PALAEONTOLOGICAL HERITAGE DESKTOP ASSESSMENT:

PROPOSED SOL INVICTUS SOLAR PV DEVELOPMENT ON PORTION 5 OF FARM OU TAAISBOSMOND 66 NEAR AGGENEYS, NORTHERN CAPE PROVINCE

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GEOLOGICAL CONTEXT

The proposed Sol Invictus 1, Sol Invictus 2, Sol Invictus 3 and Sol Invictus 4 PV Facilities (hereafter referred to as the Sol Invictus Solar PV development) on farm Ou Taaibosmond 66 is situated in fairly flat-lying terrain (*c.* 750-950 m amsl) within a very arid desert region to the south of the River Orange. There are several scattered Inselberge (island mountains) of resistant-weathering basement rocks to the north and wesVt surrounded by a sea of wind-blown Kalahari dune sands (orange on satellite images) and other superficial deposits such as braided stream sediments, sheet wash, calcrete and surface gravels (Figure 1). Rocky outcrops within the study area itself are small and mainly restricted to the southwestern corner, while there are no major drainage lines here.

The geology of the Sol Invictus PV study area is shown on 1: 250 000 geological map 2918 Pofadder (Council for Geoscience, Pretoria; Agenbacht 2007) (Figure 2). The region is underlain at depth by a range of resistant-weathering igneous and high grade metamorphic rocks of Late Precambrian (Mokolian / Mid-Proterozoic) age. The various rock units - mainly gneisses, schists, quartzites and amphibolites – crop out at surface in the southwestern corner of the area and are listed in the legend to the geological map. They include representatives of the **Gladkop Metamorphic Suite** (**Koeipoort Gneiss**) and **Little Namaqualand Suite** (**Konkyp Gneiss**). These metamorphic basement rocks are assigned to the **Namaqua-Natal Province** and are approximately two to one billion years old (Cornell *et al.* 2006, Agenbacht 2007, Almond & Pether 2008).

The great majority of the study area – including those portions that are likely to be directly affected by the proposed solar PV development - are underlain by a range of unconsolidated to semi-consolidated superficial sediments of Late Caenozoic age. These include **Quaternary to Recent sands and gravels** of probable fluvial or sheet wash origin (**Q-s_2** in Figure 2) that are locally overlain, and perhaps also underlain, by unconsolidated aeolian (*i.e.* wind-blown) sands of the Quaternary **Gordonia Formation** (**Kalahari Group**) (**Q-s_1** in Figure 2; orange dunes on satellite images, Figure 1). All these sediments can be subsumed into the Late Cretaceous to Recent **Kalahari Group**, the geology of which is reviewed by 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. Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8 Ma back to 2.588 Ma would place the Gordonia Formation almost entirely within the Pleistocene Epoch. A south-north trending drainage line with associated alluvial deposits is mapped outside and just to the east of the study area and is transected by the transmission line corridor to Aggenys Substation. It might be associated with Pleistocene or older fluvial deposits at depth.

Small **uranium deposits** (U) are mapped in the study area – probably associated with surface calcrete – as well as Creatceous **kimberlites** of the Gordonia Province (diamond symbol) (Agenbacht 2007, pp. 76-77)

PALAEONTOLOGICAL HERITAGE

To the author's knowledge, there are no previously recorded fossil sites within the present study area. The Mid-Proterozoic basement rocks of the **Namaqua-Natal Province** are entirely unfossiliferous and will therefore not be considered further here (*cf* Almond & Pether 2008, Almond 2012, Almond 2013).

The various younger superficial deposits of the Bushmanland and Karoo regions of South Africa, including aeolian sands, alluvium, calcretes and pan deposits, have been comparatively neglected in palaeontological terms. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Good examples are the Pleistocene mammal faunas at Florisbad, Cornelia and Erfkroon in the Free State and elsewhere (*e.g.* Cooke 1974, Skead 1980, Klein 1984, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al*. 1995, MacRae 1999, Churchill *et al*. 2000, Brink & Rossouw 2000, Rossouw 2006). In Bushmanland 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).

