Heritage impact assessment of the proposed additional Perseus-Gamma 765kV Transmission Line

Prepared for

Mokgope (Pty) Ltd

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Draft 2

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Executive summary

ACO Associates was appointed by Mokgope Consulting (Pty) Ltd of behalf of Eskom to undertake a heritage assesment for the construction of a second 765 kV transmission power line from the Dealesville Substation near Dealesville (Free State) to the site of Eskom's Gamma Substation the east of Victoria West in the Northern Cape. Three alternative routes (Alternatives 1 -3) and deviations a-c on Alternative 2 have been evaluated and ranked as part of this assessment. The proposed routes cross the central Karoo spanning parts of the Northern Cape and Free State Provinces.

The study area, which traverses the Great Karoo in the Northern and Eastern Cape Provinces, is rich in a wide variety of heritage sites. Since this vast landscape is generally only moderately transformed, it contains a wealth of well-preserved archaeological sites; one of the deepest palaeontological sequences in the world, and in later years was the last refuge of the Southern African San before their ancient lifestyle became extinct after settlement of the land by Dutch colonists. The study area also contains the sites of some of the most significant battles of the Boer War.

Assessment of the alternatives

The findings of the study are that in general heritage terms the preferred Alternative 1 is found to be the most desirable. The main reasons for this is that it avoids the most significant of the Boer War battle sites and that it largely follows the route of an existing suite of power lines as far as the Hydra HV yard at De Aar. It is shorter and passes through Karoo landscapes that are already visually transformed by existing transmission lines. Being the shortest and most direct of the routes, the amount of landscape that it will impact is smaller. It also avoids a numbers of potentially paleontological rich geological formations. Moderate alteration of the route will be needed to take into account the presence of the town of Luckhoff in the center corridor.

Alternative 3 would have been an ideal route in terms of minimizing impacts to built-environment but the presence of a major heritage site and a National Park as well as palaeontology-rich geological formations. On the proposed route renders it fatally flawed in its current form.

Alternative 2 is an acceptable alternative should Alternative 1 be not available on other environmental grounds. It crosses a sensitive landscape of conflict between the sites of the Battle of Poplar Grove and Paardeberg which could result in a medium degree of negative impact on heritage grounds.

Recommendations

The use of alternative 1 is generally supported in this study. Both Alternatives 1 and 2 (and deviations of 2) could form the basis of the EIA phase of this work.

Subject to the recommendations of the heritage authorities in the Free State and Northern Cape Province, or SAHRA by agency, it is not considered necessary to return to site for the assessment phase of the project unless additional concerns arise through the public process that will need a site inspection to resolve, or the proposed referred route undergoes substantive change.

A much more critical component of controlling impacts to all aspects of heritage is the fact that a **walk-down of the final alternative** must take place as only at this stage will it be possible on a micro-scale control the impacts that service roads and tower footings will have on all physical aspects of heritage. The walk-down must be considered compulsory.

The walk-down phase should include:

- At site inspection by a palaeontologist once the technical parameters of the project are established.
- The recording of the positions and contents of archaeological sites and rock engravings by an archaeologist.
- The recording of ruins, farm buildings and historic features within or adjacent to the proposed servitude.
- The identification of graves within or close to the proposed servitude.
- The presentation of such findings to the proponent for their consideration in terms of placement of infrastructure.
- The lodging of the findings with the regional heritage bodies.

Declarations

Tim Hart (MA) is an archaeologist with 25 years of working experience in heritage throughout southern Africa. He is accredited with Principal Investigator status with the Association of Professional Archaeologists of Southern Africa. He is a member of compliance committees of both SAHRA and Heritage Western Cape.

I, Tim Hart declare that I am an independent specialist consultant who is in no way connected with the proponent, other than delivery of consulting services.

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed railway project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

Dr John E. Almond
Palaeontologist, *Natura Viva* cc

GLOSSARY

Archaeology: Remains resulting from human activity, which are in a state of disuse and are in or on land and which are older than 100 years, including artefacts, human and hominid remains and artificial features and structures.

Early Stone Age: The archaeology of the Stone Age between 200 000 and 2500 000 years ago.

Fossil: Mineralised bones of animals, shellfish, plants and marine animals. A trace fossil is the track or footprint of a fossil animal that is preserved in stone or consolidated sediment.

Heritage: That which is inherited and forms part of the National Estate (Historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999.

Holocene: The most recent geological time period which commenced 10 000 years ago.

Late Stone Age: The archaeology of the last 20 000 years associated with fully modern people.

Middle Stone Age: The archaeology of the Stone Age between 20-300 000 years ago associated with early modern humans.

National Estate: The collective heritage assets of the Nation

Palaeontology: 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 or trace.

Pleistocene: A geological time period (of 3 million – 20 000 years ago).

SAHRA: South African Heritage Resources Agency – the compliance authority which protects national heritage.

Structure (historic:) Any building, works, device or other facility made by people and which is fixed to land, and includes any fixtures, fittings and equipment associated therewith. Protected structures are those which are over 60 years old.

Trekboer. A farmer who moves stock from locality to locality on a seasonal cycle.

Wreck (protected): A ship or an aeroplane or any part thereof that lies on land or in the sea within South Africa is protected if it is more than 60 years old.

Acronyms

DEA	Department of Environmental Affairs
ESA	Early Stone Age
GPS	Global Positioning System
HIA	Heritage Impact Assessment
HWC	Heritage Western Cape
LSA	Late Stone Age
MSA	Middle Stone Age
NHRA	National Heritage Resources Act
SAHRA	South African Heritage Resources Agency
PHS	Provincial Heritage site

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1. Introduction

The ACO Asociates CC was appointed by Mokgope Consulting on behalf of the proponent Eskom Distribution Ltd to conduct a heritage impact assessment (scoping level) for the construction of an additional 765 kV transmission line between Perseus substation in the western Free State and Gamma substation to the east of Victoria West in the Northern Cape Province, a direct distance of some 420 km. (see figure 1). The study area crosses both the Free State and the Northern Cape Provinces. The study area involves the following municipalities namely: Tokologo Local Municipality; Letsemeng Local Municipality; Sol Plaatje Local Municipality; Ubuntu Local Municipality; Renosterberg Local Municipality; Siyancuma Local Municipality; Thembelihle Local Municipality; Emthanjeni Local Municipality; Kareeberg Local Municipality; Beaufort West Local Municipality

This proposal has triggered a full EIA process, this report being the heritage component of this study at the scoping level, or in heritage terms, Stage 1 of a full heritage impact assessment. There are three alternatives (Figure 2) for the line route (including 3 deviations) which are weighed against each other in terms of their likelihood to create negative or positive impacts.

1.1 The need for the project

South Africa is currently experiencing an energy crisis with the national electricity provider (Eskom Holdings Limited) being unable to produce enough power to serve the nation's peak demand or projected needs to satisfy a projected 6% growth rate. Eskom is investigating a suite of generation options including conventional and nuclear generation as well as renewable energy that to alleviate the situation. The security of the electricity supply is also therefore paramount with a pressing need to transport power to the southern part of the country where generation capacity is under considerable pressure. The Perseus-Gamma project is part of a broader strengthening of the distribution capacity to the south in that a further 765kV transmission line is planned to evacuate current from Gamma Substation to the Omega Substation in the Western Cape. This is currently the subject of a separate EIA process.

1.2 The proposal

Eskom propose to construct a 765kV line of roughly 405 kilometers from Perseus substation (Free State) to Gamma substation (Northern Cape). The current status of transmission networks is not sufficient to supply the electricity requirements of customers in the area. The existing transmission lines are heavily loaded and are envisaged to reach their full capacity in the near future. Additional capacity is therefore required in this area, which will serve to reinforce the local transmission's reliability to ensure a back-up supply to the area; maintain a quality of electricity supply and meet the increasing electricity demands in the regions. As a result, Eskom Holdings SOC Limited have applied to the Department of Environmental Affairs (DEA) to construct an approximately 405 kilometers long, second new 765kV transmission power line between the existing Perseus Substation near Dealesville in Free State Province and Gamma Substation near Victoria West in Northern Cape Province (Mokgope Consulting 2013). Three routes have been proposed for the project – a preferred alternative 1, and further alternatives 2 and 3. Alternative 2 has 3 possible deviations on it (a-c) which may be required to lower impacts to enclaves of cultivated land. Each alternative route lies along the center of a 2km wide corridor which represents the maneuvering space needed for the line designer to make adjustments for topography and impact avoidance. Also making up the proposal will be construction camps, a service road along the chosen servitude and the required expansion of the substations (detailed layouts not yet provided).

The 765 kV transmission lines are the biggest class of transmission lines to be built in RSA. It is envisaged that the towers that will be used to support the high voltage lines will be of the guyed "V" form for the main part, however at any point that a direction adjustment is needed on the line, it will be necessary to construct a self-supporting strain tower to bear the additional stresses. The guyed "V" towers have a very small impact on the ground surface in that they only need a single small foundation base each. Although of a relatively transparent steel lattice construction, they are however tall – at least a third higher than the self-supporting towers that carry the 400 kV lines that are common features of the South African landscape. Their visual impact has the potential to be quite significant under certain conditions. The strain towers that are required when a route changes direction are massive structures which can evoke both physical and visual impacts, hence there is a clear advantage in keeping transmission lines as direct as possible. From an engineering perspective short direct routes makes for more efficient conducting of current, and are less expensive to build.

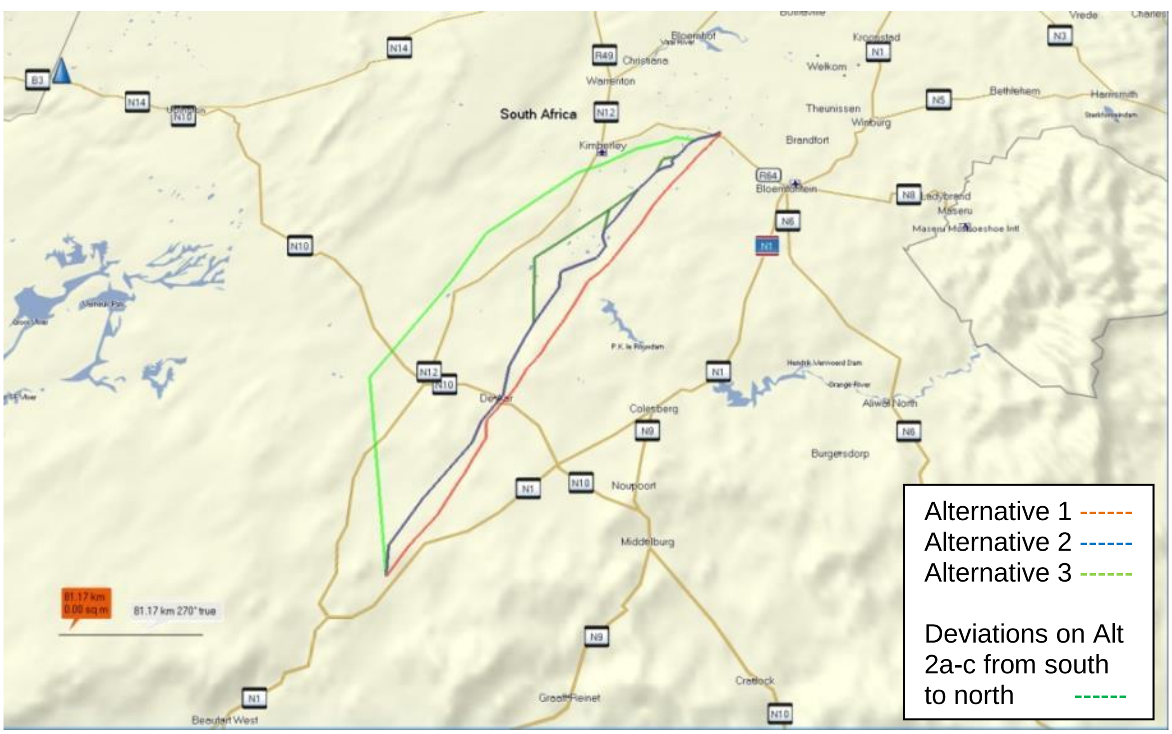

Figure 1 The three proposed alternatives.

The associated infrastructure which will accompany the installation of the 765kV transmission line will include the following activities:

- Construction of towers (either self-supporting strain towers or guyed “V” form) 47 m high.
- A service road (normally a simple un-engineered track which will need to be 8 m wide)
- The implementation of a servitude of 100 m wide which has to be kept clear of high vegetation and structures.
- The construction of camps, access roads and lay-down areas.
- A 2 km wide corridor for each line alternative is assessed impacts.

2. Methodology

This study has been commissioned as the heritage component of an EIA. It assesses the identified range of impacts in terms of accumulated knowledge of the area. The source of information that is used for this process is based on a literature review of publications and reports relating to historical, archaeological and palaeontological work in the region. The study has also been informed to some extent by a previous HIA and sites inspection (Van Jaarsveld 2006, Fourie 2009) and of the first 765kV line between Perseus Substation and the Hydra Substation at De Aar (this is approximately the northern half of the preferred alternative 1). Extensive use has been made of the SAHRIS heritage database. The study area has been subjected to very few comprehensive archaeological assessments in the past, however the extensive body of literature produced by Prof C.G. Sampson and other members of his project team (which includes the author of this report) has direct relevance. Sampson (previously of Southern Methodist University, Dallas Texas (SMU)) commenced working in central Karoo in the 1960's and continues to do so to this day (pers. comm.). His survey of the Zeekoei River catchment area which lies just to the east of the study area, is considered to be one of the largest and most comprehensive archaeological surveys in the world. The completeness of this survey and its direct applicability to the study area allows for its use as a predictive tool in determining the significance of impacts on archaeological heritage in the study area (the geology, climate, fauna and flora are similar).

The palaeontology sections of this report are contributed by Dr John Almond of Natura Viva cc. This detailed study is based on a desktop analysis of the 1:250 000 geological map series. The work is based on known palaeontology of the study area. It is necessary to consider that

A key component of this work has been a site visit to the study area during which time 4000 km of secondary roads were driven in order to traverse all the alternative transmission line routes as often as possible. Furthermore, almost all the small towns in the study area were visited. Shape files provided by the proponent where converted to GPX format and uploaded to two Garmin *GPSmap 62s* units (among the most accurate hand-held GPS units) for use in the field. Whatever roads were accessible were driven in an-off road vehicle. During the trip known historic sites were visited and assessed; the heritage of towns in the study area was appraised. As yet negotiation for servitude land has not yet commenced as only a minority of landowners are aware of the project. Given these circumstances it was just not feasible to foot-survey this vast landscape for archaeological sites. Close attention has been paid to landform which in the Karoo does work as a predictive indicator for the presence of archaeological material. The study area incorporates a landscape of conflict with respect to the second South African War. There are extensive published histories about this period available; however none of the battlefields have been comprehensively archaeologically mapped.

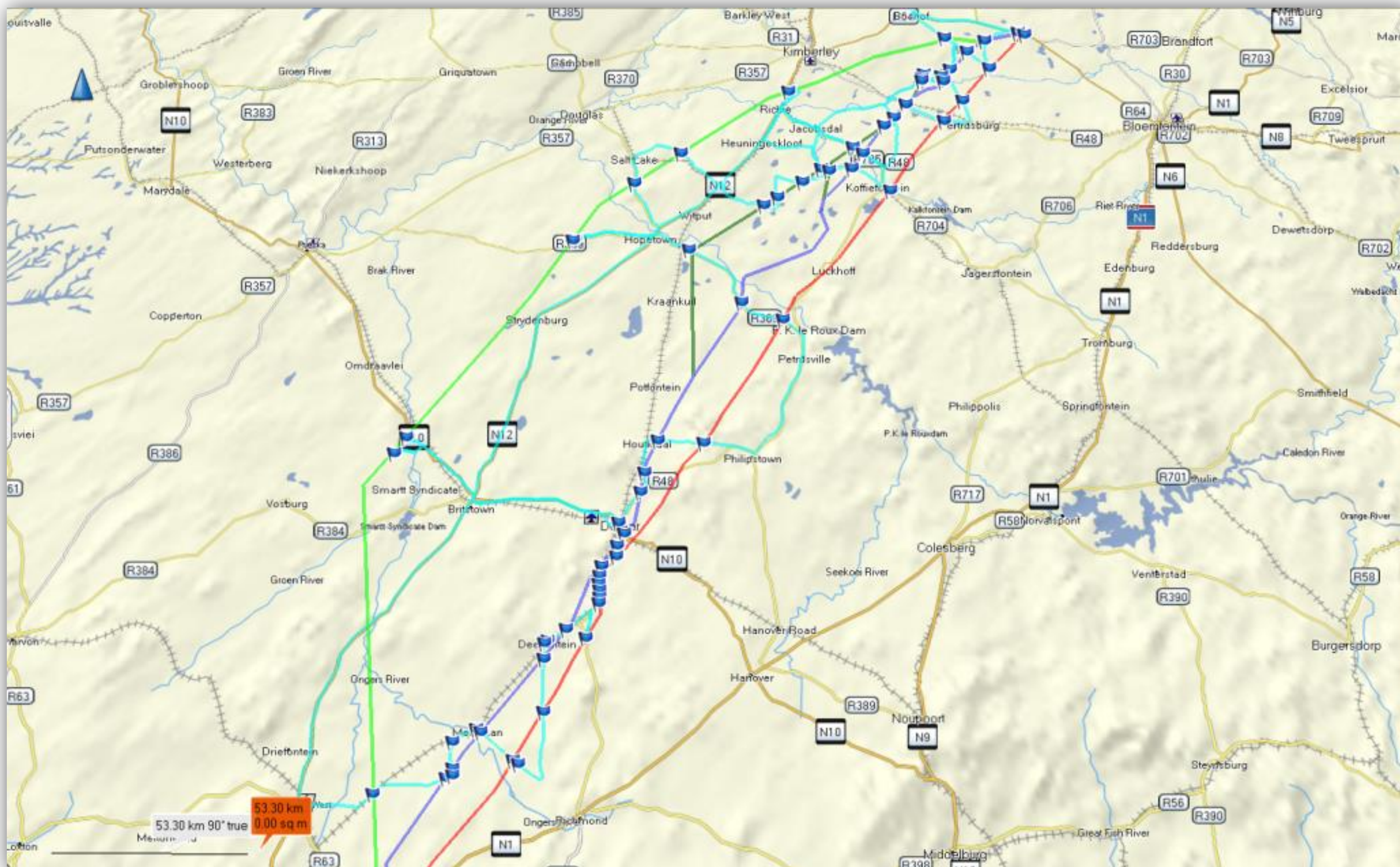

Figure 2 Track log of routes travelled during the site inspection are indicated by a light blue line. Flags represent points at which the proposed power line routes were intersected.

2.1 Assessing heritage in the context of transmission lines

The assessment of transmission lines in terms of heritage is methodologically unlike other impact assessments that involve assessing physical landscape disturbance. Since typically transmission lines evoke the greatest change to a landscape above the ground surface, the emphasis is to assess impacts to heritage that is visually sensitive. By this we mean places or structures that are publicly celebrated as heritage or have the potential to be publicly celebrated as such. Historic farms, iconic landscapes and views, places of conflict are therefore considered important.

The following guiding principles are used;

In open landscape during daylight hours transmission lines (765 or 400 kV) on self-supporting towers are visible (but not necessarily intrusive) from a distance of up to 5 km. Figure 3 depicts transmission lines of both the self – supporting type and compact cross-rope type, while figure 4 shows newly constructed 765 kV towers close to De Aar..

CNdV and DEAP (2006) in their development of guidelines for the establishment of wind energy facilities in the Western Cape have suggested that a buffer zone of 1 km be established around significant heritage sites to minimize the change to “sense of place”. The point at which a transmission line may be perceived as intrusive or offensive, is a subjective judgment, however in our experience lines within 1 km of a reference point are noticeable but not necessarily intrusive. After 450-500 m the lines become increasingly intrusive and become visually dominating to the point of serious impact after 100 m (depending on topography).

The presence of pre-existing transmission lines in an area serves as a mitigatory factor (rather than a cumulative negative impact) in terms of establishing new transmission lines in the same area. In other words electrical infrastructure clutter is best confined to existing areas or corridors of vertical visual disturbance, rather than introducing new vertical visual disturbance to undisturbed landscape.

While archaeological and palaeontological sites share the potential to be publically celebrated heritage places, they are less visible than structures in a landscape and are therefore less celebrated as tangible heritage with visual sensitivity. Since the impact on the land surface (figure 3) caused by transmission lines is very small (less than 1 sqm per tower in the case of guyed “V” towers, and roughly 4 sqm of footings for a conventional self-supporting tower) and reasonably adjustable at the level of final route selection, the emphasis at the impact assessment phase must focus on heritage that is visually sensitive (declared monuments, tourism heritage. scenic landscape and drives).

Figure 3 An example to two kinds of 400 kV lines and towers. Left: conventional self-supporting towers. Right: guyed "V" towers or compact cross-rope towers. Guyed "V" towers have a very small ground surface footprint and are more easily absorbed against a skyline.

Figure 4 A set of new 765 kV transmission lines north of De Aar (Perseus-Hydra). They are substantively taller than the 400 kV lines in the background.

The direct impact on archaeological and palaeontological sites cannot be addressed at the EIA phase in specific terms as the servitude for the transmission lines first has to be selected from three alternatives each more than 400 km long, then the final route has to be situated optimally within a typically 2 km wide corridor. Direct assessment of these impacts can only be determined at the line design and walk-down phase of the proposed activity once a afinal corridor for the transmission line has been determined. Mitigation can normally be achieved by micro-adjustment of tower positions and avoidance of sensitive areas.

2.2 Restrictions and assumptions

The study area is thinly inhabited and remote. Opportunities to travel parallel to the proposed routes were few however opportunities to transect the routes were rather more plentiful. Issues relating to crime and stock theft have resulted in many farmers locking gates onto their property and even at times tertiary and secondary provincial roads. Lands are in-accessible with prior arranged visits. Many farms were evidently non-residential farms. At the time of doing the field study, the EIA public consultation team had not managed trace all land owners and I&AP's while attendance at the first round of public meetings was limited.

