PALAEONTOLOGICAL HERITAGE: COMBINED DESKTOP & FIELD-BASED SCOPING ASSESSMENT

Proposed Impofu East Wind Farm near Humansdorp, Sarah Baartman District Municipality, Eastern Cape

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EXECUTIVE SUMMARY

Red Cap Impofu East (Pty) Ltd is proposing to develop the Impofu East Wind Farm with approximately 42 wind turbines on a site to the south of the N2 and some 20 km southwest of Humansdorp, Sarah Baartman District Municipality, Eastern Cape. The present palaeontological heritage scoping assessment is based on several desktop and field-based studies in the Humansdorp region including a recent field study of the consolidated Impofu Wind Farms project area.

The Impofu East Wind Farm study area is underlain by several Palaeozoic sedimentary bedrock units of the Cape Supergroup (Table Mountain and Bokkeveld Groups). These include the Cederberg, Baviaanskloof and Gydo Formations that are richly fossiliferous elsewhere in the Cape region. However, on the coastal platform near Humansdorp any fossils originally preserved in these bedrocks appear to have been destroyed by tectonic deformation and deep chemical weathering. Important marine trace fossil assemblages are recorded within the Peninsula Formation near Rosenhof farmstead in the adjoining Impofu West Wind Farm project area. Late Caenozoic superficial sediments overlying the Cape Supergroup bedrocks - such as alluvium, soils and ferricretes - are generally of low palaeontological sensitivity. Relict patches of Plio-Pleistocene aeolianites (wind-blown sands) of the Nanaga Formation (Algoa Group) present in the subsurface on the interior coastal platform contain Early Stone Age artefacts but any associated fossils such as mammalian remains or terrestrial gastropods have probably been destroyed by weathering here. Pleistocene aeolianites close to the coast may contain important concentrations of mammalian fossils, as recorded in the adjoining Gibson Bay WEF project area and near Oyster Bay. The near-coastal palaeodune areas have been largely excluded from the wind farm footprint (Fig. 3) and significant palaeontological impacts are therefore not anticipated here.

No significant fossil sites were recorded during the field survey of the Impofu East Wind Farm project area and the overall palaeontological sensitivity of the area is rated as low. Due to the rarity of well-preserved, unique fossils of potential scientific importance within the study area, potential impacts on palaeontological heritage during the construction phase are assessed as of *negligible (negative) significance* (both before and after mitigation). This applies equally to planned upgrading of the Brakkeduine Road across the Klipdrifrivier (Minor Road 50092). The No-Go alternative (*i.e.* no wind farm) will have a neutral impact on palaeontological heritage.

Cumulative impacts posed by the three separate Impofu Wind Farms are inferred to be *minor*. This also applies to cumulative impacts from known alternative energy developments in the region. Confidence levels for this assessment, which includes consideration of the worst case scenario (> 120 wind turbines for all three Impofu Wind Farms), are high due to comparatively good field data available for the study region.

Two quarry sites of geoheritage / palaeontological interest, labelled Q1and Q2 in Fig. 6, will not be directly impacted by the proposed wind farm development (GPS data provided in Appendix 2. Note Q2 lies just outside the wind farm project area). If it proves necessary to develop any of these sites, palaeontological mitigation will be required beforehand. This would involve geological and palaeontological documentation as well as sampling of the site by a professional palaeontologist. Pending the potential discovery of significant new fossil remains (*e.g.* vertebrate bones and teeth, horn cores, shells, trace fossils, plant compressions) during the construction phase of the Impofu East Wind Farm development, no further specialist palaeontological studies or mitigation are recommended for this project in the EIA and construction phases. There are no fatal flaws to the proposed wind farm project as far as fossil heritage is concerned. Providing that the Chance Fossil Finds Procedure outlined below and tabulated in Appendix 1 is followed through, there are no objections on palaeontological heritage grounds to the authorisation of the Impofu East Wind Farm project.

The suitably qualified and experienced Environmental Control Officer (ECO) responsible for the wind farm development construction phase should be made aware of the potential occurrence of scientifically-important fossil remains within the development footprint. During the construction phase all major clearance operations (*e.g.* for new access roads, turbine placements) and deeper (> 1 m) excavations should be monitored for fossil remains on an on-going basis by the ECO. Should substantial fossil remains be encountered at surface or exposed during construction, the ECO should safeguard these, preferably *in situ* (See Appendix 1: Chance Fossil Finds Procedure). They should then alert the Eastern Cape Provincial Heritage Resources Agency, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible. This is to ensure that appropriate action (*i.e.* recording, sampling or collection of fossils, recording of relevant geological data) can be taken by a professional palaeontologist at the proponent's expense. These monitoring and mitigation recommendations should be incorporated into the Environmental Management Programme (EMPr) for the Impofu East Wind Farm. The operational and decommissioning phases of this development are unlikely to have further significant impacts on palaeontological heritage and no additional recommendations are made in this regard (The Chance Fossil Finds Procedure still applies).

1. INTRODUCTION

The company Red Cap Energy (Pty) Ltd is overseeing the proposed development up to three adjoining wind farms with a total of up to 120 wind turbines on a consolidated site of approximately 15 500 hectares (ha) situated to the west of Humansdorp within the Sarah Baartman District Municipality (Kouga and Kou-Kamma Local Municipalities), Eastern Cape (Fig. 1). The consolidated Impofu Wind Farms site is bounded by the operational Gibson Bay and Tsitsikamma Community Wind Farms in the south and west and the Kouga Wind Farm in the east. The construction of the approved Oyster Bay Wind Farm on its eastern boundary will most likely commence in 2018. The present report provides a scoping-level palaeontological

heritage assessment (PIA) of the proposed Impofu East Wind Farm based on a combined desktop and field-based study of the entire Impofu Wind Farm project area (See Appendix 2). The *c*.120 km–long 132 kV grid connection between the project area and Port Elizabeth will be assessed separately.

Aurecon South Africa (Pty) Ltd (Aurecon) has been commissioned by the proponent to carry out three Environmental Impact Assessment (EIA) processes for the proposed Wind Farms as well as one Basic Assessment (BA) process for the associated switching stations and transmission lines (Aurecon contact details: Ms Kim White, Aurecon South Africa (Pty) Ltd. Address: Aurecon Centre, 1 Century City Drive, Waterford Precinct, Century City, South Africa. Tel: +27 21 5266013. Fax: +27 21 5269500. E-mail: Kim.White@aurecongroup.com).

2. PROJECT OUTLINE & BRIEF

The proposed Impofu East Wind Farm project area lies south of the N2 trunk road between the Tsitsikamma River and the Impofu Dam, some 25 km WSW of Humansdorp, Eastern Cape (Fig. 1). It totals approximately 5810 hectares in area and comprises the various land parcels shown in map Figure 2. The main infrastructural components of the wind farm that are relevant to the present palaeontological heritage assessment (Fig. 3) include:

- Approximately 41 wind turbines, each of 3-5 MW generation capacity. Each turbine would have a circular foundation of approximately 20-25 m diameter, a temporary disturbed area including the foundation, the hardstand and construction area of approximately 100 x 50 m for use as a laydown area and to accommodate a crane pad during installation, with a permanent hardstand footprint of approximately 50 x 30 m remaining for maintenance purposes.
- Internal access roads. The internal gravel roads will be approximately 6 m wide with potential side drains along the side and of a specification to accommodate the abnormal trucks that will deliver the turbine components. Where possible existing roads will be used and upgraded to avoid additional clearance of natural or agricultural land cover. In exceptional circumstances short sections of the roads may be surfaced with bitumen or concrete if they are excessively steep. A short section of the Brakkeduine Road (Minor Road 50092) across the Klipdrifrivier will be upgraded (See white rectangle in Appendix 2, fig. 3).
- Underground and overhead medium voltage (MV) power lines (33 kV or lower). These lines would predominantly be in the form of underground cables, but in cases where they have to cross complex terrain such as drainage lines or steep kloofs, they would be short sections of overhead power lines.
- An on-site substation (with transformer) with an associated switching station. Since the switching station component will be owned by Eskom, there will be a physical barrier between the two components in the form of a fence. The total footprint of the substation is approximately 150 x 75 m (11,250 m^2) and the adjoining Eskom switching stations would be of a similar size. A total area of 150 x 150 m (22,500 m^2) for the consolidated sub/ switching station has been considered in this assessment.
- Control, operation, workshop, storage buildings / areas, also to be located at the on-site substation site.
- The 132 kV line that connects the on-site switching station to the collector substation.

The *c*.120 km–long 132 kV grid connection between the project area and Port Elizabeth as well as the collector substation will be assessed separately.

2.1. Terms of Reference

The Terms of Reference for the desktop and field-based palaeontological heritage assessment of the Impofu Wind Farm projects have been defined by Aurecon South Africa (Pty) Ltd to comprise (1) three separate Scoping Impact Assessments, one for each wind farm, including the on-site substations and switching stations, internal roads, underground and overground cables, internal 132 kV transmission lines, and upgrading of public roads, as well as (2) one Basic Environmental Assessment for the associated 132 kV grid connection between the project area and Port Elizabeth. This scoping report focuses on the Impofu East Wind Farm.

Figure 1. Google Earth© satellite image of the southern Cape coastal platform to the west of Humansdorp, Eastern Cape, showing the location of the Impofu East Wind Farm study area *c*. 20 km southwest of Humansdorp, Eastern Cape (green polygon).

Figure 2: Map showing the location of the land parcels concerned in the proposed Impofu East Wind Farm located *c*. 20 km southwest of Humansdorp, Sarah Baartman District Municipality, Eastern Cape (Image provided by Aurecon South Africa (Pty) Ltd).

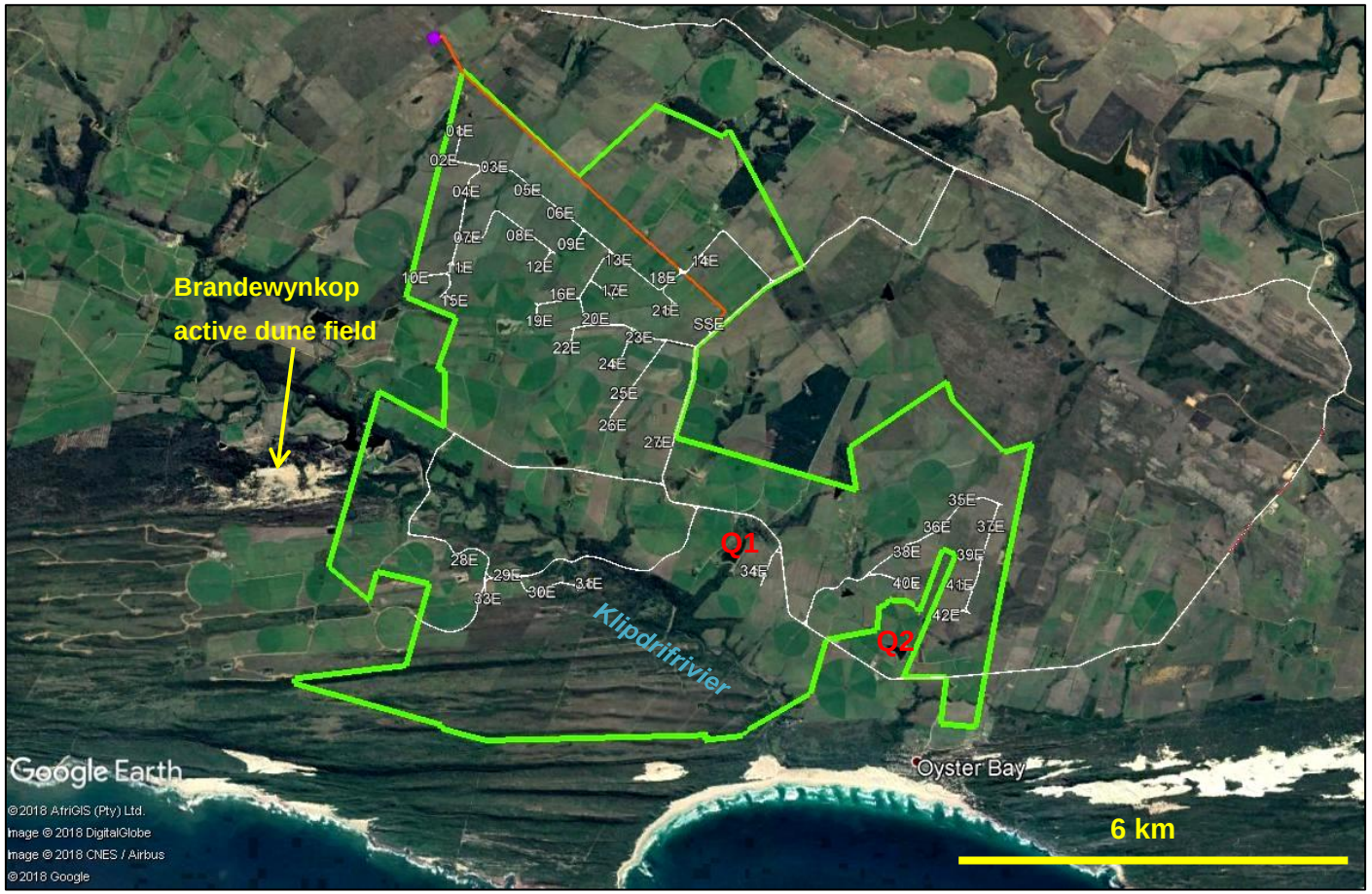

Figure 3. Google Earth© satellite image of the Impofu East Wind Farm study area (green polygon) spanning the coastal platform *c*. 20 km southwest of Humansdorp. The provisional development footprint is indicated, including wind turbine and standing area positions (numbered), access roads (white) and 132 kV line (orange) from the on-site Impofu East Substation (small blue square) to the collector substation (purple). Q1 and Q2 (red) indicate two sites of geological / palaeontological conservation value, only one of which lies within the wind farm project area (See Fig. 6 for more detail).

