PALAEONTOLGICAL HERITAGE ASSESSMENT: DESKTOP STUDY

ADDITIONAL CSP FACILITIES ASSOCIATED WITH AUTHORISED CSP SITES (1.3, 1.4, 3, 4 & 5) WITHIN THE KAROSHOEK SOLAR VALLEY DEVELOPMENT NEAR UPINGTON, ZF MGCAWU DISTRICT, NORTHERN CAPE

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Executive summary

FG Emvelo (Pty) Ltd is proposing to develop additional CSP (Concentrated Solar Power) facilities immediately adjacent to several authorised CSP sites (1.3, 1.4, 3, 4 & 5) within the Karoshoek Solar Valley Development, situated to the south of the Orange River (Gariep) and about 30 km southeast of Upington, Khara Hais Local Municipality, ZF Mgcawu District, Northern Cape.

The igneous and metamorphic basement rocks of Precambrian age underlying the entire Karoshoek Solar Valley Development study area are entirely unfossiliferous. The overlying aeolian sands, calcretes, surface gravels and stream deposits of the Kalahari Group mantling the ancient bedrocks are generally of low to very low palaeontological sensitivity. The project areas lie too far from the river to affect any possible – but unmapped - older (Tertiary - Quaternary) fossiliferous river gravels along the southern banks of the Gariep.

It is concluded that all five of the proposed new CSP facilities within the Karoshoek Solar Valley Development are unlikely to have significant negative impacts on local palaeontological heritage resources (impact significance: very low). No-go areas based on fossil heritage resources have not been identified within the study area. Anticipated cumulative impacts as a result of these five additional CSP facilities, as well as other solar facilities planned in the Upington region (including the already authorised facilities within the Karoshoek Solar Valley Development), are rated as low.

It is therefore recommended that, pending the discovery of significant new fossils remains before or during construction, exemption from further specialist palaeontological studies be granted for the proposed new facilities within the Karoshoek Solar Valley Park near Upington, Northern Cape.

Should any substantial fossil remains (*e.g.* mammalian bones and teeth) be encountered during excavation, however, these should be safeguarded, preferably *in situ*, and reported by the ECO to SAHRA, *i.e.* The South African Heritage Resources Authority, 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. These mitigation recommendations should be incorporated into the Environmental Management Programmes (EMPs) for each of the CSP facilities within the Karoshoek Solar Valley Development.

1. Outline of the proposed development and brief

The company FG Emvelo (Pty) Ltd is proposing to develop additional CSP (Concentrated Solar Power) facilities immediately adjacent to several authorised CSP sites (1.3, 1.4, 3, 4 & 5) within the Karoshoek Solar Valley Development. The proposed solar park is situated to the south of the Orange River (Gariep) and *c.* 30 km southeast of Upington in the Khara Hais Local Municipality, ZF Mgcawu District, Northern Cape (Figure 1). The following land parcels are involved in the proposed developments:

- Lot 944 Karos Settlement (Portion 0 of Zandemm 944);
- Portion 3 of Matjiesrivier (Annashoek) 41;
- Portion 2 of Matjiesrivier 41; and
- Portion RE of Matjiesrivier (Hanskopfontein Estate) 41.

The purpose of the additional CSP facilities to be investigated is to facilitate the increase in capacity of each authorised facility to 150 MW in order to meet the generating capacity thresholds specified by the Department of Energy (DoE) in its Expedited Bid Window of the Renewable Energy Independent Power Producers Procurement (REIPPP) Programme. Currently all the sites listed above are authorised for 50 MW (i.e. site 3) or 100 MW (i.e. sites 1.3; 1.4. 4 and 5) each. Additional projects that are proposed immediately adjacent to each of the authorised projects include:

- An additional 50 MW parabolic trough plant adjacent to each of the sites 1.3, 1.4, 4 and 5; and
- An additional 100 MW tower plant adjacent to Site 3 (with a maximum tower height of 270 m).

The developer intends to develop the proposed additional projects together with the already authorised projects, each project to be developed as a single 150 MW facility in total. In the case of the tower plant environmental authorisations, this would result in only a single tower being developed across both authorised projects.

