PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

Arcadia 139: Residential Development of Erf 709 and Erf 710 Kruisfontein, Humansdorp, Kouga Municipality, Eastern Cape Province

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1. SUMMARY

The proposed Arcadia 139 housing development near Humansdorp, Eastern Cape Province, is underlain by shallow marine sediments of the Baviaanskloof Formation (uppermost Table Mountain Group) that are of Early Devonian age and low to moderate palaeontological. Low diversity assemblages of marine invertebrate fossils – mainly various sorts of brachiopods and molluscs, with rare trilobites, bryozoans – as well as trace fossils and primitive land plants have been recorded from this formation elsewhere. The preservation of the limited fossil assemblages within these Table Mountain Group rocks has probably been compromised by the intense tectonic deformation within this part of the Cape Fold Belt as well as by deep bedrock weathering of the coastal belt since Cretaceous times.

It is concluded that the proposed housing development is unlikely to have a substantial impact on the very limited local fossil heritage. No further specialist mitigation of palaeontological heritage for this project is recommended. However, should substantial fossil remains be exposed during development, the responsible ECO should alert SAHRA so that appropriate mitigation measures may be considered.

2. INTRODUCTION & BRIEF

The Kouga Municipality intends to sub-divide and rezone Erf 709 and Erf 710 Kruisfontein, on the western outskirts of the town of Humansdorp (Fig. 1), to provide residential erven and associated infrastructure as part of the Kouga Human Settlement Initiative. The site is approximately 4.99 hectares in extent and is currently zoned as open space . Existing facilities on the site include a community hall, crèche and a clinic. The Kouga Municipality plans to construct 209 row houses and 68 semi-detached units on the site. The project also involves provision of the necessary bulk infrastructure (water, electricity, sanitation, stormwater) and roads (0.97 ha) to service the development.

Since the proposed development area is underlain by potentially fossiliferous bedrocks, a desktop palaeontological impact assessment for the project is necessary in accordance with the requirements of the National Heritage Resources Act, 1999. This report has accordingly been commissioned by Public Process Consultants, Greenacres, Port Elizabeth.

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.

