PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

WANHOOP BOREHOLE SCHEME EXTENSION, EDEN DISTRICT MUNICIPALITY, WESTERN CAPE PROVINCE

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1. SUMMARY

The latest phase of the ongoing upgrade of the water supply for Willowmore (Eastern Cape Province) involves several small developments *c*. 35km to the south of town on the farm Wanhoop in the adjacent Eden District Municipality. The proposed new water pipelines will involve excavations of up to one and a half metres depth but the Devonian to Cretaceous bedrocks and younger superficial sediments affected – *viz.* the Baviaanskloof Formation (Table Mountain Group), Buffelskloof Formation (Uitenhage Group) and Quaternary alluvium - are mostly of low palaeontological sensitivity. Installation of new powerlines and a short section of new access road are unlikely to involve extensive bedrock excavations and are not regarded as palaeontologically significant.

It is concluded that the proposed water supply developments on Wanhoop will not substantially compromise palaeontological heritage and there are therefore no objections to approval on these grounds, nor is any specialist palaeontological mitigation required. However, any substantial fossil remains - such as bones, teeth or dense accumulations of shells or plants – that are exposed during excavations should be reported to Heritage Western Cape and / or a qualified palaeontologist for formal collection and documentation.

2. PROJECT OUTLINE & BRIEF

As part of the ongoing upgrade of the water supply for the town of Willowmore (Eastern Cape Province) several proposed developments will take place on the remainder of Wanhoop 19, Wanhoop Farm in the adjacent Eden District Municipality, Western Cape Province, approximately *c*. 35 km south of Willowmore itself (Figs. 1, 2). Several kilometres of new pipelines, the extraction of water from two new boreholes into the Wilgekloof aquifer (BH4 drilled to a depth of 250m and BH5 to a depth of 300), as well as new Eskom powerlines and a short section of new access road are planned. Water pumped from the two new boreholes will be piped to the existing borehole BH1 in Wilgekloof and thence link up with the existing water reticulation system to the filtration works. The trench for the new pipeline will be approximately one and a half metres deep.

These developments will intersect potentially fossiliferous bedrock of the Cape Supergroup as well as the Uitenhage Group. A palaeontological impact assessment (PIA) of the project is therefore required in terms of the National Heritage Resources Act of 1999. This study has been commissioned by Anton Bok Aquatic Consultants cc, Port Elizabeth, on behalf of Uhambiso Consult (Pty) Ltd. A desktop PIA for an earlier phase of the Willowmore water supply upgrade in the same area was carried out by Almond (2008a). Background geological data for this earlier assessment was obtained from the report on the hydrogeological investigation by GCS (Pty) Ltd of June 2007.