The present palaeontological heritage assessment report of the Karoshoek Solar Valley Development project area has been commissioned as part of the broad-based Heritage and Environmental Impact Assessment that is being co-ordinated by Savannah Environmental (Pty) Ltd, (Contact details: Ms Sheila Muniongo. Savannah Environmental (Pty) Ltd. 1st Floor, Block 2, 5 Woodlands Drive Office Park, Woodlands Drive, Woodmead, 2191. Tel: +27 11 656 3237. Fax: +27 86 684 0547. Cell: +27 73 517 6823. Email: sheila@savannahsa.com. Postal address: P.O. Box 148, Sunninghill, 2157).

This report will contribute to the EIA process for the additional areas associated with each of the authorized solar energy facilities within the Karoshoek Solar Valley Park as well as to the Environmental Management Programmes (EMPs) for each facility. Ancillary infrastructure – including access roads, internal power lines and a water pipeline – will be assessed through a separate Basic Assessment process.

2. 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 proposed alternative energy development is located in an area that is underlain by Precambrian basement rocks as well as Late Caenozoic superficial sediments (Sections 4 and 5). The construction phase will entail substantial excavations into the superficial sediment cover, and perhaps also into the Precambrian bedrocks. These developments may adversely affect known or potential fossil heritage at or beneath the surface of the ground within the study area by destroying, disturbing or sealing-in fossils that are then no longer available for scientific research or other public good.

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.

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

3. Approach to the palaeontological heritage study

The approach to this 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 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 Northern Cape have already been compiled by Almond and 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 (if required), 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, 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 measures are carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

3.1. 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.

3.2. Information sources

The information used in this desktop study was based on the following:

1. A short Background Information Document (dated October 2015) provided by Savannah Environmental (Pty) Ltd;

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations, as well a limited number of desktop and field-based palaeontological assessment studies in the broader study region (*e.g.* Almond 2014, Almond 2015);

3. The author's unpublished palaeontological database and previous field experience with the formations concerned and their palaeontological heritage.

