PHASE 1 PALAEONTOLOGICAL ASSESSMENT FOR THE PROPOSED GREATER BULWER-DONNYBROOK BULK WATER SUPPLY SCHEME (GBDBWSS): HARRY GWALA DISTRICT MUNICIPALITY, KWAZULU-NATAL

FOR

Harry Gwala District Municipality

DATE: 5 January 2017

By

Dr. Gideon Groenewald

Cell: 078 713 6377

EXECUTIVE SUMMARY

Dr. Gideon Groenewald was appointed by **Kinvig and Associates** to undertake a Phase 1 Palaeontological Impact Assessment, assessing the potential Palaeontological Impact related to the proposed Greater Bulwer-Donnybrook Bulk Water Supply Scheme (GBDBWSS): Harry Gwala District Municipality, Kwazulu-Natal.

This Palaeontological Assessment forms part of the Heritage Impact Assessment (HIA) and complies with the requirements of the South African National Heritage Resource Act No 25 of 1999 as well as the KwaZulu-Natal Heritage Act No 4 of 2008. In accordance with Section 38 of the National Resources Act No 25 of 1999 (Heritage Resources Management), a HIA is required to assess any potential impacts to palaeontological heritage within the development footprint.

The development site for the proposed Palaeontological Impact related to the proposed Greater Bulwer-Donnybrook Bulk Water Supply Scheme (GBDBWSS): Harry Gwala District Municipality, Kwazulu-Natal Province, is underlain by Permian aged sedimentary rocks of the Ecca and Beaufort Groups as well as Dolerite of the Karoo Supergroup as well as minor sections underlain by Masotcheni Formation clays.

Several poorly defined fossils were observed during the field investigation. The potential for finding significant fossils in any excavation into sediments of the Ecca and Beaufort Groups is high. No fossils will be associated with areas underlain by dolerite.

It is recommended that:

- The EAP and ECO must be informed of the fact that a Moderate Palaeontological sensitivity was allocated to the areas of the development underlain by rocks of the Ecca Group and a High Palaeontological sensitivity is allocated to areas underlain by rocks of the Beaufort Group. Although highly weathered, trace and plant fossils were recorded during the Phase 1 field investigation and a “Chance Find Protocol” will be prepared to assist with planning for the conservation of Palaeontological Heritage.
- All areas allocated a red, orange or green colour in Figure 9 must be visited by a suitably qualified Palaeontologist, or an accredited assistant, during excavations of trenches exceeding 1.5m in depth into sediments of the Ecca and Beaufort Groups. A protocol for the chance find of fossils must be developed and discussed with the contractor on site.
- These recommendations must be included in the EMPr of this project.

TABLE OF CONTENT

TABLE OF FIGURES

LIST OF TABLES

INTRODUCTION

Dr. Gideon Groenewald was appointed by **Kinvig and Associates** to undertake a Phase 1 Palaeontological Impact Assessment, assessing the potential Palaeontological Impact related to the proposed Greater Bulwer-Donnybrook Bulk Water Supply Scheme (GBDBWSS): Harry Gwala District Municipality, Kwazulu-Natal.

The purpose of this Phase 1 Palaeontological Impact Assessment is to identify exposed and potential Palaeontological Heritage on the site of the proposed development, to assess the impact the development may have on this resource, and to make recommendations as to how this impact might be mitigated.

Legal Requirements

This Palaeontological Assessment forms part of the Heritage Impact Assessment (HIA) and complies with the requirements of the South African National Heritage Resource Act No 25 of 1999 as well as the KwaZulu-Natal Heritage Act No 4 of 2008. In accordance with Section 38 of the National Resources Act No 25 of 1999 (Heritage Resources Management), a HIA is required to assess any potential impacts to palaeontological heritage within the development footprint.

Categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act, and which therefore fall under its protection, include:

- geological sites of scientific or cultural importance;
- objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens; and
- objects with the potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage.

Aims and Methodology

A Phase 1 investigation is often the last opportunity to record the fossil heritage within the development footprint. These records are very important to understand the past and form an important part of South Africa's National Estate.

Following the "*SAHRA APM Guidelines: Minimum Standards for the Archaeological & Palaeontological Components of Impact Assessment Reports*" the aims of the palaeontological impact assessment are:

- to identifying exposed and subsurface rock formations that are considered to be palaeontologically significant;
- to assessing the level of palaeontological significance of these formations;
- to comment on the impact of the development on these exposed and/or potential fossil resources and
- to make recommendations as to how the developer should conserve or mitigate damage to these resources.

Prior to the field investigation a preliminary assessment (desktop study) of the topography and geology of the study area was made using appropriate 1:250 000 geological maps (2928 Drakensberg; 2930 Durban; 3028 Kokstad; 3030 Port Shepstone) in conjunction with Google Earth. Potential fossiliferous rock units (groups, formations etc) were identified within the study area and the known fossil heritage within each rock unit was inventoried from the published scientific literature, previous palaeontological impact studies in the same region and the author's field experience.

Priority palaeontological areas were identified within the development footprint to focus the field investigator's time and resources. The aim of the fieldwork was to document any exposed fossil material and to assess the palaeontological potential of the region in terms of the type and extent of rock outcrop in the area.

The likely impact of the proposed development on local fossil heritage was determined on the basis of the palaeontological sensitivity of the rock units concerned and the nature and scale of the development itself, most notably the minimal extent of bedrock excavation envisaged. The different sensitivity classes used are explained in Table 1 below.

Table 1 Palaeontological sensitivity analysis outcome classification

PALAEONTOLOGICAL SIGNIFICANCE/VULNERABILITY OF ROCK UNITS	
The following colour scheme is proposed for the indication of palaeontological sensitivity classes. This classification of sensitivity is adapted from that of Almond et al (2008, 2009) (Groenewald et al., 2014).	
RED	**Very High Palaeontological sensitivity/vulnerability.** Development will most likely have a very significant impact on the Palaeontological Heritage of the region. Very high possibility that significant fossil assemblages will be present in all outcrops of the unit. Appointment of professional palaeontologist, desktop survey, phase I Palaeontological Impact Assessment (PIA) (field survey and recording of fossils) and phase II PIA (rescue of fossils during construction) as well as application for collection and destruction permit compulsory.
ORANGE	**High Palaeontological sensitivity/vulnerability.** High possibility that significant fossil assemblages will be present in most of the outcrop areas of the unit. Fossils most likely to occur in associated sediments or underlying units, for example in the areas underlain by Transvaal Supergroup dolomite where Cenozoic cave deposits are likely to occur. Appointment of professional palaeontologist, desktop survey and phase I Palaeontological Impact Assessment (field survey and collection of fossils) compulsory. Early application for collection permit recommended. Highly likely that a Phase II PIA will be applicable during the construction phase of projects.
GREEN	**Moderate Palaeontological sensitivity/vulnerability.** High possibility that fossils will be present in the outcrop areas of the unit or in associated sediments that underlie the unit. For example areas underlain by the Gordonia Formation or undifferentiated soils and alluvium. Fossils described in the literature are visible with the naked eye and development can have a significant impact on the Palaeontological Heritage of the area. Recording of fossils will contribute significantly to the present knowledge of the development of life in the geological record of the region. Appointment of a professional palaeontologist, desktop survey and phase I PIA (ground proofing of desktop survey) recommended.
BLUE	**Low Palaeontological sensitivity/vulnerability.** Low possibility that fossils that are described in the literature will be visible to the naked eye or be recognized as fossils by untrained persons. Fossils of for example small domal Stromatolites as well as micro-bacteria are associated with these rock units. Fossils of micro-bacteria are extremely important for our understanding of the development of Life, but are only visible under large magnification. Recording of the fossils will contribute significantly to the present knowledge and understanding of the development of Life in the region. Where geological units are allocated a blue colour of significance, and the geological unit is surrounded by highly significant geological units (red or orange coloured units), a palaeontologist must be appointed to do a desktop survey and to make professional recommendations on the impact of development on

	significant palaeontological finds that might occur in the unit that is allocated a blue colour. An example of this scenario will be where the scale of mapping on the 1:250 000 scale maps excludes small outcrops of highly significant sedimentary rock units occurring in larger alluvium deposits. Collection of a representative sample of potential fossiliferous material is recommended.
GREY	**Very Low Palaeontological sensitivity/vulnerability.** Very low possibility that significant fossils will be present in the bedrock of these geological units. The rock units are associated with intrusive igneous activities and no life would have been possible during implacement of the rocks. It is however essential to note that the geological units mapped out on the geological maps are invariably overlain by Cenozoic aged sediments that might contain significant fossil assemblages and archaeological material. Examples of significant finds occur in areas underlain by granite, just to the west of Hoedspruit in the Limpopo Province, where significant assemblages of fossils and clay-pot fragments are associated with large termite mounds. Where geological units are allocated a grey colour of significance, and the geological unit is surrounded by very high and highly significant geological units (red or orange coloured units), a palaeontologist must be appointed to do a desktop survey and to make professional recommendations on the impact of development on significant palaeontological finds that might occur in the unit that is allocated a grey colour. An example of this scenario will be where the scale of mapping on the 1:250 000 scale maps excludes small outcrops of highly significant sedimentary rock units occurring in dolerite sill outcrops. It is important that the report should also refer to archaeological reports and possible descriptions of palaeontological finds in Cenozoic aged surface deposits.

When rock units of moderate to high palaeontological sensitivity are present within the development footprint, palaeontological mitigation measures should be incorporated into the Environmental Management Plan.

Scope and Limitations of the Phase 1 Investigation

The scope of a phase 1 Investigation includes:

- an analysis of the area's stratigraphy, age and depositional setting of fossil-bearing units;
- a review of all relevant palaeontological and geological literature, including geological maps, and previous palaeontological impact reports;
- data on the proposed development provided by the developer (e.g. location of footprint, depth and volume of bedrock excavation envisaged) and
- where feasible, location and examination of any fossil collections from the study area (e.g. museums).
- an on-site investigation to assess the identified palaeontological sensitive areas within the development footprint/study area rather than formal palaeontological collection. The investigation focussed on the bedrock

exposure where excavations would most probably require palaeontological monitoring.

The results of the field investigation are used to predict the potential of buried fossil heritage within the development footprint. In some investigations, this involves the examination of similar accessible bedrock exposures, such as road cuttings and quarries, along roads that run parallel to or across the development footprint.

Locality and Proposed Development

The Harry Gwala District Municipality plans to upgrade the present status of the Greater Bulwer-Donnybrook Bulk Water Supply Scheme (GBDBWSS) in KwaZulu-Natal (Figure 1).

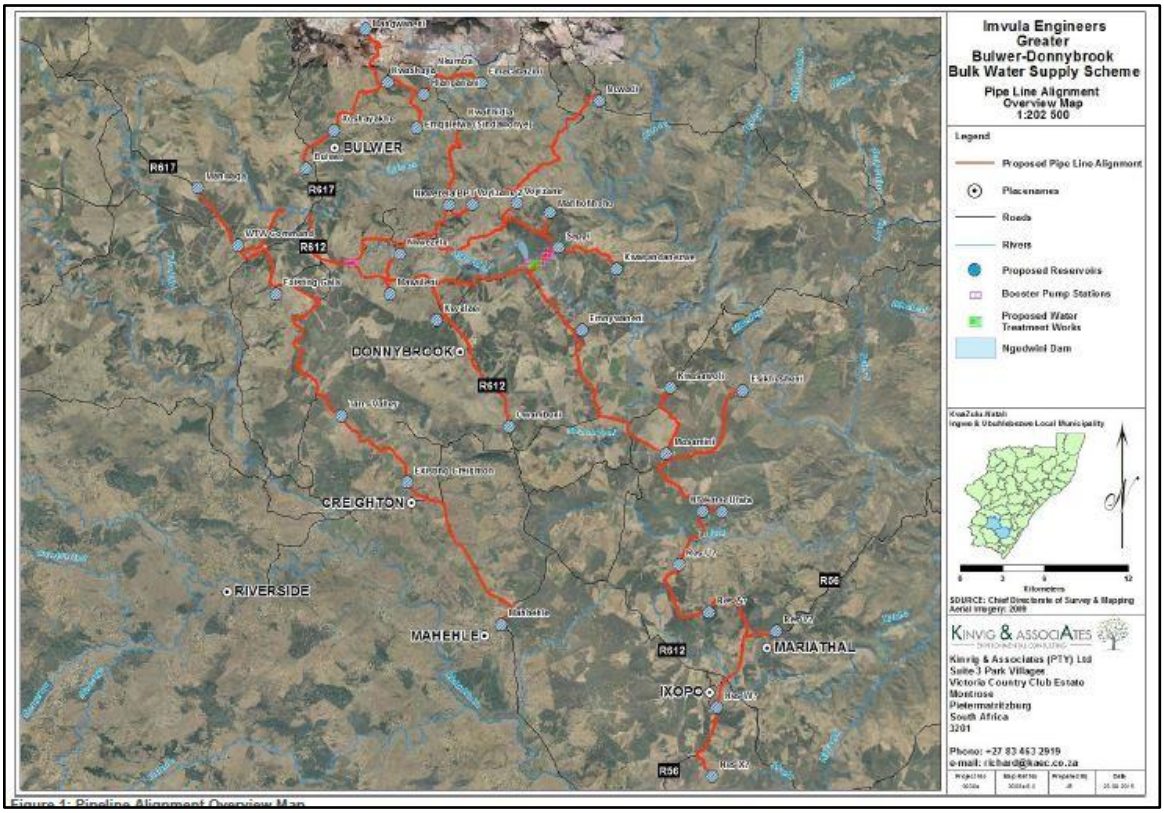


Figure 1 Layout of the GBDBWSS Project

The Harry Gwala District Municipality proposes to construct two hundred and seventy (270 km) kilometres of potable water pipe mains of diameter 110 mm to 550 mm, for the supply of water from the *Ngudwini* Dam and *Stephen Dlamini (Bulwer)* Dam to new bulk water infrastructure in the Harry Gwala District Municipality. The proposed project infrastructure is indicated in Figure 1 above:

- 270 km of potable water pipeline of size 110 mm to 800 mm;

- abstraction points from dams (Ngudwini Dam and Stephen Dlamini (Bulwer) Dam (under construction)) with existing Environmental Authorisations;
- water treatment works;
- main pump stations with 3 booster pump stations;
- 37 reservoirs with storage capacities ranging from 250 KL to 10 ML; and,
- Associated infrastructure.

The majority of the pipeline is proposed to follows existing road servitudes (alongside the R612 from the R617 to Donnybrook; and to the east on other un-named roads) connecting existing and new reservoirs and pipelines.

GEOLOGY

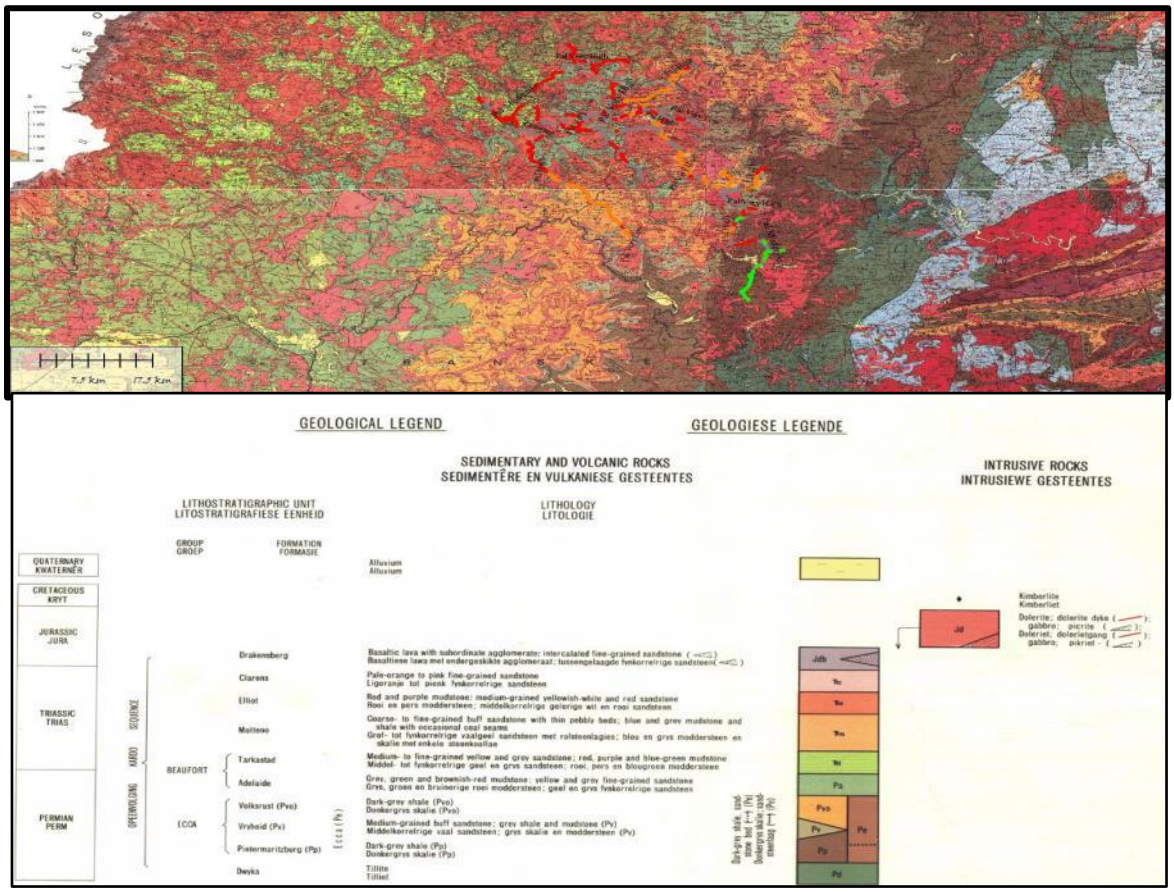


Figure 2 Geology of the study area

The study area is underlain predominantly by Permian aged rocks of the, Ecca, and Beaufort Groups and Dolerite of the Karoo Supergroup as well as Quaternary aged sand and silt of the Masotcheni Formation and Alluvium of the local rivers (Figure 2).

