Appendix G – Specialist Reports/Opinions:

G3b (Palaeontological Impact Assessment)

PALAEONTOLOGICAL SPECIALIST STUDY: COMBINED DESKTOP & FIELD-BASED ASSESSMENT

Four proposed solar PV projects on Farm Visserspan No. 40 near Dealesville, Tokologo Local Municipality, Free State Province

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January 2020

EXECUTIVE SUMMARY

Ventura Renewable Energy (Pty) Ltd is proposing to develop up to four solar PV facilities, each of up to 100 MW generation capacity, on the farm Visserspan No. 40, *c.* 10 km northwest of Dealesville and 68 km northwest of Bloemfontein, in the Tokologo Local Municipality, Free State Province.

Substantial direct impacts on fresh, potentially-fossiliferous Tierberg Formation (Ecca Group, Karoo Supergroup) bedrocks during the construction phase of the proposed PV solar projects are considered unlikely. The mapped outcrop areas of the Tierberg Formation within the PV solar project areas are small while the mudocks here are likely to be weathered near-surface and mantled by thick superficial deposits such as calcrete. In this region, the near-surface Ecca Group bedrocks are very often extensively disrupted and veined by Quaternary calcrete as well as baked by dolerite intrusions, compromising their palaeontological sensitivity. Potentially fossiliferous Pleistocene alluvial or spring deposits were not encountered in the study area, while pan and associated dune sediments here lie largely – but not exclusively - outside the development footprint. The calcrete hardpans encountered within the study area are of low palaeontological sensitivity. The only fossil remains recorded during the field survey comprise a few small blocks of petrified fossil wood – reworked from Tierberg bedrocks - among surface gravels around the margins of a pan in the SE corner of Visserspan No. 40, but *outside* the solar PV project area.

It is concluded that the palaeontological sensitivity of the four solar PV project areas on Farm Visserspan No. 40 near Dealesville is low. Anticipated impacts on local palaeontological heritage resources from the construction phase of the developments are accordingly also of LOW SIGNIFICANCE. This applies equally to all four of the proposed solar PV facilities whose cumulative impact significance would also be LOW. No further significant impacts are expected during the operational and decommissioning phases of the developments. There are no fatal flaws in the development proposals. Provided that the recommended mitigation measures outlined below and summarized in the Appendix are fully implemented, there are no objections on palaeontological heritage grounds to authorisation of the four PV solar facilities. The proposed associated grid connection to Eskom's Perseus substation has not been assessed here.

Should fossil remains such as bones, teeth, shells or petrified wood be discovered before or during the construction phase, these should be safeguarded (preferably *in situ*) and the ECO should alert the South African Heritage Resources Agency, SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). This is so that appropriate mitigation (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist (See tabulated Chance Fossil Finds Procedure appended to this report). The specialist involved would require a collection permit from SAHRA. Fossil material must be curated in an approved repository (*e.g.* museum or university collection) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA (2013).

1. INTRODUCTION & BRIEF

The company Ventura Renewable Energy (Pty) Ltd is proposing to develop up to four solar PV facilities, each of up to 100 MW generation capacity, on the farm Visserspan No. 40, situated approximately 10 km northwest of the small town of Dealesville and 68 km northwest of Bloemfontein, in the Tokologo Local Municipality, Free State Province (Figs. 1 & 2).

The following short project descriptions have been provided by EnviroAfrica CC:

- **Proposed Visserspan Solar PV Facility Project 1**

The proposed development is a solar photovoltaic (PV) array covering an area of around 218 ha, circumscribed with a perimeter fire access road and fence. The PV tables will be raised approximately 500 mm above ground level and will have single axis tracking systems allowing the generation of not more than 100 MW of alternating current. Proposed associated infrastructure includes a fenced construction staging area, maintenance shed/s, inverter-transformer stations on concrete pads and office buildings all within the 218ha proposed development site footprint, as well as a switch panel and an overhead powerline from the PV array for connection to the power grid, at Eskom's Perseus substation, south of the proposed development site.

- **Proposed Visserspan Solar PV Facility Project 2**

The proposed development is a solar photovoltaic (PV) array covering an area of around 211 ha, circumscribed with a perimeter fire access road and fence. The PV tables will be raised approximately 500 mm above ground level and will have single axis tracking systems allowing the generation of not more than 100 MW of alternating current. Proposed associated infrastructure includes a fenced construction staging area, maintenance shed/s, inverter-transformer stations on concrete pads and office buildings all within the 211 ha development site footprint, as well as a switch panel and an overhead powerline from the PV array for connection to the power grid, at Eskom's Perseus substation, south of the proposed development site.

