been summarized by Almond *in* Macey *et al.* (2008. See also articles by Cooke 1949, Wells 1964, Butzer *et al.* 1973, Helgren 1977, Klein 1984, Macrae 1999). They include remains of fish, reptiles, mammals, freshwater molluscs, petrified wood and trace fossils (*e.g.* De Wit 1990, 1993, De Wit & Bamford 1993, Bamford 2000, Bamford & De Wit 1993, Senut *et al.* 1996).

In the Brandvlei area to the southwest of Kenhardt lies the north-south trending Geelvloer Palaeo-valley, a Mid Tertiary palaeodrainage system that links up with the Commissioners Pan – Koa Valley system to the northwest. Here calcretised basal alluvial facies contain bones of hippopotamus-like artiodactyls called anthracotherids indicating a Miocene age (De Wit 1993, 1999, De Wit *et al*. 2000). Anthracotherids are an extinct group of amphibious mammalian herbivores only distantly related to true hippos that were widespread in the Miocene of Africa (Schneider & Marais 2004). Early to Mid Miocene silicified woods from Brandvlei are referable to a number of extant tree families, including the Dipterocarpaceae that mainly inhabit tropical forests in Africa and Asia today. The fossil woods and associated sediments indicate that warm, tropical to subtropical climates prevailed in the Mid Miocene and that perennial, low-sinuousity braided river systems supported lush riparian forests (De Wit & Bamford 1993, Bamford & De Wit 1993, Bamford 2000). Wet, weakly seasonal climates are suggested by the structure (indistinct growth rings) and dimensions (trunk diameters of over 50 cm) of the fossil woods (Bamford 2000).

Abraded Plio-Pleistocene fossil woods from relict alluvial terraces of the Sak River just north of Brandvlei include members of the Family Polygalaceae and also indicate humid growth conditions (Bamford & De Wit 1993). These terraces were formed by meandering rivers during intermittent pluvial (*i.e.* wetter), but still semi-arid, episodes following the onset of generally arid conditions in the western portion of southern Africa towards the end of the Miocene. So far fossils have not been recorded from the Sakrivier system closer to Kenhardt.

Pan sediments in Bushmanland have also recently yielded interesting Pleistocene mammalian faunas in association with age-diagnostic archaeological material. Important fossil mammalian remains assigned to

the Florisian Mammal Age (*c*. 300 000 – 12 000 BP; MacRae 1999) have recently been documented from stratigraphic units designated Group 4 to Group 6 (*i.e.* calcrete hardpan and below) at Bundu Pan, some 22 km northwest of Copperton (Kiberd 2006 and refs. therein). These are among very few Middle Pleistocene faunal records from stratified deposits in the southern Africa region (Klein 1980, 1984a, 1984b, 2000) and are therefore of high palaeontological significance. Characteristic extinct Pleistocene species recorded at Bundu Pan are the giant Cape Horse or Zebra (*Equus capensis*) and the Giant Hartebeest (*Megalotragus priscus*). Other extant to extinct taxa include species of warthog, blesbok, black wildebeest, springbok and baboon. There is additionally trace fossil evidence for hyaenids (tooth marks) as well as ostrich egg shell. Preliminary dating and the inferred ecology of the fossil taxa present suggests the presence of standing water within a grassy savanna setting during the 200 - 300 000 BP interval when the Bunda Pan faunal assemblage accumulated. A sequence of Earlier, Middle and Later Stone Age (MSA and LSA, respectively) artefact assemblages is also recorded from this site. Stratigraphic Groups 4 to 6 (*i.e.* calcrete hardpan and below) contain a Final Acheulian or transitional Earlier Stone Age (ESA) / MSA artefact assemblage, while Groups 2 - 3 above the calcrete horizon contain a MSA artefact assemblage. Orton (2012) recorded a single fossil equid tooth associated with a rich MSA artefact assemblage from gravels overlying a calcrete hardpan on the farm Hoekplaas near Copperton. This horizon is probably equivalent to Group 3 of Kiberd's stratigraphy at Bundu Pan, and therefore somewhat younger than the Florisian mammal fauna reported there.

The fossil record of the Kalahari Group as a whole is generally sparse and low in diversity; no fossils are recorded here in the Kenhardt geology sheet explanation by Slabbert *et al.* (1999). The Gordonia Formation dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from underlying lime-rich bedrocks may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*), tortoise remains and shells of land snails (*e.g. Trigonephrus*) (Almond *in* Macey *et al.* 2011, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*), ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands (Du Toit 1954, Dingle *et al*., 1983). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low. Underlying calcretes might also 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 expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient alluvial gravels (See Koa River Valley above). The younger (Pleistocene to Recent) fluvial and alluvial sands and gravels within the proposed development area are unlikely to contain many, if any, substantial fossil or subfossil remains.

