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Golder Associates

February 2011

DRAFT REPORT

A world of capabilities delivered locally

SHELL INTERNATIONAL EXPLORATION AND PRODUCTION B.V.

Soil Technical Report in support of the EMP for the South Western Karoo Basin Gas Exploration Application Project

CENTRAL PRECINCT

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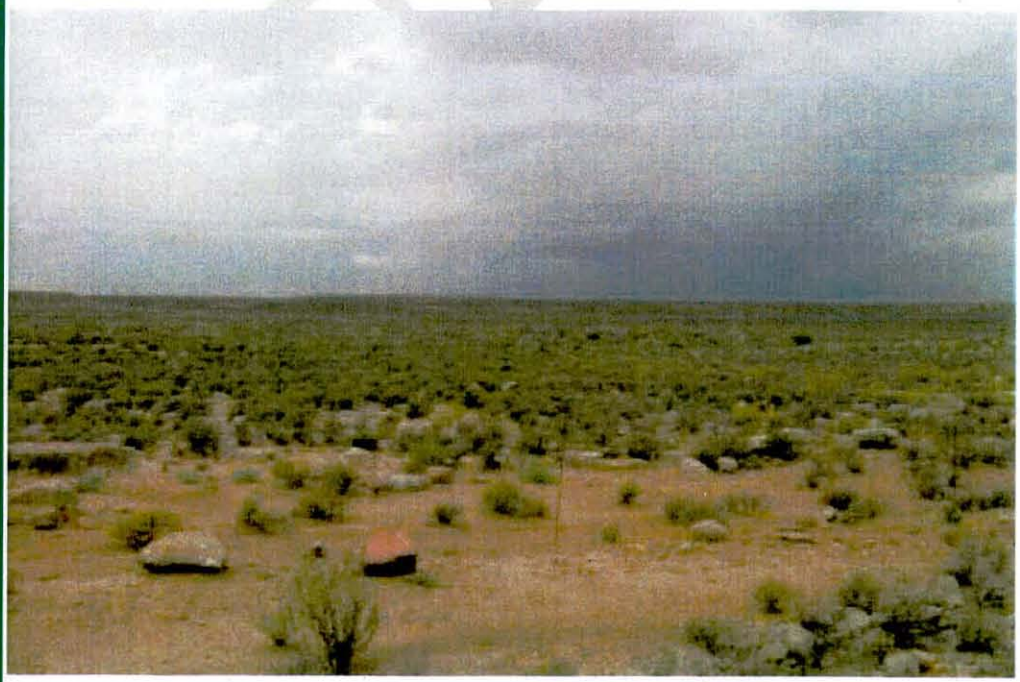

Golder Report Number: 12800-10368-6

Golder Associates

EXECUTIVE SUMMARY

Objectives of the study

Shell Exploration Company B.V., a registered company of Royal Dutch Shell plc (Shell) has applied to the Petroleum Agency of South Africa (PASA) seeking the award of exploration rights to undertake gas exploration activities in the South Western Karoo Basin, South Africa.

This report summarises the findings of a desktop soil study undertaken to support the Environmental Management Plan (EMP), in support of the application for the exploration right, for an area known as the Central Precinct (Figure 1).

The objectives of the study were as follows (Appendix A):

- To define the existing (baseline) soil classes with the Central Precinct;
- To identify the potential impacts on the soil resource; and
- To suggest mitigation measures to prevent/minimise the identified potential impacts.

Study approach

Spatial information from the GIS database held by Golder Africa (Golder) was used to create maps of the Central Precinct with the following layers:

- A 1:1 000 000 Geology map for SA;
- A general soil pattern map for SA; and
- Topographical background based on the SRTM DEM data.

These maps were used to define the board scale topography and soil types for the Central Precinct and the National Land Type Survey database (Land Type Survey, 1999 and 2005) searched to provide information on soil characteristics (Appendix B).

Baseline environment

Based on regional data the Central Precinct is contains the following five soil classes/units of significance:

- Soils with minimal development (Lithosols);
- Rock outcrops with limited soils;
- Structured soils with marked clay accumulation;
- Soils on alluvial deposits; and
- Red soils with high base status.

The majority of the Central Precinct is represented by Lithosols or structured soils with marked clay accumulation. The soils in these areas are characterised by shallow profiles and alkaline pH. Due to the largely shallow profiles and arid environment of the Karoo these soils are considered of low agricultural potential.

The proposed exploration activities would potentially impact approximately1 ha[1] (i.e. 0.01 km^2) of soil at up to eight sites within the 30 000 km^2 Central Precinct. That is less than 0.0001% of the area in the Central Precinct. It is important to note the potential impacts presented here are based on a desktop investigation and are generalised for the region rather site specific.

[1] A small amount of additional area may be required should it be necessary to build an access road, temporary accommodation, additional storage and parking, etc.

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The following potential impacts on the soil resource were identified for the proposed exploration activity:

- Disturbance of soil to carry out the Magneto-Telluric survey;
- Loss of the soil resource due to site preparation of the drilling pads and infrastructure;
- Loss of soil integrity due to soil disturbance during site preparation;
- Soil compaction due to site preparation and vehicle movement;
- Soil contamination due to accidental spills of fuel, hydraulic fracturing fluid and drilling muds; and
- Soil erosion due to removal of vegetation and disturbance of soil.

Disturbance of soil – Magneto-Telluric Survey

The Magneto-Telluric survey will require disturbing a small area of soil (<0.25m^2) to install probes for 24 hours. The top soil and vegetation will be replaced following removal of the probe and the impact on soil from this activity is conservatively rated as of low significance in Table 1, however, given the small area of disturbance this impact will be insignificant on a regional scale.

Loss of the soil resource

The proposed exploration project will result in a loss of approximately1 ha soil resource at up to eight sites within the application area, during site preparation; this impact will continue until decommissioning. The site preparation process will involve clearing of the top soil to allow for drilling of the wells. The soil will be stockpiled for remediation during decommissioning.

During the decommissioning remediation of the sites will restore the soil resource back to its original state. The remediation process will include ripping of the soil, re-application of top soil and establishment of vegetation cover.

The potential impact is likely to be of have high magnitude on the soil directly impacted at ach site and an impact of moderate significance may occur. However, give the impact soil area is <0.0001% of the Central Precinct area the impact is likely to be insignificant on a regional scale.

Loss of soil Integrity

The soil integrity is a function of the inherent fertility, nutrient and water retention, organic matter content, and a number of physical properties of the soil. When a soil is disturbed in any way, any number of these may be affected and may result in negative impacts for the soil. Disturbances expected to bring about such changes include:

- Movement of vehicles over virgin soil;
- Excavation;
- Clearing of soil for site preparation; and
- Stockpiling of stripped soils.

The loss of soil integrity will occur during the site preparation phase but will persist during the operational phase. During decommissioning the soil integrity can be remediated to a certain extent (see section 5.1).

Without mitigation the potential impact is likely to be of have high magnitude on the soil directly impacted at each site and an impact of moderate significance may occur. The magnitude of this impact can be further reduced if the mitigation measures presented in Section 5.1 of the report are implemented; however, the significance of the impact is likely to remain moderate at the site.

However, give the impact soil area is <0.0001% of the Central Precinct area the impact is likely to be insignificant on a regional scale.

Soil compaction

Soil compaction occurs when a weight is applied on the surface and soil particles including the porous network, are rearranged as a result (Singer, 1987). Soil compaction may occur as a result of the following activities:

- Heavy vehicle movement;
- Excavating operations; and
- Soil removal and restoration.

The structured soils falling within the precinct will be more susceptible to compaction than the sandy soils. Soil compaction will be largely limited to the site preparation phase.

The impacts from soil compaction are likely to be of low to moderate significance (depending on soil type) prior to mitigation of a site specific basis. However, the implementation of mitigation measures to limit the amount of soil compaction at the site will reduce this impact to one of low significance.

Soil contamination/pollution

There is potential for contamination of soil to occur at the site due to accidental spillages of fuels or chemicals (such as hydraulic fracturing fluids) at the site. The potential for soil contamination will be greatest during site preparation, however, spill management measures will be implemented to minimise the risk of spills. All hazardous chemicals will be stored in appropriate containers and pits used for drilling muds and return water will be lined to prevent infiltration into the soil.

The significance of this impact is considered moderate prior to mitigation and with the implementation of measures to prevent, contain and remediate spills the significance of this impact can be reduced to one of low significance.

Erosion

Erosion is a function of both the physical characteristics of that soil and the topography of the land. In general the lighter textured, free draining soils will be less prone to erosion than heavier clay type of soils with a wet base.

Soil situated on gentle sloped topography will be less prone to erosion compared to those on steep slopes when it comes under disturbance of human activity. Existing and established vegetation binds and stabilises the soils and ensures better resistance to erosion.

Sites on gentle slopped topography will be selected to limit the potential for erosion and erosion management measures will be implemented during site preparation.

The significance of this impact is likely to be low and can be further reduced by the implementation of mitigation measures to control soil erosion.

Key Questions to be answered in the EIA

Following this preliminary assessment, a site selection process and a full environmental impact assessment (EIA) will be carried out. The EIA will assess all potential impacts from the project and the following key questions will be answered in relation to soil impacts:

- What are the existing soil types at the selected sites?
- What is the land capability of the soils at the selected sites?
- What is the current land use of the selected sites?
- What will be the impacts on the availability of the soil resource at the site?
- What will be the potential impacts on the soil quality at the site?
- What mitigation measures can be put in place to mitigate identified impacts?

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1.0 INTRODUCTION

Shell Exploration Company B.V., a registered company of Royal Dutch Shell plc (Shell) has applied to the Petroleum Agency of South Africa (PASA) seeking the award of exploration rights to undertake gas exploration activities in the South Western Karoo Basin, South Africa.

This report summarises the findings of a desktop soil study undertaken to support the Environmental Management Plan (EMP), in support of the application for the exploration right, for an area known as the Central Precinct (Figure 1).

2.0 OBJECTIVES

The objectives of the study were as follows (Appendix A):

- To define the existing (baseline) soil classes with the Central Precinct;
- To identify the potential impacts on the soil resource; and
- To suggest mitigation measures to prevent/minimize the identified potential impacts.

3.0 DESKTOP STUDY APPROACH

Spatial information from the GIS database held by Golder Africa (Golder) was used to create maps of the Central Precinct with the following layers:

- A 1:1 000 000 Geology map for SA;
- A general soil pattern map for SA; and
- Topographical background based on the SRTM DEM data.

These maps were used to define the board scale topography and soil types for the Central Precinct and the National Land Type Survey database (Land Type Survey, 1999 and 2005) searched to provide information on soil characteristics (Appendix B).

4.0 BASELINE DESCRIPTION OF THE STUDY AREA

4.1 Topography and Geology

The study area of the Central Precinct has a footprint of 30 000 km^2. The Central Precinct contains mountains and valleys of typical Karoo landscape mainly situated on the Great escarpment that separates the coast from the high inland plateau.

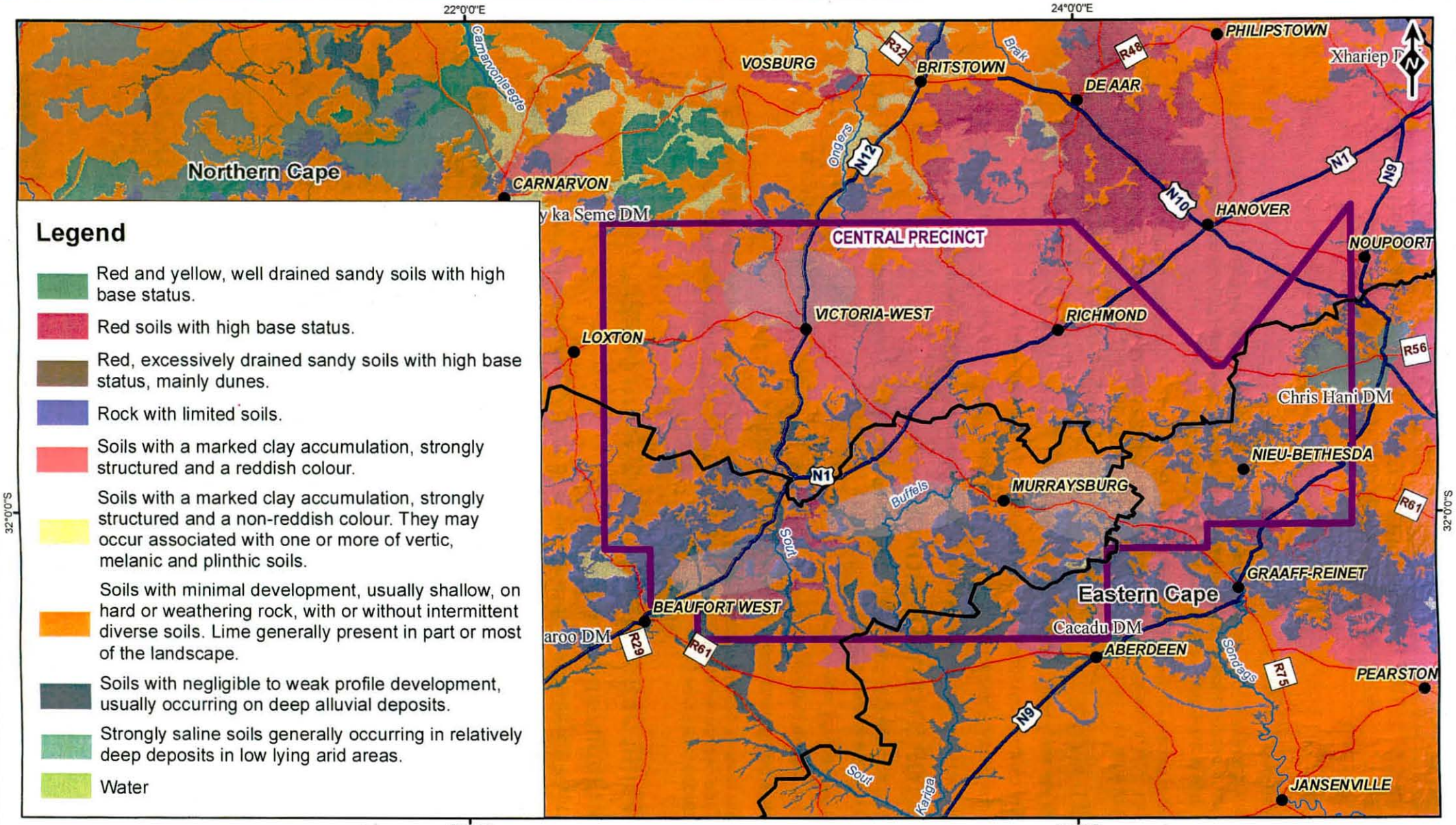
Geologically the precinct is dominated by the Beaufort Group of sediments, characterised by reddish and greenish mudstone beds, interbedded with sandstone and shale, to a lesser extent. The precinct is intruded by dolerite dykes or sills throughout and in the far northwest, shale of the Ecca group prevails.

4.2 Soil Classes of the Central Precinct

The broad scale soil map of the Central Precinct is shown if Figure 1, based on the regional data the Central Precinct contains the following five soil classes/units of significance:

- Soils with minimal development (Lithosols);
- Rock outcrops with limited soils;
- Structured soils with marked clay accumulation;
- Soils on alluvial deposits; and
- Red soils with high base status.

The majority of the Central Precinct is represented by Lithosols or structured soils with marked clay accumulation. The soils in these areas are characterised by shallow profiles and alkaline pH. Due to the largely shallow profiles and arid environment of the Karoo these soils are considered of low agricultural potential.