- **Proposed Visserspan Solar PV Facility Project 3**

The proposed development is a solar photovoltaic (PV) array covering an area of around 213 ha, circumscribed with a perimeter fire access road and fence. The PV tables will be raised approximately 500 mm above ground level and will have single axis tracking systems allowing the generation of not more than 100 MW of alternating current. Proposed associated infrastructure includes a fenced construction staging area, maintenance shed/s, inverter-transformer stations on concrete pads and office buildings all within the 213 ha proposed development site footprint, as well as a switch panel and an overhead powerline from the PV array for connection to the power grid, at Eskom's Perseus substation, south of the proposed development site.

- **Proposed Visserspan Solar PV Facility Project 4**

The proposed development is a solar photovoltaic (PV) array covering an area of around 225 ha, circumscribed with a perimeter fire access road and fence. The PV tables will be raised approximately 500 mm above ground level and will have single axis tracking systems allowing the generation of not more than 100 MW of alternating current. Proposed associated infrastructure includes a fenced construction staging area, maintenance shed/s, inverter-transformer stations on concrete pads and office buildings all within the 225 ha proposed development site footprint, as well as a switch panel and an overhead powerline from the PV array for connection to the power grid, at Eskom's Perseus substation, south of the proposed development site. The proposed site falls on either side of an existing dirt road and is denoted as either 'east' or 'west' of the existing farm road.

The proposed solar PV facility developments fall within Renewable Energy Development Zone 5 and overlie potentially fossiliferous sediments of the Ecca Group (Karoo Supergroup) (*cf* Fourie *et al* 2014). Fossiliferous alluvial, pan and spring deposits of Pleistocene age are recorded in the broader Dealesville – Boshof region (*cf* Rossouw 2016). The proposed developments are subject to a Basic Assessment process that is being co-ordinated by EnviroAfrica CC, Somerset West (Contact details: Ms Vivienne Thomson, EnviroAfrica CC. Unit 7, Pastorie Park, Reitz St, Somerset West, 7130. Postal address: P.O. Box 5367, Helderberg, 7135. Fax: 086 512 0154. Tel.: 021 8511616. E-mail: vivienne@enviroafrica.co.za). The present report provides a consolidated assessment of potential impacts on palaeontological heritage resources for all four solar PV projects, excluding the proposed connection to Eskom's Perseus substation, together with recommendations for any mitigation or further specialist studies.

1.1. Legislative context of this palaeontological study

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (1999) include, among others:

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

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:
(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources Agency.
(2) All archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources Agency, or to the nearest local Agency offices or museum, which must immediately notify such heritage resources Agency.
(4) No person may, without a permit issued by the responsible heritage resources Agency—
(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.
(5) When the responsible heritage resources Agency has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—
(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
(c) if mitigation is deemed by the heritage resources Agency to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and
(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

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

Figure 1: Extract from 1: 250 000 topographical sheet 2824 Kimberley (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the approximate location (black rectangle) of the solar PV study area on the Farm Visserspan No. 40, situated approximately 10 km northwest of the small town of Dealesville and 68 km northwest of Bloemfontein, Tokologo Local Municipality, Free State Province. The location of Eskom's Perseus Substation *c*. 1.5 km south of the solar PV project area is indicated by the red triangle.