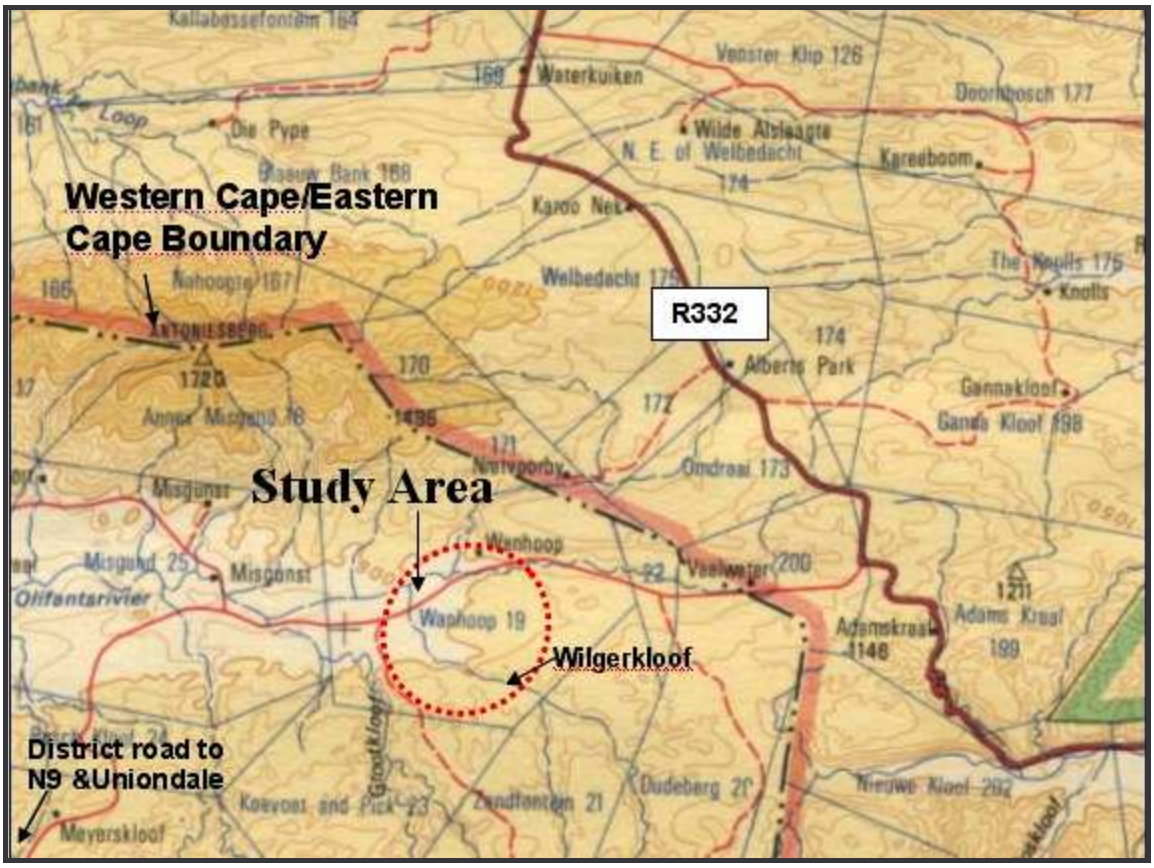
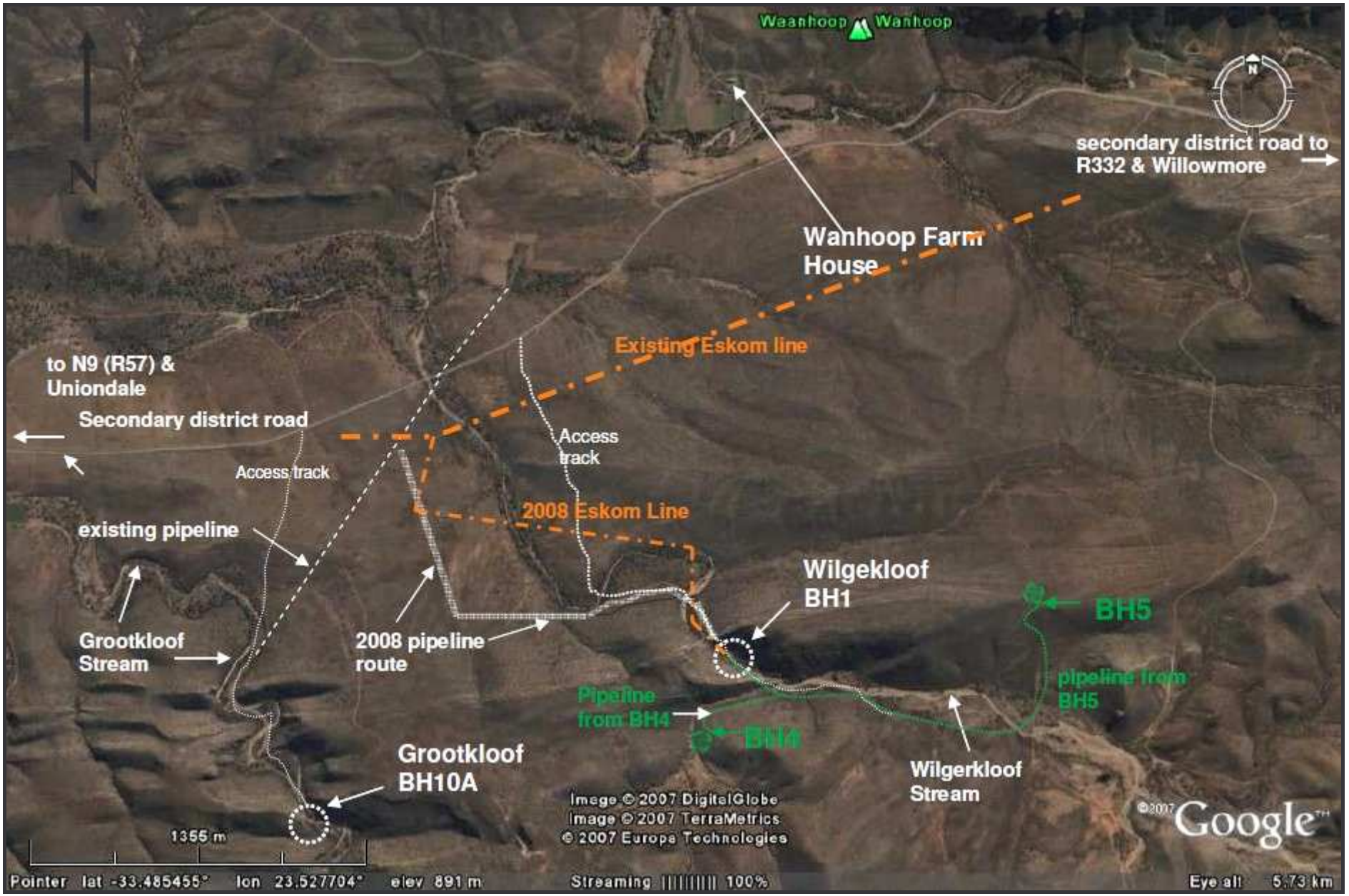