3. STUDY APPROACH

This combined desktop and field-based PIA report provides an assessment of the observed or inferred palaeontological heritage within the Impofu East Wind Farm study area, with recommendations for specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, including previous palaeontological impact assessments in the area (*e.g.* Almond 2010a, 2011a, 2011b, 2011c, 2011d, 2012, 2017 and De Klerk 2010a, 2010b, 2011), (2) published geological maps and accompanying sheet explanations, (3) a four-day field study of the consolidated Impofu Wind Farms study area (23-26 September 2017) and the resulting palaeontological heritage screening report (Almond 2017), as well as (4) the author's extensive field experience with the formations concerned and their palaeontological heritage (Almond *et al.* 2008).

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 scoping during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (provisional tabulations of palaeontological sensitivity of all formations in the Eastern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond *et al.* 2008) and are shown on the palaeosensitivity map on the SAHRIS (South African Heritage Resources Information System) website. The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most notably the extent of fresh bedrock excavation and ground clearance envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field assessment study by a professional palaeontologist is usually warranted.

The focus of palaeontological field assessment is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present (*N.B.* Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the field study where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localised (*e.g.* GPS and stratigraphic data) samples of fossil material during field assessment studies. In order to do so, a fossil collection permit from SAHRA is required and all fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Note that while fossil localities recorded during field work within the study area itself are obviously highly relevant, most fossil heritage here is embedded within rocks beneath the land surface or obscured by surface deposits (soil, alluvium *etc*) and by vegetation cover. In many cases where levels of fresh (*i.e.* unweathered) bedrock exposure are low, the hidden fossil resources have to be *inferred* from palaeontological observations made from better exposures of the same formations elsewhere in the region but outside the immediate study area. Therefore a palaeontologist might reasonably spend far *more* time examining road cuts and borrow pits close to, but outside, the study area than within the study area itself. Field data from localities even further afield (*e.g.* an adjacent province) may also be adduced to build up a realistic picture of the likely fossil heritage within the study area.

On the basis of the desktop and field 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. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological and taphonomic data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority, the Eastern Cape Provincial Heritage Resources Agency, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za). It should be emphasised 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.

4. ASSUMPTIONS AND 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 computerised database of fossil collections in major RSA institutions which can be consulted for impact studies.

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, as in the case of the present study.

In the case of the Impofu East Wind Farm study area bedrock exposure is highly constrained by extensive superficial deposits, especially in areas of low relief, as well as by grassy vegetation. The study area is very extensive and for the most part fairly flat, with some gentle hillslopes (in part reflecting palaeodunes) and few access roads. However, sufficient bedrock exposures were examined during the course of the four-day field study to assess the palaeontological heritage sensitivity of the main rock units represented within the Impofu Wind Farms study area (See Appendix 2). Comparatively few academic palaeontological studies have been carried out hitherto in the region, so any new data from impact studies here are of scientific interest. Palaeontological and geological data from the recent field study is usefully supplemented by those from several other field-based fossil heritage impact studies carried out in the Kouga (Humansdorp - Jeffrey's Bay - Cape St Francis) region by the author and other palaeontologists in recent years (See reference list). Confidence levels for this impact assessment are consequently rated as HIGH, despite the unavoidable constraints of limited exposure, time and access.

5. LEGISLATIVE CONTEXT

The present combined desktop and field-based palaeontological heritage report falls under Sections 35 and 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999), and it will also inform the EMPr for this project.

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

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

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(4) No person may, without a permit issued by the responsible heritage resources authority—

(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;

(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;

(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;

(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and

(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

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

6. GEOLOGICAL CONTEXT

The Impofu East Wind Farm study area is situated on the southern coastal platform in the Kouga region near Humansdorp, Eastern Cape. It spans elevations of from around 210 m amsl on the coastal platform in the northeast down to c. 30 m amsl close to the coast in the south. The area is drained by the Klipdrifrivier that flows NWN-ESE across the southern part of the project area while the Impofu Dam lies some 2 km to the northeast. The northern and central sectors of the area are characterised by rolling grassy agricultural terrain while west-east trending vegetated aeolian dunes are seen closer to the coast in the south. A small area of active dunes is seen at Brandywynkop just to the west of the study area (Fig. 3).

The geology of the study region to the southwest of Humansdorp is shown on 1: 250 000 geology sheet 3324 Port Elizabeth (Toerien & Hill 1989) (Fig. 4). Detailed information on the geology and palaeontology of the consolidated Impofu Wind Farms site, comprising the Impofu North, Impofu West and Impofu East Wind Farms, was documented in a desktop- and field-based screening study by Almond (2017). Appendix 2 to this report contains the relevant information. The geology of the study region is also described in several previous desktop and field-based studies by the author (notably Almond. 2008, 2012, 2013a, 2013b). It should be emphasised that mapping of the various geological formations in this area is often *schematic* because of the generally poor levels of bedrock exposure; *i.e.* the outcrop areas shown in Fig. 4 may not be very accurate. Detailed, illustrated accounts of the bedrock formations and superficial sediments encountered in the Kouga region have been given in particular by Almond (2012, 2017).

According to the 1: 250 000 geological map, the Impofu East Wind Farm study area is underlain at depth by Ordovician to Early Devonian sediments of the **Table Mountain Group** and **Bokkeveld Group**. These marine to continental Palaeozoic bedrocks are assigned to the **Peninsula, Cederberg, Goudini, Skurweberg, Baviaanskloof and Gydo Formations** of the Cape Supergroup (See stratigraphic column Fig. 5). The Cape Supergroup succession is folded along WNW-ESE fold axes, with a broad outcrop area of Peninsula Formation quartzites in the core of a mega-anticline in the northeast flanked by several tight folds in the centre of the project area. As a result the mudrock-dominated units (Cederberg and Gydo Formations) in particular display high levels tectonic cleavage. Most of the bedrocks also show high levels of near-surface chemical weathering.

Bedrock exposures are poorly-developed in general, especially on the gently-sloping coastal platform, and are largely limited to river and stream banks, erosion gullies, borrow pits and quarries, road and railway cuttings and farm dams (See Appendix 2). Elsewhere the bedrocks are largely obscured by Late Caenozoic superficial sediments such as alluvium along water courses, colluvium (scree) on steeper slopes, downwasted surface gravels and soils.

The dunefields in the southern sector of the study area are assigned to the Late Caenozoic **Algoa Group**. Two separate units of wind-blown sands are mapped here: the older, semi-consolidated and often deeply-weathered **Nanaga Formation** of Plio-Pleistocene age and the younger loose sands of the **Schelm Hoek Formation**. For the most part the west-east trending palaeodunes are stabilised by vegetation but a small area of exposed, partially mobile dune sands is seen in the Brandywynhoek area on the southern side of the Klipdrif Dam. Of geological interest are relict patches of weathered ancient coastal aeolianites (wind-blown sands) that extend intermittently across the interior of the coastal platform as far as the foothills

of the Karreedouwberge. They are provisionally assigned to the Plio-Pleistocene Nanaga Formation. Apart from occasional borrow pits and road cuttings these aeolianite patches are normally soil-covered and are not indicated on the 1: 250 000 scale geological map.

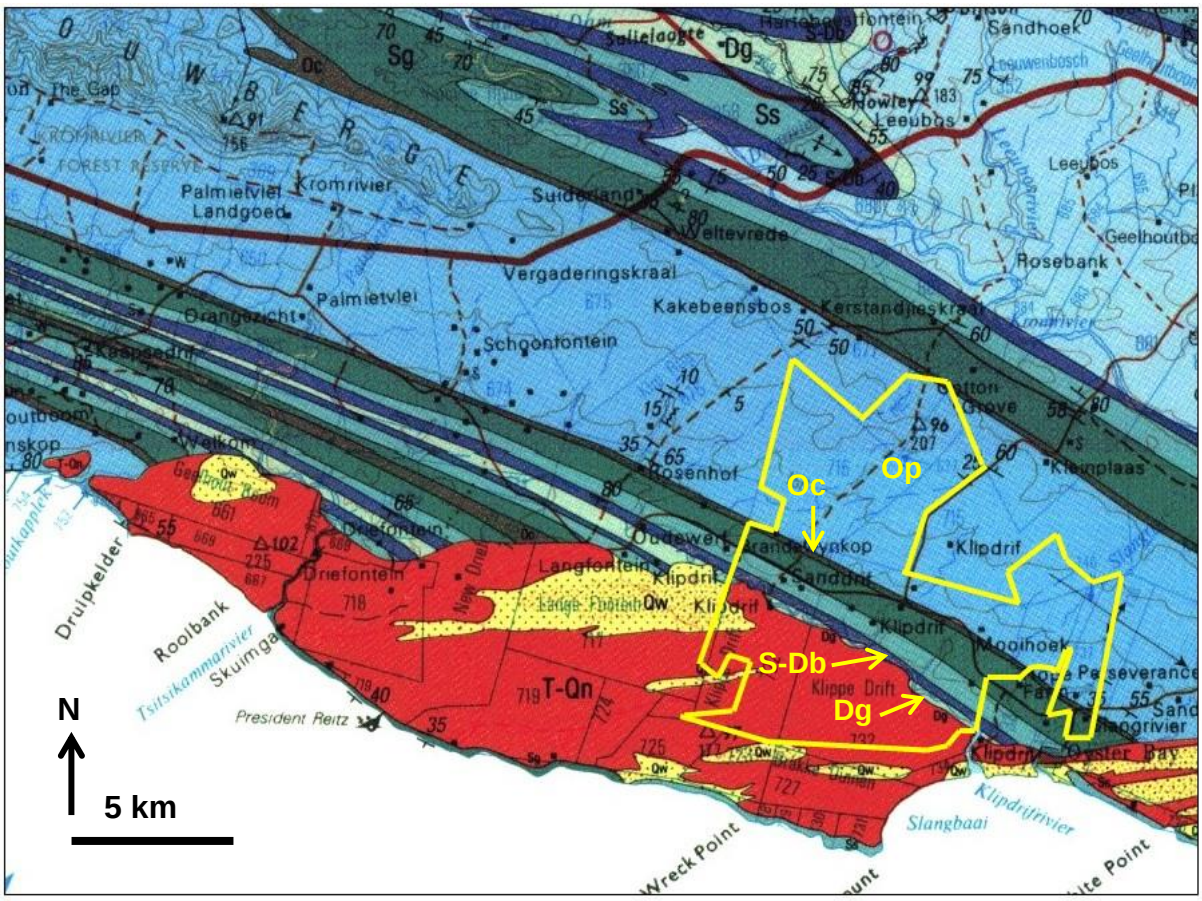

Figure 4. Extract from 1: 250 000 geology sheet 3324 Port Elizabeth (Council for Geoscience, Pretoria) showing *approximate* outline of the Impofu East Wind Farm study area near Humansdorp (yellow polygon). The main geological units represented within the study area include the following formations (Palaeontologically more sensitive marine units indicated in red below). *Please note that geological mapping at 1: 250 000 scale in this region is often schematic due to very poor levels of bedrock exposure.*

