Palaeontological Heritage Impact assessment for a proposed Albany Windfarm, east of Makhanda/Grahamstown.

Prepared for: Coastal & Environmental Services

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Background

“Albany Wind Power (Pty) Ltd (DWP) is a special purpose vehicle (SPV) created by InnoWind (Pty) Ltd, a South Africa based renewable energy generator that develops, finances, builds, operates and maintains commercial wind powered generation facilities. InnoWind’s development and operating expertise has been acquired through its French parent company EDF Energies Nouvelles, which is the renewable energy arm of the French power utility EDF.

Albany Wind Power (Pty) Ltd, plans to develop, construct and operate a Wind Energy Facility (WEF) approximately seven kilometres east of Makhanda/Grahamstown in the Eastern Cape Province. The project site is situated in Makana Local Municipality which forms part of the Sarah Baartman District Municipality. According to the data recorded by InnoWind in the area, this project site appears to have favourable wind conditions to operate a wind energy facility.

The revised proposed Albany WEF will consist of up to 43 turbines each with a 3900 m^2base. The WEF will also include a short powerline and switching station in order to connect the WEF to the existing Eskom Substation.

Coastal and Environmental Services have been appointed to carry out a full Environmental Impact Assessment for the above windfarm spanning an area on average 30 km east of Grahamstown. In response to feedback from previous surveys and applications the layout plan has been revised twice, with this report referring to the third proposed layout, that of August 2020.

Rob Gess Consulting was contracted to conduct a phase one Palaeontological Impact Assessment for this proposed development. He has previously contributed to two EIAs for the previous two layouts. As many of the tower positions have previously been surveyed by Rob Gess Consulting, in 2020 Rob Gess Consulting principally surveyed new positions (that is those of turbines 15, 21, 31, 44, 46, 68, 71) and their environs.

Geology and Palaeontology

The general area intended for development overlies strata of the Witteberg Group, the upper portion of the Cape Supergroup and the glaciogenic Dwyka Formation, lowermost portion of the unconformably overlying Karoo Supergroup. Both of these are, in part, capped by relict patches of Silcrete formed as a product of deep leaching during the Cretaceous period. This leaching reciprocally reduced underlying mudstones and diamictite to kaolinite.

Cape Supergroup rocks represent sediments deposited in the Agulhas Sea, which had opened to the south of the current southern African landmass, in response to early rifting between Africa and South America during the Ordovician period. The Witteberg Group is the uppermost of three subdivisions of the Cape supergroup and was laid down during the Late Devonian and early Carboniferous periods.

Superimposition of the planned tower positions onto geological map data of the area (Figure 1) suggest that wind towers are to be sited on strata belonging to the Witpoort Formation, and the overlying Lake Mentz subgroup, of the Witteber g Group, as well as silcrete overlying the former. This was confirmed during the surveys.