Fig. 1. Extract from 1: 250 000 topographical map 3322 Oudtshoorn showing location of study area on the farm Wanhoop *c.* 35km south of Willowmore, Eden District Municipality, Western Cape Province (Image kindly provided by Anton Bok Aquatic Consultants cc).

2.1. General approach used for palaeontological impact desktop studies

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. 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 *et al*. 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 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 scoping study by a professional palaeontologist is usually warranted.

Fig. 2 (on page 3) provided by Anton Bok Aquatic Consultants cc: Site Plan (Google image) of Wanhoop Farm 19 showing location of 2 new boreholes (BH 4, BH5) adjacent to Wilgerkloof and the new (2008) and existing pipelines, access roads and new (2008) Eskom line from the existing Eskom distribution line and other bulk water infrastructure.


Waanhoop
Wanhoop
N
secondary district road to
R332 & Willowmore
Wanhoop Farm
House
Existing Eskom line
to N9 (R57) &
Uniondale
Secondary district road
Access track
Access
track
2008 Eskom Line
existing pipeline
Wilgekloof
BH1
BH5
Grootkloof
Stream
2008 pipeline
route
pipeline from
BH5
Pipeline
from BH4
BH4
Grootkloof
BH10A
Wilgerkloof
Stream
Image © 2007 DigitalGlobe
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©2007 Google
1355 m
Pointer lat -33.485455° lon 23.527704° elev 891 m
Streaming 100%
Eye alt 5.73 km

3. GEOLOGICAL SETTING

The fairly complex geology of the study area, embedded within the WSW-ESE trending mountains of the Cape Fold Belt south of Willowmore, is shown on 1: 250 000 geology sheet 3322 Oudtshoorn (Council for Geoscience, Pretoria; Toerien 1979. See also older sheet explanation by Haughton *et al.* 1937) (Fig. 3). The Wilgekloof gorge transects a small, NE-plunging anticline of quartzitic rocks of the Early Devonian **Baviaanskloof Formation** (Sb), the uppermost unit of the Table Mountain Group (TMG, Nardouw Subgroup). These rocks are pleated into numerous minor folds, as seen in Grootkloof gorge to the west, and are therefore highly deformed. Quartzitic braided fluvial rocks of the underlying **Skurweberg Formation** (Sk, previously known as the Kouga Formation) of Silurian age are penetrated by the existing borehole BH1 in Wilgekloof (Almond 2008a) and probably also by the new boreholes BH4 and BH5 but this older unit will not be affected by the proposed new pipeline and access road.