TABLE MOUNTAIN GROUP (Ordovician to Early Devonian)
Peninsula Formation (Op, middle blue)
Cedarberg Formation (Oc, grey)
Goudini Formation (Og, grey-green)
Skurweberg Formation (Ss, pale blue)
Baviaanskloof Formation (S-Db, dark blue)

BOKKEVELD GROUP (Early Devonian)
Gydo Formation (Dg, v. pale blue)

ALGOA GROUP (Late Caenozoic, Pliocene / Quaternary to Recent)
Nanaga Formation (T-Qn, orange-brown) – *N.B.* outcrop area is underestimated on map; unmapped relict patches of this formation are present within the present study area.
Schelm Hoek Formation (Qw, yellow with stipple)

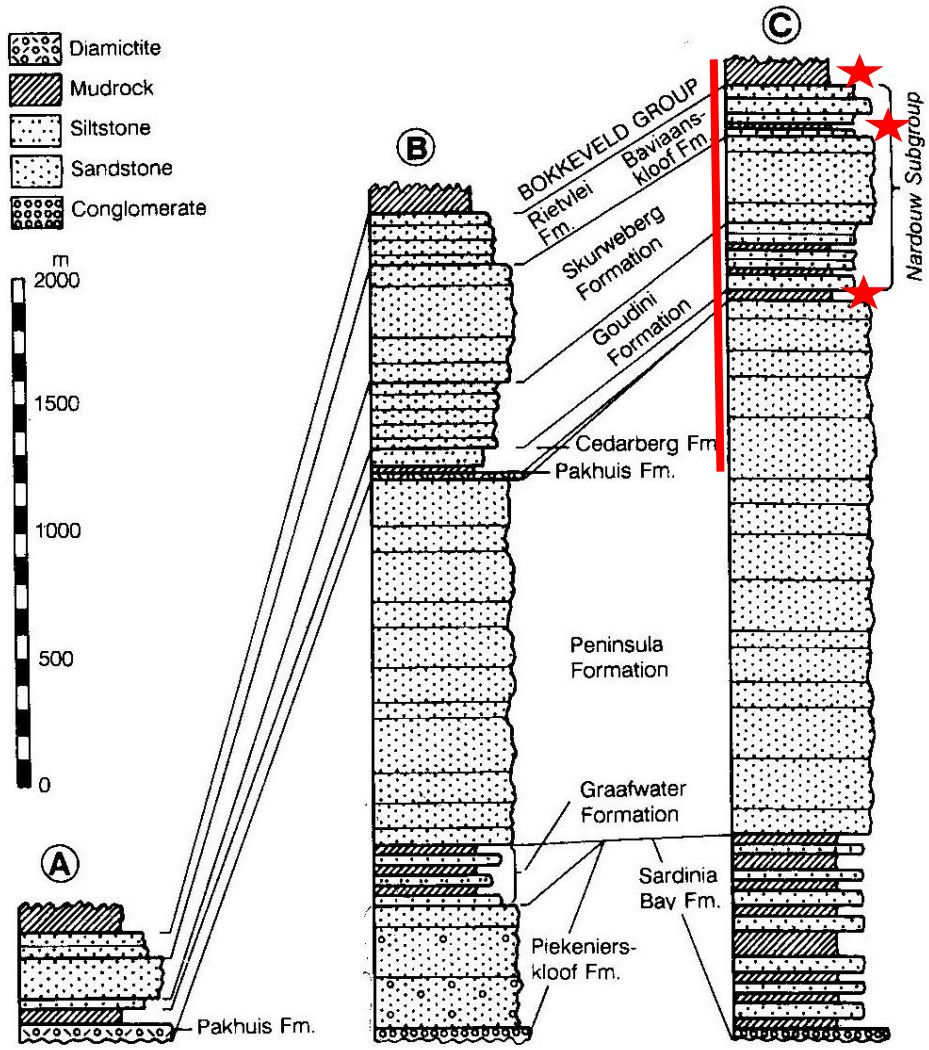

Figure 5. Stratigraphy of the Table Mountain Group and basal Bokkeveld Group (from Thamm & Johnson 2006) showing the bedrock units present in the Impofu Wind Farms study area (vertical red bar). Column C refers to the Eastern Cape region. The Cederberg, Baviaanskloof and Gydo Formations that elsewhere in the Cape are associated with an important fossil record are indicated by red stars. In the Impofu Wind Farms study area these units are apparently secondarily unfossiliferous due to high levels of tectonic deformation and weathering.

7. PALAEONTOLOGICAL HERITAGE

A fully-referenced review of fossil assemblages that have been recorded from the various geological formations represented within the Kouga study region near Humansdorp has been presented by Almond (2012). Most of the relevant rock units are only sparsely fossiliferous to unfossiliferous. However, *elsewhere* in the broader Cape region diverse and scientifically important fossil assemblages have been recorded from the Cederberg and Baviaanskloof Formations of the Table Mountain Group as well as the Gydo Formation at the base of the Bokkeveld Group (See starred units in stratigraphic column Fig. 5). As concluded by Almond (2017) the palaeontological sensitivity of all these three rock units has been seriously compromised in the Kouga study region as a result of high levels of tectonic deformation (*e.g.* cleavage formation) as well as deep chemical weathering since the fragmentation of Gondwana some 120 million years ago. Furthermore, the outcrop areas of the mudrock-rich sedimentary successions that are most likely to yield fossil remains are narrow and ill-defined, and are largely mantled in a veneer of superficial deposits such as soil, alluvium and downwasted, ferruginised gravels that shield the fossiliferous bedrocks from significant disturbance during development.

7.1. Fossils in the Table Mountain Group

Body fossils (shells, teeth, bones *etc*) are so far unknown from the **Peninsula Formation** but a modest range of shallow marine to nearshore fluvial and / or estuarine trace fossils have been recognised, mainly from the Western Cape outcrop area. Recessive weathering of trace-rich heterolithic intervals is undoubtedly responsible for under-recording of fossils within the Peninsula Formation. It is likely that relatively unweathered samples of fine-grained muddy sediments within these heterolithic intervals may eventually yield microfossil assemblages (*e.g.* organic-walled acritarchs) of biostratigraphic and palaeonvironmental significance. For the most part, Peninsula Formation arenites in the Impofu Wind Farms study area are highly weathered while heterolithic successions rich in mudrock interbeds are not exposed at surface. Unusually abundant, low-diversity trace fossil assemblages of palaeontological significance are recorded, however, in the uppermost Peninsula Formation quarry exposures near Rosenhof farmstead in the Impofu West Wind Farm project area (Almond 2012, 2017).

An exceptionally important and interesting biota of soft-bodied (*i.e.* unmineralised) and shelly invertebrates, primitive jawless vertebrates and microfossils has been recorded since the middle 1970s from finely laminated, black mudrocks of the **Soom Member**, forming the lower, mudrock-dominated portion of the **Cederberg Formation**. A low diversity shelly faunule, dominated by articulate and inarticulate brachiopods together with a small range of trace fossils is recorded from Western Cape exposures of the heterolithic **Disa Member** that forms the upper portion of the Cederberg Formation. The potentially fossiliferous beds of the Cederberg Formation are almost nowhere exposed within the Impofu Wind Farms study area. Where dark mudrocks have been seen (*e.g.* near Rosenhof Farmstead in the Impofu West Wind Farm project area) they are too cleaved and weathered to yield recognisable fossils, although some microfossils might still be preserved here.

The fossil record of the **Goudini** and **Skurweberg Formations**, dominated by braided fluvial sandstones, is very sparse indeed. Sporadic, low diversity ichnoassemblages from thin, marine-influenced stratigraphic intervals have been recorded from all three Nardouw

formations in the Western Cape. It is possible that more diverse ichnoassemblages (and even microfossils from subordinate mudrock facies where these have not been deeply weathered or tectonised) may eventually be recorded from the more marine-influenced outcrops of the Eastern Cape Fold Belt.

A distinctive marine shelly invertebrate faunule of Early Devonian, Malvinokaffric aspect characterises the upper portion of the **Baviaanskloof Formation** from the Little Karoo eastwards along the Cape Fold Belt. It is dominated by the globose, finely-ribbed articulate brachiopod *Pleurothyrella africana*. Recently, dense assemblages of primitive vascular plants with forked axes and conical terminal "sporangia" that are provisionally ascribed to the genus *Dutoitia* have been collected from Baviaanskloof Formation mudrocks near Cape St Francis, Eastern Cape (These fossil plants were originally mis-assigned to the Gydo Formation).

With the exception of the uppermost Peninsula Formation trace fossil assemblages near Rosenhof farmstead (Impofu West Wind Farm project area), no body or trace fossils were observed within the Table Mountain Group rocks within the Impofu Wind Farms study area. Apart from low exposure levels, this is probably due to high levels of bedrock weathering beneath the coastal platform.

7.2. Fossils in the Lower Bokkeveld Group (Ceres Subgroup)

The most important fossil groups recorded from the lower Bokkeveld Group (Ceres Subgroup) include shelly marine invertebrates and traces (burrows *etc*), together with rare fish remains, primitive vascular plants (probably mis-assigned to this stratigraphic unit), trace fossils (burrows, borings *etc*) and microfossils (*e.g.* foraminiferans, ostracods, palynomorphs). The overall palaeontological sensitivity of this stratigraphic unit is generally considered to be high to very high. However, most of the early geological mapping surveys revealed very few useful fossil records within the Bokkeveld Group outcrop area in the Eastern Cape – largely a scattering of poorly-preserved, often deformed marine shells and locally abundant trace fossils. The mudrock-dominated Lower Bokkeveld Group sediments in the Humansdorp area are very poorly exposed, and where visible – for example in road cuttings - are deeply weathered and cleaved. The likelihood of useful fossil material being preserved under these circumstances is very low.

7.3. Fossils in the Algoa Group

The sparse palaeontological record of the Pliocene to Early Pleistocene **Nanaga Formation** mainly consists of fragmentary marine shells, foraminifera and a small range of terrestrial snails. Dense arrays of calcretised rhizoliths (root casts) commonly occur in these and contemporary Plio-Pleistocene aeolianites along the southern and southwestern coast; spectacular arrays of *megarhizoliths* were recorded from the Nanaga Formation of the Coega area, Eastern Cape, for example. A wider range of terrestrial fossils might be found here in future, albeit only rarely due to extensive post-depositional diagenesis (*e.g.* solution and re-preciptation of carbonate by groundwater). They might include mammal remains from hyaena lairs, such as are recorded from contemporary Langebaan Formation aeolianites in the SW Cape.

Coastal aeolianites of the Algoa Group are generally of LOW palaeontological sensitivity. However, pockets of HIGH to VERY HIGH sensitivity may occur here, such as Pleistocene mammalian remains and plant material associated with ancient hyaena dens, springs or *vleis*, and ESA sites. Local examples include important Late Pleistocene hyaena den bone and coprolite assemblages recorded from the Oyster Bay and Gibson Bay WEF areas near Humansdorp by Carrion *et al.* (2000), Nilssen & Smith (2015) and Brink (2015).

No fossil remains were recorded from occasional artificial exposures into relict patches of Pleistocene Nanaga Formation aeolianites in the Impofu Wind Farms project area. The aeolianites here are generally highly weathered and in part ferricretised. They are of archaeological as well as geoheritage interest because they contain locally abundant Early Stone Age artefacts (Almond 2017) (See Q1 and Q2 quarry sites indicated in Fig. 6). Any mammalian bones or shells (*e.g.* terrestrial gastropods) originally preserved within them have probably been destroyed by later weathering and leaching of carbonate. The Q1 and Q2 sites are of geoheritage (stratigraphic) as well as potential palaeontological interest and thus conservation-worthy. They will not be directly impacted by the proposed wind farm project. If it proves necessary to develop any of these sites, palaeontological mitigation will be required beforehand.