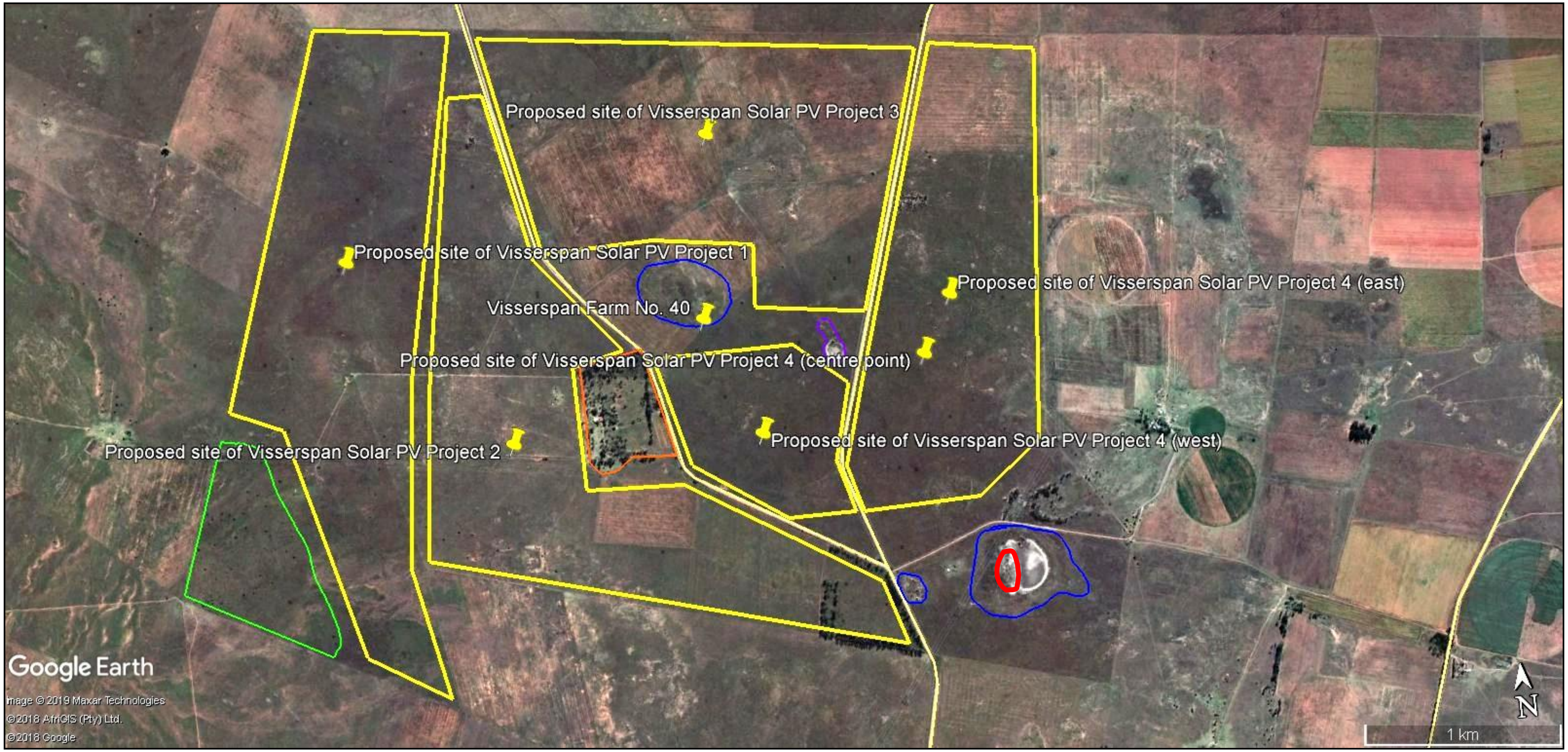

Figure 2: Google Earth© satellite image of the study areas (yellow polygons) for the four proposed solar PV facilities on the Farm Visserspan No. 40 near Dealesville, Free State Province. No-go areas (green, red), pan (blue) and dam (purple) areas are also shown. Note that much of the study area has been disturbed for agriculture and bedrock exposure is minimal. White areas around pan margins are calcrete. The small red ellipse indicates the approximate area along the pan margin where small dispersed blocks of petrified fossil wood were recorded among surface gravels. Note this site lies *outside* the solar PV project area.

Figure 3: Typical flat, grassy terrain with scattered domical termitaria on farm Visserspan No. 40 (here, the southern sector of the PV 1 project area)

Figure 4: Shallow pan in the PV4 (East) project area with no bedrock exposure seen due to pervasive grassy vegetation.

2. APPROACH TO THE PALAEONTOLOGICAL HERITAGE ASSESSMENT

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

1. Short project outlines and kmz files provided by EnviroAfrica CC, Somerset West;

2. A review of the relevant scientific literature, including published geological maps, satellite images, and previous fossil heritage assessments in the broader Dealesville - Boshof region (*e.g.* Almond 2012b, 2013b, 2013c, 2018, Rossouw 2006, 2016, Rossouw Undated 1 & 2);

3. The author's database on the formations concerned and their palaeontological heritage;

4. A one-day site visit by the author and an experienced field assistant on 11 January 2020. Fieldwork focused on areas with potential bedrock exposure, shallow pans, borrow pits and farm tracks.

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. The potential 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 Agency, *i.e.* the South African Heritage Resources Agency, SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

2.1. 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.