Legend

- Red and yellow, well drained sandy soils with high base status.
- Red soils with high base status.
- Red, excessively drained sandy soils with high base status, mainly dunes.
- Rock with limited soils.
- Soils with a marked clay accumulation, strongly structured and a reddish colour.
- Soils with a marked clay accumulation, strongly structured and a non-reddish colour. They may occur associated with one or more of vertic, melanic and plinthic soils.
- Soils with minimal development, usually shallow, on hard or weathering rock, with or without intermittent diverse soils. Lime generally present in part or most of the landscape.
- Soils with negligible to weak profile development, usually occurring on deep alluvial deposits.
- Strongly saline soils generally occurring in relatively deep deposits in low lying arid areas.
- Water

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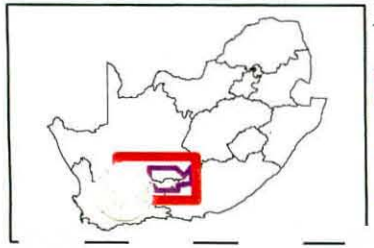

LEGEND

- Towns
- Exploration application area
- Notional area
- Rivers
- National route
- DistrictMunicipalities
- Provinces

RESOURCES\NOTES

0 10 20 30 40 Kilometres

REFERENCE

PROJECTION GCS Hartebeesthoek 1994

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PROJECT
SHELL KAROO BASIN EXPLORATION

TITLE
SOIL CLASSES OF THE CENTRAL PRECINCT

Golder Associates

GIS	IDT 2011/02/	PROJECT: 12800	
CHECK	LP 2011/02/	1,900,000	
REVIEW	LP 2011/02/25	A4	REV 0

urg, South Africa

4.2.1 Lithosols on the Beaufort sediments

The Lithosols cover a large area of the precinct, stretching in an east- west band over the centre of the project area and covering large parts in the west of the project area. Soils in this class are derived from in-situ weathering of Beaufort Group sediments and have undergone minimal development. These soils are light coloured, usually shallow (<300 mm) in profile and interface directly with hard or weathering rock (including the elliptic zones). Lime is often present in the soil profile.

No information for this specific soil class could be obtained from the National Land Type Survey database, however, the characteristics will be similar to the Lithosols of the Western Precinct (Golder 2011). These soils displayed fine-grained loamy sand to sandy loam textures, massive structure and soft to slightly firm consistency when moist often containing a small amount of angular gravel and low organic content typical of the semi-arid region. Chemically, these soils have alkaline pH, often resulting from elevated concentrations of calcium in the form of carbonates. In agricultural terms the soils are consider of poor quality that are at best useful as grazing lands.

4.2.2 Rock outcrops with limited soils

Rock outcrops with limited soils are in abundance over the precinct. This soil unit can be described as manifesting in-between rock outcrops and/or overly rock at shallow to moderate depths. These soils are associated with dolerite or Beaufort sediments. Soil characteristics are similar to the Lithosols when in association with the Beaufort sediments but tend to be more reddish in colour and of heavier texture when derived from the dolerite. These areas are perceived to have low agricultural potential due to their shallow nature and rocky surfaces.

4.2.3 Structured soils with marked clay accumulation

In the Central Precinct, soils with marked clay accumulation occur mainly in association with the Beaufort sediments but are at times associated with dolerite. When the soils are derived from Beaufort sediments they are greyish to brownish in colour colour. When the soils are of dolerite origin the soils can have relatively high magnesium and iron content which impart a strong red colour.

The texture of these soils may vary between sandy clay loam and sandy clay. Chemical profiles of the soils (Land Type Survey Staff, 1972-2003) indicate highly basic pH and high base status in the sub layer, while the topsoil is sandy with significantly lower base status. Chemically, dolerite derived soils are perceived as being more fertile than the soils from the Beaufort sediments.

The strong structure encountered in this soil class indicates poor drainage capability, which in turn, may lead to issues for storage and rehabilitation of these soils. Erosion and compaction will be of importance when management measures are considered. Soils from this class are associated with low agricultural potential.

4.2.4 Soils on alluvial deposits

This soil class is associated with riverbeds and drainage ways and are mainly present in the flatter topography or wide valleys. They are present in the south and southwest of the precinct. These alluvial soils can have varying depths and marked differences in textural characteristics. These soils can be associated with large water courses and are therefore of importance in the context of the predominately dry surrounding catchment. Rivulets and rocky streambeds serve to channels water from mountainous areas and usually comprise rocky banks and shallow soils overlying rock and are associated with steeper landscape.

4.2.5 Red soils with high base status

Red soils with high base status constitute 20% of the most south-western of the precinct. The soil profile is typically sandy in texture with an imbalance of calcium and magnesium, which may indicate a potential risk for instability. Base status is not in the same order compared to the Lithosols and clay soil classes, which can ascribed to the lower contents of calcium pH is basic and organic carbon content is low, as can be expected for this sparsely vegetated region with low precipitation.

Soil from this soil class is perceived as having high agricultural potential soils as they usually present favourable depth. Depth ranges are not provided in the available soil information but a typical profile (Land

Type Survey Staff, 2006) located in this class, indicates a depth of 0.5 m for the subsoil. The seemingly adequate depth may raise expectations of a moderate agricultural potential, but given the semi-arid setting, development of the profile at depth is very slow. It is therefore anticipated that depth of this soil class in this particular region will not be favourable for agricultural utilisation.

5.0 TECHNICAL ASSESSMENT

5.1 Assessment Method

The significance of the different impacts is partly dependant on the inherent properties of the soil and site specific conditions including terrain location, slope angle, etc. The potential impacts presented here are based on a desktop investigation and are generalised for the region rather site specific.

Potential significance of impacts was based on occurrence and severity, which are further sub-divided as follows:

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Magnitude (severity) of impact	Scale / extent of impact

To assess each impact, the following four ranking scales are used:

Probability	Duration
5 - Definite/don't know	5 – Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8-15 years)
2 - Low probability	2 - Short-term (0-7 years) (impact ceases after the operational life of the activity)
1 - Improbable	1 – Immediate
0 - None	
Scale	**Magnitude**
5 - International	10 - Very high/don't know
4 - National	8 - High
3 - Regional	6 - Moderate
2 - Local	4 - Low
1 - Site only	2 - Minor
0 - None	

The significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (probability + duration + scale) x magnitude

The maximum value is 150 significance points (SP). The impact significance will then be rated as follows:

SP >75	Indicates **high** environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates **moderate** environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates **low** environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.
+	Positive impact	An impact that is likely to result in positive consequences/effects.

5.2 Potential impacts

The proposed exploration activities would potentially impact approximately1 ha[2] (i.e. 0.01 km^2) of soil at up to eight sites within the 30 000 km^2 Central Precinct. That is less than 0.0001% of the area in the Central Precinct. It is important to note the potential impacts presented here are based on a desktop investigation and are generalised for the region rather site specific.

The following potential impacts on the soil resource were identified for the proposed exploration activity:

- Disturbance of soil to carry out the Magneto-Telluric survey;
- Loss of the soil resource due to site preparation of the drilling pads and infrastructure;
- Loss of soil integrity due to soil disturbance during site preparation;
- Soil compaction due to site preparation and vehicle movement;
- Soil contamination due to accidental spills of fuel, hydraulic fracturing fluid and drilling muds; and
- Soil erosion due to removal of vegetation and disturbance of soil.

The predicted significance of the potential impacts is presented in Table 1.

5.2.1 Disturbance of soil – Magneto-Telluric Survey

The Magneto-Telluric survey will require disturbing a small area of soil (<0.25m^2) to install probes for 24 hours. The top soil and vegetation will be replaced following removal of the probe and the impact on soil from this activity is conservatively rated as of low significance in Table 1, however, given the small area of disturbance this impact will be insignificant on a regional scale.

5.2.2 Loss of the soil resource

The proposed exploration project will result in a loss of approximately1 ha soil resource at up to eight sites within the application area, during site preparation; this impact will continue until decommissioning. The site preparation process will involve clearing of the top soil to allow for drilling of the wells. The soil will be stockpiled for remediation during decommissioning.

[2] A small amount of additional area may be required should it be necessary to build an access road, temporary accommodation, additional storage and parking, etc.

During the decommissioning phase remediation of the sites will restore the soil resource back to its original state. The remediation process will include ripping of the soil, re-application of top soil and establishment of vegetation cover.

The potential impact is likely to be of have high magnitude on the soil directly impacted at ach site and an impact of moderate significance may occur. However, give the impact soil area is <0.0001% of the Central Precinct area the impact is likely to be insignificant on a regional scale.

5.2.3 Loss of soil Integrity

The soil integrity is a function of the inherent fertility, nutrient and water retention, organic matter content, and a number of physical properties of the soil. When a soil is disturbed in any way, any number of these may be affected and may result in negative impacts for the soil. Disturbances expected to bring about such changes include:

- Movement of vehicles over virgin soil;
- Excavation;
- Clearing of soil for site preparation; and
- Stockpiling of stripped soils.

The loss of soil integrity will occur during the site preparation phase but will persist during the operational phase. During decommissioning the soil integrity can be remediated to a certain extent (see section 5.1).

Without mitigation the potential impact is likely to be of have high magnitude on the soil directly impacted at each site and an impact of moderate significance may occur. The magnitude of this impact can be further reduced if the mitigation measures presented in Section 5.1 of the report are implemented; however, the significance of the impact is likely to remain moderate at the site.

However, give the impact soil area is <0.0001% of the Central Precinct area the impact is likely to be insignificant on a regional scale.

5.2.4 Soil compaction

Soil compaction occurs when a weight is applied on the surface and soil particles including the porous network, are rearranged as a result (Singer, 1987). Soil compaction may occur as a result of the following activities:

- Heavy vehicle movement;
- Excavating operations; and
- Soil clearing and restoration.

The structured soils falling within the precinct will be more susceptible to compaction than the sandy soils. Soil compaction will be largely limited to the site preparation phase.

The impacts from soil compaction are likely to be of low to moderate significance (depending on soil type) prior to mitigation of a site specific basis. However, the implementation of the mitigation measures presented in section 5.1 will reduce this impact to one of low significance.

5.2.5 Soil contamination/pollution

There is potential for contamination of soil to occur at the site due to accidental spillages of fuels or chemicals (such as hydraulic fracturing fluids) at the site. The potential for soil contamination will be greatest during site preparation, however, spill management measures will be implemented to minimise the risk of spills. All hazardous chemicals will be stored in appropriate containers and pits used for drilling muds and return water will be lined to prevent infiltration into the soil.

The significance of this impact is considered moderate prior to mitigation and with the implementation of measures described in section 5.2 the significance of this impact can be reduced to one of low significance.

5.2.6 Erosion

Erosion is a function of both the physical characteristics of that soil and the topography of the land. In general the lighter textured, free draining soils will be less prone to erosion than heavier clay type of soils with a wet base.

Soil situated on gentle sloped topography will be less prone to erosion compared to those on steep slopes when it comes under disturbance of human activity. Existing and established vegetation binds and stabilises the soils and ensures better resistance to erosion.

Sites on gentle slopped topography will be selected to limit the potential for erosion and erosion management measures will be implemented during site preparation.

The significance of this impact is likely to be low and can be further reduced by the implementation by the mitigation measures presented in Section 5.3.

Table 1: Impact assessment and significance rating

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	Total	SP	M	D	S	P	Total	SP
Soil disturbance due to the Magneto-Telluric survey	2	1	1	5	14	L	2	1	1	5	14	L
Loss of soil resource due to site preparation and construction of access roads.	8	3	1	5	72	M	8	3	1	5	72	M
Loss of soils integrity due to site preparation and construction of access roads.	8	3	1	5	72	M	4	3	1	5	36	M
Potential compaction - lithosols soils	4	2	1	4	28	L	3	2	1	3	18	L
Potential compaction - clay soils	6	2	1	4	42	M	4	2	1	3	24	L
Potential contamination of soils	8	3	1	3	56	M	4	3	1	2	10	L
Potential erosion of soils	4	2	1	3	24	L	2	2	1	2	10	L

6.0 MITIGATION AND MANAGEMENT MEASURES

6.1 Integrity of the soils and soil compaction

The following mitigation measures can reduce the potential impacts on soil integrity and soil compaction:

- Demarcate drill site footprint and ensure construction equipment is confined to this area. Vehicles not to turn in open veld.
- Remove up a 300 mm of soil and handle as topsoil. This material should be stockpiled up slope of the well site area to avoid risk of accidental contamination in the event of a pollution incident at the drilling site. Topsoil stockpile must be protected by an upslope berm to prevent stormwater run-off erosion losses.
- Soil should be handled when dry during removal and placement to reduce the risk of compaction.
- Vegetation (grass and small shrubs) should not be cleared from the site prior to clearing (except if vegetation requires relocation as determined through an ecology assessment). This material is to be stripped together with topsoil as it will supplement the organic and possibly seed content of the topsoil stockpile depending on the time of soil stripping (whether plants are in seed or not).
- Soil should be sampled and analysed prior to replacement during rehabilitation. If necessary, and under advisement from a suitably qualified restoration ecologist, supplemental fertilisation may be necessary.

6.2 Mitigation measures for soil contamination

In order to minimise the impacts of contamination, the following are suggested:

- All fuels, lubricants and liquid chemicals to be stored in double skinned containers or bunded areas capable of containing 1.1 times the stored volume. Chemical storage areas need to be isolated from general traffic to avoid accidental vehicle damage.
- Dry chemicals to be stored on an impervious surface protected from rainfall and stormwater run-off.
- Spill kits should be on-hand to deal with spills immediately;
- Spillages or leakages must be treated according to an applicable procedure as determined by a plan of action for the specific type of disturbance;
- Vehicles and equipment must be maintained regularly and kept in good working order; and
- Vehicle maintenance will not be done on site except in emergency situations in which case mobile drip trays will be used to capture any spills. Drip trays should be emptied into a holding tank and returned to the supplier.

6.3 Mitigation measures for potential erosion impacts

In order to minimise the impacts of erosion, the following are suggested:

- Temporary erosion control measures should be implemented to direct stormwater around the construction sites (including roads) and stockpiles, best practice guidelines should employed;
- Stockpiles must be sloped sufficiently to reduce the risk of runoff;
- Areas prone to erosion or where signs of erosion are evident must be stabilised;
- If eroded areas occur, they must be filled in and/or levelled and vegetation re-established;
- Stockpiled areas must be restricted and controlled, and damage to stabilised areas shall be repaired and maintained;
- Avoid location of the drill site on steep slopes as it has a direct relation to the potential for erosion; and
- In order to limit erosion, prior to the establishment of vegetation, it is recommended that erosion controls be placed at the required intervals using contour ridges or suitable grass.

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7.0 KEY QUESTIONS THAT NEED TO BE ADDRESSED IN THE EIA

Following this preliminary assessment, a site selection process and a full environmental impact assessment (EIA) will be carried out. The EIA will assess all potential impacts from the project and the following key questions will be answered in relation to soil impacts:

- What are the existing soil types at the selected sites?
- What is the land capability of the soils at the selected sites?
- What is the current land use of the selected sites?
- What will be the impacts on the availability of the soil resource at the site?
- What will be the potential impacts on the soil quality at the site?
- What mitigation measures can be put in place to mitigate identified impacts?

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L Potgieter Snr Soil Science Technician	C Steyn Snr Soil Science Specialist	B Baxter EMP Advisor

LB/CS/BB/nbh

Reg. No. 2002/007104/07
Directors: FR Sutherland, AM van Niekerk, SAP Brown, L Greyling

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APPENDIX A

Combined overlay for the Central Precinct

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Report No. 12800

Golder Associates

APPENDIX B

Profile Descriptions and Analysis used for the Central Precinct

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February 2011
Report No. 12800

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SOIL PROFILE DESCRIPTION

NATIONAL SOIL PROFILE NO : 2204

Map/photo : 3222BD Lemoen

Latitude + Longitude: 32° 17' 55" / 22° 55' 36"

Land Type No : Ae76

Climate Zone 528S

Altitude : 1021 m

Terrain Unit: Footslope

Slope: 3 %

Slope Shape : Concave

Aspect : East

Microrelief : None

Parent Material Solum Origin binary, local colluvium, solid rock

Underlying Material : Mudstone

Geological Group / Formation : Teekloof Formation; Beaufort Group.