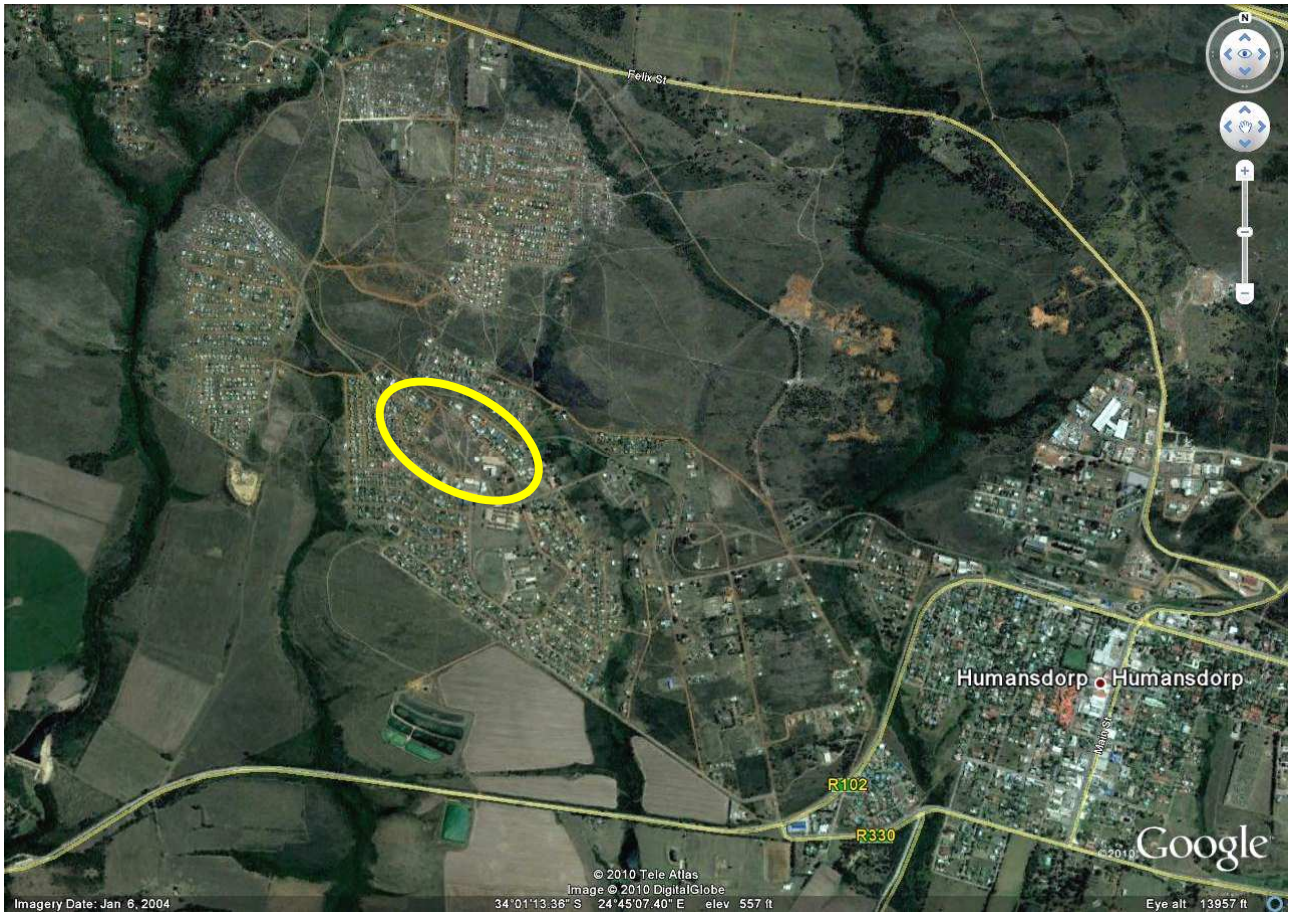

Fig. 1. *Google Earth* satellite image of the western outskirts of Humansdorp showing the location of the Arcadia 139 study area (yellow ellipse). Note outcrop of prominent-weathering, cyclically-bedded sandstones in river valley to south of the study area.

3. GEOLOGICAL BACKGROUND

The geology of the study area near Humansdorp is depicted on the 1: 250 000 scale geological map sheet 3324 Port Elizabeth (Toerien & Hill, 1989) (Fig. 2). The town of Humansdorp lies on the southwestern margin of a NW-SE trending mega-anticline of Table Mountain Group rocks (Klipfonteinsberge) that plunges southeastwards towards the coast at Jeffrey's Bay. Humansdorp itself straddles the contact between the sandstone-dominated Table Mountain Group and mudrock-dominated Lower Bokkeveld Group (= Ceres Subgroup, Dc). The proposed development area just west of Humansdorp is underlain by sandstone-dominated sediments of the upper **Table Mountain Group (Nardouw Subgroup)** of Early Devonian age, and sandstone outcrops are present on site (Dr Paul Steyn, pers. comm.., 2010). The succession here comprises wackes (= impure sandstones) and mudrocks of the **Baviaanskloof Formation (S-Db)**, interpreted to be inshore coastal marine to paralic (near-shore) fluvial deposits. Satellite images of the area suggest that the Baviaanskloof Formation outcrop area may well be considerably wider than the very narrow strip depicted on the geological map and in fact underlies most of the town of Humansdorp (Note parallel ridges of resistant-weathering sandstones cropping out in the river valley due south of the study area seen in Fig. 1). The Bokkeveld Group mudrocks are much less resistant-weathering. Their wide outcrop area south of Humansdorp has been planed down by marine erosion and subsequently dissected by Late Tertiary river incision, such as the course of the Seekoerivier and its tributaries.