In the case of the solar PV project areas on Farm Visserspan No 40, the major limitation for fossil heritage assessment was the very low levels of bedrock exposure due to cover by largely unfossiliferous soils, calcrete hardpans and pervasive grassy vegetation (summer fieldwork). Confidence levels for this assessment are accordingly rated as MEDIUM.

3. GEOLOGICAL BACKGROUND

The Visserspan solar PV project areas lie within topographically-subdued, flat to very gently hilly *pannetjeisveld* terrain between *c*. 1280 and 1290 m amsl that typifies the region between Boshof and Bloemfontein in the Free State Province (Figs. 1 & 2). Maps and satellite images of the region are dotted with mumerous small to large, shallow rounded pans such as Annaspan 4 km to the NE of the project area and Dealesville Pan 6 km to the SE. There are several smaller, very shallow pans within the project area itself. Much of landscape here has already been transformed for agriculture. It is mostly grassy (especially in summer) with small eucalyptus plantations and numerous scattered domical termitaria. There is very little bedrock exposure indeed, with the exception of the margins of pans, dolerite boulders on the crests of some low elevations or *bulte* and occasional small borrow pits exploiting weathered dolerite (*sabunga*) and calcrete material.

The geology of the Dealesville area is shown on 1: 250 000 geological map 2824 Kimberley (Council for Geoscience, Pretoria) (Fig. 4) for which a short explanation has been published by Bosch (1993). Small outcrop areas of Permian marine basinal sediments of the **Tierberg Formation** (Ecca Group, Karoo Supergroup) (Pt, orange in Fig. 5) are mapped on Farm Visserspan No. 40 but were not encountered at surface due to soil and vegetation cover. Grey areas seen on satellite images appear on the ground to be due to vegetation rather than Tierberg shale bedrocks. The Tierberg Formation is a recessive-weathering, mudrock-dominated succession consisting predominantly of dark, well-laminated, carbonaceous shales with subordinate thin, fine-grained sandstones or wackes (Visser *et al.* 1977, Prinsloo 1989, Zawada 1992, Bosch 1993, Le Roux 1993, Viljoen 2005, Johnson *et al*., 2006). The Tierberg shales are Early to Middle Permian in age and were deposited in a range of offshore, quiet water environments below wave base. These include basin plain, distal turbidite fan and distal prodelta settings in ascending order (Viljoen 2005, Almond 2008). Thin coarsening-upwards cycles occur towards the top of the formation with local evidence of soft-sediment deformation, ripples and common calcareous concretions (often with well-developed cone-in-cone structures). A restricted, brackish water environment is reconstructed for the Ecca Basin at this time. Close to the contact with Karoo dolerite intrusions the Tierberg mudrocks are baked to a dark grey hornfels which often develops a reddish-brown crust or patina (Prinsloo 1989). Tough clasts of reworked hornfels are often well-represented in surface gravels overlying Ecca bedrocks and may be anthropogenically flaked. It is unlikely that shallow solar panel footings and underground cable trenches will intersect fresh (*i.e.* unweathered) Ecca sedimentary bedrocks within the project area.

In the Dealesville area the Tierberg Formationcountry rocks are extensively intruded by igneous bodies – including large sills - of the Early Jurassic **Karoo Dolerite Suite** (Jd, red in Fig. 5) (Duncan & Marsh 2006) (Figs. 6 to 10). The dolerite exposed in several small borrow pits is generally deeply-weathered (several meters) to friable, grey-green *sabunga*, often showing corestone and onionskin weathering. It is usually mantled and penetrated to depths of several meters by calcrete veins that may be of dm-scale thickness and prominent-weathering. On the margins of pits may occur a rubbly diamictite of weathered dolerite, calcrete and soil which probably represents consolidated excavation debris. Sparse float blocks of dolerite as well as rounded, cobble- to boulder-sized downwasted dolerite corestones occur in some areas, and have locally been piled along the margins of previous fields (Fig. 20).