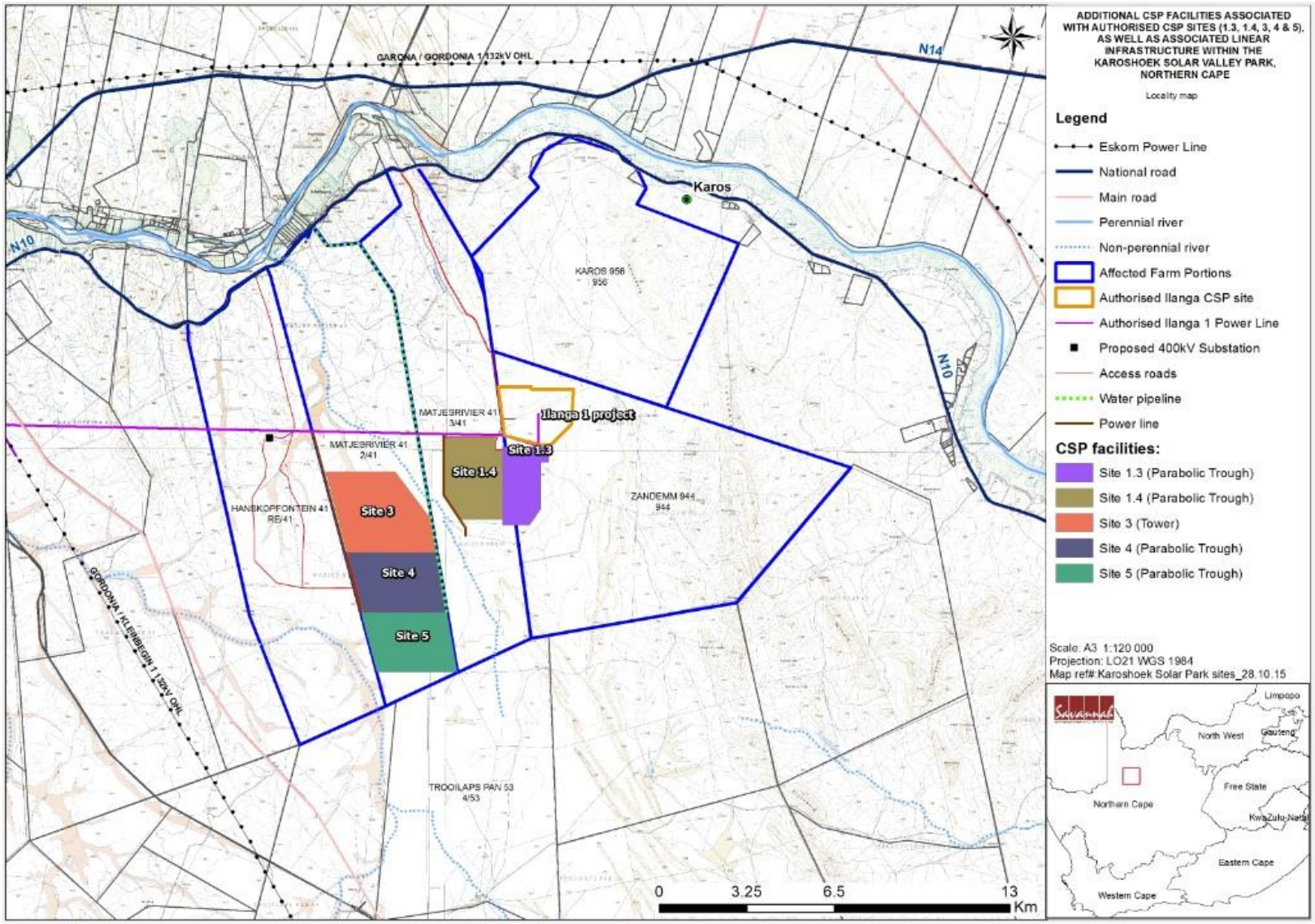

Figure 1. Map showing the land parcels and location of CSP solar projects within the Karoshoek Solar Valley Development near Upington, Northern Cape (Image supplied by Savannah Environmental (Pty) Ltd).

