PALAEONTOLOGICAL IMPACT ASSESSMENT FOR THE PROPOSED UPGRADE OF THE PROVINCIAL ROAD FROM CENTANE TO QHOLORA AND KEI RIVER MOUTH

Prepared for: SRK Consulting

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Background

The proposed project includes the rehabilitation and upgrade and tarring of the Provincial Road from Centane to Qholora and Kei River Mouth, Mnquma Local Municipality in the Eastern Cape (see Locality Plan included).

The existing gravel road is a made up of two lanes (one lane per direction) with each lane being approximately 3.4 m in width with approximately 1 – 1.5 m shoulder width. The road has a number of accesses closer to Qholorha.

The proposed road upgrade involves the tarring and widening of approximately 36.1 km of the existing road from Centane to Qholorha and the Kei River Mouth. The road will be widened from an 8.6 m unsurfaced road to a 8.8 m surfaced road comprising of a 7.4 m bitumen surface and 0.7 m unsurfaced section on either side of the surfaced road.

The proposed scope of works is to include the following:

- Tarring and widening of approximately 36.1 km of the existing provincial road;
- Three bridges to be upgraded as necessary;
- Upgrading of culverts if necessary to accommodate hydraulic load and changes to road width and/or grade line.

Assessments will also be done for the utilisation and development of borrow pits/ quarry along the road. An application will be submitted to the Department of Mineral Resources.

Rob Gess Consulting was contracted by SRK to conduct a Phase One Palaeontological Impact Assessment.

Geology and Palaeontology

The area is underlain by strata of the **Karoo Supergroup**, which were deposited within the Karoo sedimentary Basin. This basin resulted from shortening and thickening of the southern margin of Africa, with coeval folding and uplift of the Cape Supergroup strata along its southern margin. The Karoo Supergroup strata are between 310 and 182 million years old and span the Upper Carboniferous to Middle Jurassic Periods. During this interval the basin evolved from an inland sea flooded by a melting ice cap, to a giant lake (the Ecca Lake) fed by seasonal meandering (and at times braided) rivers. This lake steadily shrank as it filled with sediment and the basin's rate of subsidence stabilised. The land became increasingly arid and was covered with wind blown sand towards the end of its cycle. Finally the subcontinent was inundated with basaltic lava that issued from widespread linear cracks within the crust, to form the capping basalts of the Drakensberg Group.

The flood planes of the **Beaufort Group (Karoo Supergroup)** provide an internationally important record of life during the early diversification of land vertebrates. Giant amphibians coexisted with diapsid reptiles (the ancestors of dinosaurs, birds and most modern reptiles), anapsids (which probably include the ancestors of tortoises) and synapsids, the dominant group of the time which included the diverse therapsids (including the ancestors of mammals). Rocks of the Beaufort Group provide the worlds most complete record of the important transition from early reptiles to mammals

Therapsid diversity, along with that of most plant and animals was decimated during the end-Permian extinction event, a serious contender for the most severe extinction event to affect life on Earth. Ongoing research on the effects of this extinction event is facilitated by the detailed record afforded by Beaufort Group strata of life immediately before and after the event, as well as the gradual recovery of life afterwards.

Most of the study area falls within the outcrop area of the mudstone dominated Adelaide Subgroup (Beaufort Group, Karroo Supergroup), which is extensively intruded with dolerite. In the extreme south east of the area small amounts of stratigraphically higher strata been downthrust along a fault and outcrop near to Kei River mouth. These comprise strata of the Katberg Formation (Tarkastad Subgroup, Beaufort Group, Karroo Supergroup) and Burgersdorp Formation (Tarkastad Subgroup, Beaufort Group, Karroo Supergroup).

The **Adelaide Subgroup** (**Beaufort Group**, **Karoo Supergroup**) was deposited as the Ecca Lake silted up and exposed a subaerial (exposed) shoreline. The lake steadily shrank towards the centre of the basin, leaving behind flat silty plains across which long rivers meandered from the Cape Mountains towards the much reduced lake. Sands were deposited along the river channels whereas periodic flooding deposited muds on the broad flood planes. These in time came to form the interbedded sandstones and mudstones of the Adelaide Subgroup.

