DESKTOP PALAEONTOLOGICAL HERITAGE IMPACT ASSESSEMENT REPORT ON THE SITES OF SEVEN PROPOSED SITES OF WIDENING OF THE N4 HIGHWAY (NAMED WB1, WB3, WB4, WB5, WB7, EB1 AND EB3) TO BE LOCATED BETWEEN WATERVAL BOVEN AND NELSPRUIT, MPUMALANGA PROVINCE

7 February 2016

Prepared for:

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On behalf of:

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On Behalf of:

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Prepared By:

Prof B.D. Millsteed

EXECUTIVE SUMMARY

The South African National Roads Agency SOC Ltd (SANRAL) is proposing upgrades by widening certain sections of the existing National N4 Toll Route between eMgwenya (Waterval Boven) and Mbombela (Nelspruit), Mpumalanga. As part of continual upgrading of this road corridor between Pretoria in the west and Maputo, Mozambique in the east; a need has arisen to introduce extensions to existing passing lanes whilst new passing lanes are also required. SANRAL has an implementing agent and concessionaire for the National N4 Toll Route existing between Pretoria and Maputo known as "Trans African Concessions" (TracN4) – a concessionaire established during the mid-90's specifically for the management of the N4 corridor between South Africa and Mozambique. TracN4, as SANRAL's implementing agent ultimately needs to ensure compliance with all conditions of environmental licenses, permits and similar authorisations as custodians of the N4 road on behalf of SANRAL.

The proposed upgrade project is located on Sections N4-6X and N4-7X between Waterval-Onder and Montrose through Elandspoort on Section 6E of the Maputo Development Corridor and is generally referred to as MDC Section 6E or MDC-6E. The start point is at km 23,0 of N4-6X on the Farm Kindergoed 332-JT approximately 7,5 km east of Waterval-Onder and the project ends at km 22,7 of N4-7X on the farm Montrose 290-JT. The seven project segments are named EB1, EB3, WB1, WB3, WB4, WB5 and WB7. The total length of the project is approximately 43 km. The portions of the route where additional passing lanes are required, would be widened by an additional 2,7 m surfaced width whilst the upgrades will remain within the existing road servitude owned by SANRAL.

SANRAL has appointed Prism Environmental Management Services (Pty) Ltd as independent the environmental consultant to undertake an Environmental Impact Assessment of the proposed project. Prism Environmental Management Services (Pty) Ltd has contracted BM Geological Services to provide a desktop Palaeontological Heritage Impact Assessment Report in respect of the proposed project that will form part of the final Heritage Impact Assessment Report for the project

The effects of the required construction operations to the geological strata underlying the project area will be restricted to the early Achaean rocks of the Onverwacht Group as well as the late Achaean to early Proterozoic rocks of the Malmani Subgroup and Pretoria Groups of the Transvaal Supergroup. The rocks of the Onverwacht and Pretoria Groups are known to be unfossiliferous. Thus, the probability and significance of any negative impact upon the palaeontological heritage of the area underlying project segments EB1, WB1, WB3, WB4 and WB7 is assessed as being nil.

Project segments EB3 and WB5 are underlain by carbonates rocks of the Malmani Subgroup. The rocks of this unit are known to contain abundant stromatolite assemblages. The stromatolites within the Malmani Subgroup Transvaal Supergroup are not taxonomically diverse and tend to be similar throughout the units in which they occur. Any destruction of a small area these fossils would not unduly diminish the palaeontological heritage of the unit. As a result, while the probability of a negative impact upon the palaeontological heritage of this unit is assessed as probable, the significance of any negative impact is assessed as being low.

The social benefits of the project have been classified as beneficial, herein, and the project as positive. The value of the project to the community of South Africa outweighs any minor impacts the project may cause to the palaeontological heritage underlying the various project segments.

This desktop study has not identified any palaeontological reason to prejudice the progression of upgrading of the N4 Highway in the areas named EB1, EB3, WB1, WB3, WB4, WB5 and WB7. No damage mitigation protocols need to be implemented in order to minimise the potential negative impact of the project.

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1 INTRODUCTION

The South African National Roads Agency SOC Ltd (SANRAL) is proposing upgrades by widening certain sections of the existing National N4 Toll Route between eMgwenya (Waterval Boven) and Mbombela (Nelspruit), Mpumalanga. As part of continual upgrading of this road corridor between Pretoria in the west and Maputo, Mozambique in the east; a need has arisen to introduce extensions to existing passing lanes whilst new passing lanes are also required. SANRAL has an implementing agent and concessionaire for the National N4 Toll Route existing between Pretoria and Maputo known as "Trans African Concessions" (TracN4) – a concessionaire established during the mid-90's specifically for the management of the N4 corridor between South Africa and Mozambique. TracN4, as SANRAL's implementing agent ultimately needs to ensure compliance with all conditions of environmental licenses, permits and similar authorisations as custodians of the N4 road on behalf of SANRAL.

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2 TERMS OF REFERENCE AND SCOPE OF THE STUDY

The terms of reference for this study were as follows:

- Conduct a desktop assessment of the potential impact of the proposed project on the palaeontological heritage of the project area.
- Describe the possible impact of the proposed development on the palaeontological heritage of the site, according to a standard set of conventions.
- Quantify the possible impact of the proposed development on the palaeontological heritage of the site, according to a standard set of conventions.
- Provide an overview of the applicable legislative framework.

- Make recommendations concerning future work programs as, and if, necessary.

3 LEGISLATIVE REQUIREMENTS

South Africa's cultural resources are primarily dealt with in two Acts. These are the National Heritage Resources Act (Act 25 of 1999) and the National Environmental Management Act (Act 107 of 1998).

3.1 The National Heritage Resources Act

The following are protected as cultural heritage resources by the National Heritage Resources Act:

- Archaeological artefacts, structures and sites older than 100 years,
- Ethnographic art objects (e.g. prehistoric rock art) and ethnography,
- Objects of decorative and visual arts,
- Military objects, structures and sites older than 75 years,
- Historical objects, structures and sites older than 60 years,
- Proclaimed heritage sites,
- Grave yards and graves older than 60 years,
- Meteorites and fossils,
- Objects, structures and sites or scientific or technological value.