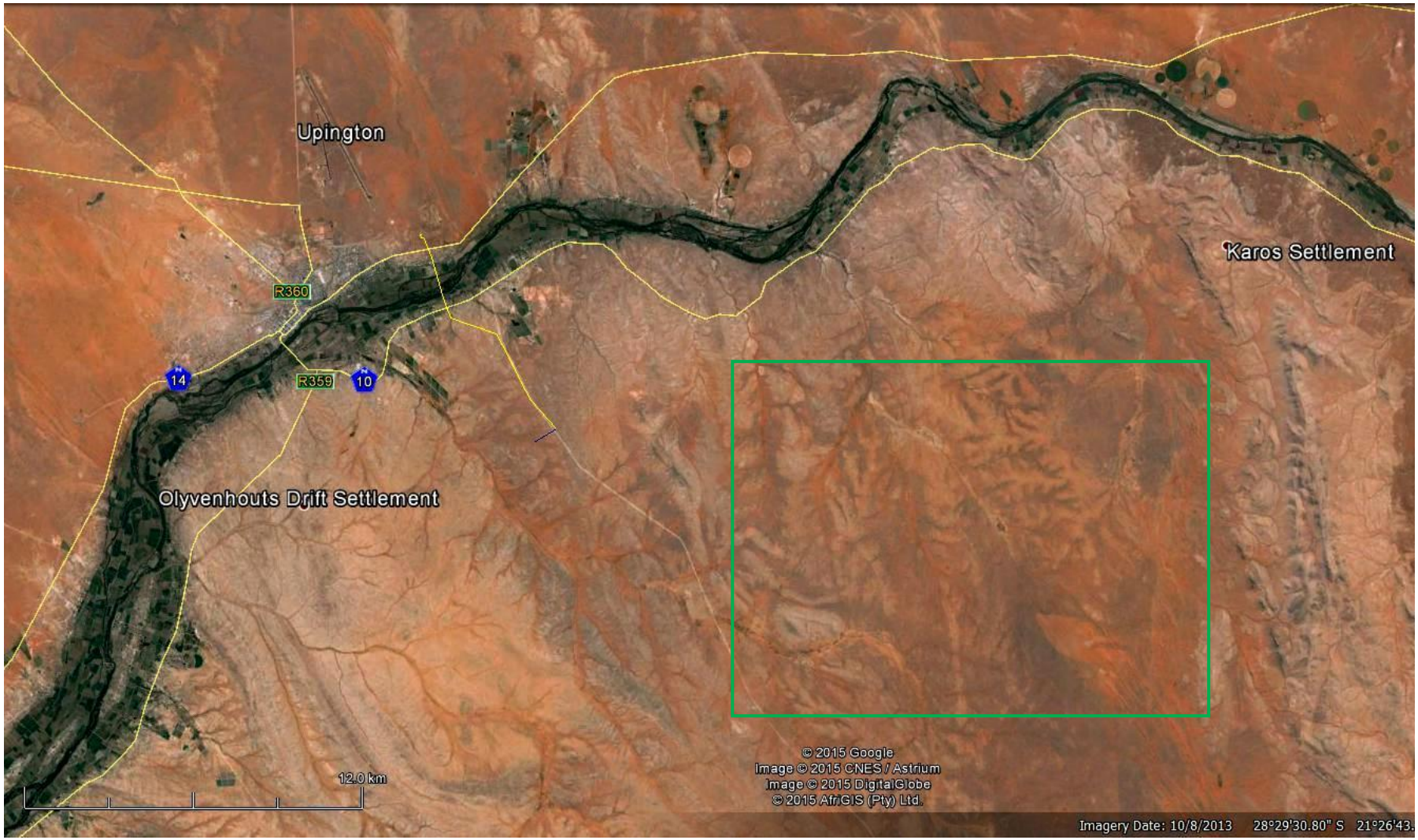

Figure 2. Google earth© satellite image of the arid dissected terrain south of the Orange River to the southeast of Upington, Northern Cape, where the Karoshoek Solar Valley Park will be situated (green rectangle). The yellow polygon to the west shows the location of the nearby Joram and Ephraim Sun solar facility developments (See Almond 2014, 2015).

4. Geological background

The Karoshoek Solar Valley Park study area features fairly flat-lying to gently-sloping or hilly, arid terrain at *c*. 840 to 930 m amsl on the southern side of the Orange (Gariep) River, some 30 km to the southeast of Upington (Figs. 1 & 2). It is traversed by numerous shallow ephemeral, dendritic water courses, including the Matjiesrivier, which ultimately feed north- or north-westwards into the Gariep. Low rocky *koppies* or ridges, such as the Langberg-Perdekop-Kronenberg ridge (1134 m amsl) are situated to the east of the study area while NNW-SSE trending linear sand dunes are visible to the southeast.

The geology of the study area near Upington is shown on the 1: 250 000 geology map 2820 Upington (Council for Geoscience, Pretoria; Fig. 3). A comprehensive sheet explanation for this map has been published by Moen (2007). The study area is underlain at depth by a range of ancient Precambrian basement rocks – largely medium to high grade metamorphic rocks (*e.g.* gneisses, metapelites, quartzites) and intrusive granitoids – that belong to the **Namaqua-Natal Province** of Mid Proterozoic (Mokolian) age (Cornell *et al.* 2006, Moen 2007). The rock units concerned include quartzites and schists of the **Vaalkoppies Group**, various metasediments and volcanics of the the **Areachap Sequence** and **Wilgenhoutsdrif Group** as well as basic and acidic lavas of the **Koras Group** (See legend to Fig. 3). These basement rocks are approximately two to one billion years old and are entirely unfossiliferous (Almond & Pether 2008). They mainly crop out as small, isolated patches of basement rocks or low *Inselberge* due to the extensive superficial sediment cover.

A large portion of the study area, especially towards the south, is covered by fine-grained aeolian (wind-blown) sands of the **Gordonia Formation** (**Qg**, pale yellow with dashed ornament in Fig. 3). This is the youngest, Pleistocene to Recent, subunit of the **Kalahari Group**. Prominent NW-SE trending linear dunes of orange-hued sands are clearly visible on satellite images in the south-eastern portion of the study area as well as along its eastern margins. 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). Areas of calcrete pedocretes in the north-eastern sector of the study area may be tentatively correlated with the Quaternary **Mokalanen Formation** of the Kalahari Group (Moen 2007, p. 148). Other Quaternary to Recent superficial deposits in the study area include downwasted surface gravels, colluvium and gravelly to sandy stream sediments. High Level Gravels associated with the Orange River are not mapped within the Karoshoek study area.

5. Palaeontological heritage

The Precambrian igneous and metamorphic **basement rocks** underlying the entire study area at depth are entirely unfossiliferous. The fossil record of the Pleistocene to Recent **Kalahari Group** is generally sparse and low in diversity. 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 the underlying bedrocks (including, for example, dolerite) 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*) and shells of land snails (*e.g. Trigonephrus*) (Almond 2008, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, 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. 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 of the **Mokolanen Formation** might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. It is noted that potentially fossiliferous alluvial gravels of Neogene or Quaternary age ("High Level Gravels") associated with the Orange River are *not* mapped within the present study area.