Though including the upper *Cistephalus* Assemblage Zone and possibly the lowermost *Lystrosaurus* Assemblage Zones, the **Balfour Formation** (**Adelaide Subgroup, Beaufort Group, Karoo Supergroup**) largely corresponds to the *Dicynodon* Assemblage Zone. Characterised by the co-occurence of *Dicynodon* and *Theriognathus* this zone demonstrates the Beaufort Groups greatest diversity of vertebrate taxa, including numerous taxa of dicynodont, biarmosuchian, gorgonopsian and therocephalian and cynodont therapsid Synapsida, together with diverse captorhinid Reptilia and less well represented eosuchian Reptilia, Amphibia and Pisces. *Glossopteris* flora plants and trace fossils are also described.

The beginning of the Triassic Period in South Africa was marked by a change in sedimentation, leading to the distinct sandstone dominated lithology of the **Katberg Formation** (**Tarkastad Subgroup, Beaufort Group, Karoo Supergroup**). Extensive sandy deposits resulted from multi channelled braided river systems that replaced the meandering rivers of the underlying Adelaide Subgroup. This change may have resulted from increased erosion of the landscape due to widespread extinction of plant groups during the end-Permian mass extinction. A marked faunal change occurs between the *Dicynodon* and *Lystrosaurus* Assemblage Zones approaching the top of the Balfour Formation, corresponding with the major extinction event associated with the Permo-Triassic boundary. The Katberg Formation falls entirely within the *Lystrosaurus* Assemblage Zone.

The *Lystrosaurus* Assemblage Zone is dominated by a single genus of dicynodont, *Lystrosaurus*, which together with the captorhinid reptile, *Procolophon*, characterise this zone. Biarmosuchian and gorgonopsian Therapsida do not survive into the *Lystrosaurus* Assemblage Zone, though therocephalian and cynodontian Therapsida exhibit moderate abundance. Captorhinid Reptilia are reduced, however an unprecedented diversity of giant amphibians characterises this interval.

The effects of the end Permian extinction event are also evident in the extensive and important record of fossil plants present in the rocks of the Karoo. Whereas faunas of Permian age are dominated by a wide range of early seed plants, the Glossopteridales (which probably include the ancestors of modern gymnosperms and ultimately angiosperms), this group appears to have gone entirely extinct during the end-Permian extinction. The rocks of the Karoo provide an unrivalled sequential record of these changes and the diversification of other groups of plants in the aftermath of the extinction. The strata of the Karoo basin have also yielded fossil insects and insect leaf damage of a range of ages.

A return to a meandering river system, possibly as a result of a recovery of vegetation cover is reflected in the mudstone dominated strata of the **Burgersdorp Formation** (**Tarkastad Subgroup, Beaufort Group, Karoo Supergroup**). Though including the uppermost level of the *Lystrosaurus* Assemblage Zone, the Burgersdorp Formation largely corresponds to the *Cynognathus* Assemblage Zone. Synapsid therapsid diversity does not demonstrate recovery between the *Lystrosaurus* and *Cynognathus* assemblage zones. The Dicynodontia, *Lystrosaurus* and *Myosaurus* are replaced by *Kombuisia* and the giant *Kannemeyeria*. Therocephalia exhibit a turnover of taxa at generic level, but an overall reduction in diversity. Cynodontia (Therapsida, Synapsida) alone amongst synapsids demonstrate a slight increase in genera. These include the small advanced Cynodont, *Cynognathus*, which together with the Cynodont *Diademodon* and the Dicynodont *Kannemeyeria*, characterise this assemblage zone. Eosuchid and captorhinid Reptilia are moderately common, though showing no generic continuity with taxa of the underlying zone. Amphibia remain diverse, though they are not as gererically diverse as in the *Lystrosaurus* Assemblge Zone and likewise demonstrate no genus level continuity therewith. Fossil fish reach their greatest known Karoo Supergroup diversity in the Burgersdorp Formation (*Cynognathus* Assemblage Zone). Plants (*Dadoxylon*, *Dicroidium* and *Schizoneura*), trace fossils (including both vertebrate and invertebrate burrows) and a freshwater bivalve (*Unio karooensis*) have also been recovered.

Dolerite, being an igneous rock does not contain fossils.