Soil form and serie Hutton mangano

Surface rockiness None

Surface stoniness : <2% exposed surface, round & flat, stones

Occurence of flooding None

Wind erosion : None

Water Erosion Rill slight, partially stabilized

Vegetation / Land use Dwarf shrubveld, open

Water table : None

Described by : T.A. Robertson

Date Described : 8003

Weathering of underlying material Weak physical, weak chemical

Horizon	Depth (mm)	Description	Diagnostic horizon
A1	0 - 100	Moist state; moist colour: reddish brown 5YR4/3; texture: loamy fine sand; structure: apedal massive; consistence: loose; very few fine <2-6mm biocasts; gradual smooth transition.	Orthic
B2	100 - 500	Moist state; moist colour: dark reddish brown 5YR3/3; texture: loamy fine sand; structure: apedal massive; consistence: loose; abrupt smooth transition.	Red apedal
R	500 - 500+	Hard rock.	Hard rock

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Described by : T.A. Robertson **Date described** 8003

Nasionale Nr / National No : 2204 **Breedtegraad / Latitude:** 32° 17' 55" **Landtipe / Land Type:** Ae76

Soil form and series Hutton mangano Hu33 **Kaart / Map :** 3222BD Lemoen **Lengtegraad / Longitude:** 22° 55' 36" **Klimaatsone / Climate Zone** 528S

Lab nr/no	Diepte Depth	Hor	Particle Size < 2mm							CBD			**Mineralogie / Mineralogy	
			coSand	meSand	fiSand			Silt	Clay	Fe	Al	Mn	2 - 50 µm	< 2 µm
	mm		%							%				
C 5466	0 - 100	A1	13.2	8.0	64.8			5.5	10.0	0.94	0.04	0.02	Qz5, Fs3, Mi1	Mi5, St3, Is2, Kt1
C 5467	100 - 500	B2	11.1	9.5	63.9			5.5	10.9	0.98	0.04	0.03	Qz5, Fs2, Vm1	St5, Mi2, Qz1

Lab nr/no	Org C	KUK CEC	Katione / Cations * Uitruilbaar / Exchangeable # Ekstraheerbaar / Extractable						Ekstr. suurheid Extractable acidity		pH		Versadigingsekstrak / Saturation Extract Oplosbare Katione / Soluble Cations								Vers. Satur.	NAV SAR	Weerst. Resist.	EG EC
				Na	K	Ca	Mg	Tot	Total	Al	H2O	KCl	Na	K	Ca	Mg	Na	K	Ca	Mg				
	%	cmol (+)/kg soil							cmol (+)/kg soil				cmol (+)/dm³				cmol (+)/ kg soil				%		ohms	mS/m
C 5466	0.10	6.30	#	0.10	0.40	3.60	3.00	7.10			7.50												1900	
C 5467	0.10	8.30	#	0.20	0.10	5.90	3.90	10.10			8.20												1400	

Lab nr/no	Mikrovoedingselemente Micro nutrients					P			Waterretentiwiteit Water Retentivity				MR	AWR	Atterberg Limiete / Limits			
	Zn	Mn	Cu	Co	B	Status P	Status Bray	Sorpsie Sorption	-33 kPa	-80 kPa	-500 kPa	-1500 kPa			Vloeigrens Liquid limit	Plastisiteitsgrens Plastic limit	Liniêre krimping Linear shrinkage	Plastisiteitsindeks Plasticity index
	mg / kg					mg/kg		%	%				kPa		%			
C 5466	0.40	97.00	1.70	3.24	0.54	19.10		0.00	7.30	6.20	4.80	4.70	34.00	2.90				
C 5467	0.57	116.20	2.26	7.10	0.49	10.30		0.42	8.80	7.60	5.80	5.80		2.70				

Lab nr/no	METODE GEBRUIK / METHOD USED							
	Status P	Status P-Bray	Sorpsie / Sorption	Boron	KUK / CEC	Katione / Cations	CBD	Mikro Elemente Micro Elements
C 5466	#Error		#Error	#Error	#Error	#Error	#Error	#Error
C 5467	#Error		#Error	#Error	#Error	#Error	#Error	#Error

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SOIL PROFILE DESCRIPTION

NATIONAL SOIL PROFILE NO : 10422

Map/photo : 3123BA Merriman

Latitude + Longitude: 31° 13' 0" / 23° 37' 30"

Land Type No : Da145

Climate Zone 1817S

Altitude : 1250 m

Terrain Unit: Lower Footslope

Slope: 2 %

Slope Shape : Concave

Aspect : North

Microrelief : None

Parent Material Solum Origin single, unconsolidated material sediments

Underlying Material : Mudstone

Geological Group / Formation : Alluvium.

Soil form and serie Valsrivier zuiderzee

Surface rockiness None

Surface stoniness : None

Occurence of flooding Occasional

Wind erosion : None

Water Erosion Sheet slight, not stabilized

Vegetation / Land use Dwarf shrubveld, open

Water table : None

Described by :

Date Described : 9303

Weathering of underlying material Weak physical, weak chemical

Horizon	Depth (mm)	Description	Diagnostic horizon
A	0 - 200	Dry state; horizon undisturbed; dry colour: strong brown 7.5YR5/6; moist colour: yellowish red 5YR4/6; texture: fine sandy loam; structure: apedal; consistence: loose, non-sticky, non-plastic; non-hardened free lime, slight effervescence; common ; water absorption: 1 second(s); common roots; clear smooth transition.	Orthic
B	200 - 550	Dry state; horizon undisturbed; dry colour: yellowish red 5YR4/6; moist colour: reddish brown 5YR4/4; texture: fine sandy clay loam; structure: strong medium angular blocky; consistence: very hard, firm, sticky, plastic; non-hardened free lime, strong effervescence; few slickensides; few clay cutans; few fine <2-6mm lime concretions; water absorption: 5 second(s); few roots; clear wavy transition.	Pedocutanic
C	550 - 1500	Dry state; horizon undisturbed; dry colour: strong brown 7.5YR5/8; moist colour: strong brown 7.5YR4/6; texture: fine sandy clay loam; few medium distinct black manganese, magnetite mottles; structure: strong medium angular blocky; consistence: very hard, very firm, sticky, plastic; non-hardened free lime, strong effervescence; common fine <2-6mm lime concretions; water absorption: 7 second(s).	Unconsolidated material, without signs of wetness

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Described by :

Date described 9303

Nasionale Nr / National No : 10422

Breedtegraad / Latitude: 31° 13' 0"

Landtipe / Land Type: Da145

Soil form and series Valsrivier zuiderzee Va20

Kaart / Map : 3123BA Merriman

Lengtegraad / Longitude: 23° 37' 30"

Klimaatsone / Climate Zone 1817S

Lab nr/no	Diepte Depth	Hor	Particle Size < 2mm							CBD			**Mineralogie / Mineralogy	
			coSand	meSand	fiSand	vfiSand	coSilt	fSilt	Clay	Fe	Al	Mn	2 - 50 µm	< 2 µm
	mm		%							%				
D 1	0 - 200	A	5.0	12.9	42.5	17.9	3.1	5.7	10.5	0.52	0.04	0.01	Qz5,Fs3,Mi2	Mi5,Kt2,St1
D 2	200 - 550	B	2.9	5.9	23.9	17.0	4.6	9.3	33.8	0.76	0.05	0.02	Qz5,Fs3,Mi2	Mi5,St3,Kt2
D 3	550 - 1500	C	4.3	6.2	16.1	20.6	9.1	13.9	27.7	0.63	0.05	0.03	Qz5,Fs3,Mi1	Mi5,St3,Kt2

Lab nr/no	Org C	KUK CEC	Katione / Cations						Ekstr. suurheid Extractable acidity		pH		Versadigingsekstrak / Saturation Extract								Vers. Satur.	NAV SAR	Weerst. Resist.	EG EC
			* Uitruilbaar / Exchangeable										Oplosbare Katione / Soluble Cations											
			# Ekstraheerbaar / Extractable																					
				Na	K	Ca	Mg	Tot	Total	Al	H2O	KCl	Na	K	Ca	Mg	Na	K	Ca	Mg				
	%	cmol (+)/kg soil							cmol (+)/kg soil				cmol (+)/dm³				cmol (+)/ kg soil				%		ohms	mS/m
D 1	0.32	8.91	#	0.05	0.90	5.90	2.56	9.41	0.07	0.06	8.76	7.31											2600	
D 2	0.32	17.78	#	0.61	0.42	20.76	6.86	28.65	0.03	0.01	9.01	7.40											1600	
D 3	0.16	14.77	#	1.37	0.54	15.88	10.99	28.78	0.02		9.50	7.86											1600	

Lab nr/no	Mikrovoedingselemente Micro nutrients					P			Waterretentiwiteit Water Retentivity				MR	AWR	Atterberg Limiete / Limits			
						Status		Sorpsie Sorption							Vloeigrens Liquid limit	Plastisiteitsgrens Plastic limit	Liniêre krimping Linear shrinkage	Plastisiteitsindeks Plasticity index
	Zn	Mn	Cu	Co	B	P	Bray		-33 kPa	-80 kPa	-500 kPa	-1500 kPa						
	mg / kg					mg/kg		%	%				kPa		%			
D 1	0.66	101.49	1.23	2.05	1.53	21.20		29.00	7.11	5.83	5.73	5.13		2.61				
D 2	0.81	21.69	8.22	0.40	1.06	4.70		30.70	21.14	18.14	15.96	15.13		8.87	37.10	15.00	5.70	22
D 3	1.24	7.26	3.52	0.27	3.44	2.10		31.70	18.30	16.02	13.60	13.09		10.08	36.70	20.00	5.70	16

Lab nr/no	METODE GEBRUIK / METHOD USED							
	Status		Sorpsie / Sorption	Boron	KUK / CEC	Katione / Cations	CBD	Mikro Elemente Micro Elements
	P	P-Bray						
D 1	#Error		#Error	#Error	#Error	#Error	#Error	#Error
D 2	#Error		#Error	#Error	#Error	#Error	#Error	#Error
D 3	#Error		#Error	#Error	#Error	#Error	#Error	#Error

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SOIL PROFILE DESCRIPTION

NATIONAL SOIL PROFILE NO : 10429

Map/photo : 3123AD Brakpoort

Latitude + Longitude: 31° 20' 52" / 23° 21' 28"

Land Type No : Da145

Climate Zone 1817S

Altitude : 1210 m

Terrain Unit: Upper Footslope

Slope: 3 %

Slope Shape : Straight

Aspect : North

Microrelief : None

Parent Material Solum Origin single, solid rock

Underlying Material : Mudstone

Geological Group / Formation : Dolerite.

Soil form and serie Swartland uitsicht

Surface rockiness None

Surface stoniness : None

Occurence of flooding None

Wind erosion : None

Water Erosion Sheet slight, not stabilized

Vegetation / Land use Dwarf shrubveld, open

Water table : None

Described by :

Date Described : 9303

Weathering of underlying material Weak physical, weak chemical

Horizon	Depth (mm)	Description	Diagnostic horizon
A1	0 - 70	Dry state; horizon undisturbed; dry colour: reddish yellow 5YR6/6; moist colour: reddish brown 5YR4/4; texture: fine sandy loam; structure: apedal massive; consistence: loose, non-sticky, non-plastic; very few fine <2-6mm ; water absorption: 1 second(s); common roots; clear smooth transition.	Orthic
B2	70 - 180	Dry state; horizon undisturbed; dry colour: reddish brown 5YR5/4; moist colour: dark reddish brown 5YR3/4; texture: fine sandy clay loam; structure: moderate medium angular blocky; consistence: very hard, firm, sticky, slightly plastic; non-hardened free lime, moderate effervescence; few clay cutans; few fine <2-6mm lime concretions; water absorption: 4 second(s); common roots; clear tonguing transition.	Pedocutanic

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Described by : **Date described** 9303

Nasionale Nr / National No : 10429 **Breedtegraad / Latitude:** 31° 20' 52" **Landtipe / Land Type:** Da145

Soil form and series Swartland uitsicht Sw20 **Kaart / Map :** 3123AD Brakpoort **Lengtegraad / Longitude:** 23° 21' 28" **Klimaatsone / Climate Zone** 1817S

Lab nr/no	Diepte Depth	Hor	Particle Size < 2mm							CBD			**Mineralogie / Mineralogy	
			coSand	meSand	fiSand	vfiSand	coSilt	fSilt	Clay	Fe	Al	Mn	2 - 50 µm	< 2 µm
	mm		%							%				
D 20	0 - 70	A1	4.5	6.6	39.6	16.0	7.3	12.1	11.4	0.60	0.02	0.02	Qz5,Fs2,Mi1	Mi5,St3,Kt2,Is1
D 21	70 - 180	B2	1.9	4.9	27.8	11.9	6.7	15.7	28.6	0.84	0.03	0.02	Qz5,Fs4,St2,Mi2	St5,Mi4,Kt1

Lab nr/no	Org C	KUK CEC	Katione / Cations * Uitruilbaar / Exchangeable # Ekstraheerbaar / Extractable						Ekstr. suurheid Extractable acidity		pH		Versadigingsekstrak / Saturation Extract Oplosbare Katione / Soluble Cations								Vers. Satur.	NAV SAR	Weerst. Resist.	EG EC
				Na	K	Ca	Mg	Tot	Total	Al	H2O	KCl	Na	K	Ca	Mg	Na	K	Ca	Mg				
	%	cmol (+)/kg soil							cmol (+)/kg soil				cmol (+)/dm³				cmol (+)/ kg soil				%		ohms	mS/m
D 20	0.36	9.35	#	0.04	0.72	15.07	1.48	17.31	0.07	0.05	8.81	7.60											2200	
D 21	0.57	16.01	#	0.11	0.46	26.26	2.29	29.12	0.08	0.06	8.78	7.53											1600	

Lab nr/no	Mikrovoedingselemente Micro nutrients					P			Waterretentiwiteit Water Retentivity				MR	AWR	Atterberg Limiete / Limits			
	Zn	Mn	Cu	Co	B	Status P	Status Bray	Sorpsie Sorption	-33 kPa	-80 kPa	-500 kPa	-1500 kPa			Vloeigrens Liquid limit	Plastisiteitsgrens Plastic limit	Liniêre krimping Linear shrinkage	Plastisiteitsindeks Plasticity index
	mg / kg					mg/kg		%	%				kPa		%			
D 20	0.45	105.48	1.00	1.20	0.68	14.00		27.30	7.93	7.76	6.68	6.01		2.99				
D 21	1.76	6.03	2.87	0.22	0.76	1.80		32.50	16.05	15.38	13.98	12.23		6.59	26.20	15.80	1.70	10

Lab nr/no	METODE GEBRUIK / METHOD USED							
	Status P	Status P-Bray	Sorpsie / Sorption	Boron	KUK / CEC	Katione / Cations	CBD	Mikro Elemente Micro Elements
D 20	#Error		#Error	#Error	#Error	#Error	#Error	#Error
D 21	#Error		#Error	#Error	#Error	#Error	#Error	#Error

APPENDIX C

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Golder Associates

February 2011

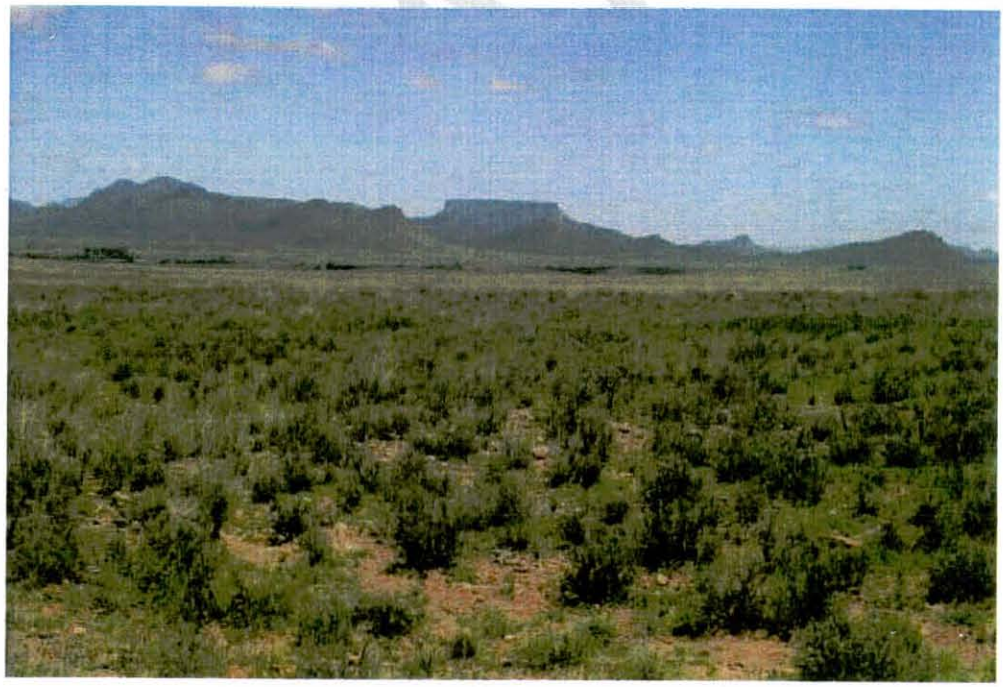
DRAFT REPORT

SHELL INTERNATIONAL EXPLORATION AND PRODUCTION B.V.

