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 Western precinct coincides with three biomes namely (*Figure 3*):

- Nama-Karoo;
- Succulent Karoo; and
- Fynbos (more specifically Renosterveld Fynbos)

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 Succulent Karoo

Most of the biome covers a flat to gently undulating plain, with some hilly and "broken" veld, mostly situated to the west and south of the escarpment, and north of the Cape Fold Belt. The altitude is mostly below 800 m, but in the east it may reach 1 500 m (Low and Rebelo, 1998).

Most of the biome covers a flat to gently undulating plain, with some hilly and "broken" veldt, mostly situated to the west and south of the escarpment, and north of the Cape Fold Belt. The altitude is mostly below 800 m, but in the east it may reach 1 500 m. The vegetation is dominated by dwarf, succulent shrubs, of which the Vygies (Mesembryanthemaceae) and Stonecrops (Crassulaceae) are particularly prominent. Mass flowering displays of annuals (mainly Daisies Asteraceae) occur in spring, often on degraded or fallow lands.

Grasses are rare, except in some sandy areas, and are of the C3 type. The number of plant species mostly succulents - is very high and unparalleled elsewhere in the world for an arid area of this size. Little data are available for the fauna of the Succulent Karoo (Low and Rebelo, 1998).

The area has little agricultural potential due to the lack of water. The paucity of grasses limits grazing, and the low carrying capacity requires extensive supplementary feeds. Much soil has been lost from the biome, through sheet erosion, as a consequence of nearly 200 years of grazing. Ostrich farming, with considerable supplementary feeding, is practised in the Little Karoo in the south of the biome. Mining is important, especially in the north of this biome (Low and Rebelo, 1998).

Less than 0.5% of the Succulent Karoo Biome has been formally conserved. The biome has a high number of rare and Red Data Book plant species. The high species richness and unique global status of the biome require urgent conservation attention (Low and Rebelo, 1998).

4.1.2.3 Fynbos (Renosterveld)

The Fynbos biome is considered by many to be synonymous with the Cape Floristic Region or Cape Floral Kingdom. However, the "biome" refers only to the two key vegetation groups (Fynbos and Renosterveld) within the region. The two major vegetation groupings in Fynbos are quite distinct and have contrasting ecological systems. Essentially, Renosterveld used to contain the large animals in the Cape Floristic Kingdom, but these are now extinct or and have only been reintroduced into conservation areas. By contrast, Fynbos is much richer in plant species, but has such poor soils that it cannot support even low densities of big game. However, most of the endemic amphibian, bird and mammal species in the region, occur in Fynbos vegetation types. The exploration application area is only associated with the Renosterveld part of this biome (Low and Rebelo, 1998).

Some three-quarters of all plants in the South African Red Data Book occur in the Cape Floral Kingdom: 1 700 plant species are threatened to some extent with extinction! This is much more than one would expect based on either the area of the Kingdom (6%) or its plant numbers (36%). This again reflects the unique nature of Fynbos vegetation: many Fynbos species are extremely localized in their distribution, with sets of such localized species organized into "centres of endemism." (Low and Rebelo, 1998).

A serious threat to this biome is alien plant encroachment, which infest large tracts of otherwise undisturbed mountains and flats: their impact on these extremely localized species is severe. Aliens are thus the major threat to Fynbos vegetation and its plant diversity, especially in the mountains. On the lowlands and on the less steep slopes the major threat is agriculture - new technologies, fertilisers and crops are steadily eating into our floral reserves. Another important threat is the misuse of fire. Fynbos must burn, but fires in the wrong season (such as in spring, instead of late summer) or too frequently (so that plants do not have time to set seed) eliminate species. Several factors influence fire dynamics in Fynbos - global warming, grazing practices and fire management (ignition events, size of burns), but their relative importance and interactions are poorly understood (Low and Rebelo, 1998).

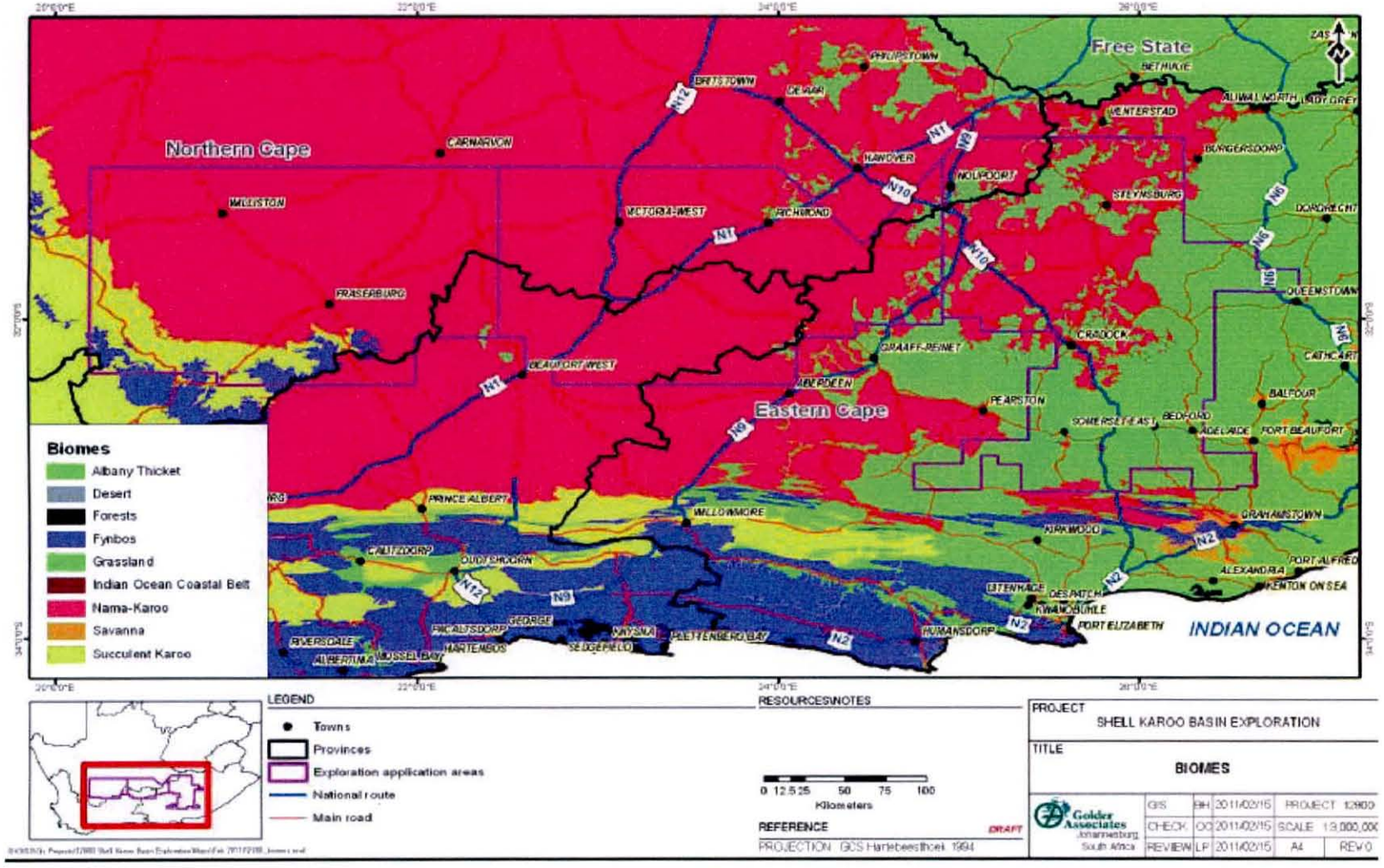

Figure 3: Vegetation biomes associated with the exploration application areas

4.1.3 Vegetation types

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

- Upper Karoo Hardeveld NKu2;
- Western Upper Karoo NKu1;
- Bushmanland Vloere AZi5;
- Roggeveld Karoo SKt3;
- Roggeveld Shale Renosterveld FRs3;
- Gamka Karoo NKl1; and
- Eastern Upper Karoo NKu4.

The distribution of these vegetation types within the Western 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
Roggeveld Karoo SKt3	None conserved in statutory conservation areas	2% transformed	Least threatened
Roggeveld Shale Renosterveld FRs3	None conserved in statutory conservation areas	1% 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	2% transformed	Least threatened

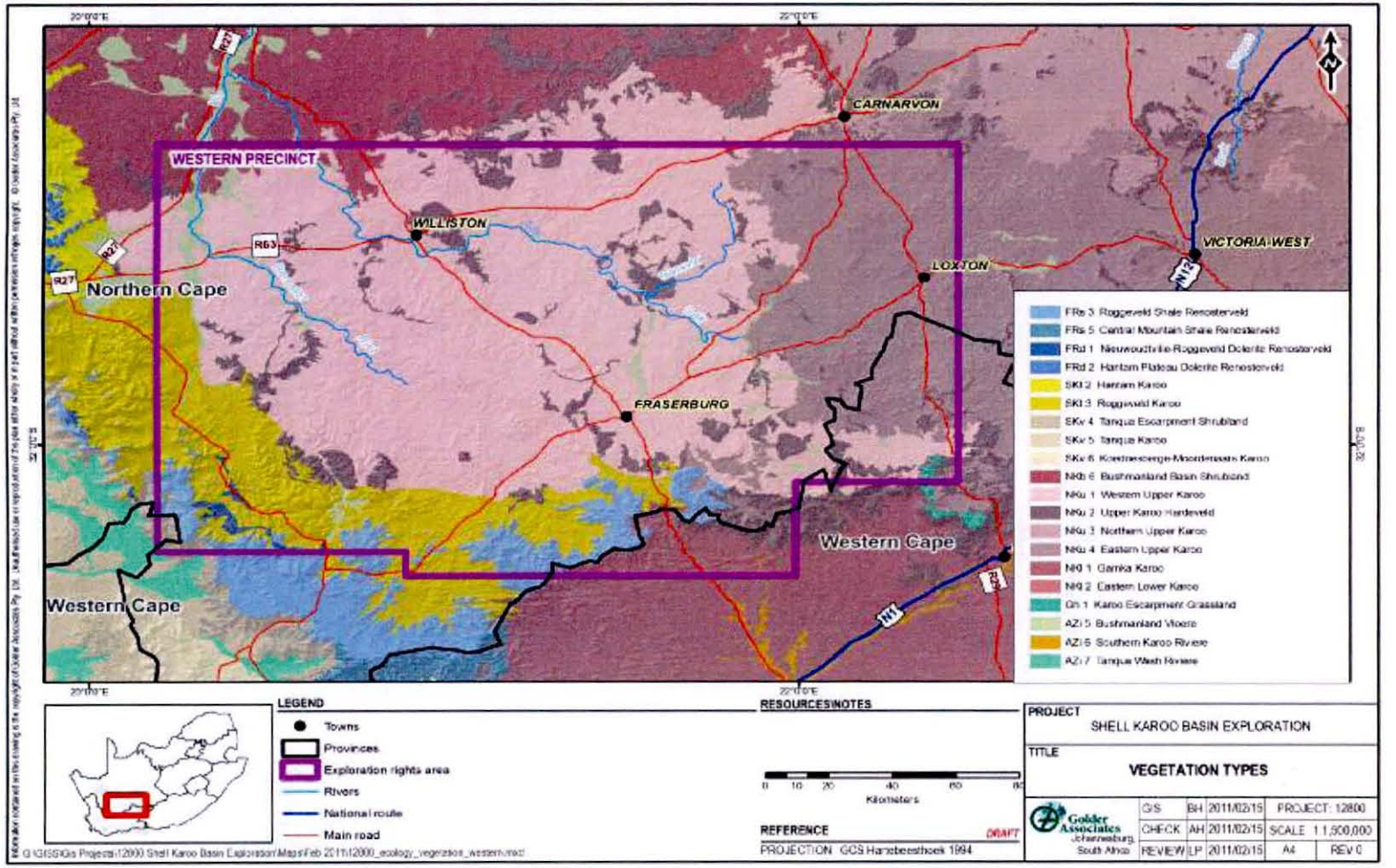

Figure 4: Vegetation types associated with the Western Precinct area

4.1.3.1 Red Data Floral Species

Based on the PRECIS (POSA, 2011) data for the corresponding grid squares, 917 plant species are known to occur within the Western 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 45 Red Data or Protected plant species are expected to occur within the Western Precinct (Table 2).

