Palaeontological Impact Assessment for Proposed establishment of the Swartwater Solar energy Facility, Eastern Cape

Prepared for: USK Environmental & Waste (Pty) Ltd

23 Ray Craib Cresent, Beacon Bay
East London,
5241
www.uskconsulting.com

Compiled by: Robert Gess (PhD)
Rob Gess Consulting
(Research Associate of the Albany Museum)

Box 40
Bathurst
6166
robg@imaginet.co.za

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Background

USK Environmental & Waste (Pty) Ltd was appointed as the Environmental Assessment Practitioners to manage the Environmental Impact Assessment Process for the proposed 75 MW Solar Energy Facility on portions 7 and 9 of De Put Farm located near Petrusville Northern Cape.

Rob Gess consulting were subcontracted to carry out a Palaeontological Impact Assessment of the land portions. This was conducted in June 2013. Subsequently a smaller area has been identified within the surveyed area, for phase one of the project.

Geology and Palaeontology

According to the Geological Survey map 3024 Colesberg, the area is largely underlain by sediments of the Tierberg Formation of the Permian aged upper **Ecca Group** (**Karoo Supergroup**). These are intruded by dolerite dykes and sills and mantled by Pleistocene to Recent cover, including calcretised duricrust. Almond (2012) has extensively reviewed the geology of an area east of De Aar and concluded that sedimentary strata there, also mapped as Tierberg Formation, are more likely to represent the Waterford Formation (uppermost Ecca Group, Karoo Supergroup). It is possible that some sediments within this study area may also represent lower Waterford Formation strata.

The strata of the **Karoo Supergroup** were deposited within the Karoo sedimentary Basin, which resulted from shortening and thickening of the southern margin of Africa, with coeval folding and uplift of the Cape Supergroup strata along its southern margin. The Karoo Supergroup strata are between 310 and 182 million years old and span the Upper Carboniferous to Middle Jurassic Periods. During this interval the basin evolved from an inland sea flooded by a melting ice cap, to a giant lake fed by seasonal meandering (and at times braided) rivers. This lake steadily shrank as it filled with sediment and the basin’s rate of subsidence stabilised. The land became increasingly arid and was covered with wind blown sand towards the end of its cycle. Finally the subcontinent was inundated with basaltic lava that issued from widespread linear cracks within the crust, to form the capping basalts of the Drakensberg Group.

During the formation of the Dwyka, beginning in the Late Carboniferous, southern Africa had drifted over the south pole, whilst simultaneously, the world was experiencing a cold episode. Glaciers flowing into the flooded Karoo basin broke up, melted and discharged a mixture of finely ground rock flour and rough chunks of rock. These formed the matrix and clasts of the Dwyka tillite (Dwyka Group, Karoo Supergroup).

Early in the Permian period the ice sheets retreated and sediment carried by rivers into the Ecca Lake formed the deposits of the **Ecca Group** (Karoo Supergroup). These rivers formed deltas where they flowed into the Ecca Lake. Proximally the deltas tended to be sandy. Mud accumulating on the more distal front of the deltas periodically slumped and cascaded down into deep water, spreading out and depositing large layered fan shaped turbidite deposits.

As the Ecca Lake silted up more shallow-water deposits were formed, which were in turn overlain by subaerial deposits of the Beaufort Group.

The upper Ecca Group sediments of the Tierberg Formation are known to contain plant fossils, including fossil wood, microvertebrate remains in the form of fossil teeth and scales of fish and a diverse range of trace fossils. These were largely produced by invertebrates, though fish trails are also known. Terrestrial vertebrate fossils have as yet not been recorded though presence of terrestrial plant remains indicates that their presence would not be impossible.