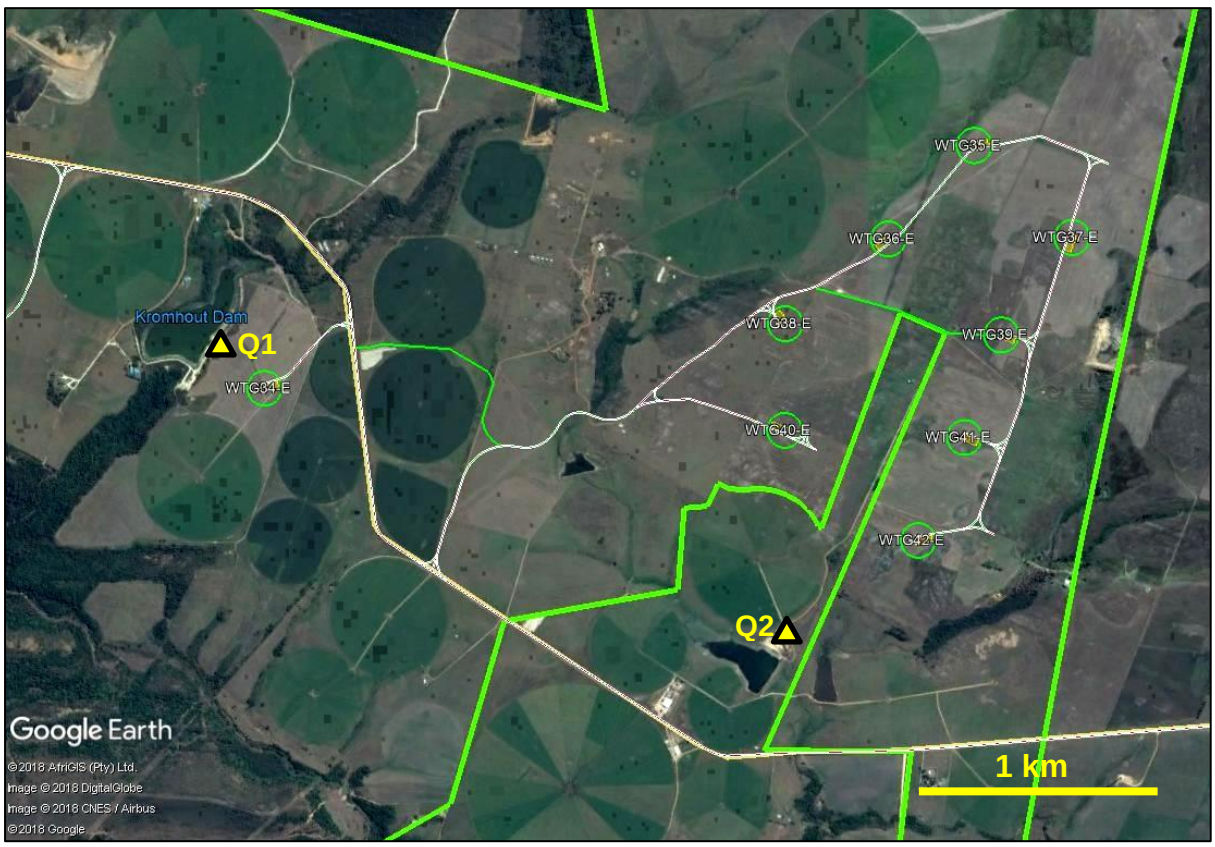

Figure 6. Google Earth© satellite image of the central part of the Impofu East Wind Farm project area showing the location of two sites of palaeontological / geoheritage interest: Q1 quarry (excellent stratigraphic section through Bokkeveld bedrocks overlain by Late Tertiary gravels and ferricretised aeolianites of Algoa Group) and Q2 quarry (ferricretised Nanaga Formation with ESA stone artefacts). These two sites will not be directly impacted by the proposed wind farm development. Only site Q1 lies within the Impofu East Wind Farm project area.

8. ASSESSMENT OF IMPACTS ON PALAEONTOLOGICAL RESOURCES

The Impofu East Wind Farm study area is underlain by several formations of potentially fossiliferous sediments of the Cape Supergroup and Algoa Group (Sections 6 & 7). Combined desktop and field studies of the broader Impofu Wind Farms project area show that in practice the bedrocks and superficial sediments here are generally are of *low* palaeontological sensitivity due to high levels of bedrock deformation as well as chemical weathering (Almond 2012, 2017). The following palaeontological heritage assessment (based on the Aurecon standard assessment methodology and summarised in Table 1 below) applies to the *construction phase* of the wind farm and takes into consideration all the key infrastructural components of the Impofu East Wind Farm outlined in Section 2. These include *inter alia* wind turbines, hard standing areas, access roads (including upgrade of the Brakkeduine Road across the Klipdrifrivier; see Appendix 2, fig. 3), cables and powerlines as well as the combined on-site substation and switching station and associated buildings. Further significant impacts on fossil heritage during the operational and decommissioning phases of the wind farm are not anticipated so these phases are not separately assessed here.

The destruction, damage or disturbance out of context of legally-protected fossils preserved at the ground surface or below ground that may occur during construction of the wind farm entail direct *negative* impacts to palaeontological heritage resources that are confined to the development footprint and limited parts of the site (*very limited* extent). These impacts can often be effectively mitigated (*medium mitigatability*) but they are *permanent* and cannot be fully rectified (*low reversibility*). All of the sedimentary formations represented within the Impofu East Wind Farm study area contain fossils of some sort (*e.g*. microfossils, trace fossils) but impacts on *scientifically important, well-preserved, unique or rare fossil material* that is worthy of special protection / conservation are likely to be *very rare / improbable*. Impacts of some sort on fossil heritage are definite but, given the general low palaeontological sensitivity of the study area, they are likely to be of *very low intensity* (Local impacts on highly-significant fossil remains – such as rare vertebrate fossils – cannot be completely excluded). Most (but *not* all) of the fossils concerned are likely to be of widespread occurrence within the outcrop areas of the formations concerned; the probability of loss of *unique or rare* fossil heritage is therefore low (*low resource irreplaceability*). Given the extensive palaeontological field and desktop data now available for the study area near Humansdorp, confidence levels for this assessment are rated as *high*.

As a consequence of (1) the paucity of irreplaceable, unique or rare fossil remains within the development footprint, (2) the high levels of chemical weathering in the study area, as well as (3) the extensive superficial sediment cover overlying most potentially-fossiliferous bedrocks within the wind farm study area, the overall impact significance of the construction phase of the proposed wind energy project *without mitigation* is assessed as *minor / negligible* (negative).

Should the recommended mitigation measures for the construction phase of the wind farm – as outlined in the Chance Fossil Finds Procedure (Appendix 1) - be fully implemented, the impact significance of the project is still likely to remain *minor / negligible* (negative). However, in this case any small residual impacts due to loss of fossil heritage would be partially offset by the *positive* impact represented by an improved palaeontological database for the Humansdorp region as a direct result of appropriate mitigation. This is a *positive* outcome because any new, well-recorded and suitably curated fossil material from this

palaeontologically under-recorded part of the Eastern Cape would constitute a useful addition to the scientific understanding of the fossil heritage here.

When considering the **No-Go Alternative** (*i.e.* no wind farm development), impacts on local fossil heritage would be essentially *neutral*. Without development natural weathering processes and erosion will continue to steadily destroy fossils preserved near or at the ground surface, but at the same time new fossils will be continually exposed. This No-Go alternative would forgo potential improvements in the palaeontological understanding of the study region through any mitigated new fossil finds made during construction.

Table 1: Assessment of impacts on fossil heritage resources during the construction phase of the Impofu East Wind Farm near Humansdorp

Project phase	**Construction**			
Impact	**Fossil heritage**			
Description of impact	**Disturbance, damage or destruction of fossils preserved at surface or below ground as consequence of clearance or excavations (e.g. for access roads, wind turbine foundations, underground cables)**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**Safeguarding and reporting of chance fossil finds by ECO to ECPHRA. Recording and sampling of significant fossils by professional palaeontologist.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Permanent	Impact may be permanent, or in excess of 20 years	Permanent	Impact may be permanent, or in excess of 20 years
Extent	Very limited	Limited to specific isolated parts of the site	Very limited	Limited to specific isolated parts of the site
Intensity	Very low	Natural and/ or social functions and/ or processes are slightly altered	Negligible	Natural and/ or social functions and/ or processes are negligibly altered
Probability	Rare / improbable	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere	Rare / improbable	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Low	The affected environment will not be able to recover from the impact - permanently modified	Low	The affected environment will not be able to recover from the impact - permanently modified
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Negligible - negative**		**Negligible - negative**	
Comment on significance				
Cumulative impacts	Minor			

8.1. Cumulative impacts

Palaeontological heritage assessments for several other alternative energy projects in the broader Jeffrey's Bay – Humansdorp region have been reviewed, including all three proposed Impofu Wind Farms projects that are currently being assessed as individual assessments (See map Fig. 6 and reports by Almond 2010a, 2011a, 2011b, 2011c, 2011d, 2012, 2017 and De Klerk 2010a, 2010b, 2011 in the reference list). The Gibson Bay, Kouga, Jeffrey's Bay and Tsitsikamma Community Wind Farms are currently operational, whereas the remaining wind

farms shown in Fig. 6 are proposed. Note that not all these projects are of equal relevance for cumulative impact assessments since they do not all cover the same spectrum of potentially fossiliferous rock units. Furthermore, cumulative palaeontological impacts are influenced by any substantial development in the region, and not just by wind farms.

All the relevant wind farm studies listed concur in that the palaeontological sensitivity of the Humansdorp region is generally low as far as the bedrocks are concerned, especially because of the high levels of chemical weathering and tectonic deformation observed here. The only significant fossil sites recorded so far are (1) marine trace fossils in the Peninsula Formation near Rosenhof (Almond 2012, 2017) in the Impofu West Wind Farm project area and (2) the Late Pleistocene hyaena den bone, tooth and coprolite assemblages within Nanaga Formation aeolianites in the Gibson Bay WEF project area and near Oyster Bay (Carrion *et al.* 2000, Nilssen & Smith 2015, Brink 2015). Cumulative impacts of the additional three Impofu Wind Farm projects on fossil heritage – considered individually as well as a consolidated unit - are inferred to be *minor* as far as the Palaeozoic bedrocks are concerned (Almond 2017). This would also apply to impacts on sparse but locally-rich fossil heritage preserved within the coastal aeolianites *provided that* adequate monitoring of major excavations here (*e.g.* wind turbine footings, roads, substations and other buildings) is carried out during the construction phase.

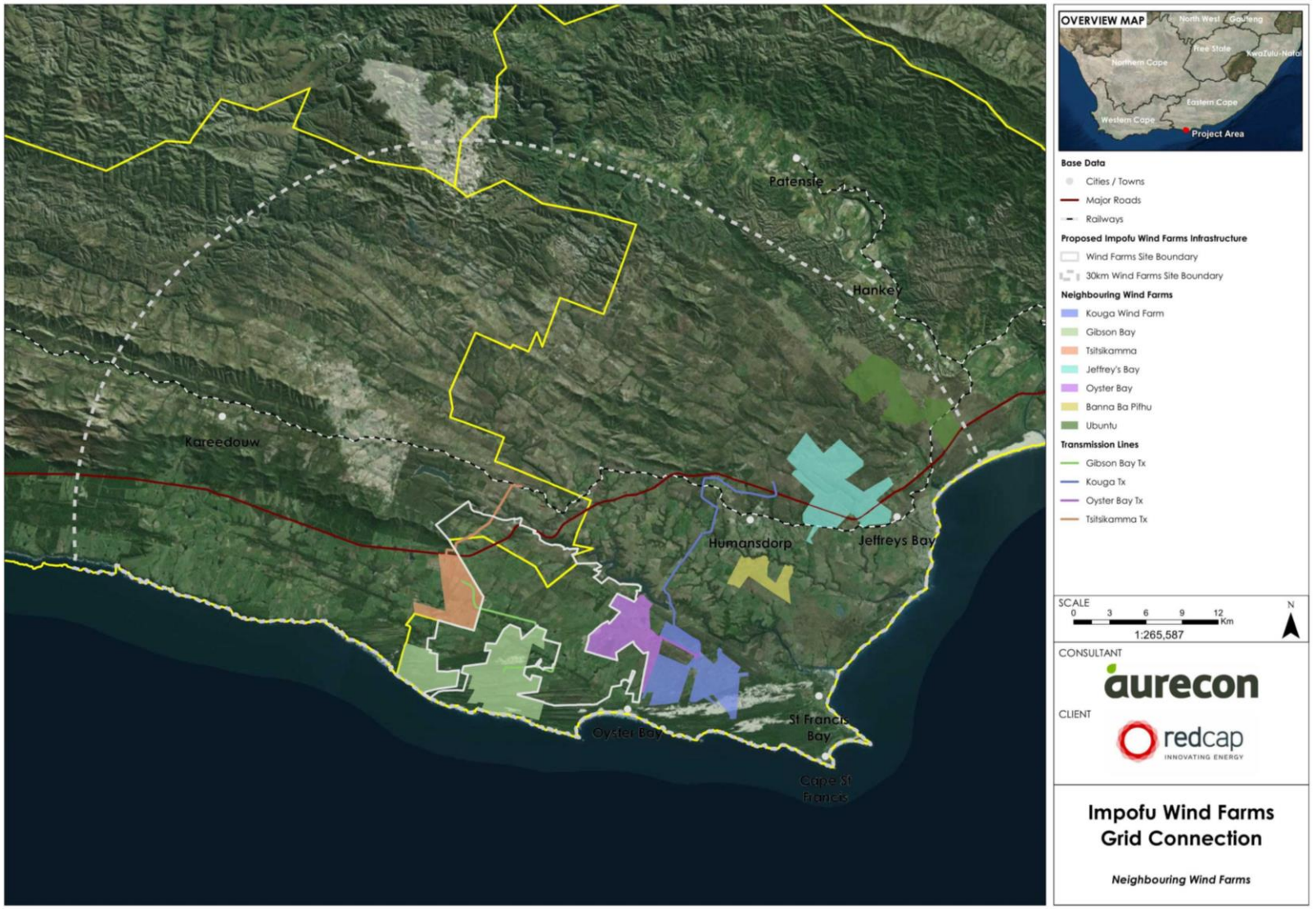

Figure 6. Satellite image showing the various alternative energy developments that are currently operational, as well as those proposed for the Jeffrey's Bay – Humansdorp region surrounding the Impofu Wind Farms project area (white polygon).