The main rock unit implicated in the new developments is the Baviaanskloof Formation. The stratotype section for this formation was measured just to the east of Willlowmore (Hill 1991). Key references for this formation and the Table Mountain Group in general include Rust (1967, 1981), Malan & Theron (1989), Hill (1991), Hiller (1992), Broquet (1992), Johnson *et a*l., (1999), De Beer (2002), Thamm & Johnson (2006), and Tankard *et al*., (2009). The Baviaansklof Formation is typically less clean-washed than the underlying subunits of the Nardouw Subgroup, giving darker hues and more recessive weathering patterns. Sandstones are often (but not invariably) greyish, impure wackes and may be massive or ripple cross-laminated. Dark grey to black carbonaceous and micaceous mudrock intervals are quite common but rarely well exposed (A 15m-thick band of micaceous shale within the upper Baviaanskloof Formation in the Gamtoos area is mentioned by Haughton *et al*., 1937, for example). The heterolithic “passage beds” of the Baviaanskloof Formation incorporate the sedimentary transition between the fluvial-dominated lower units of the Nardouw Subgroup and the marine shelf sediments of the Lower Bokkeveld Group. Locally abundant shelly fossils such as articulate brachiopods, trace fossils as well as wave ripple lamination demonstrate the shallow marine origins of at least some of the upper sandstones, while the dark mudrocks with dense mats of vascular plant remains may be lagoonal in origin.

Immediately to the south of the Wilgekloof TMG anticline runs the SW-NE trending trace of a major low angle fault of Cape age, the **Baviaanskloof Thrust**, along which the Table Mountain Group succession has been thrust some 15k to the north, including over younger Bokkeveld Group rocks (Theron 1969, Booth *et al.* 2004). Reactivation or tectonic inversion of this ancient crustal break as a normal (extensional) fault during Gondwana break-up in Late Jurassic to Early Cretaceous times led to the formation of a down-faulted hinge basin to the south of the fault line. The basin was subsequently infilled with coarse clastic deposits of the Mesozoic **Uitenhage Group**. These are indicated as Ke (“Enon and similar younger deposits”) on the geological map and are probably reddish breccio-conglomerates and minor sandstones attributable to the Early Cretaceous **Buffelskloof Formation**, although this requires confirmation on the ground (*cf* Ladismith sheet explanation by Theron *et al.* 1991, Almond 2005, Shone 2006, Almond *in* Rubidge *et al.* 2008). The proposed new pipelines from boreholes BH4 and BH5 as well as the new stretch of access road to BH4 probably transect the outcrop area of the Uitenhage Group clastic sediments situated to the south of the south-dipping Baviaanskloof Fault line (The new boreholes presumably exploit groundwater flowing along the brecciated underground fault plane here).

According to the 1: 250 000 geology map - which may not be very accurate at this point - a SW-tapering sliver of **Lower Bokkeveld Group** sediments, *i.e.* the mudrock-dominated **Gydo Formation** (Dg) of Early Devonian age, is crossed by the Wilgerkloof stream between the southern edge of the TMG anticline and the Baviaanskloof Fault. This is not easy to verify from the satellite image alone (Fig. 2). However it seems unlikely that the proposed new pipeline trench will intersect fresh Gydo Formation mudrocks that in any case are probably mantled in unfossiliferous, coarse colluvial or alluvial superficial deposits of Quaternary to Recent age.

Satellite images show that the Table Mountain Group outcrop to the south of the Wanhoop region has been planed off to form extensive high altitude pediment surfaces at over 1000m amsl. Relict patches of alluvial pediment gravels (“**High Level Gravels**”) and associated pedocretes of ill-

defined Tertiary age are mapped here (stippled pale yellow patches in Fig. 3). Some of these pediment gravels appear to be displaced or otherwise affected by the Baviaanskloof Fault, while others extend across the fault line without interruption. The proposed developments at Wanhoop do not cross the outcrop area of the Tertiary gravels. However, portions of the new pipeline will be excavated into much younger - Quaternary to Recent - alluvium of the Wilgerkloof Stream within and south of Wilgekloof.