Dolerite dykes and sills were emplaced during the Jurassic, at the time of eruption of the Drakensberg Formation (Stormsberg Group, Karoo Supergroup) basalts. Where magma cooled within vertical fissures in the crust, or in horizontal sheets injected between sedimentary layers it formed dolerite. Lydianite, a blackish hornfels was often created through metamorphism of shale in close proximity to the intrusions. Being magmatic in origin dolerite contains no traces of life. In the Karoo dolerite is far more resistant to weathering and erosion than the dominant mudstones and tends to stand out as koppies, linear ridges and hill cappings.

The more deeply weathered plains are commonly underlain by sedimentary shale and mudstone . This is covered with geologically recent alluvium and, in places, calcrete hardpan resultant from lengthy erosional stasis. Calcretes, particularly those near springs, are known to yield animal bones up to hundreds of thousands of years old. These include the remains of tortoises, large mammals and very rarely early modern humans. Middle Stone Age artifacts are also sometimes found embedded in calcretes.

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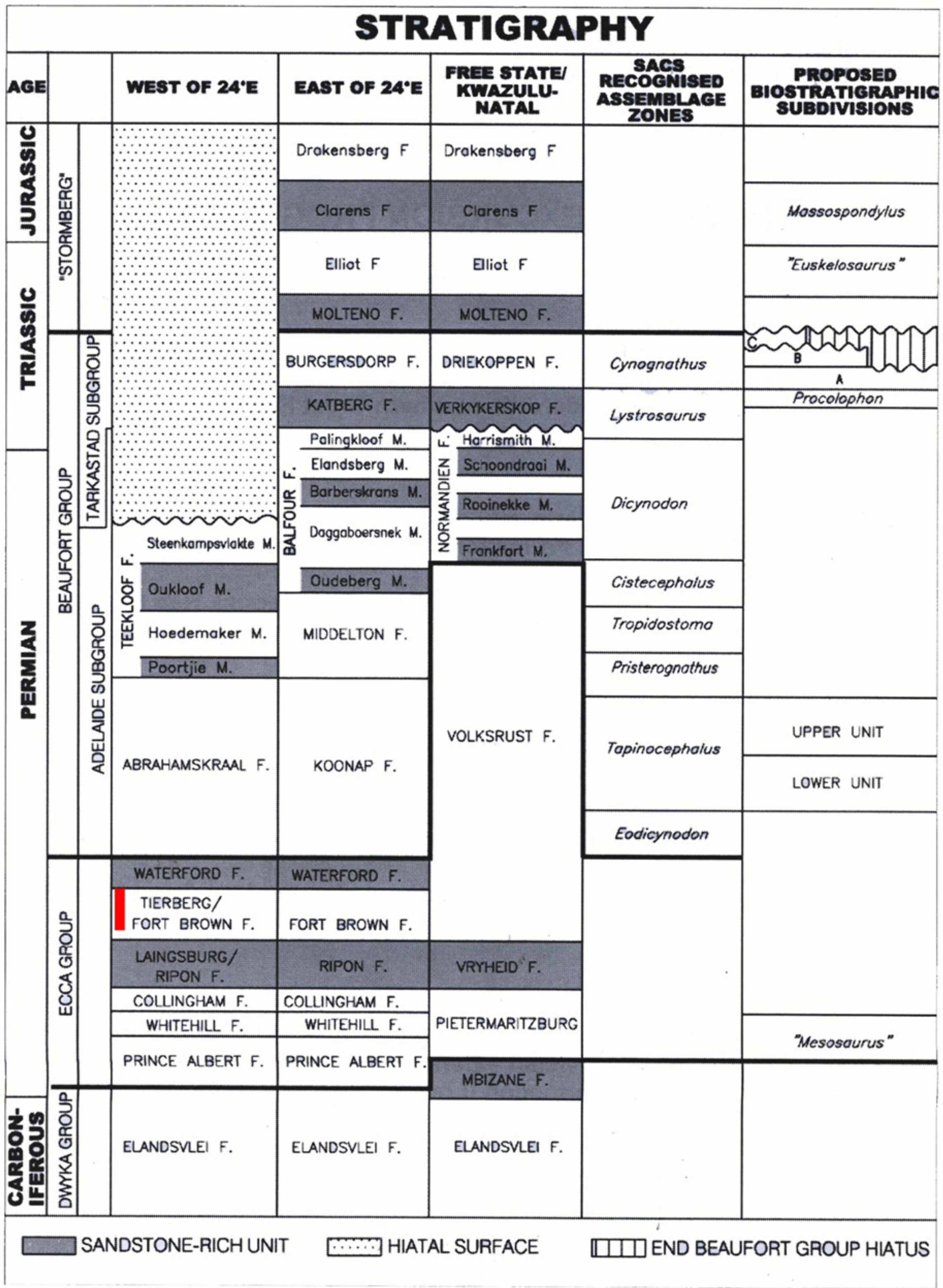