Terrestrial Ecology Technical Report in support of the EMP for the South Western Karoo Basin Gas Exploration Application Project

CENTRAL PRECINCT

Golder Associates Africa (Pty) Ltd
Environmental Services Business Unit
Midrand



Report Number. 12800-10444-21

Golder Associates

Executive Summary

Shell Exploration Company B.V., a registered company of Royal Dutch Shell plc (Shell), has applied to the Petroleum Agency of South Africa (PASA) seeking the award of Exploration Rights to undertake shale gas exploration activities in the South Western Karoo Basin, South Africa. This document relates to the Exploration Right application referred to as the Central Precinct, which intersects the Eastern, Western and Northern Cape Provinces, and covers the Cacadu, Central Karoo, Chris Hani, and Pixley ka Seme District Municipalities.

Golder Associates Africa (Pty) Ltd was tasked with conducting a terrestrial ecology assessment for the proposed gas exploration application as an integral part of the overall Environmental Management Plan (EMP).

The objective of the study was to provide a very broad scale description of the vegetation types and animal life of the Central Precinct and to identify sensitive areas within the precinct. Furthermore, generalised potential impacts and possible mitigation measures are discussed with regard to the proposed activities.

Conclusions of this study are as follows:

- All of the vegetation types within the Central Precinct are listed as Least Threatened. Although the degree of statutory protection of these vegetation communities within reserves is generally low (< 5%), the degree of historical transformation is similarly low (< 5%);
- Twenty four Red Data or Protected plant species are expected to occur within the Central Precinct. Due to the limited scale of the proposed exploration activities, the impact on indigenous vegetation communities is expected to be low, should the appropriate mitigation measures be implemented. Care needs to be taken during the site selection process to avoid areas with high densities of Red Data or Protected plant species. Any Red Data or Protected plant species that are encountered during site preparation should be removed, maintained in a nursery area and replanted on the site during rehabilitation;
- Five Red Data faunal species are expected to occur within the Central Precinct. Of these, the Riverine Rabbit is listed as Critically Endangered (CE) primarily due to habitat loss and fragmentation;
- The White-tailed mouse is listed as Endangered (E) due to habitat fragmentation associated with grazing and agricultural practises;
- The Karoo Rock Sengi has only recently been described as a separate species and is only known from 5 locations. Specific information on the abundance, distribution, and population status of the new species is lacking and although no major threats are currently known, it is tentatively listed as Data Deficient;
- The Mountain Zebra is listed as Vulnerable (VU) and is only found in the Mountain Zebra National Park, Gamka Mountain Reserve, and the Kamanassie mountains and is therefore unlikely to be impacted upon by the exploration activities;
- The Blue Crane is currently listed as Vulnerable (VU) on the IUCN Red List of Threatened Species (IUCN, 2010). *G. paradisea* is near-endemic to South Africa, with small breeding populations also occurring in northern Namibia and western Swaziland. *G. paradisea* is considered to be an uncommon resident in the region. Populations of this species have declined rapidly due to direct poisoning, power-line collisions and loss of its grassland breeding habitat due to afforestation, mining, agriculture and development;

- The two key potential impacts identified include the loss of Red Data or Protected plant species and the loss or fragmentation of habitat for Red Data faunal species resulting from well site preparation and access road construction activities. These impacts are considered to be impacts of moderate significance. Areas with high densities of Red Data or Protected Plant species should be identified and avoided during the site selection process. Such areas include *Grus paradisea* nesting sites;
- Should any Red Data or Protected Plant species be encountered during ground clearing, they should be translocated to a nursery area and returned to the site during rehabilitation;
- All of the potential drilling areas in the Central Precinct overlap, at least in part with some areas of sensitivity or conservation importance. Prior to the site selection process the status of these areas should be verified, and sites should only be selected outside of these areas. The Central Precinct does infringe on the Kromrivier Conservancy in the east. It is recommended that this area be avoided during exploration; and
- Following the submission of the EMP, and a site selection process for the well sites, a detailed environmental impact assessment (EIA) will be undertaken. The following key questions will need to be addressed in the EIA:
  - What vegetation types occur at selected drilling sites during the wet season (November to March) and dry season (May – September)?
  - Do any threatened plant species (Red Data listed), medicinal species, protected species (North West Province Conservation Act), endemic (confined to the area) taxa, species of conservation importance, etc occur within or nearby the selected drilling sites?
  - Do any threatened faunal species (Red Data listed), protected species, endemic (confined to the area) taxa, hibernation/breeding sites, important birding areas (IBA), etc occur within or nearby the selected drilling sites?
  - How will migration patterns of species be affected, or likely to be affected by proposed activities?
  - What is the surrounding land use on adjacent properties to determine cumulative effects of the proposed exploration activities?
  - What mitigation measures can be put in place for identified critical impacts; what monitoring and evaluation plans can be developed to determine the effectiveness of mitigation?
  - What measures can be put in place to successfully rehabilitate disturbed areas, taking aspects such as low and erratic rainfall and vegetation conditions in the Karoo, into consideration?

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1.0 INTRODUCTION

Shell Exploration Company B.V., a registered company of Royal Dutch Shell plc (Shell), has applied to the Petroleum Agency of South Africa (PASA) seeking the award of Exploration Rights to undertake shale gas exploration activities in the South Western Karoo Basin, South Africa. This document relates to the Exploration Right application referred to as the Central Precinct, which intersects the Eastern, Western and Northern Cape Provinces, and covers the Cacadu, Central Karoo, Chris Hani, and Pixley ka Seme District Municipalities.

Golder Associates Africa (Pty) Ltd was tasked with conducting a terrestrial ecology assessment for the proposed gas exploration application as an integral part of the overall Environmental Management Plan (EMP).

2.0 OBJECTIVES

The objective of the study was to provide a very broad scale description of the vegetation types and animal life of the Central Precinct and to identify sensitive areas within the precinct. Furthermore, generalised potential impacts and possible mitigation measures are discussed with regard to the proposed activities.

3.0 STUDY APPROACH/ METHODOLOGY

3.1 Desktop assessment

A literature survey was conducted in order to determine if any ecologically sensitive areas occur within the Central Precinct. Furthermore, the desktop study was used to obtain a list of potentially occurring species in each of the notional ellipses. This data was obtained through official databases and a literature study of relevant publications. The list of species potentially occurring in each of the notional ellipses was then cross referenced with the IUCN database (IUCN, 2010) and the national and provincial Threatened or Protected Species (TOPS) lists (NEMBA, 2007) in order to determine the probability of Red Data or protected species occurring in any of the notional ellipses.

3.2 Fieldwork

The fieldwork component involved a 10 day site visit in which the 3 precincts were visited and a ground truthing exercise undertaken. The ground truthing served to verify at a high level the data collected during the literature review.

During the site visit a broad scale overview of the vegetation was conducted in order to verify the results of the desktop assessment. The route through the Central Precinct is shown in **Figure 1**.

The following factors were noted during the field verification survey:

- Steep topography;
- Proximity to human habitation;
- Proximity to boreholes;
- Proximity to riparian zones;
- Areas of increased biodiversity;
- Proximity to roads;
- Wetlands;
- Sensitive habitats according to the Succulent Karoo Ecological Programme (SKEP) (SKEP database, 2011) and other ecological databases; and
- Formally protected areas (Nature Reserves, National Parks etc).

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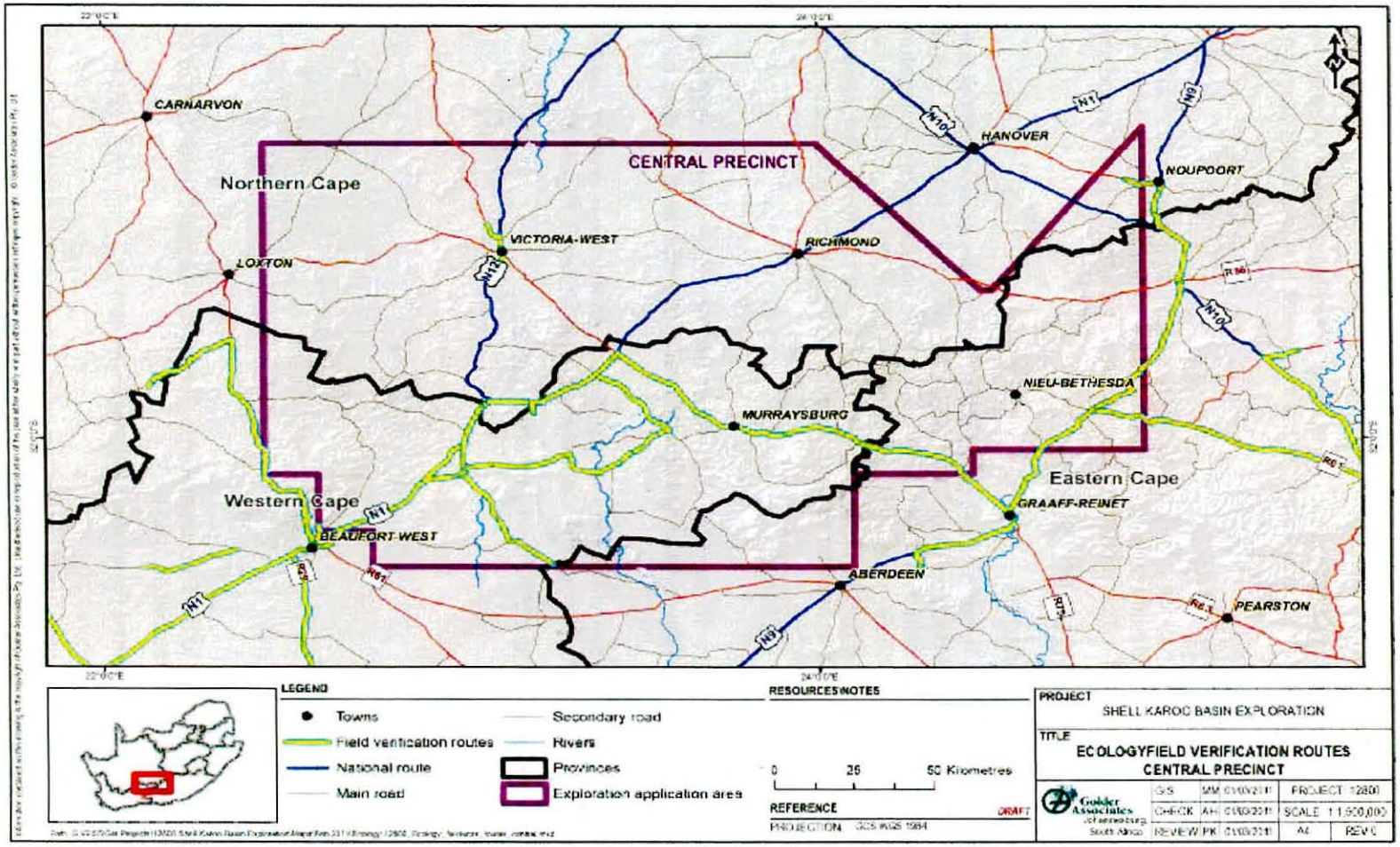

Figure 1: Routes travelled during the terrestrial ecology field verification survey.

4.0 BASELINE DESCRIPTION OF THE STUDY AREA

4.1 Desktop assessment

4.1.1 Climate

The rainfall in South Africa shows a steep upward gradient from west to east (*Figure 2*). This translates to the eastern part of the exploration area having a mean annual precipitation (MAP) of between 400 and 600 mm, whilst the western part of the exploration area has a MAP of less than 200 mm. The lowest MAP is recorded in the north western region of the exploration area and annual precipitation here can be as low as 50 mm/annum for extended periods. The rainfall of the southern African subcontinent has a marked effect on vegetation occurring on the subcontinent, the variation in precipitation will also have a marked effect on the ability to rehabilitate disturbed areas (South African Rain Atlas, 2010; Mucina and Rutherford, 2006).

The north western part of the proposed exploration area also shows a far greater variation in annual rainfall, which indicates that this area is prone to drought. Temperature variations are also very high with temperatures in excess of 40°C common in summer and temperatures dropping to well below 0°C in winter, all these factors make this a very harsh environment, and the plant species in this area reflect this with most being hardy, drought and frost resistant karroid shrubs. The south eastern region of the exploration area, by contrast shows a higher MAP, lower rainfall variance, and the temperatures are moderated by the effect of the Indian Ocean (Dean and Milton, 1999).

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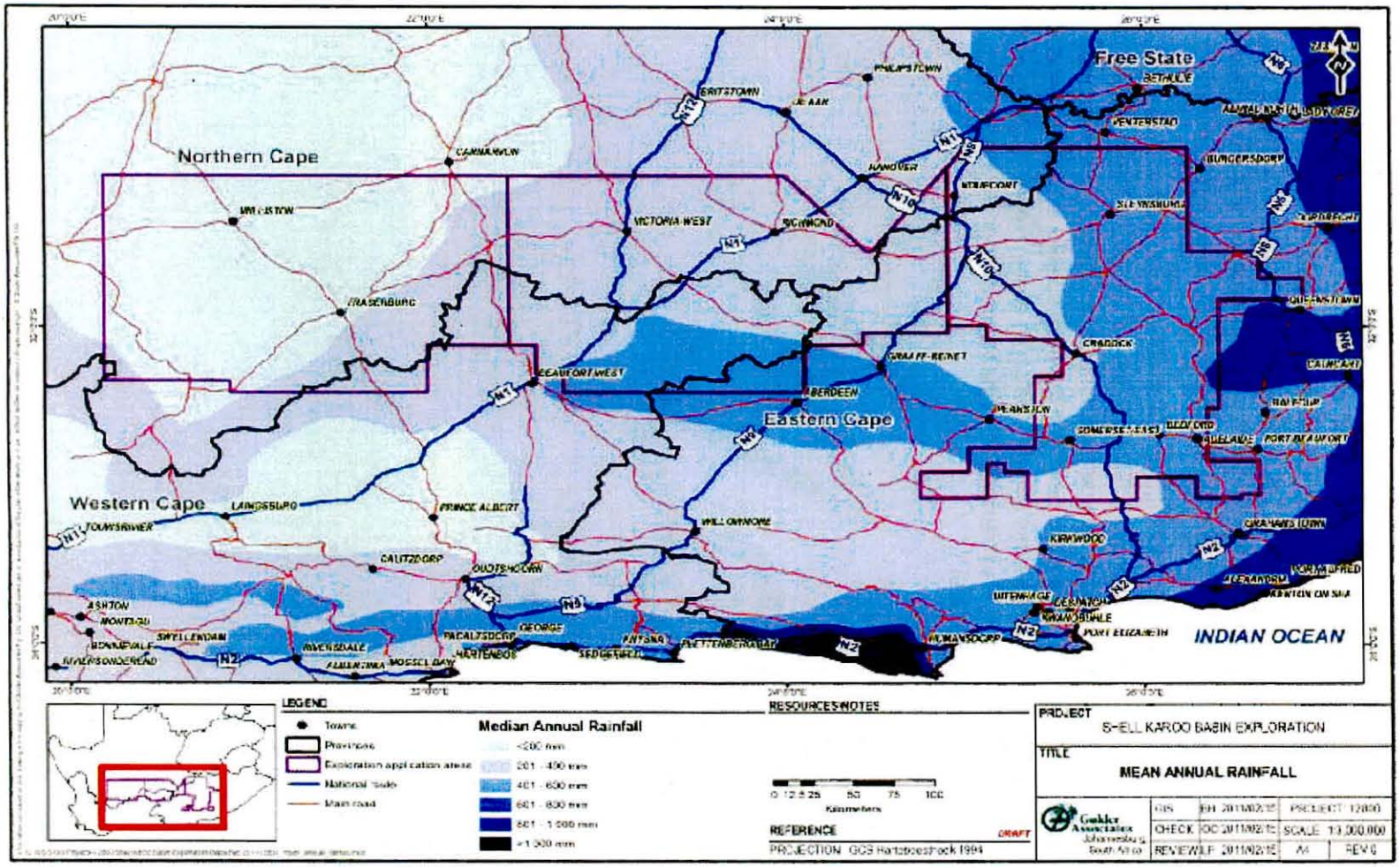

Figure 2: Median Annual Rainfall (MAP) for the exploration area

4.1.2 Biomes

Biomes can be defined as the major communities of the world, classified according to their predominant vegetation and characterised by adaptations of organisms to that particular environment. The single most important factor influencing the biomes in South Africa is the weather and, more specifically, the rainfall (Low and Rebelo, 1998).