Figure 1. Geological map of the study area showing the positions of borrow pits (1-11) as well as other areas of interest. Pa = Adelaide Subgroup, TRk = Katberg Formation (Tarkastad Subgroup), TRb = Burgersdorp Formation (Tarkastad Subgroup), Jd = dolerite, Q = Quaternary cover

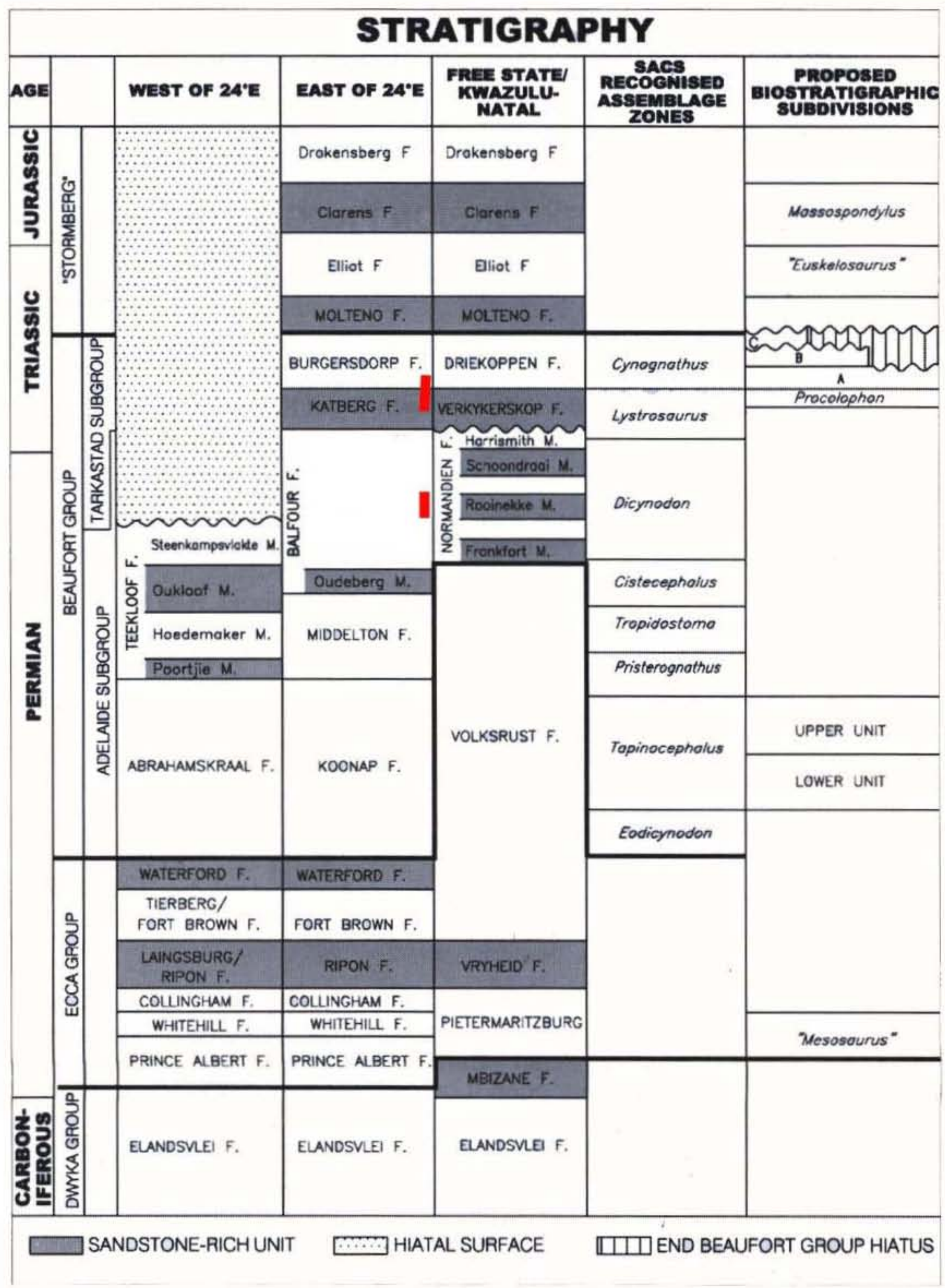

Figure 2. Stratigraphic column and corresponding biostratigraphy of the Karoo Supergroup

(modified after Rubidge, B.S. 2005. *South African Journal of Science*. 108: 135-172). Red line indicates strata affected by the development)

Site Visit

The proposed route was surveyed on the 27th and 28th of June 2011. All borrow pits were examined and all outcrops along the road route were examined.