9. RECOMMENDED MONITORING AND MITIGATION (FOR INCLUSION IN ENVIRONMENTAL MANAGEMENT PROGRAMME)

Pending the potential discovery of significant new fossil remains (*e.g.* vertebrate bones and teeth, horn cores, shells, trace fossils, plant compressions) during the construction phase of the Impofu East Wind Farm, no further specialist palaeontological studies or mitigation are recommended for this project. Two quarry sites of geoheritage / palaeontological interest, labelled Q1and Q2 in Fig. 6, will not be directly impacted by the proposed wind farm development (GPS data provided in Appendix 2. Note Q2 lies just outside the wind farm project area). If it proves necessary to develop any of these sites, palaeontological mitigation will be required beforehand. This would involve geological and palaeontological documentation as well as sampling of the site by a professional palaeontologist.

The suitably qualified and experienced Environmental Control Officer (ECO) responsible for the wind farm development construction phase should be made aware of the potential occurrence of scientifically-important fossil remains within the development footprint. During the construction phase all major clearance operations (*e.g.* for new access roads, turbine placements, substations and other buildings) and deeper (> 1 m) excavations should be monitored for fossil remains on an on-going basis by the ECO. Should substantial fossil remains be encountered at surface or exposed during construction, the ECO should safeguard these, preferably *in situ* (See Appendix 1: Chance Fossil Finds Procedure). They should then alert the Eastern Cape Provincial Heritage Resources Agency, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible. This is to ensure that appropriate action (*i.e.* recording, sampling or collection of fossils, recording of relevant geological data) can be taken by a professional palaeontologist at the proponent's expense. These recommendations are summarized in the tabulated Chance Fossil Finds Procedure appended to this report (Appendix 1).

The palaeontologist concerned with any mitigation work will need a valid fossil collection permit from ECPHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection). All palaeontological specialist work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies developed by SAHRA (2013).

These monitoring and mitigation recommendations are to be incorporated into the Environmental Management Programme (EMPr) for the Impofu East Wind Farm. The operational and decommissioning phases of the development are unlikely to have further significant impacts on palaeontological heritage and no additional recommendations are made in this regard (The Chance Fossil Finds Procedure still applies).

10. CONCLUSIONS

The present palaeontological heritage scoping assessment is based on several desktop and field-based studies in the Kouga region near Humansdorp, including a field study of the consolidated Impofu Wind Farms project area. The Impofu East Wind Farm study area is underlain by several Palaeozoic sedimentary bedrock units of the Cape Supergroup (Table Mountain and Bokkeveld Groups). These include the Cederberg, Baviaanskloof and Gydo

Formations that are richly fossiliferous elsewhere in the Cape region. However, on the coastal platform near Humansdorp any fossils originally preserved in these bedrocks appear to have been destroyed by tectonic deformation and deep chemical weathering. The overlying Late Caenozoic superficial sediments such as alluvium, soils and ferricretes, are likewise of low palaeontological sensitivity. Relict patches of Plio-Pleistocene aeolianites (wind-blown sands) of the Nanaga Formation (Algoa Group) present in the subsurface on the interior coastal platform contain Early Stone Age artefacts but any associated fossils such as mammalian remains or terrestrial gastropods have probably been destroyed by weathering here. Pleistocene aeolianites close to the coast may contain important concentrations of mammalian fossils, as recorded in the adjoining Gibson Bay WEF project area and near Oyster Bay. The near-coastal palaeodune areas have been largely excluded from the wind farm footprint (Fig. 3) and significant palaeontological impacts are therefore not anticipated here.

Potential impacts to fossil heritage resources within the Impofu Wind Farms study area involve the disturbance, damage or destruction of fossil material within the development footprint during the construction phase. Due to the rarity of well-preserved, unique fossils of potential scientific importance within the study area, potential impacts on palaeontological heritage during the construction phase are assessed as of *negligible (negative) significance* (both before and after mitigation). The No-Go alternative (*i.e.* no wind farm) will have a neutral impact on palaeontological heritage. Cumulative impacts posed by the three separate Impofu Wind Farms are inferred to be *minor*. This also applies to cumulative impacts from known alternative energy developments in the region. Confidence levels for this assessment, which includes consideration of the worst case scenario (> 120 wind turbines for all three Impofu Wind Farms), are high due to comparatively good field data available for the study region.

Pending the potential discovery of significant new fossil remains (*e.g.* vertebrate bones and teeth, horn cores, shells, trace fossils, plant compressions) during the construction phase of the Impofu East Wind Farm development, no further specialist palaeontological studies or mitigation are recommended for this project in the EIA and construction phases.

There are no fatal flaws to the proposed wind farm project as far as fossil heritage is concerned. Providing that the Chance Fossil Finds Procedure outlined below and tabulated in Appendix 1 is followed through, there are no objections on palaeontological heritage grounds to authorisation of the Impofu East Wind Farm project.

The suitably qualified and experienced Environmental Control Officer (ECO) responsible for the wind farm development construction phase should be made aware of the potential occurrence of scientifically-important fossil remains within the development footprint. During the construction phase all major clearance operations (*e.g.* for new access roads, turbine placements) and deeper (> 1 m) excavations should be monitored for fossil remains on an on-going basis by the ECO. Should substantial fossil remains be encountered at surface or exposed during construction, the ECO should safeguard these, preferably *in situ*. They should then alert the Eastern Cape Provincial Heritage Resources Agency, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible. This is to ensure that appropriate action (*i.e.* recording, sampling or collection of fossils, recording of relevant geological data) can be taken by a professional palaeontologist at the proponent's expense. These recommendations are summarized in the tabulated Chance Fossil Finds Procedure appended to this report (Appendix 1).

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These monitoring and mitigation recommendations are to be incorporated into the Environmental Management Programme (EMPr) for the Impofu East Wind Farm. The operational and decommissioning phases of this development are unlikely to have further significant impacts on palaeontological heritage and no additional recommendations are made in this regard (The Chance Fossil Finds Procedure still applies).

11. ACKNOWLEDGEMENTS

Mr Lance Blaine of Red Cap Energy (Pty) Ltd, Hout Bay as well as Ms Kim White of Aurecon South Africa (Pty) Ltd, Cape Town, are both thanked for commissioning this study, for discussing the project approach, for facilitating the fieldwork and reviewing the draft reports, as well as for providing the necessary background information. I am grateful to Dr. Peter Nilssen for helpful discussions on heritage aspects of the Impofu Wind Farms study area.

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13. 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, Limpopo,

Northwest, Gauteng, KwaZulu-Natal and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has served as 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 1: CHANCE FOSSIL FINDS PROCEDURE: Impofu East Wind Farm near Humansdorp</td></tr>
<tr><td>Province & region:</td><td colspan="2">EASTERN CAPE, Sarah Baartman District Municipality</td></tr>
<tr><td>Responsible Heritage Resources Authority</td><td colspan="2">ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za)</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Cederberg & Baviaanskloof Formation (Table Mountain Group), Gydo Formation (Bokkeveld Group); Nanaga Formation (Algoa Group).</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Shelly marine invertebrates & trace fossils, plant compressions, rare fish. Mammalian teeth & bones in aeolianites.</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 Authority 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 Authority 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 Authority and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Authority, 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 Authority</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 Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Authority minimum standards.</td></tr>
</table>

APPENDIX 2: GEOLOGICAL AND PALAEONTOLOGICAL DATA FOR THE CONSOLIDATED IMPOFU WIND FARM PROJECT AREA

1. Introduction

The consolidated Impofu Wind Farm study area, comprising the Impofu North Wind Farm, the Impofu East Wind Farm and the Impofu West Wind Farm, is situated on the southern coastal platform in the Kouga region near Humansdorp, Eastern Cape. It spans the following geomorphic provinces of Partridge *et al.* (2010): Central Cape Fold Mountains, Southern Coastal Platform and Southern Coastal Lowlands. A Screening Study of the consolidated wind farm site was undertaken by the author in September 2017. The information contained in this Appendix has been extracted from the Palaeontological Heritage Screening Assessment (Almond, 2017) to provide further detail on the palaeontological and geological context of the project area.

Please note that, based on preliminary site investigations and further consultation with affected landowners, the consolidated wind farm site that was the subject of the Screening Study has been revised and the boundary has been altered accordingly. The maps contained in this Appendix reflect the previous consolidated wind farm boundary and not the current boundary.

2. Geological and palaeontological data

The geology of the Kouga region to the southwest of Humansdorp is shown on 1: 250 000 geology sheet 3324 Port Elizabeth (Toerien & Hill 1989) (Fig. 4). It has already been outlined in several previous desktop and field-based studies by the author (notably Almond. 2008, 2012, 2013a, 2013b; please see full references therein) for several of the wind farm projects in the broader Humansdorp region (See Fig. 5 for the location of these other projects). It should be emphasised that mapping of the various geological formations in this area is often *schematic* because of the generally poor levels of bedrock exposure; *i.e.* the outcrop areas shown in Fig. 4 may not be very accurate. Exposures are largely limited to river and stream banks, erosion gullies, borrow pits and quarries, road and railway cuttings and farm dams (See Figs. 1-3, 6, 7).

2.1. Palaeozoic bedrocks

The Palaeozoic bedrocks in the study area belong to the **Table Mountain Group** and **Bokkeveld Group** (Cape Supergroup) and were laid down in a range of fluvial, coastal and shallow marine settings on the margins of Gondwana in Ordovician to Devonian times (Thamm & Johnson 2006). The bedrocks beneath the coastal platform are strongly deformed into a series of subparallel, WNW-ESE trending folds (Fig. 4). A major NW-SE trending anticline cored by the Peninsula Formation runs across the northern and central parts of the study area, with a series of smaller-scale, tighter folds in the southwest. Deformation during formation of the Cape Fold Belt (CFB) also included faulting and widespread development of tectonic cleavage, especially within the finer-grained mudrocks, compromising fossil preservation.

Three formations within the Palaeozoic Cape Supergroup succession that have yielded important fossil assemblages elsewhere in the broader Cape Fold Belt region formed an important focus during the recent palaeontological field study of the Impofu WEF project area:

1. Late Ordovician post-glacial marine mudrocks of the **Cedarberg Formation** (Oc, grey in Fig. 4). This is a Red Flag unit of VERY HIGH sensitivity elsewhere in the CFB. Due to their easily-weathered character, they are apparently not exposed at surface within the study area. Narrow outcrop areas of this formation southwest of, and subparallel to, the Impofu Dam are mantled in ferricretised colluvial gravels and soil (*cf* Almond 2012). The Cedarberg Formation was previously observed in an artificial excavation near Rosenhof Farmstead (Almond 2012; Fig. 11), where it was clearly highly weathered, but this exposure is no longer available. The palaeosensitivity of the Cedarberg Formation in the study area is inferred to be LOW.