Karoo Supergroup

Ecca Group

Pietermaritzburg Formation (Pp)

The Permian aged Pietermaritzburg Formation is a monotonous sequence of dark grey shale and mudstone, representing a marine deposit in the north-eastern part of the Karoo Basin and no outcrops have been recorded in the study area (Johnson et al, 2009).

Vryheid Formation

The Permian aged Vryheid formation consists mainly of interbedded coarse-grained sandstone and dark grey mudstone and shale. North of the study area this formation is extensively mined for economic quantities of coal (Johnson et al, 2009). The Vryheid Formation might be a time-equivalent of the Whitehill Formation in the south of the Karoo Basin.

Volksrust Formation (Pvo)

The Permian aged Volksrust Formation is an assemblage of fine-grained sediments, consisting mainly of dark grey mudstone and shale. The deposits represent Permian aged marine deposits that were deposited in offshore shelf, but possibly also nearshore / lacustrine / lagoonal environments in this part of Gondwanaland. The upper part of the formation becomes more sandstone rich and is indicative of a westward migration of a deltaic system into the predominantly marine environments that existed during the Permian in this part of the Karoo Basin (Johnson et al, 2009). The upper part of the Volksrust Formation is more sandstone rich and there is an indication that this units might correlate with the Waterford Formation in the south of the basin (Groenewald, 2016). The new information need to be assessed by SACS (South African Committee for Stratigraphy).

Beaufort Group

The Permian to Triassic aged Beaufort Group consists of two distinct units, a lower Adelaide Subgroup and an upper Tarkastad Subgroup. The Permian aged Adelaide Subgroup, comprising the Normandien Formation, consists of darker coloured mudstones and sandstone and is overlain by the Triassic aged Tarkastad Subgroup with predominantly red mudstone and sandstone.

Adelaide Subgroup, Normandien Formation

The Normandien Formation is a fluvial meandering river deposit (Groenewald, 1990) and comprises of a sequence of coarse and fine-grained sandstone with minor coal beds (Johnson et al 2009). SACS (South African Committee for

Stratigraphy) still needs to publish a formal note on the lithostratigraphy of the Escarpment at Harrismith. Groenewald (1984, 1989) completed the most recent formal academic study of the complete section and it is now informally accepted that the Normandien Formation comprises the entire Adelaide Subgroup (Groenewald, 2016; Groenewald, 1990, 1996; Johnson et al 2009).

The geological history of the Drakensberg Escarpment region represents the final sedimentation into the Ecca Sea about 260 million years ago. Deltaic deposits of the "Estcourt Formation" contain evidence of an abundance of marine and probably estuarine invertebrates that left a wealth of trace fossils in the rock record (MacRae, 1999; McCarthy and Rubidge, 2005). The overlying fluvial deposits of the Normandien Formation (Groenewald, 1989; Johnson et al 2006) with prominent sandstone members (Rooinek and Schoondraai Members) represent a progressive basin ward migration of the depositional system.

The Tarkastad Subgroup

Katberg/Verkykerskop Formations

The Katberg Formation is defined as the lower sandstone-rich unit of the Tarkastad Subgroup and consists of fine-grained sandstone with a main provenance to the southeast. The Verkykerskop Formation is a time equivalent of the Katberg Formation, but consists predominantly of coarse-grained sandstone with a provenance to the northeast (Groenewald, 1996; Johnson et al, 2006).

Burgersdorp/Driekoppen Formations

The Katberg and Verkykerskop formations are overlain by red mudstones of the Burgersdorp and Driekoppen formations (Groenewald 1996; Johnson et al, 2006).

Dolerite (Jd)

Large sections of the development cut into Jurassic aged dolerite sill areas and although not mapped on this scale, several dolerite dyke structures are known to be present in this study area.

Masotcheni Formation (Qm)

Quaternary aged sandy and clayey colluvium and alluvial soils and palaeosoils cover large low-lying parts of the landscape, with special reference to the footslopes of the hills.

Alluvium

Quaternary aged sandy alluvium represent resent deposits of sand and sandy clay along the floodplains of the local rivers in KwaZulu-Natal.

Groundwater Related Features

The study area is underlain by shale of the Pietermaritzburg Formation, coarse-grained sandstone of the Vryheid Formation, shale of the Volksrust Formation, sandstone and shale of the Normandien Formation and fine-grained sandstone of the Katberg Formation. All these secondary aquifers rocks are relatively low yielding aquifers. The dolerite sill structures and colluvium or alluvium in the valleys can be relatively good aquifers and the most vulnerable secondary aquifers are the linear dolerite dyke aquifers. These structures are mapped out as Highly Sensitive sites on the Palaeontological Sensitivity map.

The sandy soils of the colluvial and alluvial deposits are very good primary aquifer units and must be protected against groundwater pollution at all cost.

PALAEONTOLOGY

Ecca Group

Pietermaritzburg Formation (Pp)

Fossils are generally absent from the Formation although trace fossils have been recorded from the upper layers of the Pietermaritzburg Formation by Linstrom (1987).

Vryheid Formation

The Vryheid Formation is well-known for the occurrence of coal beds that resulted from the accumulation of plant material over long periods of time. Plant fossils described by Bamford (2011) from the Vryheid Formation are; *Azaniodendron fertile, Cyclodendron leslii, Sphenophyllum hammanskraalensis, Annularia sp., Raniganjia sp., Asterotheca spp., Liknopetalon enigmata, Glossopteris > 20 species, Hirsutum 4 spp., Scutum 4 spp., Ottokaria 3 spp., Estcourtia sp., Arberia 4 spp., Lidgetonnia sp., Noeggerathiopsis sp. and Podocarpidites sp.*

According to Bamford (2011) "*Little data have been published on these potentially fossiliferous deposits. Around the coalmines there is most likely to be good material and yet in other areas the exposures may be too poor to be of interest. When they do occur fossil plants are usually abundant and it would not be feasible to preserve and maintain all the sites, however, in the interests*

of heritage and science such sites should be well recorded, sampled and the fossils kept in a suitable institution".

Although no vertebrate fossils have been recorded from the Vryheid Formation, invertebrate trace fossils have been described in some detail by Mason and Christie (1985). It should be noted, however, that the aquatic reptile, *Mesosaurus*, which is the earliest known reptile from the Karoo Basin, as well as fish (*Palaeoniscus capensis*), have been recorded in equivalent-aged strata in the Whitehill Formation in the southern part of the basin (MacRae, 1999; Modesto, 2006). Indications are that the Whitehill Formation in the main basin might be correlated with the mid-Vryheid Formation. If this assumption proves correct, there is a possibility that *Mesosaurus* could be found in the Vryheid Formation (Catuneanu et al 2005).

The late Carboniferous to early Jurassic Karoo Supergroup of South Africa includes economically important coal deposits within the Vryheid Formation of Natal. The Karoo sediments are almost entirely lacking in body fossils but ichnofossils (trace fossils) are locally abundant. Modern sedimentological and ichnofaunal studies suggest that the north-eastern part of the Karoo basin was marine. In KwaZulu-Natal a shallow basin margin accommodated a prograding fluviodeltaic complex forming a broad sandy platform on which coal-bearing sediments were deposited. Ichnofossils include U-burrows (formerly *Corophioides*) which are assigned to ichnogenus *Diplocraterion* (Mason and Christie, 1985).

Volksrust Formation

Extremely well- defined and significant trace fossils as well as plant fossils of the Glossopteris Assemblage have been described from the upper layers of the Formation (Johnson et al. 2009; Groenewald, 2016). Concretions containing significant coprolites of fish and some bone material are present in this formation just to the east of Ladysmith and the recording of these remains are now the first recordings of its kind in KwaZulu-Natal. It is highly likely that similar recordings will be made during the construction phase of this road. A collection permit for fossils will be required for this project.

The bivalve *Megadesmus* is described from the Late Permian Volksrust Shale Formation in the north-eastern Karoo Basin, South Africa; this is the first reported discovery of this genus in Africa. The fossil is large, 9 cm dorsally and 8.4 cm laterally, and both valves are articulated indicating minimum transport after death. The bivalve was encased in interbedded siltstone-shale that constitutes the distal sediments of a prograding delta at the Beaufort – Ecca Group boundary.

Megadesmus is known from other continents (Australia, India, Siberia, South America and Tasmania) where its presence indicates exclusively marine conditions. The implication for the northeastern Karoo Basin during the Late Permian is that a marine enclave still existed in this geographic area and that terrestrial conditions did not yet prevail as in the southern basin region (Cairncross, 2005).

Beaufort Group

These 250 million year old rocks record the largest known extinction event, the end-Permian mass extinction, in which most of the known species died out.

The Beaufort Group is well-known for its richness in fossils of vertebrates and also includes several recordings of unique vertebrate burrows. (Groenewald 1991; Johnson and Verster , 1994; Rubidge, 1995; Groenewald 1996; Groenewald et al, 2001 and; Johnson et al, 2009, Groenewald, 2016).

Adelaide Subgroup (In some areas mapped as the Adelaide Formation, now formally the Normandien Formation)

The Adelaide Subgroup overlies the Volksrust Formation of the Ecca Group and the transition from deep water deposits of the Volksrust Formation to pro-delataic and deltaic deposits of the Beaufort Group present fieldworkers with problems in mapping these units (Groenewald, 1984; Muntingh, 1989; Johnson and Verster, 1994; Johnson et al, 2009). The Adelaide Subgroup comprises the *Daptocephalus* (previously *Dicynodon)* Assemblage Zone (and possibly the underlying *Cistecephalus* Assemblage Zone (Van der Walt et al, 2010; Viglietti et al, 2016; Groenewald, 2016).

Normandien Formation

The Normandien Formation comprises all the sediments of the Adelaide Subgroup and includes the Estcourt Formation (Johnson and Verster, 1989).The Karoo Basin in South Africa is well known for the fact that it represents the most complete sequence of sedimentary history in Gondwana and contains the remains of most of the therapsids (ancient ancestors of mammals) that roamed the Earth during the Permian Period (Rubidge, 1995; MacRae, 1999; McCarthy and Rubidge, 2005). The most significant geological event recorded in this sequence is the end-Permian mass extinction event (EPME) that occurred 252.4 million years ago when much of all life on Earth was terminated. This event is probably associated with the Schoondraai Member of the Normandien Formation. The 2010 excavations for the Bedford Dam of the Ingula Pumped Storage Scheme (Groenewald, 2011) provided a unique opportunity to collect vertebrate fossils, trace fossils

of invertebrates (i.e. trackways, burrows) as well as plants from the rocks that were deposited during the Late Permian.

Permian Vertebrates (255 to 252 million years ago)

Permian vertebrates from the *Cistecephalus* and *Daptocephalus* assemblage zones in the main Karoo Basin include at least three genera of fish, four genera of amphibians, eight genera of parareptiles (the sister group to true reptiles), three genera of diapsid reptiles (i.e. true reptiles) and 66 genera of therapsids (ancestors of mammals) (Rubidge 1995; Smith et al, 2012). Fish, amphibians, parareptiles and diapsid reptiles from these assemblage zones are relatively rare, both in terms of number of species and number of individuals. However, therapsid fossils are known by the hundreds and form the bulk of vertebrate fossils collected from these assemblage zones.

Dicynodonts ("Two Dog Toothed animals") are well-known herbivorous (plant-eating) therapsids from the Karoo Basin. They reached up to 4 metres in length and are characterized by a horny beak and tusks. Some of the oldest examples of this group have never been recorded from the Harrismith escarpment due to deep weathering of the mudstones. One such animal is the dicynodont *Rachiocephalus,* only recorded from Warden, far towards the west (Groenewald, 1984). However, at least 35 dicynodont genera are known from the Beaufort Group in South Africa and although only a few genera have been recorded from KwaZulu Natal strata, this is most likely due to a lack of collecting activity as the most intensive collecting has taken place in the main Karoo Basin. KwaZulu Natal strata however, have the potential to contain at least 21 dicynodont genera, which are known from the Permian *Cistecephalus* and *Daptocephalus* assemblage zones in the main Karoo Basin, and these deposits are also preserved in KwaZulu Natal.

The most important indicator of the beginning of the largest and most severe mass extinction on Earth is the disappearance of almost all of the dicynodont therapsids. Only one dicynodont genus, *Lystrosaurus*, has been recorded from both sides of the Permo-Triassic boundary. After this bottle neck, however, the dicynodonts recovered and diversified during the Middle Triassic.

Although the dicynodonts were by far the most abundant vertebrates in South Africa during the Permian, other therapsids lived and often predated

upon these herbivores. The gorgonopsians and therocephalians are such examples.

Gorgonopsians were one of the most fearsome predators to have roamed the Earth. These animals had unusually long canines nearly 20 cm in length (Figures 5.1 and 5.2). Gorgonopsians were the dominant predators during the Late Permian. They grew up to 5 metres in length and are often termed the 'sabred-toothed cats' of the Permian due to their exceptionally long canines. They were slightly more mammal-like compared to their ancestors and several key features in the skull and skeleton show that they had begun to move and feed similar to mammals. During the excavation of a gorgonopsian at the Ingula Bedford Dam, a small skull of a dicynodont was found associated with its ribs, possibly representing the last meal of the predator. These unique finds are only possible if the palaeontologist is on site at all times during an excavation.

Figure 3 Example of a fossil skull of a Gorgonopsid found at Ingula Transfer Scheme

At least 19 gorgonopsian genera are known from the *Cistecephalus* and *Daptocephalus* assemblage zones of the main Karoo Basin, and thus there is a potential of finding this many genera in KwaZulu Natal as well. Gorgonopsian remains are relatively rare, being the top predators of the

Figure 4 Reconstruction of the animals that roamed the deposits of the Drakensberg Escarpment during the Late Permian

food web, and thus were not nearly as abundant as the herbivorous dicynodonts. Consequently, any recovery of a gorgonopsian fossil is a significant find.

Another group of therapsids, the biarmosuchians, are closely related to gorgonopsians, but more primitive, and although exceptionally rare, have been recovered from the *Cistecephalus* and *Daptocephalus* assemblage zones of the main Karoo Basin. Five genera (Smith et al, 2012) are currently known from these strata and could potentially be recovered from equivalent strata in Kwazulu Natal as well.

The other main group of predatory therapsids during the Permian were the therocephalians. They looked superficially similar to mammals and are one of the few vertebrate groups to have survived the end-Permian mass extinction relatively unscathed and are thus important specimens in Permo-Triassic research pertaining to the end-Permian mass extinction. Twenty-

two therocephalian genera have been recovered from the *Cistecephalus* and *Daptocephalus* assemblage zones of the main Karoo Basin (Smith et al, 2012), and have the potential to be preserved in equivalent strata in Kwazulu Natal.

