PALAEONTOLOGICAL IMPACT ASSESSMENT: COMBINED DESKTOP & FIELD STUDY

PROPOSED ESKOM MOOIDRAAI – SMITKLOOF 132/22 kV POWERLINE & SUBSTATION TO THE NORTHEAST OF PRIESKA, SIYATHEMBA MUNICIPALITY, NORTHERN CAPE

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1. EXECUTIVE SUMMARY

Eskom are proposing to construct a new 132 / 22 kV powerline linking the existing Mooidraai Substation, situated on the Farm Remhoogte 152, *c*. 30 km ENE of Prieska, Northern Cape, with the proposed new Smitskloof Substation. The latter will be located close to the Orange River and *c*. 16.5 km to the north of Mooidraai Substation. Two route alternatives for the 132 / 22 kV powerline and two sites for the new substation are under consideration.

The study area for the proposed Mooidraai – Smitskloof powerline and substation development is largely underlain by Permo-Carboniferous glacial rocks of the Dwyka Group (Karoo Supergroup), including tillites, outwash channel breccio-conglomerates and grits. These bedrocks are generally highly weathered and permeated by calcrete veins near-surface. The clast-rich tillites here are, at most, sparsely fossiliferous (*e.g.* occasional erratics of Precambrian stromatolitic limestone / dolomite recorded elsewhere in the Prieska region) and are unlikely to be significantly impacted by developments such as this that do not entail deep, voluminous excavations. No potentially fossiliferous interglacial rocks were observed within the Dwyka succession in the study area.

For a considerable distance from the Orange River (several 10s of km) the Dwyka bedrocks are truncated by a gently sloping pediment surface at *c*. 1000 – 1100 m amsl. This surface is overlain by an extensive gravelly calcrete hardpan (1 m thick or more) of probable Late Tertiary age (Mokalanen Formation, Kalahari Group). Abundant solution hollows were generated by karstic weathering of the calcrete hardpan close to the escarpment edge and are especially well-exposed in areas of previous diamond diggings. They are also observed in younger hardpans closer to modern river level. These cavities could have acted as effective traps for mammalian remains (bones, teeth), including micromammals, as well as land snails and other invertebrates in the past. However, with the exception of calcretised root casts (rhizoliths) within ancient fluvial channel sediments, no fossil material was observed in association with the potholed calcretes in the study area. The various calcrete hardpans are overlain by a range of poorly-consolidated, younger superficial deposits, some of which are also assigned to the Kalahari Group. They include relict patches of older fluvial gravels ("High Level Gravels"), mainly composed of Banded Iron Formation clasts, younger silty alluvium, wind-blown sands (Gordonia Formation), and colluvial sediments such as downwasted surface gravels (Obobogorop Formation). No fossil remains were recorded within these superficial deposits, including in the two study areas for the proposed Smitskloof Substation near the Orange River.

It is concluded that the palaeontological sensitivity of the sedimentary rocks in the Mooidraai-Smitskloof study area is LOW. The proposed development, including construction of the new Smitskloof Substation, 132/22 kV transmission line, new access roads and related infrastructure, is

unlikely to have a significant impact on local fossil heritage. Pending the discovery of substantial new fossil material during construction, no further specialist palaeontological studies or mitigation are recommended for this project.

In the case of any substantial fossil finds during construction (*e.g.* vertebrate teeth, bones, burrows, petrified wood, shells), these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za), so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented.

These recommendations should be incorporated into the Environmental Management Plan (EMP) for this development.

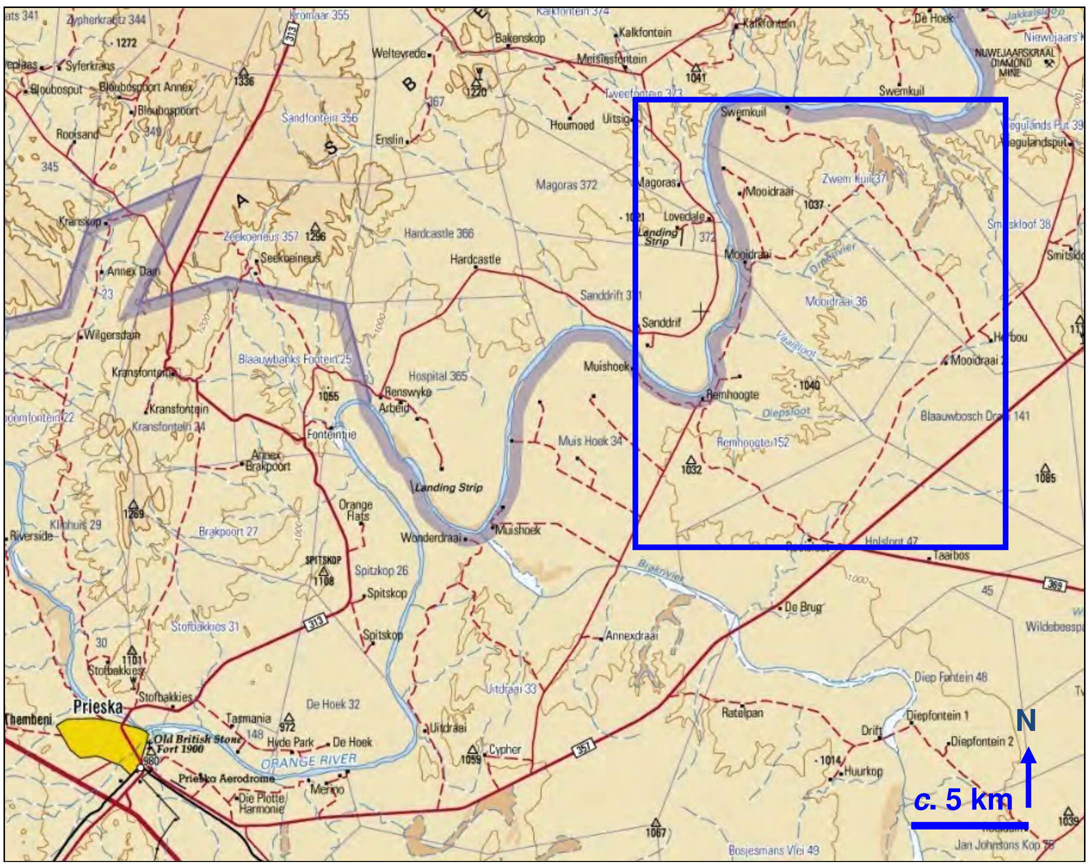

Fig. 1. Map showing the approximate location of the broader study area for the proposed new Mooidraai – Smitskloof powerline and Smitskloof Substation, *c.* 30-40 km NE of Prieska, Northern Cape (blue rectangle) (Extract from 1: 250 000 topographical map 2922 Prieska, courtesy of The Chief Directorate, National Geospatial Information, Mowbray).

2. INTRODUCTION & BRIEF

Eskom are proposing to construct a new 132 / 22 kV powerline linking the existing Mooidraai Substation, situated some three kilometres from the R357 on the Farm Remhoogte 152, *c*. 30 km ENE of Prieska, Northern Cape, with the proposed new Smitskloof Substation. The latter will be located close to the Orange River and *c*. 16.5 km to the north of Mooidraai Substation (Figs. 2 to 3). Two route alternatives for the 132 / 22 kV powerline and two sites for the new substation are under consideration (See Fig. 2). The preferred powerline route, Alternative 1, is *c*. 23.5 km long, of which some 11 km follows the existing Mooidraai servitude, running subparallel to the R357. The remainder of the route runs SE-NW close to the gravel road between Herbou and Swemkuil homesteads. The Alternative 2 route is c. 19 km long and runs more directly cross-country from the existing servitude, crossing the shallow Vaalsloot valley and approaching the proposed Smitskloof Substation sites from the south. The two alternative Smitskloof Substation sites, A and B on Figure 2, are both located to the southeast of Swemkuil farmstead, within two kilometres of the River Orange.

The proposed Eskom powerline and substation development area is underlain by potentially fossiliferous sediments of Palaeozoic to Late Caenozoic age that may be disturbed or excavated during the construction phase (*e.g.* building foundations, access roads roads, pylon footings). The present combined desktop and field-based palaeontological heritage assessment was commissioned as part of the Basic Assessment for this development by Royal HaskoningDHV (Contact details: 1st Floor Canon Building, Quenera Office Park, Beacon Bay, 5241, South Africa. Tel: 043-707 3000. E-mail: Vivienne.vorster@rhdhv.com).