Important factors to be taken into account with regard to the weather and its influence on the biomes of South Africa are:

- The western parts of the country are much drier than the east;
- Rainfall occurs in winter in the west, but in summer in most other regions; and
- Temperatures in the mountains and on the Highveld are more extreme than along the coast.

These different climatic zones give rise to different vegetation communities which result in the biomes of South Africa. These biomes range from the Forest biome, in the wetter eastern parts of the country, through the Grassland and Thicket biomes, in the higher and lower lying temperate areas, to the succulent Karoo and Desert biomes in the drier western parts of the country. It should however be noted that there is considerable overlap vegetation types within the different vegetation communities.

The Central Precinct coincides with two biomes namely (Figure 3):

- Nama-Karoo; and
- Grassland.

The vegetation biomes are described briefly below and in more detail in Appendix A.

4.1.2.1 Nama-Karoo

The Nama Karoo Biome occurs on the central plateau of the western half of South Africa, at altitudes between 500 and 2000m, with most of the biome failing between 1000 and 1400m. It is the second-largest biome in the region (Low and Rebelo, 1998).

Less than 1% of the biome is conserved in formal areas. Prickly Pear (*Opuntia aurantiaca)* and Mesquite (*Prosopis glandulosa)* are the major alien invader species. Urbanization and agriculture are minimal. Most of the land is used for grazing, by sheep (for mutton, wool and pelts) and goats, which can be commensurate with conservation. However, under conditions of overgrazing, many indigenous species may proliferate, including Three thorn (*Rhigozum trichotomum)*, Bitterbos (*Chrysocoma ciliate)* and Sweet Thorn (*Acacia karroo)*, and many grasses and other palatable species may be lost. There are very few rare or Red Data Book plant species in the Nama Karoo Biome. Tourism potential is low. Mining is important in the biome (Low and Rebelo, 1998).

4.1.2.2 Grassland

The Grassland Biome is found chiefly on the high central plateau of South Africa, and the inland areas of KwaZuluNatal and the Eastern Cape. The topography is mainly flat and rolling, but includes the escarpment itself. Altitude varies from near sea level to 2 850 m above sea level (Low and Rebelo, 1998)

Grasslands (also known locally as Grassveld) are dominated by a single layer of grasses. The amount of cover depends on rainfall and the degree of grazing. Trees are absent, except in a few localized habitats. Geophytes (bulbs) are often abundant. Frosts, fire and grazing maintain the grass dominance and prevent the establishment of trees (Low and Rebelo, 1998)

There are two categories of grass plants: sweet grasses have lower fibre content, maintain their nutrients in the leaves in winter and are therefore palatable to stock. Sour grasses have higher fibre content and tend to withdraw their nutrients from the leaves during winter so that they are unpalatable to stock. At higher rainfall and on more acidic soils, sour grasses prevail, with 625 mm per year taken as the level at which unpalatable grasses predominate. C4 grasses dominate throughout the biome, except at the highest altitudes where C3 grasses become prominent(Low and Rebelo, 1998)

Grass plants tolerate grazing, fire, and even mowing, well: most produce new stems readily, using a wide variety of strategies. Overgrazing tends to increase the proportion of pioneer, creeping and annual grasses, and it is in the transition zones between sweet and sour grass dominance that careful management is required to maintain the abundance of sweet grasses. The Grassland Biome is the mainstay of dairy, beef and wool production in South Africa. Pastures may be augmented in wetter areas by the addition of legumes and sweet grasses (Low and Rebelo, 1998)

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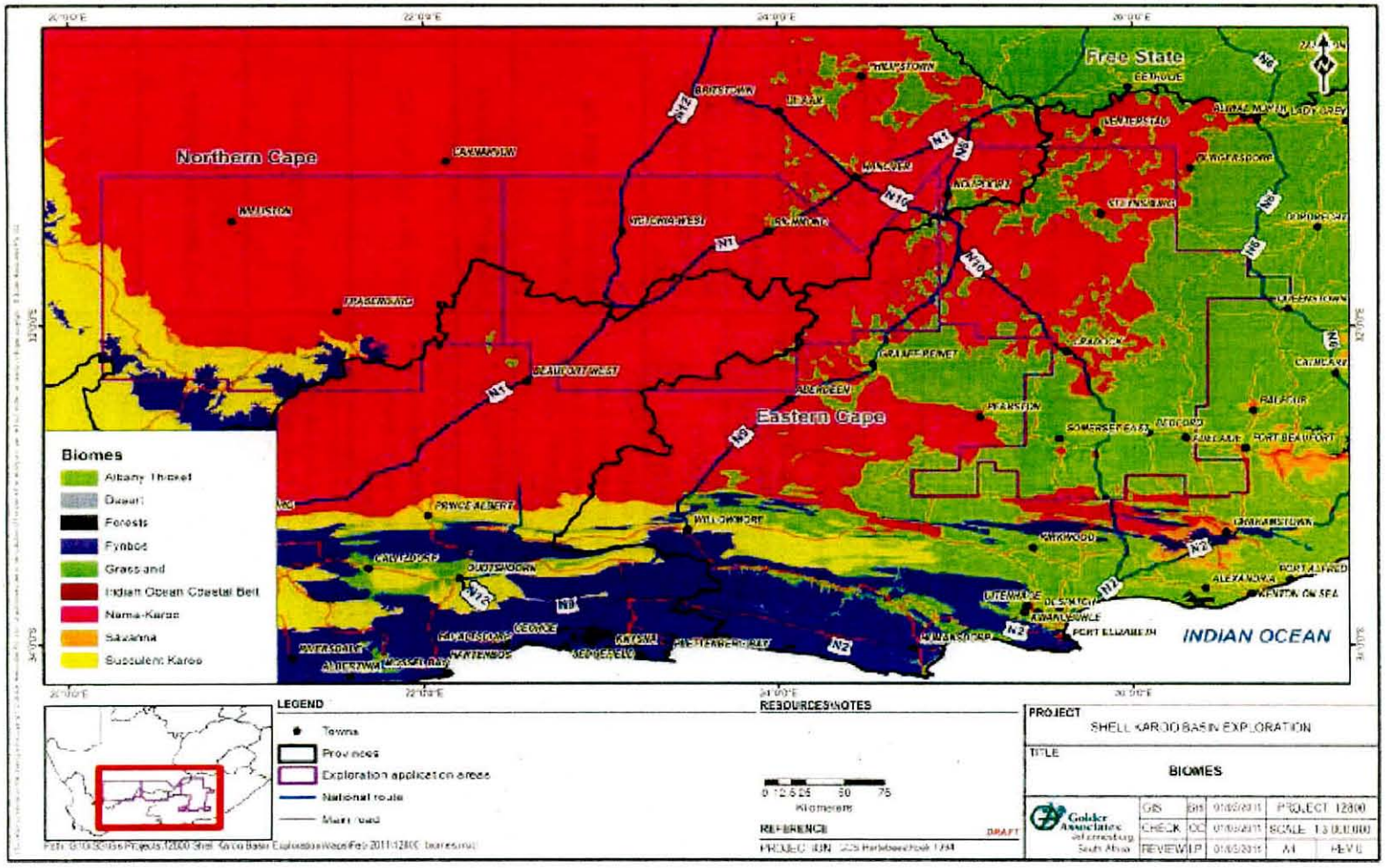

Figure 3: Vegetation biomes associated with the exploration areas

4.1.3 Vegetation types

According to Mucina and Rutherford (2006) the 3 biomes associated with the Central Precinct can be further subdivided into seven vegetation types namely:

- Upper Karoo Hardeveld NKu2;
- Gamka Karoo NKl1;
- Eastern Upper Karoo NKu4;
- Southern Karoo Riviere AZi6;
- Eastern Lower Karoo NKl2;
- Northern Upper Karoo NKu3;
- Karoo Escarpment Grassland Gh1; and
- Besemkaree Koppies Shrubland.

The distribution of these vegetation types within the Central Precinct is presented in Figure 4.

Based on Mucina and Rutherford (2006) all of the vegetation types are classified as least threatened. A summary of the vegetation types is provided in Table 1. More detail of the vegetation types is provided in Appendix B.

Table 1: Summary of vegetation types

Vegetation type	Protected within statutory conservation areas	Area transformed	Status (Mucina & Rutherford, 2006)
Upper Karoo Hardeveld NKu2	3% statutorily conserved in Karoo National Park and Karoo Nature Reserve	Low level of transformation	Least threatened
Western Upper Karoo NKu1	None conserved in statutory conservation areas	Very little transformed	Least threatened
Bushmanland Vloere AZi5	None conserved in statutory conservation areas	About 2% transformed for cultivation or building of dams	Least threatened
Eastern Lower Karoo NKl2	Some of patches statutorily conserved in Aberdeen and Karoo Nature Reserves as well as in private reserves such as Minnawill Game Farm	Between 1 % and 2% transformed	Least threatened.
Northern Upper Karoo NKu3	None conserved in statutory conservation areas.	About 4% transformed	Least threatened.
Gamka Karoo NKl1	2% statutorily conserved in the Karoo National Park and some in pnvate reserves, such as Steenbokkie Private Nature Reserve	Very little transformed	Least threatened
Eastern Upper Karoo NKu4	Protected in Mountain Zebra and Karoo National Parks as well as in Oviston, Commando Drift, Rolfontein and Gariep Dam Nature Reserves	About 2% transformed	Least threatened
Karoo Escarpment Grassland Gh1	Nearly 3% statutorily conserved in the Mountain Zebra and Karoo National Parks as well as in the Tsolwana and Karoo Nature Reserves.	Very little transformed	Least threatened
Besemkaree Koppies Shrubland Gh4	About 5% statutorily conserved in the Rolfontein, Tussen Die Riviere, Oviston, Gariep Dam, Caledon and Kalkfontein Dam Nature Reserves.	About 3% transformed	Least threatened

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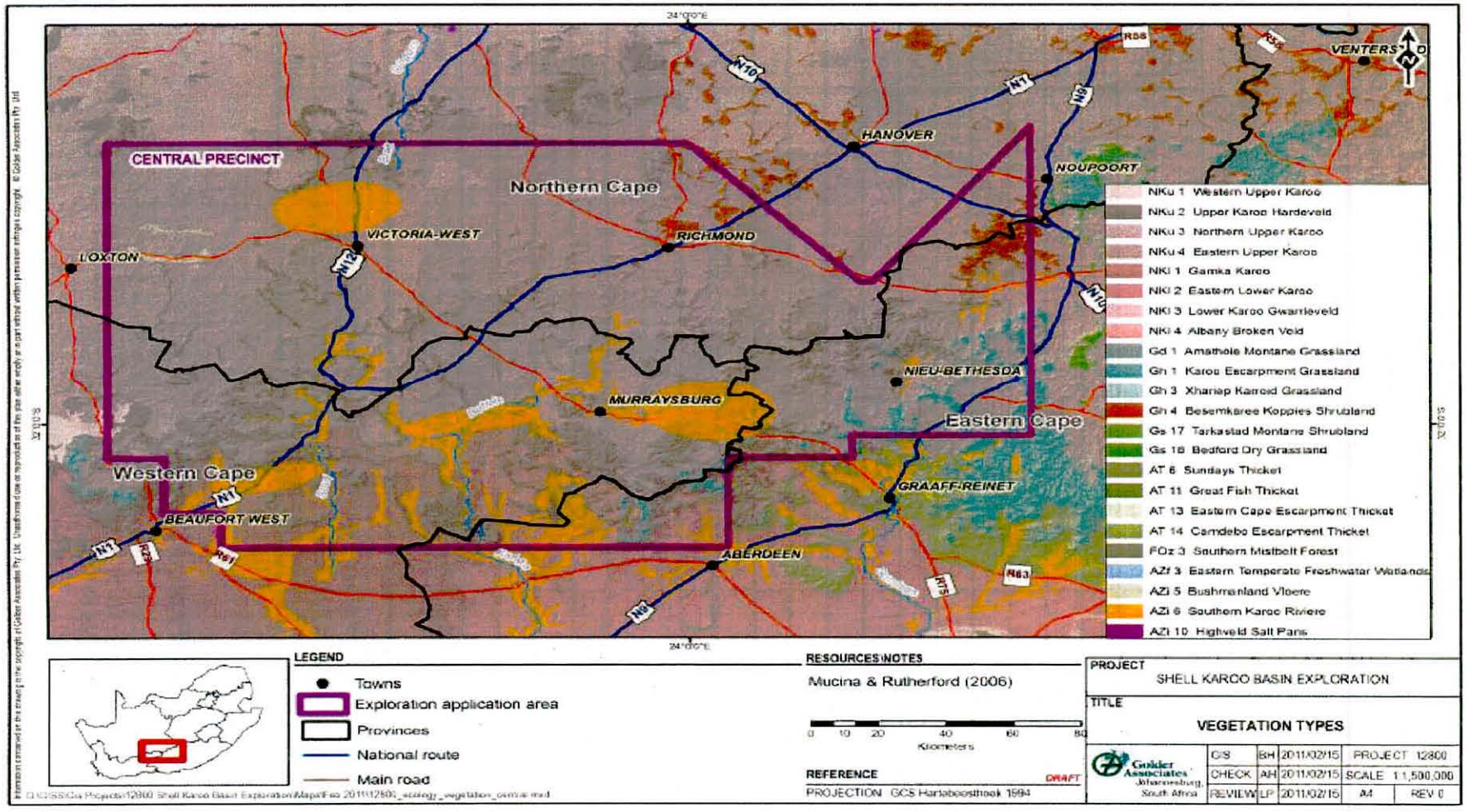

Figure 4: Vegetation types associated with the Central Precinct area

4.1.3.1 Red Data Floral Species

Based on the PRECIS (POSA, 2011) data for the corresponding grid squares, 753 plant species are known to occur within the Central Precinct. This data was used to determine whether Red Data or Protected plant species have been recorded in the area according to the IUCN (IUCN, 2010) and TOPS (NEMBA, 2007) lists. Based on this assessment 24 Red Data or Protected plant species are expected to occur within the Central Precinct (Table 2). During the field survey special attention was given to confirming the occurrence or probability of occurrence of these Red Data species.