The Act also states that those heritage resources of South Africa which are of cultural significance or other special value for the present community and for future generations must be considered part of the national estate and fall within the sphere of operations of heritage resources authorities. The national estate includes the following:

- Places, buildings, structures and equipment of cultural significance,
- Places to which oral traditions are attached or which are associated with living heritage,
- Historical settlements and townscapes,
- Landscapes and features of cultural significance,
- Geological sites of scientific or cultural importance,
- Sites of Archaeological and palaeontological importance,
- Graves and burial grounds,
- Sites of significance relating to the history of slavery,
- Movable objects (e.g. archaeological, palaeontological, meteorites, geological specimens, military, ethnographic, books etc.).

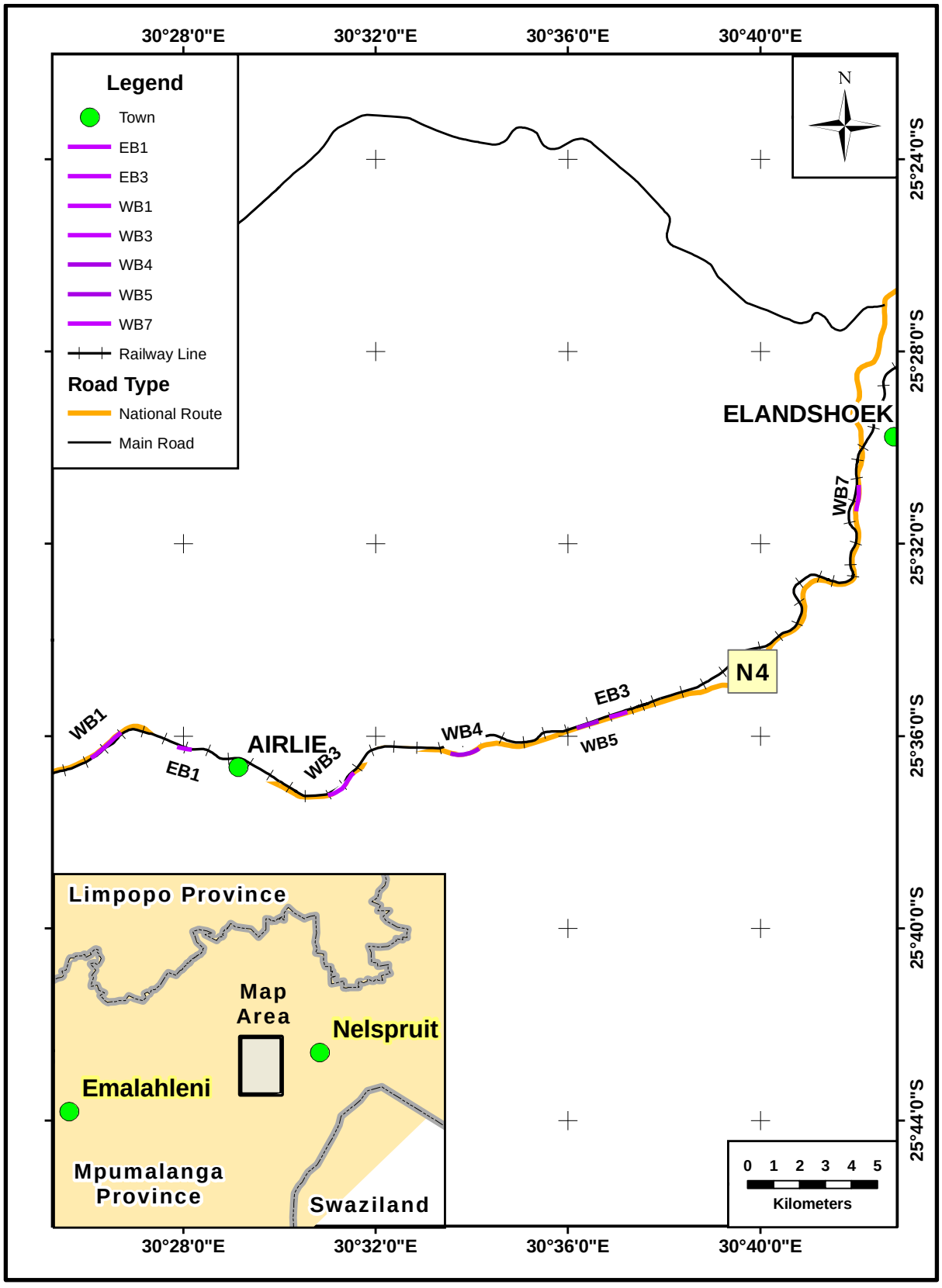

Figure 1: Location map of the seven project area segments (purple lines EB1, EB3, WB1, WB3, WB4, WB5 and WB7).

3.2 Need for Impact Assessment Reports

Section 38 of the Act stipulates that any person who intends to undertake an activity that falls within the following:

- The construction of a linear development (road, wall, power line, canal etc.) exceeding 300 m in length,
- The construction of a bridge or similar structure exceeding 50 m in length,
- Any development or other activity that will change the character of a site and exceed 5 000 m^2 or involve three or more existing erven or subdivisions thereof,
- Re-zoning of a site exceeding 10 000 m^2,
- Any other category provided for in the regulations of SAHRA or a provincial heritage authority.

must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development. If there is reason to believe that heritage resources will be affected by such development, the developer may be notified to submit an impact assessment report. A Palaeontological Impact Assessment (PIA) only looks at the potential impact of the development palaeontological resources of the proposed area to be affected.

3.3 Legislation Specifically Pertinent to Palaeontology*

*****Note: Section 2 of the Act defines "palaeontological" material as "any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains".

Section 35(4) of this Act specifically deals with archaeology, palaeontology and meteorites. The Act states that no person may, without a permit issued by the responsible heritage resources authority (national or provincial):

- Destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite,
- Destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite,
- Trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
- Bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment that assists in the detection or recovery of metals or

archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites,

- Alter or demolish any structure or part of a structure which is older than 60 years as protected.

The above mentioned palaeontological objects may only be disturbed or moved by a palaeontologist, after receiving a permit from the South African Heritage Resources Agency (SAHRA). In order to demolish such a site or structure, a destruction permit from SAHRA will also be needed.

Further to the above point, Section 35(3) of this Act indicates that "any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority". Thus, regardless of the granting of any official clearance to proceed with any development based on an earlier assessment of its impact on the Palaeontological Heritage of an area, the development should be halted and the relevant authorities informed should fossil objects be uncovered during the progress of the development.