2. Early Devonian shallow marine sandstones and minor mudrocks of the **Baviaanskloof Formation** (S-Db, purple in Fig. 4) crop out along the northern margins of the study area on the southern side of the Kromrivier Valley but are poorly-exposed here. Good exposures available in R62 and R102 road cuttings show that the Baviaanskloof beds in the region – including the mudrock interbeds - are deeply weathered (Fig. 14). The palaeosensitivity of the Baviaanskloof Formation in the study area is inferred to be LOW.

3. Marine mudrocks and wackes (impure sandstones) of the **Gydo Formation** (Lower Bokkeveld Group) (Dg, pale blue in Fig. 4) crop out along several narrow zones within the study area (*e.g.* along SW margin of the Impofu Dam as well as along the Klipdrifrivier). They are considered to be of VERY HIGH palaeontological sensitivity elsewhere in the CFB. In the Humansdorp region several previous field studies as well as the present study show that they are usually highly-weathered and deformed (Fig. 15) (*e.g.* Almond 2012, 2013b). No original fossil material has survived, with the exception of a few poorly-preserved trace fossils (simple invertebrate burrows). The palaeosensitivity of the Gydo Formation in the study area is inferred to be LOW.

Ordovician – Silurian braided fluvial to shallow marine quartzites of the **Peninsula, Goudini** and **Skurweberg Formations** (Table Mountain Group) that underlie the majority of the core study area are generally of low palaeontological sensitivity. These successions show high levels of tectonic deformation and chemical weathering in the study area, with kaolinitisation and secondary mineralisation of subordinate mudrock intervals (Figs. 12 & 13). Scattered ridges and *koppies* of resistant-weathering Peninsula quartzite projecting above the coastal plain show frequent brecciation, tectonic cleavage or shearing, quartz-veining and in addition karst weathering features (Fig. 10). They are generally unfossiliferous. However, a single site (34 05 59.09 S, 24 32 09.85 E) with an important, albeit low-diversity marine trace fossil assemblage has been previously recorded by Almond (2012) (Q3 in Fig. 3). The traces are exposed on bedding planes in a hard rock quarry and related rock rubble excavated from the **Peninsula Formation** at a farm dam due west of Rosenhof farmstead (Lange Fontein 717/1) (Figs. 8 & 9). If possible, this site should be protected from further development, or appropriate mitigation applied.

2.2. Late Caenozoic deposits

Late Caenozoic terrestrial superficial deposits - *e.g.* alluvium, soils, surface gravels, ferricretes – overlying the bedrocks of the coastal interior are generally of LOW palaeosensitivity. During the recent field assessment only a few, highly-weathered examples of *probable* subterranean termite nests were recorded within ferruginous colluvial gravels overlying weathered Peninsula Formation bedrocks (Figs. 19 & 20). The site is situated within a gravel quarry near Kakebeensbos homestead (34 03 53.7 S, 24 34 29.3 E). These somewhat equivocal trace fossils are not regarded as of high conservation significance and no mitigation of the site is considered necessary.

Towards the coast, the bedrocks building the lower-lying, planed-off and deeply-weathered margins of the coastal platform are mantled by consolidated to unconsolidated shallow marine to coastal sediments of the Miocene to Holocene **Algoa Group** (Roberts *et al.* 2006). These sediments are predominantly vegetated to mobile aeolianites (wind-blown sands) of the Plio-Pleistocene **Nanaga Formation** and the Holocene **Schelm Hoek Formation**. The coastal aeolianites are generally of LOW palaeontological sensitivity. However, pockets of HIGH to VERY HIGH sensitivity may occur here, such as Pleistocene mammalian remains and plant material associated with ancient hyaena dens, springs or *vleis*, and ESA sites (Pether 2008). Local examples include important Late Pleistocene hyaena den bone and coprolite assemblages recorded from the Oyster Bay and Gibson Bay WEF areas by Carrion *et al.* 2000, Nilssen & Smith 2015 and Brink 2015 (Orange triangle in Fig. 4).

A composite succession of Plio-Pleistocene Nanaga aeolianites is mapped as mantling a broad coastal zone extending into the southern portion of the Impofu WEF study area (T-Qn, red in Fig. 4). In fact, as shown by numerous small dam and quarry excavations further inland, relict sheets and patches of these older aeolianites extend across large parts of the study area, probably as far as the foothills of the Kareedouberge north of the N2. They are usually semi-consolidated and structureless but may include well-developed ferricrete hard pans towards the base where they overlie weathered bedrock (Figs. 16 to 18). It seems likely that most calcareous fossils, such as bones and shells, that they might originally have contained have been destroyed by protracted chemical leaching; no fossil land snail shells are observed within them, for example. Several occurrences of *in situ* Acheulean / Early Stone Age artefacts (*e.g.* hand axes, crude flakes) embedded within secondarily-ferricretised or highly weathered Nanaga Formation aeolianites are of potential chronostratigraphic as well as archaeological interest. They are exposed in several small quarries within the WEF study area (e.g. Q2, Q4 in Figs. 2 & 3) including sites in the foothills of the Kareedouberge north of the N2. Isolated examples of *possible* termitaria (termite nests) as well as carbonaceous material associated with palaeosol horizons were also observed in the Nanaga beds.

The younger, unconsolidated Schelm Hoek wind-blown sands are generally poorly-exposed away from the coast due to pervasive vegetation cover (Fig. 1). Good exposures of mobile dunes with occasional sections through cross-bedded dune deposits overlying consolidated older dune deposits can be seen in the Brandewynkop area to the south of the Klipdrif Dam (Lange Fontein 717, situated just outside the WEF study area; Fig. 3). A long history of spring activity and development of interdune *vleis* in this region is reflected in abundant lenses of dark grey carbonaceous sands as well as ferricretes (Figs. 21, 22). A wide range of fossil or subfossil plant and animal material may be associated with palaesurfaces within such dune deposits (Pether 2008). There is clearly some potential for important Plio-Pleistocene fossil remains exposed either at surface or buried in the

subsurface within the coastal aeolianites of the Algoa Group. This also applies to the older Nanaga Formation dune sands in the coastal interior that have almost no natural surface exposure although, as observed previously, fossil remains here may have been largely destroyed by weathering. Monitoring and mitigation of any such Pleistocene fossil material is best carried out in the context of archaeological monitoring during construction.

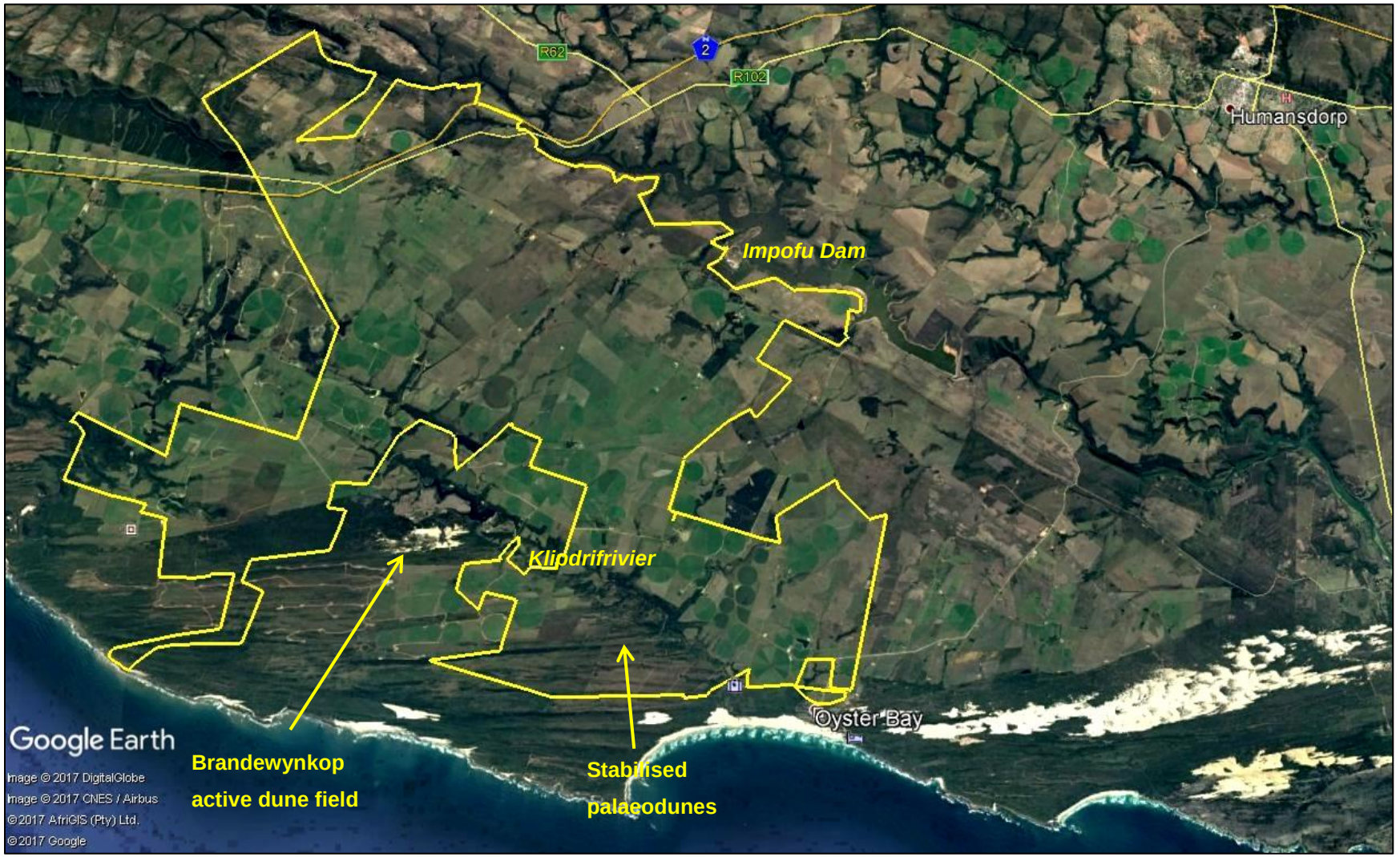


Figure 1. Google earth satellite image of the consolidated Impofu Wind Farm project area situated on the coastal platform near Humansdorp and Oyster Bay, Eastern Cape (yellow polygon).

Good exposures of the stratigraphy in the study area are seen in an extensive quarry cut face along the south-eastern side of the Kromhout Dam (Fig. 16; Q1 in Fig. 2). Here steeply-dipping, highly-weathered mudrocks and wackes of the Bokkeveld Group are erosively overlain by a several meter-thick package of coarse, poorly-sorted conglomerates that pass laterally into ferruginised and leached, semi-consolidated sands with pebbly lenses. The stratigraphic identity of this conglomerate and sandstone package is equivocal. It may comprise elevated alluvial deposits ("High Level Gravels") of the Klipdrifrivier drainage system. Alternatively, these may be a relict patch of Miocene – Pliocene coastal gravels and sands of the **Alexandria Formation**. These basal beds of the Algoa Group have not been recorded overlying the coastal platform west of the Gamtoos Valley (Toerien & Hill 1989, Le Roux 2000, Roberts *et al.* 2006). Shelly fossils (*e.g.* oysters) that would normally be expected within the Alexandria Formation were not observed during the brief site visit, but they might have been destroyed by chemical leaching, or have been overlooked. The conglomerates are capped by grey to reddish-mottled Pleistocene aeolianites of the Nanaga Formation at the base of which is a well-developed ferricete hardpan. There are further ferricretes higher up within the Nanaga succession, out of which flaked ESA artefacts (including occasional hand axes) are weathering. Given the geological interest of this quarry site, it is recommended that if possible, it be protected from further development during construction. If this is not possible, appropriate mitigation should be applied.