Cynodonts are the most mammal-like therapsids and are the direct ancestors of living mammals. They are thus fundamental to research on the origin and evolution of mammals. At least 26 cynodont genera have been recovered from the main Karoo Basin, four of which are known from the Permian *Cistecephalus* and *Daptocephalus* assemblage zones (Botha-Brink et al, 2012; Smith et al, 2012; Smith pers. Comm.. 2012), and may be potentially preserved in equivalent Kwazulu Natal deposits.

Large burrows, associated with the large dicynodonts *Daptocephalus* and *Lystrosaurus maccaigi* have also been discovered in the uppermost portion of the *Daptocephalus* Assemblage Zone in the main Karoo Basin (Botha-Brink, pers. Comm., 2012) and have the potential to be preserved in equivalent strata in Kwazulu Natal.

Plant and Insect fossils from the Permian Normandien Formation

The Normandien Formation is well known for rich assemblages of plant fossils, mainly *Glossopteris, Phyllotheca* and other flora including ferns, clubmosses, liverworts and true mosses (McCarthy and Rubidge, 2005). Insect remains have been recorded from several localities (Lacey et al, 1975; Johnson and Verster, 1994 and Michael Motovski, pers comm., 2012). Of special note is a locality near Bulwer that contains numerous plant and insect fossils. Insect families include Perlaria (including one holotype), Protorthoptera, Protelytroptera, Miomoptera (including one holotype), Psocoptera/Hemiptera, Homoptera, Neuroptera (including one holotype) and Mecoptera (including two holotypes). This site comprises one of the richest fossil insect sites in the world, but is currently unprotected and under constant destruction as was the case with localities at Mooi River, Lidgetton, Mount West, Balgowan, and Far End (Geertsemal et al 2002).

Triassic Vertebrates (252 to 180 million years ago)

Numerous remains representing the survivors of the end-Permian mass extinction have been recovered from localities in the Free State and Eastern Cape Provinces in South Africa. Although no evidence of the extinction event is known from the Drakensberg Escarpment, survivors of the event are associated with the Early Triassic *Lystrosaurus* Assemblage Zone which is mostly represented by the Harrismith Member (Groenewald, 1989;

Muntingh, 1989). *Lystrosaurus*, after which the assemblage zone is named, is the most abundant vertebrate found directly after the end-Permian mass extinction event. It is the only dicynodont genus found on either side of the Permo-Triassic boundary. Other Early Triassic vertebrates include large predators such as the archosauriform reptile *Proterosuchus* and the therocephalian therapsid *Moschorhinus*, as well as more relatively abundant cynodonts such as the insectivorous *Thrinaxodon* and *Galesaurus* (Rubidge et al, 1995; MacRae, 1999; Botha and Smith 2006). All vertebrates from this assemblage zone formed an important part of the recovery ecosystem following the end-Permian mass extinction and thus any finds from this zone are significant. Approximately one fish genus, 10 amphibian genera, five parareptile genera, five diapsid reptile genera, two dicynodont genera, seven therocephalian genera and four cynodont genera have been recorded from the *Lystrosaurus* Assemblage Zone, many of which have been recorded from the Harrismith Member in Kwazulu Natal.

The lower part of the *Lystrosaurus* Assemblage Zone is also well-known for preserving burrows of various sizes that may be associated with invertebrates (e.g. *Katbergia*) and vertebrates such as dicynodonts, therocephalians and cynodonts. These important trace fossils provide important information about the behaviour of these animals (Botha and Smith, 2006; Modesto and Botha-Brink, 2010).

In the study area, there are numerouys localities that contain the dicynodont *Lystrosaurus curvatus* . This animal is restricted to the uppermost strata of the Permian *Daptocephalus* Assemblage Zone and lowermost strata of the Triassic *Lystrosaurus* Assemblage Zone, and as such, acts as a biostratigraphic marker for the Permo-Triassic boundary (Botha and Smith, 2007). Thus, any locality that contains *Lystrosaurus curvatus* has the potential to contain a complete sequence marking the end-Permian mass extinction, and should thus be considered extremely sensitive.

Tarkastad Subgroup

Katberg/Verkykerskop Formations

The Katberg and Verkykerskop formations are well-defined sandstone rich units along the Drakensberg Escarpment and the lower boundary of the Tarkastad Subgroup is mapped out over the entire escarpment. The Katberg and Verkykerskop Formations are associated with the middle and upper portion of the *Lystrosaurus* Assemblage Zone.

Burgersdorp/Driekoppen Formations

The Burgersdorp/Driekoppen formations are associated with the Middle Triassic *Cynognathus* Assemblage Zone (Rubidge, 1995). Current database information shows that no fossils from this time have been found in Kwazulu Natal, but the lack of fossils may be ascribed to a lack of intensive collecting, as numerous vertebrate fossils have been recorded from this formation in other areas such as Qwaqwa and Golden Gate National Park (Groenewald et al, 2001; Rubidge 1995; Smith et al, 2012). These include seven fish genera, 16 amphibian genera, six parareptile genera, six diapsid reptile genera, four dicynodont genera, two therocephalian genera and 11 cynodont genera (Smith et al, 2012; Botha-Brink, pers. Comm. 2012). One of the most spectacular finds are casts of vertebrate burrows containing fossils of the cynodont *Trirachodon* near the town Clarens (Groenewald et al, 2001). Other burrows from the *Cynognathus* Assemblage Zone have been found associated with procolophonid parareptiles in the main Karoo Basin (Botha-Brink, pers. Comm. 2012).

Dolerite (Jd)

Dolerite is an igneous rock and will not contain fossils. It is however very important to note that dolerite contact zones with sedimentary rock units are the most important aquifer rocks in KwaZulu-Natal. These zones can follow dolerite sill boundaries but are also associated with very extensive linear dolerite dyke systems that are rarely mapped out on large scale geological maps.

Masothcheni Formation (Qm)

The Quaternary aged sediments of the Masotcheni Formation has up to 2016 been regarded as of low Palaeontological significance (Groenewald et al 2014). Very recent (August 2016) finds of significant vertebrate remains in this Formation just to the east of Ladysmith (PIA for Lombardskop Bulk Water Pipeline Development in progress, Groenewald, 2016) has now caused the upgrading of this formation to highly significant for Palaeontological Heritage impact. Although still unidentified, the vertebrate remains might indicate significant finds of animals as young as 5 million years ago in the sediments on the footslopes of landscapes in KwaZulu-Natal. That can lead to significant finds of similar fossils as those discovered at Cornelia in the Free State Province.

Alluvium

No significant fossils of Quaternary age have to date been recorded from the alluvium of the local rivers to date, but very significant fossils were recorded in similarly aged sediments elsewhere in KwaZulu-Natal, where these finds are now

recorded for the first time. It is therefore recommended that the ECO must be aware of the possibility of finding vertebrate remains of Quaternary aged animals. If recorded, these remains will contribute significantly to our knowledge of the past eco-systems in this part of South Africa during the Quaternary.

GROUNDWATER AQUIFERS AND HERITAGE ITEMS

The groundwater heritage items are related to known and potential groundwater resources such as recorded natural spring sites as well as potential linear aquifers that can be affected by the proposed development.

No significant spring sites are recorded on the present editions maps (2928 Drakensberg; 2930 Durban; 3028 Kokstad;3030 Port Shepstone) geological map although several obviously important potential linear aquifers (fault zones) cut the study area. The potential pollution of groundwater resources must be discussed and mitigated and, if the recommendations to mitigate are followed, no further significant influence on this National Heritage Item is foreseen by the Palaeontological Impact Specialist.

PRELIMINARY ASSESSMENT RESULTS

The palaeontological sensitivity was predicted after identifying potentially fossiliferous rock units; ascertaining the fossil heritage from the literature and evaluating the nature and scale of the development itself. The palaeontological sensitivity was predicted as highly significant, due to the potential abundance of Permian aged fossils, including trace, plant, invertebrate and vertebrate fossils, in the Ecca and Beaufort Groups.

FIELD INVESTIGATION

Dr. Gideon Groenewald, experienced fieldworker, visited the site of the proposed Greater Bulwer-Donnybrook Bulk Water Supply Scheme (GBDBWSS): Harry Gwala District Municipality, Kwazulu-Natal on Monday 19th December 2016 to Thursday 22nd December 2016. The topography of the area is mostly rugged mountains sides in the river valleys, and rolling hills of Natal Midland grassland and or exotic tree plantations away from the deeper valleys. The site of the proposed development is on all landform terrains of the landscape, varying from crests, middle slopes to footslopes and valley floors where large parts of the land surface is in some way or another altered by human development. This includes road infrastructure, informal housing development, ploughed fields, exotic forest plantations etc.

The soil cover vary from shallow to very deep Avalon, Hutton and Clovelly soil forms to deep Estcourt, Rensburg and Valsrivier soil forms on the middle and footslopes to mostly Inhoek and Dundee soils in the valley floors. Wetlands are commonly associated with dolerite sill features and seepages are common on the steep hill-sides in the study area. Weathering is in most cases very deep, leading to the unfortunate loss of fossil material, but also, on the other hand, leading to slumping at road cuttings that expose bedrock for fossil hunters.

Excavations for the new development will expose mostly siltstone and shale of the Ecca and Beaufort Group and it is highly likely that significant fossils will be exposed in the mudstone layers. This includes the illusive insect remains that abounds in these rocks, but could not be found during this field session, mostly because of time constraints. The presence of the well-defined mudstone layers with carbonaceous layers as well as confirmation of the exposure of red mudstone, is a clear indication of the possible presence of insect remains and the “Chance Find Protocol” will include the procedures that the contractor must follow to record these important finds (Geertsemal et al, 2002)

Observations were recorded at different GPS stations (Figure 5 and Table 2).

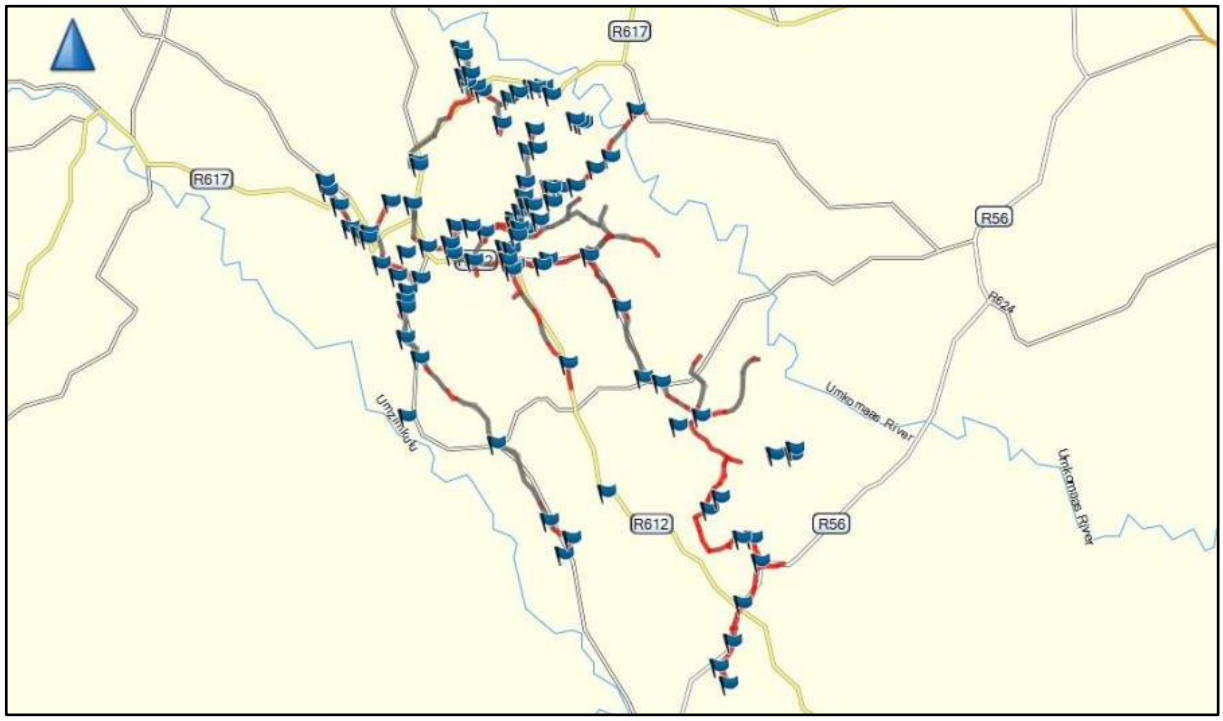


Figure 5 Observations for Palaeontological heritage

Google image (Figure 6) of the observation point sites provide a better view of the sites observed and recorded in Table 2.

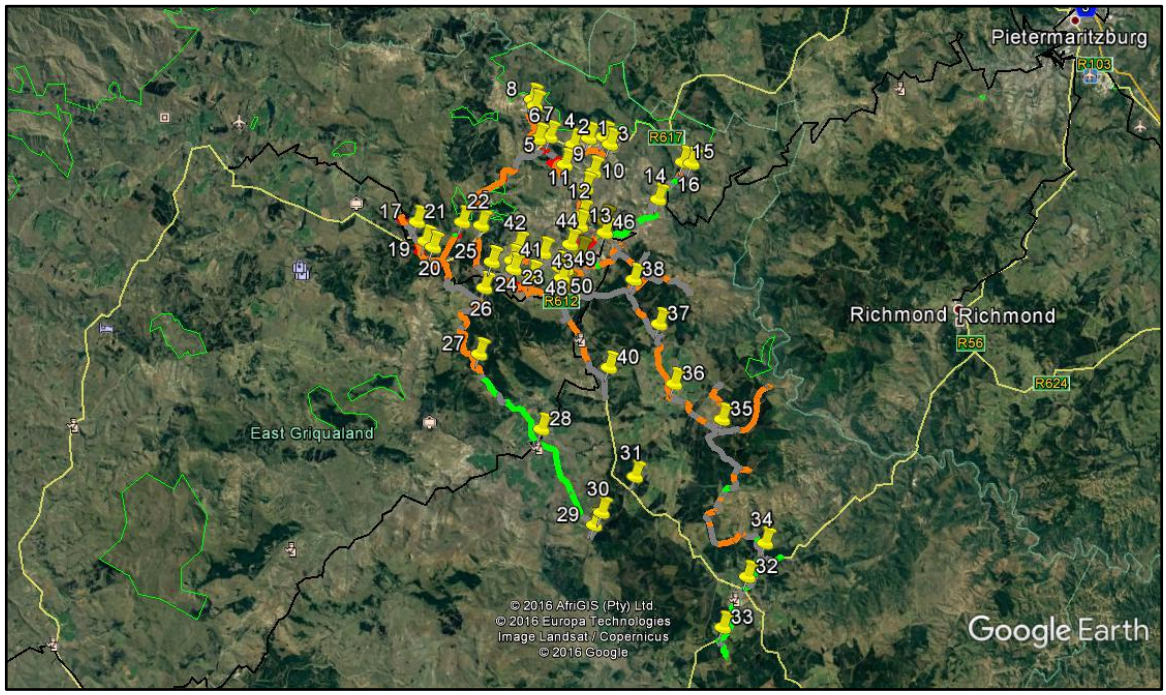


Figure 6 Google image of observation points for the Field Survey Points 1 to 50.

For reference to observation points the study area is enlarged to allow for numbers of GPS stations to be revealed in the figures. For the purpose of this report two enlargements of figure 5 are used below and referred to as Figures 7 and 8. The GPS points indicate specific points where outcrops of shale and sandstone were investigated for the presence of fossils. Weathering is unfortunately very deep (>2m) and outcrops of suitable rocks for finding of fossils are not well preserved. It is however important to note that the areas indicated as having a moderate to high potential to reveal significant Palaeontological Heritage need to be noted by the EAP and ECO. Due to the time constraints on this field assessment (270 km in three days) did not allow for timeous investigations of all outcrops and these areas will need careful inspection during the construction phase. A methodology statement will be supplied in the “Chance Find Protocol” of this field assessment.