3.4 The National Environmental Management Act [as amended]

This Act does not provide the detailed protections and administrative procedures for the protection and management of the nation's Palaeontological Heritage as are detailed in the National Heritage Resources Act, but is more general in is application. In particular Section 2(2) of the Act states that environmental management must place people and their needs at the forefront of its concerns and, amongst other issues, serve their cultural interests equitably. Further to this point section 2(4)(a)(iii) states that disturbances of sites that constitute the nation's cultural heritage should be avoided, and where it cannot be avoided should be minimised and remedied.

Section 23(1) indicates that a general objective of integrated environmental management is to identify, predict and evaluate the actual and potential impact of activities upon the cultural heritage. This section also highlights the need to identify options for mitigating of negative effects of activities with a view to minimising negative impacts.

In order to give effect to the general objectives of integrated environmental management outlined in the Act the potential impact on cultural heritage of activities that require authorisation or permission by law must be investigated and assessed prior to their implementation and reported to the relevant organ of state. Thus, a survey and evaluation of cultural resources must be done in areas where development projects that will potentially negatively affect the cultural heritage will be performed. During this

process the impact on the cultural heritage will be determined and proposals for the mitigation of the negative effects made.

4 RELEVENT EXPERIENCE

Prof Millsteed holds a PhD in palaeontology and has previously been employed as a professional palaeontologist with the Council for Geoscience in South Africa. He is currently the principle of BM Geological Services and has sufficient knowledge of palaeontology and the relevant legislation required to produce this Palaeontological Impact Assessment Report. Prof Millsteed is registered with the South African Council for Natural Scientific Professions (SACNASP), is a member of the Palaeontological Society of South African and is a fellow of the Geological Society of South Africa.

5 INDEPENDENCE

Prof Millsteed was contracted as an independent consultant to conduct this Palaeontological Heritage Impact Assessment study and shall receive fair remuneration for these professional services. Neither Prof Millsteed nor BM Geological Services has any financial interest either in the construction of the road section upgrades nor any companies or individuals associated with the project.

6 GEOLOGY AND FOSSIL POTENTIAL

Figure 2 shows that the project area is completely underlain by rocks of the early Achaean Onverwacht Group of the Barberton Greenstone as well as the late Achaean to early Proterozoic rocks of the Transvaal Supergroup. The Transvaal Supergroup strata consist of an undifferentiated succession of siliciclastic sediments of the Pretoria Group as well as the stratigraphically older carbonates of the Malmani Subgroup. A summary of the characteristics of these stratigraphic units and their fossiliferous potential follows.

6.1 Onverwacht Group

Project segment WB7 is located upon this stratigraphic unit.

6.1.1 Geology

The early Achaean (Swazian) rocks of the Onverwacht Group form the basal stratigraphic unit within the Barberton Supergroup. The rocks form the basal succession of the Barberton Greenstone Belt and, as such, constitute part of one of the oldest greenstone belts on Earth. These rocks represent a unique assemblage of some of the best-preserved, first formed rocks on Earth (Brandle *et al*., 2006). The stratigraphic sequence consists of six formations that constitute the older Tjakastad Subgroup and the stratigraphically younger Geluk Subgroup (see Table 1).

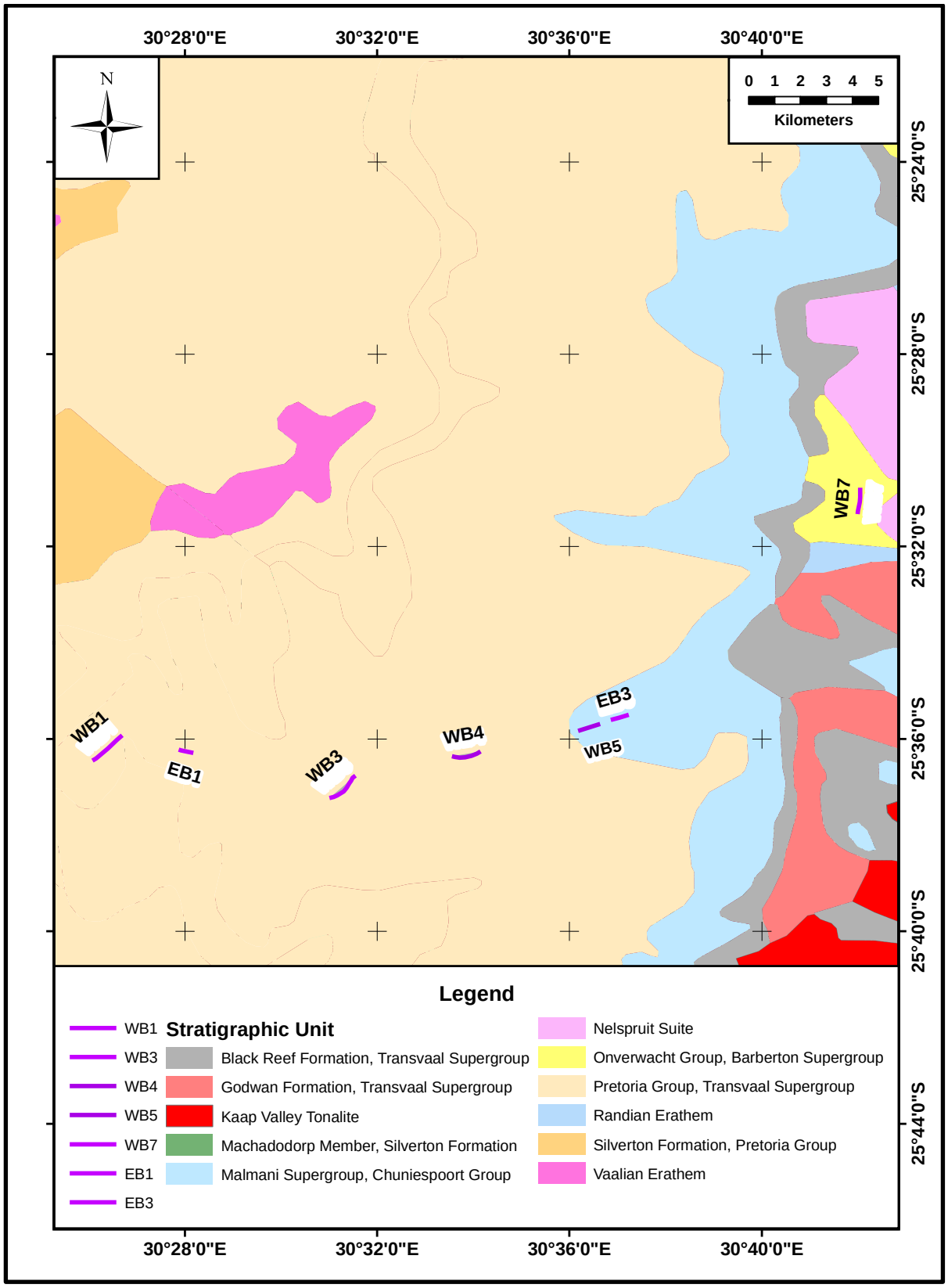

Figure 2: Geological map of the bedrock strata underlying the seven project area segments (purple lines EB1, EB3, WB1, WB3, WB4, WB5, and WB7) and their surrounding environs.