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

Family	Species	Threat status (POSA, 2011)	SA endemic
IRIDACEAE	*Hesperantha malvina* (Goldblatt)	Critically Rare	Yes
IRIDACEAE	*Moraea marginata* J.C.Manning & Goldblatt	Critically Rare	No
SCROPHULARIACEAE	*Zaluzianskya marlothii* Hilliard	DDD	Yes
SANTALACEAE	*Thesium micropogon* A.DC.	DDD	Yes
ASPHODELACEAE	*Aloe longistyla* Baker	DDD	Yes
MESEMBRYANTHEMACEAE	*Chasmatophyllum maninum* L.Bolus	DDD	Yes
ASTERACEAE	*Helichrysum albertense* Hilliard	DDD	Yes
COLCHICACEAE	*Colchicum coloratum* J.C.Manning & Vinn. subsp. Coloratum	DDT	Yes
FABACEAE	*Lessertia pauciflora Harv. var. schlechteri* L.Bolus	DDT	No
AIZOACEAE	*Galenia pallens* (Eckl. & Zeyh.) Walp.	DDT	Yes
OXALIDACEAE	*Oxalis setosa* E.Mey. ex Sond.	DDT	Yes
IRIDACEAE	*Babiana tubiflora* (L.f.) Ker Gawl.	Declining	Yes
ASTERACEAE	*Cineraria lobata L'Hér. subsp. lobata*	Declining	Yes
MESEMBRYANTHEMACEAE	*Drosanthemum lavisii* L.Bolus	EN	Yes
IRIDACEAE	*Babiana nana (Andrews) Spreng. subsp. nana*	EN	No
IRIDACEAE	*Romulea komsbergensis* M.P.de Vos	NT	Yes
IRIDACEAE	*Romulea subfistulosa* M.P.de Vos	NT	Yes
POACEAE	*Ehrharta eburnea* Gibbs Russ.	NT	Yes
GENTIANACEAE	*Sebaea scabra* Schinz	NT	Yes
AMARYLLIDACEAE	*Strumaria karooica* (W.F.Barker) Snijman	Rare	Yes
ASPHODELACEAE	*Haworthia venosa (Lam.) Haw. subsp. granulata* (Marloth) M.B.Bayer	Rare	Yes
ASTERACEAE	*Euryops marlothii* B.Nord.	Rare	Yes
CRASSULACEAE	*Adromischus phillipsiae* (Marloth) Poelln.	Rare	Yes
CRASSULACEAE	*Crassula vestita* Thunb.	Rare	Yes

Family	Species	Threat status (POSA, 2011)	SA endemic
FABACEAE	*Indigofera hantamensis* Diels	Rare	Yes
GERANIACEAE	*Pelargonium torulosum* E.M.Marais	Rare	Yes
IRIDACEAE	*Ixia brevituba* G.J.Lewis	Rare	Yes
MESEMBRYANTHEMACEAE	*Antimima emarcescens* (L.Bolus) H.E.K.Hartmann	Rare	Yes
MESEMBRYANTHEMACEAE	*Dorotheanthus booysenii* L.Bolus	Rare	Yes
IRIDACEAE	*Babiana virginea* Goldblatt	Rare	Yes
CRASSULACEAE	*Adromischus humilis* (Marloth) Poelln.	Rare	Yes
CRASSULACEAE	*Crassula socialis* Schönland	Rare	Yes
ASTERACEAE	*Euryops petraeus* B.Nord.	Rare	Yes
APOCYNACEAE	*Pectinaria articulata (Aiton) Haw. subsp. articulata*	Rare	Yes
ASTERACEAE	*Phymaspermum schroeteri* Compton	Rare	Yes
FABACEAE	*Lotononis azureoides* B.-E.van Wyk	Rare	Yes
HYACINTHACEAE	*Daubenya aurea* Lindl.	VU	Yes
IRIDACEAE	*Geissorhiza spiralis* (Burch.) M.P.de Vos ex Goldblatt	VU	Yes
IRIDACEAE	*Romulea multifida* M.P.de Vos	VU	Yes
IRIDACEAE	*Romulea syringodeoflora* M.P.de Vos	VU	Yes
OXALIDACEAE	*Oxalis lasiorrhiza* T.M.Salter	VU	Yes
POACEAE	*Helictotrichon namaquense* Schweick.	VU	Yes
ROSACEAE	*Cliffortia arborea* Marloth	VU	Yes
SCROPHULARIACEAE	*Jamesbrittenia incisa* (Thunb.) Hilliard	VU	Yes
ASPHODELACEAE	*Aloe chlorantha* Lavranos	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 Western Precinct. The area does, however, exhibit a very high degree of endemism with 22 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 Western Precinct

Common Name	Scientific Name	Probability of Occurrence	Endemism
Cape Legless Skink	*Acontias meleagris*	M	1
Southern Rock Agama	*Agama atra*	M	1
Spiny Agama	*Agama hispida*	M	1
Horned Adder	*Bitis caudalis*	I	1
Karoo Dwarf Chamaeleon	*Bradypodium karroicum*	L	1
Namaqua Chamaeleon	*Chamaeleo namaquensis*	L	2
Angulate Tortoise	*Chersina angulata*	H	1
Giant Ground Gecko	*Chondrodactylus angulifer*	M	1
Armadillo Girdled Lizard	*Cordylus cataphractus*	H	2
Mclachlan's Girdled Lizard	*Cordylus mclachlani*	H	2
Dwarf Girdled Lizard	*Cordylus minor*	H	2
Karoo Girdled Lizard	*Cordylus polyzonus*	M	1
Namaqua Plated Lizard	*Gerrhosaurus typicus*	H	2
Parrot-beaked Tortoise	*Homopus areolatus*	H	1
Southern Speckled Padloper	*Homopus signatus cafer*	H	2
Spotted Harlequin Snake	*Homoroselaps lacteus*	M	1
Fisk's House Snake	*Lamprophis fiskii*	H	2
Spotted House Snake	*Lamprophis guttatus*	M	1
Slender Thread Snake	*Leptotphylops gracilior*	H	2
Spotted Desert Lizard	*Meroles suborbitalis*	M	1
Black Spitting Cobra	*Naja nigricollis woodi*	H	2
Cape Cobra	*Naje nivea*	I	1
Bibron's Gecko	*Pachydactylus bibronii*	M	1
Cape Thick-toed Gecko	*Pachydactylus capensis*	M	2
Western Cape Gecko	*Pachydactylus labialis*	M	1
Marico Gecko	*Pachydactylus mariquensis*	M	1
Western Spotted Gecko	*Pachydactylus serval*	M	1
Spotted Sand Lizard	*Pedioplanis lineoocellata pulchella*	M	1
Namaqua Sand Lizard	*Pedioplanis namaquensis*	M	1
Sundevall's Shovel Snout	*Prosymna sundevallii*	H	1
Tent Tortoise	*Psammobates tentorius*	H	1
Long-tailed Seps	*Tetradactylus tetradactylus*	H	2
Shortlegged Seps	*Tetradactylus tetradactylus*	H	2
Delalandes Blind Snake	*Typhlops lalandei*	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 Western 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 Western 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 Western Precinct (NEMBA 2007)

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

NT: Near Threatened
VU: Vulnerable

The distribution of *G. paradisea* within the Western 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.

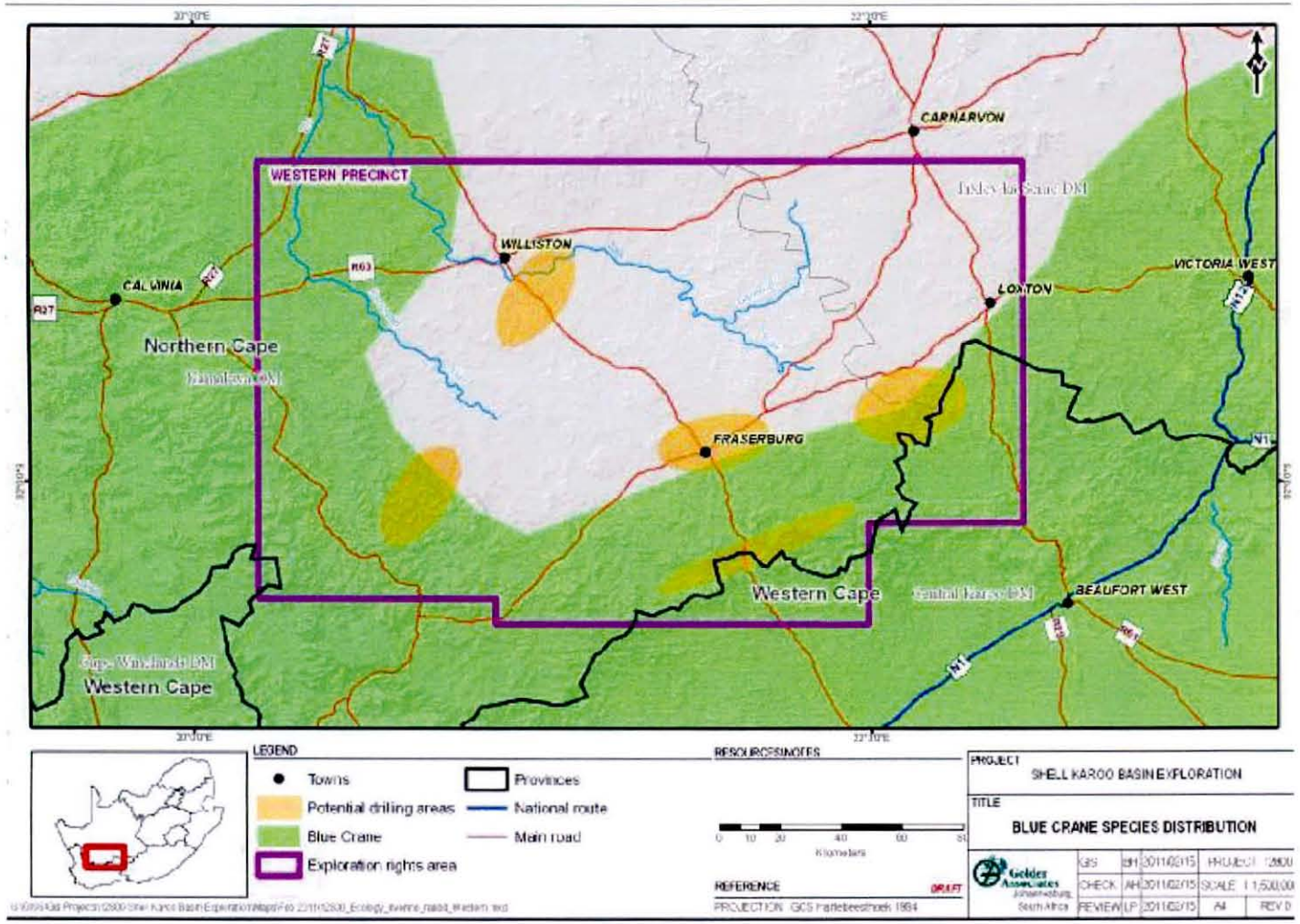

Figure 5: Distribution of Grus paradisea (Blue crane) in relation to the potential drilling areas *in the Western Precinct (IUCN, 2010)*

4.1.4.1.4 Mammals

Fifty four mammal species would historically have occurred in the Western 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);
- 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 Western 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

The distribution of the Riverine rabbit within the Western Precinct is presented in Figure 6. Based on this assessment the distribution of the Riverine rabbit coincides with 2 of the potential drilling areas. 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 Western 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 coincides with 3 of the potential drilling areas within the Western Precinct (Figure 6). Rocky outcrops that may provide habitat for this species should be avoided during the drilling programme.