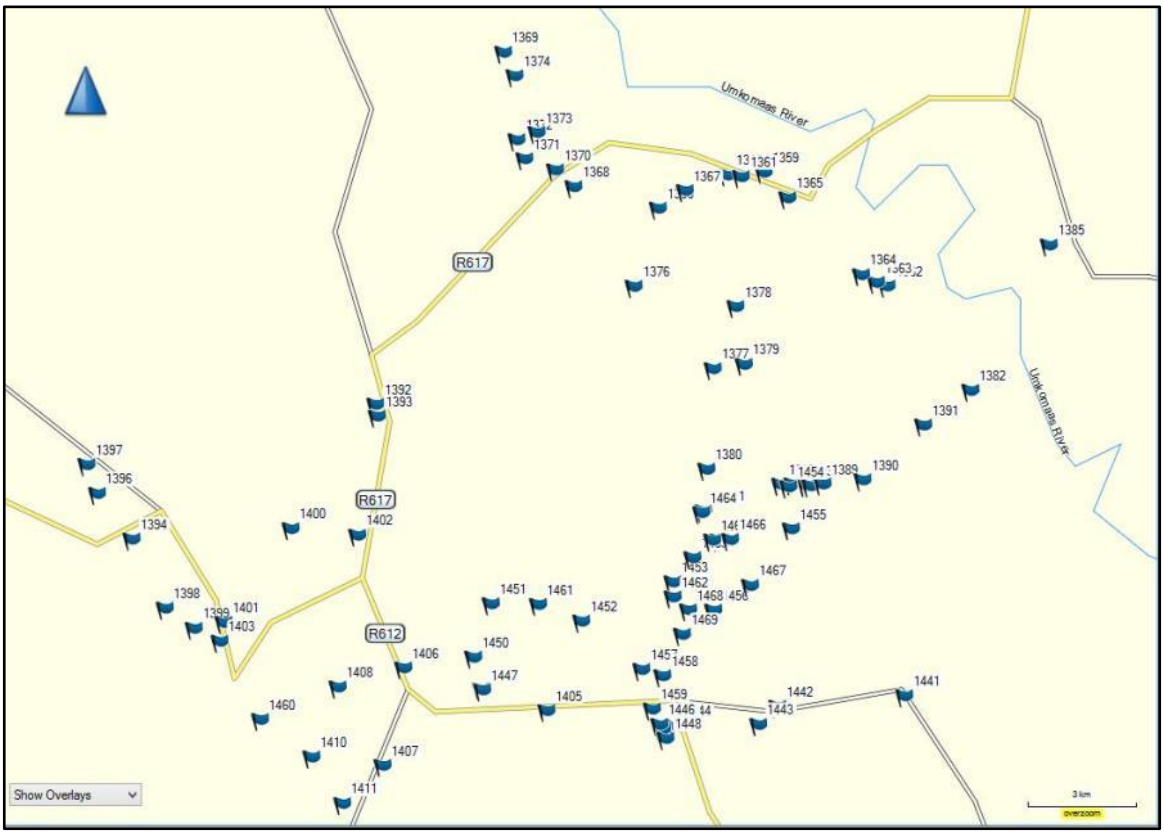


Figure 7 Northern section with GPS numbers as in Table 2

Table 2 attempts to give the reader an overview of the outcrop characteristics of the 50 points discussed (Numbered 1 to 50, Figure 6). The most important points for inspection by the ECO is shown in figures 7 and 8, with photographic illustrations of the kind of outcrop that might reveal significant plant, trace, insect as well as vertebrate fossils in this extremely sensitive geological terrain for Palaeontological Heritage in KwaZulu-Natal.

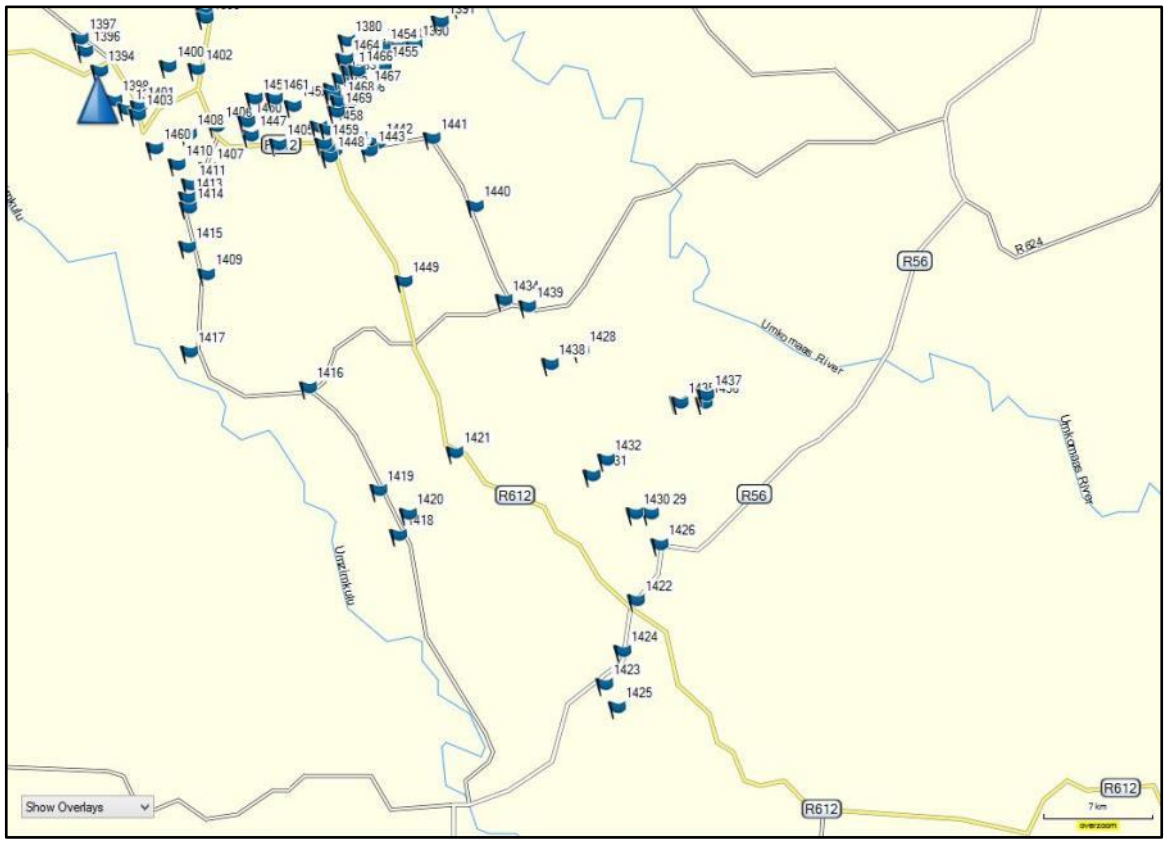


Figure 8 Southern part of the study area with GPS points referred to in Table 2

Table 2 Record of Photographic Observations. For GPS points see Figures 7&8.

Photo	(GPS station) Coordinates	Comments	Photographic Record
1	(1359, 1365) S29° 45.205' E29° 53.115'	Exposure of the Beaufort Group mudstone mostly part of the Adelaide Subgroup and Dicynodon Assemblage Zone. Chances of finding fossils are very high. The mudstones are particularly important in terms of the possible presence of insect wings (Geertsemal et al, 2002).	

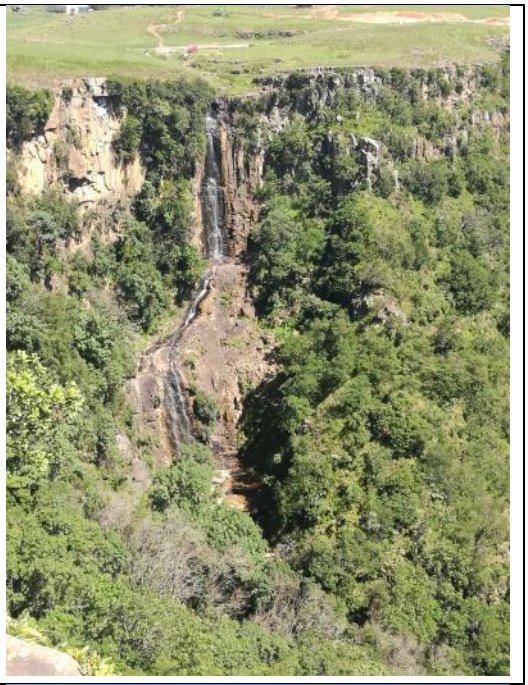
2	(1364) S29° 46.720' E29° 54.872'	Highly sensitive geological formations with intrusions of dolerite in the foreground where no fossils are expected	
3	(1367) S29° 45.476' E29° 51.696'	Deeply exposed sediments of the Beaufort Group with very high potential to find fossils. Due to time constraints little time was spent to collect fossils from these exposures and the EAP and ECO must note these potentially rich fossil beds in the study area	
4	(1373) S29° 44.620' E29° 49.022'	Good exposure of Beaufort Group sediments with very high potential to find fossils of insects. No fossils were observed or collected during this very brief site visit	
5	(1384) S29° 49.815' E29° 53.416'	Shallow soils on steeper slopes. Cut-in sites exposes well-defined Beaufort Group sediments with very high potential for finding fossils of insects and vertebrates in this area	

6	(1391) S29° 48.941' E29° 55.992'	Unidentified trace fossils are present in fine-grained sandstone in upper part of Volksrust Formation. Weathering is deep and most of the excavations will not reach the bedrock in this region	
7	(1392) S29° 48.428' E29° 56.843'	Deep weathering and erosion expose outcrops of the dark shales of the Volksrust Formation. The EAP and ECO must be aware of the presence of these units and inform the Palaeontologist if fossils are observed.	
8	(1392) S29° 48.428' E29° 56.843'	Black shale of the Volksrust Formation underlies the northern parts of the study area. Trace fossils might be exposed during excavation into this rock unit	
9	(1397) S29° 49.525' E29° 40.908'	Very deep weathering will lead to destruction of fossils. Exposure of bedrock will be unique opportunities to discover new fossils in this region	

10	(1398) S29° 51.856' E29° 43.380'	Outcrop of sandstone-rich sediments of the Beaufort Group where fossils of vertebrates are expected during exposure of bedrock	
11	(1413) S29° 54.974' E29° 45.402'	Excavation for quarries provide best options for the discovery of new fossils	
12	(1413) S29° 54.974' E29° 45.402'	Excavation for quarries provide best options for the discovery of new fossils	
13	(1413) S29° 54.974' E29° 45.402'	Deformed plant fossils in the shale of the Beaufort Group. These sites can expose significant fossils of wings of insects in this study area	

14	(1315) S29° 56.672' E29° 45.401'	Deep weathering of units in the Karoo Supergroup strata will make it highly unlikely to find new fossils in this environment	
15	(1417) S30° 00.269' E29° 45.486'	Outcrops of Volksrust Formation shale just outside the boundaries of the study area. Deep weathering in the study area can make it difficult to find significant fossils during the construction phase of the project	
16	(1424) S30° 10.539' E30° 03.642'	Vryheid Formation of the Ecca Group. Fossils of plants might be exposed during excavation of trenches	
17	(1432) S30° 03.973' E30° 02.962'	Deep weathering and deep soils with low potential to find significant fossils during construction period	

18	(1460) S29° 53.288' E29° 44.038'	Sedimentary rocks of the Beaufort Group with dolerite. Plant remains are exposed during excavation most probably representing species of the Glossopteris Assemblage, must be collected for further identification and study	
19	(1460) S29° 53.288' E29° 44.038'	Fine-grained sandstone with siliceous concretions. Exposure of this sandstone is expected during excavation for development and the rock will be highly sensitive for palaeontological heritage	
20	(1460) S29° 53.288' E29° 44.038'	Fine-grained sandstone with siliceous concretions and trace fossils. Exposure of this sandstone is expected during excavation for development and the rock will be highly sensitive for palaeontological heritage	

21	(1451) S29° 51.580' E29° 48.197'	Prominent dolerite sill in the study area. No fossils expected, no fossils found	
22	(1461) S29° 51.590' E29° 49.048'	Sandstone of the Tarkastad Subgroup. Deep weathering, no fossils observed	
23	(1464) S29° 50.233' E29° 51.991'	Red mudstone of the upper part of the Adelaide Subgroup, normally highly fossileferous, *Lystrosaurus* Assemblage zone. Weathering deep and no fossils were observed.	

23	(1465) S29° 50.640' E29° 52.189'	Beaufort Group outcrops that are associated with some of the most significant plant, insect and vertebrate fossils known from KZN. Time did not allow for careful inspection and the EAP and ECO must record these sections as of importance during the construction phase of the project	
24	(1465) S29° 50.640' E29° 52.189'	Beaufort Group outcrops that is associated with some of the most significant plant, insect and vertebrate fossils known from KZN. Time did not allow for careful inspection and the EAP and ECO must record these sections as of importance during the construction phase of the project	
25	(1465) S29° 50.640' E29° 52.189'	Beaufort Group outcrops that is associated with some of the most significant plant, insect and vertebrate fossils known from KZN. Time did not allow for careful inspection and the EAP and ECO must record these sections as of importance during the construction phase of the project	
26	(1467) S29° 51.310' E29° 52.870'	Area dominated by dolerite sill and no fossils are expected. No fossils observed.	

27	(1456) S29° 51.675' E29° 52.207'	Deeply weathered mudstone of the Volksrust Formation, Ecca Group and mudstone of the Adelaide Subgroup. Due to very tight time schedule time was not spent on trying to find the notoriously difficult insect wings in these formations. The EAP and ECO must however be aware of these fossils in this area.	
28	(1469) S29° 52.032' E29° 51.644'	Route of the pipeline dominated by dolerite sill outcrop and no fossils are expected and no fossils were observed.	
29	(1457) S29° 52.550' E29° 50.912'	Relatively deep soil on Beaufort Group sedimentary rock units will only expose fossils in excavations exceeding 1.5m and where these excavations are planned the EAP and the ECO must keep the Palaeontologist informed of any fossil observed during the construction phase of the project.	
30	(14580 S29° 52.643' E29° 51.290'	Relatively deep soil on Beaufort Group sedimentary rock units will only expose fossils in excavations exceeding 1.5m and where these excavations are planned the EAP and the ECO must keep the Palaeontologist informed of any fossil observed during the construction phase of the project.	

PALAEONTOLOGICAL IMPACT AND MITIGATION

The predicted palaeontological impact of the development is based on the initial mapping assessment and literature reviews as well as information gathered during the field investigation. The field investigation confirms that the study area is underlain by dark grey shale of the Pietermaritzburg Formation, sandstone of the Vryheid Formation and dark grey shale of the Volksrust Formation, Ecca Group. Most of the areas have very deep weathering and fossils will only be discovered during excavation of deeper than 1.5m. The larger part of the terrain is a rugged deeply incised valley of the major river systems with some spectacular waterfalls where dolerite sills are forming resistant plateaus associated with less resistant, fine-grained sandstone and khaki-coloured to dark grey shale beds of the Volksrust Formation of the Ecca Group. Deep weathering of the Beaufort Group sediments, both the green-grey coloured mudstone and yellow sandstone of the Adelaide Subgroup and the red to mottled coloured mudstone of the Tarkastad Subgroup leads to deep soil formation and excavations of 1.5m and more might uncover significant fossils in these sediments of the Karoo Supergroup. No fossils are expected in the dolerites.

The excavations for the construction of the infrastructure for this development will expose some sediments of the Ecca and Beaufort Groups. Due to weathering, no well-preserved fossils were observed during the field investigation. Exposure of bedrock during excavation might however result in the exposure of significant plant, trace, insect and possibly vertebrate fossils and the high palaeontological sensitivity of the site is restricted to areas underlain by sediments of the Karoo Supergroup. Due to the extreme weathering of the sedimentary rocks and the fact that significant fossils will only be exposed in excavations that exceed 1.5m, the overall Very High significance for Palaeontological Heritage is reduced to High, whereas the High significance of areas underlain by Volksrust shale is reduced to Moderate sensitivity (Figure 9). Areas underlain by dolerite has no significant impact on palaeontological heritage.

Groundwater aquifers associated with dolerite dykes abound and the project team must mitigate for potential ground water pollution.

To ensure that the general discussion on the sensitivity for Palaeontological Heritage can be traced more easily by the reader of this document an attempt was made to refer to specific points of interest in the area studied during the field visit. For this reason Figure 9 is referenced in terms of 50 field points, numbered as 1 to 50 and briefly discussed by GPS station number in Table 2. The most significant aspect that must be pointed out to the EAP and ECO is that large areas are underlain by very deep soil and the chances of discovering significantly new fossil remains are reduced from the theoretical Very High significance, to High and from High to Moderate. The main aim of the “Chance Find Protocol” document, that

must be read in conjunction with this Phase 1 PIA document, will be to assist the EAP and the ECO to include the mitigation measures for Palaeontological Heritage into the EMPr for the project and to provide a basic database for bidding Palaeontologists to quote for the Phase 2 PIA, which will inevitably follow during the Construction phase of this project.