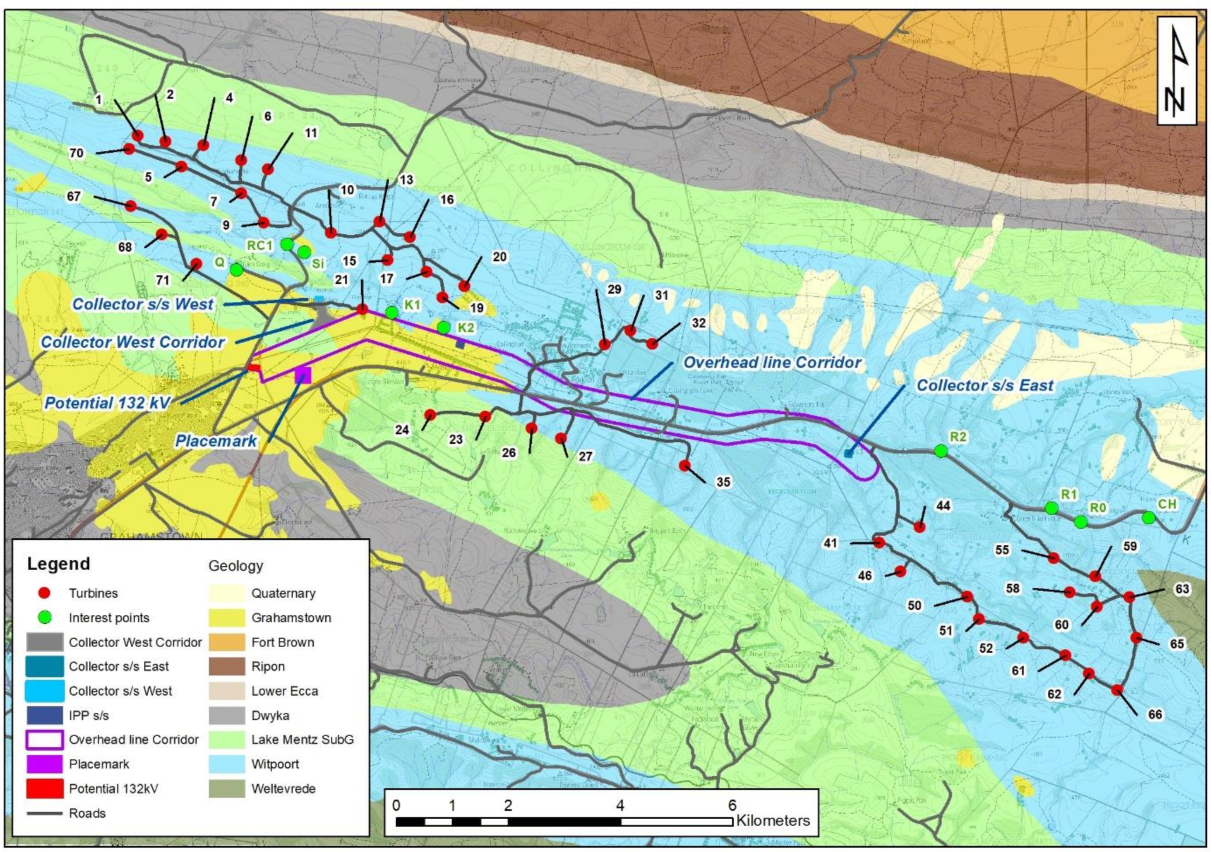

Figure 1: Superimposition of proposed tower points on a geological survey map of the study area, with additional points of interest marked.

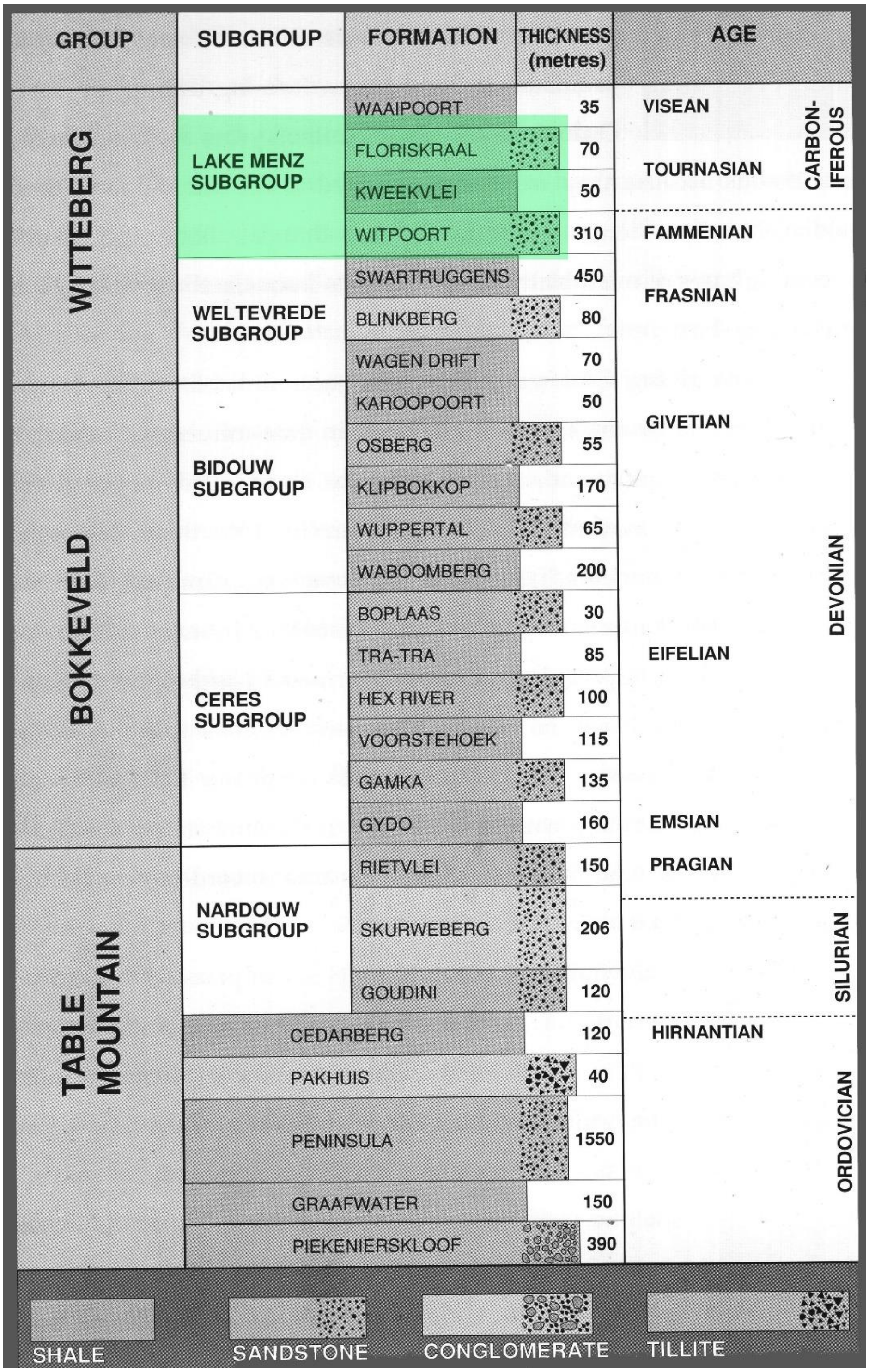

Figure 2: Stratigraphic column of the Cape Supergroup modified after Theron and Thamm (1990) following Cotter (2000). Green area indicates strata impacted by the development.