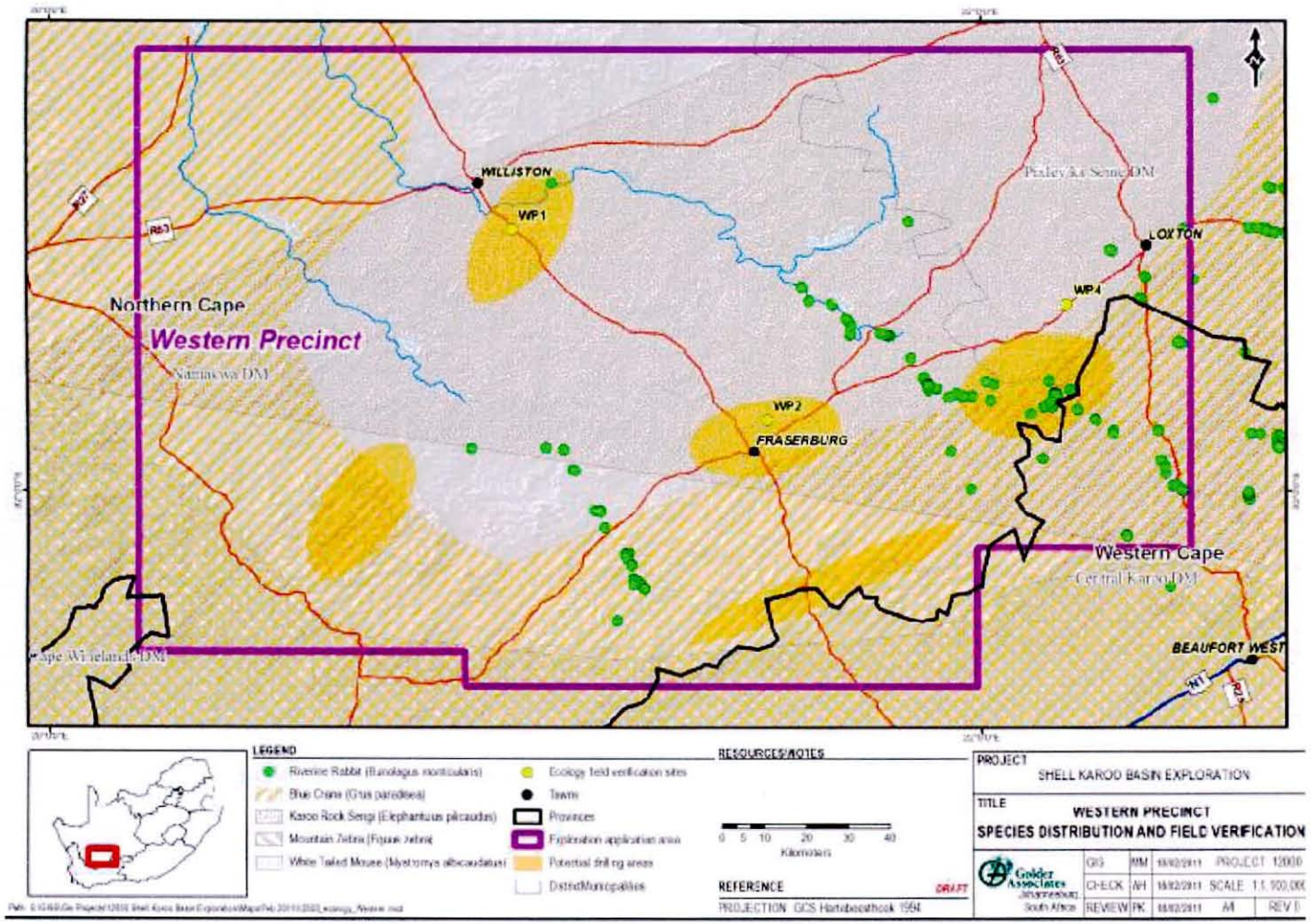

Figure 6: Distribution of Red Data faunal species in relation to the potential drilling areas *in the Western Precinct (IUCN, 2010)*

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 Western 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 Western Precinct during the field verification survey (Table 5). None of the recorded species are classified as Red Data Species, but the Cape Cobra (*Naja nivea*), a common species in the area is endemic to the Southern African region. *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 Western Precinct

COMMON NAME	BIOLOGICAL NAME	ENDEMIC	Red Data (IUCN, 2010)
Brown House Snake	*Lamprophis fuliginosus*		Unlisted
Striped Skaapsteker	*Psammophylax tritaeniatus*		Unlisted
Cape Cobra	*Naja nivea*	Endemic to Southern African region	Unlisted
Puff Adder	*Bitis arietans*		Unlisted
Horned Adder	*Bitis caudalis*		Unlisted
Cape Skink	*Mabuya capensis*		Unlisted
Striped Skink	*Mabuya striata*		Least Concern (LC)
Variable Skink	*Mabuya varia*		Unlisted
Ground Agama	*Agama aculeate*		Unlisted
Southern Rock Agama	*Agama atra*	Endemic to Southern African region	Unlisted

4.2.2.2 Amphibia

One frog species, the Common river frog (*Ametia angolensis*), was recorded in the Fraserburg area during the survey. This species has a widespread distributional range and is not restricted in terms of habitat preference. No permanent or perennial riverine areas occur within the study area and aquatic species usually occur in man-made dams in the area and drinking troughs occurring on the sites site.

4.2.2.3 Avifauna

Fifty two bird species were recorded in the study area during the field verification survey (Appendix C). Of the bird species known to occur in the study area, 13 are listed as Threatened or Protected Species (NEMBA,

2007). Of the 52 bird species recorded during the survey two are listed as Threatened or Protected Species (NEMBA , 2007) species namely the Secretary bird, (*Sagittarius serpentarius)* (NT), and Kori Bustard, *Ardeotis kori* (VU). Kori Bustards and Secretary Birds were common in the Western Precinct and are species on which the impacts will need to be investigated. No Red Data bird species were recorded during the field survey.

4.2.2.4 Mammals

Mammal species diversity in Western Precinct was moderate to low with only nine species 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. Some species have been persecuted historically. None of the species recorded were listed as Red Data species or considered protected species.

Table 6: Mammal species recorded in the Western Precinct during the field verification survey

COMMON NAME	BIOLOGICAL NAME	Red Data status (IUCN, 2010)
Cape Hare	*Lepus capensis*	LC
Cape Porcupine	*Hystrix africaeaustralis*	LC
Four-striped Grass Mouse	*Rhabdomys pumilio*	LC
Cape Fox	*Vulpes chama*	LC
Bat-eared Fox	*Otocyon megalotis*	LC
Aardvark	*Orycteropus afer*	LC
Springbok	*Antidorcas marsupialis*	LC
Klipspringer	*Oreotragus oreotragus*	LC
Steenbok	*Raphicerus campestris*	LC

The relevant IUCN status categories are:

Critically Endangered (CR)

Endangered (EN)

Vulnerable (VU)

Near Threatened (NT)

Data Deficient (DD)

Least Concern (LC)

4.3 Ecological Sensitivity Assessment

Based on the desktop assessment all of the vegetation communities within the Western 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 Western 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.

Four Red Data faunal species are expected to occur within the Western 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.

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 Western 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 Western Precinct does infringe on the Sakrivier Conservancy in the east. 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.

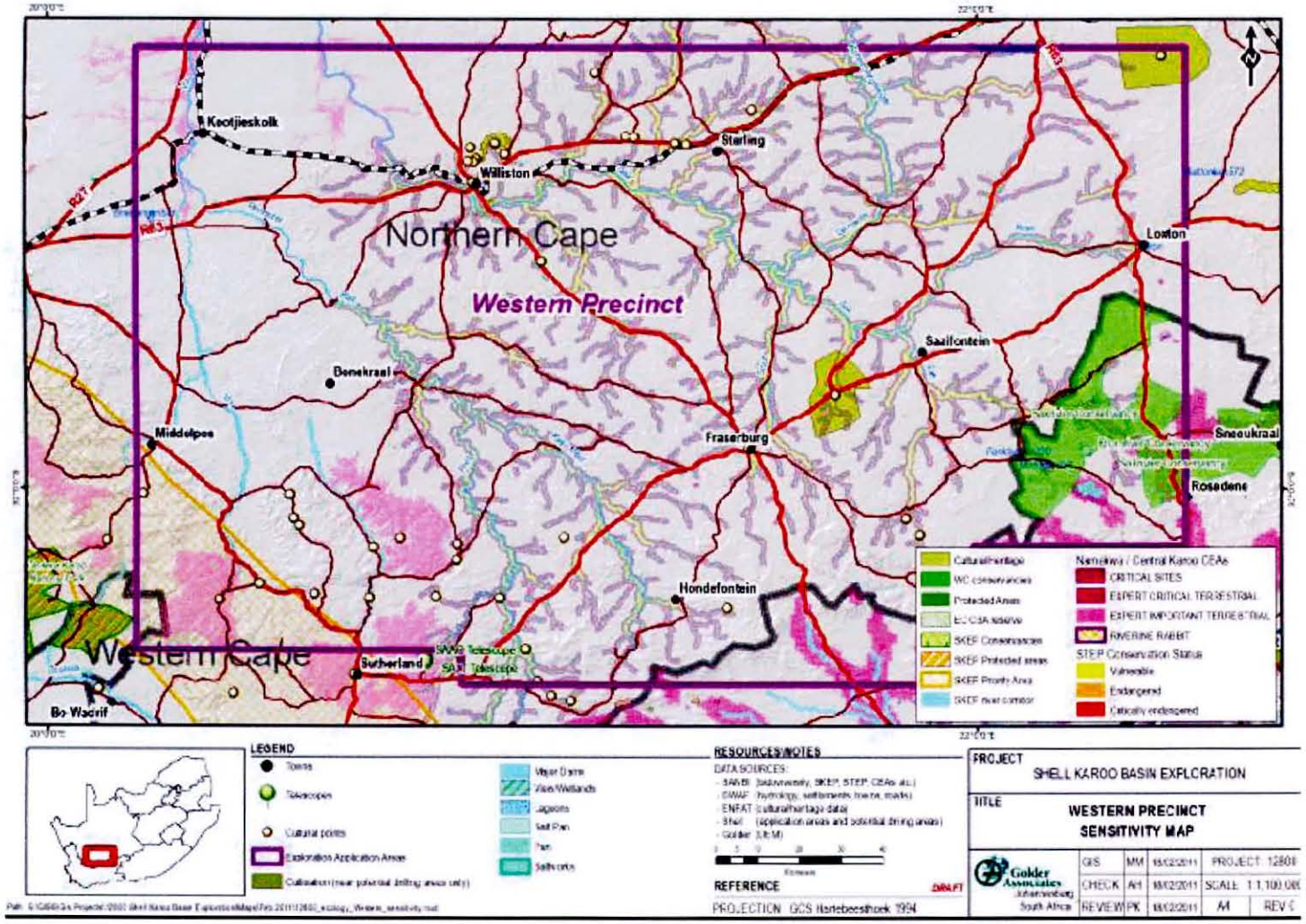

Figure 7: Sensitivity map showing location of sensitive or conservation areas within the Western Precinct

5.0 TECHNICAL ASSESSMENT

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

Well site preparation

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

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

5.2 Description of the technical assessment methodology

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 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 potential impacts 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 those potential impacts directly related to well site preparation, and provides a significance rating for each impact before and after mitigation.

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

POTENTIAL ENVIRONMENTAL IMPACT: WELL 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 access roads												
Vehicle collisions with Red Data faunal species, especially smaller, slower moving terrestrial species, such as the Riverine Rabbit, White-tailed mouse and Karoo Rock Sengi, 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 Western Precinct are listed as Least Threatened. However 45 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. Overall impact significance is therefore moderate.

This impact can, however, be mitigated by avoiding areas with high densities of Red Data or Protected Plant species 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. Should these measures be implemented, overall impact significance can be reduced to low.

Loss or fragmentation of habitat for Red Data faunal species

Technical assessment

Five Red Data faunal species are expected to occur within the Western Precinct. These species are threatened due to a variety of factors including habitat loss and fragmentation. Clearing of vegetation during well 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 and 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 these are 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

Technical assessment

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

Mitigation measures

Mitigation measures include reduced speed limits and enhanced 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 potential impacts directly related to exploration drilling and hydraulic fracturing, and provides a significance rating for each impact before and after mitigation.

Table 8: Environmental 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 wellpad 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: Environmental 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	SP	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.

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, visual 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 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

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, and *Grus paradisea* nesting sites; and
- Areas of sensitivity or conservation importance such as the Sakrivier 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 Western 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%);
- Forty five Red Data or Protected plant species are expected to occur within the Western 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 well 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 Western 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; and
- All of the potential drilling areas in the Western 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 Western Precinct does infringe on the Sakrivier 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?

9.0 REFERENCES

ACOCKS, J.P.H. 1988. Veld Types of South Africa, 3rd Ed, Memoirs of the Botanical Survey of South Africa No. 57, Botanical Research Institute.

BEUKES, P. C., COWLING, R. M. 2003. *Evaluation of Restoration Techniques for the Succulent Karoo, South Africa*, Restoration Ecology, 11: 3 Blackwell Science Inc

BLIGNAUT, A., MILTON, S. J. 2005. *Effects of Multispecies Clumping on Survival of Three Succulent Plant Species Translocated onto Mine Spoil in the Succulent Karoo Desert, South Africa* Restoration Ecology 13: 1 Blackwell Publishing Inc.

BRANCH, W.R. 1996. Snakes and other reptiles of Southern Africa, 2nd Edition. Struik. Cape Town

BRANCH, W.R. 1998. South African Red Data Book – Reptiles and Amphibians. National Scientific Programmes Report No 151.

BURKE, A. 2001 *Determining Landscape Function and Ecosystem Dynamics: Contribution to Ecological Restoration in the Southern Namib Desert*. AMBIO: A Journal of the Human Environment. 30: 1

CARRUTHERS, V. 2001. Frogs and frogging in Southern Africa. 1st Edition. Struik, Cape Town.

DE VILLIERS, A.J., VAN ROOYEN, M.W., THERON, G.K. 2004. *The restoration of Strandveld and Succulent Karoo degraded by mining: an enumeration of topsoil seed banks*. South African Journal of Botany 70: 5

DEAN, W.R.J., MILTON, S.J. 1999. The Karoo: ecological patterns and processes, Cambridge University Press

DEAT (Department of Environmental Affairs & Forestry) 2002. Specialist Studies, Information Series 4, Pretoria.