Since each of the three alternatives is situated within a two km wide study corridor, it is unfeasible to physically survey each route in detail. The positions of the towers and servitudes will be refined throughout the EIA process until a single corridor is selected. It is only at the actual design stage the final route will be known. At this point a final route walk-down will take place to make sure that physical heritage sites are identified and avoided during construction.

This study has identified sites that are sensitive to the quality of the environment around them, their setting, ambiance and historic significance and the ways that they are publically celebrated. It is these qualities that make certain heritage sites highly sensitive to visual intrusion. It is argued that archaeological and palaeontological sites in the Karoo are generally of the size that would allow mitigation through simply avoiding them in the final route planning (provided that a comprehensive specialist walk down is carried out).

3. Legislative context

The basis for all heritage impact assessment is the National Heritage Resources Act 25 (NHRA) of 1999, which in turn prescribes the manner in which heritage is assessed and managed.

Loosely defined, heritage is that which is inherited. The National Heritage Resources Act 25 of 1999 has defined certain kinds of heritage as being worthy of protection, by either specific or general protection mechanisms. In South Africa the law is directed towards the protection of human made heritage, although places and objects of scientific importance are covered. The National Heritage Resources Act also protects intangible heritage such as traditional activities, oral histories and places where significant events happened. Generally protected heritage which must be considered in any heritage assessment includes:

- Cultural landscapes
- Buildings and structures (greater than 60 years of age)
- Archaeological sites (greater than 100 years of age)
- Palaeontological sites and specimens
- Shipwrecks and aircraft wrecks
- Graves and grave yards
- Living heritage

Section 38 of the NHRA requires that Heritage Impact Assessments (HIA's) are required for certain kinds of development such as rezoning of land greater than 10 000 sq m in extent or exceeding 3 or more sub-divisions, or for any activity that will alter the character or landscape of a site greater than 5000 sq m. "Standalone HIA's" are not required where an EIA is carried out, however section 38.8 of NHRA compels the EIA process to include a heritage assessment that fulfills Section 38 provisions.

4. Background to heritage of the Karoo

4.1 Physical characteristics

Much of the Eastern and Western Cape Provinces as well as the southern part of the Free State is known as the Karoo. Most people who pass through the Karoo today do not realise that what seems to be a vast expanse of arid landscape was once home to many groups of pre-colonial people and vast herds of game. A deep understanding of this seemingly harsh environment enabled pre-historic humans to exploit the many hidden resources that this region had to offer.

The geology and paleontology of the region has been a subject of research since the early 20th century. The flat plains of the Nama Karoo are underlain by a series of shale and mudstone strata which represent some 400 million years of depositional events (Visser 1986). The basal rocks of the Karoo sequence are known as the Dwyka formation which was deposited by a wet based glacier during the Permo-Carboniferous glaciation. This was followed by the deposition of the Ecca formation which is made up of sediments deposited in a shallow lake that covered what is now the interior of Southern Africa. Ecca shales form many of the large flat plains of the Northern Karoo (Truswell 1977; Tankard et al 1982; Visser 1986). The best known depositional event of the Karoo sequence is the laying down of the Beaufort shales about 230 million years ago. These shales are rich in a stratified sequence of fish, reptilian and amphibian remains that lie fossilized in Permian and Triassic period swamp deposits (Truswell 1977; Visser 1986; Oelofsen and Loock 1987). At the end of the Triassic period a series of geological upheavals took place with the fragmentation of the Gondwanaland continent. These were largely responsible for giving the Karoo it's characteristic landscape. Triassic period volcanic activity took place over an extended period of time beginning at 187 million years ago (Truswell 1977). During this time the horizontal volcanics of the Drakensberg were laid down and the shales of the Karoo were penetrated by dolerite intrusions and extrusions in the form of vertical dykes and horizontal sills following the bedding planes of the shales. These geological structures give rise to a very characteristic topography with general occurrences of mesas, hillocks and sharp ridges (Visser 1986).In the study area extruding dolerite dykes and hillocks exposed through differential erosion are dominant features of the landscape giving rise to the vast flat plains of mudstones dolerite outcrops and hills that are so characteristic of this area (figure 5). These igneous events resulted in the formation of Hornfels a fine grained black rock with a conchoidal fracture. Hornfels is formed when a dolerite intrusion takes place and bakes the surrounding mudstone to a metamorphic form (Visser 1986). Prehistoric peoples enthusiastically exploited Horfels exposures for raw material for making artefacts – a staple resource in the Karoo for hundreds of thousands of years.

Figure 5 Typical Karoo landscape within the study area. Mudstone plains punctuated by dolerite outcrops and mesas (flat topped mountains).

The Karoo geology gives rise to numerous aquifers and fountains which has effectively made this land viable farming country. By the same token the land was habitable for prehistoric people and animals. Ground water in the Great Karoo is usually associated with dolerite dykes and to a lesser extent, sills. Cracks in the Karoo shales along dolerite intrusions (figure 5) serve as aquifers which get topped up by seasonal rains. Intensive borehole pumping and donga formation has lowered the water table in historic times. Many natural fountains no longer flow because of this.

The Karoo is arid or semi-arid with characteristic vegetation that consists of dwarf shrublands and open grasslands (Cowling and Roux 1987). Much of the Karoo has been of high economic value to South Africa. During the last 2 centuries the region has been subjected to intensive sheep at the expense of indigenous fauna and flora. Hoffman and Cowling (1987) have divided the Karoo into 2 regions on the basis of rainfall. The Succulent Karoo in the west is subject to winter rainfall, while the Nama Karoo, which covers the central interior of the country, experiences a late summer/autumn rainfall. The Karoo climate is one of extremes of temperature with heavily fluctuating yearly rainfall. Venter, Mocke and de Jager (1986) noted that South Africa's average annual rainfall decreases from east to west. The south eastern part of the country receives some 600 mm of rain per year whereas the north west gets little more than 100 mm per year. The eastern-central part of the Great Karoo (study area) has a mostly summer rainfall of about 200-300 mm per year. Winter rain can occur but this tends to be less than 10% of the total average rainfall. In the study area most of the yearly rain tends to fall in the months of February and March but the quantity can fluctuate greatly from year to year. Periods of extended drought that seriously affect grazing are a feature of this rainfall pattern. Temperatures in the Great Karoo are extreme with cold winters and bitter winds that blow from the south. For 60 days a year minimum temperatures are below freezing and frost may occur for some

160 days a year. Snowfalls on higher ground are quite common. The summers are warm with an average temperature in the summer month of January in excess of 30 degrees.

Many species of indigenous fauna in the Karoo have become depleted as the area is used for the rearing of sheep. The mammalian fauna of the area is, in comparison with that mentioned in historic texts, depleted. Large herds of *Eguus quagga* (quagga) , *Connochaetes sp*. (gnu) and *Alcelaphus buselaphus* (hartebeest) no longer exist. The huge herds of trek springbok (Green 1955) have been fragmented with the advent of barbed wire fences. Acocks (1953) is of the opinion that the great diversity and mobility of game in the Karoo would have resulted in diverse grazing habits and so maintained the veld in climax state.

4.2 Pre-history and history of the study area

The Karoo has been occupied by people for hundreds of thousands of years. This information is borne out by solid scientific studies by researchers both local and international who have worked in the central interior of the country since the early years of the 20th century. Virtually the entire full range of material evidence of human evolution is manifested in the archaeological sites of this area. To limit the scope of this study and maintain its relevancy, an impression of what the Karoo was like prior to European settlement is presented in the following historic accounts.

Sir John Barrow journeyed through the Sneeuberg Mountains in 1789 and followed the course of the Seekoei River to the Orange. By the time that Barrow reached the Graaff Reinet district there were no independent "Hottentots" in the area as they were all employed by the Dutch. There was a bitter state of conflict between the colonists and the San of the Karoo. In 1789 it was impossible for a farmer to venture out of his home unarmed less he be attacked by raiding San. In turn the Boers were actively hunting the San by means of *Kommandos* (Barrow 1801, Moodie 1838). Sheep farming, despite the circumstances, was very well entrenched and some farmers were already managing between 3-4000 animals (Barrow 1801).

Barrow (1801:259) found the plains of the Great Karoo covered with countless herds of wildebeest, eland, springbok, hartebeest and quagga. Carnivores also abounded.

In 1812 William Burchell crossed into the Great Karoo on his journey to the border of the colony from the Kuruman district. He was the last person to encounter the last free groups of indigenous people. He travelled over many miles of Karoo and wrote one of the most detailed accounts available. While travelling somewhere between where De Aar and Hanover are today in the summer of 1812 Burchell crossed several huge plains where no true grasses were seen except for "Cyperus usitatus" intermingled in various places with low bushes such "*as are generally met within the lands partaking of the nature of the Karoo* (Burchell 1822; Vii :71)." As the party penetrated deeper into the colony towards the Agtersneeuberge the amount of grasses increased and many new species of bush were seen. Somewhere between present day Hanover and Richmond Burchell found himself on a huge plain where large herds of springbok and wildebeest were grazing. The plain was covered with low bushes not more than nine inches high and mat rushes grew in abundance along the banks of the Seekoei River (Burchell 1822, vii: 79). Once in the colony, a much frequented road lay along the Seekoei River (a source of permanent water which became a travellers corridor) which serviced the needs of the transhumant *trekboers*.

Burchell makes mention of people he met while on his journey from the Orange River to the colony. The Khoekhoen group, the "Koras" (sometimes known as the Koranas) were at that time, encamped along the banks of the Orange River (Burchell 1922; Vii:6-7) where they were keeping cattle and sheep. 'Bushmen' were only seen in the central Karoo. Burchell made contact with these people with the help of Riizo, a half bushman whose kraal lay close to the confluence of the Orange and Brak rivers (Vii:13). Burchell, with Riizo acting as an interpreter, was joined by *Kaabi,* a bushman, who eventually led Burchell to a kraal of some people that he knew. Burchell took this as an act of friendship as the 'Bushmen' concealed the position of their kraals from the colonists. The kraal was situated on the summit of a ridge and consisted of "*half a dozen wretched worn huts*" (Burchell 1822; Vii:27). This kraal, according to Burchell was a melancholy picture of poverty which inspired him to depart with liberal quantities of tobacco and meat.

Two days later the party reached Kaabi's kraal which lay some 70 km north of where Britstown is today. Here Burchell gained an opportunity to make a closer study of the 'Bushmen' (Burchell 1822 Vii:35). Once initial gifts of tobacco changed hands these 'Bushmen' gave Burchell the freedom to travel in their land after they had found out that he was not one of the Boers (who were in bitter conflict with the San) but of a different nation and language. Kaabi ' s kraal was noted to be quite large with some 20 huts arranged circularly and inhabited by some 120 people. The entrances faced inwards to the area where they kept their goats and cattle. There were some 5 or 6 oxen and 100 sheep and goats. People carried bags for the collection of *uintjies*. Burchell makes no reference to the use of stone walling in the construction of kraals. These appeared to be formed by and within the arrangement of huts.

Before entering the colony Burchell reached the kraal of another “bushman” called *Old Crow Head*. He had 98 goats and kids and 50 people under his leadership. These people spent much time telling of the injustices of the Boers. Once Burchell entered the colony no more kraals were seen so it was quite clear that by 1812 indigenous people were only to be found beyond the borders of the colony. The area south of Colesberg had been cleared and occupied by the colonists.

The demise of the indigenous peoples of the Karoo came with the advent of European farmers. In 1770 a terrorist war lasting some 40 years began. Reports came back to the Cape that the colonists were being raided by San who were making forays from places of refuge in the mountains onto farms (Van der Merwe 1935). By 1774 the situation became so serious that many of the trekboer farmers of the Eastern Karoo were abandoning their farms. Calls for assistance were made to the Cape, while on the war front intensified *kommando* activity began to take place. The *kommando* was an informal detachment of *freeburgers* and armed Hottentots who actively hunted out the marauding San with the blessing of the government. The notorious actions of the veld cornet Adriaan van Jaarsveld resulted in the slaying of scores of San with 120 people being killed in a single incident (Moodie 1838; viii: 43). Accounts in Moodie's Record (1838) indicate that the colonists were facing a united front of unprecedented San resistance in 1776. In 1777 legislation passed at the Cape opened the way for the formal annihilation of the San. By the time that Burchell had passed through the region in 1812, very few San were seen.

The formal granting of farms to wandering *trekboers* saw the vast landscapes of the Karoo partitioned in 5000 morgen allocations (Sampson, Sampson and Neville 1994). These were situated close to fountains and in the best grazing land. Indigenous people were increasingly marginalised onto the few remaining patches of as yet unclaimed land. Deprived of the ability to hunt (by the early 1800's the game herds had been shot out) and with traditional social structures disrupted they had little choice but to seek work on farms or settle at mission stations established for their emancipation (Sampson, Sampson and Neville 1994). A life-style thousands of years old ended, however the archaeological heritage that has survived is prolific and manifested in the form of thousands of archaeological sites.

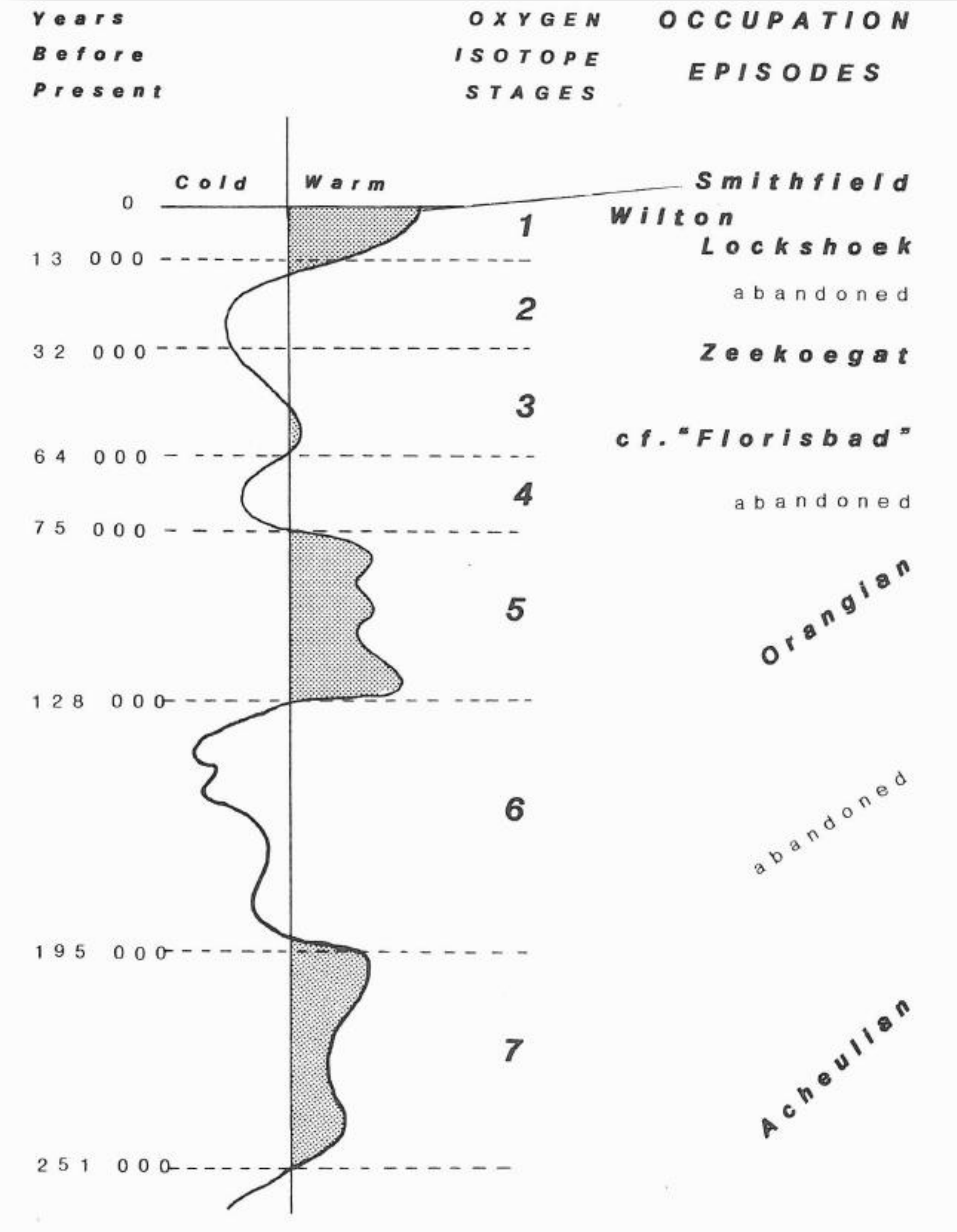

Figure 6 The sequence of occupation of the Karoo by humans as proposed by Sampson 1985 (after Sampson 1985)

5. Heritage indicators within the receiving environments

This study has focused on the notion of the Great Karoo as a series of layered cultural landscapes which form the main heritage indicators assessed in this study.

5.1 The Karoo as a cultural landscape

The central Karoo is almost entirely given over to sheep and game farming. Overgrazing since the advent of formal farming in the 19th century has caused some changes to the landscape in terms of the composition of vegetation. Acocks (1953) has claimed that pure grass veld gave way to Karoo scrub only after livestock was introduced, however it is apparent that rainfall fluctuation does cause seasonal and even cyclical oscillations with respect to prevalence of Karoo scrub versus grasslands.

Overall, the damage caused by modern surface development has been slight. To all intents and purposes the Karoo has the qualities of an intact natural area, which on a world scale is a rare resource. In areas transformation has taken place – sheet erosion and donga formation has had an impact, the scattered towns and farms represent a comparatively ephemeral imposition of the landscape of colonial settlement. The flood zones of major water courses such as the Orange, Riet and Modder River which traverse the study area, have been transformed by intensive irrigation agriculture. Aside from these comparatively moderate interventions the Karoo remains dominated by its wilderness qualities. Indications are that this situation is changing: There are numerous proposals for the establishments of renewable energy facilities which will have a significant impact in terms of industrialisation of the landscape, the a possibility of *fracking* take place as well as the construction of the Square Kilometer Array will accumulatively add a significant 21st century development layer that will impact the status-quo significantly and probably irreversibly.

The heritage of the Karoo is essentially a series of layers of events (or landscapes) that has become superimposed on the land surface. The earliest of these is the Karoo palaeontology – an ancient landscape that was deposited as a result of a vast inland sea. The shores and swamps of this landscape abounded with ancient species of fish, plants, invertebrates and early mammal-like reptiles. After the breakup of Gondwanaland the Karoo took on the geology that has resulted in its particular character. Millions of years later it was home to successions of early human occupation. Stone Age occupations of the Early, Middle and Later Stone age left half a million years of human made debris on the land surface. Superimposed on the Karoo landscape one more is the history of European colonisation and the wars that went with it.

5.2 The Palaeontological Landscape

The Great Karoo is one of the world's most important repositories of palaeontological information about the evolution on both marine and terrestrial plants and animals. In popular literature it is described thus:

*"The **Karoo Supergroup** is the largest stratigraphic unit in Southern Africa, covering almost two thirds of the present land surface, including central Cape Province, almost all of Orange Free State, western Natal, much of south-east Transvaal, Zambia, Zimbabwe and Malawi. The basins in which it was deposited formed during the formation and breakup of Pangea.*

Its strata, mostly shales and sandstones, record an almost continuous sequence of marine glacial to terrestrial deposition from the Late Carboniferous to the Early Jurassic, a period of about a hundred million years. These accumulated in a retroarc foreland basin called the "main Karoo" Basin. This basin was formed by the subduction and orogenesis along the boundary of Gondwana (the past African continent) and the Panthalassan Sea (paleo-Pacific).[3] Its sediments attain a maximum cumulative thickness of 12 km, with the overlying basaltic lavas (the Drakensberg Group) at least 1.4 km thick.[5]

Fossils include plants (both macro-fossils andpollen), rare insects and fish, common and diverse tetrapods (mostly therapsid reptiles,temnospondylamphibians, and in the upper strata dinosaurs), and ichnofossils. Their biostratigraphy has been used as the international standard for global correlation of Permian to Jurassic nonmarine strata". (2013 Wikipedia: http://en.wikipedia.org/wiki/Karoo_Supergroup)

The study area for the new Gamma-Perseus 765 kV transmission line between Victoria West and Dealesville is situated on the Interior Plateau of South Africa at elevations of between 1100 – 1400 m amsl. It lies within the Upper Karoo physiographic region according to the scheme used by Visser *et al.* (1989). In the more recent physiographic scheme of Partridge *et al.* (2010), with a strong emphasis on drainage patterns, most of the study area lies within their Upper Karoo geomorphic province that is largely underlain by flat-lying sediments of the Karoo Supergroup which here are extensively intruded by dolerite dykes and sills. The readily-eroded Karoo Supergroup sediments mainly generate gentle hillslopes and *vlaktes*, in many cases representing relict pediment surfaces, while the resistant dolerites are associated with flat-topped *tafelkoppies* (mesas) and rocky ridges. With predominantly semi-arid climates, most river systems are ephemeral and associated with wide, open valleys and braided floodplains (*ibid*.). The Gamma – Perseus transmission line study area also traverses two other geomorphic provinces, *viz*: the Lower Vaal and Orange Valleys province where it crosses the Orange River between the Vanderkloof Dam and Douglas, and the Southern Highveld portion of the Highveld Province in the region north of the Modder River. Close to the Orange River denudation of the Karoo sedimentary cover has exposed ancient Precambrian basement rocks while sets of older (Tertiary - Quaternary) alluvial terraces are well-preserved in the Kimberley region. The Southern Highveld region is largely underlain by Karoo Supergroup bedrocks generating a gently undulating landscape with shallow, open valleys, relict palaeodrainage systems marked by pans, and low levels of bedrock incision.