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

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

A two-day field assessment study of the wider development area was carried out on 30-31 August 2013.

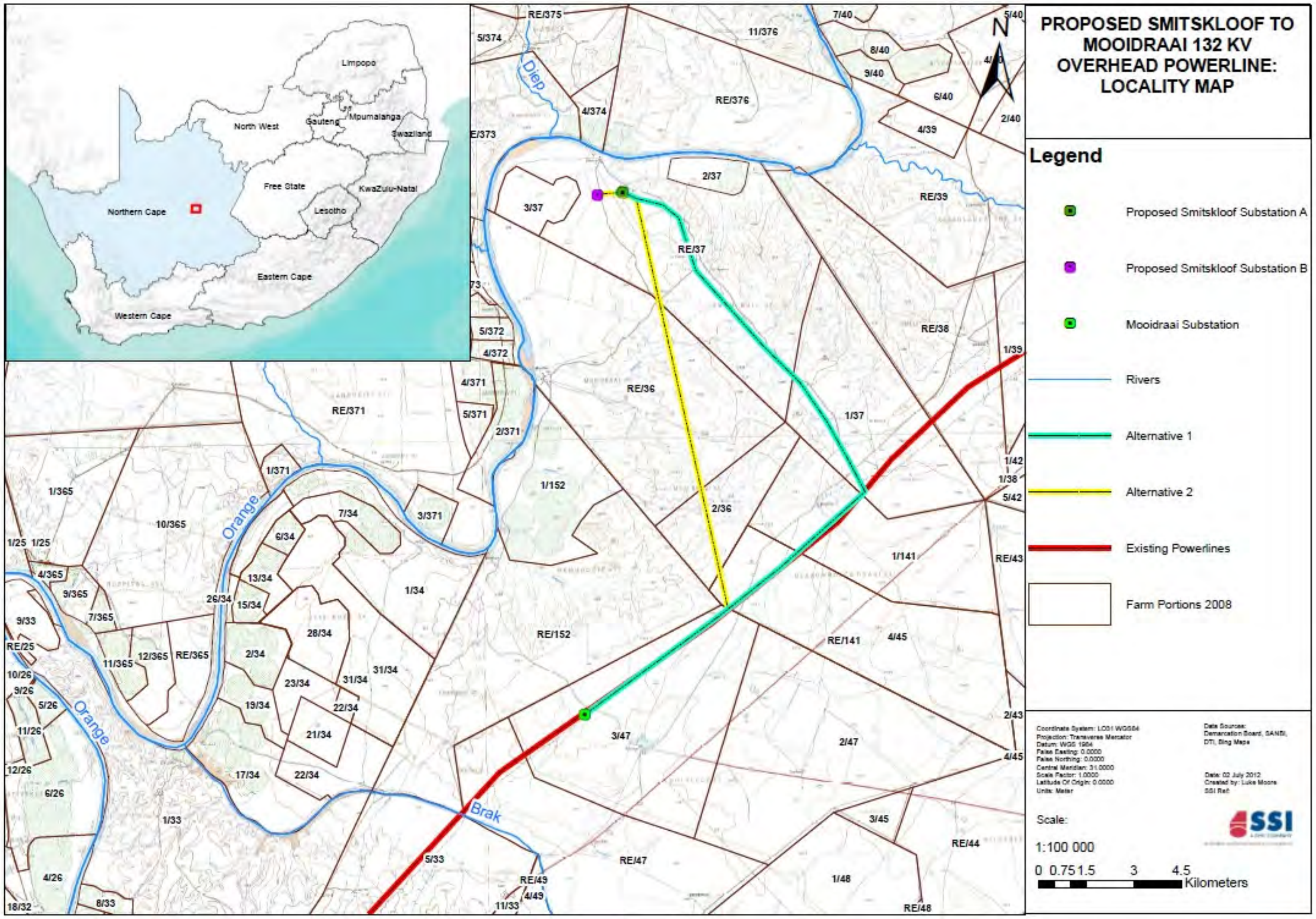

Fig. 2. Map showing the proposed alternative powerline routes from the existing Mooidraai Substation to the proposed new Smitskloof Substation, as well as alternative locations for the latter. The study area is located *c.* 30-40 km to the northeast of Prieska, Northern Cape (Image kindly supplied by Royal Haskoning DHV).

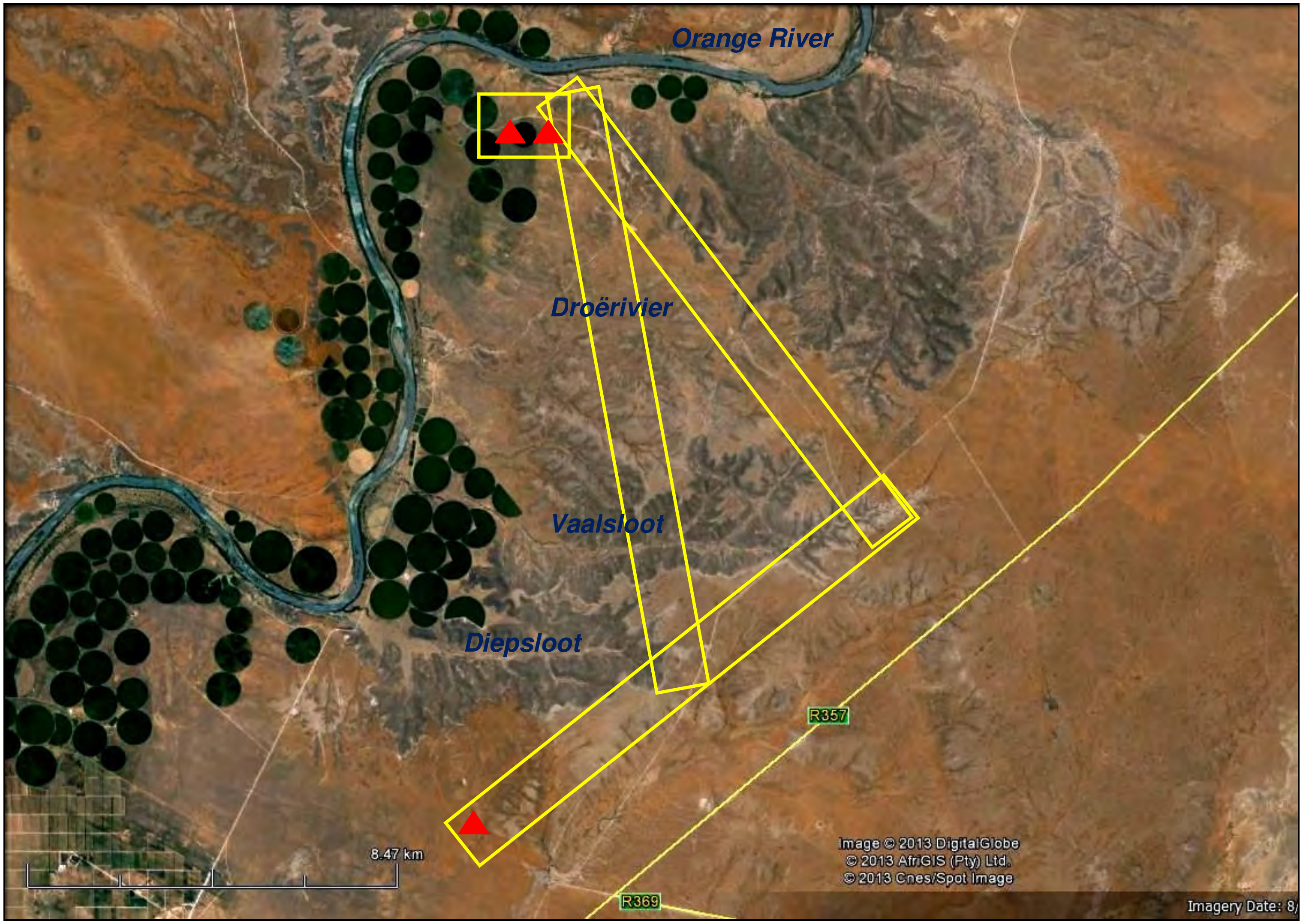

Fig. 3. **Google Earth© satellite image of the Mooidraai – Smitskloof study region to the northeast of Prieska, Northern Cape. The yellow rectangles outline the core study areas for the powerline and substation developments while the red triangles indicate existing or potential substation sites (See also Fig. 2).**

2.1. General approach used for this palaeontological impact study

This PIA report provides an assessment of the observed or inferred palaeontological heritage within the broader 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 assesments in the area (*e.g.* Almond 2013a, 2013b), (2) published geological maps and accompanying sheet explanations, (3) a two-day field study (30 – 31 August, 2013) as well as (4) the author's extensive field experience with the formations concerned and their palaeontological heritage.