ENDANGERED WILDLIFE TRUST. 2004. Red Data Book of the Mammals of South Africa: A Conservation Assessment. CBSG Southern Africa, Parkview, South Africa.

HANKE, W., GRONGROFT, A., JURGENS, N., SCHMIEDEL, U. 2011. *Rehabilitation of arid rangelands: Intensifying water pulses from low-intensity winter rainfall*, Journal of Arid Environments, 75: 2

HARRISON, J.A., ALLAN, D.G., UNDERHILL, L.G., HERREMANS, M., TREE, A.J., PARKER, V., BROWN, C.J. (Eds.) 1997a. The Atlas of southern African birds. Volume 1: Non-passerines. Johannesburg: Birdlife South Africa.

HARRISON, J.A., ALLAN, D.G., UNDERHILL, L.G., HERREMANS, M., TREE, A.J., PARKER, V., BROWN, C.J. (Eds.) 1997b. The Atlas of southern African birds. Volume 2: Passerines. Johannesburg: Birdlife South Africa.

HENDERSON, L. 2001 Alien weeds and invasive plants, Plant Protection Research Institute, ARC.

HENNING, S.F. & HENNING, G.A. 1989. South African Red Data Book – Butterflies. South African National Scientific Programmes Report No 158.

IUCN. 2001. IUCN Red List Categories and Criteria. In: Red Data Book of the Mammals of South Africa: A Conservation Assessment.

IUCN. 2010. Red List. http://www.iucnredlist.org/apps/redlist/search

LEEMING, J. 2003. Scorpions of Southern Africa. Struik Publishers, Cape Town. Nature Conservation Ordinance of Transvaal, 1983 (No 12 of 1983).

List of Threatened Species. www.iucnredlist.org

LOW, A.B., REBELO, T.C. 1998. Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

MINTER, L.R., BURGER, M., HARRISON, J.A., BRAACK, H.H., BISHOP, P.J. & Kloepfer, D., eds. 2004. Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland. SI/MAB Series #9. Smithsonian Institution, Washington DC.

MUCINA, L. & RUTHERFORD, M.C. (Eds.). 2006. *Vegetation map of South Africa, Lesotho and Swaziland.* South African National Biodiversity Institute, Pretoria.

NEMBA. 2007. Threatened and Protected Species List. In Government Gazette, No 29657, February 2007.

PICKER, M., GRIFFITHS, C., WEAVING, A. 2002. Field Guide to Insects of South Africa. Struik. Cape Town

POSA. 2011. http://posa.sanbi.org/searchspp.php

SIMONS,L., ALLSOPP, N. 2006 *Rehabilitation of Rangelands in Paulshoek, Namaqualand: Understanding vegetation change using biophysical manipulations*, Journal of Arid Environments, 70: 4

SKEP database. 2011. http://www.skep.org.za/

SKINNER, J.D., SMITHERS, R.H.N. 1990. The Mammals of the Southern African Subregion. University of Pretoria, Pretoria, RSA.

SMITHERS, R.H.N. 1986. South African Red Data Book – Terrestrial Mammals. South African National Scientific Programmes Report No 125.

SMITHERS, R.H.N. 1992. Land Mammals of Southern Africa. Southern Book Publishers Pty Ltd. Halway House

STUART, C., STUART, T. 1993. Mammals of Southern Africa, 3rd Edition. Struik Cape Town

VAN OUDTSHOORN, F. 1999. Guide to grasses of southern Africa. 1st Edition. Briza Pretoria

VAN WYK, B. VAN WYK, P. 1997. Field Guide to Trees of southern Africa. 1st Edition. Struik. Cape Town Volume 7: Aquatic Ecosystems

VISSER, N., BOTHA, J.C., HARDY, M. B. 2004. *Re-establishing vegetation on bare patches in the Nama Karoo, South Africa,* Journal of Arid Environments, 57: 2

Please note reference books, field guides and guidelines not necessarily referenced in the text but used during fieldwork and in the compilation and structure of the report have also been included in this reference list.

GOLDER ASSOCIATES AFRICA (PTY) LTD.

A. Hudson
Senior Terrestrial Ecologist

P. Kimberg
Divisional Leader: Ecology

AH/PK/AH

g:\projects\12800 -service provision for shell exploration\4_reports\final reports for printing\wp\volume 2\12800-karoo(western)ecologyreport.docx

APPENDIX A

Vegetation Biomes

February 2011
Report No. 12800-10445-22

Golder Associates

Thicket

The "Thicket Biome" was only recently recognised in the scientific literature, although it was referred to in Low and Rebelo (1998) as a biome. Mucina and Rutherford (2006) formally named the various Thickets and indicated it as a biome. The vegetation which replaces forest - where a degree of fire protection is still evident, but rainfall is too low - did not fit within the "Forest" type as it does not have the required height nor the many strata below the canopy. Nor is it a "Savanna" type, in that it does not have a conspicuous grassy ground layer.

Subtropical thicket is a closed shrubland to low forest dominated by evergreen, sclerophyllous or succulent trees, shrubs and vines, many of which have stem spines. It is often almost impenetrable, is generally not divided into strata, and has little herbaceous cover. Because the vegetation types within the "Thicket Biome" share floristic components with many other phytochoria and lie within almost all the formal biomes, Thicket types have been referred to as "transitional thicket". Thicket types contain few endemics, most of which are succulents of Karoo origin (e.g. *Crassula* spp. and *Delosperma* spp.).

Grasslands

The Grassland Biome is found chiefly on the high central plateau of South Africa, and the inland areas of KwaZulu-Natal 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.

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.

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.

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.

The Grassland Biome is the cornerstone of the maize crop, and many grassland types have been converted to this crop. Sorghum, wheat and sunflowers are also farmed on a smaller scale.

Urbanization is a major additional influence on the loss of natural areas - the Witwatersrand is centred in this biome. The Grassland Biome is considered to have an extremely high biodiversity, second only to the Fynbos Biome. Rare plants are often found in the grasslands, especially in the escarpment area. These rare species are often endangered, comprising mainly endemic geophytes or dicotyledonous herbaceous plants. Very few grasses are rare or endangered.

The most noteworthy species with a wide distribution is, *Themeda triandra*, more commonly referred to as 'rooigras'. The ungulate fauna (*hoofed animals*) of the grassland areas included vast herds of Blesbok (*Damaliscus dorcas phillipsi*), Black Wildebeest (*Connochaetes gnou*) and the Springbok (*Antidorcas marsupialis*). A rich variety of birds are found in the grasslands, including the Blue Crane (*Anthropoides paradiseus*), Black Korhaan (*Eupodotis afra*) and Helmeted Guineafowl (*Numida meleagris*).

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.

The geology underlying the biome is varied, as the distribution of this biome is determined primarily by rainfall. The rain falls in summer, and varies between 100 and 520mm per year. This also determines the predominant soil type - over 80% of the area is covered by a lime-rich, weakly developed soil over rock. Although less than 5% of rain reaches the rivers, the high erodibility of soils poses a major problem where overgrazing occurs.

The dominant vegetation is a grassy, dwarf shrubland. Grasses tend to be more common in depressions and on sandy soils, and less abundant on clayey soils. Grazing rapidly increases the relative abundance of shrubs. Most of the grasses are of the C4 type and, like the shrubs, are deciduous in response to rainfall events.

The amount and nature of the fuel load is insufficient to carry fires and fires are rare within the biome. The large historical herds of Springbok and other game no longer exist. Like the many bird species in the area - mainly larks - the game was probably nomadic between patches of rainfall events within the biome. The Brown Locust and Karoo Caterpillar exhibit eruptions under similarly favourable, local rainfall events, and attract large numbers of bird and mammal predators.

Less than 1% of the biome is conserved in formal areas. The Prickly Pear (*Opuntia aurantiaca)* and Mesquite (*Prosopis glandulosa)* are the major alien invader species. Urbanization and agriculture are minimal, and irrigation is confined to the Orange River valley and some pans. 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.

Most of the research into the dynamics of the biome has been done in the east of the region, with the Grootfontein Agricultural Station at Middelburg featuring prominently. Consequently, little research in the west of the biome has been undertaken.

Succulent Karoo

The Succulent Karoo Biome has an equal status to the other biomes in South Africa - it is not a subtype of "a Karoo Biome."

Most of the biome covers a flat to gently undulating plain, with some hilly and "broken" veld, mostly situated to the west and south of the escarpment, and north of the Cape Fold Belt. The altitude is mostly below 800 m, but in the east it may reach 1 500 m. A variety of geological units occur in the region. There is little difference between the soils of the Succulent Karoo and Nama Karoo Biomes - both are lime-rich, weakly developed soils on rock. The Olifants and Doring Rivers are the major drainage systems in the west, with the Gouritz River in the south-east of the biome.

The Succulent Karoo Biome is primarily determined by the presence of low winter rainfall and extreme summer aridity. Rainfall varies between 20 and 290 mm per year. Because the rains are cyclonic, and not due to thunderstorms, the erosive power is far less than of the summer rainfall biomes. During summer, temperatures in excess of 40°C are common. Fog is common nearer the coast. Frost is infrequent. Desiccating, hot, Berg Winds may occur throughout the year.

The vegetation is dominated by dwarf, succulent shrubs, of which the Vygies (Mesembryanthemaceae) and Stonecrops (Crassulaceae) are particularly prominent. Mass flowering displays of annuals (mainly Daisies Asteraceae) occur in spring, often on degraded or fallow lands. Grasses are rare, except in some sandy areas, and are of the C3 type. The number of plant species mostly succulents - is very high and unparalleled elsewhere in the world for an arid area of this size.

Little data are available for the fauna of the Succulent Karoo. Of importance in the area are heuweltjies, raised mounds of calcium-rich soil, thought to have been created by termites. These often support distinctive plant communities.

The area has little agricultural potential due to the lack of water. The paucity of grasses limits grazing, and the low carrying capacity requires extensive supplementary feeds. Much soil has been lost from the biome, through sheet erosion, as a consequence of nearly 200 years of grazing. Ostrich farming, with considerable supplementary feeding, is practised in the Little Karoo in the south of the biome. In areas adjoining the Fynbos Biome, wine grapes, fruit and other crops are cultivated using the Fynbos water catchments. Tourism is a major industry: both the coastal scenery and the spring mass flower displays are draw cards. Mining is important, especially in the north.

Less than 0.5% of the area of the Succulent Karoo Biome has been formally conserved. The biome has a high number of rare and Red Data Book plant species. The high species richness and unique global status of the biome require urgent conservation attention. Fortunately, there are few invasive alien plants, with only Rooikrans (*Acacia cyclops)* a major problem in the southern coastal regions. Strip-mining for diamonds is destructive in the northern coastal regions, and legislation requiring revegetation of these areas is inadequate for near-desert conditions.

Fynbos

The Fynbos Biome is considered by many to be synonymous with the Cape Floristic Region or Cape Floral Kingdom. However, the "biome" refers only to the two key vegetation groups (Fynbos and Renosterveld) within the region, whereas both the "region" and the "kingdom" refer to the general geographical area and include other vegetation types in the Forest, Nama Karoo, Succulent Karoo and Thicket Biomes, but exclude peripheral outliers of the Fynbos Biome such as the Kamiesberg, North-western and Escarpment Mountain Renosterveld (59,60) and Grassy Fynbos (65) east of Port Elizabeth. However, the contribution of Fynbos vegetation to the species richness, endemicity and fame of the region is so overwhelming, that the Cape Floristic Region and Cape Floral Kingdom can be considered to be "essentially Fynbos."

The Cape Floral Kingdom is the smallest of the six Floral Kingdoms in the world, and is the only one contained in its entirety within a single country. It is characterized by its high richness in plant species (8 700 species) and its high endemicity (68% of plant species are confined to the Cape Floral Kingdom). The Cape Floral Kingdom thus compares with some of the richest floras worldwide, surpassing many tropical forest regions in its floral diversity.

In South Africa, over one third of all plant species occur in the Cape Floral Kingdom, even though the Kingdom occupies less than 6% of the area of the country. This is not primarily due to the large number of vegetation types in the Cape Floral Kingdom. Over 7 000 of the plant species occur in only five Fynbos vegetation types, with perhaps an additional 1 000 species in the three Renosterveld vegetation types. The contribution of Succulent and Nama Karoo, Thicket and Forest vegetation types in the region to the plant species diversity is thus relatively small. Thus, although the Cape Floral Kingdom contains five biomes, only the Fynbos Biome, comprising the Fynbos and Renosterveld vegetation groups, contains most of the floral diversity. Furthermore, the Cape Floral Kingdom traditionally does not include the Fynbos and Renosterveld vegetation outliers to the north and east. Including these would mean that endemicity would approach 80%, the highest level of endemicity on any subcontinent.