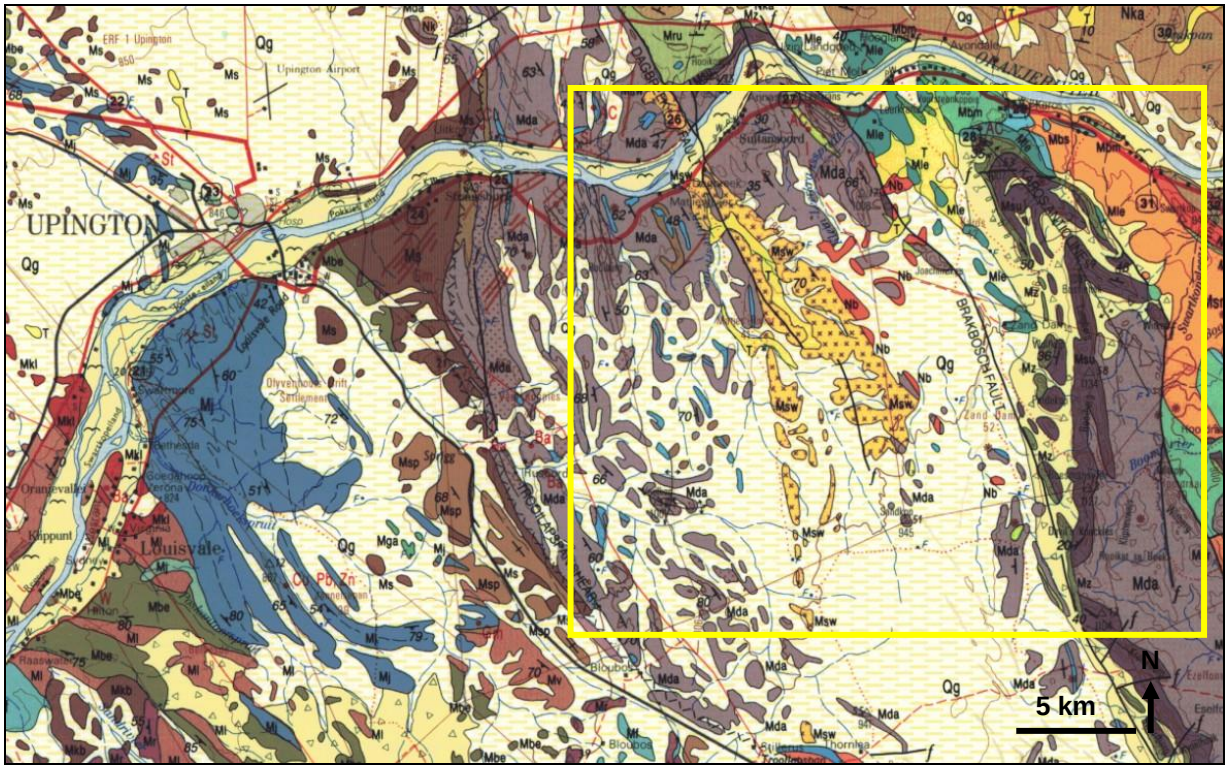

Figure 3. Extract from 1: 250 000 geological map 2820 Upington (Council for Geoscience, Pretoria) showing the *approximate* location of study area for the Karoshoek Solar valley Park (yellow rectangle), situated on the southern side of the Gariep River *c*. 30 km SE of Upington, Northern Cape Province. The study area is underlain at depth by unfossiliferous Precambrian (Middle Proterozoic / Mokolian) basement rocks of the Namaqua-Natal Metamorphic Province, including a wide range of highly metamorphosed sediments, lavas and intrusive igneous rocks. These include Msw (dark yellow with crosses) = Swanartz Gneiss; Mda (middle grey, Dagbreek Fm) and Msu (dark grey, Sultanoord Fm) = quartzites and schists of the Vaalkoppies Group; Mj (blue-grey, Jannelspan Fm) and Msp (brown, Sprigg Fm) = metasediments of the Areachap Sequence; Mz (grey-green, Zonderhuis Fm) and Mle (blue-green, Leerkrans Fm) = quartzites and volcanics of the Wilgenhoutsdrif Group; Mru (pale green, Rouxville Fm) and Msr (orange, Swartkopsleegte Fm) = basic and acidic lavas of the Koras Group. Late Proterozoic intrusions are represented by the Blauwbosch Granite (Nb, orange). The basement rocks are mantled locally by red aeolian (wind-blown) sand of the Gordonia Formation (Kalahari Group) (Qg, pale yellow with yellow stripes), Tertiary to Quaternary calcrete (T, dark yellow) as well as alluvial gravels and surface rock rubble (triangular symbols). The overall palaeontological sensitivity of the entire study area is LOW.