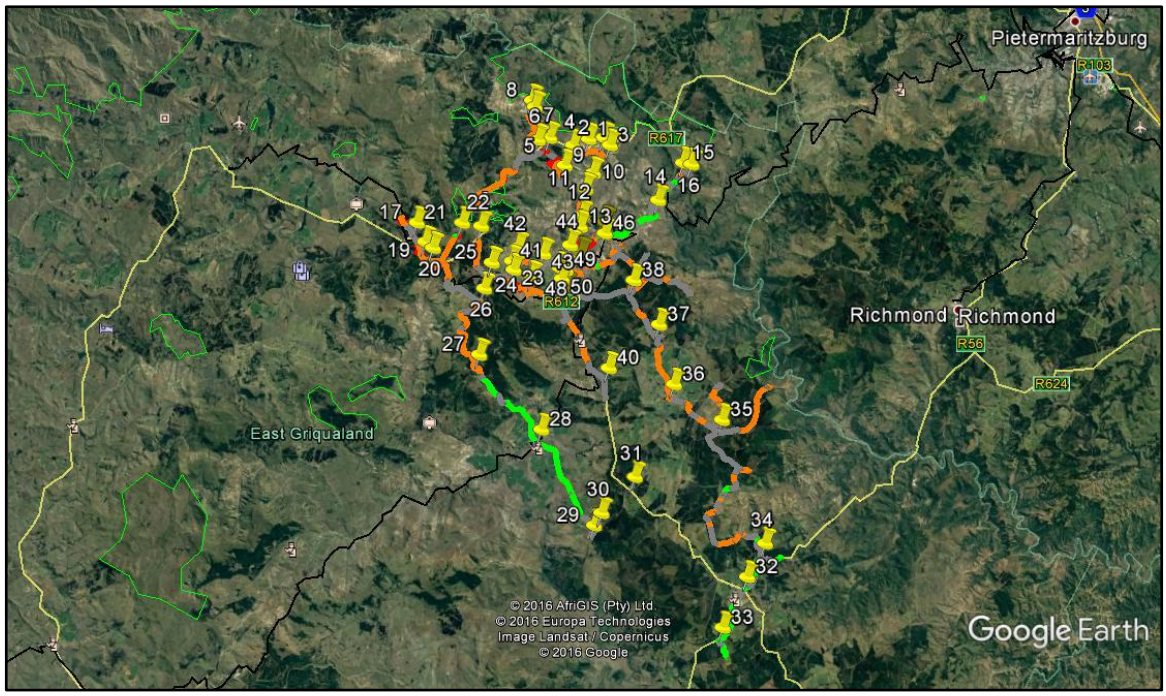


Figure 9 Google image of the points of interest specifically visited during the field surveys to ensure that the Phase 1 PIA study makes a significant contribution towards the planning of a "Chance Find Protocol" for this extensive project.

CONCLUSION

The development site for the proposed Palaeontological Impact related to the proposed Greater Bulwer-Donnybrook Bulk Water Supply Scheme (GBDBWSS): Harry Gwala District Municipality, Kwazulu-Natal Province, is underlain by Permian aged sedimentary rocks of the Ecca and Beaufort Groups as well as Dolerite of the Karoo Supergroup as well as minor sections underlain by Masotcheni Formation clays.

Several poorly defined fossils were observed during the field investigation. The potential for finding significant fossils in any excavation into sediments of the Ecca and Beaufort Groups is high. No fossils will be associated with areas underlain by dolerite.

It is recommended that:

- The EAP and ECO must be informed of the fact that a Moderate Palaeontological sensitivity was allocated to the areas of the development underlain by rocks of the Ecca Group and a High Palaeontological sensitivity is allocated to areas underlain by rocks of the Beaufort Group. Although highly weathered, trace and plant fossils were recorded during the Phase 1 field investigation and a “Chance Find Protocol” will be prepared to assist with planning for the conservation of Palaeontological Heritage.
- All areas allocated a red, orange or green colour in Figure 9 must be visited by a suitably qualified Palaeontologist, or an accredited assistant, during excavations of trenches exceeding 1.5m in depth into sediments of the Ecca and Beaufort Groups. A protocol for the chance find of fossils must be developed and discussed with the contractor on site.
- These recommendations must be included in the EMPr of this project.

REFERENCES

Almond J.E. and Pether J. 2008. *Palaeontological Heritage of the Western Cape.* Internal Report Heritage Western Cape.

Almond J.E., De Klerk B. and Gess R., 2009. *Palaeontological Heritage of the Eastern Cape*. Internal Report, SAHRA.

Cairncross, B., Beukes, NJ., Coetzee, LL. and Rehfeld, U. 2005. The Bivalve *Megadesmus* from the Permian Volksrust Shale Formation (Karoo Supergroup), northeastern Karoo Basin, South Africa: implications for late Permian Basin development. South African Journal of Geology 108: 547-556.

Geertsemal, H., Van Dijk, D.E. and Van den Heever, J.A., 2002. Palaeozoic Insects Of Southern Africa: A Review. *Palaeont. afr.,* 38, 19-25.

Groenewald, G.H. 1984. Stratigrafie en sedimentologie van die Groep Beaufort in die Noordoos-Vrystaat. Ongepubliseerde MSc Tesis. Randse Afrikaanse Universiteit, Johannesburg, South Africa.

Groenewald GH, 1990. Stratigrafie en Sedimentologie van die Groep Beaufort in die Noord-oos Vrystaat. Bull 96, Geol Surv of SA.

Groenewald G.H., Groenewald D.P. and Groenewald S.M., 2014. *Palaeontological Heritage of the Free State, Gauteng, Limpopo, Mpumalanga and North West Provinces*. Internal Palaeotechnical Reports, SAHRA.

Groenewald DP. 2016. *Tetrapod trackways and the Ecca-Beaufort contact in the Estcourt district.* Unpublished BSc Hons project, University of the Witwatersrand, Johannesburg.

Johnson MR , Anhaeusser CR and Thomas RJ (Eds). 2009. The Geology of South Africa. GSSA, Council for Geoscience, Pretoria.

Muntingh, D.J. 1997. Sedimentologie en stratigraphie van die Ecca-Beaufort-oorgang in die noordoostelike gedeelte van die hoof Karookom. Bulletin van die Geologiese Opname van Suid-Afrika 121, 46pp.

Van der Walt, M., Day, M., Rubidge, B., Cooper, A.K. & Netterberg, I. 2010. A new GIS-based biozone map of the Beaufort Group (Karoo Supergroup), South Africa. Palaeontologia Africana 45, 1–5.

Viglietti, PA, Smith, RMH, Angielczyk, KD, Kammerer, CF, Fr€obisch J€org & Rubidge BS. 2016. The *Daptocephalus* Assemblage Zone (Lopingian), South Africa: A proposed biostratigraphy based on a new compilation of stratigraphic ranges.

Appendix 1: Table of coordinates for areas allocated a very high (red), high (orange) or Moderate Palaeontological sensitivity/vulnerability (green) in Figure 9.

VERY HIGH			
Points	South	East	Sections
1	29° 53' 7"	29° 50' 17"	
2	29° 52' 58"	29° 50' 25"	
3	29° 52' 50"	29° 50' 30"	
4	29° 52' 43"	29° 50' 31"	
5	29° 52' 37"	29° 50' 37"	
6	29° 52' 31"	29° 50' 39"	
7	29° 52' 25"	29° 50' 37"	
8	29° 52' 20"	29° 50' 39"	
9	29° 52' 15"	29° 50' 38"	
10	29° 52' 10"	29° 50' 34"	1
11	29° 52' 8"	29° 50' 32"	
12	29° 52' 8"	29° 50' 30"	
13	29° 52' 4"	29° 50' 26"	
14	29° 52' 3"	29° 50' 21"	
15	29° 52' 2"	29° 50' 14"	
16	29° 52' 2"	29° 50' 12"	
17	29° 52' 0"	29° 50' 11"	
18	29° 52' 0"	29° 50' 11"	
19	29° 50' 41"	29° 45' 55"	
20	29° 50' 37"	29° 45' 53"	
21	29° 50' 36"	29° 45' 51"	2
22	29° 50' 20"	29° 45' 43"	
23	29° 50' 20"	29° 45' 43"	
24	29° 49' 52"	29° 45' 31"	
25	29° 49' 48"	29° 45' 27"	
26	29° 49' 39"	29° 45' 25"	
27	29° 49' 29"	29° 45' 25"	3
28	29° 49' 23"	29° 45' 26"	
29	29° 49' 23"	29° 45' 26"	
30	29° 44' 35"	29° 50' 25"	
31	29° 44' 40"	29° 50' 26"	
32	29° 44' 39"	29° 50' 30"	
33	29° 44' 34"	29° 50' 29"	
34	29° 44' 35"	29° 50' 25"	4
35	29° 44' 35"	29° 50' 25"	
36	29° 44' 37"	29° 50' 27"	
37	29° 44' 29"	29° 50' 26"	
38	29° 44' 29"	29° 50' 26"	

VERY HIGH Cross Sections			
Points	South	East	Sections
0	29° 49' 1"	29° 43' 52"	
1	29° 49' 10"	29° 43' 60"	1
2	29° 49' 19"	29° 44' 5"	
3	29° 49' 19"	29° 44' 5"	
4	29° 49' 10"	29° 43' 51"	
5	29° 49' 4"	29° 44' 16"	2
6	29° 49' 4"	29° 44' 16"	
7	29° 48' 48"	29° 44' 32"	
8	29° 48' 56"	29° 44' 34"	
9	29° 48' 56"	29° 44' 34"	3
10	29° 48' 48"	29° 44' 32"	
11	29° 48' 41"	29° 44' 31"	
12	29° 48' 41"	29° 44' 31"	
13	29° 48' 46"	29° 45' 35"	
14	29° 48' 53"	29° 45' 36"	4
15	29° 48' 53"	29° 45' 36"	
16	29° 50' 23"	29° 46' 0"	
17	29° 50' 38"	29° 46' 8"	5
18	29° 50' 38"	29° 46' 8"	
19	29° 50' 10"	29° 46' 9"	
20	29° 50' 38"	29° 46' 25"	6
21	29° 50' 38"	29° 46' 25"	
22	29° 47' 46"	29° 46' 31"	
23	29° 47' 57"	29° 46' 43"	7
24	29° 47' 57"	29° 46' 43"	
25	29° 47' 3"	29° 46' 56"	
26	29° 47' 18"	29° 47' 16"	
27	29° 47' 18"	29° 47' 16"	8
28	29° 46' 58"	29° 47' 6"	
29	29° 47' 19"	29° 46' 60"	
30	29° 47' 19"	29° 46' 60"	
31	29° 52' 19"	29° 47' 19"	
32	29° 52' 39"	29° 47' 29"	9
33	29° 52' 39"	29° 47' 29"	
34	29° 53' 13"	29° 45' 27"	
35	29° 53' 32"	29° 45' 28"	10
36	29° 53' 32"	29° 45' 28"	

VERY HIGH Cross Sections			
Points	South	East	Sections
37	29° 50' 18"	29° 45' 43"	
38	29° 51' 7"	29° 46' 10"	11
39	29° 51' 7"	29° 46' 10"	
40	29° 50' 10"	29° 45' 55"	
41	29° 50' 47"	29° 46' 14"	12
42	29° 50' 47"	29° 46' 14"	
43	29° 49' 52"	29° 45' 59"	
44	29° 51' 7"	29° 46' 43"	13
45	29° 51' 7"	29° 46' 43"	
46	29° 52' 21"	29° 49' 36"	
47	29° 51' 60"	29° 49' 33"	
48	29° 51' 60"	29° 49' 33"	14
49	29° 52' 14"	29° 49' 53"	
50	29° 52' 1"	29° 49' 26"	
51	29° 52' 1"	29° 49' 26"	
52	29° 52' 8"	29° 49' 60"	
53	29° 51' 40"	29° 50' 7"	15
54	29° 51' 40"	29° 50' 7"	
55	29° 52' 30"	29° 50' 26"	
56	29° 52' 14"	29° 50' 50"	16
57	29° 52' 13"	29° 50' 50"	
58	29° 52' 36"	29° 50' 25"	
59	29° 52' 36"	29° 50' 52"	
60	29° 52' 36"	29° 50' 52"	17
61	29° 52' 36"	29° 50' 25"	
62	29° 52' 48"	29° 50' 37"	
63	29° 52' 48"	29° 50' 37"	
64	29° 53' 15"	29° 49' 37"	
65	29° 53' 48"	29° 49' 59"	18
66	29° 53' 48"	29° 49' 60"	
67	29° 48' 58"	29° 52' 47"	
68	29° 49' 29"	29° 52' 45"	19
69	29° 49' 29"	29° 52' 44"	
70	29° 48' 27"	29° 52' 49"	
71	29° 48' 51"	29° 53' 14"	20
72	29° 48' 51"	29° 53' 14"	

VERY HIGH Cross Sections			
Points	South	East	Sections
73	29° 47' 48	29° 52' 11	
74	29° 48' 8"	29° 52' 30	21
75	29° 48' 8"	29° 52' 30	
76	29° 40' 35	29° 49' 46	
77	29° 41' 9"	29° 49' 38	22
78	29° 41' 9"	29° 49' 38	
79	29° 40' 48	29° 49' 50	
80	29° 41' 16	29° 49' 55	23
81	29° 41' 16	29° 49' 55	
82	29° 41' 56	29° 51' 3"	
83	29° 42' 24	29° 51' 16	24
84	29° 42' 24	29° 51' 15	
85	29° 41' 56	29° 51' 26	
86	29° 42' 32	29° 51' 36	25
87	29° 42' 32	29° 51' 36	
88	29° 43' 28	29° 51' 52	
89	29° 43' 49	29° 52' 8"	26
90	29° 43' 49	29° 52' 8"	
91	29° 43' 19	29° 52' 8"	
92	29° 43' 25	29° 52' 22	27
93	29° 43' 25	29° 52' 22	

HIGH			
Points	South	East	Sections
1	29° 57' 58"	29° 52' 2"	
2	29° 57' 48"	29° 51' 58"	
3	29° 57' 41"	29° 51' 55"	
4	29° 57' 33"	29° 51' 56"	1
5	29° 57' 33"	29° 51' 60"	
6	29° 57' 33"	29° 52' 1"	
7	29° 57' 33"	29° 52' 1"	
8	29° 55' 47"	29° 51' 21"	
9	29° 55' 44"	29° 51' 19"	
10	29° 55' 41"	29° 51' 17"	
11	29° 55' 39"	29° 51' 13"	
12	29° 55' 38"	29° 51' 13"	
13	29° 55' 36"	29° 51' 13"	
14	29° 55' 32"	29° 51' 11"	2
15	29° 55' 28"	29° 51' 8"	
16	29° 55' 25"	29° 51' 6"	
17	29° 55' 23"	29° 51' 5"	
18	29° 55' 23"	29° 51' 5"	
19	29° 54' 28"	29° 50' 59"	
20	29° 54' 25"	29° 50' 47"	
21	29° 54' 25"	29° 50' 43"	
22	29° 54' 30"	29° 50' 38"	
23	29° 54' 30"	29° 50' 38"	3
24	29° 54' 30"	29° 50' 38"	
25	29° 54' 34"	29° 50' 35"	
26	29° 54' 37"	29° 50' 33"	
27	29° 54' 37"	29° 50' 33"	
28	29° 54' 50"	29° 50' 25"	
29	29° 55' 4"	29° 50' 16"	4
30	29° 55' 4"	29° 50' 16"	
31	29° 58' 33"	29° 46' 7"	
32	29° 58' 25"	29° 46' 6"	
33	29° 58' 22"	29° 46' 11"	
34	29° 58' 15"	29° 46' 14"	5
35	29° 58' 14"	29° 46' 17"	
36	29° 58' 14"	29° 46' 17"	
37	29° 53' 16"	29° 49' 53"	
38	29° 53' 16"	29° 49' 56"	
39	29° 53' 14"	29° 49' 60"	
40	29° 53' 13"	29° 50' 1"	6
41	29° 53' 9"	29° 50' 2"	
42	29° 53' 9"	29° 50' 3"	
43	29° 53' 9"	29° 50' 3"	
44	29° 51' 27"	29° 51' 7"	
45	29° 51' 29"	29° 51' 14"	
46	29° 51' 27"	29° 51' 21"	7
47	29° 51' 13"	29° 51' 26"	
48	29° 51' 13"	29° 51' 26"	
49	29° 51' 57"	29° 51' 57"	
50	29° 52' 3"	29° 51' 57"	
51	29° 52' 9"	29° 51' 59"	
52	29° 52' 15"	29° 52' 0"	
53	29° 52' 21"	29° 52' 1"	8
54	29° 52' 30"	29° 52' 0"	
55	29° 52' 33"	29° 51' 59"	
56	29° 52' 41"	29° 51' 56"	
57	29° 52' 41"	29° 51' 56"	