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 Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). 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 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-localized (*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, SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

3. GEOLOGICAL BACKGROUND

The Mooidraai – Smitskloof powerline study area is mainly situated on flat-lying to gently sloping hilly terrain on the southern side of the River Orange (Gariep), some 30 to 40 km northeast of Prieska, and northwest of the R357 tar road to Douglas (Figs. 1 to 3). Most of this area forms part of an extensive pediment surface lying at *c*. 1000 – 1080 m amsl (above mean sea level) that is mantled by calcrete hardpans, thin surface gravels and, locally, by relict patches of Kalahari wind-blown sands. The surface slopes very gradually towards the Orange and is incised by the shallow, dendritic valleys of several intermittently flowing south bank tributaries of the Orange River, including the Diepsloot, Vaalsloot and Droërivier (Fig. 3). Apart from the irrigated agricultural lands along the Orange River banks, the terrain is dominated by rocky to sandy, semi-arid thornveld that is mapped within the Northern Upper Karoo vegetation type. The Alternative 1 powerline route keeps mainly to the ± 1000 m amsl pediment surface, apart from its northernmost sector, while the Alternative 2 route covers a greater range of relief since it crosses the Vaalsloot and Droërivier valleys *en route* from the existing power line servitude to the proposed new Smitskloof Substation study area. This last lies on a low pediment surface at around 970 m amsl, not far above the modern river level (here at *c*. 940 m amsl) .

The geology of the Prieska region is outlined on the 1: 250 000 geological sheet 2922 Prieska, for which a sheet explanation has not yet been published (Council for Geoscience, Pretoria) (Fig. 4). The 1000-1080 m amsl pediment surface bordering the River Orange in the study area is largely incised into glacial rocks of the Permo-Carboniferous **Dwyka Group** (Karoo Supergroup) (C-Pd). Closer to Prieska the Dwyka rocks can be clearly seen to infill palaeovalleys cut into basement (Kuruman Formation) synclines in pre-Dwyka or early Dwyka times (Almond 2013a). Away from the river most of the pediment surface is capped by a thick, laterally persistent **calcrete hardpan** that is probably of late Tertiary to Quaternary age (T-Qc). This hardpan is locally mantled by relict patches of younger windblown sands (**Gordonia Formation**, Qg) of the **Kalahari Group** as well as by various colluvial and downwasted surface gravels (**Obobogorop Formation**) and alluvial sediments. These last include older coarse-grained "High Level Gravels" (indicated on the geological map by a double "flying bird" symbol) as well as younger alluvial siltstones and gravels (single "flying bird" symbol) that are more closely associated with the modern drainage network. These superficial deposits overlying the calcrete are poorly dated but probably Quaternary to Holocene in age for the most part.

A brief illustrated account of the various major rock units encountered within the Mooidraai – Smitskloof study area is given in this section.

GPS data for numbered sites mentioned in the text are given in the Appendix at the end of this report. Elevation data (m amsl) given in this report is mainly based on GPS readings and is therefore of limited accuracy.

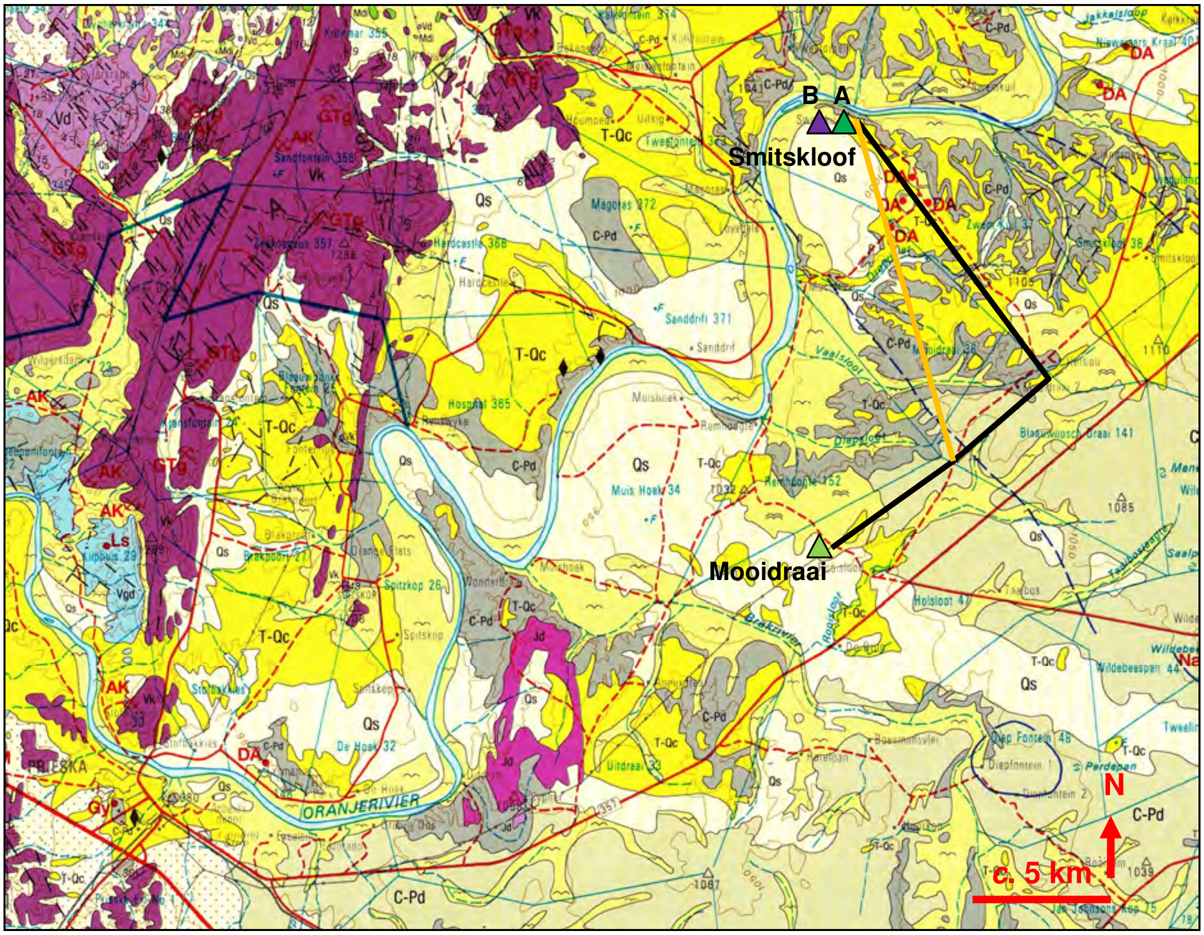

Fig. 4. Extract from 1: 250 000 geology sheet 2922 Prieska (Council for Geoscience, Pretoria) showing the approximate location of the proposed Mooidraai – Smitskloof transmission line and substation project. The study area is underlain at depth by Permo-Carboniferous glacial sediments of the Dwyka Group (C-Pd, dark grey = surface outcrop; pale grey = subsurface occurrence). The Dwyka bedrocks are mantled by Late Caenozoic calcretes (T-Qc, dark yellow), older alluvial gravels or "High Level Gravels" (pale yellow, double "flying bird" symbol), younger alluvium (pale yellow, single "flying bird" symbol), Quaternary aeolian sands of the Gordonia Formation (Kalahari Group) (Qs, white) as well as other superficial sediments such as surface gravels and scree. The red DA symbols indicate old alluvial diamond mines (of which there are several more than show here) associated with calcrete karst, while the black diamond symbols along the Orange River to the west are kimberlite occurrences. The dashed blue line striking NW-SE across the study area is a dyke intrusion of unspecified lithology (possibly a kimberlite or dolerite).