The geology of the Gamma-Perseus transmission line study area is covered on six adjoining 1: 250 000 geological maps published by the Council for Geoscience, Pretoria. These are geology sheets 3122 Victoria West (explanation by Le Roux & Keyser 1988), sheet 3022 Britstown (explanation by Prinsloo 1989), sheet 3014 Colesberg (explanation by Le Roux 1993), sheet 2922 Prieska (explanation not yet published), sheet 2914 Koffiefontein (explanation by Zawada 1992), and sheet 2824 Kimberley (explanation by Bosch 1993). The geology along the various 765 kV transmission line route options between Hutchinson and Dealesville is shown a series of 52 strip maps or "sections" abstracted from these 1: 250 000 geological maps (Appendices 1 to 4). These strip maps form the main basis for the present desktop assessment of potential palaeontological heritage impacts for the transmission line project. A more regional geological map at 1: 1 000 000 scale is also available (sheet explanation by Visser *et al.* 1989) but differs in several respects from the more detailed 1: 250 000 maps that form the preferred basis for the present desktop study (*e.g.* regarding the outcrop area of the Dwyka Group).

The Gamma-Perseus 765 kV transmission line study area traverses the northern margins of the Main Karoo Basin of South Africa along a roughly SW-NE trending band. In very broad terms, progressively older sediments of the Karoo Supergroup are intersected from SW to NE. Routes 1 and 2 are fairly closely aligned and are entirely underlain by Middle to Late Permian bedrocks of the Lower Beaufort

Group and upper Ecca Group, together with numerous dolerite intrusions (See stratigraphic column in Figs. 7 & 8). Route 3, which makes a longer excursion to the NW, closer to the edge of the Main Karoo Basin, crosses in addition the outcrop areas of older, Late Carboniferous to Early Permian, Karoo Supergroup bedrocks, namely the lower Ecca Group and Dwyka Group. Furthermore, small outcrop areas of pre-Karoo igneous and sedimentary basement rocks (Late Archaean Ventersdorp Supergroup) are intersected close to the Orange River as well as to the south of Kimberley.

In the following section of the report, the rock units encountered along each of the transmission line route options are briefly reviewed. All major rock units mapped along the transmission line corridors between Hutchinson and Dealesville are listed in Table 1, together with a brief summary of their geology, age, known fossil heritage and inferred palaeontological sensitivity (data largely based on Almond & Pether 2008). The location of these rock units within the stratigraphic column for South Africa is shown in Figs. 3 and 4. They include a wide range of sedimentary and igneous rocks ranging in age from Late Archaean (2.7 Ga = billion years old) to Recent. The igneous rocks (*e.g.* lavas, dolerite and kimberlite intrusions) are entirely unfossiliferous while a high proportion of the sedimentary rocks are of low palaeontological sensitivity. The main exceptions are various subunits of the Karoo Subgroup including interglacial to post-glacial sediments of the Dwyka and Lower Ecca Groups, shallow marine shelf sediments of the uppermost Ecca Group, continental sediments of the Lower Beaufort Group (Adelaide Subgroup) and possible Late Tertiary (Neogene) to Pleistocene alluvial gravels along the major drainage courses such as the Orange River. Based on the known fossil record of the geological units concerned potential impacts on palaeontological heritage of the various route options are then assessed and compared *plus* recommendations for further specialist palaeontological input made in the concluding sections of the study (section prepared by J Almond 2013).

Fossil biotas recorded from each of the main sedimentary rock units mapped along the Gamma – Perseus 765 kV transmission line route options are briefly reviewed below and summarized in Table 1, where an indication of the palaeontological sensitivity of each rock unit is also given (Based largely on Almond & Pether 2008 and references therein). The quality of fossil preservation may compromised in some areas due to intense near-surface chemical weathering. Furthermore, extensive dolerite intrusion (resulting in thermal metamorphism as well as secondary chemical alteration) and calcrete formation has compromised fossil heritage in many portions of the Karoo Supergroup outcrop area (*e.g.* Ecca Group) (*cf* Almond 2013c).

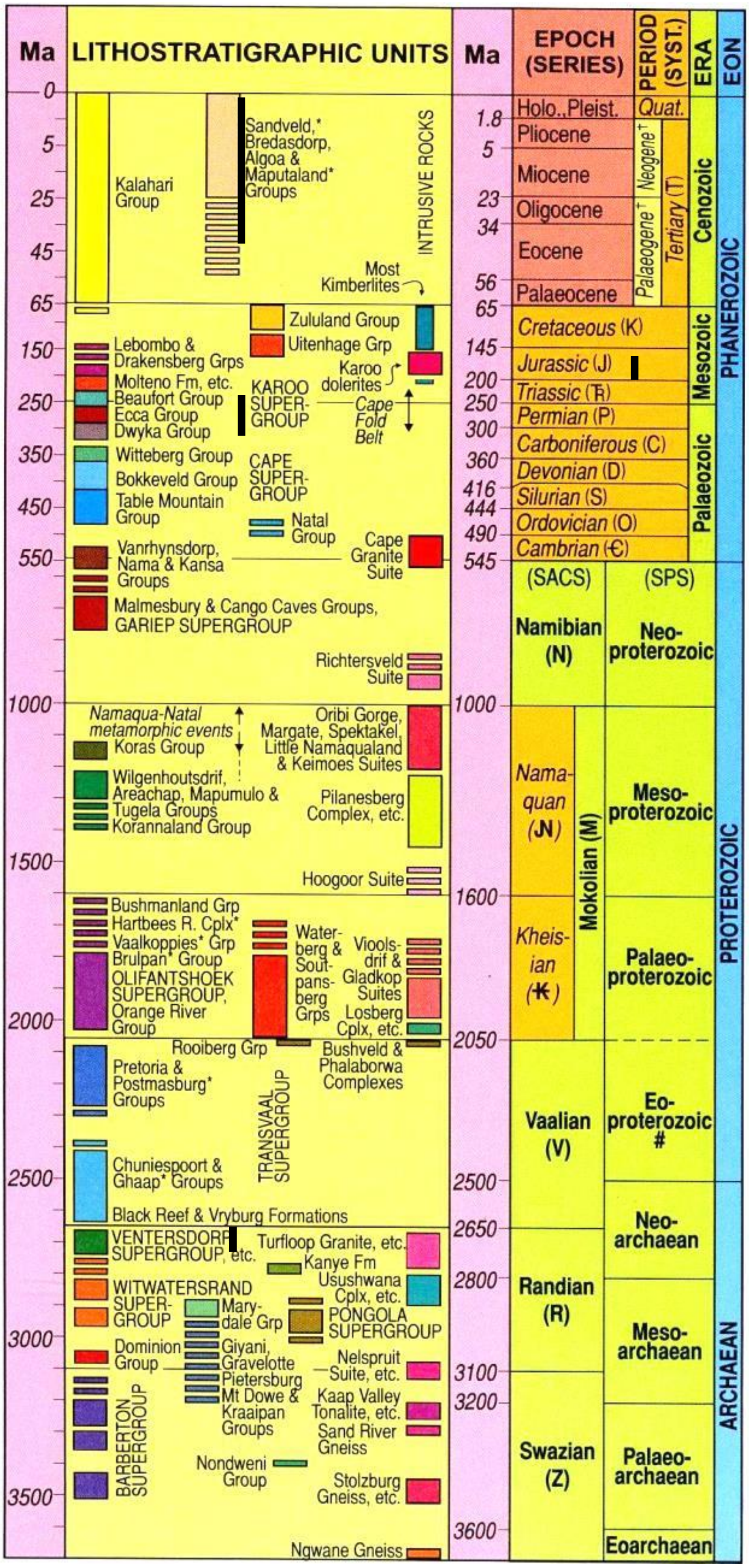

Figure 7. Stratigraphic column for southern Africa showing the main rock units represented within the Gamma – Perseus 765 kV transmission line study area, Northern Cape & Free State (thick vertical black lines) (Modified from Johnson *et al.* 2006).

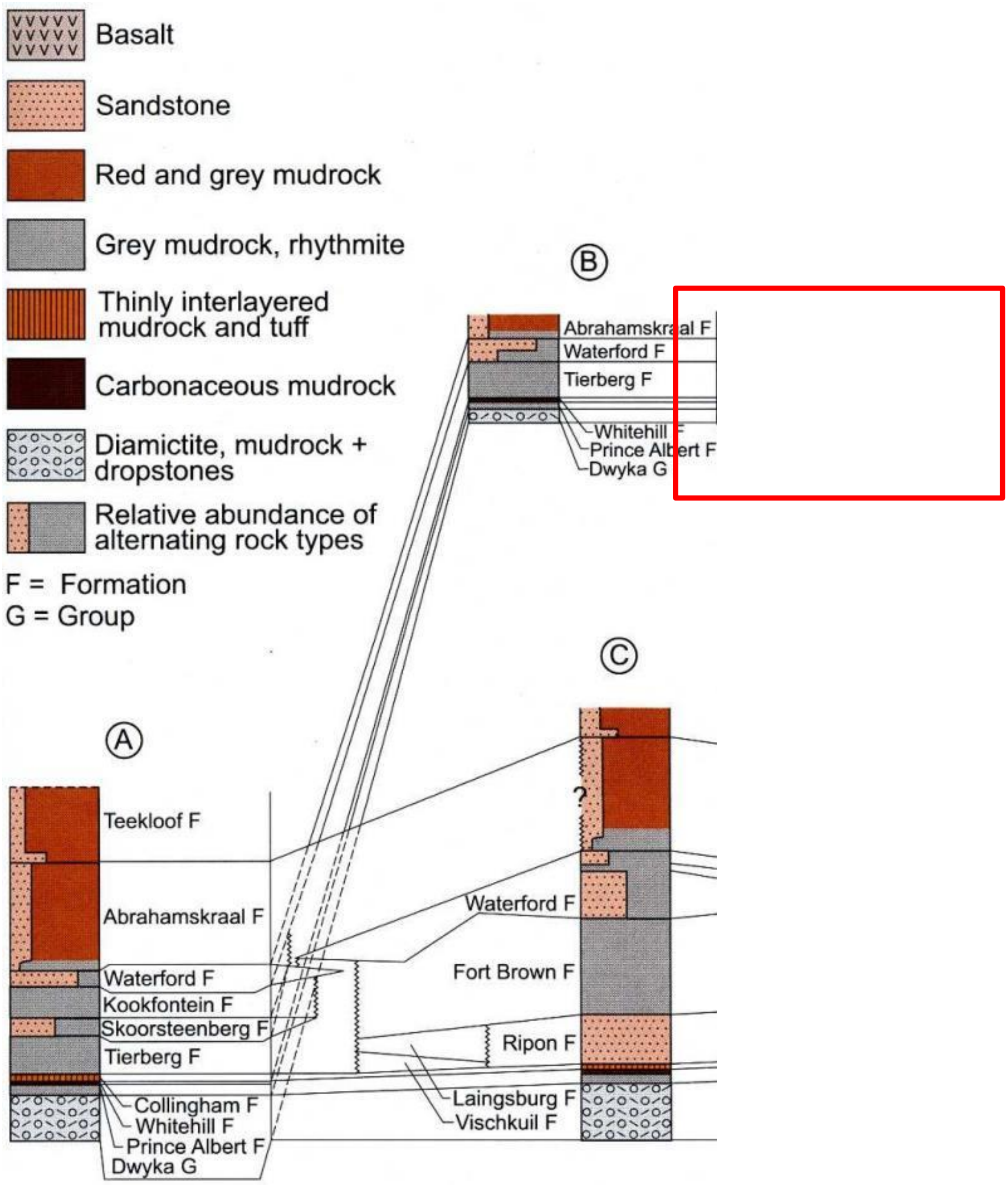

Figure 8 Stratigraphic column of the Karoo Supergroup (Dwyka, Ecca and Beaufort Groups) in the western half of the Main Karoo Basin with the formations represented in the Gamma – Perseus study area towards the northern basin margin emphasised in red (Modified from Johnson *et al*. 2006). *N.B.* The Teekloof Formation is also well-represented above the Abrahamskraal Formation in the study area, as shown in Fig. A.

5.2.1 Fossils within the Ventersdorp Supergroup

The Kameeldoorns Formation, to which the 'Tcuip succession of mixed lavas and sediments is now assigned (Van der Westhuizen *et al.* 2006, p. 194), contains carbonate sediments with stromatolitic bioherms near Taung (Christiana 1: 250 000 sheet area; Schutte 1994). Domical stromatolites are recorded from shallow water lacustrine calcarenites within the volcano-sedimentary succession of the Rietgat Formation at the top of the Platberg Group (Schopf 2006, Van der Westhuizen *et al.* 2006). The overlying predominantly siliciclastic Bothaville Formation contains conical stromatolites, probably also developed within lacustrine settings (Schopf 2006). Carbonate sediments are not reported in association with the Allanridge Formation lavas at the top of the Ventersdorp Supergroup, however.

5.2.2 Fossils within the Dwyka Group

The fossil record of the Permo-carboniferous Dwyka Group is generally poor, as expected for a glacial sedimentary succession (McLachlan & Anderson 1973, Anderson & McLachlan 1976, Visser 1989, Visser *et al*., 1990, MacRae 1999, Visser 2003, Almond 2008a, 2008b). Sparse, low diversity trace fossil biotas from the Elandsvlei Formation along the southern basin margin mainly consist of delicate arthropod trackways (probably crustacean) and fish swimming trails associated with recessive-weathering dropstone laminites (Savage 1970, 1971, Anderson 1974, 1975, 1976, 1981). Sporadic vascular plant remains (drifted wood and leaves of the *Glossopteris* Flora) are also recorded (Anderson & Anderson 1985, Bamford 2000, 2004), while palynomorphs (organic-walled microfossils) are likely to be present within finer-grained mudrock facies. Glacial diamictites (tillites or "boulder mudstones") are normally unfossiliferous but do occasionally contain fragmentary transported plant material as well as palynomorphs in the fine-grained matrix (Plumstead 1969). There are biogeographically interesting records of limestone glacial erratics from tillites along the southern margins of the Great Karoo that contain Cambrian eodiscid trilobites as well as diverse assemblages of archaeocyathid sponges. Such derived fossils provide important data for reconstructing the movement of Gondwana ice sheets (Cooper & Oosthuizen 1974, Stone & Thompson 2005).

Low diversity ichnoassemblages dominated by non-marine arthropod trackways are widely associated with cold water periglacial mudrocks, including dropstone laminites, within the Mbizane Formation in the Main Karoo Basin (Von Brunn & Visser, 1999, Savage 1970, 1971, Anderson 1974, 1975, 1976, 1981, Almond 2008a, 2009). They are assigned to the non-marine / lacustrine *Mermia* ichnofacies that has been extensively recorded from post-glacial epicontinental seas and large lakes of Permian age across southern Gondwana (Buatois & Mangano 1995, 2004). These Dwyka ichnoassemblages include the arthropod trackways *Maculichna*, *Umfolozia* and *Isopodichnus*, the possible crustacean resting trace *Gluckstadtella*, sinuous fish-fin traces (*Undichna*) as well as various unnamed horizontal burrows. The association of these interglacial or post-glacial ichnoassemblages with rhythmites (interpreted as varvites generated by seasonal ice melt), the absence of stenohaline marine invertebrate remains, and their low diversity suggest a restricted, fresh- or brackish water environment. Herbert and Compton (2007) also inferred a freshwater depositional environment for the Dwyka / Ecca contact beds in the SW Cape based on geochemical analyses of calcareous and phosphatic diagenetic nodules within the upper Elandsvlei and Prince Albert Formations respectively. Well-developed U-shaped burrows of the ichnogenus *Rhizocorallium* are recorded from sandstones interbedded with varved mudrocks within the upper Dwyka Group (Mbizane facies) on the Britstown sheet (Prinsloo 1989). Similar *Rhizocorallium* traces also described from the Dwyka Group of Namibia (*e.g.* the Hardap Shale Member, Miller 2008). References to occurrences of the complex helical spreiten burrow *Zoophycos* in the Dwyka of the Britstown sheet and elsewhere (*e.g.* Prinsloo 1989) are probably in error, since in Palaeozoic times this was predominantly a shallow marine to estuarine ichnogenus (Seilacher 2007).

Scattered records of fossil vascular plants within the Dwyka Group of the Main Karoo Basin record the early phase of the colonisation of SW Gondwana by members of the *Glossopteris* Flora in the Late Carboniferous (Plumstead 1969, Anderson & McLachlan 1976, Anderson & Anderson 1985 and earlier refs. therein). These records include fragmentary carbonized stems and leaves of the seed ferns *Glossopteris* / *Gamgamopteris* and several gymnospermous genera (*e.g. Noeggerathiopsis, Ginkgophyllum*) that are even found within glacial tillites. More "primitive" plant taxa include lycopods (club mosses) and true mosses such as *Dwykea*. It should be noted that the depositional setting (*e.g.* fluvial *versus* glacial) and stratigraphic position of some of these records are contested (cf Anderson & McLachlan 1976). Petrified woods with well-developed seasonal growth rings are recorded from the upper Dwyka Group (Mbizane Formation) of the northern Karoo Basin (*e.g.* Prinsloo 1989) as well as from the latest Carboniferous of southern Namibia. The more abundant Namibian material (*e.g. Megaporoxylon*) has recently received systematic attention (Bangert & Bamford 2001, Bamford 2000, 2004) and is clearly gymnospermous (pycnoxylic, *i.e.* dense woods with narrow rays) but most woods cannot be assigned to any particular gymnosperm order.

5.2.3 Fossils within the Ecca Group

Useful overviews of the geology of the Ecca Group are given by Johnson *et al.* (2006) and Johnson (2009). The fossil record of the Ecca Group in the Western Cape has recently been reviewed by Almond (2008a, b) and many of the same fossil groups can be expected in the Northern Cape and Free State outcrop areas that form part of the same Main Karoo Basin.

5.2.4 Prince Albert Formation

The fossil biota of the post-Dwyka mudrocks of the Prince Albert Formation has been summarized by Cole (2005) and Almond (2008a, 2008b), among others. Typical *Umfolozia / Undichna* – dominated trace fossil assemblages of the non-marine *Mermia* Ichnofacies are commonly found in basinal mudrock facies of the Prince Albert Formation throughout the Ecca Basin. Low diversity Prince Albert trace fossil assemblages within the Kimberley sheet area are briefly mentioned by Bosch (1993). Diagenetic nodules containing the remains of palaeoniscoids (primitive bony fish), sharks, spiral bromalites (coprolites *etc*) and wood have been found in the Ceres Karoo and rare shark remains (*Dwykaselachus*) near Prince Albert on the southern margin of the Great Karoo (Oelofsen 1986). Microfossil remains in this formation include sponge spicules, foraminiferal and radiolarian protozoans, acritarchs and miospores.

The most diverse as well as biostratigraphically, palaeobiogeographically and palaeoecologically interesting fossil biota from the Prince Albert Formation is that described from calcareous concretions exposed along the Vaal River in the Douglas area of the Northern Cape (McLachlan and Anderson 1971, Visser *et al.,* 1977-78). The important Douglas biota contains petrified wood (including large tree trunks), palynomorphs (miospores), orthocone nautiloids, nuculid bivalves, articulate brachiopods, spiral and other “coprolites” (probably of fish, possibly including sharks) and fairly abundant, well-articulated remains of palaeoniscoid fish. Most of the fish have been assigned to the palaeoniscoid genus *Namaichthys* but additional taxa, including a possible acrolepid, may also be present here (Evans 2005). The invertebrates are mainly preserved as moulds.

5.2.5 Fossils within the Whitehill Formation

In palaeontological terms the Whitehill Formation is one of the richest and most interesting stratigraphic units within the Ecca Group (Almond 2008a, 2008b and refs. therein). In brief, the main groups of Early Permian fossils found within the Whitehill Formation include:

- small aquatic mesosaurid reptiles (the earliest known sea-going reptiles)
- rare cephalochordates (ancient relatives of the living lancets)
- a variety of palaeoniscoid fish (primitive bony fish)
- highly abundant small eocarid / notocarid crustaceans (bottom-living, shrimp-like forms)
- insects (mainly preserved as isolated wings, but some intact specimens also found)
- a low diversity of trace fossils (*e.g.* king crab trackways, possible shark coprolites / faeces)
- palynomorphs (organic-walled spores and pollens)
- petrified wood (mainly of primitive gymnosperms)
- other sparse vascular plant remains (*Glossopteris* leaves, lycopods *etc*).

The stratigraphic distribution of the most prominent fossil groups – mesosaurid reptiles, palaeoniscoid fishes and notocarid crustaceans – within the Whitehill Formation has been documented by several authors, including Oelofsen (1987), Visser (1992, 1994) and Evans (2005). Kensley (1975) reported notocarid crustaceans from the Whitehill Formation near Oranjerivier.

5.2.6 Fossils within the Tierberg and Waterford Formations

The fossil record of the **Tierberg Formation** has been reviewed in detail by Almond (2008a, 2008b). Rare body fossil records include disarticulated microvertebrates (*e.g.* fish teeth and scales) from calcareous concretions in the Koffiefontein sheet area (Zawada 1992) and allochthonous plant remains (drifted leaves, petrified wood). The latter become more abundant in the upper, more proximal (prodeltaic) facies of the Tierberg (*e.g.* Wickens 1984). Prinsloo (1989) records numerous plant impressions and unspecified “fragmentary vertebrate fossils” (possibly temnospondyl amphibians) within fine-grained sandstones in the Britstown sheet area. Dark carbonaceous Ecca mudrocks are likely to contain palynomorphs (*e.g.* pollens, spores, acritarchs). Bosch (1993) and Visser *et al.* (1977) briefly mention body fossils within the Tierberg mudrocks in the broader Kimberley region. Concretions within the lower part of the formation at Kaffirs Kop 193 (southeast of Belmont) and on Klippiespan 205, for example, contain fish scales, coprolites and sponge spicules. Records of abundant silicified wood within the uppermost Tierberg succession are mostly referred to the Waterford Formation (see below). Siliceous nodules containing ornamented fish scales as well as enamel- or bone-like material (probably pseudofossils in the last two cases) were recently reported from the De Aar area by Almond (2013d).