Borrow pits 1, 3, 6, 7 and 8 consist entirely of dolerite and are therefore of no palaeontological interest.

Figure 3. Dolerite borrowpits. Borrowpit 8 (above) and borrowpit 6 (below)

Borrowpits 2, 4, 5, 9 and 10 are situated in sandstones and mudstones of the **Adelaide Subgroup**.These were all exhaustively examined for palaeontological material, without significant success.

Borrowpit 2 consists of of interbedded tan sandstone and crumbly mudstone.

Figure 4. Mudstone at borrowpit 2

Borrowpit 4 is a small borrowpit consisting of pale sandstone containing abundant ripple cross lamination and interbedded shale layers.

Figure 5. Borrowpit 4 (above) with detail of ripple cross lamination (below).

Borrowpit 5 consists of a fairly large quarry comprised mainly of sandstone with interbedded dark greenish shale. These are much altered by dolerite dykes, one of which cuts through the outcrop. Rocks are jointed into baked blocks and Iron/magnesium rich fluids have permeated the cracks leaving behind abundant mineral precipitates that form dendrites. These should not be mistaken for fossils.

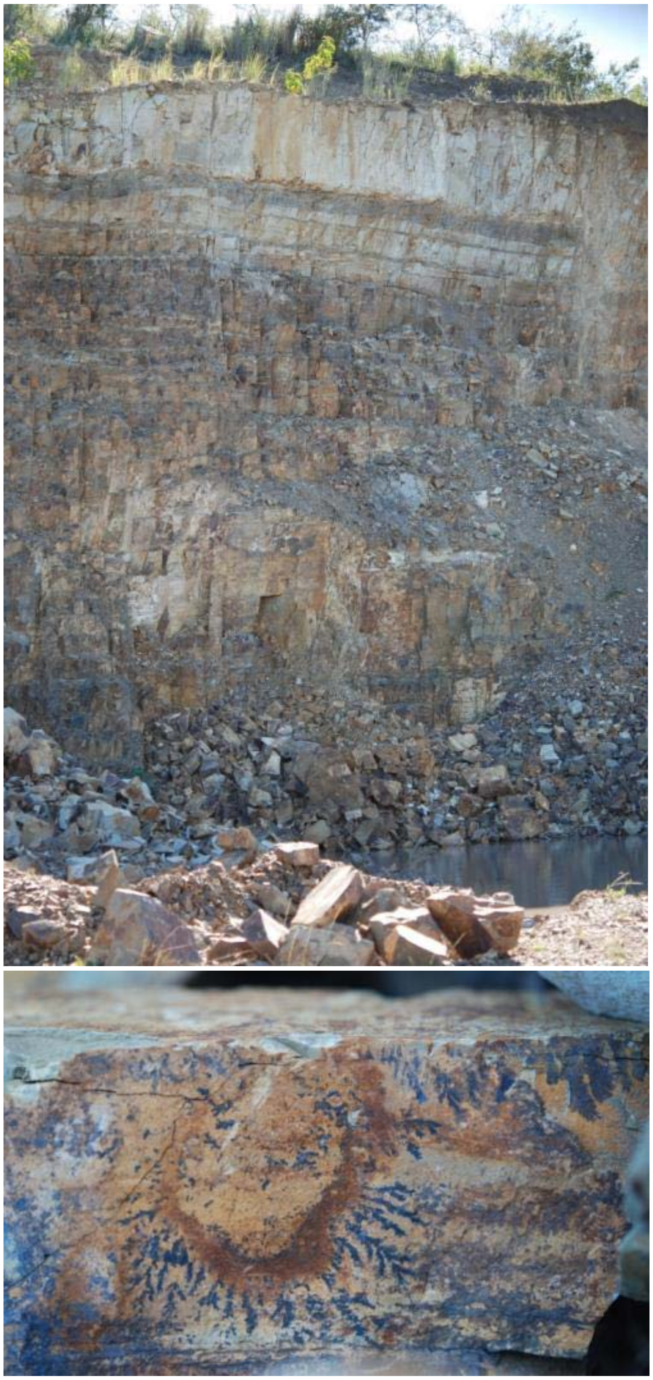

Figure 6. Borrow pit 5. Sandstone with interbedded mudstone, cut by a dolerite dyke on the extreme right (above). Dendrites (not fossils) below.