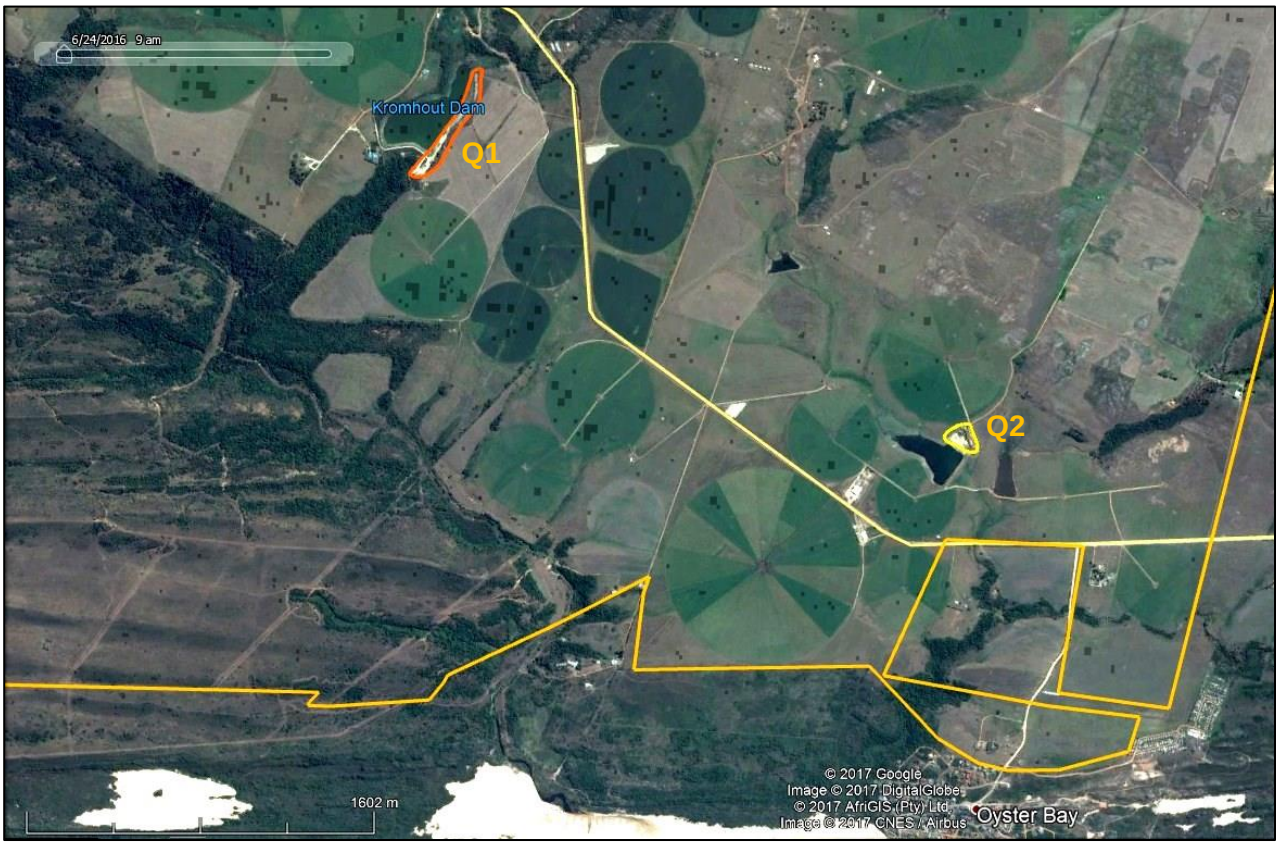


Figure 2. Satellite image showing the location of quarry site Q1 on the eastern side of Kromhout Dam and Q2 adjacent to a farm dam on Slange Rivier 733. Both these quarries are of geoheritage as well as archaeological interest and should be protected from further development, if possible. Q1 lies within the Impofu East Wind Farm study area while Q2 has been excluded from the wind farm study area.

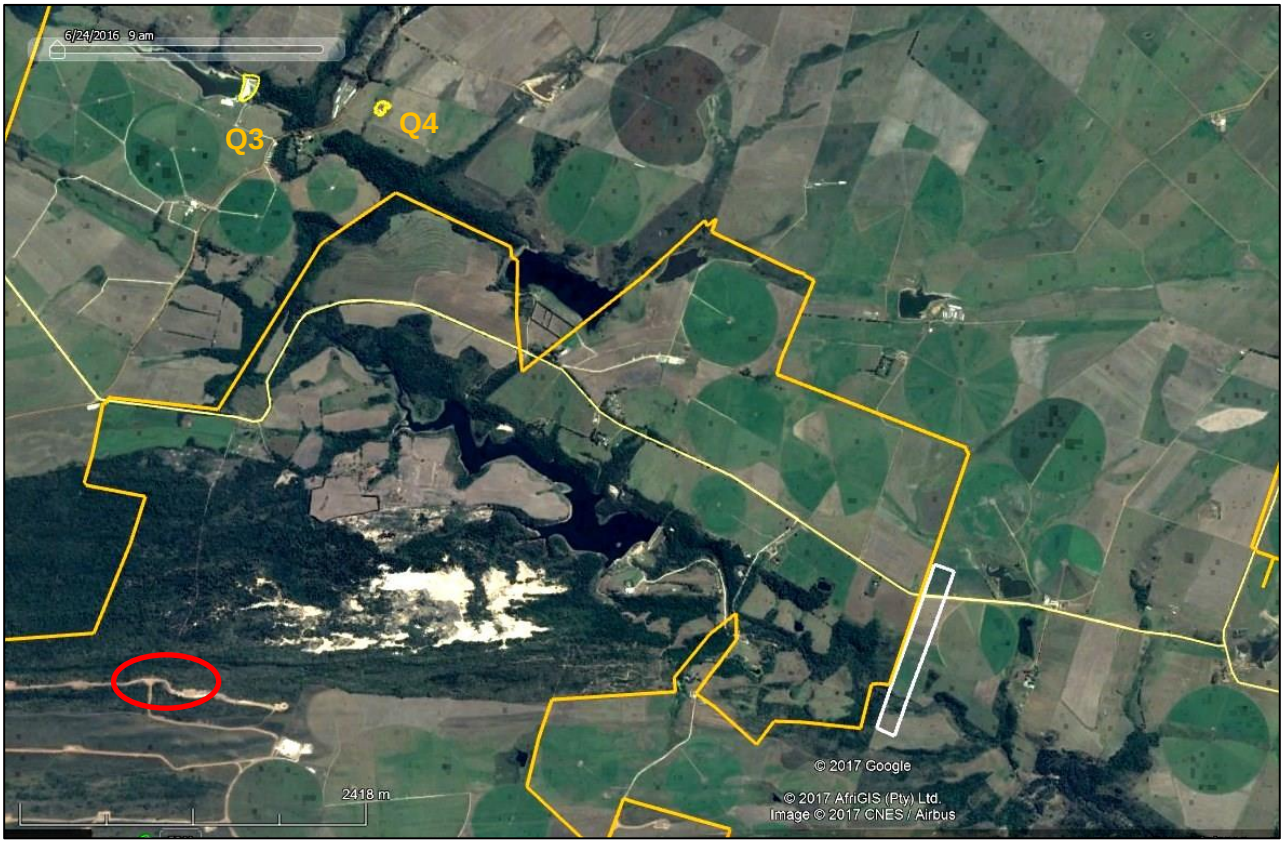


Figure 3. Satellite image showing the location of two quarry sites near Rosenhof farmstead. Q3 displays important trace fossils within the Peninsula Formation while Q4 is of geoheritage as well as archaeological interest. Both sites lie within the Impofu West Wind Farm study area. An important hyaena den accumulation of mammal bones and coprolites has been recorded in the area encircled in red to the southwest of the Brandewynkop dunefield (Nilssen & Smith 2015). New road and / or powerline developments across the valley of the Klipdrifrivier within the elongated white rectangle are of low palaeontological heritage significance.

Figure 4 (following page). Extract from 1: 250 000 geology sheet 3324 Port Elizabeth (Council for Geoscience, Pretoria) showing *approximate* outline of the consolidated Impofu Wind Farm study area near Humansdorp (yellow polygon). Two sites of high palaeontological sensitivity in the region are marked:

- **Red triangle – Ordovician trace fossils within the Peninsula Formation, Rosenhof dam wall and quarry (Almond 2012)**

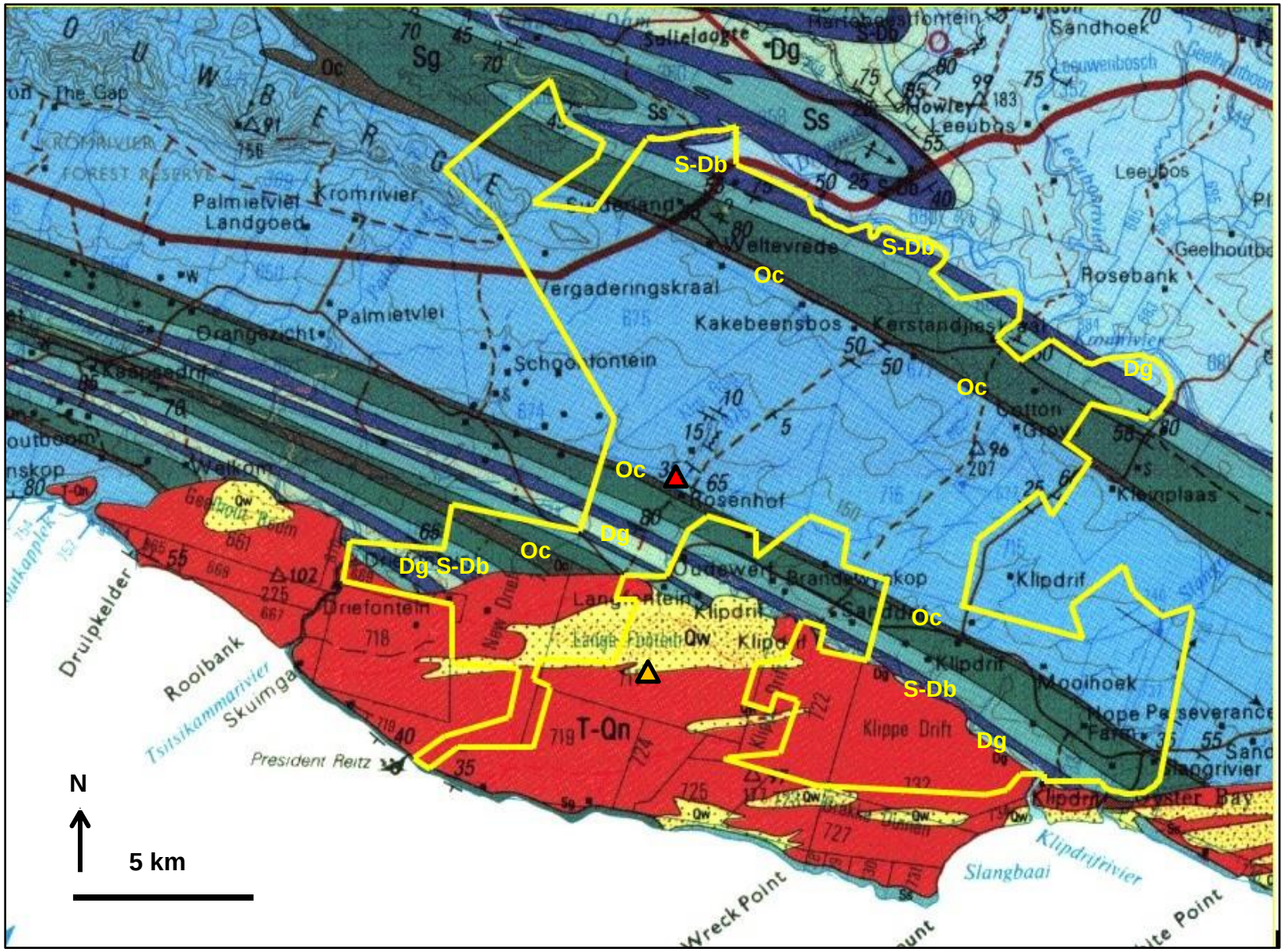
- **Orange triangle – Late Pleistocene hyaena den accumulation of mammalian bones and coprolites, Lange Fontein 717 (Nilssen & Smith 2015)**

The main geological units represented within the study area include the following formations (Palaeontologically more sensitive marine units indicated in red below; selected outcrop areas indicated on geological map in yellow). *Please note that geological mapping at 1: 250 000 scale in this region is often schematic due to very poor levels of bedrock exposure.*

TABLE MOUNTAIN GROUP (Ordovician to Early Devonian)
Peninsula Formation (Op, middle blue) *N.B.* One important fossil site recorded near Rosenhof farmstead (red triangle)
Cedarberg Formation (Oc, grey)
Goudini Formation (Og, grey-green)
Skurweberg Formation (Ss, pale blue)
Baviaanskloof Formation (S-Db, dark blue)

BOKKEVELD GROUP (Early Devonian)
Gydo Formation (Dg, v. pale blue)