The majority of wind towers have been sited along resilient quartzites of the Witpoort Formation. These are folded up into a series of giant north-east to south-west trending anticlinal folds that define the parallel ridges of the Blaaukrantz basin hills, and the Kap River Hills both of which converge obliquely with the largest of all, that which defines the structure of Governors Kop and Botha's Ridge. A minority of proposed positions (23, 24, 26 and 27) are situated on the flanks of this anticlinal ridge, on the stratigraphically overlying Lake Mentz subgroup. Proposed position 68, on the southernmost slopes of Bothas Hill is also (superficially at least) situated over strata of the lowermost Lake Mentz subgroup. Field survey indicates that the proposed positions of turbines 19 and 21 are situated where silcrete overlies degraded Witpoort Formation mudstone.

The Witpoort Formation is Famennian (uppermost Devonian) in age. That is approximately 359 to 372 million years old. It is a largely quatzitic unit representing mature sandy strata deposited along a linear barrier island type coast. The lower portion of the Witpoort Formation tends to have a brownish weathering character, whereas the upper portion (sometimes referred to as the Perdepoort Member) tends to comprise much cleaner whiter weathering quartzites. Particularly around Makhanda/Grahamstown black shale lenses are interbedded within the Witpoort Formation quartzites. These are interpreted as estuarine deposits preserved during brief transgressive events, and have proven remarkably fossiliferous.

A series of lenses at Waterloo Farm, to the south of Grahamstown, have provided southern Africa's most important Late Devonian locality, representing an entire coastal estuarine ecosystem and adjacent terrestrial environment. It has yielded fragmentary remains of Africa's earliest known four legged animals, the aquatic tetrapods, *Tutusius umlambo* and *Umzantsia amazana* and at least 20 taxa of fossil fish (including jawless fish (Agnatha), armoured fish (Placodermi), spiny sharks (Acanthodii), sharks (Chondrichthyes), ray finned fish (Actinopterygii) and lobe finned fishes (Sarcopterygii) including Coelacanths (Actinistia), lungfish (Dipnoi) and Osteolepiformes. Of these nine have as yet been described including the world's oldest lamprey fossil, *Priscomyzon riniensis*, and Africa's earliest coelacanth from the world's oldest known coelacanth nursery, *Serenichthys kowiensis*. Seaweeds, brack water charophytes and fresh to brack water bivalves have been described and a giant Eurypterid identified. The terrestrial realm is represented by the remains of a scorpion, *Gondwanascorpio emzantsiensis*, the oldest known terrestrial animal from the supercontinent Gondwana, Dozens of land plant taxa have been revealed, including zosterophylls, lycopods (eg. *Kowieria alveofolis*), iridopteralians, sphenophytes (eg *Rinistachya hilleri*) and early progymnosperms, such as *Archaeopteris notosaria*, southern Africa's earliest known fossil tree. Abundant trace fossils have also been collected. Witpoort Formation quartzites have yielded a range of plant stem taxa and trace fossils. Lag deposits of bone have not, as yet, been discovered, but may be expected.