3.1. Dwyka Group

Beneath the superficial sediment cover Permo-Carboniferous glacial sediments of the **Dwyka Group** (**C-Pd, Karoo Supergroup**) underlie most or perhaps all of the study area close to the Orange River. The geology of the Dwyka Group has been summarized by Visser (1989), Visser *et al.* (1990) and Johnson *et al.* (2006), among others.

The Dwyka Group along the north-western margin of the Main Karoo Basin, including the Prieska Subbasin in particular, has been reviewed in some detail by Visser *et al.* (1977) and Visser (1982, 1985). The Prieska – Kimberley area as a whole is well known for its numerous, and sometimes spectacular, glaciated pavements. The Dwyka Group succession within the Prieska Basin, located south of the Ghaap Plateau and northeast of the Doringberg Range, is 100 m or more in thickness. It mainly comprises massive diamictites (basal tillite of a grounded ice sheet), bedded diamictites and laminated mudrocks (respectively proximal and distal subaqueous sediments beneath or in front of a floating ice sheet) as well as heterolithic packages of well-bedded sandstones, grits and breccio-conglomerates. These last are attributed to subaerial glacial outwash processes reworking lodgement tills. Two major phases of glaciation are identified, with ice sheet movement predominantly but not exclusively from the NE to SW. The source area of many of the exotic boulder erratics (*e.g.* stromatolitic carbonates of Griqualand West succession, amygdaloidal lavas of the Ventersdorp Supergroup) seen in the Dwyka succession in the Prieska Basin is the elevated Ghaap Plateau to the north of Prieska (Visser 1982).

According to maps in Visser *et al.* (1990) and Von Brunn and Visser (1999) the Dwyka rocks in the Prieska-Copperton area close to the northern edge of the Main Karoo Basin belong to the **Mbizane Formation**. This is equivalent to the Northern (valley and inlet) Facies of Visser *et al*. (1990). The Mbizane Formation, up to 190 m thick, is recognized across the entire northern margin of the Main Karoo Basin where it may variously form the whole or only the *upper* part of the Dwyka succession. It is characterized by its extremely heterolithic nature, with marked vertical and horizontal facies variation (Von Brunn & Visser 1999). The proportion of diamictite and mudrock is often low, the former often confined to basement depressions. Orange-tinted sandstones (often structureless or displaying extensive soft-sediment deformation, amalgamation and mass flow processes) may dominate the succession. The Mbizane-type heterolithic successions characterize the thicker Dwyka of the ancient palaeovalleys cutting back into the northern basement rocks.

Dwyka Group bedrocks underlie the majority of the Prieska study area at depth but are very poorly exposed in the study region to the northeast of town due to the pervasive superficial sediment cover (calcrete, aeolian sands, alluvium, surface gravels *etc*). An extensive Dwyka outcrop area is indicated on the 1: 250 000 geological map (Fig. 4). Satellite images (Fig. 3) show dark grey areas along shallow tributary valley slopes south of the Orange River where Dwyka bedrocks would be expected. However, these dark areas in fact reflect the abundance of dark, desert-varnished boulder surface gravels that have accumulated here due to downwasting and colluvial processes and do *not* indicate Dwyka tillite exposed at surface (*e.g.* bouldery slopes of Vaalsloot valley near Mooidraai homestead, Fig. 21; Dwyka slopes near Swemkuil, Fig. 8).

Exposures of Dwyka diamictite beneath the calcrete hardpan are usually highly weathered (pale grey-green, friable) as well as permeated and disrupted by calcrete veins and layers towards the top of the succession (Fig. 7). Clast lithologies include BIF (generally much less abundant than in the younger Caenozoic gravels), ferruginous chert, quartzite, ferruginous sandstone and limestone, pale grey and brown limestone (sometimes stromatolitic), gritty and gravelly conglomerates, gneiss, granite, basalt, amydaloidal to vesicular Ventersdorp lava, dolomite, jasper *etc*. Many of the larger clasts show glacial faceting, polishing and well-developed surface striation. Weathered, grey-green, clast-poor Dwyka tillite is well seen in a borrow pit close to the Orange River near Remhoogte homestead (Loc. 352a). The Dwyka succession exposed in the borrow pit Loc. 354 near Herbou homestead (Fig. 5) contains boulder-sized erratics with striated surfaces. Also seen here are resistant-weathering lenses of tough, grey-green, calcified grits, pebbly sandstones and polymict, matrix- to clast-supported breccio-conglomerates interbedded with the more weathered, calcretised tillites. The varied lithofacies represented within the clastic lenses are well seen in numerous large reworked blocks dumped at the edge of the pit (Fig. 6). The coarse clasts mainly comprise weathering-resistant lithologies (chert, quartzite, lavas, quartz), are poorly sorted and generally better rounded than equivalent clasts within the tillites themselves. They are well-cemented by calcite. According to earlier work by Visser *et al.* (1977) these beds, previously termed "gravelly tillites", represent lag deposits generated subaqueously beneath a floating ice sheet through reworking and winnowing of glacial diamictite by bottom currents (ibid., p. 168 and their fig. 6.3). However, later studies (Visser 1982) preferred to interpret them as subaerially deposited proglacial outwash and perhaps ice contact deposits, reworking lodgement tills, with the coarser channel conglomerates attributed to high-energy braided streams (ibid., pp. 72-73).

No evidence for post-glacial mudrocks of the Prince Albert Formation (Ecca Group) was observed during field assessment. These Permian mudrocks are known to be highly fossiliferous in the Douglas area, for example, some 100 km to the northeast of the present study area (McLachlan & Anderson 1971, Almond 2010c). The Dwyka tillite succession is planed off by a calcrete-capped pediment surface of probable Late Tertiary age and the uppermost tillite directly beneath the calcrete hardpan is frequently secondarily calcretised.

An elongate NW-SE trending dyke indicated by a dashed line on the geological map (Fig. 4) crosses the Mooidraai powerline route (*e.g.* on the farm Mooidraai 36) and can be faintly picked up on satellite images. It intrudes the Dwyka Group bedrocks and might be an Early Jurassic dolerite dyke; an extensive dolerite intrusion is mapped less than 20 km to the southwest. Alternatively it may be related to Cretaceous kimberlite intrusive activity. This dyke was not seen at surface during the present field study and is not of palaeontological heritage significance, so it will not be considered further here.

Fig. 5. Borrow pit exposure of Dwyka tillites and interbedded, prominent-weathering pebbly sandstone lenses near Herbou farmstead (Loc. 354) (Hammer = 30 cm).

Fig. 6. Displaced block of well-cemented pebbly channel conglomerate from the margins of the Dwyka borrow pit near Herbou farmstead (Loc. 354) (Hammer = 30 cm).

Fig. 7. Deeply-weathered, secondarily calcretised Dwyka tillite with boulder erratics and thin sandstone interbeds overlain by calcrete hardpan, borrow pit on Zwem Kuil 37 (Loc. 366) (Hammer = 30 cm).

Fig. 8. View northwards towards the Orange River Valley in the Swemkuil area. Grey cliff exposures of Dwyka tillite on the northern riverbank contrast with complete mantling of the Dwyka outcrop on the gentle slopes in the foreground by dark, downwasted surface gravels (See also Fig. 21).

3.2. Late Caenozoic superficial sediments

A wide range of coarse- to fine-grained superficial sediments of ill-defined, Late Caenozoic age mantle the Palaeozoic bedrocks in the Prieska study area. Tentative correlations may be made between several of these superficial sediment units and the Kalahari Group succession established to the north (Fig. 24).

3.2.1. Calcrete hardpans

The majority of the study area is underlain at or near-surface by well-developed calcrete hardpans (T-Qc) of variable thickness and age, probably formed during arid climatic intervals in the Late Tertiary to Quaternary for the most part (See papers by Netterberg in the reference list). Such hardpans typically mantle much of the Dwyka Group outcrop area in the Northern Cape and overlie river-cut pediment surfaces at several different levels and ages along the Orange River. The main hardpan mantling the *c.*1000-1100 m amsl pediment surface might be correlated with the Late Pliocene to Pleistocene **Mokolanen Formation** of the Kalahari Group (Partridge *et al.* 2006, Fig. 24 herein) which is probably a composite unit.