Useful overviews of Table Mountain Group geology in general include Rust (1967, 1981), Hiller (1982), Malan & Theron (1989), Broquet (1992), Johnson *et a*l., (1999), De Beer (2002), Thamm & Johnson (2006), and Tankard *et al*., (2009). For the Port Elizabeth sheet area specifically, these rocks are briefly described by Toerien and Hill (1989) and Le Roux (2000) as well as in older sheet explanations such as those by Engelbrecht *et al*. (1962) and Haughton *et al*. (1937). Also useful are various reports by the South African Committee for Stratigraphy (SACS), such as that by Hill (1991) which deals with the Baviaanskloof Formation.

The **Baviaanskloof Formation (S-Db)** 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 (See following section).

As is clearly apparent from aerial and satellite images of the Klipfonteinsberge region, the folded, resistant-weathering Table Mountain Group rocks have been extensively planed-off by erosion to form a gently seawards-sloping surface (peneplain) at around 200m amsl. This probably corresponds to the "George terrace" that is recognised in the George area at around 180-280m amsl and extends eastwards as far as Port Elizabeth (Roberts *et al*., 2008). These last authors favour an origin for this near-coastal surface by marine planation rather than by fluvial erosion during sea-level highstands of Tertiary age. This interpretation is supported by the absence of extensive mantles of quartzitic fluvial gravels ("High Level Gravels") on top of the surface, as well as by the presence of coastal to shallow marine deposits of the Late Miocene / Pliocene Alexandria Formation directly above it in the Port Elizabeth area. An Early Tertiary (Paleogene), perhaps as early as Eocene, age for the George – PE surface is suggested by its deep dissection by younger drainage systems as well as by deep weathering of underlying bedrock. Alternatively, the surface may have been planed off at a lower level (*c*. 100-150m amsl) by marine highstands of later, Mid Miocene age and subsequently elevated to its present level by tectonic uplift of Southern Africa in Late Miocene times (*ibid*.). Soil and weathered sandstone regolith at the study site extends down

to at least 1.5m below the surface (Dr P. Steyn, pers. comm.., 2010) so it is unlikely that significant excavation of fresh, potentially-fossiliferous bedrock will occur during construction of the Arcadia development.