Figure 1: Karoo stratigraphy and biostratigraphy (after Smith *et al*., 2012). Red lines indicate approximate stratigraphic interval impacted by proposed development.

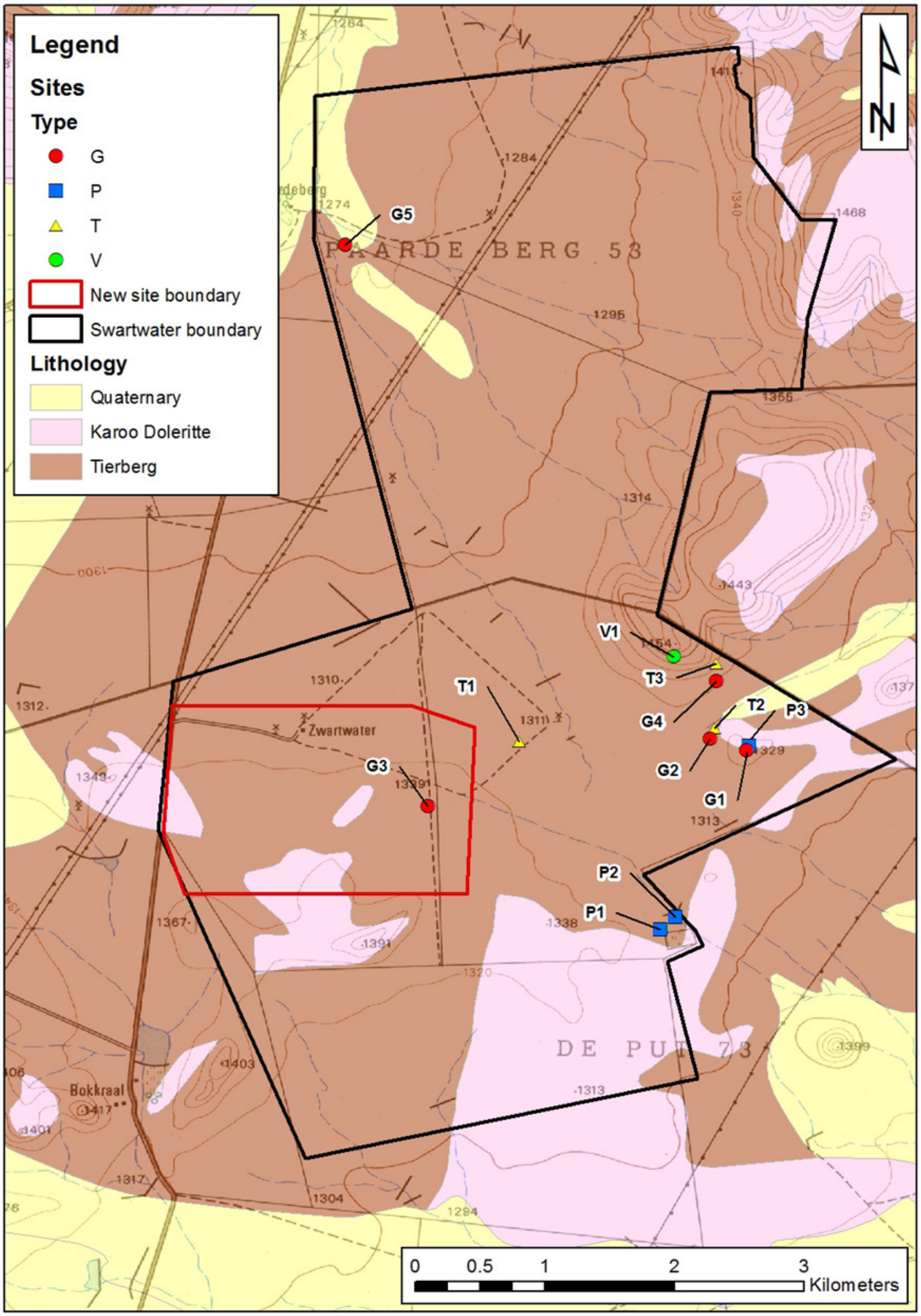

Figure 2: Published geological survey data and borrow pit positions superimposed on 1: 50 000 topographic map data.

Site Visit

The entire land parcel was surveyed on foot and with a vehicle between the 24th and 26th of June 2013. Most of the area consists of a flat plain (Fig.3) covered in a veneer of recent soily alluvium. This is thinnest towards the south where the bedrock of greenish mudstones and thin sandstones is intermittently exposed in washouts and trackways.

Figure 3: Panoramic view of the study area from near V1.

In the north-west the plain slopes downwards towards a small river tributary, and is cut by a number of drainage channels. Erosional removal of superficial alluvium reveals a thick calcrete layer (Fig.4). This was extensively surveyed however no fossil bones were discovered. Palaeontological material was limted to small invertebrate burrow traces or possibly root casts (Fig.5). A layer of deflated gravel scattered across the surface of the calcrete hardpan was seen to be very rich in Middle Stone Age lydianite flakes (Fig.6).

Figure 4: Calcrete hardpan layer revealed by wash away of overlying soily alluvium (back, left) at G5, Fig.2.

Figure 5: Small invertebrate traces or root casts in lime hardpan near G5, Fig.2.

Figure 6: Stone Age flakes made of Lydianite scattered on a deflation surface near G5, Fig.2.