6. Evaluation of impacts and identification of management actions

The anticipated impacts of the various proposed CSP developments within the Karoshoek Solar Valley Development near Upington are briefly assessed here and summarised in Table 1, together with recommendations for monitoring and mitigation of chance fossil finds for inclusion in the EMP for each CSP development. Please note that, given the fairly uniform geology and palaeontology of the study area as a whole, this assessment applies equally to all five additional CSP sites under consideration (*i.e.* sites 1.3, 1.4, 3, 4 & 5).

6.1. Evaluation of impact significance

The study area for the proposed Karoshoek Solar Valley Park near Upington is largely underlain by unfossiliferous Precambrian basement rocks of the Namaqua-Natal Province as well as a range of unfosssiliferous to poorly-fossiliferous superficial sediments of Late Caenozoic age (Sections 4 & 5). The *construction phase* of the solar park will entail extensive surface clearance as well as shallow excavations into the superficial sediment cover (soils, alluvial gravels *etc.*) and locally also into the underlying bedrock. These excavations notably include site clearance activities as well as excavations for the parabolic mirror array and heliostat footings, excavation for the power tower foundations, buried cables, new internal access roads, power line pylon footings, storm water infrastructure, as well as foundations for various buildings such as the central tower and control buildings. All these developments may adversely affect any fossil remains within the study area by destroying, disturbing or permanently sealing-in fossils at or below the ground surface that are then no longer available for scientific research or other public good. Once constructed however, the *operational and decommissioning phases* of the solar facilities will not involve potential further adverse impacts on palaeontological heritage.

In general, the destruction, damage or disturbance out of context of fossils preserved at the ground surface or below ground that may occur during construction represents a *negative* consequence. The palaeontological sensitivity of the bedrocks and superficial sediments within the study area is rated as low to very low (Section 5) and therefore the impact significance is rated as *Very low* (-). Negative impacts on fossil heritage resources can usually be mitigated but cannot be fully rectified or reversed; *i.e.* they are *permanent* in duration and *non-reversible*. Potential impacts are confined to the development footprint *i.e. very limited* in extent. No *no-go areas* of high palaeontological sensitivity were identified within the study area during the present desktop study.

Some of the superficial sedimentary formations represented within the study area – such as the Quaternary calcretes (T, dark yellow in geological map Fig. 3) - contain fossils of some sort (*e.g.* trace fossils, microfossils, possible vertebrate remains). Low-level impacts on fossil heritage here are probable. However, the probability of *significant* impacts on palaeontological heritage is considered to be *low* because of (a) the generally very sparse occurrence of palaeontologically valuable fossils (*i.e.* unusual fossils such as well-preserved vertebrate remains) within the superficial sediments, (b) the widespread occurrence of the most of the fossils concerned outside the study area (*i.e.* not unique).

While all fossils, once damaged or destroyed, are *irreplaceable*, this has to be seen in the context of the probable widespread occurrence of most fossil groups within the rock units concerned here (with the notable exception of any well-preserved vertebrate remains).

With specialist mitigation, as outlined below in proposals for the Environmental Management Programme, any residual negative impacts from loss of fossil heritage during construction would be partially or fully offset by an improved palaeontological database for the study region as a direct result. This is a *positive* outcome because any new, well-recorded and suitably curated fossil material from this palaeontologically under-recorded region would constitute a useful addition to our scientific understanding of the fossil heritage here.

Should specialist mitigation of rare but valuable chance fossil finds (*e.g.* well-preserved vertebrate remains) be followed through, the consequence of the development – in terms of improved understanding of the fossil heritage of southern Africa - would be rated as *positive* and the impact significance of the development as medium (positive).

Given the scarcity of significant fossils within the broader study region and the widespread occurrence of the fossiliferous sedimentary rocks affected, the *cumulative impact* of various proposed CSP solar energy facilities within the Karoshoek Solar Valley Development is rated as *low*. This also applies when the various other solar energy facilities proposed for the Upington area are taken into consideration (*cf* Almond 2014, 2015).