HIGH			
Points	South	East	Sections
153	29° 59' 40"	29° 58' 42"	
154	29° 59' 50"	29° 58' 45"	
155	29° 59' 56"	29° 58' 52"	
156	29° 59' 54"	29° 58' 60"	14
157	29° 59' 58"	29° 59' 9"	
158	30° 0' 3"	29° 59' 15"	
159	30° 0' 3"	29° 59' 15"	
160	30° 0' 32"	29° 59' 29"	
161	30° 1' 4"	29° 59' 45"	15
162	30° 1' 4"	29° 59' 45"	
163	30° 1' 31"	29° 57' 46"	
164	30° 1' 29"	29° 57' 58"	
165	30° 1' 27"	29° 58' 1"	
166	30° 1' 20"	29° 58' 11"	
167	30° 1' 40"	29° 58' 22"	
168	30° 1' 45"	29° 58' 25"	
169	30° 1' 48"	29° 58' 26"	
170	30° 1' 50"	29° 58' 30"	
171	30° 1' 50"	29° 58' 30"	
172	30° 1' 50"	29° 58' 30"	
173	30° 1' 48"	29° 58' 33"	
174	30° 1' 49"	29° 58' 34"	
175	30° 1' 53"	29° 58' 37"	
176	30° 1' 56"	29° 58' 37"	
177	30° 1' 59"	29° 58' 37"	16
178	30° 2' 1"	29° 58' 38"	
179	30° 2' 1"	29° 58' 38"	
180	30° 2' 1"	29° 58' 38"	
181	30° 2' 4"	29° 58' 42"	
182	30° 2' 6"	29° 58' 45"	
183	30° 2' 7"	29° 58' 47"	
184	30° 2' 10"	29° 58' 48"	
185	30° 2' 11"	29° 58' 48"	
186	30° 2' 13"	29° 58' 48"	
187	30° 2' 6"	29° 59' 2"	
188	30° 1' 56"	29° 59' 22"	
189	30° 1' 48"	29° 59' 38"	
190	30° 1' 44"	29° 59' 45"	
191	30° 1' 44"	29° 59' 45"	
192	30° 5' 5"	29° 57' 35"	
193	30° 5' 2"	29° 57' 34"	
194	30° 4' 58"	29° 57' 31"	
195	30° 4' 56"	29° 57' 31"	17
196	30° 4' 52"	29° 57' 32"	
197	30° 4' 52"	29° 57' 32"	
198	30° 4' 45"	29° 57' 35"	
199	30° 4' 43"	29° 57' 37"	
200	30° 4' 32"	29° 57' 41"	
201	30° 4' 30"	29° 57' 42"	
202	30° 4' 25"	29° 57' 47"	
203	30° 4' 21"	29° 57' 51"	
204	30° 4' 20"	29° 57' 55"	
205	30° 4' 18"	29° 58' 0"	
206	30° 4' 16"	29° 58' 4"	
207	30° 4' 14"	29° 58' 7"	
208	30° 4' 12"	29° 58' 10"	
209	30° 4' 12"	29° 58' 11"	
210	30° 4' 12"	29° 58' 11"	
211	30° 4' 12"	29° 58' 11"	
212	30° 4' 11"	29° 58' 15"	
213	30° 4' 12"	29° 58' 19"	

HIGH			
Points	South	East	Sections
283	30° 2' 21"	30° 6' 20"	
284	30° 2' 29"	30° 6' 19"	
285	30° 2' 36"	30° 6' 17"	
286	30° 2' 41"	30° 6' 16"	
287	30° 2' 50"	30° 6' 15"	
288	30° 2' 56"	30° 6' 14"	
289	30° 2' 59"	30° 6' 14"	
290	30° 3' 4"	30° 6' 11"	
291	30° 3' 9"	30° 6' 8"	
292	30° 3' 15"	30° 6' 6"	
293	30° 3' 20"	30° 6' 4"	
294	30° 3' 25"	30° 6' 3"	
295	30° 3' 28"	30° 6' 7"	
296	30° 3' 30"	30° 6' 8"	
297	30° 3' 30"	30° 6' 9"	
298	30° 3' 30"	30° 6' 9"	
299	30° 3' 25"	30° 6' 3"	25
300	30° 3' 28"	30° 6' 2"	
301	30° 3' 31"	30° 6' 0"	
302	30° 3' 34"	30° 5' 58"	
303	30° 3' 40"	30° 5' 49"	
304	30° 3' 44"	30° 5' 44"	
305	30° 3' 45"	30° 5' 43"	
306	30° 3' 47"	30° 5' 41"	
307	30° 3' 47"	30° 5' 41"	
308	30° 3' 53"	30° 5' 40"	
309	30° 3' 56"	30° 5' 42"	
310	30° 4' 0"	30° 5' 45"	
311	30° 4' 3"	30° 5' 47"	
312	30° 4' 5"	30° 5' 48"	
313	30° 4' 6"	30° 5' 48"	
314	30° 4' 6"	30° 5' 48"	
315	29° 51' 52"	29° 54' 34"	
316	29° 52' 1"	29° 54' 44"	
317	29° 52' 17"	29° 55' 2"	26
318	29° 52' 29"	29° 55' 14"	
319	29° 52' 35"	29° 55' 20"	
320	29° 52' 35"	29° 55' 20"	
321	29° 52' 54"	29° 55' 53"	
322	29° 52' 55"	29° 56' 2"	
323	29° 52' 59"	29° 56' 5"	
324	29° 53' 1"	29° 56' 13"	
325	29° 53' 1"	29° 56' 22"	
326	29° 53' 1"	29° 56' 25"	
327	29° 53' 5"	29° 56' 31"	27
328	29° 53' 10"	29° 56' 37"	
329	29° 53' 17"	29° 56' 44"	
330	29° 53' 22"	29° 56' 52"	
331	29° 53' 22"	29° 56' 52"	
332	29° 53' 22"	29° 56' 52"	
333	29° 47' 48"	29° 52' 32"	
334	29° 47' 55"	29° 52' 40"	
335	29° 48' 3"	29° 52' 52"	
336	29° 48' 9"	29° 53' 1"	
337	29° 48' 18"	29° 53' 5"	
338	29° 48' 38"	29° 53' 2"	
339	29° 48' 51"	29° 52' 59"	
340	29° 49' 2"	29° 53' 4"	
341	29° 49' 12"	29° 53' 9"	
342	29° 49' 20"	29° 53' 11"	
343	29° 49' 24"	29° 53' 12"	
344	29° 49' 47"	29° 53' 8"	
345	29° 50' 5"	29° 53' 14"	

HIGH			
Points	South	East	Sections
465	29° 48' 59"	29° 45' 35"	
466	29° 48' 57"	29° 45' 34"	
467	29° 48' 52"	29° 45' 19"	
468	29° 48' 48"	29° 45' 4"	
469	29° 48' 47"	29° 45' 0"	
470	29° 48' 39"	29° 44' 57"	
471	29° 48' 33"	29° 44' 54"	
472	29° 48' 36"	29° 44' 45"	
473	29° 48' 38"	29° 44' 42"	
474	29° 48' 47"	29° 44' 34"	
475	29° 48' 53"	29° 44' 29"	
476	29° 48' 58"	29° 44' 26"	
477	29° 48' 58"	29° 44' 19"	
478	29° 48' 54"	29° 44' 12"	
479	29° 48' 51"	29° 44' 10"	
480	29° 48' 56"	29° 44' 1"	
481	29° 48' 57"	29° 44' 2"	
482	29° 48' 57"	29° 44' 5"	
483	29° 48' 58"	29° 44' 7"	
484	29° 48' 60"	29° 44' 8"	
485	29° 49' 1"	29° 44' 8"	33
486	29° 49' 4"	29° 44' 6"	
487	29° 49' 1"	29° 44' 2"	
488	29° 48' 60"	29° 43' 59"	
489	29° 48' 56"	29° 43' 58"	
490	29° 48' 50"	29° 43' 57"	
491	29° 48' 47"	29° 43' 54"	
492	29° 48' 45"	29° 43' 53"	
493	29° 48' 43"	29° 43' 53"	
494	29° 48' 41"	29° 43' 52"	
495	29° 48' 39"	29° 43' 50"	
496	29° 48' 38"	29° 43' 47"	
497	29° 48' 37"	29° 43' 44"	
498	29° 48' 33"	29° 43' 41"	
499	29° 48' 32"	29° 43' 40"	
500	29° 48' 30"	29° 43' 36"	
501	29° 48' 28"	29° 43' 33"	
502	29° 48' 27"	29° 43' 29"	
503	29° 48' 26"	29° 43' 27"	
504	29° 48' 25"	29° 43' 26"	
505	29° 48' 25"	29° 43' 26"	
506	29° 47' 52"	29° 46' 34"	
507	29° 47' 51"	29° 46' 37"	
508	29° 47' 48"	29° 46' 41"	
509	29° 47' 42"	29° 46' 43"	
510	29° 47' 37"	29° 46' 42"	
511	29° 47' 32"	29° 46' 40"	
512	29° 47' 26"	29° 46' 39"	
513	29° 47' 17"	29° 46' 40"	
514	29° 47' 13"	29° 46' 42"	
515	29° 47' 9"	29° 46' 47"	
516	29° 47' 8"	29° 46' 58"	
517	29° 47' 9"	29° 47' 9"	
518	29° 47' 8"	29° 47' 14"	
519	29° 47' 7"	29° 47' 17"	
520	29° 46' 59"	29° 47' 24"	34
521	29° 46' 56"	29° 47' 25"	
522	29° 46' 47"	29° 47' 30"	
523	29° 46' 38"	29° 47' 34"	
524	29° 46' 28"	29° 47' 40"	
525	29° 46' 22"	29° 47' 45"	
526	29° 46' 12"	29° 47' 50"	
527	29° 45' 58"	29° 47' 56"	
528	29° 45' 50"	29° 48' 1"	

HIGH			
Points	South	East	Sections
590	29° 45' 9"	29° 54' 35"	
591	29° 45' 5"	29° 54' 38"	
592	29° 45' 5"	29° 54' 40"	
593	29° 45' 5"	29° 54' 44"	
594	29° 45' 5"	29° 54' 46"	
595	29° 45' 7"	29° 54' 49"	
596	29° 45' 8"	29° 54' 51"	
597	29° 45' 13"	29° 54' 54"	
598	29° 45' 17"	29° 54' 56"	
599	29° 45' 19"	29° 54' 55"	
600	29° 45' 22"	29° 54' 56"	
601	29° 45' 26"	29° 55' 1"	
602	29° 45' 28"	29° 55' 3"	39
603	29° 45' 29"	29° 55' 6"	
604	29° 45' 29"	29° 55' 8"	
605	29° 45' 30"	29° 55' 11"	
606	29° 45' 29"	29° 55' 12"	
607	29° 45' 28"	29° 55' 16"	
608	29° 45' 27"	29° 55' 19"	
609	29° 45' 26"	29° 55' 19"	
610	29° 45' 23"	29° 55' 22"	
611	29° 45' 19"	29° 55' 25"	
612	29° 45' 16"	29° 55' 25"	
613	29° 45' 16"	29° 55' 25"	
614	29° 45' 5"	29° 55' 35"	
615	29° 45' 4"	29° 55' 37"	
616	29° 45' 4"	29° 55' 38"	
617	29° 45' 6"	29° 55' 40"	
618	29° 45' 8"	29° 55' 41"	
619	29° 45' 9"	29° 55' 44"	
620	29° 45' 14"	29° 55' 46"	
621	29° 45' 18"	29° 55' 47"	
622	29° 45' 20"	29° 55' 47"	
623	29° 45' 23"	29° 55' 48"	
624	29° 45' 25"	29° 55' 50"	
625	29° 45' 26"	29° 55' 51"	
626	29° 45' 27"	29° 55' 53"	
627	29° 45' 24"	29° 55' 58"	
628	29° 45' 21"	29° 56' 1"	
629	29° 45' 22"	29° 56' 3"	
630	29° 45' 23"	29° 56' 6"	
631	29° 45' 22"	29° 56' 10"	
632	29° 45' 20"	29° 56' 13"	
633	29° 45' 18"	29° 56' 14"	
634	29° 45' 18"	29° 56' 17"	
635	29° 45' 21"	29° 56' 21"	
636	29° 45' 17"	29° 56' 23"	
637	29° 45' 13"	29° 56' 23"	
638	29° 45' 11"	29° 56' 24"	
639	29° 45' 10"	29° 56' 26"	
640	29° 45' 10"	29° 56' 28"	
641	29° 45' 17"	29° 56' 31"	
642	29° 45' 18"	29° 56' 31"	
643	29° 45' 22"	29° 56' 35"	
644	29° 45' 24"	29° 56' 37"	
645	29° 45' 26"	29° 56' 39"	
646	29° 45' 24"	29° 56' 42"	
647	29° 45' 23"	29° 56' 43"	
648	29° 45' 23"	29° 56' 44"	
649	29° 45' 23"	29° 56' 46"	
650	29° 45' 27"	29° 56' 47"	
651	29° 45' 32"	29° 56' 49"	
652	29° 45' 37"	29° 56' 51"	
653	29° 45' 39"	29° 56' 52"	40

58	29° 52' 54"	29° 51' 46"	
59	29° 52' 53"	29° 51' 43"	
60	29° 52' 54"	29° 51' 39"	
61	29° 52' 57"	29° 51' 37"	
62	29° 53' 1"	29° 51' 34"	
63	29° 53' 5"	29° 51' 34"	9
64	29° 53' 8"	29° 51' 35"	
65	29° 53' 9"	29° 51' 34"	
66	29° 53' 15"	29° 51' 34"	
67	29° 53' 21"	29° 51' 33"	
68	29° 53' 21"	29° 51' 33"	
69	29° 53' 37"	29° 51' 31"	
70	29° 53' 46"	29° 51' 28"	
71	29° 53' 55"	29° 51' 24"	
72	29° 54' 2"	29° 51' 20"	
73	29° 54' 6"	29° 51' 17"	
74	29° 54' 10"	29° 51' 16"	
75	29° 54' 10"	29° 51' 16"	9
76	29° 54' 10"	29° 51' 16"	
77	29° 54' 11"	29° 51' 16"	
78	29° 54' 15"	29° 51' 17"	
79	29° 54' 19"	29° 51' 16"	
80	29° 54' 23"	29° 51' 15"	
81	29° 54' 28"	29° 51' 10"	
82	29° 54' 28"	29° 51' 10"	
83	29° 56' 38"	29° 52' 4"	
84	29° 56' 31"	29° 52' 11"	
85	29° 56' 25"	29° 52' 16"	
86	29° 56' 21"	29° 52' 20"	
87	29° 56' 21"	29° 52' 20"	
88	29° 56' 36"	29° 52' 2"	
89	29° 56' 26"	29° 52' 12"	
90	29° 56' 18"	29° 52' 19"	
91	29° 56' 18"	29° 52' 19"	
92	29° 56' 18"	29° 52' 19"	
93	29° 56' 4"	29° 52' 32"	
94	29° 55' 56"	29° 52' 39"	
95	29° 55' 50"	29° 52' 33"	10
96	29° 55' 35"	29° 52' 29"	
97	29° 55' 35"	29° 52' 29"	
98	29° 56' 5"	29° 52' 32"	
99	29° 55' 57"	29° 52' 27"	
100	29° 55' 48"	29° 52' 36"	
101	29° 55' 48"	29° 52' 36"	
102	29° 56' 5"	29° 52' 32"	
103	29° 55' 54"	29° 52' 42"	
104	29° 55' 54"	29° 52' 41"	
105	29° 55' 55"	29° 52' 43"	
106	29° 56' 21"	29° 52' 20"	
107	29° 56' 21"	29° 52' 20"	
108	29° 52' 30"	29° 53' 18"	
109	29° 52' 27"	29° 53' 19"	11
110	29° 52' 25"	29° 53' 19"	
111	29° 52' 25"	29° 53' 19"	
112	29° 56' 8"	29° 53' 46"	
113	29° 56' 16"	29° 53' 52"	
114	29° 56' 22"	29° 53' 60"	
115	29° 56' 24"	29° 54' 2"	
116	29° 56' 29"	29° 54' 2"	12
117	29° 56' 32"	29° 54' 1"	
118	29° 56' 35"	29° 54' 5"	
119	29° 56' 37"	29° 54' 9"	
120	29° 56' 42"	29° 54' 13"	
121	29° 56' 42"	29° 54' 13"	
122	29° 57' 46"	29° 55' 38"	
123	29° 57' 53"	29° 55' 42"	