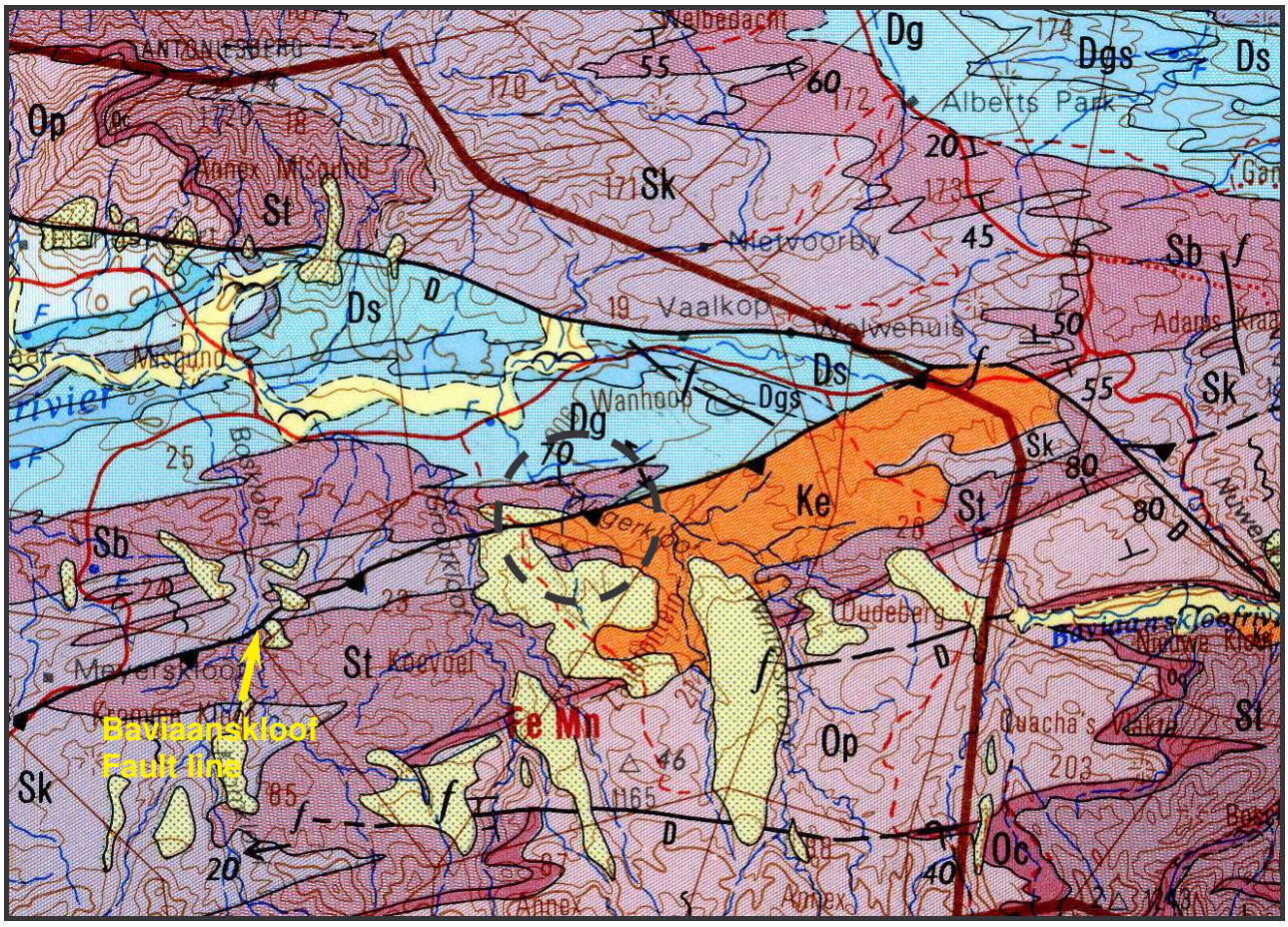

Fig. 3. Extract from 1: 250 000 geological map 3322 Oudtshoorn (Council for Geoscience, Pretoria) with study area highlighted within black circle. Note trace of the major Baviaanskloof Fault line (yellow arrow) which runs through the study area.