5. Identification of Issues

The ancient Precambrian basement rocks that underlie the entire Nieuwehoop Solar Development study area at depth are entirely unfossiliferous. A wide range of fossil material – such as vertebrate bones and teeth, terrestrial molluscs, trace fossils (*e.g.* calcretised termitaria and other burrows) and petrified wood - might occur within some of the Late Caenozoic superficial deposits that mantle the bedrocks over large parts of the study area (*e.g.* calcretes, older consolidated alluvial and pan deposits). However, there are, to the author's knowledge, no previous fossil records from this particular area of Bushmanland while potentially fossiliferous calcretes and alluvial sediments are not mapped within either the preferred or alternative sites for the Gemsbok Solar PV1 facility. Fossil remains within the development footprint might

be disturbed, damaged, destroyed or sealed-in during the construction phase, for example as a result of excavations made for solar panel footings, underground cables, building foundations or internal access roads. However, most of the fossils concerned are either rare (*e.g.* fossil vertebrates) or of widespread occurrence (*e.g.* fossil burrows). Significant impacts on palaeontological heritage are therefore not anticipated for the Gemsbok Solar PV1 development (See Section 7).

The operational and decommissioning phases of the solar energy facility are very unlikely to involve further adverse impacts on local palaeontological heritage.

6. Permit Requirements

This palaeontological heritage assessment report is to be submitted for comment to the relevant heritage management authority for the Northern Cape, SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za). SAHRA may request further specialist palaeontological studies or mitigation measures, should significant fossil material be discovered on site during the construction phase of the development.

The palaeontologist concerned with any necessary mitigation work will need a valid fossil collection permit from SAHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection). All palaeontological specialist work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies recently developed by SAHRA (2013).

7. Impact Assessment and Recommendations for Environmental Management Programme

In this section of the report the potential impacts of the proposed solar energy facility development on local fossil heritage resources are assessed and recommendations are made for inclusion within the Environmental Management Programme for this project.

7.1. Palaeontological heritage impact assessment for Gemsbok Solar PV1

The construction phase of the proposed solar energy facility will entail substantial excavations into the superficial sediment cover (aeolian sands, surface gravels, alluvium *etc*), which may contain fossil remains, and in some cases also into the underlying unfossiliferous bedrock. These include, for example, excavations for the solar panel foundations, underground cables, internal access roads, 132 kV transmission line towers, on-site substation, laydown areas, water pipeline, energy storage facility and foundations for buildings. As a result, fossils at the ground surface or buried beneath it may be disturbed, damaged, destroyed or sealed-in while their scientifically informative sedimentary context will also be disturbed or destroyed. Once constructed, the operational and decommissioning phases of the wind energy facility will not involve further adverse impacts on palaeontological heritage, however.

Desktop analysis of the fossil records of the various rock units underlying the Nieuwehoop Solar Development study area indicates that the majority of these units are of zero to low palaeontological sensitivity (Section 4.2 and Table 1). The basement rocks are entirely unfossiliferous while the overlying Late Caenozoic superficial sediments (wind-blown sands, alluvium, gravels *etc*) are of low to very low palaeontological sensitivity. Construction of the solar panel arrays, overhead power lines and associated infrastructure is therefore unlikely to entail significant impacts on local fossil heritage resources.

The inferred impact of the proposed solar facility development on local fossil heritage is analysed in Table 2 below. This assessment applies only to the construction phase of the development since further impacts on fossil heritage during the operational and decommissioning phases of the solar energy facility are not anticipated. The assessment also applies equally to all site options for the solar facility (Figure 2), due to the essential similarity in the underlying geology.

The destruction, damage or disturbance out of context of fossils preserved at the ground surface or below ground represents a direct *negative* impact that is confined to the development footprint (*site specific*). Such impacts are made only during the *construction period*, can usually be partially mitigated but cannot be fully rectified (*i.e. non-reversible or permanent*). Several of the sedimentary units represented within the study area do contain fossils of some sort, so impact on fossil heritage are *probable*. However, because of the generally very sparse occurrence of well-preserved fossils within the superficial sediments, and because most of the fossils encountered are likely to be of widespread occurrence (*low irreplaceability*), the intensity of these impacts is rated as *low*. Due to the paucity of palaeontological field studies within this part of Bushmanland, confidence levels for this desktop palaeontological heritage assessment are only moderate (*medium*).