Good vertical sections through the main calcrete hardpan at *c.* 1020-1050 m amsl were observed in several borrow pits (*e.g.* Locs. 339, 341). Well away from the Orange River the hard pan is commonly of the order of a meter or so thick and variously shows a nodular to rubbly fabric and / or pseudobedding (Loc. 362, Fig. 10), with a dense, often laminated surface crust and a covering of weathered surface rubble. Dispersed gravel clasts and gravel lenses are common within the hardpan succession (Figs. 9 & 12).

Fresh sections through the dense calcrete hardpan are seen on quarried blocks on the margins of a quarry on Remhoogte 152 (Loc. 346a) at *c*. 1030 m amsl. It is clear that the hardpan here is a complex, composite feature with multiple episodes of pedogenic precipitation, solution (*e.g.* karstic weathering), erosion and re-deposition. This is shown by features such as shallow to deep, subcylindrical erosional cavities, recemented calcrete breccias and pebbly layers, cavity infills and lenses composed of reworked, rounded calcrete clasts in a calcrete matrix (Some clasts with concentric, symmetrical to asymmetrical outer calcareous rinds like oncoids) (Fig. 11). Some cavities are open (vugs) while others have been infilled by drusy calcite or orange-brown sand. Lenses and cavity infills of matrix-supported, gravelly breccia are dominated by BIF clasts, whose angular to well-rounded shapes suggest minimal to high levels of current transport respectively.

A sizeable NW-SE trending channel feature within the near-surface hardpan is seen along the edge of the calcrete plateau at c. 980 m amsl at Loc. 350 (Remhoogte 152) (Fig. 9). The channel, possibly an ancient branch of the Diepsloot drainage system, is several tens of meters wide and over 6 m deep along the midline. It is infilled with gently inclined beds of calcretised alluvium, including lenses and horizons of fine to coarse alluvial gravels (BIF, Ventersdorp lava, reworked calcrete *etc*), dispersed gravels, sandstone, and occasional buff silty interbeds. Along the plateau edge a coarse, rubbly scree of calcrete blocks mantles the Dwyka beds beneath the calcrete *krans*. An apparently bedded and folded calcrete hardpan of several (> 5 m) meters thickness at *c*. 1030 m amsl is exposed at the southern end of the large borrow pit excavated into weathered Dwyka tillite on Zwem Kuil 37 (Loc. 366). Poorly-sorted, coarse, bouldery river gravels at *c*. 960 m amsl embedded within a calcrete hardpan are well-exposed in road cuttings along the R357 some 4 km south of Mooidraai Substation (Loc. 353). Topographic inversion due to the greater weathering-resistance of the calcretised channel conglomerates may be involved here.

Towards the edge of the various pediment surfaces, facing the Orange River or its main tributary valleys (*e.g.* Droërivier, Vaalsloot), the calcrete hardpan is extensively potholed. The potholes are best exposed in the numerous small areas that have been exploited for alluvial diamonds in the past (*e.g.* Remhoogte 152, Mooidraai 36, Zwem Kuil 37; Locs. 346b, 348, 358, 361, 365 at 1020 – 1080 m amsl) (Figs. 12 to 16). The cavities, which may extend up to a meter or more downwards, sometimes right to the base of the hardpan. They were probably initially generated by subaerial karstic (*i.e.* solution weathering) processes following exhumation of the hardpan from beneath the overlying mantle of soil. Between the potholes and sometimes along their rims the calcrete often retains a rough, etched surface texture with polygonal cracks and crusts suggesting limited later remodelling of the original karstic surface. However, in other areas the pothole margins and surfaces are extensively smoothed and undercut, probably by stream abrasion. The potholed calcrete surfaces are generally infilled and overlain by coarse fluvial gravels (mainly platy BIF, chert, quartzite, calcrete) and Kalahari sands. The gravels must have been introduced by vigorous, bedload-laden river currents that would have eroded the karstified bed prior to as well as during the initial phases of deposition. BIF gravels infilling earlier generations of potholes, later completely calcretised, indicate that several phases of karstification and gravel infilling of cavities were involved. Other gravel inclusions within the calcrete hardpan (sometimes highly angular) stem from the assorted alluvial sediments within which the Pleistocene or older calcretes originally developed.

Close to the Orange River and just south of the proposed Smitskloof Substation development area, calcrete hardpans (locally kartified and potholed) are developed on gentle, flat slopes beneath a veneer of surface gravels, BIF coarse alluvial gravels, Kalahari sands and silty alluvium at *c*. 1000 m amsl, not far above the modern river level (Locs. 367-368).

Fig. 9. Thick calcrete hardpan along the escarpment edge near Remhoogte farmstead (Loc. 350). The inclined beds of gravel-rich calcrete here represent the infill of a sizeable ancient channel feature.

Fig. 10. Pseudobedded, composite calcrete hardpan with a rubbly internal fabric and dense calcrete capping, Loc. 362 (Hammer = 30 cm).

Fig. 11. Detail of composite calcrete hardpan excavated at quarry site Loc. 346a (Remhoogte 152) showing breccia of reworked calcrete clasts below, dense laminated zone in the middle, and upper conglomeratic zone with rounded calcrete pebbles with some orange-brown sandy matrix (Scale in cm).

Fig. 12. Karstified calcrete hardpan on Remhoogte 152 (Loc. 361) showing abundant gravel inclusions (mainly BIF), solution cavities / potholes and mantle of coarse High Level Gravels and Kalahari sands (Hammer = 30 cm).

Fig. 13. Intensely potholed calcrete hardpan on Remhoogte 152 exposed by diamond mining. Most of the overlying sands and gravels have been manually removed here (Loc. 348) (Hammer = 30 cm).

Fig. 14. Detail of potholes in calcrete hardpan showing rough, etched upper surfaces (adjacent to hammer) and BIF gravels within the hardpan as well as infilling the potholes (Loc. 361) (Hammer = 30 cm).

3.2.1. Older Alluvial Gravels

Relict patches of Late Tertiary to Quaternary alluvial gravels ("High Level Gravels") are mapped along both the Vaal and Orange Rivers in the Windsorton – Kimberley – Douglas - Prieska area, where they have been associated with diamond mining (De Wit *et al*., 2000, their table 4.1 and fig. 4.1). In the Windsorton area to the north of Kimberley heavily calcretized "Older Gravels" have been grouped into the **Windsorton Formation** and are suspected to be Miocene-Pliocene in age (Partridge & Brink 1967, De Wit *et a*l., 2000, Partridge *et al.* 2006). The "Younger Gravels" (**Rietputs Formation**) of the Vaal River system, at lower elevations, are associated with Acheulian stone tools and are therefore considered to be Early to Middle Pleistocene (Cornelian) in age (Klein 1984, Table 2, Butzer *et al*., 1973, Partridge *et al*., 2006). Recent cosmogenic nuclide dating of coarse gravels and sands in the Rietputs Formation gave an age of *c*. 1.57 Ma (Gibbon *et al.,* 2009).

The older pediment gravels of alluvial origin ("terrace gravels" or "High Level Gravels") at elevations of *c*. 1000 to 1080 m amsl along the Orange River in the Prieska study area are predominantly composed to subrounded to subangular, pebble to cobble-sized clasts of resistant lithologies such as banded iron formation (BIF), with minor quartzite, Ventersdorp lava, chert, vein quartz *etc* (Figs. 15 & 16). Many of the BIF gravels are platy in form and anthropogenically flaked (ESA / Fauresmith, MSA). The gravels are locally calcretised and may themselves be mantled by thin to thick Kalahari sands or younger, finer-grained alluvium. The coarse gravels infill potholed / karstified surfaces in the underlying calcrete hardpan towards the margins of the pediment, as well seen at the various small alluvial diamond diggings (DA) in the study area (See previous section) (Fig. 17). These older "High Level Gravels" now lie at elevations of 60 to 140 m above the present Orange River and are probably of Late Tertiary / Quaternary age (*cf* Plio-Pleistocene age inferred for the underlying calcretes of the Mokalanen Formation). By comparison, the "older gravels" at elevations of + 60 m along the Vaal River (Windsorton Formation) are considered to be of probable Miocene age, but are generally highly calcretised (Partridge *et al.* 2006).

Fig. 15. Calcrete hardpan near the edge of the 1000 m amsl escarpment on Zwem Kuil 37 with mantle of High Level Gravels, largely composed of BIF.