Subgroup	Formation
Geluk	Mendon
	Kromberg
	Hoeggenoeg
Tjakastad	Komati
	Threespruit
	Sandspruit

Table 1: Stratigraphic subdivision of the Onverwacht Group, Barberton Supergroup

The strata comprising the Tjakastad Subgroup consist of a thick succession of mostly igneous rocks. The Sandspruit Formation is a poorly understood, ca. 2100m thick, collection of tectonic slices (i.e., megaxenoliths). Lithologically it consists of deformed and metamorphosed mafic and ultramafic rocks and subordinate metasedimentary beds. The Threespruit Formation contains lavas, tuffs and rare pillow lavas (demonstrating subaqueous eruption) either of high-Mg basalt, komatiitic basalt or tholeiitic basalt composition. The Komati Formation consists mainly of metamorphosed komatiite and komatiitic basalts; some of the komatiites evince subaqueous eruption via the presence of spinifex textures (Brandle *et al*., 2006). The rocks of the Geluk Subgroup are dominated by rocks of volcanic origin (as in the underlying Tjakastad Subgroup), but the subgroup is distinguished from the underlying subgroup by the presence of subordinate felsic lavas and the presence of conspicuous .banded chert sequences (silicified pyroclastics) at the base of each formation (Brandle. *et al*., 2006). The geological development of the Onverwacht Group is believed to represent a succession of Achaean-age marine crust that was thrust against a volcanic arc. This tectonic thrusting caused much of the deformation and metamorphism observed in the unit. The banded cherts and felsic lavas present within the Geluk Subgroup are believed to result from increasing proximity of the sea-floor sequence to the volcanoes of the volcanic arc (Brandle *et al*., 2006). The term "greenstone" is applied to the succession as the volcanic rocks have been subjected to low grade metamorphism with the resultant pervasive presence of green metamorphic minerals such as chlorite. The formation(s) that occur beneath the project segment are unknown to the author (i.e., they are undifferentiated herein in Figure 2). However, as all six formations are uniformly composed of volcanic strata this is unimportant for the purposes of this report.

6.1.2 Palaeontological potential

None of the rocks in this sequence are known to be fossiliferous. Their unfossiliferous nature is due to a combination of their extreme antiquity (pre-dating the evolution of

multicellular life) and the dominance of the unit by rocks of volcanic origin. Accordingly, the palaeontological potential of the rocks of the Onverwacht Group is assessed as nil.

6.2 Malmani Subgroup

Project segments WB5 and EB3 are located upon this stratigraphic unit.

6.2.1 Geology

The carbonate rocks of the Malmani Subgroup of the Transvaal Supergroup are up to 2000 m thick and consist of five formations based on variation in the chert content, stromatolite morphology, intercalated shales and the presence of erosion surfaces (Button, 1973). The Malmani Subgroup has been dated as being between 2600 Ma and 2500 Ma subgroup within the late Achaean (Eriksson *et al*., 2006). The names of the five formations are provided in Table 2.

Subgroup	Formation
Malmani	Frisco
	Eccles
	Lyttelton
	Monte Christo
	Oaktree

Table 2: Formations that comprise the Malmani Subgroup (listed in order from youngest to oldest downwards).

The carbonate sediments of the Malmani Subgroup reflect three major transgressive-regressive macrocycles, upon which are superimposed a number of subordinate cycles. Each macrocycle commences with a chert breccia at the base of a thin carbonaceous shale and is capped by a thick succession of carbonates. The chert-breccia residues mark important regressive phases when the carbonates were subjected to intense chemical weathering and are believed to mark regional disconformities. The fundamental subdivisions of the Malmani Subgroup are based on the recognition of two main lithofacies. The first is a pale grey, chert-rich dolomite (the Monte Christ and the Eccles Formations) and the second is dark grey to black, chert poor, fine-grained dolomites and limestones, often in association with higher than normal amounts of clastic sediment (the Oaktree, Lyttelton and Frisco Formations). The pale chert–rich units are believed to comprise tidal-flat and shallow subtidal environments whereas the dark grey to black, chert poor units deeper water subtidal deposits, as indicated by the

large size of some of the stromatolitic mounds. The formation of chert is a replacement process due to the mixing of fresh water (meteroic) and marine (phreatic) water.

6.2.2 Palaeontological potential

The stromatolite assemblages within the carbonates in the Transvaal Supergroup tend to be abundant where they occur and can dominate the lithology in some areas. The palaeontological potential of the Malmani Subgroup is, accordingly, **high**. No other fossil materials are known to occur within the rocks neither of the subunit nor in any rocks of comparable age within South Africa.

6.3 Undifferentiated Pretoria Group

Project segments WB1, WB3, WB4 and EB1 are located upon this stratigraphic unit.

6.3.1 Geology

The entire Pretoria Group consists of an approximately 6-7 km thick succession comprised mainly of mudrocks alternating with quartzitic sandstones, significant interbedded basaltic–andesitic lavas and subordinate conglomerates, diamictites, and carbonate rocks (Eriksson *et al*., 2006). The rocks that underlie project segments WB1, WB3, WB4 and EB1 comprise an undifferentiated sequence of strata that lie stratigraphically between the older Malmani Subgroup (which crops out to the immediate east) and the younger Silverton Formation that crop out to the immediate west (Figure 2). Accordingly, the lithological sequence may well possibly contain any, or all, of the rocks of the Rooihoogte, Timeball Hill, Boshoek, Hekpoort, Dwaalheuwel, Strubenkop and Daspoort Formations (Table 3). Thus, the sequence may consist of any of an alternating sequence of sandstones and mudstones save for the additional possibility of andesites of the Hekpoort Formation. The sequence is, therefore dominated by sandstones and mudstones, except for the lavas and pyroclastic frocks of the Hekpoort Formation.