The commonest fossils by far in the Tierberg Formation are sparse to locally concentrated assemblages of trace fossils that are often found in association with thin event beds (*e.g.* distal turbidites, prodeltaic sandstones) within more heterolithic successions. A modest range of ten or so different ichnogenera have been recorded from the Tierberg Formation (*e.g.* Abel 1935, Anderson 1974, 1976, Wickens 1980, 1984, 1994, 1996, Prinsloo 1989, De Beer *et al*., 2002, Viljoen 2005, Almond 2008a). These are mainly bedding parallel, epichnial and hypichnial traces, some preserved as undertracks. Penetrative, steep to subvertical burrows are rare, perhaps because the bottom sediments immediately beneath the sediment / water interface were anoxic. Most Tierberg ichnoassemblages display a low diversity and low to moderate density of traces. Apart from simple back-filled and / or lined horizontal burrows (*Planolites, Palaeophycus*) they include arthropod trackways (*Umfolozia*) and associated resting impressions (*Gluckstadtella*), undulose fish swimming trails (*Undichna*) that may have been generated by bottom-feeding palaeoniscoids, horizontal epichnial furrows (so-called *Scolicia*) often attributed to gastropods (these are also common in the co-eval Collingham Formation; Viljoen 1992, 1994), arcuate, finely-striated feeding excavations of an unknown arthropod (*Vadoscavichnia*), beaded traces ("*Hormosiroidea*" or "*Neonereites*"), small sinusoidal surface traces (*Cochlichnus*), small star-shaped feeding burrows (*Stelloglyphus*) and zigzag horizontal burrows (*Beloraphe*), as well as possible narrow (<1cm) *Cruziana* scratch burrows. The symmetrical, four-pronged trace *Broomichnium* (= *Quadrispinichna* of Anderson, 1974 and later authors) often occurs in groups of identical size (*c*. 3.5cm wide) and similar orientation on the bedding plane. This trace has frequently been misinterpreted as a web-footed tetrapod or arthropod trackway (*e.g.* Van Dijk *et al*. 2002 and references therein). However, Braddy and Briggs (2002) present a convincing case that this is actually a current-orientated arthropod resting trace (cubichnion), probably made by small crustaceans that lived in schools of similar-sized individuals and orientated themselves on the seabed with respect to prevailing bottom currents. Distinctive broad (3-4cm), strap-shaped, horizontal burrows with blunt ends and a more-or-less pronounced transverse ribbing occur widely within the Tierberg mudrocks. They have been described as "fucoid structures" by earlier workers (*e.g.* Ryan 1967) by analogy with seaweeds, and erroneously assigned to the ichnogenera *Plagiogmus* by Anderson (1974) and *Lophoctenium* by Wickens (1980, 1984). Examples up to one metre long were found in Tierberg mudrocks near Calvinia in 1803 by H. Lichtenstein, who described them as "eel fish". These are among the first historical records of fossils in South Africa (MacRae 1999). These as yet unnamed burrows are sometimes infilled with organized arrays of faecal pellets (Werner 2006). Good examples of these strap-shaped burrows up to 10 cm across were recent described from the De Aar area by Almond (2013d). Sandstone sole surfaces with casts of complex networks of anastomosing (branching and fusing) tubular burrows have been attributed to the ichnogenus *Paleodictyon* (Prinsloo 1989) but may more appropriately assigned to *Megagrapton* (Almond 1998). These so-called graphoglyptid burrows are associated with turbidite facies from the Ordovician to Recent times and have been interpreted as gardening burrows or *agrichnia* (Seilacher, 2007). Microbial mat textures, such as *Kinneyia*, also occur in these offshore mudrocks but, like the delicate grazing traces with which they are often associated, are generally under-recorded.

As discussed previously (Section 2.3.3) it is considered likely that the uppermost Ecca Group rocks in the De Aar region belong to the **Waterford Formation** rather than the Tierberg Formation as mapped. Rare fragments of poorly-preserved tetrapod bone are recorded in channel lags within the upper Waterford Formation in the Williston sheet area (Viljoen 1989) and the southern Great Karoo. These probably belong to aquatic temnospondyl amphibians ("labyrinthodonts") but large fish and terrestrial therapsids might also be represented. Scattered palaeoniscoid fish scales and fish coprolites are common in the Waterford Formation, and several genera of non-marine bivalves have been described from the southern Karoo (Bender *et al*. 1991, Cooper & Kensley 1984).

Upper delta platform facies of the Waterford Formation (including the Koedoesberg Formation of earlier authors) contain abundant, low diversity trace assemblages of the *Scoyenia* ichnofacies. They are dominated by the rope-like, horizontal and oblique burrows of the ichnogenus *Scoyenia* that has been attributed to small arthropods (possibly insects) and / or earthworms. These tubular, meniscate back-filled scratch burrows characterise intermittently moist, firm substrates such as channel and pond margins on the upper delta platform (Smith & Almond 1998, Buatois & Mángano 2004, 2007). Good examples, often associated with wave-rippled surfaces, are recorded from Waterford thin-bedded sandstones and siltstones in the Roggeveld Escarpment zone by Wickens (1984, 1996) and Viljoen (1989). Offshore delta platform facies of the Waterford Formation have very impoverished, poorly-preserved ichnofaunas due to rapid sedimentation rates with abundant soft-sediment deformation and perhaps also to fluctuating salinities.

Petrified wood and other plant material of the *Glossopteris* Flora (*e.g. Glossopteris, Phyllotheca*) is also common in the Waterford Formation (Theron 1983, Anderson & Anderson 1985, Viljoen 1989, Wickens 1984, 1996, Rubidge *et al*. 2000). Leaves and stems of arthrophytes (horsetails) such as *Schizoneura* have been observed in vertical life position. Substantial fossil logs (so-called "*Dadoxylon*") showing clearly developed seasonal growth rings are mostly permineralised with silica but partially or completely calcified material is also known (Viljoen 1989). At least two different genera of gymnospermous woods, *Prototaxoxylon* and *Australoxylon,* have been identified so far (Bamford 1999, 2004). Fragments of silicified gymnospermous woods, some showing the original xylem tissue preserved in fine detail (*e.g.* clear seasonal growth rings), are among the commonest fossil remains from the Ecca Group outcrop area near De Aar reported in the various recent field studies by Almond (2012a, 2012b, 2012c, 2013a to d). Sheetwash and other near-surface gravels overlying the upper Ecca Group outcrop area consistently contain small cherty fragments of silicified woods reworked from the underlying bedrocks. Larger petrified wood samples also occur within subsurface gravels overlying Ecca bedrocks where these are exposed at surface near De Aar.

The storm-dominated shelf sediments of the Carnarvon-type facies of the Waterford Formation, as seen near De Aar, are typically associated with pervasive low intensity bioturbation by low diversity trace fossil assemblages. The latter have been assigned to the shallow marine *Cruziana* Ichnofacies as well as the marginal marine *Skolithos* and *Scoyenia* Ichnofacies (*e.g.* Rust *et al.* 1991 and references therein). Good examples of these traces are illustrated by Siebrits (1987), Prinsloo (1989) and Rust *et al.* (1991). Abundant *Cruziana* ichnofacies traces have been recorded from uppermost Ecca beds near De Aar by Almond (2013d). Prominent "Carnarvon" trace fossil taxa include cm-sized horizontal to oblique burrows with striated walls (*cf Palaeophycus striatus*) and vertical spreiten burrows of the ichnogenus *Teichichnus*. Non-marine arthropod feeding and resting scratch burrows of the ichnogenera *Cruziana* and *Rusophycus* are also reported here; they may have been generated by crustaceans rather than trilobites. Possibly limb and belly impressions of large temnospondyl amphibians were recorded from a wave-rippled surface northeast of De Aar (Almond 2012a). The Holostratotype section through the Tierberg Formation designated by Viljoen (2005) features a variety of *Cruziana* ichnofacies trace fossil occurrences as well as occasional fossil wood material, supporting its assignment to the Waterford Formation.

5.2.7 Fossils in the Lower Beaufort Group

The overall palaeontological sensitivity of the Beaufort Group sediments is high to very high (Almond & Pether 2008). These continental sediments have yielded one of the richest fossil records of land-dwelling plants and animals of Permo-Triassic age anywhere in the world (MacRae 1999, Rubidge 2005, McCarthy & Rubidge 2005). Bones and teeth of Late Permian tetrapods have been collected in the Great Karoo region since at least the 1820s and this region remains a major focus of palaeontological research in South Africa.

Mid to Late Permian age vertebrate fossil assemblages of the lower Beaufort Group are dominated by a variety of small to large true reptiles and – more especially – by a wide range of therapsids. This last group of animals are also commonly, but misleadingly, known as "mammal-like reptiles" or protomammals (*e.g.* Cluver 1978, Rubidge 1995, MacRae 1999). By far the most abundant group among the Late Permian therapsids are the dicynodonts, an extinct group of two-tusked herbivorous therapsids. Other important therapsid subgroups are the dinocephalians, gorgonopsians, therocephalians and cynodonts. Aquatic animals include large, crocodile-like temnospondyl amphibians and various primitive bony fish (palaeoniscoids). Note that fossil dinosaurs are *not* found within the Great Karoo area *sensu stricto* (*i.e.* below the Great Escarpment); this group only evolved some thirty million years *after* the Lower Beaufort Group sediments were deposited.

A high proportion of the tetrapod (*i.e.* four-limbed, terrestrial vertebrate) fossils from the Beaufort Group are found within the overbank mudrocks. They are very commonly encased within calcrete or pedogenic limestone that often obscures their anatomy and makes such fossils difficult to recognise in the field, even for experienced palaeontologists (Smith 1993a, b). Rarer fossil specimens preserved within the Beaufort Group sandstones are usually disarticulated and fragmentary due to extensive, pre-burial transport. Occasionally vertebrate fossils are found embedded within baked (thermally metamorphosed) mudrocks or hornfels in the vicinity of dolerite intrusions. However, such fossils are extremely difficult to prepare out in the laboratory and so are generally of limited scientific value.

Key studies on the taphonomy (pre-burial history) of Late Permian vertebrate remains in the Great Karoo have been carried out in the Beaufort West area and have yielded a wealth of fascinating data on Late Permian terrestrial wildlife and palaeoenvironments (*e.g.* Smith 1980, 1993a). Therapsid fossils are most abundant and best preserved (well-articulated) within muddy and silty overbank sediments deposited on the proximal floodplain (*i.e.* close to the river channel). Here they are often associated with scoured surfaces and mature palaeosols (ancient soils), these last indicated by abundant calcrete nodules. In the distal floodplain sediments, far from water courses, fossils are rarer and mostly disarticulated. Channel bank sediments usually contain few fossils, mostly disarticulated, but occasionally rich concentrations of calcrete-encrusted remains, some well-articulated, are found. These dense bone assemblages may have accumulated in swale fills or chute channels which served as persistent water holes after floods

(Smith 1993a, 1993b). Such detailed interdisciplinary field studies re-emphasise how essential it is that fossil collecting be undertaken by experienced professionals with a good grasp of relevant sedimentology as well as palaeontology, lest invaluable scientific data be lost in the process.

Plant fossils in the lower Beaufort Group are poorly represented and often very fragmentary (*cf*. Anderson & Anderson 1985, dealing primarily with material from the eastern Karoo Basin, Gastaldo *et al*. 2005, dealing with Permo-Triassic boundary floras in the Main Karoo Basin). They belong to the *Glossopteris* Flora that is typical of Permian Gondwana and include reedy sphenophytes or "horsetails" (Arthrophyta, now recognised as a fern subgroup) and distinctive tongue-shaped leaves of the primitive, tree-sized gymnosperm *Glossopteris*. Well-preserved petrified wood ("*Dadoxylon*") occurs widely and may prove of biostratigraphic and palaeoecological value in future (*e.g.* Bamford 1999, 2004) Elongate plant root casts or *rhizoliths* are frequently found associated with calcrete nodule horizons. Transported plant debris preserved within channel sandstones is often associated with secondary iron ("*koffieklip*") and uranium mineralization (Cole & Smith 2008 and refs. therein).

Late Permian invertebrate fossils from the western Karoo Basin comprise almost exclusively relatively featureless, thin-shelled freshwater bivalves, while fairly low diversity insect faunas are recorded from plant-rich horizons further east. The most prominent vertebrate trace fossils in the Lower Beaufort Group are well-preserved tetrapod trackways attributed to various groups of reptiles and therapsids (Smith 1993a), as well as substantial, inclined to helical scratch burrows that were probably constructed by smaller therapsids as an adaptation to the highly seasonal, and occasionally extreme, continental climates at high palaeolatitudes of 60-70º S. (Smith 1987). Invertebrate trace fossils from the Karoo National Park at Beaufort West include the locally abundant scratch burrows of the ichnogenus *Scoyenia* that are generally attributed to infaunal arthropods such as insects or even earthworms. Diverse freshwater ichnofaunas (trace fossil assemblages) with trails, burrows and trackways generated by fish, snails, arthropods, worms and other animals have been recorded by Smith (1993a, Smith & Almond 1998).

A chronological series of mappable fossil biozones or assemblage zones (AZ), defined mainly on their characteristic tetrapod faunas, has been established for the Main Karoo Basin of South Africa (Rubidge 1995, 2005). Maps showing the distribution of the Beaufort assemblage zones within the Main Karoo Basin have been provided by Kitching (1977), Keyser and Smith (1977-78) and Rubidge (1995, 2005). An updated version based on a comprehensive GIS fossil database has recently been published (Van der Walt *et al.* 2010). Three successive Middle to Late Permian fossil assemblage zones are represented within the Abrahamskraal and Teekloof Formations in the Gamma – Perseus study area (Fig. 5). These are the *Tapinocephalus*, *Pristerognathus* and *Tropidostoma* AZ. Radiometric age constraints for these assemblage zones have recently been published by Rubidge *et al.* (2013).

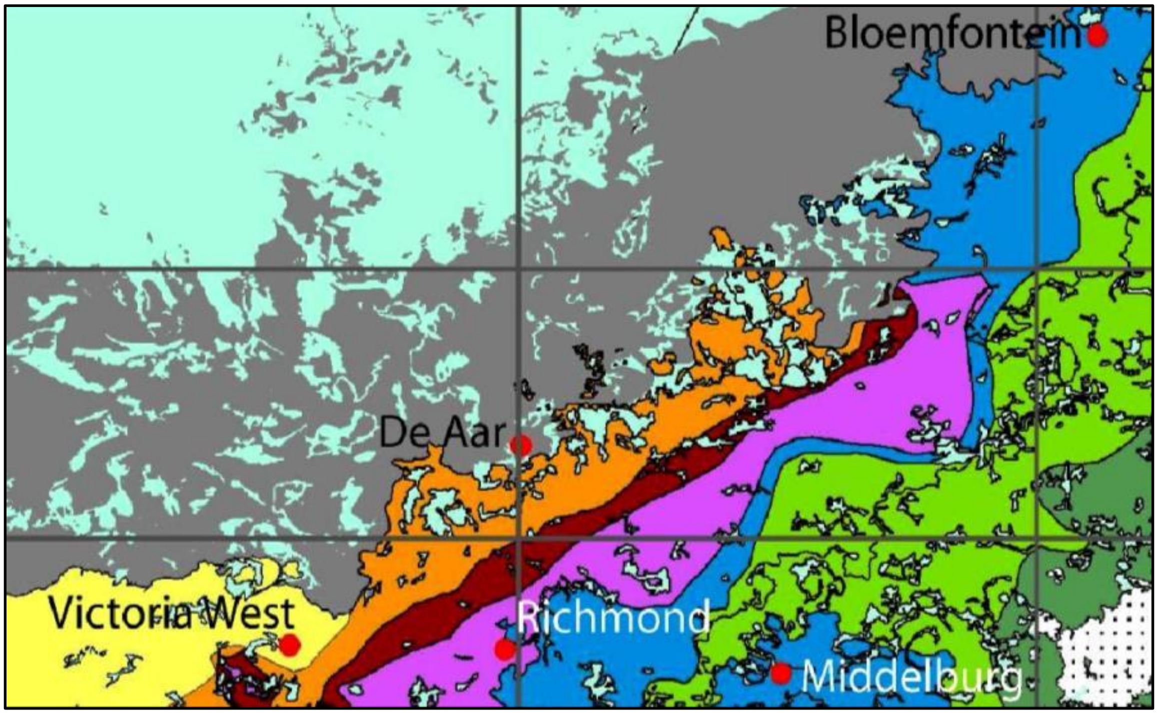

Figure 9 Extract from the new Karoo vertebrate biozone map by Van der Walt *et al.* (2010) showing the distribution of the three Middle to Late Permian biozones represented in the Lower Beaufort Group sediments cropping out within the broader Gamma – Perseus transmission line study area between Victoria West and Bloemfontein. In biostratigraphic order these biozones are: (1) *Tapinocephalus* Assemblage Zone (buff), (2) *Pristerognathus* Assemblage Zone (orange) and (3) *Tropidostoma* Assemblage Zone (reddish-brown).

It should be noted that on the basis of international faunal correlation, the *Tropidostoma* and following *Cistecephalus* Assemblage Zones of the Lower Beaufort Group have until recently been assigned to the Wuchiapingian Stage of the Late Permian Period, with an approximate age range of 260-254 Ma. The underlying *Tapinocephalus* and *Pristerognathus* AZ were referred to the preceding Capitanian Stage (266-260 Ma) of the Middle Permian (Rubidge 2005 and refs. therein). The end-Guadalupian (*i.e.* end – Middle Permian) mass extinction event was inferred to lie at the contact between the *Tapinocephalus* and *Pristerognathus* AZ within the uppermost Abrahamskraal and Koonap Formations (Retallack *et al.* 2006). Recent radiometric dates for the Lower Beaufort Group tuffs assign a late Guadalupian (Capitanian) age to the *Pristerognathus* AZ (261-260.36 Ma), an early Lopingian (Wuchiapingian) age to the *Tropidostoma* AZ (259.3 Ma), and a later Wuchiapingian age to the *Cistecephalus* AZ (256.6-255.2Ma) (Rubidge *et al.* 2013). This places the Mid / Late Permian boundary and End Guadalupian mass extinction event, if it is indeed reflected on land, between the *Pristerognathus* and *Tropidostoma* AZs within the Teekloof and Middleton Formations, rather than at the base of the *Pristerognathus* AZ as previously assumed.

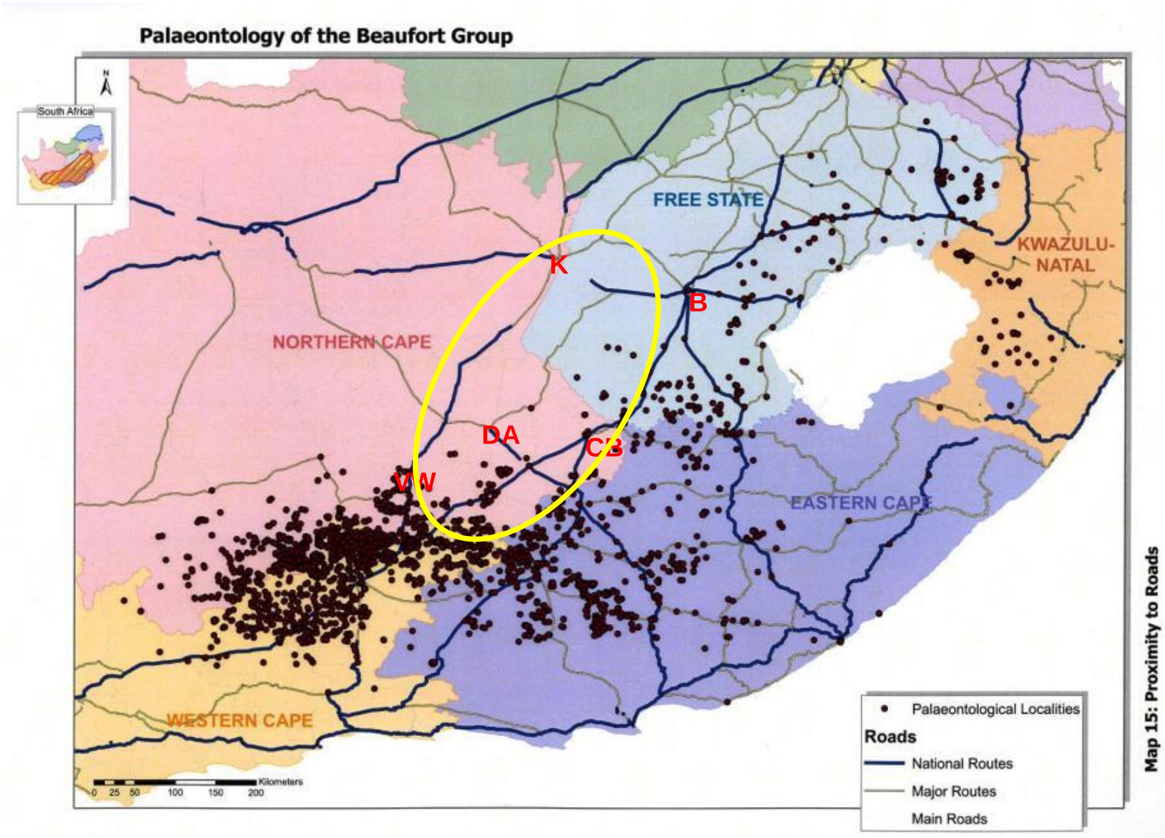

Figure 10 Distribution map of recorded vertebrate fossil sites (dots) within the Beaufort Group of the Main Karoo Basin around the junction of the Western, Northern and Eastern Cape and the Free State (From Nicolas 2007). Vertebrate fossil sites within the broader Gamma-Perseus study region in the Northern Cape and Free State (yellow ellipse) are concentrated in the southwest part in the area near Victoria West and De Aar. The comparative paucity of fossil records here is in large part probably due to the low levels of bedrock exposure, as well as generally lower abundance of fossils in the *Pristerognathus* Assemblage Zone. Rare vertebrate fossils have been recorded recently during field studies by Almond (2012a).