Other late Caenozoic fossil biotas from these arid-region superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant remains such as peats or palynomorphs (pollens, spores) in organic-rich alluvial horizons (Scott 2000) and siliceous diatoms in pan sediments. Calcrete hardpans might also contain trace fossils such as rhizoliths, termite nests and other insect burrows, or even mammalian trackways. Solution hollows within well-developed calcrete horizons may have acted as fossil traps in the past, as seen in Late Caenozoic limestones near the coast and Precambrian carbonate successions of the Southern African interior. Dense concentrations of vertebrate remains (*e.g.* small mammals, reptiles) or terrestrial molluscs, for example, are a possibility here. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest. Stone artefacts of Pleistocene and younger age may additionally prove useful in constraining the age of superficial deposits such as gravelly alluvium and pedocretes within which they are occasionally embedded.

The fossil record of the **Kalahari Group** as a whole is generally sparse and low in diversity; no fossils are recorded here in the recent Pofadder geology sheet explanation by Agenbacht (2007). 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 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. Subsurface or exposed 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 occasionally expected within Kalahari Group sediments and calcretes, notably those associated

with ancient alluvial gravels. Any younger fluvial and alluvial sands and gravels within the proposed development area are unlikely to contain any substantial fossil or subfossil remains.

CONCLUSIONS & RECOMMENDATIONS

The overall impact significance of the proposed Sol Invictus Solar PV development on fossil heritage is considered to be VERY LOW because:

- Most of the study area is underlain by unfossiliferous metamorphic basement rocks (gneisses *etc*) or mantled by superficial sediments of low palaeontological sensitivity;
- Most fossils within the superficial deposits are likely to be of widespread occurrence (*i.e.* not unique), with the exception of rare vertebrate remains;
- Extensive, deep excavations into older alluvial deposits are unlikely to be involved in this solar park project.

It is therefore recommended that exemption from further specialist palaeontological studies and mitigation be granted for this solar plant development.

Should substantial fossil remains be exposed during construction, however, the ECO should safeguard these, preferably *in situ*, and alert SAHRA as soon as possible so that appropriate action (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist.