Formation	Lithology
Daspoort	Mature quartz arenites and subordinate mudstones and ironstones
Strubenkop	Alternating mudstones and siltstones with subordinate sandstones
Dwaalheuwel	Immature sandstones, conglomerates and subordinate mudstones
Hekpoort	Andesitic lavas and pyroclastics
Boshoek	Immature conglomerates, sandstones and subordinate mudrocks

Timeball Hill	Black mudrocks with minor quartzites and lavas
Rooihoogte	Chert conglomerate, chert-rich sandstones, immature sandstones

Table 3: The formations (listed from youngest to oldest downwards) and the lithologies that comprise the seven formations that may underlie project segments WB1, WB3, WB4 and EB1 [data from Eriksson *et al*., (2006)].

The environment of deposition of the rocks of the Pretoria group has been subject to considerable debate. Models in which the rocks represent a shallow-marine basin fill succession and, alternatively, as a closed continental (non-marine) succession have been proposed (Eriksson *et al*., 2006). Evidence in the form of boron contents of the sediments provides tentative evidence that the Rooihoogte Formation to Strubenkop Formation sequence was deposited within a closed (terrestrial) basin (Eriksson *et al*., 2006).

6.3.2 Palaeontological potential

No palaeontological materials are known to occur in any of the strata that may possibly constitute this geological sequence anywhere within their known aerial extent. Accordingly, the palaeontological potential of this lithological sequence is assessed as being **nil**.

7 ENVIRONMENT OF THE PROPOSED PROJECT SITE

The seven areas reported upon herein are large, collectively attaining a length of approximately 43 km. The road will be widened by an additional 2.7 m resulting in a total aerial extent of approximately 116,100 m^2 of disturbed ground. It is evident from Figures 3 and 4 that all seven project area segments are located within the Elands River Valley. All project areas are located immediately proximal to, and on the southern and eastern sides of, the Elands River at the toe of the valley side. Accordingly, surface drainage from all seven project areas runs into the Elands River. It is also evident from Figure 3 that significant fluvial drainage lines cross-cut all seven project segments. Figure 4 clearly indicates the region is mountainous with steep topography; the surface run-off along the fluvial drainage lines should be rapid and potentially highly erosive following rainfall.

Figure 5 shows that project segments the eastern segments of EB1 and WB1 and all of EB3, WB3, WB4, WB5 and WB7 lie within the Legogote Sour Bushveld vegetation zone. The western portions of EB1 and WB1 lie within the Lydenburg Montane Grassland vegetation zone. Mucina and Rutherford (2006) describe the conservation status of the Legogote Sour Bushveld as being endangered while that of the Lydenburg Montane Grassland is described as being vulnerable. However, all seven project segments lie immediately adjacent to the existing N4 Highway (Figures 1 and 3) and within the

existing road servitudes. Because of the location of the project segments within the existing servitudes it is probable that the land surface in these areas has historically been disturbed during the construction of the highway. Due to this historical disturbance it is unlikely that much, if any, of the original vegetation cover remains in its natural state.

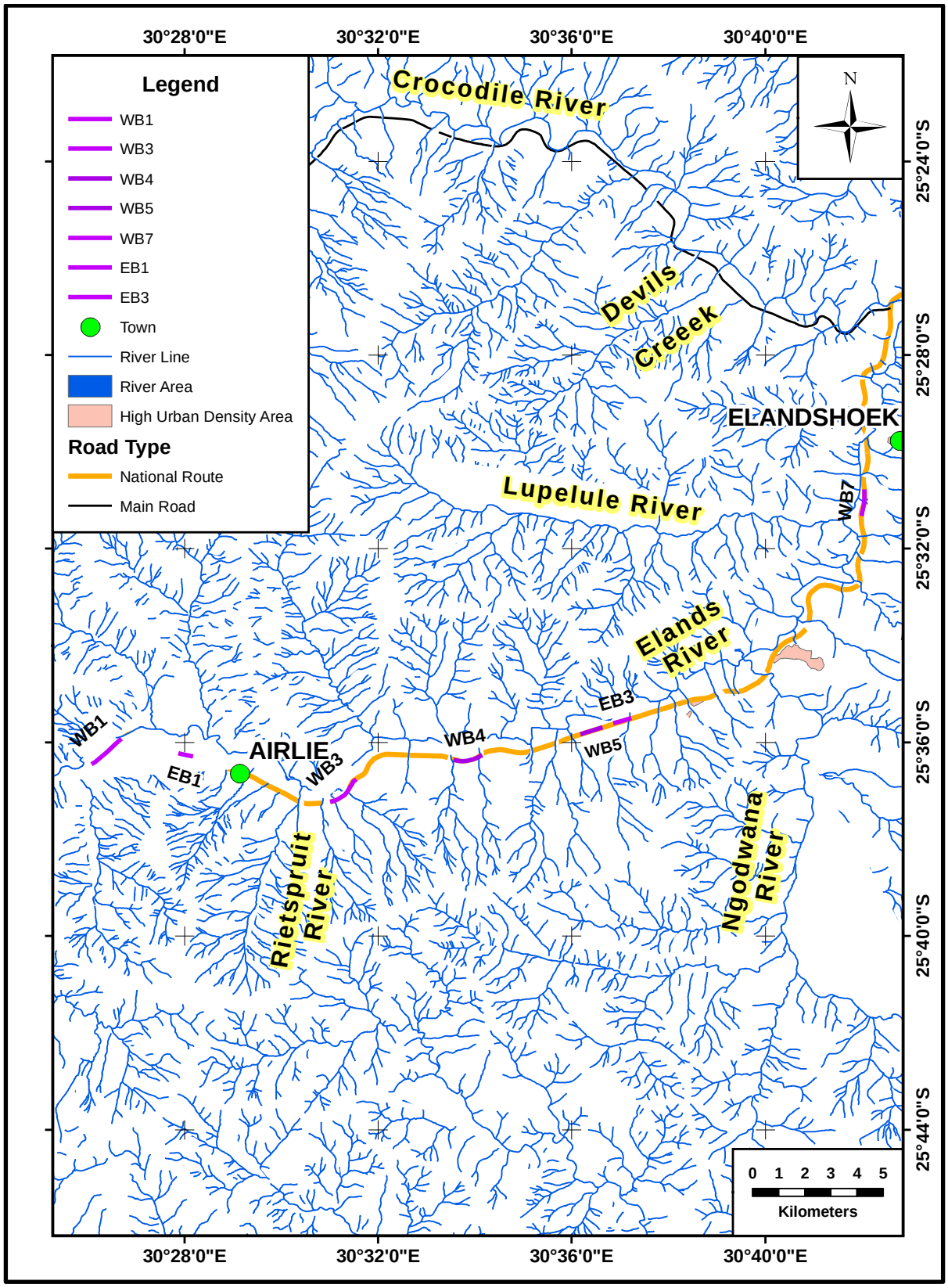

Figure 3: Map of the project area segments and the surrounding environs. The seven project segment areas are located on the margins of the N4 Highway, within the Elands River Valley.