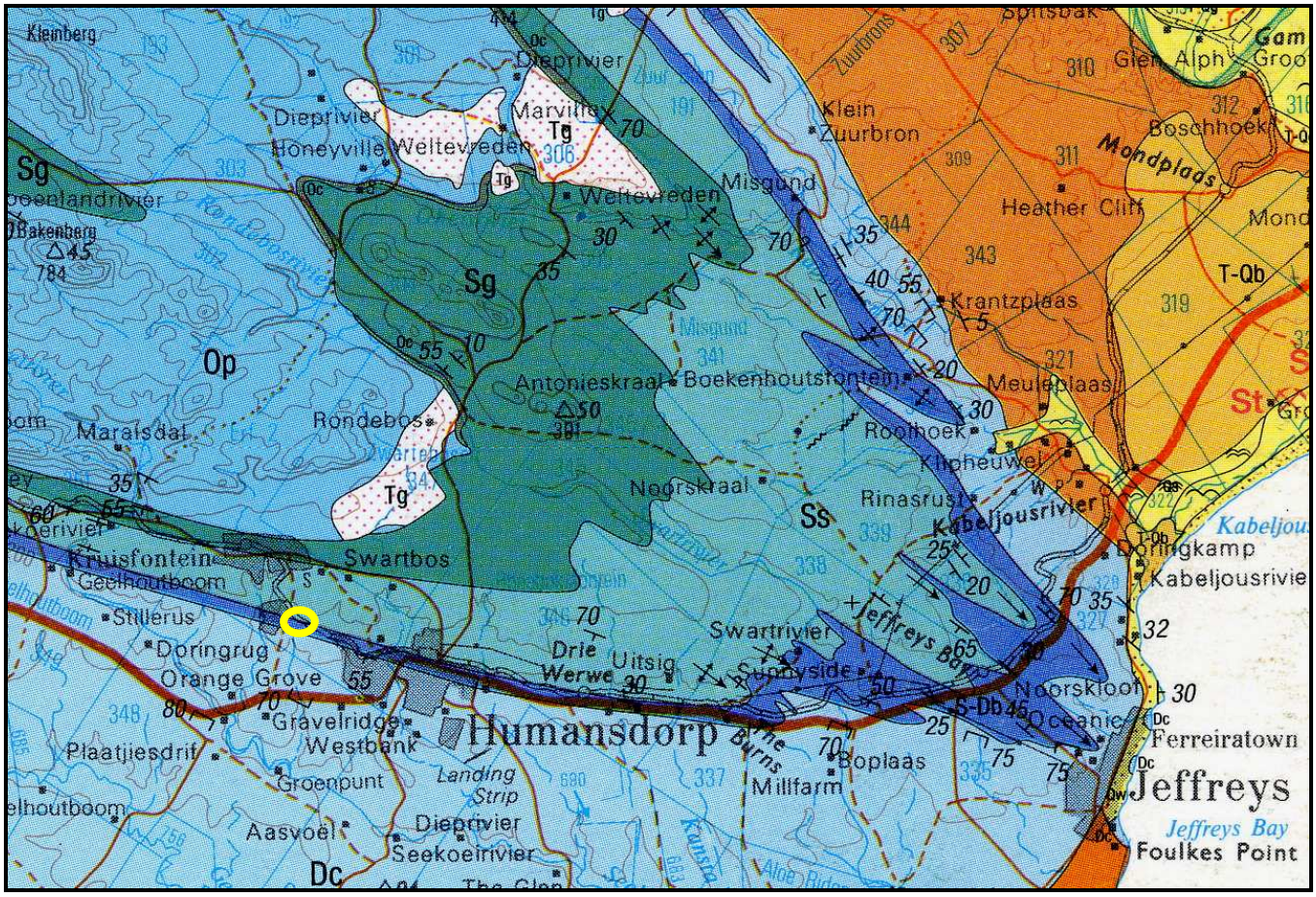

Fig. 4. Geological map of the study area (yellow ellipse) near Humansdorp, to the west Jeffrey's Bay, Eastern Cape Province, extracted from 1: 250 000 geological map sheet 3324 Port Elizabeth (Council for Geoscience, Pretoria). Sg (greenish-blue) = Goudini Formation; Ss (mid-blue) = Skurweberg Formation; S-Db (dark blue) = Baviaanskloof Formation; Dc (pale blue) = Ceres Subgroup (Lower Bokkeveld Group); Tg (white with red dots) = Grahamstown Formation. The N2 trunk road is not indicated on this map.

4. PALAEONTOLOGICAL HERITAGE

The bulk of the thick Table Mountain Group succession is composed of quartz arenites and pebbly sandstones of alluvial braidplain facies that are unlikely to yield fossils, especially given their early to mid-Palaeozoic age and the poor exposure of mudrock units. Biostratigraphically significant body fossils are recorded from marine-dominated parts of the succession, *i.e.* the Cederberg Formation of latest Ordovician (Hirnantian) age and the Baviaanskloof Formation of Early Devonian (Lochkovian / Pragian) age (Broquet 1992, Hiller 1992, Theron 1993). Only the second of these is represented in the study area.

It should be emphasized that the Table Mountain Group rocks within the southern Cape Fold Belt have frequently experienced fairly extreme levels of tectonism, including intense folding, faulting, jointing, brecciation and cleavage development, the last especially within finer-grained facies (*i.e.* mudrocks). These effects, combined with low grade regional or dynamic metamorphism and deep, intense weathering since the break-up of Gondwana (*e.g.* leaching, secondarily mineralization, notably by iron and manganese compounds), have conspired to severely compromise the

preservation of fossils even within that minority of Table Mountain Group rocks that may originally have contained a fairly rich palaeontological heritage.