Distressingly, some three-quarters of all plants in the South African Red Data Book occur in the Cape Floral Kingdom: 1 700 plant species are threatened to some extent with extinction! This is much more than one would expect based on either the area of the Kingdom (6%) or its plant numbers (36%). This again reflects the unique nature of Fynbos vegetation: many Fynbos species are extremely localized in their distribution, with sets of such localized species organized into "centres of endemism." The city of Cape Town sits squarely on two such centres of endemism and several hundred species are threatened by urban expansion. However, a more serious threat is alien plants, which infest large tracts of otherwise undisturbed mountains and flats: their impact on these extremely localized species is severe. Aliens are thus the major threat to Fynbos vegetation and its plant diversity, especially in the mountains. On the lowlands and on the less steep slopes the major threat is agriculture - new technologies, fertilisers and crops are steadily eating into our

floral reserves. Another important threat is the misuse of fire. Fynbos must burn, but fires in the wrong season (such as in spring, instead of late summer) or too frequently (so that plants do not have time to set seed) eliminate species. Several factors influence fire dynamics in Fynbos - global warming, grazing practices and fire management (ignition events, size of burns), but their relative importance and interactions are poorly understood.

The two major vegetation groupings in Fynbos are quite distinct and have contrasting ecological systems. Essentially, Renosterveld used to contain the large animals in the Cape Floristic Kingdom, but these are now extinct or else have been reintroduced into conservation areas. By contrast, Fynbos is much richer in plant species, but has such poor soils that it cannot support even low densities of big game. However, most of the endemic amphibian, bird and mammal species in the region, occur in Fynbos vegetation types. The study are falls only within the Renosterveld part of this biome.

APPENDIX B

Vegetation types

February 2011
Report No. 12800-10445-22

Golder Associates

Upper Karoo Hardeveld NKu2

Synonyms: Arid Karoo and Desert False Grassveld (23%), F 27 central Upper Karoo (15%), VT 26 Karroid Broken Veld (12%), Vi 35 False Arid Karoo (12%) (Acocks 1953). LR 50 Upper Nama Karoo (31 %), LR 49 Bushmanland Nama Karoo (23%) (Low & Rebelo 1996).

Distribution

Northern, Western and Eastern Cape Provinces: Discrete areas of slopes and ridges including dolerite dykes and sills in the region spanning Middelpos in the west and Strydenburg, Richmond and Nieu-Bethesda in the east. Most crest areas and steep slopes of the Great Escarpment facing south between Teekloofpas (connecting Leeu-Gamka and Fraserburg) and eastwards to Graaff-Reinet. Altitude varies mostly from 1 000—1 900 m.

Vegetation & Landscape Features

Steep slopes of koppies, butts, mesas and parts of the Great escarpment covered with large boulders and stones supporting sparse dwarf Karoo scrub with drought-tolerant grasses of genera such as *Aristida, Eragrostis* and *Stipagrostis.*

Climate

In the western part of its area this unit experiences the same climate as the Western Upper Karoo. In the eastern part the climate is very close to that of Karoo Escarpment. The MAP ranges from about 1 50 mm in the northwest to 350 mm along some grassland margins on the Great Escarpment and in the east. Water concentrates between rocks as a result of rainfall runoff. Incidence of frost is relatively high, but ranging widely from <30 days per year at lower altitudes to >80 days at high est altitudes. See also climate diagram for NKu 2 Upper Karoo Hardeveld.

Important Taxa

Tall Shrubs: *Lycium cinereum* (d), *Rhigozum obovatum* (d), *Cadaba aphylla, Diospyros austro-africana, Ehretia rigida* subsp. *rigida, Lycium oxycarpum, Melianthus comosus, Rhus burchellii.*

Low Shrubs: *Chrysocoma ciliata* (d), *Eriocephalus ericoides* subsp. *ericoides* (d), *Euryops lateritiorus* (d), *Felicia muricata* (d), *Limeum aethiopicum* (d), *Pteronia glauca* (d), *Aptosimum elongatum, Tetragonia arbuscula, Wahlenbergia tenella.*

Succulent Shrubs: *Aloe broomii, Drosanthemum lique, Faucania bosscheana, Kleinia longiflora, Pachypodium succulentum, Trichodiadema barbatum, Zygophyllum flexuosum.* Semiparasitic Shrub: *Thesium lineatum* (d). Herbs: *Troglophyton capillaceum* subsp. *capilaceum, Dianthus caespitosus* subsp. *caespitosus, Gazania krebsiana, Lepidium atnicanum* subsp. *atricanum, Leysera tenella, Pelargonium minimum, Sutera pinnatitida, Tribulus tenrestnis.* Geophytic Herbs: *Albuca setosa, Androcymbium albomarginatum, Asplenium cordatum, Boophone disticha, Cheilanthes bergiana, Drimia intricata, Oxalis depressa,* Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *A. diffusa* (d), *Cenchrus ciliaris* (d), *Enneapogon desvauxii* (d), *Eragrostis lehmanniana* (d), *E. obtusa* (d), *Sporobolus fimbniatus* (d),

Stipagrostis obtusa (d), *Cynodon incompletus, Digitaria eriantha, Ehrharta calycina, Enneapogon scaberi, F. scoparius, Eragrostis cunvula, F. nindensis. F. procumbens, Fingerhuthia africana, Heteropogon con tontus, Merxmuellera disticha, Stipagrostis cillata, Themeda triandra, Tragus benteronianus, T. koelerioides.*

Endemic Taxa

Succulent Shrubs: *Aloe chlorantha, Crassula barbata* subsp. *broomii, Delosperma robustum, Sceletium expansum, Stomatium suaveolens.*

Low Shrubs: *Cineraria polycephala, Euryops petraeus, Lotononis azureoides, Selago magnakarooica.*

Tall Shrub: *Anisodontea malvastroides.*

Herbs: *Cineraria arctotidea, Vellereophyton niveum.*

Succulent Herbs: *Adromischus tallax, A. humilis.*

Geophytic Herbs: *Gethyllis longistyla, Lachenaiia auriolae, Ornithogaium paucifolium* subsp. *karooparkense.*

Conservation

Least threatened. Target 21%. Only about 3% statutorily conserved in Karoo National Park and Karoo Nature Reserve. Small percentage also protected in private reserves such as Rupert Game Farm. Erosion is moderate (64%) and high (2%).

Remarks

One of the richer floras of the Nama-Karoo Biome, this type also contains a substantial number of diagnostic species relative to the surrounding extensive flats (i.e. the Eastern, Northern and Western Upper Karoo vegetation units). Examples are the widespread occurrence of *Asparagus mucronatus, A. striatus, Cissampelos capensis, Pachypodium succulentum,*

Western Upper Karoo NKu1

Synonyms: VT 29 Arid Karoo and Desert False Grassveld (82%) (Acocks 1953). LR 49 Bushmanland Nama Karoo (84%) (Low & Rebelo 1996).

Distribution

Northern Cape Province and a small part in the Western Cape Province: Plains from the Fish River and upper reaches of the Renoster River in the west as far as Fraserburg and Carnarvon in the east, sandwiched between the Bushmanland Basin in the north and the Roggeveld Karoo and edges of the Great Escarpment in the south. Altitude varies mostly from 1 000—1 500 m.

Vegetation & Landscape Features

Much dissected landscape in the sot-west associated with the tributaries the upper catchment of the Sak River (e.g. Renoster River, Riet River, Klei Sak River), often rocky. Mixture of small leaved shrubs and shrubby succulents *(Drosanthemum, Ruscha* etc.) with drought-resistant (mostly 'white') grasses is the determinant feature of the vegetation structure.

Climate

Most of the precipitation occurs in autumn, peaking ii March. MAP ranges from about 120-220 mm. Mean maxim and minimum monthly temperatures in Fraserburg are 36.2°C and -5.7°C for January and July, respectively. Corresponding values for Williston are 38.1°C and -4.5°C. Incidence of frost ranges from around 30 frost days per year in the north about 60 days in the south. See also climate diagram for NKu Western Upper Karoo (Figure 7.2).

Important Taxa

Tall Shrubs: *Lycium cinereum* (d), *Rhigozum trichotomum, Tripteris sinuata*

Low Shrubs: *Chrysocoma ciliata* (d), *Eriocephalus ericoa* subsp. *ericoides* (d), *E. spinescens* (d), *Hehchrysum lucihioides, Osteospermum spinescens* (d), *Pentzia globosa* (d), *P. spinescens* (d), *Tetragonia arbuscuha* (d), *Amphiglossa triflora, A. spinescens, Asparagus capensis, Berkheya annectens, Eriocephalus decussates, E. pauperrimus, Euryops imbricatus, F. muftifidus, Fehicia macs— rrhiza, F. muricata, Hermannia cuneifohia, H. grandiflora, H. spinosa, Limeum aethiopicum. Microloma armatum, Pegolettia retrofracta, Pentzia incana, P. lanata, Plinthus karooicus, Polygala pungens, Pteronia adenocarpa, P. glauca, P. mucronata, P. sordida, Rosenla glandulosa, R. humilis, Selago albida, Stachys cuneata, Zygophyllum microphyllum. Succulent Shrubs: Ruschia intricata (d), Aridana noctiflora subsp. straminea, Bassia salsoloides, Brownanthus ciliatus subsp. cillatus, Drosanthemum spp, Euphorbia rectirama, Galenia sarcophylla, Salsola calluna, S. glabrescens, S. rabieana, S. tuberculata, Sarcocaulon patersonii, Zygophyllum flexuosum.*

Herbs: *Lepidium africanum subsp. africanum, L. desertorum, Leysera tenella, Pelargonium minimum, Sutera pinnatifida, Ursinia nana.*

Succulent Herbs: *Mesembryanthemum crystallinurri, Psilocaulon coriarium.*

Geophytic Herbs: *Drimia intricata, Oxalis depressa, Tritonia karooica.*

Graminoids: *Aristida congesta (d), Enneapogon desvauxii (d), Stipagrostis ciliata (d), S. obtusa (d), Aristida adscensionis, A. diffusa, Eragrostis bicolor, E. obtusa, Fingerhuthia africana, Tragus berteronianus, T. koelenioides.*

Biogeographically Important Taxon

(Western distribution limit) Graminoid: *Eragrostis lehmanniana.*

Endemic Taxa

Succulent Shrub: *Stomatium villetii.* Herb*: Zaluzianskya bella.*

Conservation

Least threatened. Target 21%. None conserved in statutory conservation areas. Very little transformed. Erosion is moderate (52%) and low (44%).

Remarks

Even when present in relatively small quantities, species such as *Drosanthemum lique* and *Pteronia sordida* are shown by fistula samples to be consistently grazed by several types of sheep and goats in this vegetation type in all seasons of the year. By contrast, even when common, species such as *Pentzia globosa* appear to be consistently avoided by these animals throughout the year.

Bushmanland Vloere AZi5

Distribution

Northern Cape Province: Vloere (salt pans) of the central Bushmanland Basin as well as the broad riverbeds of the intermittent Sak River (functioning as temporary connection between some of the pans) as well as its numerous ancient (today dysfunctional) tributaries. The patches of this vegetation unit are embedded especially within NKb 6 Bushmanland Basin. Shrubland and NKb 3 Bushmanland Arid Grassland and to a lesser extent also within NKb 4, NKu 1, NKu 2 as well as marginal Succulent Karoo units summarised within the bioregion of Trans-Escarpment Succulent Karoo. Altitude 850—1 450 m.

Vegetation & Landscape

Features Flat and very even surfaces of pans and broad bottoms of intermittent rivers. The centre of a pan (or the river drainage channel itself) is usually devoid of vegetation; loosely patterned scrub dominated by *Rhigozum trichotomum* and various species of *Salsola* and *Lycium,* with a mixture of nonsucculent dwarf shrubs of Nama-Karoo relationship. In places loose thickets of *Parkinsonia africana, Lebeckia linearilifolia* and *Acacia* karroo can be found.

Climate

Arid, seasonal climate with bimodal (equinoctial) precipitation regime—two peaks, one in March and another in November. Overall MAP 141 mm (range 91 mm in western Bushmanland to 306 mm at northern edges of the Roggeveld). Overall MAT 16.8°C (range 17.4°C in northern Bushmanland to 14.5°C on northern edge of the Roggeveld). The region where the Bushmanland Vloere occur, is known for thermic extremes, both long-term (mean daily temperature in January approaching 32°C and in July only several degrees above zero) and short- term (daily temperature amplitude around 25°C). Frequent occurrence of frost is also indicative of the high thermic continentality of the region. See also climate diagram for AZi 5 Bushmanland Vloere.