A line of hills that define the north eastern boundary of the land parcel are capped by remnants of a dolerite sill. This is supplemented in the north by a dolerite dyke that cuts the hillside. The dolerite sill extends as far as V1 (Fig.1), contrary to the map (Fig.7). The slopes of these hills are, by and large, mantled by weathered dolerite debris in the form of scree and soil. This largely obscures all underlying sedimentary strata. This is also true of hills in the west of the study area which extend into the Phase 1 project area ('new site boundary', Fig.2), which are likewise crested by dolerite and mantled by scree (Fig.8).

Figure 7: Dolerite from hilltop defining sill. Looking south from near V1, Fig.2.

Figure 8: View of proposed Phase 1 developmental area (middle distance), showing small dolerite hills (taken from near VI, Fig.2).

On the southern side of the hills near T3, Fig.2, greenish shale and sandstone layers are exposed in the hillside by small gullies (Figs.9, 10). Here, trace fossils are preserved at the confluence between the sandstone and shale (Figs 11, 12).

Figure 9: Green shale exposed in hillside at T3 (Fig.2)

Figure 10: Sandstone exposed in hillside near T3 (Fig.2) with possible vertical burrow cast.

Figure 11: Sole mark of vertical invertebrate burrow and horizontal trace near T3 (Fig.2).

Fig 12: Trace fossil of spiral infaunal invertebrate burrow near T3 (Fig.2).

Similar outcrop occurs across a drainage depression to the south, along the ridge at G1 (Fig.2). Despite this ridge being shown on the map as being capped with dolerite the crest is actually defined by a sandstone layer (Fig.13). Just below the ridge, to the north, fossil ripple marks and invertebrate trace fossils were noted in the shale, as well as fragments of petrified, "*Dadoxylon*" wood (P3, Fig.2) (Figs.14, 15).