Fig. 16. Close up of coarse surface gravels near Mooidraai Substation (Loc. 345) showing moderate degree of rounding (indicating river transport) and predominance of BIF lithologies (frequently flaked) (Hammer = 30 cm).

Fig. 17. Previous alluvial diamond mining area on Zwem Kuil 37 showing (reworked) coarse BIF gravels blanketing the potholed calcrete hardpan surface (Loc. 365).

3.2.3. Younger alluvium

Close to the Orange River massive to laminated, greyish-green alluvial siltstones with dispersed to lenticular gravels are seen overlying weathered Dwyka tillite in road cuttings close to Remhoogte homestead (Loc. 351). The silty alluvium and Dwyka bedrock here are incised by coarse fluvial gravels at *c*. 960 m amsl showing normal grading, *possible* potholes along the basal contact with the Dwyka, and well-developed current imbrication of the more platy BIF clasts (Fig. 18). Crude Acheulian bifacials of BIF were observed in a roadside ditch at this locality. They show a thin, impersistent calcrete patina as well as somewhat blunted edges and so may well have been reworked from *within* the coarse river gravels rather than overlying downwasted material. This suggests a maximum age for these "low level" gravels of around 2.5 Ma. Comparable coarse alluvial gravels at less than 20 m above the present day Vaal River ("Younger Gravels" or **Rietputs Formation**) contain Acheulian artefacts and a Middle Pleistocene mammalian fauna (Partridge *et al.* 2006).

The floors of major stream valleys such as Vaalsloot and Diepsloot are mantled in fine silty to coarse gravelly alluvium. Thick (> 2m), young silty alluvium, locally with a gravel-rich base, is seen near the mouth of the Vaalsloot drainage system on Remhoogte 352 (Loc. 352b) as well as in a tributary of the Droërivier on Zwem Kuil 37 (Loc. 363). Sparse dispersed gravels are often of reworked calcrete. In the Smitskloof Substation study area (*e.g.* Loc. 369) brown silty alluvium is overlain by a thin veneer of fine alluvial gravels and Kalahari aeolian sands.

Patches or stringers of well-consolidated, silty to sandy older alluvium with dispersed gravels or gravel lenses locally underlie the superficial aeolian sands, gravels and younger silty alluvium in shallow stream beds well away from the Orange River (Loc. 338). In areas dominated by coarse surface gravels, these are reworked into stream beds as unconsolidated boulder conglomerates (Loc. 356).

Fig. 18. Coarse conglomeratic infill of a fluvial channel incising silty alluvium close to the Orange River near Remhoogte farmstead (Loc. 351) (Hammer = 30 cm). These lightly calcretised "Lower Gravels" appear to contain crude Acheulian bifaces.

3.2.4. Surface Gravels

Within the Dwyka Group and Late Caenozoic calcrete outcrop areas the land surface is very extensively mantled with a veneer of dispersed to concentrated surface gravels that have been generated by a combination of downwasting, colluvial (gravity-driven) and fluvial processes, and subsequently modified by sheet wash. The gravels may directly overlie Dwyka tillite, calcrete hardpan, alluvial deposits or sandy soils. They are equated with the **Obobogorop Formation** of the Kalahari Group (Partridge *et al.* 2006, Fig. 24 herein).

The grainsize spectrum, roundedness and lithological composition of the gravels is highly variable. For the most part they comprise poorly-sorted (grit to small boulder-sized), angular to subrounded clasts that are mainly composed of Ventersdorp lava (often amygdaloidal, with dark patina of desert varnish), pale grey and dark grey quartzite, sandstone, calcareous grits, banded iron formation (BIF), porphyritic lava, grey and rusty brown limestone / dolomite and rubbly Quaternary calcrete. Minor components include vein quartz, orange-red jaspilite, agates and various cherts. The ground surface between the clasts is usually covered with reddish-brown aeolian or pale brown silty soil. Where sheetwash processes are dominant, larger dispersed clasts predominate (dominantly cobbles to boulders of dark, desert-varnished Ventersdorp lavas), most of the smaller rocks having been swept away during rainstorms (Fig. 28). The boulder-sized clasts are often moderately well-rounded. Some retain glacially facetted and striated surfaces indicating a Dwyka provenance. The abundance of surface gravels with a dark patina of desert varnish overlying the Dwyka Group outcrop area is responsible for the dark grey areas along valley and pediment slopes seen in satellite images, as remarked earlier (Figs. 8 & 21).

Fig. 19. Typical polymict downwasted surface gravels overlying calcrete hardpan close to the existing Mooidraai servitude, looking towards the southwest (Hammer = 30 cm).

Fig. 20. Surface gravels winnowed by sheetwash, dominated by larger clasts of dark grey-green Ventersdorp lava (Loc. 340) (Hammer = 30 cm).

Fig. 21. Typical dark-hued, bouldery surface gravels (Obobogorop Formation) generated by downwasting from the underlying Dwyka tillite, east of Mooidraai homestead (Loc. 355) (Hammer = 30 cm) (See also Fig. 8).

3.2.5. Kalahari Sands

Relict patches of orange-brown Kalahari wind-blown sands (Gordonia Formation, Kalahari Group; see Fig. 24) of Pleistocene or younger age are seen near the Mooidraai Substation (Loc. 344) as well as at several points along the Alternative 1 study area between Herbou and Swemkuil homesteads (Locs. 264, 369-370). South of the River Orange linear dune fields with a pronounced NW-SE trend are clearly seen on satellite images to the northwest of Mooidraai Substation (Muis Hoek 34) as well as to the south of Swemkuil (Mooidraai 36) (Fig. 3). The dune crests appear to be more densely vegetated with small trees and woody shrubs than the intervening dune streets. The dune sands may be several meters thick within the study area and towards the Orange often overlie coarse BIF older alluvial gravels. The surface of the well-sorted aeolian sands is sparsely covered in dispersed surface gravels, mainly fine-grained, angular to well-rounded, and composed of BIF and calcrete. Coarse High Level Gravels (mainly BIF, quartzite, also calcrete) have been reworked downslope by colluvial processes and perhaps sheetwash from the main pediment surface over Kalahari sands at lower elevations to the south of Mooidraai Substation (Loc. 344).

The two alternative sites for the proposed new Smitskloof Substation (A, B in Fig. 2) are underlain by poorly-consolidated superficial deposits dominated by orange-brown reworked aeolian sands and sparse surface gravels (Fig. 23), probably overlying a calcrete hardpan at depth. No fossil remains were recorded here.

Fig. 22. Typical Kalahari sand dunefield looking down the crest of a vegetated linear dune, Zwem Kuil 37 (Loc. 364).

Fig. 23. Subdued topography in the vicinity of the Smitskloof Substation Alternative A study area showing reddish sandy soil with sparse fine surface gravels.