No previously recorded areas or sites of exceptional fossil heritage sensitivity or significance have been identified within the study area. Due to the inferred scarcity of exceptional fossil remains within the study area, the overall impact significance of the construction phase of the proposed solar energy project is assessed as LOW. This applies equally to all the site options under consideration. No significant further impacts on fossil heritage are anticipated during the operational and decommissioning phases of the solar energy facility. There are no fatal flaws in the proposed development proposal as far as fossil heritage is concerned.

Should previously unrecorded fossil remains be discovered during construction, *and* the recommended mitigation measures as outlined below (Section 7.3) be fully implemented, this would be considered a highly significant *positive* outcome because of the improved scientific understanding of local palaeontological heritage in a hitherto poorly-studied region of South Africa.

7.2. Assessment of cumulative impacts

In the absence of comprehensive data on further alternative energy or other developments to the northeast of Kenhardt, it is impossible to realistically assess cumulative impacts on fossil heritage resources. The palaeontological heritage impact significance of all three solar energy developments proposed within the Nieuwehoop Solar Development are rated equally as **LOW**. The potentially fossiliferous sedimentary rock units represented within this area are of widespread occurrence and this is also likely to apply to most of the fossils they contain. It concluded that the cumulative impacts on fossil heritage resource posed by the known solar energy developments to the northeast of Kenhardt is low.

7.3. Recommendations for Environmental Management Programme

Given the low palaeontological sensitivity of the broader Nieuwehoop Solar Development study area, as determined from desktop analysis, as well as the inferred low impact significance of the alternative energy project for fossil heritage conservation, no specialist palaeontological mitigation is recommended here, pending the discovery of substantial new fossil remains during construction.

During the construction phase all substantial bedrock excavations should be monitored for fossil material by the responsible ECO. Should substantial fossil remains - such as vertebrate bones and teeth, plant-rich fossil lenses, petrified wood or dense fossil burrow assemblages - be exposed during construction, the responsible Environmental Control Officer should safeguard these, preferably *in situ*. SAHRA, *i.e.* The South

African Heritage Resources Authority, should be alerted as soon as possible (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za) so that appropriate action can be taken by a professional palaeontologist, at the developer's expense. Mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy) by a professional palaeontologist.

The palaeontologist concerned with mitigation work will need a valid fossil collection permit from SAHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection). All palaeontological specialist work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies recently developed by SAHRA (2013).

No mitigation is required during the operational and decommissioning phases of the development.

These mitigation recommendations (as summarized in Table 2) should be incorporated into the Environmental Management Programme for all alternative energy developments within the Nieuwehoop Solar Development.

Table 2: Assessment of potential impacts on local palaeontological heritage resources for the proposed Gemsbok Solar PV1 solar energy facility (This assessment applies to the construction phase and equally to all alternative development sites and options)

Nature of impact	Spatial Extent	Duration	Intensity	Probability	Reversibility	Irreplaceability	Mitigation/Management Actions	Significance and Status		Confidence level
								Without Mitigation	*With Mitigation*	
CONSTRUCTION PHASE										
Scenario 1: Damage or destruction of fossils during excavation										
Disturbance, damage or destruction of fossils at surface or beneath the ground	Site specific	Permanent	Low	Probable.	Non-reversible	Low	Monitoring of all deeper (> 1m) excavations into sedimentary rocks for fossil material by ECO. Fossil finds made during construction phase should be safeguarded and reported to SAHRA for possible recording and sampling by a professional palaeontologist.	Low (negative)	High (positive)	Medium

Table 3: Recommended mitigation and management actions for the proposed Gemsbok Solar PV1 solar energy facility (These recommendations apply to the construction phase and equally to all alternative development sites and options).

Project aspect	Mitigation Objectives	Management actions	Monitoring		
			Methodology	***Frequency***	***Responsibility***
CONSTRUCTION PHASE					
Disturbance or destruction of fossil remains during excavation of sedimentary rocks (*e.g.* solar panel footings, underground cables, access roads)	Recording and sampling or collection of fossil remains exposed during excavation	Safeguard newly exposed fossil material, preferably *in situ*. Immediately report all fossil finds exposed during construction to SAHRA for recording and sampling by a professional palaeontologist (where warranted).	Monitoring of deep (> 1m) excavations into sedimentary rocks for fossil material (fossil bones, teeth, petrified wood, shells, burrows *etc*)	Daily	ECO

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9. Acknowledgements

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Qualifications and 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 development project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

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