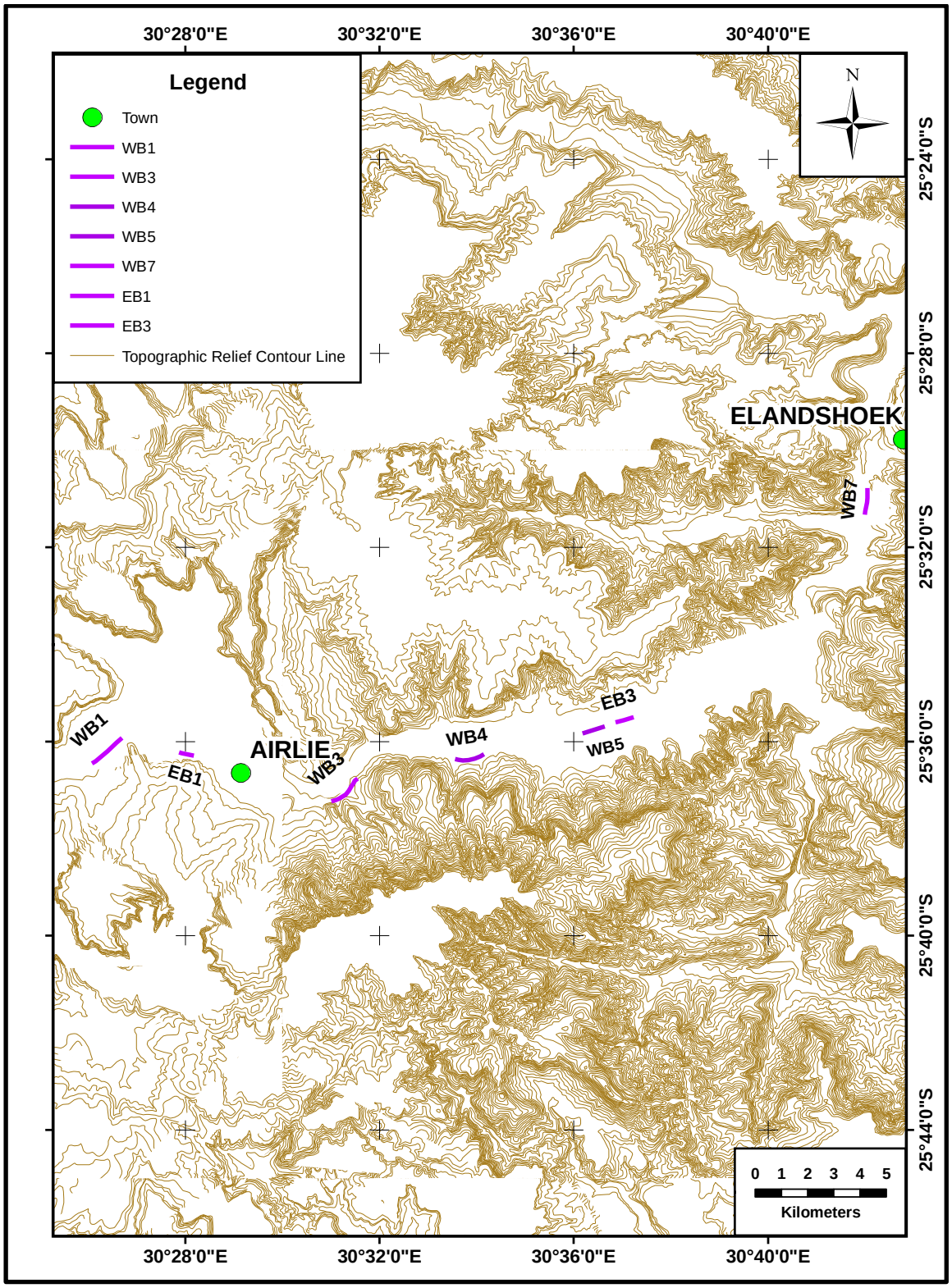

Figure 4: Topographic relief contour map of the area surrounding the seven project area segments (purple lines EB1, EB3, WB1, WB3, WB4, WB5 and WB7). The area is mountainous, but all project segments are located within the Elands River Valley. The topographic relief contour interval is 20 m.