Table 2: Red Data or rare plant species occurring in the Central Precinct

Family	Species	Threat status	SA Endemic
ASPHODELACEAE	*Gasteria disticha*	CR	Yes
ASPHODELACEAE	*Aloe longistyla*	DDD	Yes
MALVACEAE	*Hermannia repetenda*	DDD	Yes
POLYGALACEAE	*Polygala bowkerae*	DDD	Yes
APOCYNACEAE	*Schizoglossum aschersonianum var. longipes*	DDT	Yes
CRASSULACEAE	*Crassula barbata subsp. broomii*	DDT	Yes
GERANIACEAE	*Pelargonium sidoides*	Declining	No
MESEMBRYANTHEMACEAE	*Drosanthemum calycinum*	NT	Yes
ASPHODELACEAE	*Haworthia fasciata*	NT	Yes
CRASSULACEAE	*Crassula decumbens var. brachyphylla*	NT	Yes
SCROPHULARIACEAE	*Polycarena capensis*	NT	Yes
CRASSULACEAE	*Adromischus humilis*	Rare	Yes
MALVACEAE	*Anisodontea malvastroides*	Rare	Yes
CRASSULACEAE	*Crassula socialis*	Rare	Yes
AMARYLLIDACEAE	*Gethyllis longistyla*	Rare	Yes
FABACEAE	*Indigofera hantamensis*	Rare	Yes
LOBELIACEAE	*Lobelia eckloniana*	Rare	Yes
FABACEAE	*Lotononis azureoides*	Rare	Yes
GERANIACEAE	*Pelargonium denticulatum*	Rare	Yes
ASTERACEAE	*Phymaspermum schroeteri*	Rare	Yes
ASTERACEAE	*Pteronia hutchinsoniana*	Rare	Yes
MESEMBRYANTHEMACEAE	*Ruschia altigena*	Rare	Yes
ROSACEAE	*Cliffortia arborea*	VU	Yes
ERICACEAE	*Erica passerinoides*	VU	Yes

4.1.4 Fauna

4.1.4.1 Red Data Faunal Species

For the purpose of this study only protected or Red Data species, probably occurring within the notional areas, were considered. The list of possibly affected species will be extended to include other species in order to fulfil the requirements of future phases of the study.

4.1.4.1.1 Reptiles

No Red Data reptile species are expected to occur within the Central Precinct. The area does, however, exhibit a very high degree of endemism with 20 species being endemic to southern Africa and 11 species being endemic to the region (Table 3).

Table 3: Endemic reptiles that may occur in the Central Precinct

Scientific Name	Common Name	Probability of Occurrence	Endemism
Acontias meleagris	Cape Legless Skink	M	1
Agama atra	Southern Rock Agama	M	1
Agama hispida	Spiny Agama	M	1
Bitis caudalis	Horned Adder	I	1
Bradypodium karroicum	Karoo Dwarf Chamaeleon	L	1
Chersina angulata	Angulate Tortoise	H	1
Chondrodactylus angulifer	Giant Ground Gecko	M	1
Cordylus mclachlani	Mclachlan's Girdled Lizard	H	2
Cordylus polyzonus	Karoo Girdled Lizard	M	1
Gerrhosaurus typicus	Namaqua Plated Lizard	H	2
Homopus areolatus	Parrot-beaked Tortoise	H	1
Homopus signatus cafer	Southern Speckled Padloper	H	2
Homoroselaps lacteus	Spotted Harlequin Snake	M	1
Lamprophis fiskii	Fisk's House Snake	H	2
Lamprophis guttatus	Spotted House Snake	M	1
Leptotphylops gracilior	Slender Thread Snake	H	2
Meroles suborbitalis	Spotted Desert Lizard	M	1
Naja nigricollis woodi	Black Spitting Cobra	H	2
Naje nivea	Cape Cobra	I	1
Pachydactylus bibronii	Bibron's Gecko	M	1
Pachydactylus capensis	Cape Thick-toed Gecko	M	2
Pachydactylus maculatus	Spotted Gecko	L	2
Pachydactylus oculatus	Golden Spotted Gecko	M	2
Pachydactylus mariquensis	Marico Gecko	M	1
Pedioplanis lineoocellata pulchella	Spotted Sand Lizard	M	1
Pedioplanis namaquensis	Namaqua Sand Lizard	M	1
Prosymna sundevallii	Sundevall's Shovel Snout	H	1
Psammobates tentorius	Tent Tortoise	H	1
Tetradactylus tetradactylus	Long-tailed Seps	H	2
Tetradactylus tetradactylus	Shortlegged Seps	H	2
Typhlops lalandei	Delalandes Blind Snake	M	1

Probability of occurrence: L = Low, M = Medium, H = High, I = Identified

Endemism: 0 =Not Endemic, 1 = Endemic to Southern Africa, 2 = Endemic to Region (South Africa, Lesotho and Swaziland)

4.1.4.1.2 Amphibia

No Red Data amphibian species are expected to occur in the Central Precinct. None of the possibly occurring species are listed as endemic.

4.1.4.1.3 Avifauna

Approximately 350 species of birds are known to occur in the Central Precinct. Of these, thirteen are listed in the Threatened or Protected species list (NEMBA, 2007) (Table 4). Although the only species of special concern that could potentially be affected by the positioning of the exploration sites is the Blue Crane (*Grus paradisea*), due to the fact that this is a breeding resident in the area, this is also the only species listed on the IUCN Red Data list and is currently listed as Vulnerable (VU) (IUCN, 2010). The other species that may occur in the areas are mostly non-breeding bird species and do not frequent lower-lying flat habitat in which this development is likely to take place. *Grus paradisea* is near-endemic to South Africa, with small breeding populations also occurring in northern Namibia and western Swaziland (IUCN, 2010). *G. paradisea* is considered to be an uncommon resident in the region. Populations of this species have declined rapidly due to direct poisoning, power-line collisions and loss of its grassland breeding habitat owing to afforestation, mining, agriculture and development (IUCN, 2010).

Table 4: Protected bird species that may occur in the Central Precinct (NEMBA 2007)

Common Name	Scientific Name	Status (NEMBA, 2007)
Blue Crane	Grus paradiseus	NT
Secretary bird	*Sagittarius serpentarius*	NT
Gypaetus barbatus	Bearded Vulture	NT
Gyps africanus	White-backed Vulture	NT
Gyps coprotheres	Cape Vulture	NT
Aquila rapax	Tawny Eagle	NT
Ardeotis kori	Kori Bustard	VU
Eupodotis caerulescens	Blue Korhaan	VU
Falco naumanni	Lesser Kestrel	VU
Falco peregrinus	Peregrine Falcon	VU
Neotis ludwigii	Ludwig's Bustard	VU
Polemaetus bellicosus	Martial Eagle	VU
Tyto capensis	Grass Owl	VU

NT: Near threatened

The distribution of *G. paradisea* within the Central Precinct is illustrated in *Figure 5*. The distribution of this species coincides with 4 of the potential drilling areas. The impact of drilling activities on terrestrial fauna is likely to be very localised with birds especially able to move away from areas of disturbance. However special care needs to be taken during the selection of drilling sites to ensure that these are well away from *Grus paradisea* nesting sites.

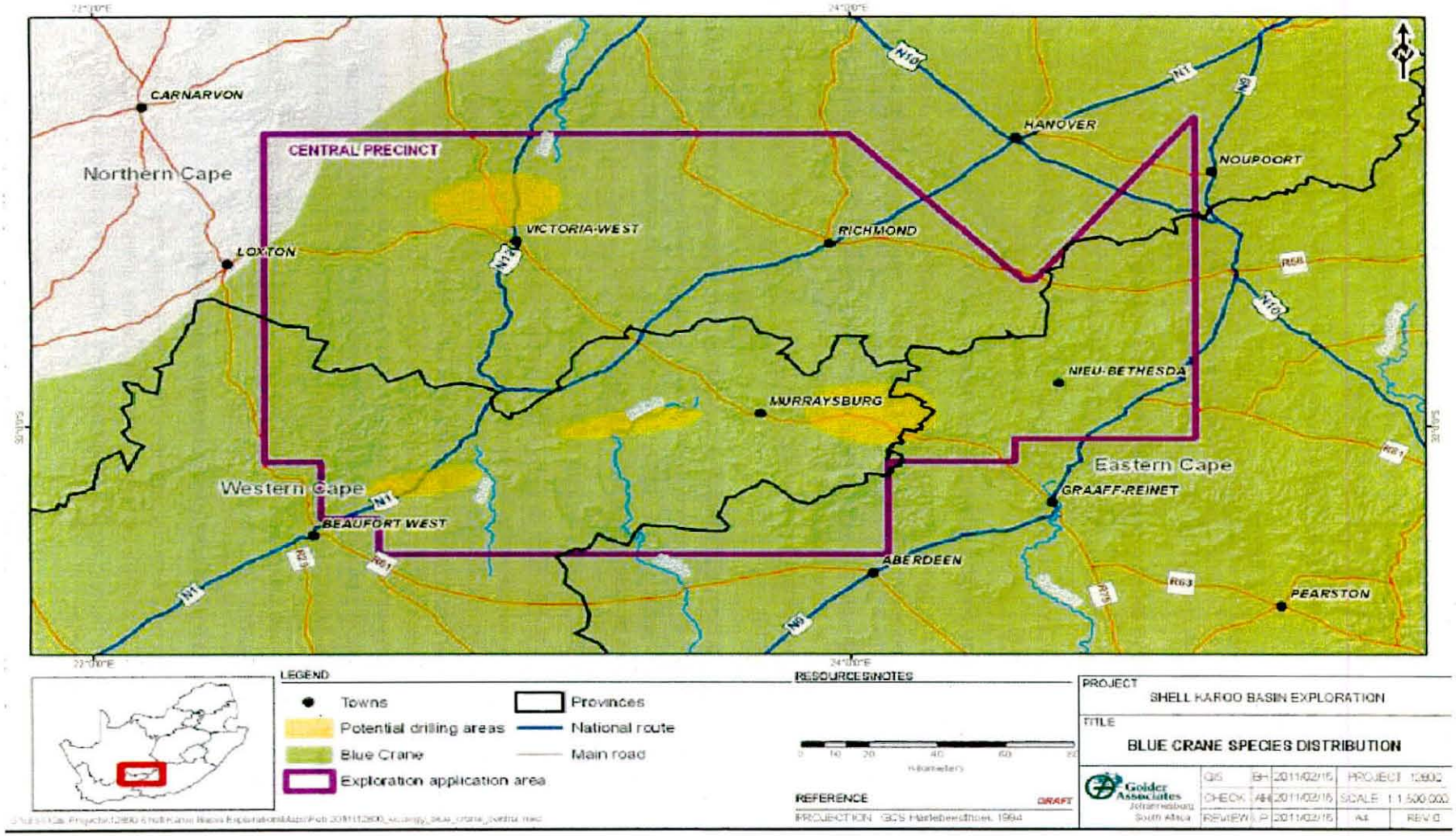

Figure 5: Distribution of Grus paradisea (Blue crane) in relation to the potential drilling areas *in the Central Precinct (IUCN, 2010)*

4.1.4.1.4 Mammals

Forty eight mammal species would historically have occurred in the Central Precinct area. Of these, 19 can be considered locally extinct (Stuart and Stuart, 1993).

Based on the literature survey four Red Data mammal species that are expected to occur in the project area namely (IUCN, 2011):

- Riverine Rabbit ((*Bunolagus monticularis*) (Critically Endangered (CE); IUCN, 2010);
- White-tailed mouse (*Mystromys albicaudatus*) (Endangered (E); IUCN, 2010);
- Mountain zebra (*Equus zebra zebra*) (Vulnerable (VU); IUCN, 2010); and
- Karoo Rock Sengi (*Elephantulus pilicaudus*) (Data Deficient (DD); IUCN 2010).

The distribution of the Red Data faunal species in relation of the potential drilling areas in the Central Precinct is shown in Figure 6.

4.1.4.1.4.1 Riverine Rabbit (Bunolagus monticularis)

This species is endemic to the central Karoo region of South Africa (IUCN, 2010). The Riverine Rabbit is one of the most endangered species in Africa and occurs in a small distribution range in the Karoo.

The Riverine Rabbit has very specific habitat requirements and inhabits dense riparian growth along the seasonal rivers in the central Karoo (Nama-Karoo biome) (IUCN, 2010). It occurs specifically in riverine vegetation on alluvial soils adjacent to seasonal rivers (IUCN, 2010). This habitat type is highly fragmented and transformed (IUCN, 2010).

The distribution of the Riverine rabbit within the Central Precinct is presented in Figure 6. Based on this assessment the distribution of the Riverine rabbit does not coincide with any of the potential drilling areas in the Central Precinct. Any impacts on the riparian habitats within these areas may impact on Riverine rabbit habitat and would therefore be rated as highly significant.

4.1.4.1.4.2 Mountain zebra (Equus zebra zebra)

The range of the Mountain Zebra extends across the Central Precinct (Figure 6), but this species is not free ranging and is restricted in distribution to formally protected areas and private game ranches. Historically, Mountain Zebras occurred from the southern parts of South Africa through Namibia and into extreme south-western Angola. Today, surviving natural populations of Cape Mountain Zebra occur only in Mountain Zebra National Park, Gamka Mountain Reserve, and the Kamanassie mountains. Populations have been reintroduced to various parts of their former range, including Karoo National Park, De Hoop Nature Reserve, Karoo Nature Reserve (recently proclaimed as the Camdeboo National Park), Commando Drift Nature Reserve, Baviaanskloof Wilderness Area, Tsolwana Nature Reserve. and Gariep Dam Nature Reserve.

Providing that drilling activities take place beyond the confines of these reserves the proposed drilling poses no threat to the Mountain zebra.

4.1.4.1.4.3 Karoo Rock Sengi (Elephantulus pilicaudus)

The Karoo Rock Sengi has only recently been described as a sister species of the Cape Rock Sengi, *Elephantulus edwardii* (IUCN, 2010). Specific information on the abundance, distribution, and population status of the new species is lacking and although no major threats are currently known, it is tentatively listed as Data Deficient (IUCN, 2010).

The new species is endemic to South Africa in the Northern Cape Province and the north-western edge of Western Cape Province (IUCN, 2010). The species has only been recorded in the Nama-Karoo vegetation biome (IUCN, 2010). This species has only been recorded at five known locations (IUCN, 2010). Within its range the species is associated with boulders and rocky habitats at altitudes of > 1,300 m above seas level (IUCN, 2010).

The distribution of this species does not coincide with any of the potential drilling areas within the Central Precinct (Figure 6). Rocky outcrops that may provide habitat for this species should be avoided during the drilling programme.

4.1.4.1.4.4 White-tailed mouse (Mystromys albicaudatus)

This species is relatively widespread across South Africa and Lesotho (IUCN, 2010). The species occurs in shrubland and grassland areas (IUCN, 2010). A major requirement of the species is black loam soils with good vegetation cover (IUCN, 2010).

Although this species occurs over a wide area it is listed as Endangered (E) on the IUCN Red List of Threatened Species (IUCN, 2010) due to habitat fragmentation associated with grazing and agricultural practises (IUCN, 2010). It is estimated that 51-80% of suitable habitat for the species has been lost over the last 40 years, and over 50% of the remaining habitat is expected to be lost over the next ten years if current agricultural practices continue (IUCN, 2010).

The distribution of the White-tailed mouse is superimposed on the Western Precinct in Figure 6. Based on this assessment the only area where this species may occur in the Central Precinct is the far eastern section where habitat for this species is available. The range of the White-tailed Mouse does not coincide with any of the potential drilling areas in the Central Precinct.