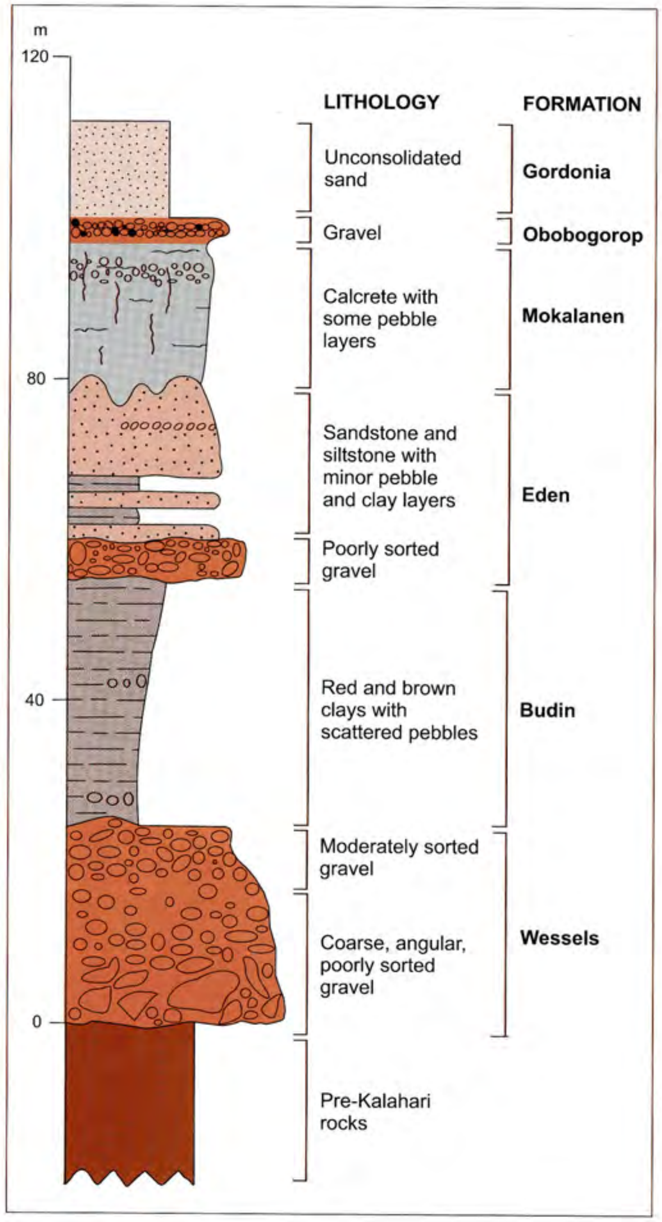

Fig. 24. Stratigraphy of the Late Cretaceous to Recent Kalahari Group (From Partridge *et al.,* 2006). Calcretes, downwasted polymict gravels and aeolian sands that are *possibly* equivalent to the Mokalanen, Obobogorop and Gordonia Formations respectively of the Kalahari Group are represented in the Prieska study area.

4. PALAEONTOLOGICAL HERITAGE

Fossil heritage previously recorded from each of the main rock units represented within the Mooidraai – Smitskloof study area near Prieska is briefly summarized here, together with notes on fossils observed during the present field study.

4.1. Fossils in the Dwyka Group

Although a wide range of fossils are now known from the Dwyka Group, most sediments assigned to this succession are unfossiliferous (with the possible exception of microfossils). The overall palaeontological sensitivity of the Dwyka Group is therefore rated as low (Almond & Pether 2008). Any well-bedded interglacial mudrocks and heterolithic successions (*i.e.* interbedded sandstones and mudrocks) are worth investigating for fossils, however. Although interglacial / postglacial mudrocks are reported from the Prieska Basin (*e.g.* Visser 1982) none were observed in the study area during fieldwork. Late-glacial or post-glacial mudrocks, such as those of the Prince Albert Formation ("Upper Dwyka Shales") that contain a fairly rich shelly fossil record at Douglas in the Northern Cape (McLachlan & Anderson 1973), have probably been largely lost to erosion in the Prieska region.

The Dwyka group exposures seen in the study area are limited, highly weathered and calcretised, factors mitigating against fossil preservation. The only body fossils recorded from the Dwyka Group sediments near Prieska are small domical to columnar stromatolites within bouldery erratics of grey or ferruginous carbonate (probably dolomite) (Almond (2013a). These erratics have probably been transported by ice movement from the Archaean Campbell Rand Subgroup (Ghaap Group) that crops out in the Ghaap Plateau to the north of Prieska.

4.2. Fossils in the superficial deposits

The various superficial "drift deposits" of the Bushmanland and Karoo regions of South Africa, including aeolian sands, alluvium, calcretes and pan deposits, have been comparatively neglected in palaeontological terms. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Good examples are the Pleistocene mammal faunas at Florisbad, Cornelia and Erfkroon in the Free State and elsewhere (Wells & Cooke 1942, Cooke 1974, Skead 1980, Klein 1984, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al*. 1995, MacRae 1999, Meadows & Watkeys 1999, Churchill *et al*. 2000 Partridge & Scott 2000, Brink & Rossouw 2000, Rossouw 2006). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant remains such as peats or palynomorphs (pollens, spores) in organic-rich alluvial horizons (Scott 2000) and siliceous diatoms in pan sediments. Calcrete hardpans might also contain trace fossils such as rhizoliths, termite nests and other insect burrows, or even mammalian trackways. Solution hollows within well-developed calcrete horizons may have acted as fossil traps in the past, as seen in Late Caenozoic limestones near the coast and Precambrian carbonate successions of the Southern African interior. Dense concentrations of vertebrate remains (*e.g.* small mammals, reptiles) or terrestrial molluscs, for example, are a possibility here. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest (*e.g.* Smith 1999 and refs. therein). Stone artefacts of Pleistocene and younger age may additionally prove useful in constraining the age of superficial deposits such as gravelly alluvium and pedocretes within which they are occasionally embedded.

Fossil mammalian remains assigned to the Florisian Mammal Age (*c*. 300 000 – 12 000 BP; MacRae 1999) have recently been documented from stratigraphic units designated Group 4 to Group 6 (*i.e.* calcrete hardpan and below) at Bundu Pan, some 22 km northwest of Copperton near Prieska (Kiberd 2006 and refs. therein). These are among very few Middle Pleistocene faunal records from stratified deposits in the southern Africa region (Klein 1980, 1984a, 1984b, 2000) and are therefore of high palaeontological significance. Characteristic extinct Pleistocene species recorded at Bundu Pan are the giant Cape Horse or Zebra (*Equus capensis*) and the Giant Hartebeest (*Megalotragus priscus*). Other extant to extinct taxa include species of warthog, blesbok, black wildebeest, springbok and baboon. There is additionally trace fossil evidence for hyaenids (tooth marks) as well as ostrich egg shell. Preliminary dating and the inferred ecology of the fossil taxa present suggests the presence of standing water within a grassy savanna setting during the 200-300 000 BP interval when the Bunda Pan faunal assemblage accumulated. A sequence of Earlier, Middle and Later Stone Age artefact assemblages is also recorded from this site. Stratigraphic Groups 4 to 6 (*i.e.* calcrete hardpan and below) contain a Final Acheulian or transitional ESA / MSA artefact assemblage, while Groups 2-3 above the calcrete horizon contain a MSA artefact assemblage.

The "Older" Vaal River Gravels near Kimberley (Windsorton Formation) of possible Miocene-Pliocene age have not yet yielded well-dated fossil biotas (Partridge *et al.,* 2006). A "sparse, poorly provenanced vertebrate fauna from diamond diggings" is noted herein by De Wit *et al.* (2000) who favour a Pliocene age (4.5-3.5 Ma). In contrast, a wide range of Pleistocene mammal remains (bones, teeth) as well as Acheulian stone tools are recorded from the "Younger" Vaal River Gravels or Rietputs Formation (Cooke 1949, Wells 1964, Partridge & Brink 1967, Butzer et al. 1973, Helgren 1977, Klein 1984, Bosch 1993). These are assigned to the Mid Pleistocene Cornelian Mammal Age and include various equids and artiodactyls as well as African elephant and hippopotamus (See MacRae 1990, De Wit 2008 for brief reviews, and Gibbon *et al.* 2009 for recent dating of the matrix).

Poorly-consolidated younger alluvial sediments along the lower Orange River and its tributaries contain a range of fossil and subfossil remains of Pleistocene / Holocene age, as elsewhere in Namaqualand (*cf* the Kwagga's Kop Formation of the Calvinia and Loeriesfontein sheet areas). These include shells of freshwater and terrestrial mollusks (clams, snails), mammalian bones and teeth, calcretised rhizoliths and termitaria, carbonized plant material, ostrich egg shells, as well as vertebrate and invertebrate trackways (Almond 2009).

The fossil record of the Kalahari Group is generally sparse and low in diversity. The Gordonia Formation dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from underlying lime-rich bedrocks may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*), tortoise remains and shells of land snails (*e.g. Trigonephrus*) (Almond 2008, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands (Du Toit 1954, Dingle *et al*., 1983). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low. Underlying calcretes might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient alluvial gravels.

With the exception of subfossil plant root casts within calcretised older alluvial channel deposits on Remhoogte 152 (outside the development footprint. Loc. 350, Figs. 25 & 26), no fossil remains were recorded within the superficial deposits during the present field assessment. Comparable calcretised rhizoliths were recorded from younger alluvial deposits close to the Orange River near Prieska by Almond (2013a).

Fig. 25. Calcretised sands within an infilled river channel at Loc. 350 showing subvertical rhizolith or plant root cast (arrowed) (Hammer = 30 cm).

Fig. 21, Irregular calcretised root cast (arrowed), same locality and horizon as previous figure (Hammer = 30 cm).