214	30° 4' 12"	29° 58' 21"	
215	30° 4' 14"	29° 58' 23"	
216	30° 4' 15"	29° 58' 26"	
217	30° 4' 14"	29° 58' 36"	
218	30° 4' 13"	29° 58' 51"	
219	30° 4' 13"	29° 58' 54"	
220	30° 4' 10"	29° 59' 3"	
221	30° 4' 10"	29° 59' 4"	18
222	30° 4' 12"	29° 59' 7"	
223	30° 4' 11"	29° 59' 10"	
224	30° 4' 11"	29° 59' 12"	
225	30° 4' 10"	29° 59' 16"	
226	30° 4' 9"	29° 59' 18"	
227	30° 4' 8"	29° 59' 21"	
228	30° 4' 6"	29° 59' 24"	
229	30° 4' 5"	29° 59' 26"	
230	30° 4' 5"	29° 59' 31"	
231	30° 4' 4"	29° 59' 32"	
232	30° 4' 2"	29° 59' 35"	
233	30° 3' 58"	29° 59' 39"	
234	30° 3' 51"	29° 59' 45"	
235	30° 3' 44"	29° 59' 51"	
236	30° 3' 39"	29° 59' 56"	
237	30° 3' 35"	29° 59' 60"	
238	30° 3' 35"	29° 59' 60"	
239	30° 3' 31"	29° 59' 59"	
240	30° 3' 24"	29° 59' 59"	
241	30° 3' 16"	29° 59' 59"	
242	30° 3' 15"	29° 59' 59"	
243	30° 3' 15"	29° 59' 59"	
244	30° 3' 32"	30° 2' 8"	
245	30° 3' 38"	30° 2' 9"	
246	30° 3' 48"	30° 2' 8"	
247	30° 3' 54"	30° 2' 8"	19
248	30° 4' 4"	30° 2' 14"	
249	30° 4' 6"	30° 2' 16"	
250	30° 4' 6"	30° 2' 16"	
251	30° 3' 9"	30° 2' 24"	
252	30° 3' 6"	30° 2' 31"	
253	30° 3' 5"	30° 2' 36"	
254	30° 3' 7"	30° 2' 44"	20
255	30° 3' 10"	30° 2' 49"	
256	30° 3' 13"	30° 2' 52"	
257	30° 3' 14"	30° 2' 54"	
258	30° 3' 14"	30° 2' 54"	
259	30° 2' 23"	30° 3' 47"	
260	30° 2' 20"	30° 3' 54"	21
261	30° 2' 17"	30° 3' 58"	
262	30° 2' 17"	30° 3' 58"	
263	30° 2' 9"	30° 4' 24"	
264	30° 2' 8"	30° 4' 28"	22
265	30° 2' 11"	30° 4' 34"	
266	30° 2' 11"	30° 4' 34"	
267	30° 2' 8"	30° 4' 36"	
268	30° 1' 55"	30° 4' 35"	
269	30° 1' 55"	30° 4' 35"	
270	30° 1' 53"	30° 4' 35"	
271	30° 1' 50"	30° 4' 37"	
272	30° 1' 48"	30° 4' 38"	23
273	30° 1' 43"	30° 4' 40"	
274	30° 1' 39"	30° 4' 42"	
275	30° 1' 37"	30° 4' 43"	
276	30° 1' 35"	30° 4' 46"	
277	30° 1' 34"	30° 4' 48"	
278	30° 1' 34"	30° 4' 48"	

346	29° 50' 10"	29° 53' 16"	
347	29° 50' 21"	29° 53' 14"	
348	29° 50' 21"	29° 53' 14"	
349	29° 49' 36"	29° 52' 17"	28
350	29° 49' 31"	29° 52' 22"	
351	29° 49' 28"	29° 52' 24"	
352	29° 49' 25"	29° 52' 29"	
353	29° 49' 22"	29° 52' 33"	
354	29° 49' 21"	29° 52' 39"	
355	29° 49' 17"	29° 52' 45"	
356	29° 49' 15"	29° 52' 48"	
357	29° 49' 15"	29° 52' 52"	
358	29° 49' 20"	29° 52' 59"	
359	29° 49' 18"	29° 53' 3"	
360	29° 49' 14"	29° 53' 6"	
361	29° 49' 12"	29° 53' 10"	
362	29° 49' 12"	29° 53' 14"	
363	29° 49' 19"	29° 53' 27"	
364	29° 49' 22"	29° 53' 29"	
365	29° 49' 22"	29° 53' 29"	
366	29° 48' 12"	29° 51' 34"	
367	29° 48' 28"	29° 51' 32"	
368	29° 48' 31"	29° 51' 32"	
369	29° 48' 44"	29° 51' 33"	29
370	29° 49' 7"	29° 51' 36"	
371	29° 49' 13"	29° 51' 36"	
372	29° 49' 13"	29° 51' 36"	
373	29° 45' 54"	29° 52' 3"	
374	29° 45' 49"	29° 51' 60"	
375	29° 45' 51"	29° 51' 38"	
376	29° 45' 54"	29° 51' 9"	
377	29° 45' 55"	29° 50' 59"	
378	29° 45' 53"	29° 50' 50"	30
379	29° 45' 51"	29° 50' 43"	
380	29° 45' 52"	29° 50' 40"	
381	29° 45' 49"	29° 50' 35"	
382	29° 45' 47"	29° 50' 34"	
383	29° 45' 47"	29° 50' 34"	
384	29° 52' 30"	29° 48' 2"	
385	29° 52' 23"	29° 48' 0"	
386	29° 52' 12"	29° 48' 0"	
387	29° 52' 10"	29° 48' 6"	
388	29° 52' 10"	29° 48' 10"	
389	29° 52' 7"	29° 48' 11"	
390	29° 52' 6"	29° 48' 13"	
391	29° 52' 8"	29° 48' 32"	
392	29° 52' 10"	29° 48' 38"	
393	29° 52' 8"	29° 48' 42"	31
394	29° 52' 12"	29° 48' 49"	
395	29° 52' 11"	29° 48' 55"	
396	29° 52' 16"	29° 48' 59"	
397	29° 52' 17"	29° 49' 7"	
398	29° 52' 13"	29° 49' 16"	
399	29° 52' 9"	29° 49' 23"	
400	29° 52' 7"	29° 49' 28"	
401	29° 52' 6"	29° 49' 33"	
402	29° 52' 4"	29° 49' 37"	
403	29° 52' 4"	29° 49' 37"	
404	29° 50' 46"	29° 46' 51"	
405	29° 50' 47"	29° 46' 47"	
406	29° 50' 50"	29° 46' 44"	
407	29° 50' 51"	29° 46' 39"	
408	29° 50' 47"	29° 46' 36"	
409	29° 50' 41"	29° 46' 30"	
410	29° 50' 38"	29° 46' 29"	
411	29° 50' 33"	29° 46' 26"	
412	29° 50' 30"	29° 46' 24"	

529	29° 45' 42"	29° 48' 5"	
530	29° 45' 40"	29° 48' 15"	
531	29° 45' 38"	29° 48' 26"	
532	29° 45' 39"	29° 48' 36"	
533	29° 45' 41"	29° 48' 47"	
534	29° 45' 41"	29° 48' 47"	
535	29° 44' 22"	29° 50' 31"	
536	29° 44' 19"	29° 50' 36"	
537	29° 44' 10"	29° 50' 53"	
538	29° 43' 59"	29° 51' 13"	
539	29° 43' 55"	29° 51' 21"	
540	29° 43' 49"	29° 51' 33"	
541	29° 43' 43"	29° 51' 44"	
542	29° 43' 39"	29° 51' 51"	35
543	29° 43' 32"	29° 51' 52"	
544	29° 43' 23"	29° 51' 53"	
545	29° 43' 15"	29° 51' 53"	
546	29° 43' 12"	29° 51' 55"	
547	29° 43' 5"	29° 51' 55"	
548	29° 42' 55"	29° 51' 55"	
549	29° 42' 51"	29° 51' 56"	
550	29° 42' 51"	29° 51' 56"	
551	29° 42' 46"	29° 51' 53"	
552	29° 42' 43"	29° 51' 49"	36
553	29° 42' 39"	29° 51' 47"	
554	29° 42' 39"	29° 51' 47"	
555	29° 43' 49"	29° 51' 53"	
556	29° 43' 51"	29° 51' 58"	
557	29° 43' 52"	29° 52' 2"	
558	29° 43' 55"	29° 52' 4"	
559	29° 43' 58"	29° 52' 6"	
560	29° 44' 0"	29° 52' 15"	
561	29° 44' 1"	29° 52' 18"	
562	29° 44' 5"	29° 52' 26"	37
563	29° 44' 9"	29° 52' 33"	
564	29° 44' 10"	29° 52' 37"	
565	29° 44' 10"	29° 52' 42"	
566	29° 44' 7"	29° 52' 46"	
567	29° 44' 5"	29° 52' 48"	
568	29° 44' 6"	29° 52' 51"	
569	29° 44' 6"	29° 52' 53"	
570	29° 44' 6"	29° 52' 53"	
571	29° 46' 8"	29° 53' 54"	
572	29° 46' 14"	29° 53' 55"	
573	29° 46' 16"	29° 53' 55"	
574	29° 46' 16"	29° 53' 56"	
575	29° 46' 12"	29° 53' 60"	
576	29° 46' 10"	29° 54' 2"	
577	29° 46' 8"	29° 54' 4"	
578	29° 46' 6"	29° 54' 5"	
579	29° 46' 6"	29° 54' 6"	
580	29° 46' 5"	29° 54' 8"	38
581	29° 46' 1"	29° 54' 10"	
582	29° 45' 58"	29° 54' 12"	
583	29° 45' 54"	29° 54' 14"	
584	29° 45' 53"	29° 54' 16"	
585	29° 45' 51"	29° 54' 19"	
586	29° 45' 49"	29° 54' 21"	
587	29° 45' 45"	29° 54' 23"	
588	29° 45' 44"	29° 54' 23"	
589	29° 45' 44"	29° 54' 24"	

654	29° 45' 44"	29° 56' 52"	
655	29° 45' 47"	29° 56' 52"	
656	29° 45' 49"	29° 56' 53"	
657	29° 45' 53"	29° 56' 55"	
658	29° 45' 54"	29° 56' 57"	
659	29° 45' 55"	29° 56' 58"	
660	29° 45' 57"	29° 56' 59"	
661	29° 45' 60"	29° 56' 60"	
662	29° 46' 1"	29° 57' 2"	
663	29° 46' 3"	29° 57' 5"	
664	29° 46' 4"	29° 57' 10"	
665	29° 46' 5"	29° 57' 12"	
666	29° 46' 6"	29° 57' 14"	
667	29° 46' 7"	29° 57' 16"	
668	29° 46' 7"	29° 57' 19"	
669	29° 46' 6"	29° 57' 21"	
670	29° 46' 6"	29° 57' 24"	
671	29° 46' 4"	29° 57' 26"	
672	29° 46' 3"	29° 57' 28"	
673	29° 46' 4"	29° 57' 30"	
674	29° 46' 6"	29° 57' 31"	
675	29° 46' 6"	29° 57' 33"	
676	29° 46' 8"	29° 57' 34"	
677	29° 46' 10"	29° 57' 36"	
678	29° 46' 14"	29° 57' 36"	
679	29° 46' 22"	29° 57' 36"	
680	29° 46' 25"	29° 57' 36"	
681	29° 46' 28"	29° 57' 39"	
682	29° 46' 29"	29° 57' 42"	
683	29° 46' 31"	29° 57' 45"	
684	29° 46' 31"	29° 57' 48"	
685	29° 46' 31"	29° 57' 49"	
686	29° 46' 32"	29° 57' 51"	
687	29° 46' 35"	29° 57' 51"	
688	29° 46' 36"	29° 57' 52"	
689	29° 46' 34"	29° 57' 55"	
690	29° 46' 34"	29° 57' 56"	
691	29° 46' 34"	29° 57' 59"	
692	29° 46' 34"	29° 57' 59"	
693	29° 43' 49"	29° 51' 53"	
694	29° 43' 44"	29° 51' 56"	
695	29° 43' 42"	29° 51' 57"	
696	29° 43' 37"	29° 52' 5"	
697	29° 43' 33"	29° 52' 7"	
698	29° 43' 30"	29° 52' 7"	
699	29° 43' 21"	29° 52' 6"	
700	29° 43' 17"	29° 52' 10"	
701	29° 43' 13"	29° 52' 13"	
702	29° 43' 0"	29° 52' 16"	41
703	29° 42' 52"	29° 52' 9"	
704	29° 42' 42"	29° 51' 59"	
705	29° 42' 29"	29° 51' 49"	
706	29° 42' 22"	29° 51' 42"	
707	29° 42' 19"	29° 51' 37"	
708	29° 42' 15"	29° 51' 19"	
709	29° 42' 12"	29° 51' 11"	
710	29° 42' 7"	29° 51' 4"	
711	29° 42' 5"	29° 51' 1"	
712	29° 42' 5"	29° 51' 1"	
713	29° 41' 14"	29° 50' 4"	
714	29° 41' 11"	29° 49' 59"	
715	29° 41' 4"	29° 49' 56"	
716	29° 41' 2"	29° 49' 52"	
717	29° 40' 57"	29° 49' 45"	
718	29° 40' 55"	29° 49' 44"	42
719	29° 40' 54"	29° 49' 40"	
720	29° 40' 56"	29° 49' 36"	
721	29° 40' 54"	29° 49' 31"	
722	29° 40' 54"	29° 49' 31"	

124	29° 57' 52"	29° 55' 47"	
125	29° 57' 45"	29° 55' 53"	
126	29° 57' 39"	29° 56' 1"	
127	29° 57' 39"	29° 56' 5"	
128	29° 57' 46"	29° 56' 21"	
129	29° 57' 47"	29° 56' 41"	
130	29° 57' 50"	29° 56' 49"	
131	29° 57' 51"	29° 56' 53"	
132	29° 57' 53"	29° 56' 56"	
133	29° 57' 56"	29° 56' 60"	
134	29° 58' 11"	29° 57' 13"	
135	29° 58' 23"	29° 57' 24"	
136	29° 58' 27"	29° 57' 31"	
137	29° 58' 28"	29° 57' 40"	13
138	29° 58' 28"	29° 57' 57"	
139	29° 58' 38"	29° 58' 17"	
140	29° 58' 40"	29° 58' 20"	
141	29° 58' 40"	29° 58' 25"	
142	29° 58' 40"	29° 58' 25"	
143	29° 58' 40"	29° 58' 24"	
144	29° 58' 38"	29° 58' 28"	
145	29° 58' 36"	29° 58' 32"	
146	29° 58' 36"	29° 58' 33"	
147	29° 58' 39"	29° 58' 32"	
148	29° 58' 43"	29° 58' 31"	
149	29° 58' 44"	29° 58' 31"	
150	29° 58' 46"	29° 58' 31"	
151	29° 58' 47"	29° 58' 31"	
152	29° 58' 47"	29° 58' 31"	

279	30° 1' 43"	30° 5' 9"	
280	30° 1' 47"	30° 5' 18"	24
281	30° 1' 49"	30° 5' 24"	
282	30° 1' 49"	30° 5' 24"	