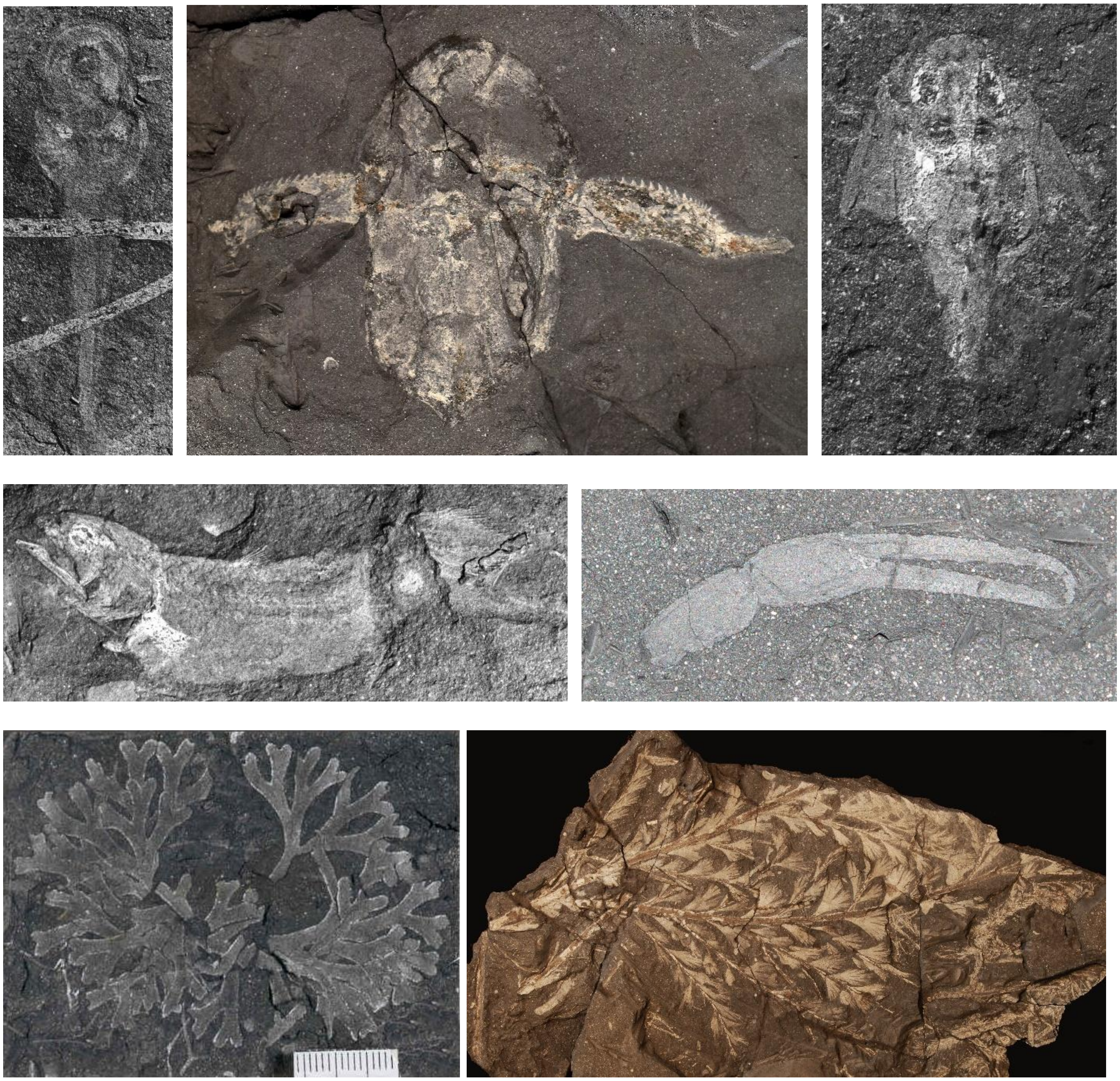

Figure 3: Selection of fossils recovered from a black shale lens at Waterloo Farm: *top left*, 4.2 cm long *Priscomyzon riniensis* (the world's oldest fossil lamprey); *top middle*, 6.5 cm long head and trunk armour of a young *Bothriolepis Africana*, an antiarch placoderm fish; *top right*, 2.5 cm long neonatal *Groenlandaspis riniensis*, an arthrodire placoderm fish; *middle left*, 5.5 cm long type specimen of the coelacanth *Serenichthys kowiensis*; middle left, 3,4 cm long pincer of the scorpion, *Gondwanascorpio emzantsiensis* (the oldest known terrestrial animal from Gondwana); *bottom left*, 7 cm across tuft of the seaweed *Hungerfordia fionae*; *bottom right*, 30 cm long fronds of the progymnosperm tree *Archaeopteris notosaria* (the oldest known species of woody tree from southern Africa).


Figure 4: Fossils in quartzites at Waterloo Farm: left lycopod *Leptophloem rhombicum* stems; right, progymnosperm *Archaeopteris* trunk.

In 2015, roadworks at Coombs Hill and Rabbit Ridge, immediately adjacent to the present study area (see Fig.1., Information Points R0-R2, CH) uncovered a number of palaeontologically important black shale lenses. Those along Rabbit Ridge (Information Points R0-R2) represented exposure of an extensive vertically tilted black shale horizon that yielded evidence for a monotaxic assemblage of lingulid brachiopods in a back-barrier tidal flats environment. This represented the first record of predominantly marine invertebrate shells within the Witpoort Formation. These sites also produced fragmentary plant remains and extensive trace fossils.


Figure 5: *left*, Lingulid brachiopods and a lycopod stem on a slab from Rabbit ridge; *right*, Chris Harris, chief excavator of Rabbit Ridge and Coombs Hill at a shale outcrop on Rabbit Ridge in 2015.

The roadworks at Coombs Hill (Fig.1, Information Point CH) revealed a number of black shale horizons, which contained more than one species of bivalve, in addition to a wealth of plant fossils, some of which are remarkable well preserved. Plant fossils included lycopod taxa new to science and the best preserved fronds of the progymnosperm tree, *Archaeopteris notosaria* known.