5.2.8 The *Tapinocephalus* Assemblage Zone

The fossil biota of the greater part of the Abrahamskraal Formation is assigned to the *Tapinocephalus* Assemblage Zone of Middle Permian (Capitanian) age on the basis of key tetrapod fossils, notably large dinocephalian therapsids *plus* smaller carnivorous therocephalians. The main categories of fossils recorded within the *Tapinocephalus* fossil biozone (Boonstra 1969, Keyser & Smith 1977-78, Kitching 1977, Anderson & Anderson 1985, Smith & Keyser 1995a, MacRae 1999, Rubidge 2005, Nicolas & Rubidge 2010, Almond 2010) include:

- isolated petrified bones as well as rare articulated skeletons of tetrapods (*i.e.* air-breathing terrestrial vertebrates) such as true reptiles (notably large herbivorous pareiasaurs like *Bradysaurus*, small insectivorous millerettids), rare pelycosaurs, and diverse therapsids or “mammal-like reptiles” (Fig. 7). The last group includes numerous genera of large-bodied dinocephalians, smaller herbivorous dicynodonts as well as flesh-eating biarmosuchians, gorgonopsians and therocephalians

- aquatic vertebrates such as large temnospondyl amphibians (*Rhinesuchus*, usually disarticulated), and palaeoniscoid bony fish (*e.g. Atherstonia*, *Namaichthys*) that are often represented by scattered scales rather than intact corpses (Bender 2004)

- freshwater bivalves (*Palaeomutela*)

- trace fossils such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings) and plant root casts

- vascular plant remains (usually sparse and fragmentary), including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora, especially glossopterid trees and arthrophyte ferns or "horsetails" (Anderson & Anderson 1985, Bamford 1999)

In general, tetrapod fossil assemblages in this zone are dominated by a wide range of dinocephalian genera and small therocephalians *plus* pareiasaurs while relatively few dicynodonts are present (Nicolas 2007, Day & Rubidge 2010, Jirah & Rubidge 2010 and refs. therein). Vertebrate fossils in this zone are generally much rarer than in younger assemblage zones of the Lower Beaufort Group, with almost no fossils to be found in the lowermost beds (Loock *et al.* 1994).

Despite their comparative rarity, there has been a long history of productive fossil collection from the *Tapinocephalus* Assemblage Zone in the Great Karoo area, as summarized by Rossouw and De Villiers (1952) and Boonstra (1969). Well-preserved fossil remains of robust dinocephalians and pareiasaurs as well as smaller-bodied therapsids and previously under-recorded vertebrate burrows, vascular plants and coprolites can still be found at the surface in the Koup region, as noted in the recent impact study by Almond (2010). Fossil skeletal material from the *Tapinocephalus* Assemblage Zone is found within several different taphonomic settings, including:

1. disarticulated, usually ferruginised bones within thin intraformational conglomerates (*beenbreksie*) at the base of shallow, unistorey channel sandstones (Rossouw & De Villiers 1952, Turner 1981, Smith & Keyser 1995). The bones here vary from fragmentary and rounded to intact and well-preserved. They occur at the base of, within, or floating at the top of the conglomerates in association with calcrete nodules, mudflakes, petrified wood and gypsum pseudomorphs. Bones in these channel lags were variously eroded out of riverbanks or washed from upland areas, riverine areas and floodplains into drainage channels during floods or episodes of landscape denudation.

2. disarticulated bones within or at the top of channel sandstones.

3. bones coated with calcrete or embedded within calcrete nodules associated with palaeosols (ancient soils). These bones are often suncracked, showing that lay exposed on the land suface for a long time before burial.

4. isolated bones or articulated skeletons embedded within levee or floodplain mudrocks .

5. well-articulated skeletons preserved within fossil burrows (Botha-Brink & Modesto 2007).

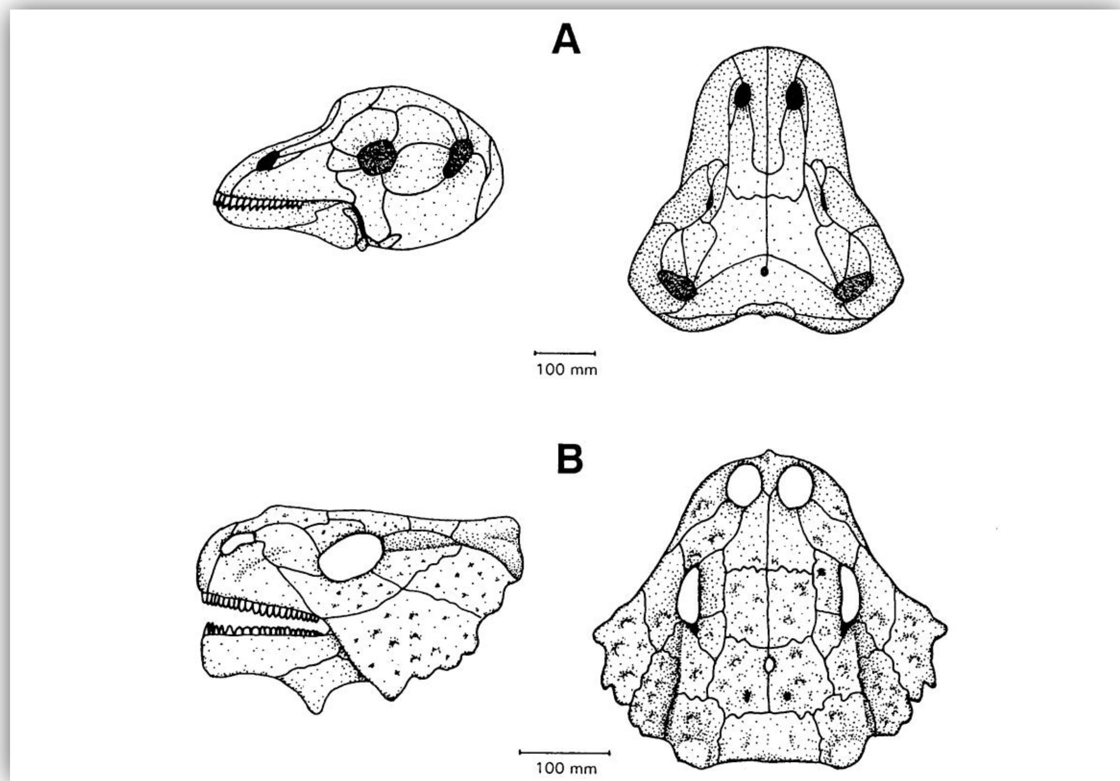

Figure 11 Skulls of two key herbivorous tetrapods of the *Tapinocephalus* Assemblage Zone: A – the dinocephalian therapsid *Tapinocephalus*; B – the pareiasaur *Bradysaurus* (From Smith & Keyser 1995a).

There have been a number of attempts, hitherto only partially successful, to subdivide the very thick Abrahamskraal Formation succession in both lithostratigraphic and biostratigraphic terms. Among the most recent these was the study by Loock *et al.* (1994) in the Moordenaarskaroo area north of Laingsburg. Detailed geological mapping here led to the identification of six lithologically-defined members within the Abrahamskraal Formation. Intensive fossil collection within the middle part of the succession suggested that a significant faunal turnover event may have occurred at or towards the top of the sandstone-rich Koornplaats Member as defined by these authors, with the replacement of a more archaic, dinocephalian-dominated fauna (with primitive therapsids like the biarmosuchians) by a more advanced, dicynodont-dominated one at this level. This is the "faunal reversal" previously noted by Boonstra (1969) as well as Rossouw and De Villiers (1953). Other fossil groups such as therocephalians and pareiasaurs do not seem to have been equally affected. Problems have arisen in trying to correlate the lithologically-defined members recognized within the Abrahamskraal Formation by different authors across the whole outcrop area, with evidence for complex lateral interdigitation of the sandstone-dominated packages (D. Cole, pers. com., 2009). A research project is currently underway to further subdivide the *Tapinocephalus* Assemblage Zone on a biostratigraphic basis, emphasizing the range zones of various genera of small dicynodonts such as *Eodicynodon, Robertia* and *Diictodon* (Rubidge & Angielczyk 2009, Day & Rubidge 2010, Jirah & Rubidge 2010).

5.2.9 The *Pristerognathus* Assemblage Zone

Fossils of the *Pristerognathus* Assemblage Zone characterize the arenaceous Poortjie Member and the uppermost beds of the underlying Abrahamskraal Formation in the western Main Karoo Basin as well as the beds spanning the Koonap / Middleton Formation boundary in the eastern Karoo (Smith & Keyser 1995b). This important terrestrial biota is dominated by various therapsids ("mammal-like reptiles") such as the moderate-sized therocephalian carnivore *Pristerognathus* as well as several gorgonopsian predators / scavengers and herbivorous dicynodonts (Fig. 8). The commonest genus by far is the small burrowing dicynodont *Diictodon* (Keyser and Smith 1977-78, Smith & Keyser 1995b, MacRae 1999, Cole *et al*., 2004, Rubidge 2005, Almond 2010, Nicolas 2007, Nicolas & Rubidge 2010). There are also large, rhino-sized herbivorous reptiles (*Bradysaurus* spp.), crocodile-like temnospondyl amphibians (*Rhinesuchus*), palaeoniscoid fish, vascular plant fossils of the *Glossopteris* Flora (fossil wood, leaves *etc*) and various trace fossils, including invertebrate burrows and tetrapod trackways. The comparatively low number of specimens and major taxa represented in fossil collections from this biozone demonstrated by Nicolas (2007). The fossil biota of the *Pristerognathus* AZ is of special interest because it *possibly* represents an impoverished post-extinction recovery fauna following a late Mid Permian extinction event that preceded the well-known end-Guadalupian biotic crisis (*cf* Benton 2003, Retallack *et al.,* 2006, Lucas 2009, Rubidge *et al.* 2013).

Most fossils in the *Pristerognathus* Assemblage Zone are found in the softer-weathering mudrock facies (floodplain sediments) that are usually only exposed on steeper hill slopes and in stream gullies. Fossils here are often associated with pedogenic limestone nodules or calcretes (Smith 1993a, Smith & Keyser 1995b). The mudrocks lie between the more resistant-weathering channel sandstones, which in the Poortjie Member display a distinctive "golden yellow" tint. Fossil skeletal remains also occur in the lenticular channel sandstones, especially in intraformational lag conglomerates towards the base, but are usually very fragmentary and water-worn ("rolled bone").

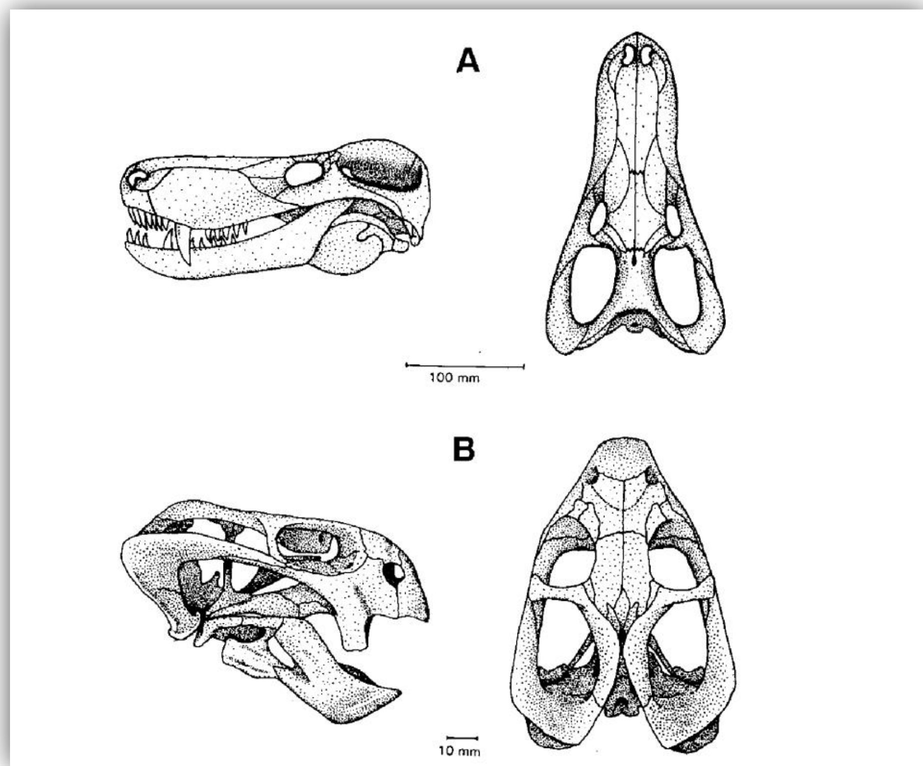

Figure 12 Skulls of typical therapsids from the *Pristerognathus* Assemblage Zone: A. the dog-sized carnivorous therocephalian *Pristerognathus* and B. the small herbivorous dicynodont *Diictodon* (From Smith & Keyser 1995b).

5.2.10 The *Tropidostoma* Assemblage Zone

The *Tropidostoma* Assemblage Zone (AZ) characterizes the Hoedemaker Member of the Teekloof Formation in the western Karoo and the middle part of the Middleton Formation in the eastern Karoo (Le Roux & Keyser 1988, Smith & Keyser, 1995c).

The following major categories of fossils are recorded within *Tropidostoma* AZ sediments (Kitching 1977, Keyser & Smith 1977-78, Le Roux & Keyser 1988, Anderson & Anderson 1985, Smith & Keyser 1995c, MacRae 1999, Cole *et al*., 2004, Nicolas 2007, Nicolas & Rubidge 2010, Almond 2010):

- isolated petrified bones as well as rare articulated skeletons of terrestrial vertebrates (tetrapods) such as true reptiles (notably large herbivorous pareiasaurs) and therapsids or “mammal-like reptiles” (*e.g.* diverse herbivorous dicynodonts, flesh-eating gorgonopsians, and insectivorous therocephalians) (Fig. 9)

- aquatic vertebrates such as large temnospondyl amphibians (*Rhinesuchus* spp., usually disarticulated), and palaeoniscoid bony fish (*Atherstonia*, *Namaichthys*, often represented by scattered scales rather than intact fish)

- freshwater bivalves (*e.g. Palaeomutela*)
- trace fossils such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings), fish swimming trails
- vascular plant remains including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterid trees and arthrophytes (horsetails).

According to Smith and Keyser (1995c) the tetrapod fauna of the *Tropidostoma* Assemblage Zone is dominated by the small burrowing dicynodont *Diictodon* that constitutes some 40% of the fossil remains recorded here. There are several genera of small toothed dicynodonts (*e.g. Emydops, Pristerodon*) as well as medium-sized forms like *Rachiocephalus* and *Endothiodon* (*cf* Cluver & King 1983, Botha & Angielczyk 2007). Carnivores are represented by medium-sized gorgonopsians (*e.g. Lycaenops, Gorgonops;* Fig. 9) as well as smaller, insectivorous therocephalians such as *Ictidosuchoides*. Among the large (2.3-3 m long), lumbering pareiasaur reptiles the genus *Pareiasaurus* replaces the more primitive *Bradysaurus* seen in older Beaufort Group assemblages.

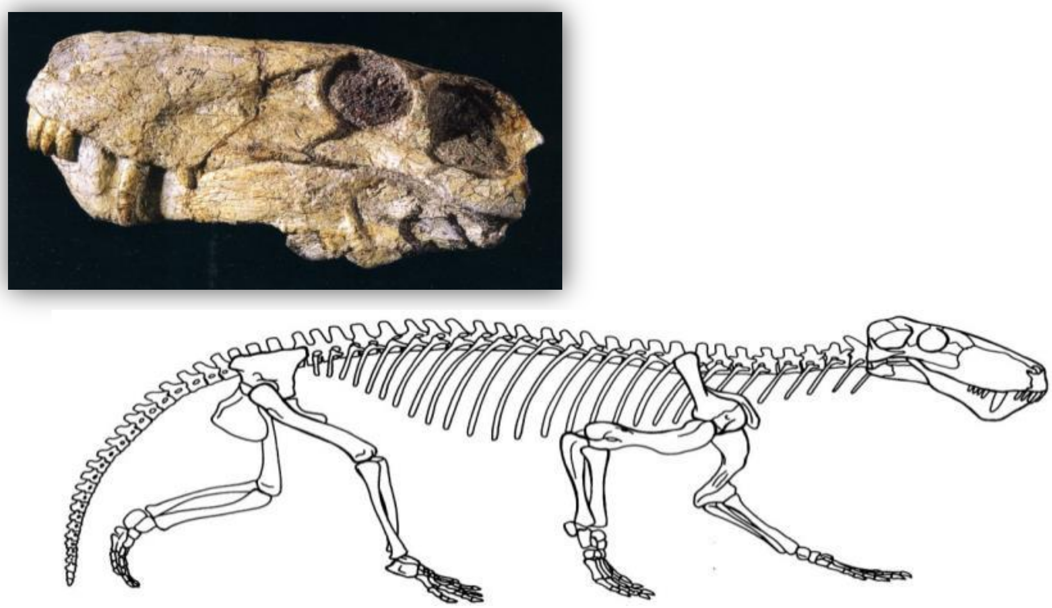

Figure 13 Skull and skeleton of a saber-toothed carnivore, the gorgonopsian *Lycaenops* – a typical member of the *Tropidostoma* Assemblage Zone.

The marked increase in fossil abundance and high level taxonomic diversity within the *Tropidostoma* AZ compared with the underlying impoverished *Pristerognathus* AZ is clear from recent Karoo fossil database analyses (Nicolas 2007). The *Tropidostoma* assemblage may represent a post-extinction recovery fauna following the major end-Guadalupian exctinction event.

As far as the biostratigraphically important tetrapod remains are concerned, the best fossil material within the Hoedemaker Member succession is generally found within overbank mudrocks, whereas fossils preserved within channel sandstones tend to be fragmentary and water-worn (Rubidge 1995, Smith 1993b). Many vertebrate fossils are found in association with ancient soils (palaeosol horizons) that can usually be recognised by bedding-parallel concentrations of calcrete nodules. Smith and Keyser (1995b) report that in the *Tropidostoma* Assemblage Zone / Hoedemaker Member most tetrapod fossils comprise isolated disarticulated skulls and post-cranial bones, although well-articulated skeletons of the small dicynodont *Diictodon* are locally common, associated with burrows (See also Smith 1993b for a benchmark study of the taphonomy of vertebrate remains in the Hoedemaker Member.

5.2.11 Fossils in the Karoo Dolerite Suite

The dolerite outcrops in the Renosterberg / De Aar study area are in themselves of no palaeontological significance. These are high temperature igneous rocks emplaced at depth within the Earth's crust so they do not contain fossils. However, as a consequence of their proximity to large dolerite intrusions in the Great Escarpment zone, some of the Ecca and Beaufort Group sediments in the study area have been thermally metamorphosed or "baked" (*i.e*. recrystallised, impregnated with secondary minerals). Embedded fossil material of phosphatic composition, such as bones and teeth, is frequently altered by baking – bones may become blackened, for example - and can be very difficult to extract from the hard matrix by mechanical preparation (Smith & Keyser 1995). Thermal metamorphism by dolerite intrusions therefore tends to reduce the palaeontological heritage potential of Beaufort Group sediments. In some cases (*e.g.* trace fossils such as *Plagiogmus*, fossil moulds of mesosaurid reptiles and palaeoniscoid fish) baking may enhance the visibility or quality of preservation of Ecca fossils while other fossil groups (*e.g*. carbonaceous remains of plants, organic-walled palynomorphs) are more likely to be compromised.

5.2.12 Fossils associated with Kimberlite intrusions

Kimberlite rocks themselves are unfossiliferous. However, where crater-lake sediments associated with Kimberlite pipes are preserved beneath cover sands they sometimes prove to be highly fossiliferous, as in the case of rich Cretaceous to Paleocene fossil assemblages recorded from Bushmanland (*e.g.* Scholtz 1985, Smith 1986a, 1986b, 1988b, 1995d).

5.2.13 Fossils within the Late Caenozoic superficial sediments

The fossil record of the **Kalahari Group** is generally sparse and low in diversity. The **Gordonia Formation** dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying bedrocks (including, for example, dolerite) may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (*e.g. Trigonephrus*) (Almond

2008a, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands (Du Toit 1954, Dingle *et al*., 1983). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low. Underlying calcretes of the **Mokolanen Formation** might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient, Plio-Pleistocene alluvial gravels.

The remaining central Karoo drift deposits have been comparatively neglected in palaeontological terms. However, sediments associated with ancient drainage systems, springs and pans in particular may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Good examples are the Pleistocene mammal faunas at Florisbad, Cornelia and Erfkroon in the Free State and elsewhere (Wells & Cooke 1942, Cooke 1974, Skead 1980, Klein 1984, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al*. 1995, MacRae 1999, Meadows & Watkeys 1999, Churchill *et al*. 2000, Partridge & Scott 2000, Brink & Rossouw 2000, Rossouw 2006). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, tortoise remains, trace fossils (*e.g.* calcretised termitaria, coprolites, invertebrate burrows, rhizocretions), and plant material such as peats or palynomorphs (pollens) in organic-rich alluvial horizons (Scott 2000) and diatoms in pan sediments. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest (*e.g.* Smith 1999 and refs. therein). Ancient solution hollows within extensive calcrete hardpans may have acted as animal traps in the past. As with coastal and interior limestones, they might occasionally contain mammalian bones and teeth (perhaps associated with hyaena dens) or invertebrate remains such as snail shells.