5. REFERENCES

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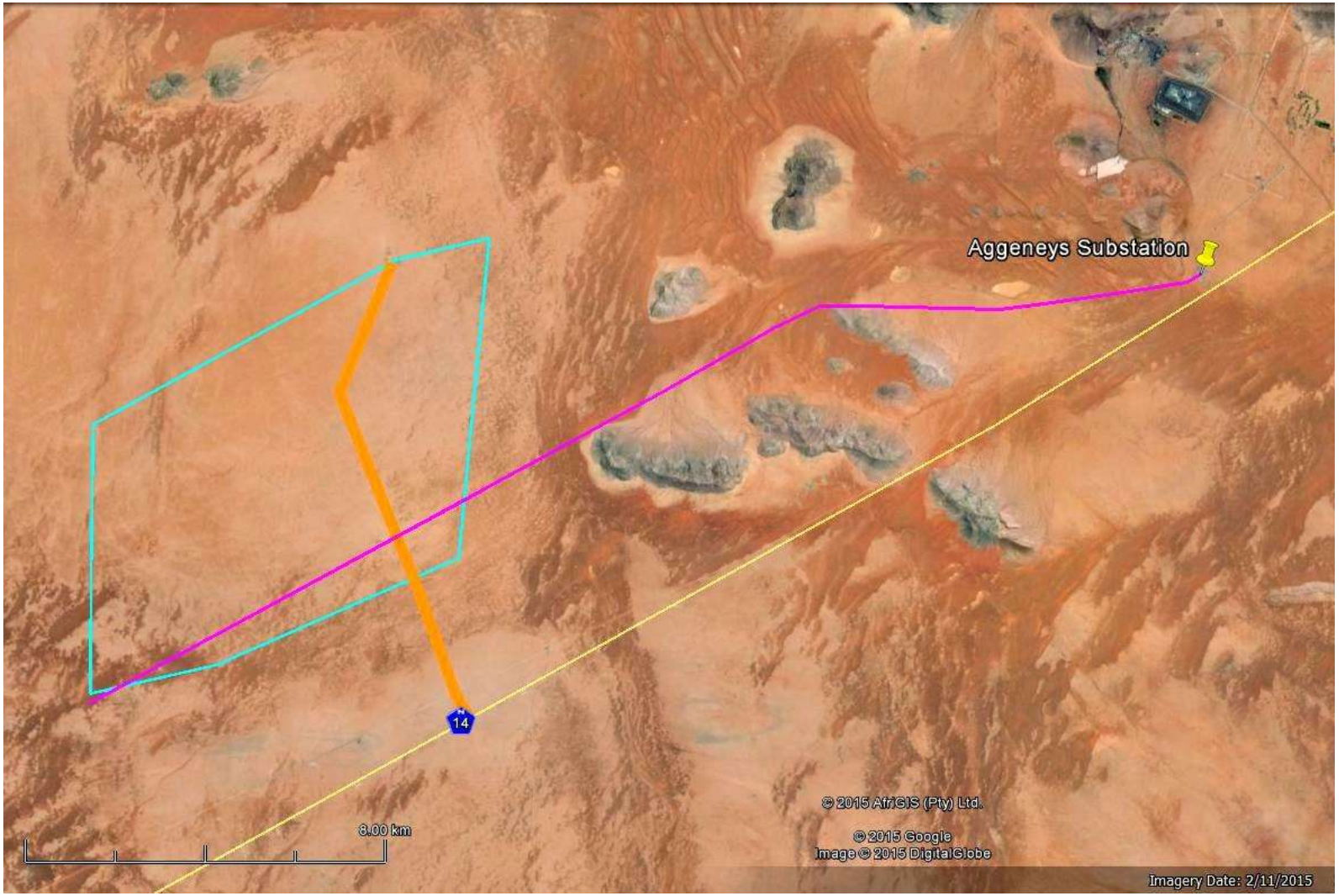

Figure 1. Google earth© satellite image of the study area for the Sol Invictus 600 MW Solar PV development on Portion 5 of Farm Ou Taaisbosmond located *c.* 35 km west-southwest of Aggeneys, Northern Cape Province showing scattered small Inselberge of Precambrian basement rocks to the southwest of the Black Mountain (grey) surrounded by a sea of wind-blown Kalahari sands (orange) and paler alluvial and sheet wash deposits (pale flesh-coloured, calcretised in much of the area). The pink line shows the proposed 132 kV overhead power line connection to Eskom's Aggeneys Substation. The existing access road from the N14 trunk road to the south is shown in orange.