The Palaeozoic and Mesozoic bedrocks in the Dealesville region are extensively mantled by **Late Caenozoic superficial deposits**, notably including pan and associated dune sediments, downwasted surface gravels (*e.g.* dolerite and calcrete rubble) and lateritic or sandy soils (possibly largely of aeolian origin). The pan deposits are extensively calcretised, as is usually the case in doleritic regions; this is seen by pale creamy hues along pan margins in satellite images (Figs. 2, 14 & 15). Calcretised aeolian dunes occur along the higher, eastern edges of several pans. Surface exposures of **calcrete** or **surface limestone** (Qc, dark yellow in Fig. 5) occur overlying the Karoo Dolerite Suite - the probable source of much of the carbonate, and are also associated with pan sediments overlying the Tierberg Formation and dolerite outcrops elsewhere (Figs. 11, 12 & 16). These pedogenic limestone deposits replace or displace the near-surface bedrocks to a depth of several meters. They reflect seasonally arid climates in the region over the last five or so million years and are briefly described for the Kimberley sheet area by Bosch (1993). Although calcrete is still forming in the study area today, it originally develops in the subsurface and when exposed at the surface is “almost definitely fossil” (Botha 1988). Key review papers on South African calcretes are those by Netterberg (1978, 1980 among other papers). Calcrete types commonly encountered include glaebular calcrete (with discrete nodules), honeycomb calcrete (with coalescent glaebules) and hardpan calcrete (solid limestone within at most minor voids). The surface limestones in the Kimberley sheet area may reach thicknesses of over 10 m, but – as in the present study area - are often much thinner, and are locally conglomeratic with clasts of reworked calcrete, mudchips as well as occasional exotic pebbles. The calcrete has been extensively used historically for building construction in this region, as with the main ruined farmstead on Farm Visserspan 40 (Fig. 13).

Throughout the study area the soils are mainly orange-brown hued, sandy to loamy, and thin to several meters thick (Figs. 18 to 20). Sparse dispersed gravels of reworked calcrete, dolerite, hornfels and wacke occur pervasively. The soils may be extensively bioturbated by aardvark and other vertebrate burrows and termitaria. Lines of stones probably mark clearance for fields (dominated by dolerite corestones, calcrete blocks). Surface gravels downwasted onto calcrete hardpans and around pan margins include clasts of calcrete, dolerite, hornfels (with abundant dark grey or brown-patinated hornfels flaked artefacts round pan margins), quartzite / wacke as well as dense dark grey matt-granular to shiny-patinated ironstone and rare fragments of silicified fossil wood. The small pans are floored by greyish-brown muddy sediment , extensively vegetated and desiccation-cracked (Figs. 15 & 17).