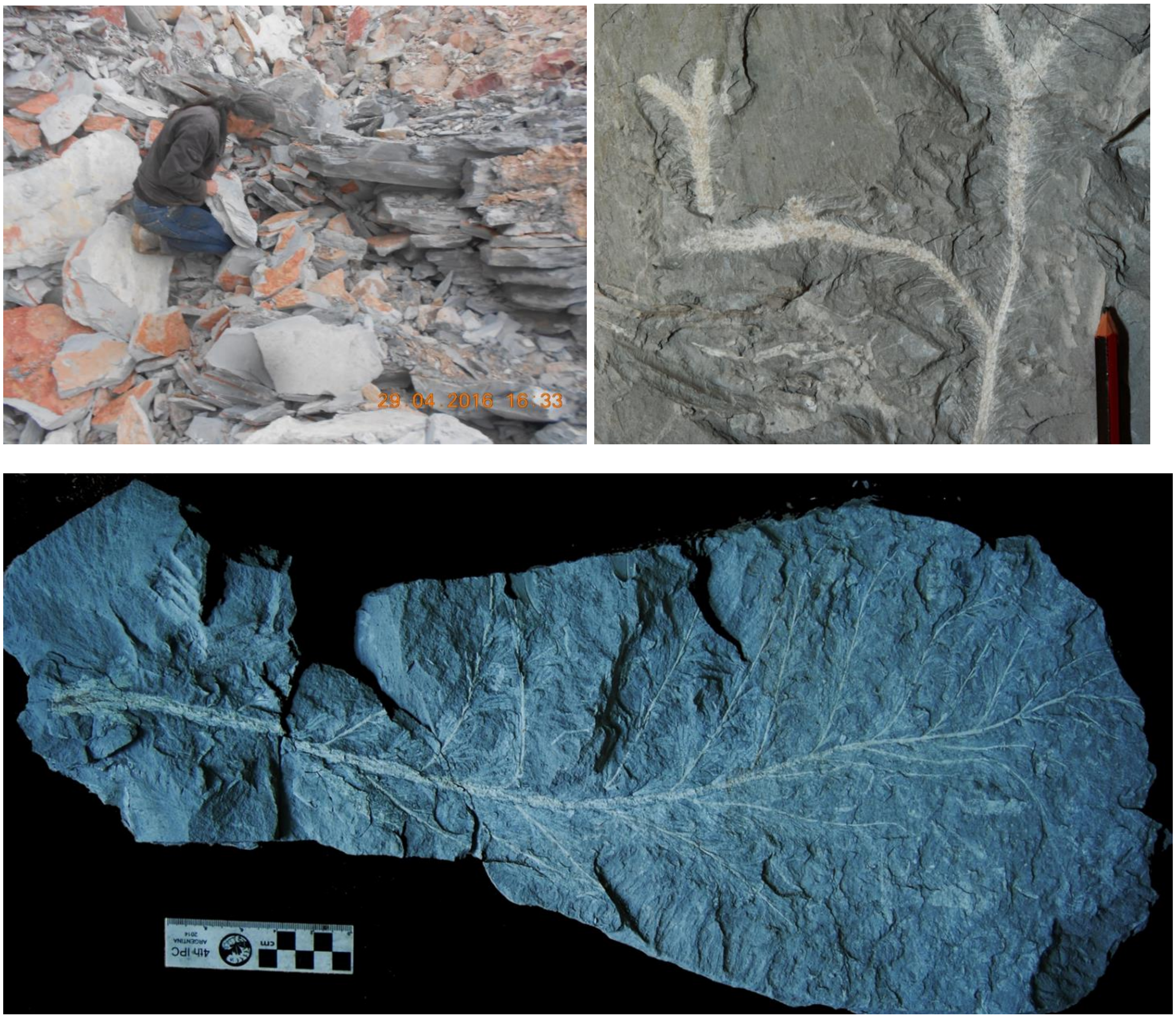

Figure 6: Black shale and fossils from Coombs Hill: *top left*, black shale disturbed during roadworks at Coombs Hill, *top right*, new species of lycopod plant; *bottom*, frond of *Archaeopteris notosaria*.

The top of the Witpoort Formation coincides with the end of the Devonian and is similar in age to the end-Devonian extinction event. It is overlain by rocks of the early Carboniferous aged Lake Mentz Subgroup. The End Devonian Mass Extinction Event completely changed diversity patterns of life on Earth, wiping out all placoderm (armoured fish) as well as most acanthodians (spiny finned fish) and lobe finned fish groups. Thereafter, ray-finned fish and sharks dominated the waters, and tetrapods (animals with four legs) went on to populate the land. Although there are as yet no tetrapods known from South Africa’s early Carboniferous rocks, there are a number of fish fossil sites that well illustrate this change in fish diversity. Most famous of these is the

’Lake Mentz’ site from near the Darlington Dam in the Addo National Park. Here several layers of rock covered in fossil fish of many species have been discovered. These appear to have died suddenly from cold or lack of oxygen. In strong contrast to the fish of the Waterloo Farm site, the fish from near Darlington Dam are all ray-finned fish, the group of fish that dominates our seas, lakes and rivers today. Some shark and acanthodian remains have also been recovered from the Lake Mentz Subgroup.

Figure 7: Layers of ray finned fish fossils from rocks of the Lake Mentz subgroup near Darlington Dam, now in the Greater Addo National Part.

In the later part of the Carboniferous and early part of the Permian period, during the breakup of Gondwana, the Agulhas Sea floor was folded up into a chain of high mountains that separated the Karoo Basin from the Sea. The area thereafter became an erosional environment and largely ceased to accumulate sediments. Around 200 million years later, during the Cretaceous and early Tertiary Periods much of Africa was weathered down to a number of level horizons collectively known as the African Surface. The area in the vicinity of Grahamstown was reduced to a flat plain close to sea level, remnants of which are referred to as the Grahamstown Peneplane. During the Tertiary, mudstones, shales and diamictites were leached to considerable depth, transforming them into soft white kaolin clay. Silica, iron and magnesium from these rocks was carried in solution by groundwater and deposited near the ground surface due to steady evaporation of mineral rich waters. This lead to the formation of a hard mineralised capping layer, often consisting of silicified soil. Resultant silcretes are referred to as the **Grahamstown Formation**. Though occasional occurrences of root and stem impressions have been recorded from the Grahamstown Formation it is generally considered unfossiliferous.