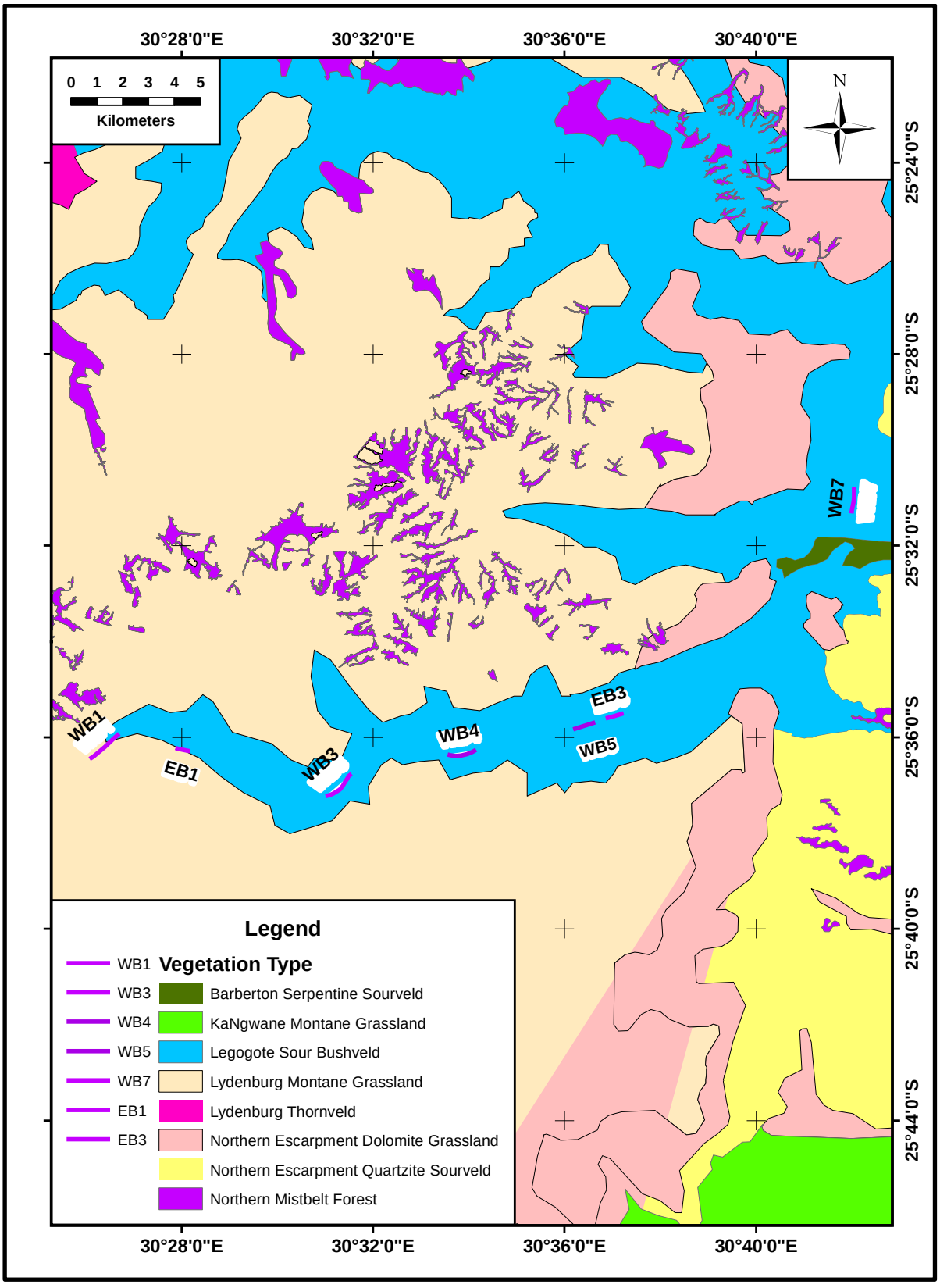

Figure 5: Map of the distribution of the vegetation veld types located beneath the project area segments and their surrounding environs (after Mucina and Rutherford, 2006).

8 OVERVIEW OF SCOPE OF THE PROJECT

The development footprint of the proposed pipeline will be approximately 43 km long. The width of the area to be affected by the development is approximately 2.7 m wide. The resultant aerial extent of the area that will be directly impacted by the project is approximately 116,100 m^2. The areas that will be impacted fall within the existing highway servitudes.

8.1 Effect of project on the geology

The construction methods to be employed during the construction of the road-widening project are unknown to the author. However, it is assumed (for the purposes of this report) it is that in the maximum depth of disturbance of the land surface will be approximately 1 m where the road is not bounded by road cuttings. Where a road cutting is to be widened the volume of bed rock that will be disturbed from the toe of the slope will be greater than on a flat surface (i.e., equal to the total rock extending up to 2.7 m from the road margin and to a depth of 1 m below the current road level). Any rock material that will be impacted by this road widening will be destroyed as it will be excavated and removed.

9 IMPACT ASSESSMENT

The potential impact of the proposed mining area is categorised below according to the following criteria:-

9.1 Nature of Impact

The potential negative impacts of the proposed project on the palaeontological heritage of the area are:

- Damage or destruction of fossil materials during the construction of project infrastructural elements to a maximum depth of those excavations. Many fossil taxa (particularly vertebrate taxa) are known from only a single fossil and, thus, any fossil material is potentially highly significant. Accordingly, the loss or damage to any single fossil can be potentially significant to the understanding of the fossil heritage of South Africa and to the understanding of the evolution of life on Earth in general. Where fossil material is present and will be directly affected by the building or construction of the project's infrastructural elements the result will potentially be the irreversible damage or destruction of the fossil(s).
- Movement of fossil materials during the construction phase, such that they are no longer *in situ* when discovered. The fact that the fossils are not *in situ* would either significantly reduce or destroy their scientific significance.

- The loss of access for scientific study to any fossil materials present beneath the new road surface for the life span of the existence of those constructions.

9.2 Extent of impact

The possible extent of the permanent impact of the proposed project on the palaeontological heritage of South Africa is restricted to the damage, destruction or accidental relocation of fossil material caused by the excavations of any bedrock during the road widening. The possible source of a less permanent negative impact on the palaeontological heritage is the loss of access for scientific research to any fossil materials present in the undisturbed bedrock that may become covered by the new road surface. The extent of the area of potential impact is, accordingly, categorised as **local** (i.e., restricted to the project site).

9.3 Duration of impact

The anticipated duration of the identified potential impact is assessed as potentially **permanent to long term**. This is assessment is based on the fact that, in the absence of mitigation procedures (should fossil material be present within the area to be affected) the damage or destruction of any palaeontological materials will be permanent. Similarly, any the negative impacts upon any fossil materials that may be either damaged, moved or destroyed will be permanent and irreversible. Any materials that are not unearthed by the construction process, but which exist below the new road surface will be unavailable for scientific study for the life of the existence of those features. The expected life span of the facility is permanent.

9.4 Probability of impact

There are common and widespread occurrences of stromatolitic carbonate that are known to occur throughout the Malmani Subgroup. This unit underlies project sections WB5 and EB3. It is very possible that these stromatolitic carbonates may be present beneath both of these project sections. The probability of a negative impact upon the palaeontological heritage of this rock sequence is accordingly, assessed as being **probable**.

Sediments of the Pretoria Group are dominantly composed of unfossiliferous sandstones and mudstones underlie project segments WB1, WB3, WB4 and EB1. Should the Hekpoort Formation be present its andesitic lavas and pyroclastic rocks are also unfossiliferous. The probability of a negative impact upon the palaeontological heritage of this unit is, accordingly, **nil**.