Table 1. Fossil heritage previously recorded within the main rock units cropping out along the various Gamma – Perseus 765 kV transmission line corridor options

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
OTHER LATE CAENOZOIC TERRESTRIAL DEPOSITS OF THE INTERIOR (Qs, T-Qc) (Most too small to be indicated on 1: 250 000 geological maps)	Fluvial, pan, lake and terrestrial sediments, including diatomite (diatom deposits), pedocretes (e.g. calcrete), spring tufa / travertine, cave deposits, peats, colluvium, soils, surface gravels including downwasted rubble MOSTLY QUATERNARY TO HOLOCENE (Possible peak formation 2.6-2.5 Ma)	bones and teeth of wide range of mammals (*e.g.* mastodont proboscideans, rhinos, bovids, horses, micromammals), reptiles (crocodiles, tortoises), ostrich egg shells, fish, freshwater and terrestrial molluscs (unionid bivalves, gastropods), crabs, trace fossils (*e.g.* termitaria, horizontal invertebrate burrows, stone artefacts), petrified wood, leaves, rhizoliths, diatom floras, peats and palynomorphs. calcareous tufas at edge of Ghaap Escarpment might be highly fossiliferous (*cf* Taung in NW Province – abundant Makapanian Mammal Age vertebrate remains, including australopithecines)	LOW to MEDIUM Scattered records, many poorly studied and of uncertain age	pre-construction field assessment by professional palaeontologist any substantial fossil finds to be reported by ECO to SAHRA
Gordonia Formation (Qs) KALAHARI GROUP *plus* SURFACE CALCRETES (Tl / Qc)	Mainly aeolian sands *plus* minor fluvial gravels, freshwater pan deposits, calcretes PLEISTOCENE to RECENT	calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (*e.g.* tortoise) bones, teeth freshwater units associated with diatoms, molluscs, stromatolites *etc*	LOW	any substantial fossil finds to be reported by ECO to SAHRA
Windsorton & Rietputs Formations HIGH LEVEL ALLUVIAL GRAVELS (Qa) e.g. Orange & Vaal Rivers	Ancient alluvial gravels, locally diamondiferous and calcretised MIOCENE TO PLEISTOCENE	sparse Tertiary vertebrates in older gravels. Rich Pleistocene mammalian fauna (bones, teeth) in younger gravels (*e.g.* equids, elephants, hippo) associated with Acheulian stone artefacts	HIGH	pre-construction field assessment by professional palaeontologist
KIMBERLITE INTRUSIONS (diamond symbol)	Kimberlite / olivine melilitite / carbonatite volcanic pipes and related intrusions (fissure fills), sometime diamondiferous. JURASSIC, CRETACEOUS TO PALAEOCENE	rare fossiliferous xenoliths of country rocks (*e.g.* Beaufort Group sediments with fossil fish). Bryophytes, vascular plants (leaves, wood, fruit), fish, pipid frogs (adults, tadpoles), reptiles (tortoises, lizards), rare dinosaurs, birds (ratites), insects, ostracods, palynomorphs (bryophytes, ferns, gymnosperms,	LOW	none

	c. **200-60 Ma**	**angiosperms) within crater lake sediments**		

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
KAROO DOLERITE SUITE **(Jd)**	**Intrusive dolerites (dykes, sills), associated diatremes** **EARLY JURASSIC** **(182-183 Ma)**	**no fossils recorded**	**ZERO** (also cause baking of adjacent fossiliferous sediments)	**None**
ADELAIDE SUBGROUP (LOWER BEAUFORT GROUP) **Adelaide Subgroup** **Abrahamskraal Fm (Pa)** **Teekloof Fm (Pt, Ptp, Pth, Pto)**	**Fluvial sediments with channel sandstones (meandering rivers), thin mudflake conglomerates interbedded with floodplain mudrocks (grey-green, purplish), pedogenic calcretes, playa lake and pond deposits, occasional reworked volcanic ashes** **Late Permian**	**diverse continental biota dominated by a variety of therapsids (*e.g.* dinocephalians, dicynodonts, gorgonopsians, therocephalians, cynodonts) and primitive reptiles (*e.g.* pareiasaurs), sparse *Glossopteris* Flora (petrified wood, rarer leaves of *Glossopteris*, horsetail stems), tetrapod trackways, burrows & coprolites. Freshwater assemblages include temnospondyl amphibians, palaeoniscoid fish, non-marine bivalves, phyllopod crustaceans and trace fossils (esp. arthropod trackways and burrows, "worm" burrows, fish fin trails, plant rootlet horizons).**	**HIGH**	**Pre-construction field assessment by professional palaeontologist**
Waterford Fm **(Pwa/Pw=Pko, Pc in part)**	**Prodelta to delta plain sediments (mudrocks, sandstones / wackes, ferruginous carbonate diagenetic nodules)**	**low diversity non-marine trace assemblages (especially arthropod scratch burrow *Scoyenia*), common petrified logs (silicified/ calcified), twigs and other remains of *Glossopteris* Flora (*e.g.* horsetails), palaeoniscoid fish scales, rare rolled fragments of tetrapod bone (probably from large temnospondyl amphibians)**	**HIGH**	**Pre-construction field assessment by professional palaeontologist**
Tierberg and Waterford Formations (Pt)	**Dark basinal, prodelta and submarine fan mudrocks with minor sandstones (Tierberg Fm) OR Storm-influenced coastal sandstones and**	**locally abundant non-marine trace fossils (*Mermia* and *Cruziana* ichnofacies), common petrified wood, plant debris, microvertebrates incl. fish scales as well as sponge spicules, coprolites in**	**MEDIUM**	**Pre-construction field assessment by professional palaeontologist**

ECCA GROUP	mudrocks (Carnarvon facies of Waterford Fm) EARLY TO MIDDLE PERMIAN	diagenetic concretions		

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
Whitehill Formation (Pp / Ppw in part) ECCA GROUP	Carbonaceous offshore non-marine mudrocks within minor volcanic ashes, dolomite nodules EARLY PERMIAN	well-preserved mesosaurid reptiles, rare cephalochordates, variety of palaeoniscoid fish, small eocarid crustaceans, insects, low diversity of trace fossils (*e.g.* king crab & eurypterid trackways, possible shark coprolites), palynomorphs, petrified wood and other sparse vascular plant remains (*Glossopteris* leaves, lycopods *etc*)	HIGH	Pre-construction field assessment by professional palaeontologist
Prince Albert Formation (Ppr/ Ppw in part; locally mapped within C-Pd) ECCA GROUP	Basinal mudrocks with calcareous concretions EARLY PERMIAN	marine invertebrates (esp. molluscs, brachiopods), coprolites, palaeoniscoid fish & sharks, trace fossils, various microfossils, petrified wood	HIGH IN KIMBERLEY - DOUGLAS REGION	Pre-construction field assessment by professional palaeontologist
Mbizane Formation (C-Pd) DWYKA GROUP	Tillites, interglacial mudrocks, deltaic & turbiditic sandstones, minor thin limestones LATE CARBONIFER-OUS – EARLY PERMIAN	sparse petrified wood & other plant remains, palynomorphs, trace fossils (*e.g.* arthropod trackways, fish trails, U-burrows) possible stromatolites in limestones	LOW TO MODERATE (*N.B.* stratotype section in the Douglas area)	Pre-construction field assessment by professional palaeontologist
Allanridge Formation (Ra / Ral) VENTERSDORP SUPERGROUP	Basic lavas and volcaniclastic sediments LATE ARCHAEAN 2.7 Ga	no fossils recorded	ZERO	None recommended Any substantial fossil finds to be reported by ECO to SAHRA

Bothaville Formation **(Rb)** **VENTERSDORP SUPERGROUP**	**Conglomerates & quartzites with minor volcanic ashes** **LATE ARCHAEAN** **2.7 Ga**	**conical stromatolites (probably lacustrine)**	**LOW TO MODERATE**	**Pre-construction field assessment by professional palaeontologist**

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
Makwassie Formation **(Rm)** **VENTERSDORP SUPERGROUP**	**Porphyritic felsite lavas (ash flows)** **LATE ARCHAEAN** **2.67 Ga**	**no fossils recorded or expected**	**ZERO**	**None recommended** **Any substantial fossil finds to be reported by ECO to SAHRA**
"SODIUM GROUP" **'TCuip Formation** **(Rt)** **= PLATBERG GROUP (Kameeldoorns Formation)** **VENTERSDORP SUPERGROUP**	**Porphyritic lavas with lenses of tuff and arkose, *plus* dacite** **LATE ARCHAEAN** **2.7 Ga**	**No fossils recorded** **(Kameeldoorns Fm near Taung contains stromatolitic carbonates)**	**LOW**	**None recommended** **Any substantial fossil finds to be reported by ECO to SAHRA**

5.3 The pre-colonial cultural landscape

Sampson (1985) stated that one of the many reasons for him choosing to undertake archaeological research in to the Karoo was that it was that the heritage was intact and untouched by ploughing and recent intervention. The pre-colonial archaeology of the Karoo was not only visible, but also prolific and in exceptionally good condition. A comprehensive survey of a 5000 square kilometre catchment area (the Valley of the Zeekoei River from the Sneeuberg Mountains to the Gariep River Valley) revealed the presence of some 10 000 archaeological sites representing a history of human occupation that dates back at least 250 000 years (or more). Of the 10 000 sites recorded and identified to industry (phases), some 6000 were attributable to the Late Stone Age. Sampson identified some 7 industries (phases) of human history within his study area – each of which are legible on the landscape today, and each of which represent a pre-colonial layer of the human history of the Karoo (figure 6).. A deep discussion of technicalities of Karoo archaeology is not warranted in this report as it is complex and pre-supposes knowledge of archaeology that most members of the general public don't have. Figure 6 depicts the phasing of the human occupation of the Karoo (directly applicable to Northern Cape and Free State). It would be inappropriate to discuss the details of the specific occupation phases in this report, other than to mention that each one the phases of human occupation described by Sampson (1985) represents a pulse of human occupation of the central Karoo – the population of people at any given time reflecting variations in climate and the degrees of aridity and temperature that dictate the viability of the landscape as a place suitable for people to live. Each phase of occupation has left its archaeological signature on the landscape which is identifiable by the kinds of stone artefacts that have been left behind. The different phases are broadly termed the Early Stone Age and Middle Stone Age. Artefacts of both the Early and Middle Stone Age are widespread and may generally be described as an ancient litter that occurs at a low frequency across the landscape. Where definable scatters of Early and Middle Stone Age material occur, they are considered to be significant heritage sites. More intensive occupation of the Karoo started around 13 000 years ago during the Later Stone Age, which is essentially the heritage of Khoisan groups who lived throughout the region.

The latest phase of occupation of the Great Karoo is a period known as the Late Stone Age. It is a very important layer on the landscape as this represents the heritage of the Khoekhoen (historically known as "Hottentot" by early writers) and San (popularly known as Bushman) people of South Africa. The direct descendants of these groups make up a significant proportion of the population today. This heritage is represented by two industries (phases). These are the Interior Wilton which is characterised by a microlithic stone artefact industry characterised by lightly patinated hornfels (indurated shale stone) and the later Smithfield industry characterised by specific classes of stone artefacts and the presence of grass tempered ceramics.

The scarcity of natural caves and shelters in the Karoo landscape has resulted in the majority of archaeological sites being open occurrences of stone artefacts, ostrich eggshell fragments and occasionally, pottery. Bone remains are rarely preserved in open contexts. The most recent archaeological remains relating to the San have been historically described as the "Smithfield Industry", and are found from the Free State to the Northern and Eastern Cape. The Smithfield typically contains flaked lithics (on unpatinated blue-black hornfels), grinding equipment, bored stones, and potsherds (typically relating to bowl-shaped pots with stamp impressed decoration). Formal stone tools include end scrapers. Sampson also recognized a Khoekhoen ceramic tradition and he speculates on the chronological ordering of the settlement in the valley (1988, 2010). Also associated with the Late Stone age of the Karoo are rare rock paintings which occur in the few caves and shelters to be found in the dolerites, however more plentiful are engraved rocks and stones and stone surfaces.

After 1000 years BP (before present) people who were herding sheep/goats and possibly cattle, made an incursion into Karoo and established a new economic order based on transhumant pastoralism (Hart 1989, Sampson, Hart, Wallsmith and Blagg 1989, Sampson 2010). The presence of herding people is represented by stone walled structures that occur throughout the Karoo. They have been recorded within the Zeekoei River Valley, between De Aar and Victoria West (within this project study area) and even in the inhospitable high Karoo near Sutherland (Hart 2005) and on the West Coast (Sadr 2007).

The spatial distribution of Late Stone Archaeological sites in the Karoo is quite patterned. People needed to be close to water so rivers, pans and springs played an important role in influencing where people lived. The climate of the Karoo also played a key role. The winters can be extremely cold with temperatures dropping well below zero, made worse by freezing winds. The summers in contrast are harsh, hot and rainfall is unreliable. Sampson has observed that almost all Late Stone Age sites are situated at the bottom of the breaks of dolerite dykes, in sheltered areas on the crests of dolerite dykes, as well as in dolerite mazes and outcrops. So too, are the stone circles and circle complexes (figure 14) built by Khoekhoen groups after 1000 AD which are almost always built on the edges of low ridges and dykes. The higher ridges provided a view, some security, loose stones with which to build kraals and screens and allowed people to be elevated above the frost levels in winter. Definable sites of the Late Stone Age are sparse on the vast flat shale plains as these areas offered little protection from the wind and collect frost in winter. Hence, natural features such as rock outcrops and dolerite dykes played a significant role for Late Stone Age people.

The archaeology of the Karoo is so intact that Sampson (1988) was able to gather enough observations to postulate the existence on the landscape the territorial boundaries of different groups of people based on the variations on the decorative motifs on pottery. Recent evidence (Sampson 2010) indicates that once herding groups settle in the Karoo, their presence was continuous until the incursion of European *trekboere* in the 1700's.

Earlier archaeological sites (ESA and MSA) may also be found associated with natural foci, however indications are that the location of this kind of material more widely broadcast. Distinct foci are few and in places scatters of dispersed and eroded material may be found over vast expanses of landscape.

Figure 14 A Khoekhoen type stone-piled herder kraal on the side of a dolerite ridge close to De Aar.

5.4 The landscape of colonial settlement

The indigenous people of Karoo waged a bitter war against colonial expansion as they gradually lost control of their traditional land. Penn (2005) notes the most determined indigenous resistance to *trekboer* expansion occurred when they entered the harsh environment of the escarpment of the interior plateau (namely Hantam, Roggeveld and Nieuweveld Mountains). Similarly *trekboer* settlers find their progress onto the upper escarpment halted as the Sneeuberg San launched an almost successful campaign to drive them out. Numerous place names throughout the Karoo such as Oorlogspoort and Oorlogskloof are testimony the skirmishes of the late 18th century. The situation became so desperate that the colonists fought back by establishing the “Kommando” system – the “hunting” of San was officially sanctioned in 1777 (Dooling 2007) and in some instances bounties were obtainable from the local landrost. The Drosdy of Graaf Reinett played a significant role in this long and bitter war which eventually saw the almost complete destruction of the Karoo bushmen.

The advent of the early European Settlers into the Great Karoo is one which is largely un-documented. These European pastoralists were highly mobile; trekking between winter and summer grazing on and off the escarpment. Land ownership was informal, and only became regulated after the implementation of the quitrent system used by the Government to control the lives and activities of the farmers.

The Europeans moved onto land associated with water sources or perennial fountains (Westbury and Sampson 1993), Many of the early settlers at first attempted to cultivate wheat, and to all accounts were successful at first. Almost all historic ruins of farm houses have associated *traplvloere* – floors where wheat was winnowed in all likelihood for domestic use. The San resisted the presence of the Europeans vigorously – life on the frontiers of the Cape was no easy matter for all parties involved. The San saw their traditional territories and hunting areas diminishing, the vast game herds of the Karoo dwindled. The San used every opportunity to impede the progress of the Europeans by raiding lonely farms, murdering the occupants and stealing stock. The Europeans were allowed by law to shoot San males on sight and take women and children into servitude. By 1770 the Karoo was the furthest frontier of the Cape Colony. By 1820 after the suppression of the San the Karoo was quickly divided into quitrent or loan farms, the process of land seizure from the indigenous inhabitants was formalized through a government regulated process of formal land grants. Even in the early 19th century there were tracts of landscape simply known as “crown land” – much of this was marginal being away from rivers and fountains. It was on these patches of crown land that the last surviving groups of San eked out a meager existence. As the land parcels that were available to them diminished, they found themselves with little option other than to works as herdsmen and servants for the colonists (Sampson, Sampson and Neville 1994, Penn 2004).

The two major regional centers in the area, Beaufort West and Graaf Reinett were established as administrative centers to exert hegemony over the activities of the *Trekboere* who were prone to behave as free agents without governance. Of the two centers, Graaf Reinett, is the oldest being establish under the Dutch rule at the Cape as a legal and administrative center. The town has an extraordinarily colourful history, as being so remote from Cape Town, its citizens were inclined to exert independence to the point that Graaff Reinet was the seat of several rebellions, and for a period a self-proclaimed republic. The appointment of the a firm-handed administrator, Andries Stockenstroom saw the dissent quelled, and ongoing problems for farmers caused by the Sneeuberg San brought to an end by force of arms. (Franzen 2006).

The central Karoo region was administered from the Drosdy at Tulbagh. Given the problems of law enforcement in remote regions Stockenstroom motivated the establishment of a sub-drosdy on the farms Hooivlakte and Bosjesmansberg. The farms were procured in 1818 and a new district was proclaimed. The new district and town subsequently became known as Beaufort West. Historically Beaufort West and Graaf Reinett were the main administrative centers until the Great Trek of the mid 19th century opened saw the settlement of lands to the north of the Gariep River. (Bulpin 1986, Fransen 2006). Outside of the main administrative areas the development of small towns took place mostly after 1860.

5.4.1 The towns

Many of the small towns of the study area developed as “kerksdorpies” or church towns (Jacobsdal, Petrusville, Luckhoff). It was a tradition of the early farmers to gather together on a monthly basis at a central area conduct a church service, socialize and trade. Eventual formal churches were built at these points (on land generally donated by farmers) that became the catalysts for settlement and commerce (Fransen 2006). The discovery of diamonds at Kimberly circa 1860 motivated the eventual construction of the railway system by the Cape Government as it wished to exert control over remote areas (Luger, Finnegan and Hart 2007). A remote farm in the Northern Cape called De Aar was selected as the meeting point of the Western, Central and Eastern railway systems linking the interior of the country with the major sea ports of the time (Cape Town, Durban and Port Elizabeth). This town started its life as a railway junction and continues to serve this function today. In the Free State the discovery of kimberlite pipes played a significant role in the development of the towns of Koffiefontein and Jagersfontein. A mission station established to evangelise destitute San and Khoekhoen was established at Colesberg.

Generally the small towns of the Free State and Northern Cape contain a wealth of heritage resources with respect to built environment (Henderson undated). Notable for surviving buildings of the mid 19th – early 20 century are Victoria West, Richmond, Hanover and Colesberg where there are a wealth of domestic and civil structures. (Northern Cape). Unfortunately whereas heritage-rich towns near Cape Town (for example) have attractive significant tourism numbers and job opportunities which help sustain their heritage qualities, few small Karoo towns appear to be using heritage in a sustainable manner. Many buildings show signs of lack of care, vacancy and illegal modification. Koffiefontein (FS) which has a deep and eventful history appears to be struggling with many of its surviving heritage buildings in poor condition. Petrusville stood out on the site inspection has having an impressive suite of conservation-worthy buildings and considerable heritage related tourism potential (figures 15,16). The town of Jacobsdal (one of the older towns in the area) which is situated in the heart of battlefield country shows no overt signs of a heritage related tourism industry despite its location, history and a number of conservation-worthy buildings in the town.

5.4.2 The farm houses

There are roughly 120 places of human settlement, the majority of which are farms (excluding towns) within the two km broad study areas of the combined three main proposed alternatives. It was not possible to document this amount of structures with the scope of this project, however almost all of these contain elements that are greater than 60 years old and as such fall within the general protections of the National Heritage Resources Act. An review of material contained within the SAHRIS database of recorded historic sites has indicated that the majority of proclaimed provincial heritage sites and graded buildings lie almost exclusively within the towns. The database material within the rural districts reflects a number of declared Boer War block houses and places of conflict. The site inspection revealed that farm houses, although many were quite old, had been heavily modified and have lost heritage value (figure 17). This is understandable as these structures are living residences which are adapted by generations of residents according to the needs and fashions of the day. A large number of older farm houses were not occupied or have been occupied by farm workers. In the Northern Cape and the Free State Province the scorched earth policy of Lord Kitchener towards the end of the South African war was a period of destruction for the vernacular architecture of the former Boer Republics. Farm houses and farms were burned and blown up so as to impede the support base of Boer Kommando's. Therefore much of the built heritage of the western Free State consists of structures built after the Union of South Africa once stability had been achieved. No farms of outstanding heritage significance were noted during the site inspection, similar a Google Earth survey of farm building foot-print forms indicated that many of the farms have been subject to alteration and were no longer in original condition.

Figure 16 Well preserved streetscape in Petrusville (will not be impacted by proposal)

Figure 15 19th century dwellings in Petrusville. Left: Victorian cottage with curvilinear veranda. Right: a pair of Dorpshuisies – one has a parapet, the other (closest) has had its windows modernized. These houses could date to just after the mid-19th century**.**

Figure 17 A series of typical rural dwellings in the western Free State. These are typically early 20th century. They are in variable, but more or less original condition.

5.5 The landscape of conflict

The Great Karoo has seen its share of conflict. The conflict between Europeans and indigenous peoples was wide-spread, however the physical remnants on this war on the landscape is almost invisible. Very few sites of this conflict has ever been identified.

The greatest impact on the landscape was that of the second South African war. The study area includes a significant landscape of conflict that has involved some of bloodiest battles of the time, including what was termed by the British as the “Black Week”. The railway line across the Northern Cape from De Aar to Kimberly was the main means of conveyance of commonwealth forces to the battle front during the opening years of the war. The Modder and Riet Rivers which cross the western Free State through the study area formed a natural barrier between the commonwealth forces intent of reaching Kimberly and later Bloemfontein (figure 22). The railway bridges and river crossings were points of heavy fighting. The town of Jacobsdal lay in the midst of the landscape of conflict which stretched from Ritchie in the West to Koffiefontein in the East forming a belt across the study area.

5.5.1 The Battle of Modder River

In late 1899 British forces under Lt General Lord Methuen worked their way northwards up the railway line with the Object of relieving Kimberly – the diamond rich city that was besieged by Boer forces. The British engaged with Boer forces first at Belmont Station south east of the railway line and fought a series of running engagements as the worked their way to the north. The Boers under the leadership of Generals Koos de la Rey and Piet Cronje dug themselves in on the Northern bank of the Modder River close to its confluence with the Riet. The Boers opened fire on unsuspecting British forces who after a day of heavy but disjointed fighting took comparatively heavy losses. In the end the commonwealth forces won the day forcing the Boers to retreat after an intense artillery fire. The Boers held up the British advance for 10 days during which time they took the opportunity to entrench themselves at a series of low dolerite hills called Magersfontein (Selby 1969, Rayner 2006). The site (figure 21) of the Battle of Modder River marked by a Commonwealth war graves cemetery (it was traditional for the British army to bury their dead on the battlefield) as well as an explanatory display board which is no longer legible. Also present at the nearby rail bridge is a partially restored block house listed on SAHRA records as having been declared a monument. The site was in a neglected condition and judging by physical evidence in its interior, was being used as a brothel.