Figure 13: Sandstone and shale exposed along the top of a ridge at G1 (Fig.2).

Figure 14: Ripple casts in mudstone near G1 (Fig.2).

Figure 15: Silicified wood (*left*) and horizontal invertebrate trace fossils (right) near G1.

Outcrop of finer grained, darker green, stratigraphically lower mudstone was located in a drainage gulley between the above two outcrops, at G2 (Fig.2) (Fig.16). An orange coloured carbonate rich sandstone interbed is also exposed (Fig.17). Abundant brown spheroidal ferruginous diagenetic carbonate concretions, featuring cone in cone structures, are found in both the shales and the sandstone at this point (Figs. 18-20). Similar shale containing carbonate nodules was observed at G4 (Fig.2). Trace fossils were noted at T2 (Fig,2) (Fig.21). A piece of sandstone occurring as drift at T1 (Fig 2) was also found to preserve vertical and horizontal invertebrate trace fossils (Fig. 23).

Figure 16: Dark green mudstone exposed in a gulley at G2 (Fig.2).

Figure 17: Orange coloured carbonate rich sandstone interbedded with green shale at G2 (Fig.2).

Figure 18: Cross section of brown spheroidal ferruginous diagenetic carbonate concretion, featuring cone in cone structures at G2 (Fig.2)

Figure 19: Ferruginous carbonate nodules in dark green shale near G2 (Fig.2).

Figure 20: Ferruginous carbonate nodules in carbonate rich sandstone near G2 (Fig.2).

Figure 21: Invertebrate trace fossils at T2 (Fig.2).

Figure 22: Sinuous trace fossil or plant axis near G2 (Fig.2).

Figure 23: Horizontal and vertical invertebrate trace fossils in isolated slab of sandy rock at T1 (Fig. 2).

Greenish shale and sandy interbeds occur sporadically to the south of these outcrop areas. At P2 (Fig.2) sandy shale horizons are well exposed in the spillway of a small dam (Fig.24). These contain fossilised plant stems (Fig. 25). This same horizon outcrops along the north-south trackway and plant stems were seen at P1 (Fig.2) (Fig.26). Similar sandy shale outcrops also occur alongside the track in the Phase 1 project area at G3 (Fig.2) though fossils were not found there.

Figure 24: Sandy shale exposed in dam spillway at P2 (Fig.2).

Figure 25: Fossil plant stems, including probable Sphenophyte stems (left) at P2 (Fig.2)

Figure 26: Fossil plant stem at P1 (Fig 2).

Conclusions and Recommendations

Although the entire land parcel was explored only limited outcrop was discovered. Where Ecca Group outcrop occurred, palaeontological material in the form of silicified wood, impressions of plant stems and fairly diverse invertebrate trace fossils were located. None of these were, however, of remarkable value.

Within the Phase one project area sedimentary outcrop was extremely scarce, consisting solely of sandy greenish shale belonging to a type that, further to the east, was found to contain plant stem impressions. It may be concluded that beneath a thin veneer of recent alluvium much of the low lying ground of the initial development area is underlain by this horizon.

Within the initial development area it is therefore **probable** that plant stem impressions will be disturbed during excavation of cable trenches. These stems are however of **low significance** and their disturbance would be of **low severity**.

It is also **possible** that other palaeontological material, such as large portions of silicified tree trunk will be **disturbed**. These would be **moderately significant**.

It is **improbable** that fossil vertebrate bones or fish impressions will be disturbed, though this would be **highly significant** and of international interest.

It is therefore recommended that no **further palaeontological survey work or excavation will be required prior to the commencement of work**. **No monitoring of excavations by a palaeontologist will be required.**

Should any large portions of silicified wood, any fossil bones or impressions of fish be disturbed during development of the site SAHRA or a qualified palaeontologist should immediately be notified.

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