The main stratigraphic units mapped in study area are:

TABLE MOUNTAIN GROUP (Nardouw Subgroup)
St (purple) = Goudini Formation (previously Tchando Fm); Sk (purple) = Skurweberg Formation (previously Kouga Fm); Sb (purple) = Baviaanskloof Formation

BOKKEVELD GROUP (Ceres Subgroup)
Dg (pale blue) = Gydo Formation

UITENHAGE GROUP
Ke (orange) here probably = Buffelskloof Formation

SUPERFICIAL DEPOSITS
yellow stippled areas = Tertiary High Level Gravels

4. PALAEONTOLOGY OF RELEVANT STRATIGRAPHIC UNITS

A brief summary of the known palaeontological heritage preserved in the sedimentary rock units represented in the Wanhoop area is given in Table 1 below, together with an indication of its significance in scientific / conservation terms. This data is mainly compiled from the references cited at the end of this report, and from the unpublished report by Almond and Pether (2008) prepared for Heritage Western Cape.

The **Skurweberg (= Kouga) Formation** (Table Mountain Group) is the target of the proposed new boreholes but is very sparsely fossiliferous, since it is predominantly a braided fluvial deposit of Silurian age. So far only trace fossils (burrows, trackways *etc*) but no body fossils have been reported from this unit (Almond 2005, 2008b). Therefore any body fossils such moulds of shells in mudrock or heterolithic intervals exposed in the drill core would be of considerable palaeontological interest and should be reported.

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* (Fig. 4) that may be locally very abundant. Rare homalonotid trilobites, a small range of articulate and inarticulate brachiopods, nuculid and other bivalves, plectonotid "gasteropods" and bryozoans also occur within impure brownish-weathering wackes (Haughton *et al.,* 1937, Boucot *et al*. 1963, Rossouw *et al*. 1964, Johnson 1976, Toerien & Hill 1989, Hill 1991, Theron *et al.* 1991, Almond *in* Rubidge *et al*. 2008). In many cases fossil shells are scattered and disarticulated, but *in situ* clumps of pleurothyrellid brachiopods also occur. This shelly assemblage establishes an Early Devonian (Pragian / Emsian) age for the uppermost Nardouw Subgroup, based on the mutationellid brachiopod *Pleurothyrella* (Boucot *et al*. 1963, Theron 1972, Hiller & Theron 1988). Trace fossils include locally abundant, mud-lined burrows (*Palaeophycus*, *Rosselia*) and rare giant rusophycid burrows of Devonian aspect (*R. rhenanus*) that are attributed to homalonotid trilobites. 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 (Dr Mark Goedhart, Council for Geoscience, Port Elizabeth, pers. comm., 2008, *cf* Hoeg 1930, Anderson & Anderson 1985). These are currently the oldest known fossil vascular plants in southern Africa and are likely to co-occur with organic-walled microfossils such as spores, though these have not been looked for to date.

The hydrogeological report by GCS (Pty) Ltd (June 2007) indicates that the Baviaanskloof Formation beds in the study region are highly deformed by folding (S- and Z-folds) and nearby thrusting, so good preservation of fossils, especially in less competent mudrock-rich horizons, is perhaps not to be expected here. Shelly fossils discovered or exposed during development should be conserved and reported to Heritage Western Cape.

The **Gydo Formation** (Bokkeveld Group, Ceres Subgroup) is often highly fossiliferous, especially within the darker, mudrock-dominated lower part of the succession, just above the top of the Table Mountain Group. However, few records of shelly invertebrates from the Gydo Formation in the Willowmore area are found in the palaeontological literature (*e.g.* Haughton *et al.* 1937, Theron 1962, 1972, 1999, Toerien 1979). This is almost certainly due to under-collection, rather than absence of fossils, and any new records from the Wanhoop excavations would be of palaeontological significance. Shelly or other fossils discovered or exposed during development should therefore be conserved and reported to Heritage Western Cape.