Borrowpit 9 is a small borrowpit, the source of pale coarse sandy aggregate.

Figure 7. Coarse grained aggregate at borrowpit 9

Borrowpit 10 consists of a large quarry exposing fine olive greenish mudstone with whitish interbedded sandstones. Small discoids within some sandstone layers may represent some form of trace fossil.

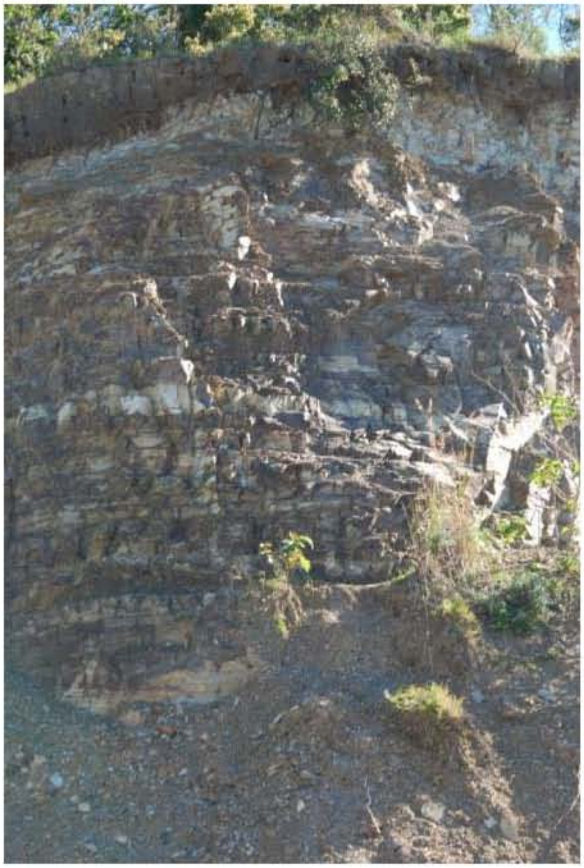

Figure 8. Laminated mudstones and sandstones at borrowpit 10 (above). Detail of possible trace fossils at borrowpit 10 (below).

Only one outcrop of Tarkastad subgroup strata is sampled by a borrow pit within this study area. This outcrop was identified as belonging to the Burgersdorp Formation (Tarkastad Subgroup) by the Geological Survey maps.

Within the borrowpit (borrowpit 11) is a small amount of baked sandstone containing alteration concretions resultant from its close proximity to a dolerite dyke, exposed in the back wall of the borrowpit.

Figure 9. Tarkastad Subgroup strata exposed in borrowpit 11.

The **Road Route** itself largely passes over rolling deeply weathered grassy hills. As a result there is not much bedrock exposed along the route. Exeptions include a small pass approximately two kilometers south of Kentani (see Figure 1, A). The eastern side of the pass exposed sandstone and some tan mudstone of the Adelaide Subgroup.

Figure 10. Sandstone and mudstone of the Adelaide Subgroup exposed in road cuttings about 2 km south of Kentani (see Figure 1 A)

Small amounts of sandstone outcrop at the junction of the Trenneries and Kei mouth turnoffs and small outcrops of pale greenish mudstone occur in the roadbank between this turnoff and Trenneries. Somewhat larger outrops occur in roadbanks alongside the road to Kei River mouth, notably at Pleseni, and just after Mazinyo (see Figure 1 B). Although all these outcrops were rigourousely examined for palaeontological material only one trace fossil was found. This comprised a small horizontal invertebrate burrow south of Mazinyo (Figures 1 B, 11).

Figure 11. Adelaide Subgroup mudstones exposed in the roadbank south of Mazinyo (see Fig 1 B) (top), natural cast of a horizontal invertebrate burrow (below).

Conclusions and Reccomendations

1. Those borrow pits that are cut into dolerite will in no way impinge on palaeontological heritage.

2. There remains the possibility that palaeontological material is situated beneath the surface in mudstones and sandstones of the Adelaide Subgroup (Beaufort Group) which will be disturbed by the planned activities. It would not, however, be practical for these activities to be monitored.

3. **It is therefore recommended that these cuttings should be re-inspected after completion of the construction phase and before any vegetation or other rehabilitation is conducted. This should form part of the Environmental Management Plan**.