Site visits

The proposed development area was surveyed by vehicle and on foot in 2018, with progressive revisions being surveyed in April 2019 and August 2020.

The development is to be situated on a series of quartzitic hills and ridges. These result from erosion of Witteberg strata upwardly folded in a large asymmetrical south east- north west trending anticline with parasitic folds. The resilient Witpoort Formation strata have differentially resisted erosion being exhumed to form the parallel ridges. In the eastern part of the study area, partial loss of the uppermost quartzitic strata, that once comprised the top of the fold arch, occurred during erosion of the Cretaceous to Tertiary African Surface. This exposed, towards the northern side of the fold, a thick horizon of black carbon-rich shaley mudstone interbedded within the upper Witpoort Formation and thickened within the fold of the anticline. This black shale may be sedimentologically similar to the black shales exposed at Waterloo Farm (30 kilometres to the east), which have proved the most important Late Devonian palaeontological site in Africa, as well as the important fossiliferous horizons at Coombs Hill and Rabbit Ridge within the study area. Unfortunately (from a palaeontological perspective), its exposure led to deep weathering of the carbonaceous shale in the east of the study area during the Tertiary, reducing the shale to a fine quality kaolin clay capped by silcrete of the Grahamstown Formation. Subsequent differential weathering of this soft clay led to the development of an east-west trending valley towards the north of the fold, hemmed in by quartzitic hills. Nonetheless significant deposits of clay remained along the sides and bottom of the valley and where protected by remnants of silcrete. These deposits were utilised in precolonial times and a number of large quarries were exploited during the 20^{th} century Some continue to be exploited (eg. Fig. 1. Points K1-K2). These were generally mined downwards until weathered remains of the original black shale were encountered (Fig. 8). In some cases these continue to be mined for potter’s clay. Where exposed by the quarries these strata were carefully examined, during the surveys, but no fossil material was located.

A quarry within the western extent of the study area (Fig. 1, Point Q) provides a good profile of the local Witpoort Formation guartzites. These are underlain within the quarry by unleached deposits of carbonaceous shale. Preliminary investigation revealed these to contain silvery white plant fossil fragments (Figs. 9, 10).

The Witpoort Formation quartzites are well exposed in valleys and roadcuttings (eg. Fig. 11) throughout the area but are weathered to smooth heath covered surfaces on many of the hill crests intended for the installation of turbines. Where they are well exposed they comprise stacked packages of cross bedded mature sandstones, generally altered to metamorphic quartzite.

Figure 8: Vertically tilted leached formerly black shale deposits exposed in a quarry at K1.

Figure 9: Stacked Witpoort Formation quartzite strata in a quarry at Point Q, overlying black shale visible at bottom right.

Figue 10: Black carbonaceous shale exposed in quartzite quarry (Fig 1., Point Q) showing reddish possibly sideritic layers (*left*) and silvery white fossil plant fragments (*right*).

Figure 11: Roadcutting (Fig. 1., Point RC) showing weathered, tilted Witpoort Formation quartzites overlain by a partially silcritised soil profile.

Figure 12: Conglomerate comprised of chunks of weathered Witpoort Formation Quartzite cemented together by silcrete (at Fig.1., Point Si).