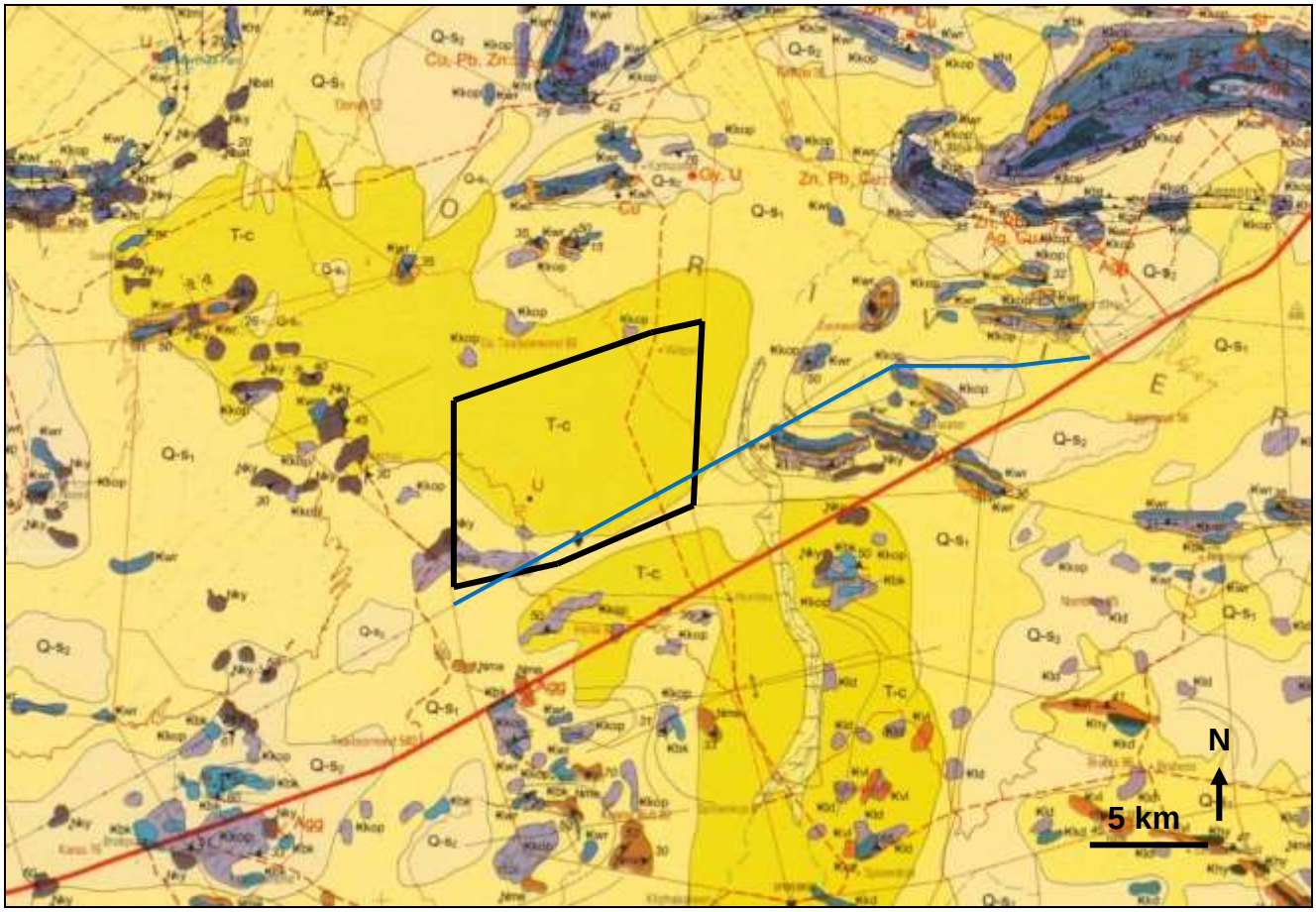

Figure 2. Extract from 1: 250 000 geological map 2918 Pofadder (Council for Geoscience, Pretoria) showing approximate location (black polygon) of the study area for the proposed Sol Invictus 600 MW Solar PV development on Portion 5 of Farm Ou Taaisbosmond 66 situated *c*. 35 km WSW of Aggeneys, Northern Cape. The blue line indicates the proposed 132 kV transmission line connection to Aggenys Substation.

Geological units mapped in the study area include:

(a) Mid Proterozoic (Mokolian) igneous and metamorphic basement rocks

Kwr (blue-grey & buff) = Wortel Formation (Bushmanland Group)
Kkop (grey) = Koeipoort Gneiss (Gladkop Metamorphic Suite)
Nky (brown) = Konkyp Gneiss (Little Namaqualand Suite)

(b) Late Caenozoic superficial sediments

Q-s_1 (medium yellow) = red aeolian sands of the Gordonia Formation (Kalahari Group) and Q-s_2 (pale yellow) = sand, scree, rubble and sandy soil
T-C (dark yellow) = Tertiary / Quaternary calcrete

(c) Mineral occurrences

U = uranium deposit
Diamond symbol = kimberlite

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 and Madagascar. 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 numerous palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape, Free State, Northwest, Mpumalanga and Gauteng under the aegis of his Cape Town-based company *Natura Viva* cc. He was 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 APHAP (Association of Professional Heritage Assessment 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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