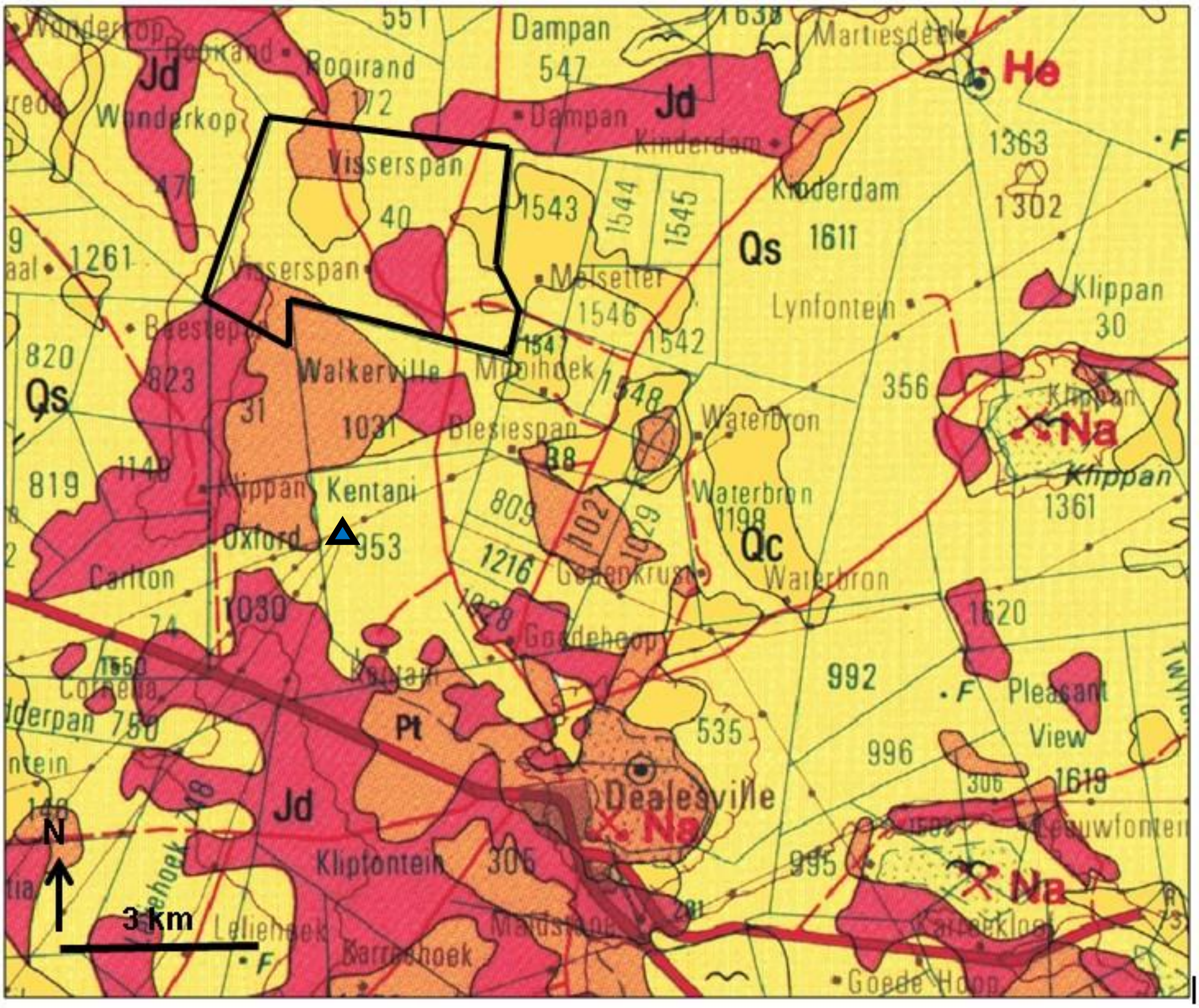

Figure 5: Extract from 1: 250 000 geological map 2824 Kimberley (Council for Geoscience, Pretoria). The farm Visserspan No. 40 is outlined in black. Rock units mapped here include: Early to Middle Permian basinal mudrocks of the Tierberg Formation (Ecca Group, Karoo Supergroup) (Pt, orange); Early Jurassic intrusions of the Karoo Dolerite Suite (Jd, red); Quaternary calcrete hardpans, pan and associated dune lunette sediments (Qc, dark yellow); Quaternary to Holocene orange sands, in part of aeolian origin (Qs, pale yellow). There are no major water courses in this topographically subdued region of Free State *pannetjiesveld*. The location of Eskom's Perseus Substation *c*. 1.5 km south of the solar PV project area is indicated by the blue triangle.

Figure 6: Circular quarry excavation or farm dam excavated into weathered dolerite, located between the Solar PV 3 and 4 (West) project areas.

Figure 7: Extensive, deeply-penetrating calcrete veining and hardpan around the western rim of the dolerite pit illustrated above.

Figure 8: Weathered dolerite on margins of borrow pit situated on the south-western edge of Solar PV 4 project area showing a thick inclined vein and sheet of subsurface calcrete (Hammer = 30 cm).

Figure 9: Onionskin weathering in dolerite sabunga, same pit as illustrated in the previous figure (Hammer = 30 cm).

Figure 10: Diamictite of interspersed blocks of weathered dolerite, calcrete and soil – probably the product of excavation, same pit as the previous two figures (Hammer = 30 cm).

Figure 11: Extensive near-surface calcrete hardpan overlying dolerite bedrocks, area just south of main ruined farmstead on Visserspan 40.

Figure 12: Detail of the exposed calcrete hardpan illustrated above (Hammer = 30 cm).

Figure 13: Calcrete blocks within the walls of the main ruined farmstead on Visserspan 40 (Hammer = 30 cm). These blocks provide good sections through the local calcrete hardpan in the search for bones / teeth / trace fossils and snail shells.

Figure 14: Sizeable shallow pan in the SE corner of Visserspan 40, *outside* the solar PV project areas. The raised far (eastern) edge is built up of wind-blown sediments forming a lunette on the lee side of the pan.

Figure 15: Southern margins of the pan shown in the previous illustration showing the rim of pale calcrete (some of which is reworked downslope from the adjoining raised pan rim) as well as the dark, organic-rich silty pan sediments (foreground).

Figure 16: Close-up of strongly-calcretised lunette sediments on the eastern rim of the pan shown above (Hammer = 30 cm).

Figure 17: Sun-cracked pan surface sediments with a veneer of sparsely dispersed gravels, mainly composed of pitted dark grey hornfels (many of these are flaked artefacts) (Hammer = 30 cm). This is the setting for the reworked petrified wood blocks shown in Figure 21. The pan is shown in Figure 15 above.

Figure 18: Gravels of calcrete, hornfels and quartzite weathering out onto a calcrete hardpan beneath sandy soils, margins of a shallow pit on the NE edge of Solar PV 2 project area.