Confidence levels for this evaluation are *moderate* because there is very little first-hand palaeontological field data available for the Upington region as a whole.

6.2. Environmental Management Programme

Given the low impact significance of the all five proposed CSP facilities as far as palaeontological heritage is concerned, no further specialist palaeontological heritage studies or mitigation are considered necessary for the Karoshoek Solar Valley Park project, pending the discovery or exposure of substantial new fossil remains during construction (See Table 1).

During the construction phase all deeper (> 1 m) excavations into sedimentary bedrock should be monitored for fossil remains by the responsible Environmental Control Officer (ECO). Should substantial fossil remains such as vertebrate bones and teeth, petrified wood, plant-rich fossil lenses or dense fossil burrow assemblages be exposed during construction, the responsible ECO should safeguard these, preferably *in situ*, and alert the South African Heritage Resources Authority (SAHRA) so that appropriate action can be taken by a professional palaeontologist, at the developer's expense (SAHRA contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za). 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.

These mitigation recommendations should be incorporated into the Environmental Management Programmes (EMP) for each of the CSP facilities within the Karoshoek Solar Valley Development.

Provided that the recommended mitigation measures are carried through, it is likely that any potentially negative impacts of the proposed additional development on local palaeontological resources will be substantially reduced. Furthermore, they will be partially offset by the positive impact represented by increased understanding of the palaeontological heritage of the Upington region.

Please note that:

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

- 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);and

- 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).

Table 1: Evaluation of impacts on palaeontological heritage within the Karoshoek Solar Valley Development near Upington (CSP sites 1.3, 1.4, 3, 4 & 5), with mitigation recommendations for inclusion in the EMP.

Impact on palaeontological heritage resources			
Issue	**Nature of Impact**	**Extent of Impact**	**No-Go Areas**
Loss of unique fossil heritage	Disturbance, damage or destruction or sealing-in of fossils, especially by ground-clearance and excavations during the construction phase	Restricted to the development footprint, construction phase	None identified
Description of expected significance of impact • Impact significance: VERY LOW • Consequence: negative (loss of local fossil heritage) • Duration: permanent • Probability: low • Degree to which these impacts- can be reversed: non-reversible may cause irreplaceable loss of resources: unlikely can be avoided, managed or mitigated: high (see below)			
Gaps in knowledge & recommendations for further study Little paleontological fieldwork has been carried out in the broader study region (esp. close to the Orange River) No further specialist palaeontological studies recommended, pending discovery of significant new fossil material on site during or before the construction phase. **Recommended monitoring & mitigation for EMP** Monitoring of all substantial excavations into sedimentary bedrock by ECO. Reporting of chance fossil finds (*e.g.* vertebrate bones, teeth, shells, petrified wood) by ECO to SAHRA and professional palaeontologist for recording and collection.			

7. Conclusions & recommendations

The igneous and metamorphic basement rocks of Precambrian age underlying the entire Karoshoek Solar Valley Development study area are entirely unfossiliferous. The overlying aeolian sands, calcretes, surface gravels and stream deposits of the Kalahari Group mantling the ancient bedrocks are generally of low to very low palaeontological sensitivity. The project areas lie too far from the river to affect any possible – but unmapped - older (Tertiary - Quaternary) fossiliferous river gravels along the southern banks of the Gariep.

It is concluded that all five of the proposed additional CSP facilities within the Karoshoek Solar Valley Devrlopment are unlikely to have significant negative impacts on local palaeontological heritage resources (impact significance: very low). No-go areas based on fossil heritage resources have not been identified within the study area. Anticipated cumulative impacts as a result of these five additional CSP facilities, as well as other solar facilities planned in the Upington region, are rated as low.

It is therefore recommended that, pending the discovery of significant new fossils remains before or during construction, exemption from further specialist palaeontological studies be granted for the proposed new CSP facilities proposed within the Karoshoek Solar Valley Development near Upington, Northern Cape.

Should any substantial fossil remains (*e.g.* mammalian bones and teeth) be encountered during excavation, however, these should be safeguarded, preferably *in situ*, and reported by the ECO to SAHRA, *i.e.* The South African Heritage Resources Authority, 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. These mitigation recommendations should be incorporated into the Environmental Management Programmes (EMP) for each of the CSP facilities within the Karoshoek Solar Valley Development.

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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, Free State, Mpumulanga and Northwest Province 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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