Important Taxa Tall Shrubs: *Parkinsonia africana.* Low Shrubs: *Rhigozum trichotomum* (d), *Aizoon schellenbergii, Asparagus glaucus, Eriocephalus decussatus, E. spinescens, Pegolettia retrofracta.* Succulent Shrubs: *Salsola aphylla* (d), *S. glabrescens* (d), *S. rabieana* (d), *Lycium pumilum, Salsola gemmifera.* Herbs: *Amaranthus dinteri* subsp. *dinten, Lotononis minima.* Geophytic Herb: *Crinum vaniabile.* Graminoids: *Stipagrostis ciliata* (d), *S. obtusa* (d), *Sporobolus nervosus, Stipagrostis namaquensis.*

Conservation Least threatened. Target 24%. None conserved in statutory conservation areas. About 2% transformed for cultivation or building of dams (Vanwyksvlei Dam). Alien *Prosopis* occurs as scattered in some vloere and dry river- beds. Several of the pans are mined for salt production.

Remark A reliable floristic characterisation of this unit is not feasible at this stage due to the pending taxonomic revision of the South African representatives of the genus *Salsola,* one of the most important generic components of vegetation of Bushmanland. The vegetation of the AZi 5 Bushmanland Vloere remains of the least studied in the country.

Roggeveld Karoo SKt3

VT 28 Western Mountain Karoo (69%) (Acocks 1953). LR 56 Upland Succulent Karoo (69%) (Low & Rebelo 1996).

Distribution

Northern (and to a very small extent also Western) Cape Province: Keiskiesberg and Kapgat se Berge southeast of Calvinia, surrounds of Sutherland and Hondefontein as far west as Teekloof Pass in the Nuweveld Mountains southeast of Fraserburg: the area constitutes a gradually sloping plateau situated inland of the Roggeveld Escarpment towards the Bushmanland Basin. Only negligible patches of this vegetation type move into Western Cape Province in the Besemgoedberge area (Nuweveld Mountains region). Altitude 1 040—1 680 m.

Vegetation & Landscape Features

Diverse landscape including vast stretches of slightly undulating hills, steeper mountain slopes as well as extensive slightly sloping plateaus. The dominant image of the vegetation is sparse dwarf shrubland with high proportions of both succulent and nonsucculent (low microphyllous shrubs). The dominant shrubby genera include *Antimima, Eriocephalus, Pentzia, Pteronia* and *Salsola.* The occurrence and structural appearance of grasses *(Aristida, Stipagrostis,* but also *Ehrharta)* is notable and probably one of the most striking features within Succulent Karoo units—all these characters indicate the transitional position of Roggeveld Karoo between the Succulent Karoo and Nama-Karoo Biomes.

Climate

Roggeveld is climatically one of the most peculiar regions of southern Africa due to the unusual combination of high altitude, a land-locked continental position and a transitional position between two major climatic systems responsible for winter- and summer-rainfall regimes. It is a semidesert region under slight influence of a rainshadow (the area slopes landwards, away from the elevated Escarpment), with MAP reaching around 230 mm. Pronounced precipitation peaks are in March and June, and the overall precipitation in December to January is markedly lower than during the rest of the year. MAT 14—15°C, but the high frequency of low temperatures in autumn and winter resulting in an average of 56 frost days per year, has won the region (the town of Sutherland in particular) the reputation as the coldest place in South Africa. Clear skies (low cloudiness due to overall dry climate and high altitude as well as remoteness from major settlements and especially sources of air pollution) put Sutherland on the world map of astronomy through its famous telescope centre built near the town. See also climate diagram for SKt 3 Roggeveld Karoo (Figure 5.60).

Important Taxa

Succulent Shrubs: *Lycium cinereum* (d), *Euphorbia stolonifera, Galenia sarcophylla, Salsola glabrescens, S. tuberculata, Tetragonia arbuscula, Zygophyllum flexuosum.*

Low Shrubs: *Chrysocoma ciliata* (d), *Eriocephalus ericoides* (d), *E. spinescens* (d), *Fellcia muricata* (d), *Hellchrysum lucilloides* (d), *Pentzia spinescens* (d), *Pteronia glauca* (d), *P glomerata* (d), *Amphiglossa triflora, Aptosimum elongatum, Asparagus capensis* var. *capensis*

Semi parasitic Shrub: *Thesium lineatum.*

Woody Climber: *Asparagus multituberosus.*

Herbs: *Leysera tenella* (d), *Alonsoa unilabiata, Amellus strigosus* subsp. *pseudoscabridus, Arctotheca calendula, Ursinia nana.*

Geophytic Herbs: *Drimia intricata* (d), *Bulbine asphodeloides, Drimia physodes, Oxalis densa, 0. obtusa, Strumaria karooica.*

Succulent Herbs: *Delianthe thudichumii, Mesembryanthemum stenandrum.*

Graminoids: *Aristida diffusa* (d), *Stipagrostis cillata* (d), *S. obtusa* (d), *Chaetobromus involucratus* subsp. *dregeanus, Ehrharta capensis, E. pusilla, Karroochloa tenella.*

Biogeographically Important Taxa

(RH Roggeveld..Hantam endemic, W Western distribution limit)

Succulent Shrubs: *Antimima androsacea, A. prolongata.*

Low Shrubs: *Pentzia punctata, Pteronia aspalatha, Selago articulata.*

Herbs: *Alyssum minutumRH, Corycium deflexum RH, C. decumbens , C. hamulosumF , C. plantaginis , Diascia macrophylla* RH *Galeomma oculus, Gazania othonnitesRH, Heliophila pubescens RH, Hemimeris centrodes, Lotononis maximillani, Polycarena aurea* RH *Zaluzianskya cohabitans, Z. minima, Z. violacea.*

Geophytic Herbs: *Androcymbium hantamenseRH, Bulbinella eleganssH, Eriospermum marginatum , Gladiolus pritzelli,*

Graminoids: *Heliotrichon namaquenseRH, Pentaschistis aristitolia* RH *Secale strictum* subsp. *africanumR.*

Endemic Taxa

Succulent Shrubs: *Drosanthemum ebumeum* (d).

Conservation

Least threatened and none of the area is conserved in statutory conservation areas. Target 18%. Transformed only to a very small extent (about 2%) and hardly suffering invasions of alien plants. Erosion is moderate (71%) and low (29%).

Remarks

Roggeveld Karoo is a botanically poorly researched vegetation type and this despite its intriguing transitional position between three major biomes (Fynbos, Succulent Karoo and Nama-Karoo) and high level of local endemism (see SKt 2 Hantam Karoo for more details). The classification of the unit itself into a biome still remains a contentious issue demanding research into vegetation and phytogeography patterns (and history) of the SKt 3 Roggeveld Karoo as well as the spatially and floristically associated units such as FRd 1 Nieuwoudtville Roggeveld Dolerite Renosterveld, FRs 3 Roggeveld Shale Renosterveld and SKy 4 Tanqua Escarpment Shrubland.

Roggeveld Shale Renosterveld FRs3

VI 43 Mountain Renosterbosveld (65%), VT 28 Western Mountain Karoo (33%) (Acocks 1953). LR 60 Escarpment Mountain Renosterveld (52%), LR 56 Upland Succulent Karoo (43%) (Low & Rebelo 1996).

Distribution

Northern and Western Cape Provinces: Major part of the Roggeveld bordered by the edge of the Western Great Escarpment mostly above the Tanqua Basin. South of the Hantam Plateau region in the upper parts of the range of the Keiskieberge and isolated high plateaus to the south including plateaus such as Grootberg, Saalfontein se Berg, Sneewkrans and Swaarweerberg encompassing the vicinity of Middelpos and Sutherland, reaching as far east as the higher-lying areas of the Teekloof Pass south of Fraserburg along the northwest summit plateaus of the Nuweveldberge. Altitude 1 200—1 900 m.

Vegetation & Landscape Features

Undulating, slightly sloping plateau landscape, with low hills and broad shallow valleys, supporting mainly moderately tall shrublands dominated by renosterbos, with a rich geophytic flora in the wetter and rocky

habitats.

Climate

MAP 180—430mm (mean: 305 mm), even throughout the year, showing a slight peak in March. Mean daily maximum and minimum temperatures 29.3°C and 0.2°C for January and July, respectively. Frost incidence is remarkably high for a renosterveld type (30—70 days per year). See also climate diagram for FR5 3 Roggeveld Shale Renosterveld (Figure 4.101).

Important Taxa:

Pteronia erythrochaeta, Rosenia oppositifolia, Selago articulata, S. saxatilis, Ursinia pilifera, Zygophyllum spinosum. Succulent

Shrub: *Stomatium rouxii.*

Herbs: *Cotula microglossa, Diascia parviflora, Lasiopogon muscoides, Phamaceum croceum, Senecio hastatus.*

Geophytic Herbs: *Drimia intricata, Geissorhiza heterostyla, Hesperantha cucullata, Oxalis obtusa, Romulea atrandra, R. diversiformis, R. rosea, R. tetragona, R. tortuosa, Spiloxene capensis.*

Succulent Herb: *Crassula corallina* subsp. *corallina.*

Herbaceous Succulent Climber: *Crassula roggeveldii.*

Graminoids: *Ehrharta calycina, , Pentsia patula, Schismus scaberrimus.*

Biogeographically Important Taxa

(both Roggeveld-Hantam endemics)

Herb: *Zaluzianskya violacea.*

Geophytic Herb: *Androcymbium hantamense.*

Endemic Taxa

Low Shrub: *Euryops sulcatus.*

Herbs: *Lasiospermum poterioides, Manulea diandra.*

Geophytic Herbs: *Daubenya aurea, Gladiolus marlothii, Ixia thomasiae, Polyxena longituba, Romulea hallii, R. komsbergensis, R. multiflora, R. subfistulosa, R. syringadeoflora.*

Conservation

Least threatened. Target 27%. None conserved in statutory or private conservation areas. Only 1 % transformed, but danger of overgrazing is locally high. Erosion mainly moderate, with the remainder low.

Remarks

The Roggeveld is named after the indigenous rye species *(Secale africana)* now almost extinct due to grazing pressure. The Roggeveld region is rich in endemic geophytes, most notably the monotypic *Devia xeromorpha.* It is an important centre of radiation for several other genera such as *Hesperantha* and *Romulea* (Iridaceae), *Zaluzianskya* (Scrophulariaceae) as well as *Lachenalia* and *Polyxena* (both Hyacinthaceae). Most of the endemics of this vegetation type are found on the dolerite cappings. This unit belongs to the core of the Hantam-Roggeveld Centre of Endemism (Van Wyk & Smith 2001).

Gamka Karoo NKI1

VT 26 Karroid Broken Veld (76%) (Acocks 1953). LR 53 Great Nama Karoo (70%) (Low & Rebelo 1996). BHU 91 Gamka Broken Veld (cowling & Heijnis 2001).

Distribution

Western Cape and Eastern . Cape Provinces and marginally into the Northern Cape Province: Large basin between the Great Escarpment (Nuweveld Mountains) in the north and northwest and Cape Fold Belt Mountains (mostly Swartberg Mountains) in the south. From approximately the edge of the Gamka basin

catchment area (i.e. of the Dwyka River tributary) in the west to about the Kariega River in the east. Altitude varies mostly from 500—1 100 m.

Vegetation & Landscape Features

Extremely irregular to slightly undulating plains covered with dwarf spiny shrubland dominated by Karoo dwarf shrubs (e.g. *Chrysocoma ciliata, Eriocephalus ericoides)* with rare low trees (e.g. *Euclea undulata).* Dense stands of drought-resistant grasses *(Stipagrostis, Aristida)* cover (especially after abundant rains) broad sandy bottomlands.

Climate

One of the most arid units of the Nama-Karoo Biome. Rainfall mainly in autumn and summer, with a marked peak in March and low levels of cyclonic rain in winter. This region is in the rainshadow of Cape Fold Belt mountains in the south, MAP ranging from about 100 mm in some areas between the Dwyka and Gamka Rivers to about 240 mm against the Great Escarpment. Mean maximum and minimum monthly temperatures in Beaufort West are 38.7°C and —3.2°C for January and July, respectively. Strong northwesterly winds occur in winter.