No fossil remains were noted within the "High Level Gravels" of Late Tertiary age overlying the main calcrete hardpan within the study region. Extensive solution hollows within karstified calcrete hardpans constitute a potentially effective trap for mammalian remains (bones, teeth), including large-bodied forms as well as micro-mammals, and also for gastropods and other invertebrates. Bone accumulations associated with hyaena dens might also be encountered here. Where the karst has been modified by river action (potholes) and the surface / subsurface cavities infilled with resistant-weathering alluvial gravels, good preservation of fossil remains is not expected. A concerted search for fossil remains associated with the Late Caenozoic hard pans of the Northern Cape region might well prove worthwhile in future.

5. SUMMARY & RECOMMENDATIONS

The study area for the proposed Mooidraai – Smitskloof powerline and substation development is largely underlain by Permo-Carboniferous glacial rocks of the Dwyka Group (Karoo Supergroup), including tillites, outwash channel breccio-conglomerates and grits. These bedrocks are generally highly weathered and permeated by calcrete veins near-surface. The clast-rich tillites here are, at most, sparsely fossiliferous (*e.g.* occasional erratics of Precambrian stromatolitic limestone / dolomite recorded elsewhere in the Prieska region) and are unlikely to be significantly impacted by developments such as this that do not entail deep, voluminous excavations. No potentially fossiliferous interglacial rocks were observed within the Dwyka succession in the study area.

For a considerable distance from the Orange River (several 10s of km) the Dwyka bedrocks are truncated by a gently sloping pediment surface at *c*. 1000 – 1100 m amsl. This surface is overlain by an extensive gravelly calcrete hardpan (1 m thick or more) of probable Late Tertiary age (Mokalanen Formation, Kalahari Group). Abundant solution hollows were generated by karstic weathering of the calcrete hardpan close to the escarpment edge and are especially well-exposed in areas of previous diamond diggings. They are also observed in younger hardpans closer to modern river level. These cavities could have acted as effective traps for mammalian remains (bones, teeth), including micromammals, as well as land snails and other invertebrates in the past. However, with the exception of calcretised root casts (rhizoliths) within ancient fluvial channel sediments, no fossil material was observed in association with the potholed calcretes in the study area. The various calcrete hardpans are overlain by a range of poorly-consolidated, younger superficial deposits, some of which are also assigned to the Kalahari Group. They include relict patches of older fluvial gravels ("High Level Gravels"), mainly composed of Banded Iron Formation clasts, younger silty alluvium, wind-blown sands (Gordonia Formation), and colluvial sediments such as downwasted surface gravels (Obobogorop Formation). No fossil remains were recorded within these superficial deposits, including in the two study areas for the proposed Smitskloof Substation near the Orange River.

It is concluded that the palaeontological sensitivity of the sedimentary rocks in the Mooidraai-Smitskloof study area is LOW. The proposed development, including construction of the new Smitskloof Substation, 132/22 kV transmission line, new access roads and related infrastructure, is unlikely to have a significant impact on local fossil heritage. Pending the discovery of substantial new fossil material during construction, no further specialist palaeontological studies or mitigation are recommended for this project.

In the case of any substantial fossil finds during construction (*e.g.* vertebrate teeth, bones, burrows, petrified wood, shells), these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za), so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented.

These recommendations should be incorporated into the Environmental Management Plan (EMP) for this development.

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8. 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 under the aegis of his Cape Town-based company *Natura Viva* cc. He is 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 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
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Appendix: GPS LOCALITY DATA

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

30 – 31 August 2013

Location number	South	East	Comments
337	S29 34 57.4	E23 03 31.7	Surface gravels on calcrete, east of Rooisloot homestead
338	S29 33 31.5	E23 04 36.8	Older semi-consolidated stream alluvium, east of Rooisloot homestead
339	S29 33 08.3	E23 04 51.9	Calcrete borrow pit, Holsloot 47
340	S29 32 31.5	E23 05 10.5	Sheetwash gravels overlying calcrete hardpan, Holsloot 47
341	S29 32 23.0	E23 05 12.3	Borrow pit into calcrete hardpan and weathered Dwyka Group, Holsloot 47
343	S29 32 16.5	E23 05 44.7	Karstified calcrete hardpan in track, Holsloot 47
344	S29 34 56.8	E23 02 34.9	Kalahari sands overlain by reworked (colluvial) BIF gravels north of Rooisloot homestead
345	S29 34 45.0	E23 02 28.1	High Level Gravels (mainly BIF) near Mooidraai Substation, Remhoogte 152
346a	S29 34 04.5	E23 01 46.9	Quarry into calcrete hardpan, Remhoogte 152
346b	S29 33 41.6	E23 00 46.5	Karstified / potholes calcrete hardpan overlain by BIF alluvial gravels, old diamond mining area, Remhoogte 152
348	S29 33 40.6	E23 00 47.6	Karstified / potholes calcrete hardpan overlain by BIF alluvial gravels, old diamond mining area, Remhoogte 152
350	S29 32 23.1	E23 00 02.5	Thick calcretised channel infill with gravel lenses, calcretised plant root casts (rhizoliths) near Remhoogte homestead, Remhoogte 152
351	S29 32 11.6	E23 00 04.3	Incised channel of "Lower gravels" overlying silty alluvium close to Orange River, east of Remhoogte homestead, Remhoogte 152. Acheulian bifaces, probably from within gravels.
352a	S29 32 10.4	E23 00 13.3	Borrow pit onto clast-poor Dwyka tillite, Remhoogte 152
352b	S29 30 28.0	E23 00 57.0	Road cutting through fine silty alluvium of Vaalsloot drainage system, Remhoogte 152
353	S29 36 41.4	E23 02 12.7	R357 road cuttings through calcretised boulder channel deposits, due south of Mooidraai Substation

354	S29 30 27.8	E23 07 23.6	Borrow pit excavated into Dwyka tillite plus interbedded calcified pebbly grits and breccio-conglomerates, west of Herbou farmstead, Zwem Kuil 37
355	S29 30 46.0	E23 07 00.3	Downwasted surface gravels from Dwyka tillite, gentle slopes of Vaalsloot Valley to east of Mooidraai homestead, Zwem Kuil 37
356	S29 30 48.9	E23 07 00.8	Stream bed and bank exposure of Dwyka tillite, calcified sandstones, recent alluvial gravels as well as downwasted surface gravels, Vaalsloot Valley to east of Mooidraai homestead, Zwem Kuil 37
357a	S29 30 04.0	E23 06 52.7	Downwasted and sheetwashed gravels overlying calcrete hardpan, Zwem Kuil 37
357b	S29 29 41.5	E23 06 46.0	Relict patch of Kalahari aeolian sands, Zwem Kuil 37
358	S29 29 42.0	E23 06 45.9	Old diamond mine, BIF surface gravels and Kalahari sands overlying potholed calcrete hardpan, Zwem Kuil 36
361	S29 29 44.7	E23 06 46.4	Old diamond mine, BIF surface gravels and Kalahari sands overlying potholed calcrete hardpan, Zwem Kuil 36
362	S29 29 38.5	E23 06 43.6	Trench exposure through pseudobedded calcrete hardpan, Zwem Kuil 36
363	S29 28 35.6	E23 05 37.9	Modern silty stream alluvium, Droerivier, Zwem Kuil 36
364	S29 27 51.8	E23 04 59.8	Kalahari dune sands, Zwem Kuil 36
365	S29 26 51.2	E23 04 08.3	Old diamond mine, BIF surface gravels and Kalahari sands overlying potholed calcrete hardpan, Zwem Kuil 36
366	S29 26 27.1	E23 04 03.8	Large borrow pit into weathered Dwyka tillite capped by thick, pseudobedded calcrete hardpan
367	S29 26 04.9	E23 03 34.9	Surface gravels and reworked orange-brown sands overlying calcrete at c. 1000 m amsl
368	S29 26 03.7	E23 03 31.1	Old diamond mine, BIF surface gravels and Kalahari sands overlying potholed calcrete hardpan, Zwem Kuil 36 at c. 1000 m amsl
369	S29 25 54.8	E23 02 47.0	Reworked Kalahari sands, sparse surface gravels near Smitskloof Substation study area A, near Zwemkuil homestead
370	S29 25 56.8	E23 03 08.1	Kalahari dune sands, Zwem Kuil 37