The Achaean rocks of the Onverwacht Group underlie project segment WB7. This stratigraphic unit consists predominantly of mafic and ultramafic lavas and cherts derived from alteration of pyroclastic tuffs. The age and lithology of these rocks precludes the presence of fossil materials and, indeed, the sequence is known to be unfossiliferous. The probability of a negative impact throughout the stratigraphic unit is, accordingly, assessed as being **nil**.

9.5 Significance of the impact

Where stromatolitic carbonates occur elsewhere in the Malmani Subgroup they are richly abundant. Despite the abundance of these stromatolites within the associated carbonate lithologies the stromatolite assemblages tend not to be morphologically diverse and are be reasonably uniform over large areas. As such, it is expected that any negative impacts on the palaeontological heritage of the carbonates underlying project sections WB5 and EB3 would be of **low significance**.

The rocks of the Onverwacht Group that underlie project segment WB7 are unfossiliferous as are the Pretoria Group rocks underlying project segments WB1, WB3, WB4 and EB1. Accordingly, any negative impacts upon the geology underlying these five project segments will have **nil significance** on the palaeontological heritage of the area.

The scientific and cultural significance of fossil materials is underscored by the fact that many fossil taxa (particularly vertebrate taxa) are known from only a single fossil and, thus, any fossil material is potentially highly significant. Accordingly, the loss or damage to any single fossil can be potentially significant to the understanding of the fossil heritage of South Africa and to the understanding of the evolution of life on Earth in general. Where fossil material is present and will be directly affected by the construction of project infrastructural elements the result will potentially be the irreversible damage or destruction of the fossil(s).

The certainty of the exact *in situ* location of fossils and their precise location within the stratigraphic sequence is essential to the scientific value of fossils. The movement of any fossil material during the construction of the facility that results in the exact original location of the fossil becoming unknown will either greatly diminish or destroy the scientific value of the fossil.

9.6 Severity / Benefit scale

The proposed project is categorised, herein, as being potentially **beneficial**. This classification is based on the intention that the project will facilitate the smooth flow of traffic along the N4 Highway creating safer travel and facilitating trade between South

Africa and Mozambique. This impact will also access for South African trade goods to Mozambiquan ports (and of goods into South Africa).

The probability of a negative impact on the palaeontological heritage of the seven project areas has been categorised as moderate beneath only two of the project segments and nil over the remainder of the segments. While there is a reasonable probability of the project negatively impacting upon the stromatolite assemblages within the Malmani Subgroup the significance of that impact will be low. It is, accordingly, suggested, herein, that the benefits to the South African community will significantly outweigh the chance and significance of any negative impacts.

9.7 Status

The proposed project would provide safer road travel along the N4 Highway and facilitate South African trade. As such, the project is determined as having a **positive status** herein.

10 DAMAGE MITIGATION, REVERSAL AND POTENTIAL IRREVERSABLE LOSS

The degree to which the possible negative effects of the proposed project can be mitigated, reversed or will result in irreversible loss of the palaeontological heritage can be determined as discussed below.

10.1 Mitigation

No damage mitigation protocols are required to preserve the palaeontological heritage of this area and none are suggested herein.

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10.2 Reversal of damage

Any damage to, or the destruction of, palaeontological materials or reduction of scientific value due to a loss of the original location is **irreversible**.

10.3 Degree of irreversible loss

Once a fossil is damaged, destroyed or moved from its original position without its geographical position and stratigraphic location being recorded the **damage is irreversible**.

Fossils are usually scarce and sporadic in their occurrence and the chances of negatively impacting on a fossil in any particular area are low. However, any fossil material is potentially of the greatest scientific and cultural importance. Thus, the potential always

exists during construction and excavation within potentially fossiliferous rocks for the permanent and irreversible loss of extremely significant or irreplaceable fossil material. This said, many fossils are incomplete in their state of preservation or are examples of relatively common taxa. As such, just because a fossil is present it is not necessarily of great scientific value. Accordingly, not all fossils are necessary significant culturally of scientifically significant and the potential degree of irreversible loss will vary from case to case. The judgement on the significance of the fossil must be made by an experienced palaeontologist.

11 ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

The information provided within this report was derived from a desktop study of available maps and scientific literature; no direct observation was made of the area as result of a site visit.

12 ENVIRONMENTAL IMPACT STATEMENT

A desktop Palaeontological Impact Assessment Study has been conducted on the site of seven proposed sections of the N4 Highway (named EB1, EB3, WB1, WB3, WB4, WB5 and WB7) as part of a program of upgrading the highway between Waterval Boven and Nelspruit, Mpumalanga Province. Cumulatively the seven segments constitute a length of approximately 43 km and the area to be impacted in approximately 2.7 m wide. As such, the aerial extent of the affected area will be approximately 116,100 m^2. Any negative impacts to the palaeontological heritage of the region will be limited to the footprint area of the seven areas where the road will be widened and the extent of any impacts is accordingly characterised as being local.

The effects of the required construction operations to the geological strata underlying the project area will be restricted to the early Achaean rocks of the Onverwacht Group and the late Achaean to early Proterozoic rocks of the Malmani Subgroup and Pretoria Group both part of the Transvaal Supergroup. The rocks of the Onverwacht and Pretoria Groups are known to be unfossiliferous. The rocks of these two stratigraphic units underlie project segments EB1, EB3, WB1, WB4, and WB7. Thus, the probability and significance of any negative impact upon the palaeontological heritage of the strata underlying these five project segments is assessed as being nil.

Rocks of the Malmani Subgroup underlie project segments EB3 and WB5. The carbonates that comprise the Malmani Subgroup are known to richly fossiliferous due to the presence of stromatolites. Despite the high probability of the project impacting upon the stromatolite assemblages they are not diverse and tend to be similar throughout the units in which they occur. Any destruction of a small area these fossils would not unduly diminish the palaeontological heritage of the unit. It is also pertinent that the project

The social benefits of the project have been classified as beneficial, herein, and the project as positive. The value of the project to the community of South Africa outweighs any minor impacts the project may cause to the palaeontological heritage underlying the various project segments.

This desktop study has not identified any palaeontological reason to prejudice the progression of upgrading of the N4 Highway in the areas named EB1, EB3, WB1, WB3, WB4, WB5 and WB7. No damage mitigation protocols need to be implemented in order to minimise the potential negative impact of the project.

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