Figure 19: Thick, orange-brown sandy soils overlying dolerite, Solar PV 1 project area (Hammer = 30 cm). The soils are extensively burrowed here.

Figure 20: Concentration of rounded dolerite corestones, probably cleared from adjoining fields, Solar PV 2 project area (Hammer = 30 cm).

5. PALAEONTOLOGICAL HERITAGE

Fossil occurrences already recorded from the main rock units represented in the study area are briefly reviewed in this section of the report, together with a short account of new fossil records made during the recent field survey.

The fossil record of the **Tierberg Formation** (Ecca Group) has been reviewed in detail by Almond (2008a). Rare body fossil records include disarticulated microvertebrates (*e.g.* fish teeth and scales) from calcareous concretions in the Koffiefontein sheet area (Zawada 1992) and allochthonous plant remains (drifted leaves, petrified wood). The latter become more abundant in the upper, more proximal (prodeltaic) facies of the Tierberg (*e.g.* Wickens 1984). Prinsloo (1989) records numerous plant impressions and unspecified “fragmentary vertebrate fossils” (possibly temnospondyl amphibians) within fine-grained sandstones in the Britstown sheet area. Dark carbonaceous Ecca mudrocks are likely to contain palynomorphs (*e.g.* pollens, spores, acritarchs). Bosch (1993) and Visser *et al.* (1977) briefly mention body fossils within the Tierberg mudrocks in the broader Kimberley region. Concretions within the lower part of the formation at Kaffirs Kop 193 (southeast of Belmont) and on Klippiespan 205 contain fish scales, coprolites and sponge spicules. Records of abundant silicified wood within the upper Tierberg succession near De Aar are better referred to the Waterford Formation (*cf* Almond 2012, 2013). Several small blocks (few cm across max.) of silicified fossil wood with a purplish hue and well-developed growth rings were encountered during the present field study in dispersed surface gravels along the western edge of the sizeable pan in the SE corner of Visserspan 40 (Fig. 21). Several similar petrified wood blocks have been collected on the farm by the current manager but precise locality details for these finds are not available (J. Kaplan, ACRM, pers. comm., 2019). The material has been reworked from the Tierberg Formation bedrocks in the region and presumably represents driftwood floating offshore in the Ecca Sea.

The commonest fossils by far in the Tierberg Formation are sparse to locally concentrated assemblages of trace fossils that are often found in association with thin event beds (*e.g.* distal turbidites, prodeltaic sandstones) within more heterolithic successions. A modest range of ten or so different ichnogenera have been recorded from the Tierberg Formation (*e.g.* Abel 1935, Anderson 1974, 1976, Wickens 1980, 1984, 1994, 1996, Prinsloo 1989, De Beer *et al*., 2002, Viljoen 2005, Almond 2008a). These are mainly bedding parallel, epichnial and hypichnial traces, some preserved as undertracks. Penetrative, steep to subvertical burrows are rare, perhaps because the bottom sediments immediately beneath the sediment / water interface were anoxic. Most Tierberg ichnoassemblages display a low diversity and low to moderate density of traces.

The **Karoo Dolerite Suite** bedrocks underlying large parts of the study area are high temperature igneous rocks and are themselves completely unfossiliferous. Baking of Tierberg country rocks by hot dolerite intrusions has probably compromised much of their original fossil heritage.

Figure 21: Small blocks of cherty silicified wood among surface gravels on the margins of pan in the SE corner of Farm Visserspan 40 (28º 36' 33.0" S, 25º 45' 19.8" E). The largest block is only 3.5 cm across.

The various **Late Caenozoic superficial deposits** in the broader region, include aeolian sands, calcretes and pan deposits. They are generally poorly known and usually of low sensitivity in palaeontological terms. However, older pan, spring and alluvial deposits may occasionally contain important Late Caenozoic fossil biotas, notably the bones, teeth and horn cores of mammals, hyaena lairs, as well as remains of reptiles like tortoises, non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), plant remains such as peats or palynomorphs (pollens, spores) in organic-rich alluvial horizons as well as 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. In particular, Pleistocene and older alluvial, pan and *vlei* deposits have yielded important fossil mammalian remains as well as stone artefacts in the Free State region (*e.g.* Skead 1980, Scott & Klein 1981, Klein 1984, MacRae 1999, Partridge & Scott 2000, Brink & Rossouw 2000, Churchill *et al.* 2000, Rossouw 2006, Rossouw undated). A very useful review of potential Pleistocene fossil remains associated with older alluvial, spring and pan (including dune lunette) deposits in the Dealesville area is provided by Rossouw (2016). Resistant-weathering clasts of petrified wood reworked from the Karoo bedrocks are occasionally found among downwasted gravels in the region, as reported above around local pan margins (Fig. 21). No trace fossils, fossil snails, teeth or bones were observed among calcrete blocks used in stone walling on Visserspan 40; these provided some of the freshest calcrete exposures in the study area (Fig. 13).