Important Taxa

Tall Shrubs: *Lycium cinereum* (d), *L. oxycarpum* (d), *Rhigozum obovatum* (d), *Acacia karroo, Cadaba aphylla, Lycium schizocalyx, Rhus burchelli.*

Low Shrubs: *Chrysocoma cilliata* (d), *Eriocephalus ericoides* subsp. *ericoides* (d), *F. spinescens* (d), *Fellcia muricata* (d), *Galenia fruticosa* (d), *Limeum aethiopicum* (d), *Pentzia incana* (d), *Pteronia adenocarpa* (d), *Rosenia humullis* (d), *Asparagus burchellil, Blepharis mitrata, Eriocephalus microphyllus* var. *pubescens, Fellicia muricata* subsp. *cinerascens, Galenia secunda, Garuleum bipinnatum, G. latifolium, Gomphocarpus fillformis, Hellchrysium luciloides, Hermannia desertorum, H. grandiflora, H. spinosa, Melolobium candicans, Microloma armatum, Pentzia pinnatisecta, Plinthus karooicus, Polygala seminula, Pteronia glauca, P sordida, P viscosa, Selago geniculata.*

Succulent Shrubs: *Ruschia intricata* (d).*Qassula muscosa, Galenia sarcophylla, Kleinia longiflora,Ruschia spinosa, Salsola tuberculata.*

Herbs: *Gazania lichtensteinii* (d), *Chamaesyca inaequilatera, Dicoma capensis, Galenia glandulifera, Lepidium africanum* subsp. *africanum, L. desertorum, Lessertia pauciflora, Tribulus terrestris, Ursinia nana.* Geophytic Herbs: *Drimia intricata, Moraea polystachya.*

Graminoids: *Aristida congesta* (d), *A. diffusa* (d), *Fingerhuthia africana* (d), *Stipagrostis ciliata* (d), *S. obtusa* (d), *Aristida adscensionis, Cenchrus ciliaris. Digitaria argyrograpta, Enneapogon desvauxii, Enneapogon scaber.*

Biogeographically Important Taxa

(*Endemic to Great Karoo Basin)

Succulent Shrubs: *Hereroa latipetala** (also found in Prince Albert Succulent Karoo), *H. odorata** (also found in Koedoesberge-Moordenaars Karoo), *Pleiospilos compactus* (southern and western limits of distribution), *Rhinephyllum luteum*, Stapelia engleriana**.*

Geophytic Herb: *Tritonia tugwelliae**.

Low Shrub: *Fellcia lasiocarpa**.

Succulent Herbs:
Piaranthus comptus, Tridentea parvipuncta* subsp. *parvipuncta**. Graminoid: *Oropetium capense* (westernmost limit of distribution).

Endemic Taxa

Succulent Shrubs: *Chasmatophyllum stanleyi. Hereroa incurva, Hoodia drega Ruschia beaufortensis.*

Shrubs: *Jamesbrittenia tenuifolia.*

Herb: *Manulea karrooica.*

Succulent Herb: *Piaranthus comptus.*

Conservation

Least threatened. Target 16%. About 2% statutorily conserved in the Karoo National Park and some in pnvate reserves, such as Steenbokkie Private Nature Reserve (near Beaufort West). Only small part has undergone transformation. The alien *Salsola kali* is a serious infestation problem locally. Erosion is moderate (78%), low (11%) and high (11 **%).**

Eastern Upper Karoo NKu4

VT 36 False Upper Karoo (54%) (Acocks 1953). LR 52 Eastern Mixed Nama Karoo (61%) (Low & Rebelo 1996)

Distribution

Northern Cape, Eastern Cape and Western Cape Provinces: Between Carnarvon and Loxton in the west, De Aar, Petrusville and Venterstad in the north, BUrgersdorp, Hofmeyr and Cradock in the east and the Great Escarpment and the Sneeuberge-Coetzeesberge mountain chain in the south. Altitude varies between mostly 1 000—1 700 m.

Vegetation & Landscape Features

Flats and gently sloping plains (interspersed with hills and rocky areas of Upper Karoo Hardeveld in the west, Besemkaree Koppies Shrubland in the northeast and Tarkastad Montane Shrubland in the southeast), dominated by dwarf microphyllous shrubs, with 'white' grasses of the genera *Aristida* and *Eragrostis* (these become prominent especially in the early autumn months after good summer rains). The grass cover increases along a gradient from southwest to northeast.

Climate

Rainfall occurs mainly in autumn and summer, peaking in March. MAP ranges from about 180 mm in the west to 430 mm in the east. Incidence of frost is relatively high, but ranging widely from <30 days (in the lower-altitude Cradock area) to >80 days of frost per year (bordering the Upper Karoo Hardeveld on the Compassberg and mountains immediately to the west). Mean maximum and minimum monthly temperatures in Middelburg (Grootfontein) are 36.1°C and —7.2°C for January and July, respectively. Corresponding values are 37°C and —8°C for Victoria West and 36.6°C and —4.2°C for Hofmeyr.

Important Taxa

Tall Shrubs: *Lycium cinereum* (d), *L. horridum, L. oxycarpum.*

Low Shrubs: *Chrysocoma ciliata* (d), *Eriocephalus ericoides* subsp. *ericoides* (d), *F. spinescens* (d), *Pentzia globosa* (d), *P. incana* (d), *Phymaspermum parvifolium* (d), *Salsola calluna* (d), *Aptosimum procumbens, Feilicia muricata, Gnidia polycephala, Helichrysum dregeanum, H. lucilioides, Limeum aethiopicum,* Nenax *microphylla, Osteospermum leptolobum, Plnithus karooicus, Pteronia glauca, Rosenia humilis, Selago geniculata, S. saxatilis.*

Succulent Shrubs: *Euphorbia hypogaea, Ruschia intricata.*

Herbs: *Indigofera alternans, Pelargonium minimum, Tribulus terrestris.*

Geophytic Herbs: *Moraea pallida* (d), *Moraea polystachya, Syringodea bifucata, S. concoior.*

Succulent Herbs: *Psilocaulon corlarium, Tridentea jucunda, T virescens.*

Graminoids: *Aristida congesta* (d), *A. diffusa* (d), *Cynodon incompletus* (d), *Eragrostis bergiana* (d), *E. bicolor* (d), *E. Jehmanniana* (d), *E. obtusa* (d), *Sporobolus fimbriatus* (d), *Stipagrostis ciliata* (d), *Tragus koelerioldes* (d), *Aristida adscensionis, Chloris virgata, Cyperus usitatus, Digitaria eriantha, Enneapogon desvauxii, E. scoparius, Eragrostis curvula, Fin gerhuthia africana, Heteropogon contortus, Sporobolus ludwigii, S. tenellus, Stipagrostis obtusa, Themeda triandra, Tragus berteronianus.*

Endemic Taxa

Succulent Shrubs: *Chasmatophyllum rouxii, Hertia cluytifolia, Rabiea albinota, Salsola tetrandra.*

Tall Shrub: *Phymaspermum scoparium.*

Low Shrubs: *Aspalathus aclcuiaris* subsp. *plantolla, Selago persimius, S. walpersii.*

Conservation

Least threatened. Target 21%. Statutorily conserved in Mountain Zebra and Karoo National Parks as well as in Oviston, Commando Drift, Rolfontein and Gariep Dam Nature Reserves. About 2% of the unit has been transformed, largely due to building of dams (Gariep, Grassridge, Killowen, Kommandodrift, Kriegerspoort, Lake Arthur, Modderpoort, Schuil Hoek, Vanderkloof, Victoria West, Wonderboom and Zoetvlei). *Medicago laciniata* is a common and widespread alien plant. Erosion is moderate (60%) and high (38%). Veld managers perceive much of the Eastern Upper Karoo to be experiencing changes in species composition requiring high-priority action (Hoffman et al. 1999).

Remarks

This vegetation type has the largest mapped area of all vegetation units. The regions between Colesberg (Northern Cape) and Springfontein (Free State) fall within a broad ecotone where grassy Eastern Upper Karoo grades into Ghariep Karroid Grassland.

APPENDIX C

Observed avifauna

February 2011
Report No. 12800-10445-22

Golder Associates

Roberts No.	Common Name	Biological Name	Red Data (IUCN, 2010)
102	Egyptian Goose	*Alopochen aegyptiacus*	LC
104	Yellow-billed Duck	*Anas undulata*	LC
118	Secretary bird	*Sagittarius serpentarius*	LC
152	Jackal Buzzard	*Buteo rufofuscus*	LC
172	Lanner Falcon	*Falco biarmicus*	LC
181	Rock Kestrel	*Falco rupicolus*	Unlisted
203	Helmeted Guineafowl	*Numida meleagris*	LC
230	Kori Bustard	*Ardeotis kori*	LC
401	Spotted Eagle Owl	*Bubo africanus*	LC
425	White-backed Mousebird	*Colius colius*	LC
426	Red-faced Mousebird	*Urocolius indicus*	LC
431	Malachite Kingfisher	*Alcedo cristata*	LC
438	Eurasian Bee-eater	*Merops apiaster*	LC
465	Pied Barbet	*Tricholaema leucomelas*	LC
493	Monotonous Lark	*Mirafra passerina*	LC
494	Rufous-naped Lark	*Mirafra africana*	LC
497	Fawn-coloured	*Mirafra africanoides*	LC
507	Red-capped Lark	*Calandrella cinerea*	LC
518	Barn swallow	*Hirundo rustica*	LC
526	Greater Striped Swallow	*Hirundo cucullata*	LC
557	Cape Penduline Tit	*Anthoscopus minutus*	LC
589	Familiar Chat	*Cercomela familiaris*	LC
593	Mocking Chat	*Thamnolaea cinnamomeiventris*	Unlisted
595	Anteating Chat	*Myrmecocichla formicivora*	LC
601	Cape Robin	*Cossypha caffra*	LC
615	Kalahari Scrub robin	*Cercotrichas paena*	LC
619	Garden Warbler	*Sylvia borin*	LC
635	Cape Reed Warbler	*Acrocephalus gracilirostris*	LC
638	African Sedge Warbler	*Bradypterus baboecala*	LC
643	Willow Warbler	*Phylloscopus trochilus*	LC
664	Fantailed Cisticola	*Cisticola juncidis*	LC
665	Desert Cisticola	*Cisticola aridulus*	LC
672	Rattling Cisticola	*Cisticola chinianus*	LC
677	Levaillant's Cisticola	*Cisticola tinniens*	LC
685	Blackchested Prinia	*Prinia flavicans*	LC
698	Fiscal Flycatcher	*Sigelus silens*	LC
711	African Pied Wagtail	*Motacilla aguimp*	LC
713	Cape Wagtail	*Motacilla capensis*	LC
732	Fiscal Shrike	*Lanius collaris*	LC
756	White-crowned Shrike	*Eurocephalus anguitimens*	LC

Roberts No.	Common Name	Biological Name	Red Data (IUCN, 2010)
760	Wattled Starling	*Creatophora cinerea*	LC
761	Plumcoloured Starling	*Cinnyricinclus leucogaster*	LC
762	Pied Starling	*Lamprotornis australis*	LC
801	House Sparrow	*Passer domesticus*	LC
803	Cape Sparrow	*Passer melanurus*	LC
804	Southern Grey-headed Sparrow	*Passer diffusus*	LC
805	Yellow-throated Sparrow	*Petronia superciliaris*	LC
814	Masked Weaver	*Ploceus velatus*	LC
824	Red Bishop	*Euplectes orix*	LC
826	Golden Bishop	*Euplectes afer*	LC
844	Blue Waxbill	*Uraeginthus angolensis*	LC
845	Violet-eared Waxbill	*Uraeginthus granatinus*	LC

The relevant IUCN status categories are:

Critically Endangered (CR)

Endangered (EN)

Vulnerable (VU)

Near Threatened (NT)

Data Deficient (DD)

Least Concern (LC)

APPENDIX D

Blue Crane Description

February 2011
Report No. 12800-10445-22

Golder Associates

Blue Crane (Grus paradisea)

Red List Category: Vulnerable

This species has declined rapidly, largely owing to direct poisoning, power-line collisions and loss of its grassland breeding habitat owing to afforestation, mining, agriculture and development. It is therefore listed as Vulnerable. Although probably stable at present, the population could easily decline again unless appropriate conservation measures are implemented. Evidence of continued population stability or increases may qualify the species for downlisting to Near Threatened in due course.

Range Description: *Grus paradisea* is near-endemic to South Africa, with small breeding populations also in northern Namibia (c.60 birds at Etosha, isolated and rapidly declining) and western Swaziland (c.12 birds). In South Africa, numbers in the south Western Cape have increased as the species has expanded into agricultural areas but, overall, the national population has fallen by half since the 1970s, with dramatic declines in many former strongholds, e.g. of up to 80% in Mpumalanga, KwaZulu-Natal, Free State and Eastern Cape during the 1980s. The latest population estimate is of c. 25,700 individuals.

Population: The population has been estimated at over 25,580 individuals (Beilfuss et al. 2007), with a minimum of 25,520 in South Africa (McCann et al. 2007).

Population Trend: Decreasing

Habitat and Ecology: It inhabits short, dry, natural grasslands, pastures, cropland and fallow fields, only occasionally using wetlands1. Most breeding is concentrated in the period September-January3.

Major Threat(s): The main factors behind its drastic population decline since the 1970s are widespread poisoning on agricultural land (both intentional and accidental) and the commercial afforestation of large tracts of its grassland nesting habitat. Other major threats include collision with power-lines and fences, and illegal capture of fledglings (for pets or food), while domestic-dog predation and chicks drowning in water-troughs are also problems. Prolonged dry spells are suspected to be the cause of the decline in Namibia.