5.5.2 Battle of Magersfontein

In December 1899 after the Battle of Modder River, Boer forces converged at Jacobsdal, then marched north west to the Magersfontein hills where they set an ambush for the commonwealth army. Under the leadership of Generals Cronje and de la Rey, the African laborers (Nkuna 1999) that accompanied the Boer army dug a system of trenches running some 10 km from the railway line to just in front of the Magersfontein hills. Here they lay in wait for the commonwealth forces.

Lord Methuen, who had very poor intelligence with respect to the layout of the Boer defenses, ordered an artillery barrage on the hills of Magersfontein believing that that was where the Boers were positioned. After a full day of artillery bombardment, the commonwealth forces advanced on foot at dawn. The Boers, safely dug into their slit tranches at the base of the hills opened fire at a range of 400 m. Within the first five minutes of the attack some 700 commonwealth troops had fallen (Rickard 2007. Selby 1969, The Magersfontein Museum).

After two days of fierce fighting, the British Forces retreated to Modder River camp to await reinforcements before attempting to reach Kimberly. The Boers had also some serious losses – their victory was attributed to excellent tactics and the valiant fight of the Scandinavian Volunteer Brigade, most of who gave their lives. Magersfontein was a huge shock for the invincible commonwealth army, but worse was to come. At Modderfontein Camp typhoid fever broke out which eventually claimed the lives of thousands of troops (Selby 1969).

Today Magersfontein battle site is one of the best preserved anywhere (figure 22). The landscape is largely intact, the trenches remain visible and the dead are still on the Battlefield. The site is run as a satellite of the McGregor Museum in Kimberly. There is a well set up field museum with a good multimedia display, a small restaurant, shop and self-guided paths around the battle site. The place itself is a powerful memorial to conflict – its natural qualities are preserved along with a sense solemnity and tranquility and vast un-spoiled vistas of the Kimberly thornveld. Here sense of place is paramount (personal observations 2013 site visit).

5.5.3 Battles of Paardeberg and Poplar Grove

These two battle sites both lie in the study area. After the battle of Magersfontein General Cronje returned to his base at Jacobsdal, but decided to move his 5000 troops as he feared that Jacobsdal would come under siege from the British. Cronje then tried to re-establish a *laager* at the crossing of the Modder River at Paardeberg (figure 19). Cronje's *laager* came under attack from Lt General Lord Kitchener. At first the Boer forces had the upper hand as they mowed down columns of commonwealth troops, however superiority in numbers prevailed. The Boer *laager* was subject to a vigorous bombardment by British artillery which destroyed horses, wagons, munitions and stores. Exhausted, starving and demoralized, General Cronje found that he had no choice but to surrender his army of 5000. This was a hard fought, but significant British victory that opened the way for the invasion of Bloemfontein. The Canadian army played a significant role (Selby 1969, Rayner 2006, Rickard 2007).

The battle of Poplar Grove which took place up a little way up the Modder River to the East, was an aftermath of the Battle of Paardeberg. The remaining Boer forces under General de Wet made a half-hearted attempt to regroup at a series of dolerite hills, but being weakened after the capture of General Cronje at Paardeberg, the Boers were no longer interested in battle in their weakened state. The British although also weekend by battle, prevailed without firing a shot.

Despite Paardeberg being a major entanglement of the Boer War with a significant outcome, the battle site is not physically commemorated. There is a memorial to fallen commonwealth troops which is evidently maintained from time to time (figure 19). At Poplar Grove there is a memorial commemorating the surrender of General Cronje however this lies behind a locked gate in a game fence. Trenches are still visible on Google Earth images. The Paardeberg itself, which marks the core of the engagement, is the site of a variety of unsightly telecommunication facilities, despite the fact that the battle site is a Provincial Heritage Site.

5.5.4 The landscape of battle

The four sites described are all related components of landscape of the Boer War in the study area (see figures 23, 24, 25). Although these events are described as "battles" in the history books, they are the hot spots of a broader confrontation that lasted for the summer of 1899-1900 involving the same generals and often the same soldiers. The town of Jacobsdal played a key role, being at first the Boer headquarters and later taken over by the British for the same purpose. Smaller skirmishes occurred across the whole area. Even further south, there are linkages to other places with the study area. At Deelfontein Station closer to Richmond are the remains of the Yeomanry hospital (Watt, AB 1987). Although now an archaeological site there is an extensive cemetery (British, Canadian, Australian troops), the remains of the Yeomanry Hotel (severely vandalized) and the foundations of hospital wards (observation; project site inspection). The site is unknown to tourists and un-commemorated, although it is frequently mentioned in historic documents.

Figure 18 A Boer War period block house near Richmond guards a railway bridge and drift. Alternative 3 would cross the road on the ridge in the background resulting in visual impacts that will change the intangible qualities of the site.

Figure 20 The Commonwealth war graves at Deelfontein (see Watt 1987) lie some 2 km away from alternative 2. The intangible and "sense of place" qualities of the site will not be affected.

Figure 19 The site of the Battle of Paardeberg is commemorated with a memorial garden. Paardeberg hill in the background has been impacted by telecommunications infrastructure despite the battle site being a provincial heritage site.

Figure 22 Magersfontein battle site is a museum and a provincial heritage site which enjoys spectacular views over the landscape (which is relatively unchanged in over 100 years). The alternative 3 route will cross the landscape resulting in immitigable impacts to the sites setting and character.

Figure 21 A memorial marks the site of the Battle of Modder River. The information board at this provincial heritage site is no longer legible.

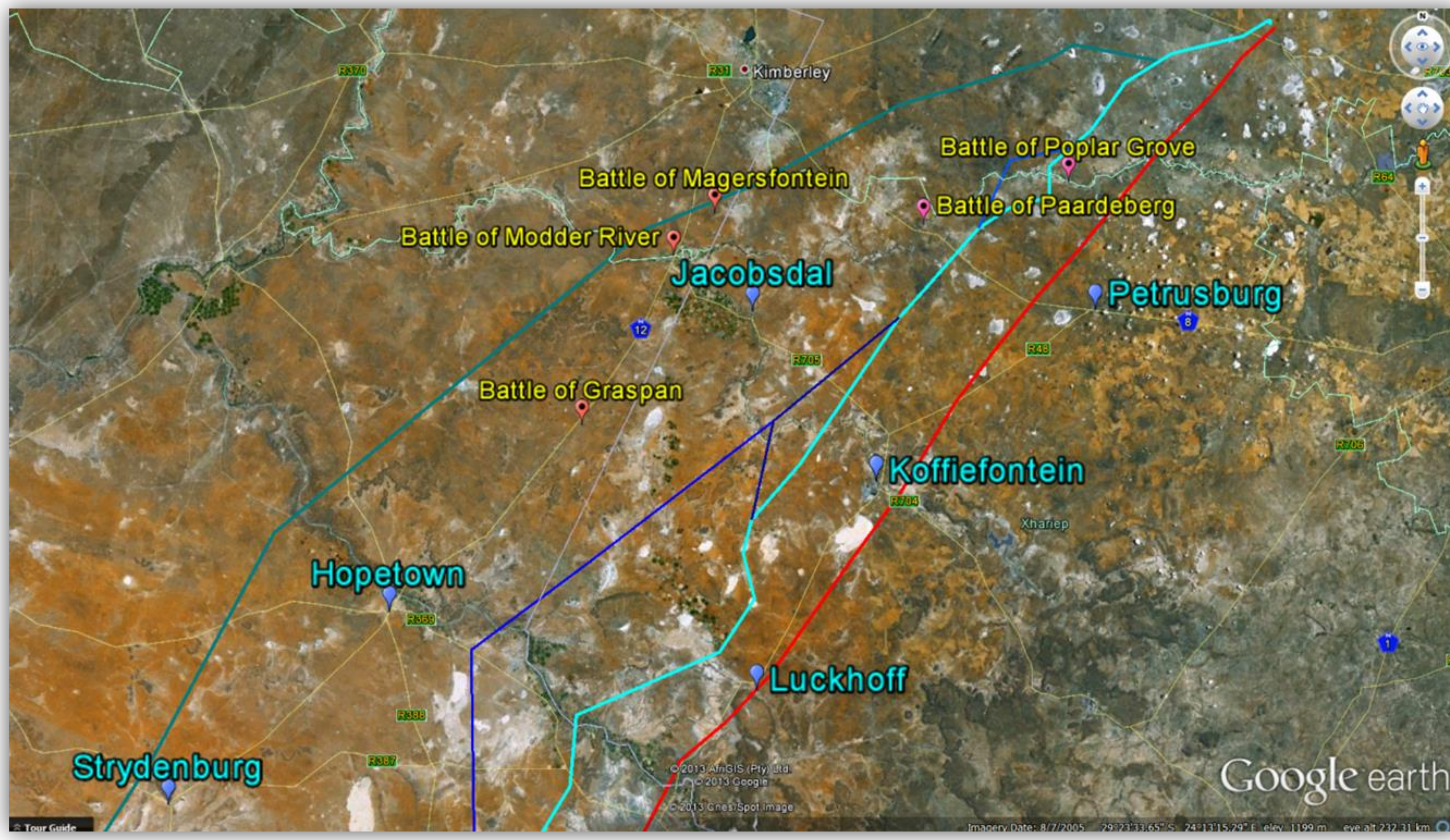

Figure 23 Map of study area north of the Gariep River. Small towns that contain protected streetscapes and buildings are indicated in blue text, while Boer War Battlefields are indicated in yellow text.

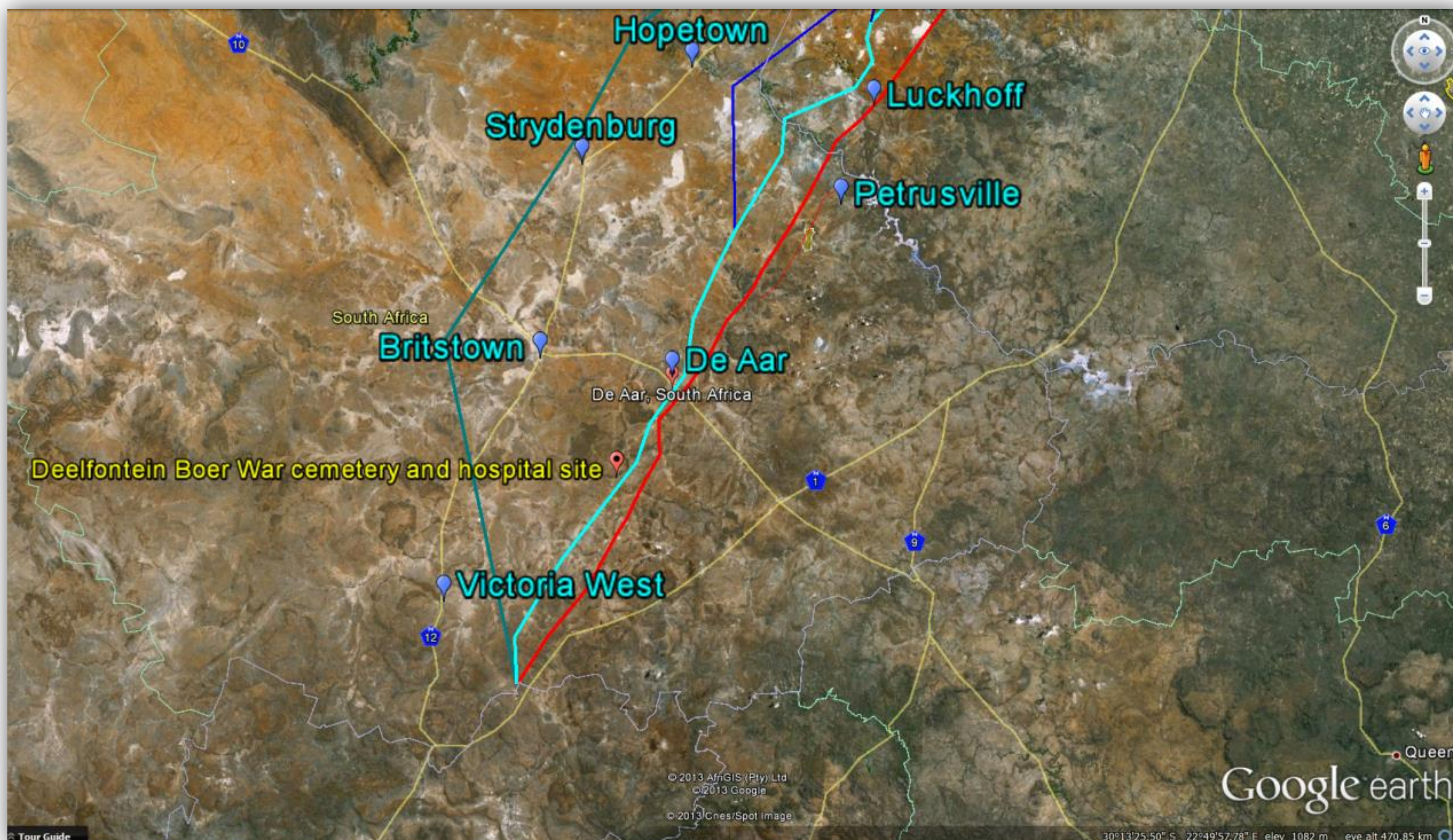

Figure 24 Map of study area south of the Gariep River. Small towns that contain protected streetscapes and buildings are indicated in blue text, while Boer War Battlefields are indicated in yellow text. Most of the major conflicts took place north of the Gariep, however the Deelfontein Military Hospital was located in safer territory south of the battle lines.

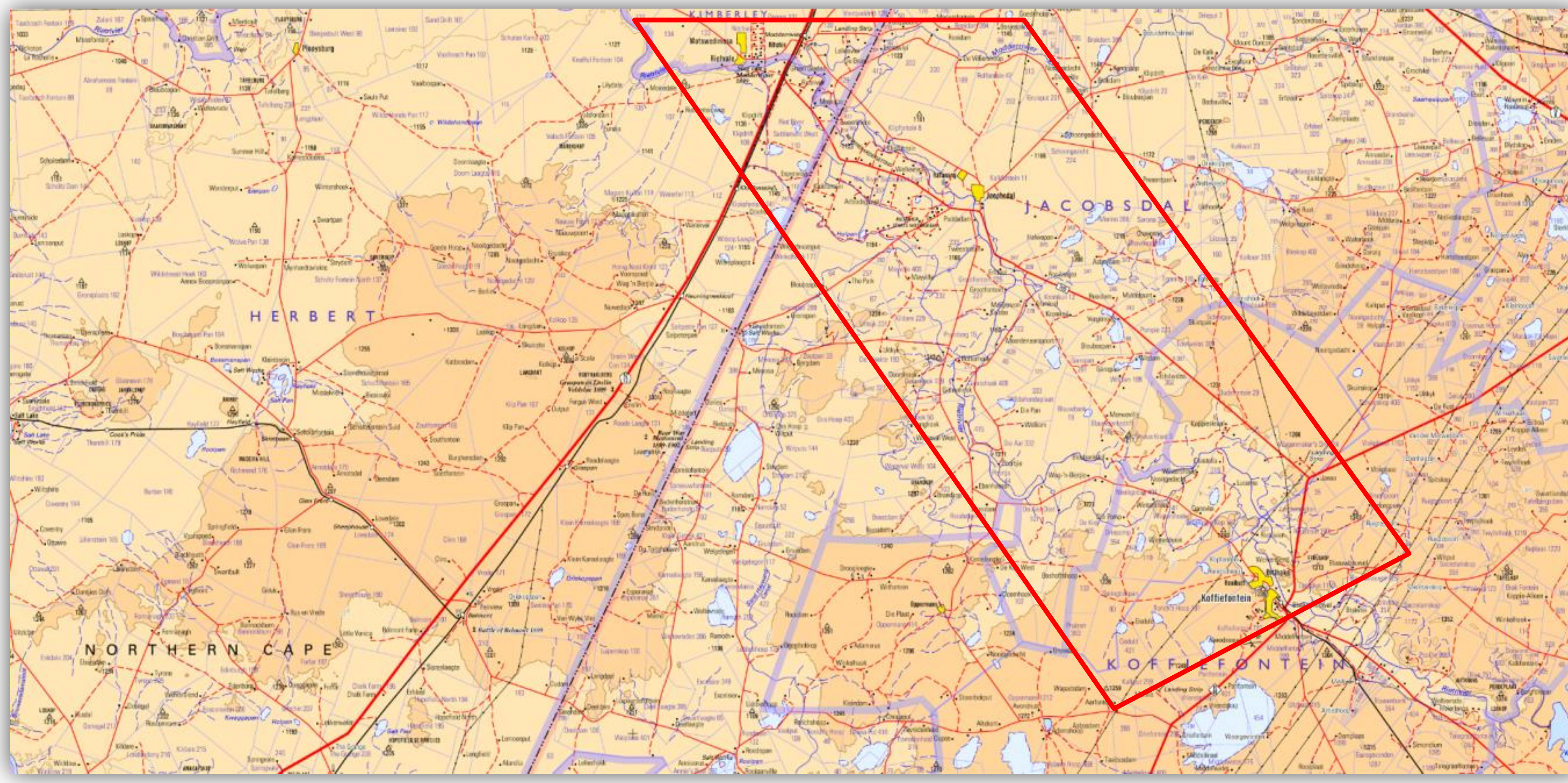

Figure 25 Extract from 1:250 000 map (Chief Director Surveys and Mapping: 2924) showing the landscape of conflict that was associated with the natural barriers of the Riet and Modder Rivers systems. Commonwealth troops engaged the Boers over a wide front between Koffiefontein and the railway to Kimberly. It is within the red polygon that 4 major battles and numerous smaller engagements took place..

6. Impacts of the alternatives

6.1 Activities that will affect the heritage environment

The transmission lines will consist of overhead cables suspended from towers (47 m high) placed 400-500 m apart. Each steel tower will need to be mounted on a concrete footing (1 sqm each) and supported by steel guy cables which are drilled into bedrock. Hence each point of land surface disturbance is confined to the few square meters of the towers bases. The actual servitude (which will be 100 m wide) will require a service road (normally an unpaved track) while the servitude will have to be cleared of tree cover. During construction the landscape will be subject to a period of temporary disturbance when construction equipment is brought onto site for building of the towers and lifting of the cables.

Heritage sites can be negatively affected through disturbance of the land surface, destruction of significant structures and places as well as any action that will alter the feel and appearance of an historic place or building. Hence, transmission lines are likely to result in moderate impacts to the land surface during the construction phase but permanent changes in terms of visual impacts and changes to the feel of a landscape.

The transmission lines will be visible to any receptor within 5-8 kms (weather and time of day dependent), but the degree that they would be considered unsightly or intrusive is a subjective perception. For purposes of this study the position has been taken that a transmission line situated within 500 m of a heritage site will negatively affect the setting of that heritage site. Furthermore heritage sites that derive significance from their context may be negatively affected by cluttering of scenery and views.

The following potential impacts on heritage resources for the alternatives have been identified.

6.2 Potential Impacts to Palaeontological heritage

Palaeontology is susceptible to physical impacts that destroy fossils. Typically destructive activities are quarrying, construction of road cuttings and excavations. Of concern with respect to this project is destruction of fossil material that may be caused by excavation of the footings for the transmission line towers. The advantage of using “v” towers is that the excavations that are required are very small and thus the impact of the proposed activity will be of LOW significance relative to the size of the overall project. The impact to palaeontology is unlikely to carry enough weight alone to influence the choice of route alternative, but combined with other heritage related factors, it will play a role in the overall outcome.

Negative impacts on local fossil heritage are mainly anticipated during the construction phase of the transmission line development in connection with excavations for transmission tower footings and stays as well as surface clearance and new cuttings made for service roads and laydown areas. The magnitude of these impacts is largely determined by the transmission line corridor that is chosen. Upgrading of existing substations, installation of a telecommunication mast and construction camps are unlikely to generate significant additional palaeontological impacts. Once constructed, the operational and decommissioning phases of the transmission line are unlikely to involve further adverse impacts on palaeontological heritage.

There are positive benefits in terms of impacts to handling palaeontology correctly. Already the amount of knowledge that has accumulated as a result of the numerous assessments throughout the country is beginning to make its mark on science and knowledge – more is known about RSA as a result. It is possible that important scientific benefit can be derived from material rescued as part of a mitigation program, however a fossil that is destroyed without allowing it to yield knowledge, is information lost forever.

6.2.1 Comparison of route options in terms of palaeontological sensitivity

Alternative 1 (preferred option) has the advantage of being the shortest, most direct route between the Gamma and Perseus substations, running essentially SW – NE between Hutchinson (Northern Cape) and Dealesville (Free State) *via* De Aar along existing servitudes. The number of transmission line tower positions and length of new service roads are therefore at a minimum. The underlying bedrock geology is less varied than for Route 3 (see below). It mainly comprises Permo-Carboniferous lacustrine / marine to continental Karoo Supergroup sediments of the Ecca Group (Tierberg and Waterford Formations) and Lower Beaufort Group (Abrahamskraal and Teekloof Formations) that are extensively intruded by sills and dykes of the Early Jurassic Karoo Dolerite Suite. These older bedrocks are mantled by Late Caenozoic superficial sediments of generally low palaeontological sensitivity (*e.g.* alluvium, colluvium, calcrete hardpans, windblown sands, surface gravels) over large stretches of the proposed transmission line corridor. Potentially fossiliferous High Level Gravels of Tertiary / Quaternary age are not mapped along major drainage systems (*e.g.* Orange, Riet and Modder Rivers) within the Route 1 corridor. The overall palaeontological sensitivity along most sectors of the line is LOW, in large part due to poor exposure, near-surface calcretisation and weathering, as well as thermal metamorphism (baking) of potentially fossiliferous Palaeozoic bedrocks (notably the Lower Beaufort Group). Sectors of potentially HIGH palaeontological sensitivity are largely confined to the Victoria West, south-eastern Britstown and south-western Colesberg 1: 250 000 sheet areas between Hutchinson and De Aar. These sectors are underlain by the Lower Beaufort Group (Abrahamskraal and Teekloof Formations), well-known for its diverse Middle to Late Permian vertebrate faunas, and/or by shallow shelf facies of the Waterford Formation that are characterised by abundant trace fossils as well as well-preserved petrified wood and other plant remains. Small areas of pan sediments on flatter terrain within the Koffiefontein and Kimberley sheet areas may also be of palaeontological significance (*e.g.* for Caenozoic mammal remains). Older (pre-Holocene) alluvial sediments and surface gravels throughout the transmission line corridor may also contain important fossil biotas (e.g. mammalian skeletal remains, reworked petrified wood) but these deposits are not usually mapped at 1: 250 000 scale and can only be recognised through fieldwork.