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. 3). 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.

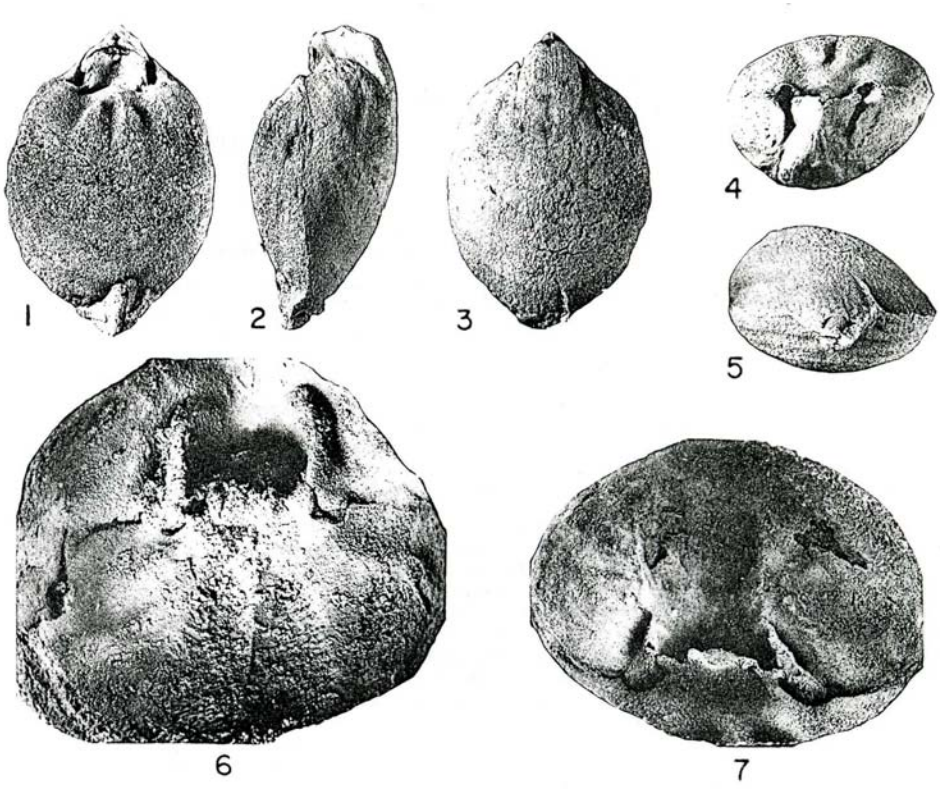

Fig. 3. Well-preserved internal casts of the common Early Devonian brachiopod *Pleurothyrella* from the Baviaanskloof Formation (From Boucot *et al.* 1963). The specimens are *c*. 2-4cm long and highly convex. The casts represent loose sand that filled the space between the two valves of the shell once 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).

5. CONCLUSIONS & RECOMMENDATIONS

The Arcadia development study area near Humansdorp is underlain by Devonian, sandstone-dominated sediments of the Baviaanskloof Formation (uppermost Table Mountain Group) that are of low to moderate overall palaeontological sensitivity (Almond *et al.* 2008). The bedrocks here are mantled by at least 1.5m of weathered sandstone regolith and soil. The preservation of the limited shelly fossil assemblages within these Table Mountain Group rocks has furthermore been compromised by the intense tectonic deformation within this part of the Cape Fold Belt as well as by deep bedrock weathering of the coastal belt since Cretaceous times.

It is concluded that the proposed housing development will not have a substantial impact on the very limited local fossil heritage at the construction stage or later. No further specialist mitigation of palaeontological heritage for this project is recommended. However, should substantial fossil remains be exposed during development, the responsible ECO should alert SAHRA so that appropriate mitigation measures may be considered.

6. ACKNOWLEDGEMENTS

Dr Paul-Pierre Steyn of Public Process Consultants, Port Elizabeth, is thanked for commissioning this study and for kindly providing the necessary background information.

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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 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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