413	29° 50' 24"	29° 46' 21"	
414	29° 50' 22"	29° 46' 16"	
415	29° 50' 24"	29° 46' 12"	
416	29° 50' 27"	29° 46' 6"	
417	29° 50' 28"	29° 46' 3"	
418	29° 50' 38"	29° 45' 58"	
419	29° 50' 42"	29° 45' 58"	
420	29° 50' 41"	29° 45' 55"	
421	29° 50' 45"	29° 45' 56"	
422	29° 50' 51"	29° 45' 59"	
423	29° 50' 52"	29° 45' 60"	
424	29° 50' 58"	29° 45' 58"	
425	29° 51' 4"	29° 45' 51"	
426	29° 51' 9"	29° 45' 46"	
427	29° 51' 12"	29° 45' 43"	
428	29° 51' 12"	29° 45' 39"	
429	29° 51' 19"	29° 45' 34"	
430	29° 51' 24"	29° 45' 31"	
431	29° 51' 23"	29° 45' 27"	
432	29° 51' 25"	29° 45' 21"	
433	29° 51' 27"	29° 45' 21"	
434	29° 51' 28"	29° 45' 20"	32
435	29° 51' 33"	29° 45' 19"	
436	29° 51' 37"	29° 45' 16"	
437	29° 51' 46"	29° 45' 17"	
438	29° 51' 51"	29° 45' 18"	
439	29° 51' 57"	29° 45' 21"	
440	29° 51' 58"	29° 45' 20"	
441	29° 52' 2"	29° 45' 22"	
442	29° 52' 4"	29° 45' 23"	
443	29° 52' 7"	29° 45' 20"	
444	29° 52' 14"	29° 45' 20"	
445	29° 52' 21"	29° 45' 16"	
446	29° 52' 21"	29° 45' 16"	
447	29° 52' 21"	29° 45' 15"	
448	29° 52' 29"	29° 45' 15"	
449	29° 52' 33"	29° 45' 15"	
450	29° 52' 37"	29° 45' 15"	
451	29° 52' 39"	29° 45' 14"	
452	29° 52' 44"	29° 45' 14"	
453	29° 52' 50"	29° 45' 13"	
454	29° 52' 53"	29° 45' 13"	
455	29° 52' 60"	29° 45' 15"	
456	29° 53' 4"	29° 45' 13"	
457	29° 53' 7"	29° 45' 12"	
458	29° 53' 9"	29° 45' 14"	
459	29° 53' 13"	29° 45' 18"	
460	29° 53' 19"	29° 45' 23"	
461	29° 53' 21"	29° 45' 26"	
462	29° 53' 23"	29° 45' 29"	
463	29° 53' 30"	29° 45' 33"	
464	29° 53' 30"	29° 45' 33"	

MODERATE			
Points	South	East	Sections
1	29° 58' 8"	29° 46' 32"	1
2	29° 57' 60"	29° 46' 38"	
3	29° 57' 54"	29° 46' 43"	
4	29° 57' 54"	29° 46' 43"	
5	29° 57' 38"	29° 46' 59"	2
6	29° 57' 36"	29° 47' 1"	
7	29° 57' 21"	29° 46' 57"	
8	29° 57' 17"	29° 47' 1"	
9	29° 57' 20"	29° 47' 15"	
10	29° 57' 17"	29° 47' 21"	
11	29° 57' 10"	29° 47' 23"	
12	29° 57' 5"	29° 47' 28"	
13	29° 56' 57"	29° 47' 30"	
14	29° 56' 54"	29° 47' 36"	
15	29° 56' 54"	29° 47' 36"	
16	29° 56' 51"	29° 48' 25"	3
17	29° 56' 59"	29° 48' 32"	
18	29° 56' 55"	29° 48' 37"	
19	29° 56' 47"	29° 48' 37"	
20	29° 56' 31"	29° 48' 43"	
21	29° 56' 12"	29° 48' 45"	
22	29° 56' 11"	29° 48' 47"	
23	29° 56' 3"	29° 48' 50"	
24	29° 55' 59"	29° 48' 55"	
25	29° 55' 56"	29° 48' 58"	
26	29° 55' 54"	29° 48' 59"	
27	29° 55' 52"	29° 48' 60"	
28	29° 55' 51"	29° 49' 0"	
29	29° 55' 51"	29° 49' 0"	

MODERATE			
Points	South	East	Sections
77	30° 5' 9"	30° 6' 56"	11
78	30° 5' 9"	30° 6' 57"	
79	30° 5' 5"	30° 7' 2"	
80	30° 5' 4"	30° 7' 4"	
81	30° 5' 3"	30° 7' 5"	
82	30° 5' 2"	30° 7' 6"	
83	30° 5' 1"	30° 7' 7"	
84	30° 4' 60"	30° 7' 10"	
85	30° 4' 59"	30° 7' 15"	
86	30° 4' 58"	30° 7' 22"	
87	30° 4' 56"	30° 7' 34"	
88	30° 4' 55"	30° 7' 41"	
89	30° 4' 54"	30° 7' 49"	
90	30° 4' 53"	30° 7' 54"	
91	30° 4' 53"	30° 7' 57"	
92	30° 4' 52"	30° 7' 59"	
93	30° 4' 52"	30° 7' 59"	
94	30° 4' 32"	30° 8' 33"	12
95	30° 4' 21"	30° 8' 37"	
96	30° 4' 18"	30° 8' 40"	
97	30° 4' 15"	30° 8' 43"	
98	30° 4' 12"	30° 8' 46"	
99	30° 4' 12"	30° 8' 46"	
100	30° 3' 56"	30° 9' 12"	
101	30° 3' 56"	30° 9' 15"	
102	30° 3' 56"	30° 9' 18"	
103	30° 3' 56"	30° 9' 20"	
104	30° 3' 55"	30° 9' 24"	
105	30° 3' 52"	30° 9' 29"	

MODERATE			
Points	South	East	Sections
166	29° 44' 29"	29° 50' 26"	17
167	29° 44' 25"	29° 50' 26"	
168	29° 44' 22"	29° 50' 31"	
169	29° 44' 22"	29° 50' 31"	
170	29° 46' 34"	29° 57' 59"	18
171	29° 46' 34"	29° 57' 59"	
172	29° 46' 34"	29° 58' 0"	
173	29° 46' 34"	29° 58' 0"	
174	29° 46' 45"	29° 58' 10"	19
175	29° 46' 47"	29° 58' 12"	
176	29° 46' 51"	29° 58' 13"	
177	29° 46' 57"	29° 58' 16"	
178	29° 47' 5"	29° 58' 22"	
179	29° 47' 11"	29° 58' 28"	
180	29° 47' 12"	29° 58' 32"	
181	29° 47' 13"	29° 58' 35"	
182	29° 47' 15"	29° 58' 38"	
183	29° 47' 21"	29° 58' 40"	
184	29° 47' 23"	29° 58' 43"	
185	29° 47' 25"	29° 58' 46"	
186	29° 47' 33"	29° 58' 53"	
187	29° 47' 36"	29° 58' 57"	
188	29° 47' 44"	29° 58' 60"	
189	29° 47' 45"	29° 58' 60"	
190	29° 47' 45"	29° 58' 60"	
191	29° 48' 15"	29° 59' 22"	
192	29° 48' 19"	29° 59' 22"	
193	29° 48' 23"	29° 59' 21"	

30	29° 55' 33"	29° 49' 13"	4
31	29° 55' 32"	29° 49' 16"	
32	29° 55' 31"	29° 49' 16"	
33	29° 55' 31"	29° 49' 16"	
34	29° 53' 22"	29° 49' 49"	5
35	29° 53' 33"	29° 49' 50"	
36	29° 53' 36"	29° 49' 50"	
37	29° 54' 2"	29° 49' 51"	
38	29° 54' 27"	29° 49' 44"	
39	29° 54' 35"	29° 49' 43"	
40	29° 54' 45"	29° 49' 43"	
41	29° 54' 54"	29° 49' 46"	
42	29° 55' 8"	29° 49' 40"	
43	29° 55' 8"	29° 49' 34"	
44	29° 55' 15"	29° 49' 30"	
45	29° 55' 18"	29° 49' 27"	
46	29° 55' 22"	29° 49' 23"	
47	29° 55' 22"	29° 49' 23"	
48	29° 53' 21"	29° 51' 33"	6
49	29° 53' 25"	29° 51' 32"	
50	29° 53' 31"	29° 51' 31"	
51	29° 53' 34"	29° 51' 31"	
52	29° 53' 37"	29° 51' 31"	
53	29° 53' 37"	29° 51' 31"	
54	29° 52' 25"	29° 53' 19"	7
55	29° 52' 20"	29° 53' 16"	
56	29° 52' 18"	29° 53' 15"	
57	29° 52' 18"	29° 53' 15"	

106	30° 3' 47"	30° 9' 35"	13
107	30° 3' 45"	30° 9' 37"	
108	30° 3' 38"	30° 9' 41"	
109	30° 3' 36"	30° 9' 45"	
110	30° 3' 36"	30° 9' 46"	
111	30° 3' 36"	30° 9' 48"	
112	30° 3' 36"	30° 9' 50"	
113	30° 3' 37"	30° 9' 52"	
114	30° 3' 50"	30° 9' 51"	
115	30° 3' 50"	30° 9' 51"	
116	30° 3' 37"	30° 9' 51"	
117	30° 3' 38"	30° 9' 53"	
118	30° 3' 45"	30° 10' 3"	
119	30° 3' 46"	30° 10' 8"	
120	30° 3' 44"	30° 10' 15"	
121	30° 3' 40"	30° 10' 29"	
122	30° 3' 35"	30° 10' 47"	
123	30° 3' 31"	30° 10' 57"	
124	30° 3' 27"	30° 11' 4"	
125	30° 3' 22"	30° 11' 11"	
126	30° 3' 20"	30° 11' 14"	
127	30° 3' 15"	30° 11' 16"	
128	30° 3' 13"	30° 11' 20"	
129	30° 3' 12"	30° 11' 25"	
130	30° 3' 11"	30° 11' 27"	
131	30° 3' 9"	30° 11' 28"	
132	30° 3' 3"	30° 11' 30"	
133	30° 2' 59"	30° 11' 31"	
134	30° 2' 57"	30° 11' 33"	
135	30° 2' 54"	30° 11' 37"	
136	30° 2' 53"	30° 11' 39"	
137	30° 2' 53"	30° 11' 41"	
138	30° 2' 55"	30° 11' 43"	

194	29° 48' 26"	29° 59' 23"	20
195	29° 48' 26"	29° 59' 27"	
196	29° 48' 40"	29° 59' 37"	
197	29° 48' 55"	29° 59' 47"	
198	29° 48' 58"	29° 59' 44"	
199	29° 48' 60"	29° 59' 39"	
200	29° 49' 3"	29° 59' 40"	
201	29° 49' 8"	29° 59' 43"	
202	29° 49' 17"	29° 59' 39"	
203	29° 49' 24"	29° 59' 43"	
204	29° 49' 30"	29° 59' 54"	
205	29° 49' 58"	30° 0' 19"	
206	29° 50' 1"	30° 0' 23"	
207	29° 50' 1"	30° 0' 54"	
208	29° 50' 2"	30° 0' 54"	
209	29° 50' 3"	30° 1' 2"	
210	29° 50' 3"	30° 1' 3"	
211	29° 50' 6"	30° 1' 6"	
212	29° 50' 7"	30° 1' 9"	
213	29° 50' 9"	30° 1' 12"	
214	29° 50' 17"	30° 1' 18"	
215	29° 50' 19"	30° 1' 19"	
216	29° 50' 21"	30° 1' 22"	
217	29° 50' 28"	30° 1' 29"	
218	29° 50' 42"	30° 1' 33"	
219	29° 50' 48"	30° 1' 34"	
220	29° 50' 55"	30° 1' 37"	
221	29° 50' 55"	30° 1' 38"	
222	29° 51' 1"	30° 1' 40"	
223	29° 51' 7"	30° 1' 42"	
224	29° 51' 28"	30° 1' 46"	
225	29° 51' 34"	30° 1' 47"	
226	29° 51' 39"	30° 1' 51"	

58	30° 2' 58"	30° 3' 15"	
59	30° 2' 56"	30° 3' 13"	
60	30° 2' 51"	30° 3' 14"	
61	30° 2' 47"	30° 3' 14"	
62	30° 2' 42"	30° 3' 14"	8
63	30° 2' 38"	30° 3' 20"	
64	30° 2' 36"	30° 3' 27"	
65	30° 2' 36"	30° 3' 28"	
66	30° 2' 36"	30° 3' 28"	
67	30° 2' 31"	30° 3' 35"	
68	30° 2' 29"	30° 3' 39"	9
69	30° 2' 29"	30° 3' 39"	
70	30° 4' 50"	30° 5' 50"	
71	30° 4' 52"	30° 5' 54"	
72	30° 4' 53"	30° 5' 60"	
73	30° 4' 54"	30° 6' 4"	10
74	30° 4' 54"	30° 6' 6"	
75	30° 4' 54"	30° 6' 7"	
76	30° 4' 54"	30° 6' 7"	

139	30° 2' 58"	30° 11' 44"	
140	30° 2' 58"	30° 11' 44"	
141	30° 2' 58"	30° 11' 44"	
142	30° 3' 10"	30° 11' 52"	
143	30° 3' 13"	30° 11' 58"	
144	30° 3' 13"	30° 12' 6"	
145	30° 3' 13"	30° 12' 9"	
146	30° 3' 16"	30° 12' 11"	
147	30° 3' 19"	30° 12' 14"	
148	30° 3' 25"	30° 12' 17"	14
149	30° 3' 26"	30° 12' 22"	
150	30° 3' 25"	30° 12' 27"	
151	30° 3' 27"	30° 12' 30"	
152	30° 3' 32"	30° 12' 31"	
153	30° 3' 33"	30° 12' 31"	
154	30° 3' 35"	30° 12' 31"	
155	30° 3' 35"	30° 12' 31"	
156	30° 5' 4"	30° 7' 5"	
157	30° 5' 20"	30° 7' 6"	15
158	30° 5' 24"	30° 7' 1"	
159	30° 5' 24"	30° 7' 1"	
160	30° 6' 11"	30° 6' 60"	
161	30° 6' 25"	30° 6' 51"	
162	30° 6' 28"	30° 6' 49"	16
163	30° 6' 30"	30° 6' 49"	
164	30° 6' 29"	30° 6' 54"	
165	30° 6' 29"	30° 6' 54"	

227	29° 51' 40"	30° 1' 53"	
228	29° 51' 43"	30° 2' 3"	
229	29° 51' 48"	30° 2' 29"	
230	29° 51' 50"	30° 2' 36"	
231	29° 51' 57"	30° 2' 54"	
232	29° 52' 3"	30° 3' 8"	
233	29° 52' 11"	30° 3' 22"	
234	29° 52' 22"	30° 3' 27"	
235	29° 52' 27"	30° 3' 30"	
236	29° 52' 33"	30° 3' 34"	
237	29° 52' 40"	30° 3' 46"	
238	29° 52' 46"	30° 3' 56"	
239	29° 52' 52"	30° 4' 6"	
240	29° 52' 52"	30° 4' 6"	
241	29° 52' 54"	30° 4' 10"	
242	29° 52' 60"	30° 4' 19"	
243	29° 52' 60"	30° 4' 19"	
244	29° 52' 60"	30° 4' 19"	
245	29° 53' 7"	30° 4' 31"	
246	29° 53' 34"	30° 5' 16"	
247	29° 53' 39"	30° 5' 19"	
248	29° 53' 39"	30° 5' 19"	

QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

Dr. Gideon Groenewald has a PhD in Geology from the University of Port Elizabeth (Nelson Mandela Metropolitan University) (1996) and the National Diploma in Nature Conservation from Technicon RSA (the University of South Africa) (1989). He specialises in research on South African Permian and Triassic sedimentology and macrofossils with an interest in biostratigraphy, and palaeo-ecological aspects. He has extensive experience in the locating of fossil material in the Karoo Supergroup and has more than 20 years of experience in locating, collecting and curating fossils, including exploration field trips in search of new localities in the southern, western, eastern and north-eastern parts of the country. His publication record includes multiple articles in internationally recognized journals. Dr Groenewald is accredited by the Palaeontological Society of Southern Africa (society member for 25 years).

DECLARATION OF INDEPENDENCE

I, Dr. Gideon Groenewald, declare that I am an independent specialist consultant and have no financial, personal or other interest in the proposed development, nor the developers or any of their subsidiaries, apart from fair remuneration for work performed in the delivery of palaeontological heritage assessment services. There are no circumstances that compromise the objectivity of my performing such work.

Dr. Gideon Groenewald
Geologist