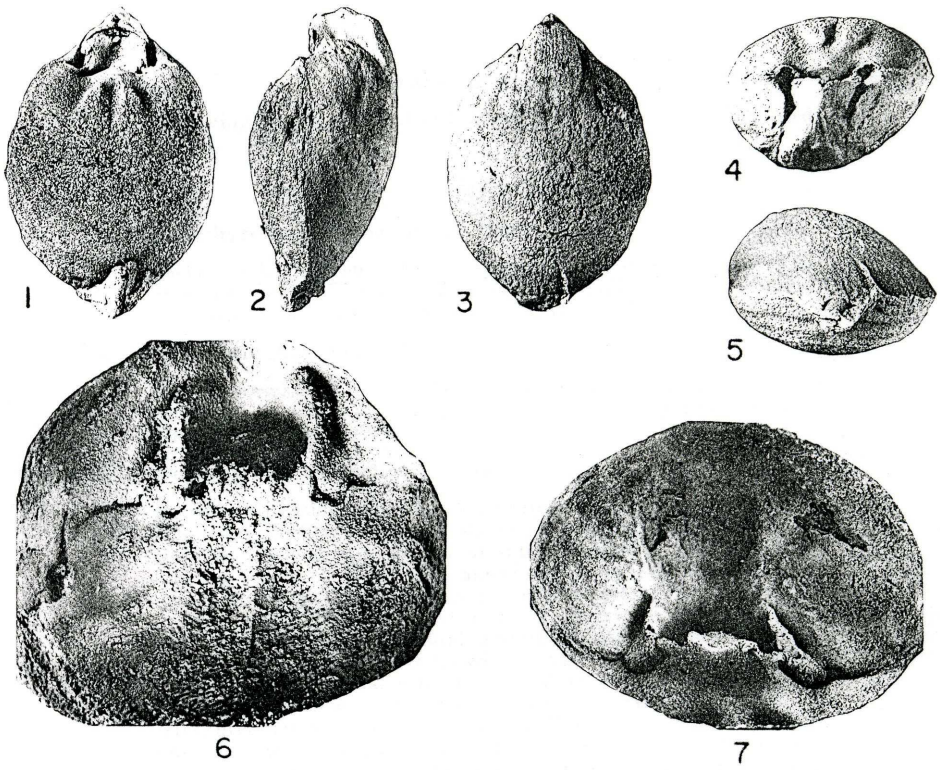

Fig. 4. Well-preserved internal casts of the common Early Devonian brachiopod *Pleurothyrella* from the Baviaanskloof Formation (From Boucot *et al.* 1963). The specimens are *c.* 2-4cm long and highly convex. The casts represent loose sand that filled the space between the two valves of the shell once the fleshy tissues of the animal had rotted away. The sandy infill was later cemented together to form sandstone, while the calcareous shells dissolved away. The resulting casts preserve impressions of the inside of the original shells. Impressions of the finely ribbed exterior of the shells are preserved in the sandstone matrix (not shown here).

The fossil record of the **Buffelskloof Formation** is largely unknown since this unit has only been differentiated from the "true" Enon Formation on more recent geological maps. It is often unclear within which formation of the Uitenhage Group the very sparse fossil record assigned to the "Enon" may in fact occur. Several authors (*e.g.* Toerien & Hill 1989, Le Roux 2000) refer to records of fossil wood from the Enon Formation, apparently – but mistakenly - based on the early sheet explanation by Haughton *et al.* (1937). In some cases this may refer to fossil plant material from the younger (Early Cretaceous) Kirkwood Formation ("Wood Beds") which is recorded from several localities in the Gamtoos Basin. Rare and fragmentary fossil wood specimens are recorded from conglomeratic facies of the Uitenhage Group in the Algoa Basin (McLachlan & McMillan 1976, Dingle *et al.* 1983, p. 117 and refs. therein). Fragments of transported wood as well as rolled vertebrate bones and teeth (*e.g.* of dinosaurs) might occasionally be preserved in the Buffelskloof breccio-conglomerates, especially in association with the finer-grained sandstone interbeds. However, the overall palaeontological sensitivity of the coarser grained facies of the "Enon" *sensu lato* is clearly low to very low (Almond & Pether 2008).