Alternative 2 runs broadly sub-parallel to Route 1 and only some 20 km or less further to the west. The underlying geological is very similar to that already outlined for Route 1 and involves the same spectrum of rock units. As for the preferred route, sectors of HIGH palaeontological sensitivity due to the presence here of Lower Beaufort and uppermost Ecca Group bedrocks are confined to the south-western portion of the transmission line corridor (Victoria West, Britstown and Colesberg 1: 250 000 sheet areas). Most sectors are of LOW palaeontological sensitivity, with the possible exception of isolated pans. There is no marked preference between Routes 1 and 2 on palaeontological heritage grounds.

The three diversions from Route 2, known as Routes 2a, 2b and 2c, share a very similar geology to Route 2 itself, and are in all cases are assessed as having a LOW palaeontological sensitivity. **Route 2a** provides a longer, slightly more westerly route across the Orange and Riet Rivers. It passes close to, but does not cross, potentially fossiliferous Lower Ecca Group sediments close to the Orange River, and probably has a lower impact on pans than Route 2. **Route 2b** provides an alternative, more westerly crossing of the Riet River as does **Route 2c** with respect the Modder River. Apart from probable higher impacts on pans than Route 2 itself, they are not otherwise significantly different to the last in terms of palaeontological sensitivity. Consequently none of these diversions are preferred to the basic Route 2 on palaeontological heritage grounds.

Alternative 3 is by far the longest of the proposed transmission line corridors. From Hutchinson it follows a broadly curved route, convex towards the northwest, taking it fairly close to Britstown, Strydenburg, Hopetown, Ritchie, Kimberley and Boshof *en route* to Dealesville. It is also the most varied route in geological terms, cutting down-section through the Karoo Supergroup stratigraphy onto basement rocks along the northern margin of the Main Karoo Basin. In addition to the bedrock units and Late Caenozoic superficial sediments represented along Routes 1 and 2 (listed above), Route 3 also transects marine / lacustrine sediments of the Early to Middle Permian lower Ecca Group (Prince Albert and Whitehill Formations), Permo-carboniferous glacial sediments of the Dwyka Group, lavas and interbedded sediments of the Precambrian Ventersdorp Supergroup (*e.g.* Allanridge Formation) as well as very minor kimberlite intrusions of probable Cretaceous age. Of these, the lower Ecca formations may be highly fossiliferous (marine invertebrates, aquatic mesosaurid reptiles and fish, petrified wood, trace fossils *etc*). Sectors of HIGH palaeontological sensitivity along Route 3 include those underlain by Lower Beaufort Group and Waterford Formation rocks on the Victoria West sheet, by alluvial deposits of the ancient Koa River drainage system (known elsewhere for Tertiary mammal remains) towards the middle of the Britstown sheet, and by lower Ecca Group mudrocks (Prince Albert Formation) on the Britstown and (to a minor extent) Prieska sheets. The remaining sectors are assessed as having a LOW overall palaeontological sensitivity, with the possible exception of fairly numerous pans, for similar reasons to those given above for comparable sectors along Routes 1 and 2. Given its greater length (more tower positions, longer service roads) as well as better representation of palaeontologically sensitive rock units, Route 3 is anticipated to have a significantly higher overall impact on palaeontological heritage resources than Routes 1 and 2.

6.2.2 Palaeontological heritage: comparison of the alternatives

It is argued that alternatives 1 and 2 are likely to be of similar palaeontological sensitivity as the geology is similar overall. The shorter the route, the lower the possibility of impacts.

Least favoured

Alternative 3 is the longest of the routes. Its passes through sensitive geology with a high potential to yield fossils.

Most favoured

The preferred alternative 1 and 2 (including deviations) are equally favoured, as this is the shortest route which also utilizes a corridor that already has transmission line infrastructure. This could allow sharing of access roads thus decreasing new impacts.

6.3 Potential impacts to pre-colonial archaeology

The Zeekoei Valley Archaeological Project is the only existing saturation survey in the Great Karoo that can used as a device to "predict" the frequency of direct impacts to archaeological sites. Sampson 1985 conducted an audit of impacts his area of work in the Great Karoo and states the following:

"Widening of the N I national road took place during the survey, and we recorded the destruction of 11 surface sites (over a distance of 34 km)*. It is reasonable to estimate, therefore, that another dozen sites were lost during the original N1 construction, and another dozen or so during the railway construction. Powerlines have no marked impact on surface sites in this terrain* (with reference to the De Aar to Eastern Cape 400 kV lines over a 37 km stretch)*. Secondary roads fail to obliterate surface sites, except for very small lithic scatters of only a few dozen flakes. Hundreds of surface sites have been truncated by such roads, but their presence is still obvious on the graded edges, and they are almost all still identifiable to industry (phase). In many cases their surface areas can still be measured as well. Farm tracks have no serious impact on surface sites.*

Among the farming developments most threatening to surface sites are dams, weirs, and soil conservation programs involving mechanical levelling of eroded streambank silts – a relatively recent innovation. Any of these can totally obliterate surface sites. Ubiquitous small earthen weirs placed immediately upslope of most spring eyes invariably destroyed the configuration of a few sites, but their site identities are still mappable from the artifacts caught up in the dam walls. Surprisingly, farm buildings and stockpens also fail to completely obliterate sites, although shapes and sizes of sites are usually not recoverable once they are incorporated within a farm werf. However, any large , well-kept lawn in front of the farmhouse will obliterate a site. Beyond the *farm yard, sheep camp fences, boundary fences, and telephone poles have virtually no impact at all. Many hundreds of sites have fences passing through them without any visible distortions. Dry-stone walled stock enclosures used before the advent of barbed wire fences to pen livestock at night were positioned in many of the same places used by the makers of the Lockshoek, Interior Wilton and Smithfield industries. Although they frequently disrupted the configurations of these sites, they do not submerge them completely. Lucerne lands are a minor disruptive feature, but they tend to be placed in areas not frequently used in the prehistoric past." (Sampson 1985).*

Given Sampson's observations and our own experience it is argued that the impact of the construction of power lines is limited. The likelihood of towers directly impacting archaeological sites is low, and in the event of this happening the impact will be over a small area.

Of perhaps greater concern are the service roads, laydown areas and construction camps. If these are to be physically prepared or mechanically scraped, impacts can be expected to occur. If the power line service road (which runs through the servitude) is to be a simple 4x4 track, the amount of damage that will occur will be substantially less. Impacts to sites on the plains are likely to be very small, however the likelihood of impacts occurring increases in hilly areas, river valleys and on dolerite dykes and outcrops is rather higher as this is where many archaeological are typically situated.

Summary

- Archaeological sites of the Early, Middle and Late Stone Age will be found in the corridors of all alternatives with similar frequency. Dolerite ridges, dykes and mazes are likely to be the most sensitive land forms in terms of the archaeology of Khoekhoen and San.
- Rock engravings are also likely to be found in the corridors of all alternatives.
- There are no declared sites in any of the alternatives.

6.3.1 Archaeological heritage: comparison of the alternatives

It is argued that the three alternative routes and the three deviations on route 2 are likely to be of similar archaeological sensitivity as the frequency of archaeological sites per km is likely to be similar overall. Clearly, the shorter the route, the lower the possibility of impacts.

Least favoured

Alternative 3 is the longest of the routes. It passes through the most isolated and least transformed portions of the study area (including Mokala National Park). Good quality archaeological sites are more likely to occur in these areas and it is best that they and their context are conserved. The length of this alternative renders impacts more likely therefore its use is discouraged.

Intermediate

Alternative 2 and deviations is an acceptable but not favoured option on account that this is a new route that passes through mostly untransformed landscape hence the archaeology is probably well preserved. It is marginally longer than alternative 1.

Most favoured
The preferred alternative 1 is most favoured, as this is the shortest route which also utilizes a corridor that already has transmission line infrastructure. This could allow sharing of access roads thus decreasing new impacts.

6.4 Impacts to colonial period heritage

Impacts to colonial period heritage are expected to be confined to changes to the quality of the setting of farm houses on the selected alternative. Eskom will try as a first option to avoid impacting farm houses and settlements, but should it not be possible to exclude a structure from the servitudes, demolition may be necessary. While there are farms within 1 km of the corridor center on all alternatives, none of these have been declared as Provincial Heritage sites. Almost all the farms that were examined (as is typical of the Karoo) were found to have attributes that were historical and fell within the general protections of the National Heritage Resources Act. Such attributes include farm grave yards, old stone wall alignments barns and sheds and farm residences. Aside from unlikely event of total demolition, the main impact that will occur relate to changes to sense of place and setting, and not to physical fabric.

Any heritage site that relies on its context to derive is income or sustainability will be affected. For example a heritage building that is used as a guest house or hotel will come under medium to long term threat if the setting and context of the site is damaged by degrading of its aesthetic values. Fortunately within the study area indications are that there are few such sites that fit into this category.

Individual residences that lie within 2 km of the transmission lines will experience changes to their views, however how an individual interprets this aesthetic change is subjective. Certainly any residence within 500 m of the transmission line will experience a noticeable, and negative change in the quality of the local environment.

Few of the towns in the study area will be directly affected by the proposed transmission lines as the majority of them lie outside of danger of visual impact. Two towns lie close or on preferred alternative 1. These are Koffiefontein where the transmission line would pass over the R704 some 3 km outside of town, and the small church town of Luckhoff where the transmission line corridor passes directly through the town.

Koffiefontein. This is an old diamond mining town with an interesting history containing much 19th and early 29th century heritage in terms of the buildings of the town and its early industrial heritage (Raper undated). It was also involved and various engagements during the second Boer War. The point at which the proposed transmission line crosses the R704 outside the town will not result in any aesthetic impacts that will affect the town as the “gateway precinct” or entry into the town is very well defined and at the urban edge.

Luckhoff is a small church town dating to the late 19th century. It contains a variety of Victorian buildings which are not formally declared or graded. There is one graded Provincial Heritage Site – a explosives magazine. The placing of Alternative 1 transmission line through this town cannot be entertained therefore the route would need to be adjusted to avoid the town by moving it 3000 m east or west of the indicated alignment. If this can be achieved, impacts would largely be avoided (Raper undated).

De Aar lies to the east of both Alternatives 1 and 2. This central Karoo town continues to play a regional economic role, however it is much changed in heritage terms. Few of the early 20th century buildings have been conserved apart from the town churches and administrative buildings. Being a railway junction and an economic hub, it is very much a working town. The proposed transmission line routes alternatives 1 and 2 pass the west side of town through a corridor already used by power lines to the Hydra HV Yard. The area (on the west side of De Aar Junction) is fairly industrial in character and contains a number of new sub-economic development areas. The qualities of the town will not be impacted.

In summary:

- No graded urban or farm related buildings will be impacted by any of the alternatives.
- There is a low possibility that protected structures (farm houses and ruins) may be directly impacted or require demolition (all alternatives but less so for alternative 3).
- There is a strong possibility that structures, farm cemeteries and farm houses will be visually impacted within 1 km of all alternatives, but less so for alternative 3.
- The town of Luckhoff is the only small town that may be impacted (by alternative 1). No other urban areas will be impacted.

6.4.1 Built environment: Comparison of alternatives

Alternative 2 is *least preferred*. Although it is estimated there are some 40 – 45 groups of buildings within the 2 km radius (depending which deviation is used), nine of these lie within 200 m of the center of the corridor. There is no precedent of existing power lines which means that new impacts will be very intrusive.

Alternative 1 is the *intermediary preferred* as there a at least 44 building clusters (excluding towns) within the 2 km radius of the lines, of which 9 lie within 200 m of the center of the corridor. Having said this there are very few structures that are of high heritage value, so the degree of "least preferred-ness" is mitigated by the presence of other existing power lines in the corridor. To avoid proliferating visual impacts through the Karoo, it makes sense to confine areas of vertical visual impact to a restricted area.

Alternative 1 is arguably *preferred* for the reason that this is the least populated area. Only 18 clusters of buildings were identified along the route, of which only 3 lie within 200 m of the center of the corridor, hence impacts on the built environment will be the lowest. Unfortunately alternative 3 has other flaws in terms of its crossing a National Park and Magersfontein Battle Site (a declared monument).

Summary:

- There is a landscape of conflict of *international significance* in the study area that includes the railway to Kimberly in the west and continues eastwards along the Modder and Riet Rivers as far as Koffiefontein in the east. It is the most commemorated of all the heritage sites in the study area.
- The landscape of conflict includes 4 battlefields and sites of numerous smaller engagements.
- The battle sites include war graves, trenches, features and battle related archaeology.
- The most celebrated of the battle sites is Magersfontein. This constitutes a fatal flaw for alternative 3.

6.5 Impacts to the landscape of conflict

The battle sites that lie within the study area are clearly the most celebrated heritage sites and therefore should be considered the most sensitive. This significance of this conflict must not be under estimated. It was an international war – British soldiers (English, Scottish and Welsh) as well as units from Canada and Australia fought for the Commonwealth, while on the Boer's sides there were volunteers from Scandinavia, Germany, Eastern Europe as well as at least 15 000 black South Africans (Nkuna 1999). It was the dawn of the age of modern fire arms warfare – the lessons learned by the nations involved were later employed during WW1. The term "Commando" is used in connection with elite forces around the world. The loss of life from both disease and action was considerable. All the battlefields are effectively graves, which are also protected as "Victims of Conflict" by the NHRA.

Battlefields are remembered as places where important historic events took place, as places of memory dignity and serenity. It is important that these aesthetic qualities are maintained in any development planning.

Summary:

- There is a landscape of conflict in the study area that includes the railway to Kimberly in the west and continues eastwards along the Modder and Riet Rivers as far as Koffiefontein in the east. It is the most commemorated of all the heritage sites in the study area.
- All the battle sites are Provincial Heritage sites and should be considered to be cemeteries.
- The landscape of conflict includes 4 battlefields and sites of numerous smaller engagements.
- The battle sites include war graves, trenches, features and battle related archaeology.
- The most celebrated of the battle sites is Magersfontein. This constitutes a fatal flaw for alternative 3.

Least favoured: The corridor for alternative route 3 crosses the Magersfontein Battle Site between the railway line and the Magersfontein hills. In heritage terms this is a fatal flaw in terms of the possible physical impacts of bisection of the heritage site, physical disturbance, but also from the destruction of sense of place. The Magersfontein Museum is heavily focused on the commemoration of the landscape and vistas over the historic site. Without an extensive deviation that would move the transmission lines at least 15 km east of the site, immitigable impacts will result.

Intermediary favoured: Alternative 2 passes through the landscape of conflict between the battle sites at Paardeberg and Poplar Grove. While neither of these sites is as visually sensitive or celebrated as Magersfontein the transmission lines would be uncomfortably close and will constitute a visual aesthetic impact to this highly significant battle site landscape.

Preferred alternative: The site of the Battle of Poplar Grove marks most westerly point of major engagement on the Riet-Modder River landscape of conflict. The preferred alternative passes comfortably to the east bypassing the landscape of conflict. Of the three alternatives presented, alternative 1 will have the least impact.

7. Overall ranking of the alternatives

Table 1 contained below summarizes preferences in terms of the sub-disciplines of heritage that we have considered in this study. It is important to note that this is an un-weighted visual representation. No aspect of heritage is weighted against another in terms of priority. The nature of this impacts that could result are taken into final consideration.

Sub discipline	*Alternative 1*	*Alternative 2*	*Alternative 3*
Palaeontology	Most preferred	Most preferred	Least preferred
Archaeology	Most preferred	Intermediate preferred	Least preferred
Built Environment	Least preferred	Intermediate preferred	Most preferred
Military history	Most Preferred.	Intermediate preferred	Least preferred (fatally flawed)

The findings of the study are that in general heritage terms the preferred Alternative 1 is found to be the most desirable. The main reasons for this is that it avoids the most significant of the Boer War battle sites and that it largely follows the route of an existing suite of power lines as far as the Hydra HV yard at De Aar. It is shorter and passes through Karoo landscapes that are already visually transformed by existing transmission lines. Being the shortest and most direct of the routes, the amount of landscape that it will impact is smaller. Technically negotiations for servitude rights may be easier as land owners in many instances will already have been involved in prior negotiation. The more direct the route, the less the need to erect unsightly strain tower at points where the line changes direction. Moderate alteration of the route will be needed to take into account the presence of the town of Luckhoff in the center corridor.

Alternative 3 would have been an ideal route in terms of minimizing impacts to built-environment but the presence of a major heritage site and a National Park on the proposed route renders it fatally flawed in its current form.

Alternative 2 is an acceptable alternative should Alternative 1 be not available on other environmental grounds. It crosses a sensitive landscape of conflict between the sites of the Battle of Poplar Grove and Paardeberg which could result in a medium degree of negative impact on heritage grounds.

The use of alternative 1 is generally supported in this study. Both Alternatives 1 and 2 (and deviations of 2) could form the basis of the EIA phase of this work.

8. Recommendations

8.1 Palaeontology

Palaeontological heritage considerations are unlikely to play a major role in deciding between the various transmission line routes under consideration. A realistic palaeontological heritage impact assessment for the Gamma – Perseus second 765 kV transmission line project, with recommendations for any mitigation necessary, is only possible once the chosen transmission line corridor has been surveyed in the field by a professional palaeontologist. It is recommended that such a pre-construction field-based assessment be carried out at the earliest opportunity once the route is chosen so that any significant palaeontological heritage issues may be addressed at the project design stage.

It should be noted that the most likely outcome of such a field assessment study is that most - but not all - sectors of the transmission line corridor prove to be palaeontologically insensitive in practice because of a thick superficial sediment cover, high degree of near-surface weathering, baking by igneous intrusions, or sparse fossil content. No further specialist studies or mitigation is then required within these insensitive sectors, pending the discovery of significant new fossil remains during construction. However, short sectors of high palaeontological sensitivity, with a concentration of near-surface fossil material, may also be identified and mapped. These sensitive corridor sectors may require Phase 2 mitigation or, in exceptional cases, reconsideration of tower positions.

The recommended pre-construction palaeontological field survey should focus on areas of good sedimentary rock exposure along, or close to, the chosen transmission line corridor. The focus of the study should be on identifying those sectors of the corridor (if any) that are demonstrably, or inferred to be, of high palaeontological sensitivity so that detailed recommendations regarding mitigation of impacts during the pre-construction or construction phases may be developed.

Effective mitigation of palaeontological heritage within the transmission line corridor may only be feasible once the route and positions of individual structures (towers, substations, access roads, construction camps, borrow pits *etc*) have been finalised. However, pre-construction specialist mitigation of selected development sites and corridor sectors may be necessary in some more sensitive cases – for example, to:

- locate, record and judiciously sample any valuable fossil material already exposed at the ground surface which might be damaged during early development (*e.g.* vertebrate remains and petrified wood from the Karoo Supergroup), together with pertinent geological data, and

- make specific recommendations for mitigation during the construction phase, such as monitoring of key excavations, recording and sampling of newly exposed fossil material. These mitigation recommendations should be incorporated into the EMP for the transmission line development.

8.2 General heritage

Subject to the recommendations of the heritage authorities in the Free State and Northern Cape Province, or SAHRA by agency, it is not considered necessary to return to site for the assessment phase of the project unless additional concerns arise through the public process that will need a site inspection to resolve, or the proposed referred route undergoes substantive change.

A much more critical component of controlling impacts to all aspects of heritage is the fact that a **walk-down of the final alternative** must take place as it is only at this stage will it be possible on a micro-scale control the impacts that service roads and tower footings will have on all physical aspects of heritage.

The walk-down phase should include:

- At site inspection by a palaeontologist once the technical parameters of the project are established.
- The recording of the positions and contents of archaeological sites and rock engravings by an archaeologist.
- The recording of ruins, farm buildings and historic features within or adjacent to the proposed servitude.
- The identification of graves within or close to the proposed servitude.
- The presentation of such findings to the proponent for their consideration in terms of placement of infrastructure.
- The lodging of the findings with the regional heritage bodies.

9. Conclusion

The study area, which traverses the Great Karoo in the Northern and Eastern Cape Provinces, is rich in a wide variety of heritage sites. Since this vast landscape is generally only moderately transformed, it contains a wealth of well preserved archaeological sites; one of the deepest palaeontological sequences in the world, and in later years was the last refuge of the Southern African San before their ancient lifestyle became extinct after settlement of the land by Dutch colonists. The study area also contains the sites of some of the most significant battles of the Boer War. It is no exaggeration to state that the heritage of this region is diverse and profoundly interesting. The proposed activity, while massive in its extent involves an accumulatively very moderate amount of disturbance of the physical landscape, which results in it being an acceptable activity in terms of the laws of the land, as long as mitigation is carried out where needed and the best route is chosen.

9.1 Accumulative impacts

From a broader perspective the possible accumulative impacts of projects of this nature as well as the fluorescence of renewable energy proposals is a cause for concern and needs to be incorporated in overall planning for the region. The open spaces of the Karoo, its wilderness qualities and characteristic small towns collectively form a heritage resource of both national and international significance.

The proposed activity is considered acceptable in heritage terms as defined in the NHRA. The low physical impact of the proposed activity has a low chance of significantly affecting any heritage sites, places, buildings, palaeontology, archaeology or objects. It is anticipated that successful mitigation of impacts is expected to be achievable provided that a **walk-down** is carried out and minor adjustments to the final route and tower footing positions is carried out.

The preferred alternative 1 is considered to be the most appropriate for the proposed activity, while alternative 2 and deviations are also acceptable, but will result in moderate impacts to the Boer War landscape of conflict.

10. References

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