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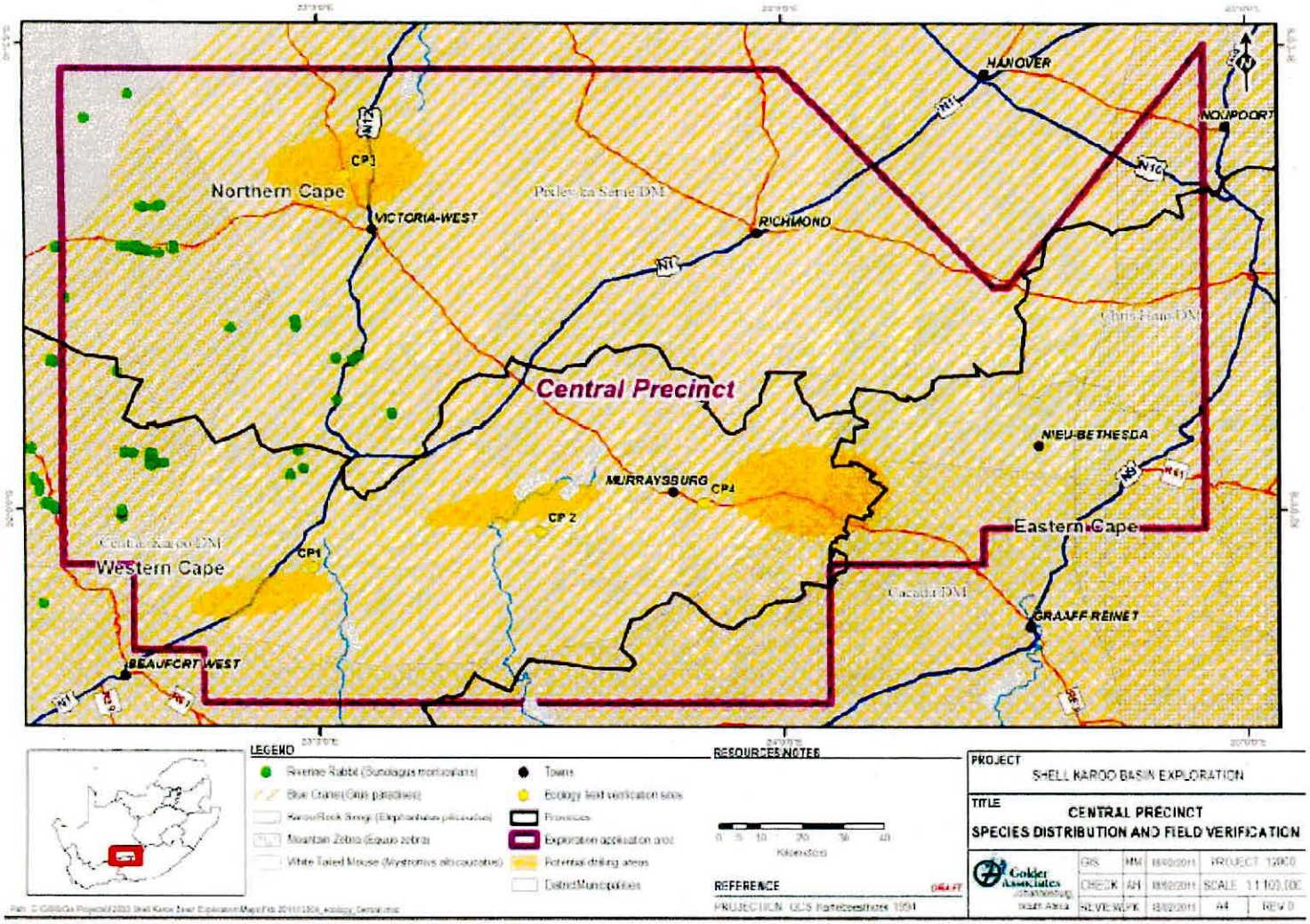

Figure 6: Distribution of Red Data faunal species in relation to the potential drilling areas *in the Central Precinct (IUCN, 2010)*

4.2 Fieldwork

4.2.1 Flora

During the site visit a broad scale overview of the vegetation was conducted in order to verify the results of the desktop assessment. The route through the Central Precinct is in Figure 1. Areas of importance were noted and short stops were taken at certain sites in order to verify the desktop vegetation classification. The species composition of the sites verified, at a very broad scale that the mapping according to vegetation communities is correct.

Subtle differences in species composition and physiognomy were noted in the various vegetation types, according to the different vegetation types as well as due to different grazing pressures, recent rainfall and management styles of farmers on whose farm the vegetation occurred, no Red Data species were recorded. However as the surveys were rapid and conducted in road reserves (degraded habitat) this information is not representative of the region as whole and specific site investigations will be required once sites have been selected. .

4.2.2 Fauna

4.2.2.1 Reptiles

Nine reptile species were recorded in the Central Precinct during the field verification survey (Table 5). None of the recorded species are classified as Red Data Species. *Mabuya striata* (Striped skink) is listed as Least Concern (LC) on the IUCN Red List of Threatened Species (IUCN, 2010). Species in this category are considered to be widespread and abundant (IUCN, 2010).

Table 5: Reptile species recorded at all sites in the Central Precinct

BIOLOGICAL NAME	COMMON NAME	ENDEMIC	Red Data (IUCN, 2010)
Psammophylax rhombeatus	Rhombic Skaapsteker	No	Not Listed
Bitis arietans	Puff Adder	No	Not Listed
Bitis caudalis	Horned Adder	No	Not Listed
Mabuya capensis	Cape Skink	No	Not Listed
Mabuya striata	Striped Skink	No	Least Concern (LC)

4.2.2.2 Amphibia

No frog species were recorded during the study in the Central Precinct area, and therefore no Red Data or protected species were recorded. Amphibian species may occur in seasonal rivers which occur in the area and may occupy the wetlands in the area, these will, however, be unsuitable as drilling sites and therefore it is unlikely that any amphibian species will be affected by the exploration activities. Aquatic species such as *Xenopis* sp usually occur in man-made dams in the area and drinking troughs occurring on the farms in the area but these were not investigated during the site visit due to lack of permissions for access to farms.

4.2.2.3 Avifauna

No Red Data bird species were recorded during the field survey. Thirty species were found to occur within the study area during the time of the study Of the bird species known to occur in the study area, 12 are listed as Threatened or Protected Species (NEMBA, 2007), of the 30 recorded species, only the Kori Bustard, *Ardeotis kori* (VU) was listed as a Red Data species. Kori Bustards were common species in the northern part of the Central Precinct around the Nelspoort and Victoria West areas and is a species on which the impacts will need to be investigated

4.2.2.4 Mammals

Mammal species diversity was assumed to be moderate to low in the study area, with only seven species being recorded. The reasons for the low mammalian species diversity may be due to degradation of habitat in the study area due to anthropogenic impacts such as grazing and the fact that some species have been persecuted historically. None of the species recorded were listed as Red Data species or considered protected species. A more in depth census of small mammal species at the sites selected for exploration drilling is suggested as this type of survey is unlikely to be adequate for a small mammal census.

Table 6: Mammal species recorded for all sites in the Central Precinct

BIOLOGICAL NAME	COMMON NAME
Lepus capensis	Cape Hare
Hystrix africaeaustralis	Cape Porcupine
Rhabdomys pumilio	Four-striped Grass Mouse
Orycteropus afer	Aardvark
Antidorcas marsupialis	Springbok
Oreotragus oreotragus	Klipspringer
Raphicerus campestris	Steenbok

4.3 Ecological Sensitivity Assessment

Based on the desktop assessment all of the vegetation communities within the Central Precinct are listed as Least Threatened. Although the degree of statutory protection of these vegetation communities within reserves is generally low (< 5%) the degree of historical transformation is similarly low (< 5%). However 45 Red Data or Protected plant species are expected to occur within the Central Precinct. Due to the limited scale of the proposed exploration activities the impact on indigenous vegetation communities is expected to be low. However special care needs to be taken during the site selection process to avoid areas with high numbers of Red Data or Protected plant species. Any Red Data or Protected plant species that are encountered during the exploration activities need to be translocated before ground clearing begins.

Five Red Data faunal species are expected to occur within the Central Precinct. Of these the Riverine Rabbit is listed as Critically Endangered (CE) primarily due to habitat loss and fragmentation (IUCN, 2010). The Karoo Rock Sengi has only recently been described as a separate species and is only known from 5 locations. Specific information on the abundance, distribution, and population status of the new species is lacking and although no major threats are currently known, it is tentatively listed as Data Deficient (IUCN, 2010).The Mountain Zebra is listed as Vulnerable (VU) and is only found in the Mountain Zebra National Park, Gamka Mountain Reserve, and the Kamanassie mountains. The Blue Crane is currently listed as Vulnerable (VU) on the IUCN Red List of Threatened Species (IUCN, 2010). *G. paradisea* is near-endemic to South Africa, with small breeding populations also occurring in northern Namibia and western Swaziland (IUCN, 2010). *G. paradisea* is considered to be an uncommon resident in the region. Populations of this species have declined rapidly due to direct poisoning, power-line collisions and loss of its grassland breeding habitat due to afforestation, mining, agriculture and development (IUCN, 2010). The impact of exploration activities on terrestrial fauna is likely to be very localised with birds especially able to move away from areas of disturbance. However special care needs to be taken during the selection of drilling sites to ensure that these are well away from *Grus paradisea* nesting sites. The White-tailed mouse (Mystromys albicaudatus) is relatively widespread across South Africa and Lesotho (IUCN, 2010). The species occurs in shrubland and grassland areas (IUCN, 2010). A major requirement of the species is black loam soils with good vegetation cover (IUCN, 2010). Although this species occurs over a wide area it is listed as Endangered (E) on the

IUCN Red List of Threatened Species (IUCN, 2010) due to habitat fragmentation associated with grazing and agricultural practises (IUCN, 2010). It is estimated that 51-80% of suitable habitat for the species has been lost over the last 40 years, and over 50% of the remaining habitat is expected to be lost over the next ten years if current agricultural practices continue (IUCN, 2010).

Figure 6 presents the distribution of these species in relation to the potential drilling areas. Based on this, all of the potential drilling areas overlap with the distributions of one or more of the Red Data species occurring within the area. Any potential impacts on Red Data species whether due to disturbance, or habitat loss or fragmentation etc. will be significant. Of all the Red Data species it is highly unlikely that exploration will affect The Mountain Zebra (*Equus zebra zebra*) due to its distribution being limited to formally protected areas and some private game ranches. The other species are limited within their ranges by very specific habitat preferences and by avoiding these habitat types impacts on these species can be avoided.

Figure 7 shows the location of sensitive or conservation areas in relation to the potential drilling areas within the Central Precinct. Based on this assessment all of the potential drilling areas overlap, at least in part with some areas of sensitivity or conservation importance. Prior to the site selection process the status of these areas should be verified, and sites should only be selected outside of these areas. The Central Precinct does infringe on the Kromrivier Conservancy and other Riverine Rabbit conservancies in the west. It is recommended that this area be avoided during exploration.

Rehabilitation in this area will be very difficult due to climatic and vegetation conditions and the low and erratic rainfall. A number of publications are available on rehabilitation of vegetation in the Karoo (De Villiers *et al.*, 2004; Beukes and Cowling, 2003; Blignaut and Milton, 2005; Simons and Allsopp, 2006; Burke, 2001; Hanke *et al.*, 2011; Visser *et al.*, 2004). The difficulty in rehabilitation further stresses the importance of site selection. Removing and maintaining vegetation from the site in a nursery for transplanting back on the site during decommissioning is an option that should be investigated.

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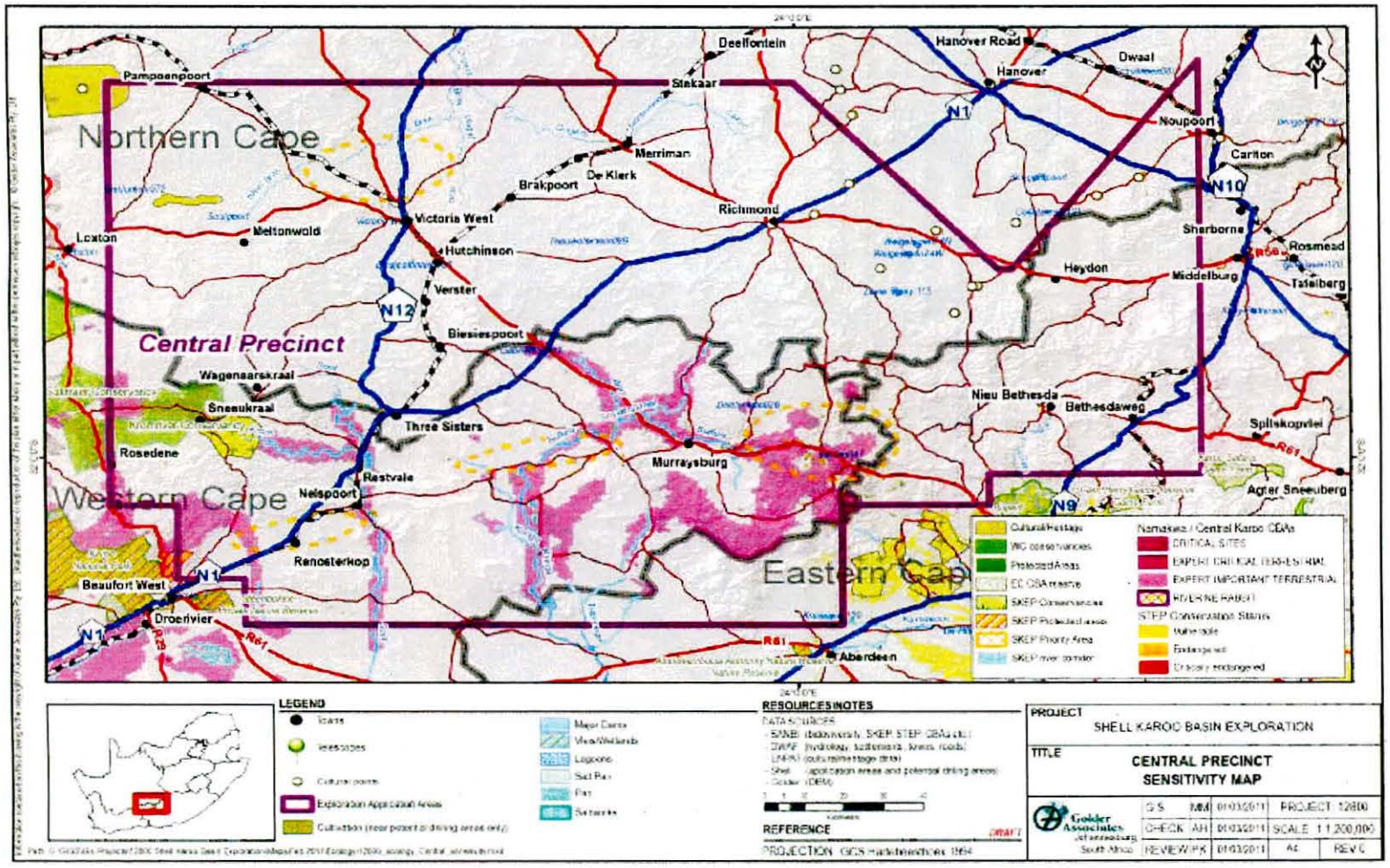

Figure 7: Sensitivity map showing location of sensitive or conservation areas within the Central Precinct

5.0 TECHNICAL ASSESSMENT

5.1 Exploration activities that could potentially impact the environment[1]

Site preparation

The activities that could potentially impact the environment during site preparation include:-

- The removal of vegetation to establish the drilling site and access roads may result in loss of Red Data or Protected plant species and loss or fragmentation of Red Data faunal species habitat; and
- Collisions with Red Data faunal species on roads.

Exploration drilling and hydraulic fracturing

The activities that could potentially impact the environment during exploration drilling and hydraulic fracturing include:-

- Disturbance of Red Data fauna due to increased dust and noise.

Decommissioning

The activities that could potentially impact the environment during decommissioning include:-

- Degradation of habitat due to establishment of invasive alien plants.

5.2 Description of the assessment methodology

Potential significance of the potential impacts was based on occurrence and severity, which are further sub-divided as follows:

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Magnitude (severity) of impact	Scale / extent of impact

To assess each impact, the following four ranking scales are used:

PROBABILITY	DURATION
5 - Definite/don't know	5 – Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8-15 years)
2 - Low probability	2 - Short-term (0-7 years) (impact ceases after the exploration life of the activity)
1 – Improbable	1 – Immediate
0 – None	
SCALE	**MAGNITUDE**
5 – International	10 - Very high/don't know
4 – National	8 – High
3 – Regional	6 – Moderate
2 – Local	4 – Low
1 - Site only	2 – Minor
0 – None	

[1] It is assumed that geophysical data acquisition (e.g. Magneto-Telluric Surveys) will have negligible impacts on terrestrial ecology and thus has been excluded from this assessment.

The significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (probability + duration + scale) x magnitude

The maximum value is 150 significance points (SP). The significance of the potential impact will then be rated as follows:

SP >75	Indicates **high** environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates **moderate** environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates **low** environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.
+	Positive impact	An impact that is likely to result in positive consequences/effects.