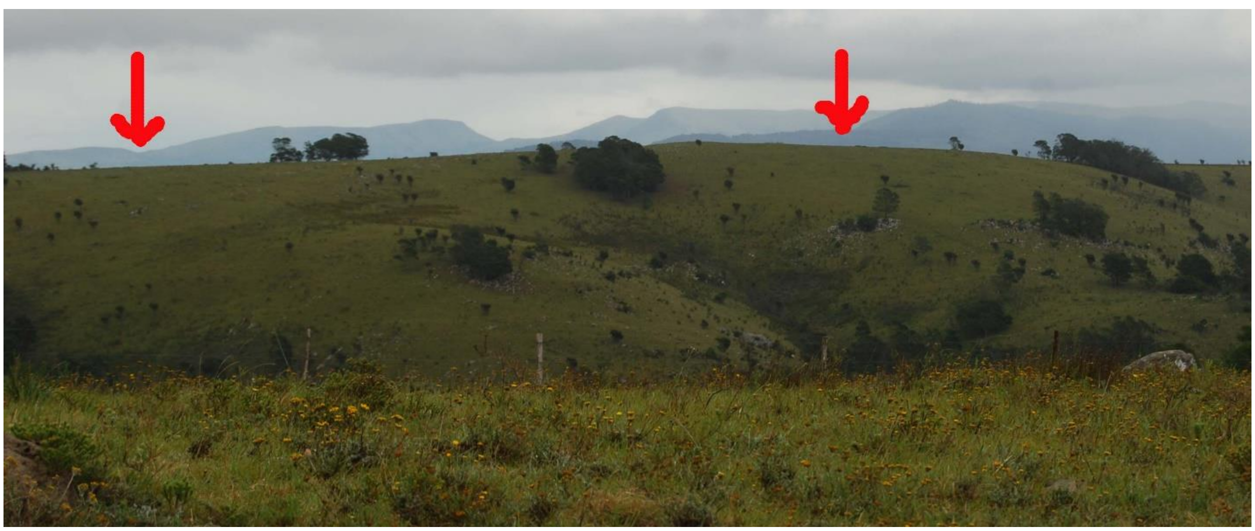

Figure 13: View from the north of a section of the Blaaukrantz catchment hills with proposed positions of WTG 62 (*left*), WTG 61 (*right*).

Figure 14: View from the north of a section of the Blaaukrantz catchment hills along which it is proposed to situate WTG 41.

Figure 15: proposed position of WTG 46, on the south western slope of the Blaaukrantz catchment hills.

Figure 16: Clean white Witpoort Formation quartzites exposed immediately to the south of proposed WTG 46.

Figure 17: Detail of quartzite to the south of proposed WTG 46 showing planar bedding highlighted by alternate heavy mineral banding.

Figure 18: Proposed position of WTP 41 along the Blaaukrantz catchment hills seen from the north, with white weathering Witpoort Formation outcrops.

Figure 19: View from the north of the southern branch of the Kap River Hills showing the section along which WTG 58 is proposed to be positioned.

Figure 20: View from the east of the top of the ridge on which WTG 65 is proposed (background centre) along southern branch of the Kap River Hills, showing Witpoort Formation Strata gently dipping towards the south west (left).

Figure 21: Southwardly dipping cross bedded white weathering Witpoort Formation strata in foreground with proposed position of WTG 55 marked by person, on the northern branch of the Kap River Hills.

Figure 22: Proposed position of WTG 44 on the south eastern slope of Governors Kop with Witpoort Formation quartzite in the foreground.

Figure 23: Proposed WTG 27 position on the south western flank of Governor's Kop.

Figure 24: Proposed position of WTG 29 in the central region of Governors Kop

Figure 25: Proposed position of WTG 31 along the central crest of Governors Kop.

Figure 26: Proposed position of WTG 31 along the central crest of Governors Kop.

Figure 27: Detail of cross bedded Witpoort Formation quartzite 7m south of the centre of proposed WTG 32.

Figure 28: Distant view (from near proposed position of WTG 15) of proposed position of WRG 21, to the west of the Kaolin mine K1 (figure 1), note small kaolin test pit immediately to the west (see fig. 31).

Figure 29: Proposed position of WRG 21, to the west of the Kaolin mine K1 (figure 1), note small kaolin test pit in the background (see fig. 31).

Figure 30: Silcrete capping exposed at proposed position of WTG 21.

Figure 31: Kaolin test pit 80 metres to the west of the centre of the proposed position of WTG 21 showing white kaolin at the bottom (derived from black Witpoort Formation mudstone) overlain by chunky Grahamstown Formation silcrete.

Figure 32: Proposed position of WTG 15 near the confluence between Governor’s Kop and Botha’s Hill, with Kaolin mine K1 (Fig 1) in the background.

Figure 33: Slightly overturned vertically orientated cross bedded layer of Witpoort Formation quartzite adjacent to the proposed position of WTG 19, near the confluence between Governor’s Kop and Botha’s Hill.

Figure 34: Proposed position of WTG 13 near the top of the northern slope of Botha's Hill.

Figure 35: Southerly dipping Witpoort Formation strata 15 metres to the east of proposed WTG 13.

Figure 36: Distant view of proposed WTG position 15 (from near proposed WTG position 21) near the top of the southern slope of Bothas Hill.

Figure 37: Proposed WTG position 15 near the top of the southern slope of Bothas Hill.

Figure 38: Detail of finely bedded Witpoort Formation quartzitic sandstone at proposed WTG position 15

Figure 39: Proposed position of WTG 71 with quartzite quarry (Fig.1, Q, Figs 9, 10) in background.

Figure 40: Outcrop of south westerly dipping white weathering Witpoort Formation quartzite 50 metres south of the centre of WTG 71.

Figure 41: Proposed position of WTG 68 towards the bottom of the southern slope of Bothas Hill, overlying argillaceous layers of the Lower Lake Metz Subgroup, with the uppermost Witpoort Formation exposed along a secondary ridge to the north, dipping southwards below the more negatively weathering Lake Mentz Subgroup strata.

Figure 42: Planar bedded clean quartzites of the uppermost Witpoort Formation approximately 80 metres north of the proposed position of WTG 68.