ALGOA GROUP (Late Caenozoic, Pliocene / Quaternary to Recent)
Nanaga Formation (T-Qn, orange-brown) – *N.B.* outcrop area is underestimated on map
Schelm Hoek Formation (Qw, yellow with dots)



John E. Almond (2017) *Natura Viva* cc

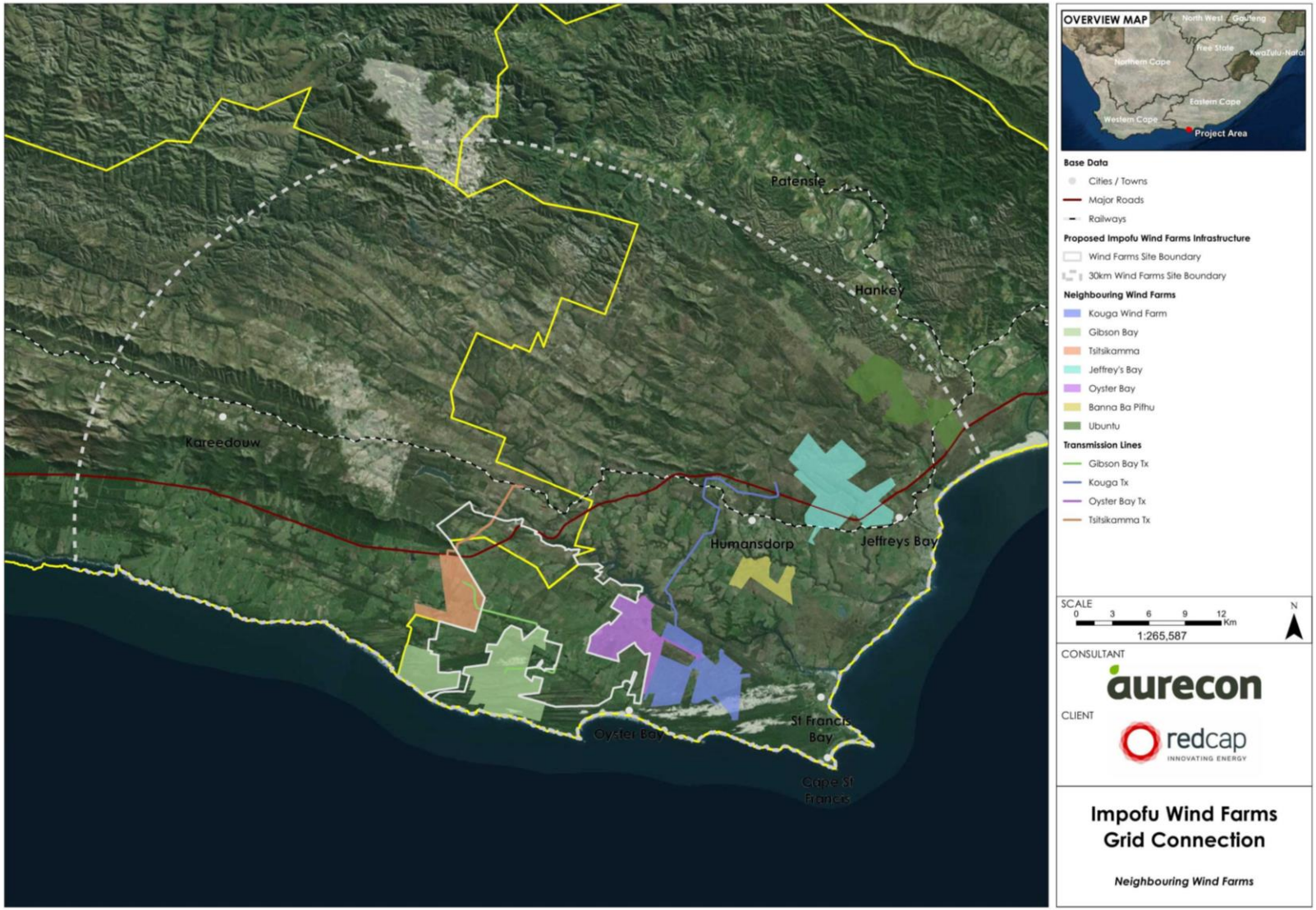


Figure 5. Satellite image showing the various alternative energy developments currently operational and proposed for the Jeffrey's Bay – Humansdorp region surrounding the Impofu WEF project area (white polygon).

Figure 6. Low-relief terrain in the NE sector of the consolidated Impofu Wind Farm project area (Impofu North Wind Farm project area), looking N towards the Kareedouwberge in the background.

Figure 7. Ridge and valley topography in the SW sector of the consolidated Impofu Wind Farm project area (Impofu West wind farm study area) reflecting a relict Pleistocene dune field mantled by vegetation in the area.

Figure 8. Rare extensive bedding plane exposures of the Peninsula Formation in quarry (Q3) near Rosenhof (Impofu West Wind Farm study area). *In situ* trace fossil assemblages are recorded here.

Figure 9. Excavated trace fossil-bearing quartzite block from the Impofu West study area quarry seen in the previous figure (Scale = 15 cm) (Almond 2012).

Figure 10. Craggy relict outcrops of quartz-veined and karstified Peninsula Formation quartzites capping ridges in the NE sector of the study area (Kakebeens Bosch 766) (Impofu North Wind Farm study area).

Figure 11. Small trench exposure (now covered-over) of Cedarberg Formation weathered mudrocks near Rosenhof farmstead (From Almond 2012) (Impofu West Wind Farm study area).

Figure 12. Highly-weathered, cleaved and quartz-veined beds of the Goudini Formation exposed in quarry near Rosenhof farmstead (Hammer = 30 cm) (Impofu West Wind Farm study area).

Figure 13. Tabular, cross-bedded, highly-jointed and quartz-veined fluvial quartzites of the Silurian Skurweberg Formation exposed at the coast just east of Oyster Bay (outside the consolidated wind far study area). Fresher bedrocks are available at the coast than in the interior.

Figure 14. Steeply-dipping, highly-weathered quartzites and mudrocks of the Baviaanskloof Formation just west of the Kromrivier gorge, Farm Diep Rivier's Mond 358 (Impofu North Wind Farm study area). Note rubbly ferruginised gravels overlying the truncated beds here.

Figure 15. Deeply-weathered, mottled mudrocks of the Gydo Formation (Bokkeveld Group), R102 road cutting just west of Impofu Dam (Impofu North Wind Farm study area).

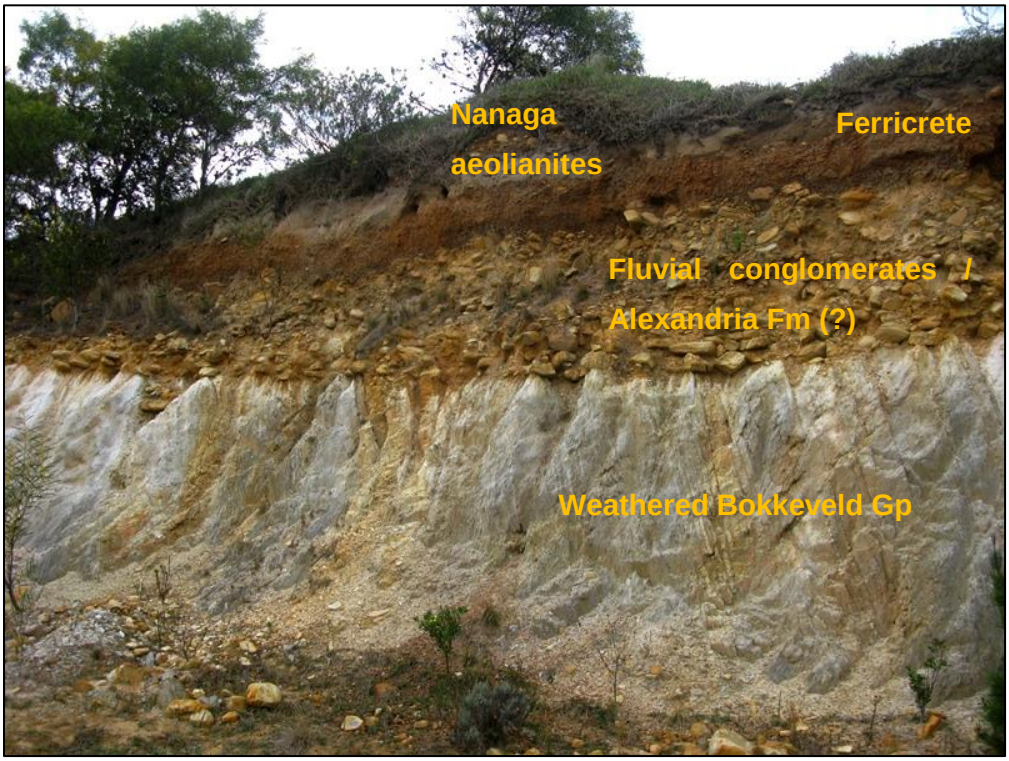


Figure 16. Good sections through the local stratigraphy in quarry Q1 east of Kromhout Dam (Impofu East Wind Farm study area).

Figure 17. Quarry Q2 on Slange Rivier 733 (just outside the Impofu East Wind Farm study area) showing weathered Cape Supergroup bedrocks overlain by thin pebbly conglomerate and then well-developed nodular ferricrete within the base of the Pleistocene Nanaga Formation

aeolianites (Hammer = 30 cm). Note dispersed flaked ESA artefacts of pale brown quartzite suspended within the ferricrete (encircled).

Figure 18. Vertical section through Pleistocene Nanaga aeolianites and intercalated palaeosol in quarry Q2 just outside the Impofu East Wind Farm study area (Hammer = 30 cm).

Figure 19. Ferruginised colluvial breccias infilling gullies within Peninsula Formation quartzites, gravel quarry near Kakebeensbos homestead (Hammer = 30 cm) (Impofu North Wind Farm study area).

Figure 20. *Possible* poorly-preserved fossil termite nests embedded within ferruginous gravels illustrated above (Scale is 15 cm long).

Figure 21. Relict exposure of dark grey, consolidated aeolianites capped by ferricrete horizon, Nanaga Formation in Brandewynkop dunefield, situated just outside the Impofu West and Impofu East Wind Farm study areas (Lange Fontein 717).

Figure 22. Brandewynkop dune field showing older grey aeolianites with ferricrete lenses and palaeosurfaces (Pleistocene Nanaga Formation) overlain by paler, unconsolidated sands of the Holocene Schelm Hoek Formation.

3. GPS Locality Data

This table provides locality data for palaeontologically significant geosites or palaeontological sites mentioned in the text.All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

LOC	GPS data	Comments
354	34 03 53.7 S 24 34 29.3 E	Impofu North Wind Farm project area. Possible but equivocal fossil termitaria preserved within ferruginous gravels overlying Peninsula Formation bedrocks, gravel quarry near Kakebeensbos homestead (See Figs. 19 & 20 herein).
357	34 08 38.2 S 24 37 27.2 E	Impofu East Wind Farm project area. Quarry (Q1 herein) on eastern edge of Kromhout Dam showing well-exposed stratigraphic succession through weathered Bokkeveld Group mudrocks & wackes erosively overlain by cobbly to pebbly conglomerates (either High Level Gravels or Alexandria Formation) and Nanaga Formation aeolianites with ferricretes and occasional ESA artefacts (See Fig. 16 herein).
362	34 09 13.6 S 24 39 06.3 E	Outside and south of southern edge of Impofu East Wind Farm project area. Quarry on northern margin of farm dam *c*. 1 km east of Meyers Hope farmstead (Q2 herein). Good exposures of basally ferricretized Nanaga Formation aeolianites with numerous embedded, fresh-looking ESA stone artefacts (See Figs. 17 & 18 herein).
375	34 06 03.9 S 24 32 47.6 E	Impofu West Wind Farm project area. Shallow borrow pit *c*. 600 m NE of Rosenhof farmstead (Q4 herein). Good exposures of ferricretized basal Nanaga Formation aeolianites containing abundant ESA stone artefacts.
376	34 05 59.09 S 24 32 09.85 E	Impofu West Wind Farm project area. Existing quarry (Q3 herein) into Peninsula Formation *c.* 0.5 km NW of Rosenhof farmstead as well as excavated blocks in adjoining dam wall. Important assemblages of Ordovician shallow marine trace fossils originally reported by Almond (2012) (See Figs. 8 & 9 herein above).

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