5.3 Technical Assessment

5.3.1 Well site preparation

Table 7 below summarises the potential impacts directly related to site preparation, and provides a significance rating for each potential impact before and after mitigation.

Table 7: Technical Assessment Matrix for the proposed South Western Karoo Basin Gas Exploration Application Project – site preparation

POTENTIAL ENVIRONMENTAL IMPACT: SITE PREPARATION	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	Total	SP	M	D	S	P	Total	SP
1. Loss of Red Data Plant species due to clearing of exploration sites and roads												
Clearing of vegetation during site preparation may result in the destruction of Red Data or Protected plant species.	6	5	2	3	60	**Mod**	4	5	1	0	24	**Low**
2. Loss or fragmentation of habitats for Red Data fauna species due to clearing of exploration sites and roads												
Clearing of vegetation may result in loss or fragmentation of habitat for Red Data faunal species.	6	2	2	3	42	**Mod**	4	2	2	2	24	**Low**
3. Collisions with Red Data faunal species on roads												
Vehicle collisions with Red Data faunal species, especially smaller, slower moving terrestrial species, on road networks.	8	2	3	2	56	**Mod**	4	2	3	1	24	**Low**

Loss of Red Data or Protected plant species

Technical assessment

All of the vegetation communities within the Central Precinct are listed as Least Threatened. However 24 Red Data or Protected plant species are expected to occur in the area.

Mitigation measures

Areas with high densities of Red Data or Protected Plant species should be identified and avoided during the site selection process. Any Red Data or Protected Plant species encountered during ground clearing should be translocated to a nursery area and returned to the site during rehabilitation.

Significance

Due to the low level of historical transformation of the vegetation types within the precinct, one would expect an impact of high magnitude; however, due to the limited scale of the ground clearing required for site preparation and access road construction, and the naturally sparse cover of the vegetation within the region, impact magnitude is considered moderate. Should Red Data or Protected plant species be lost during site preparation, this impact will be permanent and irreversible. Overall impact significance is therefore moderate. Should the mitigation measures mentioned above be implemented, overall impact significance can be reduced to low.

Loss or fragmentation of habitat for Red Data faunal species

Assessment

Five Red Data faunal species are expected to occur within the Central Precinct. These species are threatened due to a variety of factors including habitat loss and fragmentation. Clearing of vegetation during site preparation may constitute a further loss or fragmentation of habitat for these species.

Mitigation measures

All of the Red Data species are limited within their ranges by very specific habitat preferences; by avoiding these habitat types, impacts on these species can be mitigated. The impact of exploration activities on terrestrial fauna is likely to be localised, with birds especially able to move away from areas of disturbance. However, special care needs to be taken during the selection of drilling sites to ensure that sites are located well away from *Grus paradisea* nesting sites.

Significance

Due to the limited scale of surface disturbance required for site preparation and access road construction, the naturally sparse cover of the vegetation within the region, and that impacts are likely to be localised (with birds especially), impact significance is considered to be moderate. All of the Red Data species are limited within their ranges by very specific habitat preferences; by avoiding these habitat types, impacts on these species can be mitigated to low.

Collisions with Red Data faunal species on road networks

Impact assessment

While travelling on road networks, vehicles moving to and from the site could collide with Red Data faunal species, especially the smaller, slower moving terrestrial species, such as Riverine Rabbit, the White-tailed mouse and the Karoo Rock Sengi.

Mitigation measures

Mitigation measures include reduced speed limits and awareness.

Significance

Impacts of high magnitude will occur over a regional scale; impact significant is therefore rated as moderate. Should appropriate mitigation measures, such as reduced speed limits and awareness, impact significance can be reduced to low.

5.3.2 Exploration drilling and hydraulic fracturing

Table 8 below summarises those impacts directly related to exploration drilling and hydraulic fracturing, and provides a significance rating for each impact before and after mitigation.

Table 8: Technical Assessment Matrix for the proposed South Western Karoo Basin Gas Exploration Application Project – exploration drilling and hydraulic fracturing

POTENTIAL ENVIRONMENTAL IMPACT:EXPLORATION DRILLING AND HYDRAULIC FRACTURING	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	Total	SP	M	D	S	P	Total	SP
1. Disturbance of Red Data fauna due to increased dust and noise												
Impacts on fauna may result due to localised increases in noise, light and dust levels.	6	2	2	5	54	Mod	4	2	2	3	28	Low

Disturbance of Red Data fauna due to increased dust, noise and light

Technical assessment

Exploration activities will result in a temporary localised increase in noise, light and dust levels.

Increased noise levels may affect a wide range of taxa (including avifauna, mammals, reptiles, amphibians and arthropods) due to the associated increase in vibration. Avifauna, especially songbirds, and amphibians may find it difficult to find mates in areas of increased noise. Most taxa will move away from areas with increased noise. In general, most species seem to tolerate constant, even very loud, sounds better than sudden, unfamiliar ones.

Increased atmospheric dust may occur in the vicinity of the well site and access road construction. Dust settling on plant material can reduce the amount of light reaching the chlorophyll in the leaves, thereby reducing photosynthesis, which in turn reduces plant productivity, growth and recruitment.

Lights at night are likely to attract insects which may in turn attract night feeding birds, lizards or amphibians at the site.

Mitigation measures

Implement mitigation measures for air quality, visual and noise impacts.

Significance

The impact on terrestrial fauna is likely to be temporary and localised, but will definitely occur. Impact significance is therefore anticipated to be moderate. Should the appropriate mitigation measures for air quality, visual and noise impacts be implemented, impact significance can, however, be reduced to low.

5.3.3 Decommissioning

Table 9 summarises those impacts directly related to decommissioning, and provides a significance rating for each impact before and after mitigation. The wells will only be decommissioned if no gas is found or if the gas is found to be technically/commercially not viable to extract.

Table 9: Technical Assessment Matrix for the proposed South Western Karoo Basin Gas Exploration Application Project – decommissioning

POTENTIAL ENVIRONMENTAL IMPACT: DECOMMISSIONING	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	Total	of M	M	D	S	P	Total	SP
1. Degradation of habitat due to establishment of invasive alien plants												
Upon decommissioning, infrastructure will be removed and the site rehabilitated. This may result in the establishment of invasive plant species on the site.	6	3	2	3	48	**Mod**	4	2	2	2	24	**Low**

Technical assessment

During site preparation, vegetation will be cleared and will be maintained in this state during exploration. Upon decommissioning, infrastructure will be removed and the site rehabilitated. This may result in the colonisation of the site by invasive alien plant species such as *Prosopis sp.*, *Salsola kali* and *Medicago laciniata*.

Mitigation measures

This impact can be mitigated by implementing an invasive plant monitoring programme at the site, until such a time as the indigenous vegetation community has been re-established.

Significance

The significance of this impact is rated as moderate due to the localised nature of this impact. Should, however, the monitoring programme be implemented and, if necessary, invasive alien plant species removed, impact significance can be reduced to low.

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6.0 MITIGATION AND MANAGEMENT MEASURES

Well site preparation

The following mitigation measures have been identified for well site preparation (Table 10).

Table 10: Environmental Management Plan for proposed South Western Karoo Basin Gas Exploration Application Project – Well site preparation

Well site preparation Environmental Management Plan			Timeline and frequency	Responsible party
1. Ecology				
1.1	**Project activity:**	Clearing of vegetation during site preparation	-	-
	Impact:	Destruction of Red Data or Protected plant species.	-	-
	Mitigation measure(s):	Areas with high densities of Red Data or Protected Plant species should be identified and avoided during the site selection process. Any Red Data or Protected Plant species encountered during ground clearing should be translocated to a nursery area and returned to the site during rehabilitation.	As appropriate, throughout site selection and well site preparation	Shell
1.2	**Project activity:**	Clearing of vegetation during site preparation.	-	-
	Impact:	Loss or fragmentation of habitat for Red Data faunal species.	-	-
	Mitigation measure(s):	Avoid Red Data species habitat types during site selection.	As appropriate, throughout well site preparation	Shell
1.3	**Project activity:**	Use of road network	-	-
	Impact:	Vehicle collisions with Red Data faunal species, especially smaller, slower moving terrestrial species.	-	-
	Mitigation measure(s):	Reduce speed limits on roads and enhance awareness	As appropriate, throughout well site preparation	Shell

Exploration drilling and hydraulic fracturing

The following mitigation measures have been identified for exploration drilling and hydraulic fracturing (Table 11).

Table 11: Environmental Management Plan for proposed South Western Karoo Basin Gas Exploration Application Project – Exploration drilling and hydraulic fracturing

Exploration drilling and hydraulic fracturing Environmental Management Plan			Timeline and frequency	Responsible party
1. Ecology				
1.1	**Project activity:**	Use of chemicals and harmful or toxic substances	-	-
	Impact:	Spillage of harmful or toxic substances	-	-
	Mitigation measure(s):	Implement groundwater mitigation measures.	As appropriate, throughout exploration	Shell
1.2	**Project activity:**	Drilling and hydraulic fracturing operations	-	-
	Impact:	Vibration and Noise	-	-
	Mitigation measure(s):	Implement noise and air quality mitigation measures.	As appropriate, throughout exploration	Shell
1.3	**Project activity:**	Hydraulic fracturing	-	-
	Impact:	Contamination of shallow groundwater	-	-
	Mitigation measure(s):	Implement groundwater mitigation measures.	As appropriate, throughout exploration	Shell

Decommissioning

The following mitigation measures have been identified for decommissioning (Table 12).

Table 12: Environmental Management Plan for proposed South Western Karoo Basin Gas Exploration Application Project – Decommissioning

Decommissioning Phase Environmental Management Plan			Timeline and frequency	Responsible party
1. Ecology				
1.1	**Project activity:**	Infrastructure will be removed and the site rehabilitated	-	-
	Impact:	Establishment of invasive plant species on the site	-	-
	Mitigation measure(s):	Implement an invasive plant monitoring programme at the site. If necessary, remove invasive alien plant species.	Until such a time as the indigenous vegetation community has been re-established.	Shell

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6.1 Recommended monitoring programmes

- Fauna and flora monitoring programmes in surrounding areas, in order to assess whether any unforeseen impacts are occurring as well as assess the scale and magnitude of the impacts occurring throughout site preparation, exploration drilling and hydraulic fracturing and decommissioning.

6.2 Recommended emergency procedures

Emergency procedures should be put in place for:

- Spillage of harmful or toxic substances; and
- Fire.

7.0 RECOMMENDATIONS FOR THE DETAILED IMPACT ASSESSMENT

Following the submission of the EMP, and a site selection process for the well sites, a detailed environmental impact assessment (EIA) will be undertaken.

7.1 Site selection criteria

The following aspects will be taken into consideration during site selection:

- Areas with high densities of Red Data or Protected Plant species;
- Areas with high densities of Red Data faunal species, e.g. Riverine Rabbit habitat types, i.e. riverine vegetation on alluvial soils adjacent to seasonal rivers, Karoo Rock Sengi habitat types, i.e. rocky outcrops, White-tailed Mouse habitat types, i.e. shrubland and grassland areas, and *Grus paradisea* nesting sites; and
- Areas of sensitivity or conservation importance such as the Kromrivier Conservancy.

7.2 Key questions that need to be addressed in the EIA

The following key questions will need to be addressed in the EIA:

- What vegetation types occur at selected drilling sites during the wet season (November to March) and dry season (May – September)?
- Do any threatened plant species (Red Data listed), medicinal species, protected species (North West Province Conservation Act), endemic (confined to the area) taxa, species of conservation importance, etc occur within or nearby the selected drilling sites?
- Do any threatened faunal species (Red Data listed), protected species, endemic (confined to the area) taxa, hibernation/breeding sites, important birding areas (IBA), etc occur within or nearby the selected drilling sites?
- How will migration patterns of species be affected, or likely to be affected by proposed activities?
- What is the surrounding land use on adjacent properties to determine cumulative effects of the proposed exploration activities?
- What mitigation measures can be put in place for identified critical impacts; what monitoring and evaluation plans can be developed to determine the effectiveness of mitigation?
- What measures can be put in place to successfully rehabilitate disturbed areas, taking aspects such as low and erratic rainfall and vegetation conditions in the Karoo, into consideration?

8.0 CONCLUSIONS

Conclusions of this study are as follows:

- All of the vegetation types within the Central Precinct are listed as Least Threatened. Although the degree of statutory protection of these vegetation communities within reserves is generally low (< 5%) the degree of historical transformation is similarly low (< 5%);
- Twenty four Red Data or Protected plant species are expected to occur within the Central Precinct. Due to the limited scale of the proposed exploration activities the impact on indigenous vegetation communities is expected to be low;
- Care needs to be taken during the site selection process to avoid areas with high densities of Red Data or Protected plant species. Any Red Data or Protected plant species that are encountered during site preparation removed, maintained in a nursery area and replanted on the site during rehabilitation.
- Five Red Data faunal species are expected to occur within the Central Precinct. Of these the Riverine Rabbit is listed as Critically Endangered (CE) primarily due to habitat loss and fragmentation;
- The White-tailed mouse is listed as Endangered (E) due to habitat fragmentation associated with grazing and agricultural practises (IUCN, 2010);
- The Karoo Rock Sengi has only recently been described as a separate species and is only known from 5 locations. Specific information on the abundance, distribution, and population status of the new species is lacking and although no major threats are currently known, it is tentatively listed as Data Deficient (IUCN, 2010).
- The Mountain Zebra is listed as Vulnerable (VU) and is only found in the Mountain Zebra National Park, Gamka Mountain Reserve, and the Kamanassie mountains and is therefore unlikely to be impacted upon by the exploration activities;
- The Blue Crane is currently listed as Vulnerable (VU) on the IUCN Red List of Threatened Species (IUCN, 2010). *G. paradisea* is near-endemic to South Africa, with small breeding populations also occurring in northern Namibia and western Swaziland (IUCN, 2010). *G. paradisea* is considered to be an uncommon resident in the region. Populations of this species have declined rapidly due to direct poisoning, power-line collisions and loss of its grassland breeding habitat due to afforestation, mining, agriculture and development (IUCN, 2010).
- The two key potential impacts identified include the loss of Red Data or Protected plant species and the loss or fragmentation of habitat for Red Data faunal species resulting from well site preparation and access road construction activities. These impacts are considered to be impacts of moderate significance. Areas with high densities of Red Data or Protected Plant species should be identified and avoided during the site selection process. Such areas include *Grus paradisea* nesting sites;
- Should any Red Data or Protected Plant species be encountered during ground clearing, they should be translocated to a nursery area and returned to the site during rehabilitation; and
- All of the potential drilling areas in the Central Precinct overlap, at least in part with some areas of sensitivity or conservation importance. Prior to the site selection process the status of these areas should be verified, and sites should only be selected outside of these areas. The Central Precinct does infringe on the Kromrivier Conservancy in the east. It is recommended that this area be avoided during exploration.

- Following the submission of the EMP, and a site selection process for the well sites, a detailed environmental impact assessment (EIA) will be undertaken. The following key questions will need to be addressed in the EIA:
  - What vegetation types occur at selected drilling sites during the wet season (November to March) and dry season (May – September)?
  - Do any threatened plant species (Red Data listed), medicinal species, protected species (North West Province Conservation Act), endemic (confined to the area) taxa, species of conservation importance, etc occur within or nearby the selected drilling sites?
  - Do any threatened faunal species (Red Data listed), protected species, endemic (confined to the area) taxa, hibernation/breeding sites, important birding areas (IBA), etc occur within or nearby the selected drilling sites?
  - How will migration patterns of species be affected, or likely to be affected by proposed activities?
  - What is the surrounding land use on adjacent properties to determine cumulative effects of the proposed exploration activities?
  - What mitigation measures can be put in place for identified critical impacts; what monitoring and evaluation plans can be developed to determine the effectiveness of mitigation?
  - What measures can be put in place to successfully rehabilitate disturbed areas, taking aspects such as low and erratic rainfall and vegetation conditions in the Karoo, into consideration?

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