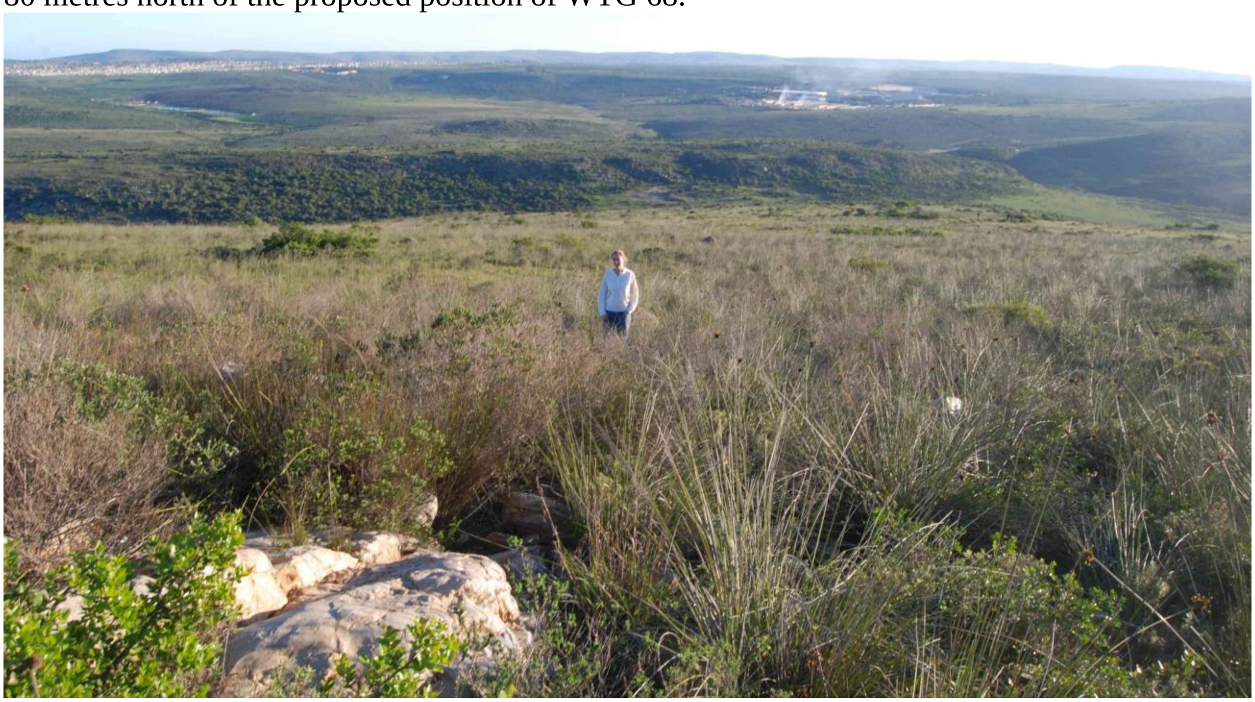

Figure 43: Proposed position of WTG 5 on the southern slope of Botha's Hill.

Figure 44: Cross bedding in vertically tilted Witpoort Formation quartzite 50 metres north west of point 5 (top to south).

Figure 45: Proposed position of WTG 4 on the north side of Botha's Hill, seen from the west.

Conclusions and Recommendations.

It is the nature of palaeontological resources that important sites may be spatially very limited, yet they may prove to be of international significance. Discovery of such resources during development may be of great permanent benefit to the scientific community. Their destruction represents a severe permanent loss which may be of international significance.

It was found during the survey that most proposed wind tower positions are situated on strata of the Witpoort Formation, with the exception of WTG positions 23, 24, 26, 27 and 68 which are situated on strata of the Lake Mentz subgroup, and Wind towers 19 and 21 which are proposed to be constructed where silcrete overlies degraded Witpoort Formation mudstone.

Due to the extreme weathering of strata at surface along the ridges, soil development and extensive vegetation cover, current outcrop was found to be extremely sparse and no palaeontological material was observed at the actual proposed wind tower positions.

Quarries and roadworks within the study area and within the district have however demonstrated that excavation into the Witpoort Formation not infrequently intercepts black shale layers and lenses that may be of great palaeontological value. Palaeontological investigations of these layers, in the Grahamstown district, has provided the world's only window into high latitude conditions at the end of the Devonian, a time of extreme importance in understanding the process of vertebrate terrestrialisation and the lead up to the second global Mass Extinction Event.

There is therefore a reasonable chance that excavation of holes for casting wind tower footings will intercept fossiliferous shales, which may contain important unique heritage material. Lag deposits, containing fossil plant stems and possibly vertebrate bones might also be found preserved within the quartzites. The extreme inaccessibility of many of the proposed positions furthermore requires that access roads will need to be excavated in order for construction equipment to reach the positions. These may also disturb palaeontological material.

Excavations into Lake Mentz Subgroup strata are somewhat less likely to disturb palaeontological material, but should they do so this would also be significant, potentially providing insights into the recovery fauna and flora after the end Devonian Extinction.

It is therefore recommended that:

1) **All excavated holes for wind tower footings (with the exception of WTG positions 19 and 21) should be examined by a palaeontologist after excavation and before casting of footings.**

2) **All new access roads should simultaneously be inspected by a palaeontologist prior to any rehabilitation.**

3) **During excavation of WTG positions 19 and 21 the ECO should check for any palaeontological material and immediately report any finds or suspected finds to the palaeontologist.**