Likewise, gravelly to bouldery alluvium of Late Tertiary to Quaternary age has a low palaeontological sensitivity (Table1).

4. CONCLUSIONS

The proposed new water pipelines and access road will involve excavations of up to one and a half metres depth but the Devonian to Cretaceous bedrocks and younger superficial sediments affected (Baviaanskloof Formation, Buffelskloof Formation, Quaternary alluvium) are mostly of low palaeontological sensitivity. Installation of new electrical power lines is unlikely to involve extensive bedrock excavations and is not regarded as palaeontologically significant.

It is concluded that the proposed water supply developments on Wanhoop will not substantially compromise palaeontological heritage and there are therefore no objections to approval on these grounds, not is any specialist mitigation required. However, any substantial fossil remains - such as bones, teeth or dense accumulations of shells or plants – that are exposed during excavations should be reported to Heritage Western Cape and / or a qualified palaeontologist for formal collection and documentation.

5. ACKNOWLEDGEMENTS

Dr Anton Bok of Anton Bok Aquatic Consultants cc, Mill Park, Port Elizabeth, is cordially thanked for commissioning this report and for kindly providing the necessary background data, including map images, for the proposed developments.

TABLE 1: PALAEONTOLOGICAL HERITAGE IN WANHOOP REGION			
GEOLOGICAL UNIT	**LITHOLOGY & AGE**	**FOSSIL HERITAGE**	**PALAEONTOLOGICAL SIGNIFICANCE**
High Level Gravels (no symbol on map)	coarse bouldery conglomerates and breccias (fluvial / colluvial) Mid to late Tertiary (Neogene)	rare mammal bones, teeth, freshwater molluscs shells	**LOW**
"Enon" Formation (Ke) **(The Buffelskloof Formation of Early Cretaceous age is probably be present here)**	coarse reddish conglomerates, breccio-conglomerates and breccias (fluvial / colluvial) Late Jurassic / Early Cretaceous	rare transported bone fragments, coalified wood	**LOW**
Gydo Formation (Dg)	dark grey-green mudrocks, wackes (shallow marine) Early Devonian	high diversity shallow marine invertebrate assemblages dominated by trilobites, brachiopods, molluscs and echinoderms, *plus* minor groups rich trace fossil assemblages occasional vascular plants (*e.g.* lycopods) and rare fish (*e.g.* acanthodians)	**HIGH** **body fossils (shells *etc* preserved as moulds) are most abundant and diverse within fine-grained mudrocks at base of succession** **trace fossils best preserved within upper, more heterolithic portion of succession**
Baviaanskloof Formation (Sb)	impure sandstones / wackes, feldspathic sandstones, subordinate thin mudrocks (shallow marine) Early Devonian	low diversity shelly biotas dominated by globose brachiopods (*Pleurothyrella*), with rarer nuculid bivalves, chonetids, *Australoceolia*, inarticulate brachiopods, bellerophontids, crinoids, tentaculitids and phacopid trilobites trace fossils (*e.g. Palaeophycus* and *Rosselia*) locally common primitive vascular plants (psilopsids) and palynomorphs in mudrocks	**MODERATE** **body fossils (preserved as moulds) and traces mainly occur above more heterolithic Kareedouw Member, within upper part of succession**
Skurweberg Formation (= Kouga Fm) (Sk)	clean-washed sandstones, thin pebbly conglomerates, minor mudrock interbeds (braided fluvial & shallow marine) Mid to Late Silurian	sparse, low diversity trace fossils (including possible trilobite burrows) at rare intervals	**LOW**

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7. 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 APHAP (Association of Professional Heritage Assessment 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.

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