6. CONCLUSIONS & RECOMMENDATIONS

Substantial direct impacts on fresh, potentially-fossiliferous Tierberg Formation (Ecca Group, Karoo Supergroup) bedrocks during the construction phase of the proposed PV solar projects are considered unlikely. The mapped outcrop areas of the Tierberg Formation within the PV solar project areas are small while the mudocks here are likely to be weathered near-surface and mantled by thick superficial deposits such as calcrete. In this region, the near-surface Ecca Group bedrocks are very often extensively disrupted and veined by Quaternary calcrete as well as baked by dolerite intrusions, compromising their palaeontological sensitivity. Potentially fossiliferous Pleistocene alluvial or spring deposits were not encountered in the study area, while pan and associated dune sediments here lie largely – but not exclusively - outside the development footprint. The calcrete hardpans encountered within the study area are of low palaeontological sensitivity. The only fossil remains recorded during the field survey comprise a few small blocks of petrified fossil wood – reworked from Tierberg bedrocks - among surface gravels around the margins of a pan in the SE corner of Visserspan No. 40, but *outside* the solar PV project area.

It is concluded that the palaeontological sensitivity of the four solar PV project areas on Farm Visserspan No. 40 near Dealesville is low. Anticipated impacts on local palaeontological heritage resources from the construction phase of the developments are accordingly also of LOW SIGNIFICANCE. This applies equally to all four of the proposed solar PV facilities whose cumulative impact significance would also be LOW. No further significant impacts are expected during the operational and decommissioning phases of the developments. There are no fatal flaws in the development proposals. Provided that the recommended mitigation measures outlined below and summarized in the Appendix are fully implemented, there are no objections on palaeontological heritage grounds to authorisation of the four PV solar facilities. The proposed associated grid connection to Eskom’s Perseus substation has not been assessed here.

Should fossil remains such as bones, teeth, shells or petrified wood be discovered before or during the construction phase, these should be safeguarded (preferably *in situ*) and the ECO should alert the South African Heritage Resources Agency, SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). This is so that appropriate mitigation (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist (See tabulated Chance Fossil Finds Procedure appended to this report). The specialist involved would require a collection permit from SAHRA. Fossil material must be curated in an approved repository (*e.g.* museum or university collection) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA (2013).

7. ACKNOWLEDGEMENTS

Ms Vivienne Thomson of EnviroAfrica CC. Somerset West, is thanked for commissioning this study and for providing the relevant project information. I am also grateful to Mr Jonathan Kaplan of ACRM, Rondebosch, for additional field data and photographs, as well as to Ms Madelon Tusenius for logistical support and companionship in the field. Access to the study areas on Visserspan No. 40 was kindly facilitiated by Mnr Dries Nel and Mnr Paul Gous.

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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, Mpumalanga, Free State, Limpopo, Gauteng, Northwest and KwaZulu-Natal under the aegis of his Cape Town-based company *Natura Viva* cc. He has been 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.

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

<table>
<tr><td colspan="3">APPENDIX. CHANCE FOSSIL FINDS PROCEDURE: PV solar projects on Farm Visserspan No. 40 near Dealesville, Free State Province</td></tr>
<tr><td>Province & region:</td><td colspan="2">Free State Province, Tokologo Local Municipality</td></tr>
<tr><td>Responsible Heritage Resources Agency</td><td colspan="2">SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za)</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Permian Tierberg Formation (Ecca Group), Late Caenozoic pan sediments, calcrete hardpans.</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Petrified wood, rare vertebrate remains in Tierberg mudrocks. Mammalian teeth, bones and horncores (e.g. associated with hyaena dens), fossil peats, non-marine molluscs and trace fossils (e.g. calcretised termitaria, burrows) within Caenozoic sediments.</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
• Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
• Context – describe position of fossils within stratigraphy (rock layering), depth below surface
• Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
• Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation
• Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Agency for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
• Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
• Photograph fossils against a plain, level background, with scale
• Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
• Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
• Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Agency, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Resources Agency</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Agency. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Agency minimum standards.</td></tr>
</table>