Conservation Actions: Conservation measures have expanded in scale since the mid-1980s, including efforts to mitigate powerline collisions, the adoption of stricter legal protection, local and national surveys in South Africa, increasing research on the species' biology and ecology, habitat protection and management programmes (especially on private land), establishment of local conservation organisations, and the development of educational facilities, programmes and publications.

APPENDIX E

Mountain Zebra Description

February 2011
Report No. 12800-10445-22

Golder Associates

Mountain Zebra (*Equus zebra*)

The range of the Mountain Zebra extends across the Western Precinct (), but this species is not free ranging and is restricted in distribution to formally protected areas and private game ranches.

Red List Category: Vulnerable

Listed as Vulnerable as the total population is currently estimated at ca. 9,000 mature individuals, and could be subject to a decline exceeding 10% over the course of the coming 27 years, largely driven by annual harvesting of the Hartmann's Mountain Zebra population. At present, there is limited information available on the population trend of Hartmann's Mountain Zebras, but there is some evidence to suggest that they may well be declining. With the availability of further information on trends from parks and private lands, the species may need reassessment.

Range Description: Historically, Mountain Zebras occurred from the southern parts of South Africa through Namibia and into extreme south-western Angola. Two subspecies are recognized: Cape Mountain Zebras (*E. z. zebra*) were widely distributed along mountain ranges forming the southern and western edge of the of the central plateau of the Eastern Cape and Western Cape provinces of South Africa, from the Amatola Mountains in the Cathcart District westward and northward to the Kamiesberg in Namaqualand in the Northern Cape; Hartmann's Mountain Zebras (*E. z. hartmannae*) occur in the mountainous transition zone between the Namib Desert and the central plateau in Namibia, with a marginal extension into south-western Angola). Novellie et al. (2002) postulate that the ranges of the two subspecies were separated by an area devoid of mountainous habitat between the northernmost point of the Cedarberg and Bokkeveldberg ranges, and the southernmost point of the Kamiesberg range.

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.

Population: In 1998, the number of Cape Mountain Zebras had increased from <100 animals in the 1950s to about 1,200 individuals, with the largest population (reintroduced), estimated to number 250 in 1998, in the Karoo National Park. The average annual rate of increase of the entire Cape Mountain Zebra population from 1985 to 1995 was 8.6%, and from 1995 to 1998, 9.6%). From 1998 to 2006 there has been a steady increase in the populations of Cape Mountain Zebras from 1003 to 1389 in National Parks and Provincial Nature reserves. In 1998, there were approximately 165 Cape Mountain Zebra on private lands; more recent figures are not available. Hence, the Cape Mountain Zebra population in South Africa has been steadily increasing since the 1980s. The current population size is estimated to be more than 1,500 individuals (ca. 500 mature).

In 1998, the Hartmann's Mountain Zebras population was estimated to number about 25,000, or approximately 8,300 mature individuals (Novellie et al. 2002). Limited data from Namibia indicates that populations are increasing on communal lands in the north-western part of the country (G. Stuart-Hill pers. comm. 2008); from 2000 to 2006, numbers have increased from 6 to 27 individuals observed per 100 km of road surveyed. However, there is no information on the status of populations of Hartmann's Mountain Zebra in the protected, private and communal areas in the rest of Namibia (and see Major Threats).

Population Trend: Unknown

Habitat and Ecology: Mountain Zebra inhabit rugged, broken mountainous and escarpment areas up to around 2,000 m with a rich diversity of grass species and perennial water sources (Penzhorn in press). They are predominantly grazers, only browsing if forced to do so. The typical social structure is one of small harems comprising an adult stallion and one to three (maximum five) mares and their dependent foals; non-breeding groups consist primarily of bachelors, but sometimes include young fillies (Penzhorn in press).

Major Threat(s): Cape Mountain Zebra were once extensively hunted for their skins, because they competed with livestock for grazing, and allegedly because they broke fences (Penzhorn 1988). Today, however, the greatest threat to the Cape subspecies may stem from the risk of crossing with Hartmann's Mountain Zebra, which are introduced to the Eastern and Western Cape.

Conservation Actions: *E. z. zebra* is listed on CITES Appendix I; E. z. hartmannae is listed on CITES Appendix II. Over 90% of the current total population of 1,389 Cape Mountain Zebras are derived from animals relocated from the Mountain Zebra National Park. The management of the Cape Mountain Zebra metapopulation requires the mixing of at least some animals from the three relict populations (MZNP, Gamkaberg, and Kamanassie), all of which are genetically depauperate, although this has been hampered by the relatively slow growth of the Kamanassie population

APPENDIX F

Riverine Rabbit Description

February 2011
Report No. 12800-10445-22

Golder Associates

Riverine Rabbit (*Bunolagus monticularis*)

The Riverine Rabbit is one of the most endangered species in Africa and occurs in a small distribution range in the Karoo (?).The likelihood of occurrence of Riverine Rabbit in the Western Precinct is high and areas such as the Koopmans Graft area will need to be carefully considered in the next phase of the project. Areas likely to host this species are riparian areas especially those with the following characteristics:

- Occur in the central Karoo region
- Are seasonal
- Have large, alluvial floodplain with shallow slopes.
- Have dense riverine vegetation (scrub)
- Have scrub of 0.5 - 1 m (1.6 - 3.2') in height
- Have soil types that allow stable burrows to be constructed. *(*Stuart & Stuart 1996*)*

Red List Category: Critically Endangered

No subpopulation is estimated to contain more than 50 individuals, and these subpopulations appear to be isolated due to anthropogenic barriers to dispersal. Quantitative analysis using VORTEX 3.1 showed that the probability of extinction in the wild was more than 50% within the next 100 years.

Range Description: This species is endemic to the central Karoo region of South Africa. The extent of occurrence is 101-5,000 km² and area of occupancy is 11-500 km².

Population: There are less than 90% of mature individuals in one subpopulation. There are 10 subpopulations. There has been a rapid decline of population due to loss of 50-60% of habitat in the past 70 years, this decline has been arrested due to a decrease in cultivation and public awareness and establishment of conservancies. The current population is estimated at less than 250 breeding pairs and is declining. It is estimated that over the last 70 years the population has declined by 60% or more. Population decline of 10% or more is predicted to occur between 2002 and 2022. The population is fragmented, with no subpopulation containing more than 50 individuals. Population densities were estimated at 0.064-0.166/ha.

Population Trend: Decreasing

Habitat and Ecology: The Riverine Rabbit inhabits dense riparian growth along the seasonal rivers in the central Karoo (Nama-Karoo - shrubland). Occurs specifically in riverine vegetation on alluvial soils adjacent to seasonal rivers. The habitat is highly fragmented and transformed. Studies show the habitat to be 67% fragmented in certain areas that can be considered representative of the entire distribution.

Generation length for this species is two years. This species has a single litter per year with 1-2 young per litter. Reproductive periodicity occurs from August through May. Gestation time is 35-36 days. Longevity in captivity is five years. Home range is 12 ha. Total length ranges from 33.7-47.0 cm.

Major Threat(s): Loss and degradation of habitat are the main threats to the species. Over the last century, 50-80% of habitat has been lost as a result of cultivation (mostly in the past) and livestock farming (ongoing). Other threats to the species include hunting (the rabbit is hunted for sport and by farm workers), and accidental mortality in traps set for pest animals on farmlands.

Conservation Actions: *Bunolagus monticularis* is listed as Endangered in the 1986 South African National Red Data Book, and there is a genetic study of the species underway. At the CBSG CAMP South Africa workshop, conservation actions recommended included further research into the life history of this species, management of habitat, wild population management, limiting factors, captive breeding/cultivation, and increased public awareness. The captive breeding/cultivation recommendations include plans for species recovery, education, reintroduction, research, and a management plan workshop. There is currently a coordinated species management program in South Africa.

APPENDIX G

Karoo Rock Sengi

February 2011
Report No. 12800-10445-22

Golder Associates

Karoo Rock Sengi (*Elephantulus pilicaudus*)

Red List Category: Data Deficient

The Karoo Rock Sengi has recently been described as a sister species of the Cape Rock Sengi, *Elephantulus edwardii*. 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 pending the availability of further study and survey work.

Range Description: The new species is endemic to South Africa in the Northern Cape Province and the north-western edge of Western Cape Province. The species therefore appears limited to the Nama-Karoo vegetation biome in the south-central semi-arid Karoo of South Africa. The Nama-Karoo is subdivided into Bushmanland and the Upper and Lower Karoo bioregion vegetational units (Mucina and Rutherford 2006). Based on genetic evidence, *E. pilicaudus* is divided into two clades. Specimens from the Upper Karoo bioregion have a different genetic profile than those from the Lower Karoo bioregion. Because there are only five known locations where the new species occurs, the distribution is not well understood, although it appears to be highly restricted. It is possible that the distributions of the Cape Rock Sengi (*E. edwardii*) and the Western Rock Sengi (*E. rupestris*) do not overlap with E. pilicaudus. Within the range of the new species, it is not likely to be continuously distributed because its boulder and rock habitats are highly fragmented. All known locations are >1,300 m above sea level.

Population: The abundance and population size is unknown. Despite numerous field excursions in the region, only 17 specimens of the new species from five locations in the Nama Karoo are known (three live trapped by Hannelie Smit; two trapped by Galen Rathbun, and 12 museum specimens housed in South African museums). In October 2008, a farm near Calvinia in the Northern Cape Province of South Africa, where three live specimens were trapped in September 2006, was revisited by H. Smit and an effort to trap additional live specimens was unsuccessful. This reinforces the evidence of a species with a low abundance.

Population Trend: Unknown

Habitat and Ecology: This species is confined to rocky or boulder-strewn habitats against mountain slopes or on ridges. Based on the five locations where it has been trapped, the species may have similar ecology as its sister species the Cape Rock Sengi (*E. edwardii*), and the boulder- and rock-dwelling Western Rock Sengi (*E. rupestris*).

Major Threat(s): The species occurs in an area of ongoing livestock farming, which poses no direct threat to the species. Because it occupies rocky and boulder habitats that are not suitable for most agricultural or urban development, there are no known threats to the Karoo Rock Sengi.

Conservation Actions: Concerted efforts should be made to assess the relative abundance of the new species and further document its apparent limited distribution. It is unknown whether the species occurs in any protected areas other than the Karoo National Park, Beaufort-West. The species is limited to a region of local endemism and shares a distribution with other Karoo endemic mammals, such as *Bunolagus monticularis* and *Aethomys grantii*, which may be an important consideration in identifying and establishing additional protected areas in the region.

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Africa (Pty) Ltd.
25 Main Avenue
Cnr Die Ou Pad
Florida
Roodepoort
South Africa
T: [+27] (11) 672 0666

Golder Associates

Project done on behalf of
Golder Associates Africa (Pty) Ltd

AIR QUALITY TECHNICAL ASSESSMENT: REPORT IN SUPPORT OF THE EMP FOR THE SOUTH WESTERN KAROO BASIN GAS EXPLORATION APPLICATION PROJECT – WESTERN PRECINCT

Report No.: APP/10/GAA-11 Rev 0

DATE: FEBRUARY 2011

L W Burger

Airshed Planning Professionals (Pty) Ltd

P O Box 5260
Halfway House
1685

Tel : +27 (0)11 805 1940
Fax : +27 (0)11 805 7010
e-mail : mail@airshed.co.za

REPORT DETAILS

Reference	APP/10/GA-11
Status	Revision 0
Report Title	Air Quality Technical Assessment: Report in Support of the EMP for the South Western Karoo Basin Gas Exploration Application Project – Western Precinct
Date Submitted	February 2011
Client	Golder Associates Africa (Pty) Ltd
Prepared by	Lucian Burger PhD (Natal), MSc Eng (Chem), BSc Eng (Chem)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighborhood concerns to regional air pollution impacts. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.
Copyright Warning	Unless otherwise noted the copyright in all text and other matter (including the manner of presentation) is the exclusive property of Airshed Planning Professionals (Pty) Ltd. It is a criminal offence to reproduce and/or use, without written consent, any matter, technical procedure and/or technique contained in this document

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 Western Precinct, which intersects the Western and Northern Cape Provinces and covers the Cape Winelands, Central Karoo, Namakwa, and Pixley ka Seme District Municipalities.

Airshed Planning Professionals (Pty) Ltd was tasked with conducting an air quality assessment for the proposed gas exploration as an integral part of the overall Environmental Management Plan (EMP), which is being completed by Golder Associates Africa (Pty) Ltd.

METHODOLOGY

The main objective of this study was to compile the necessary air quality and meteorological information for input into the EMP. This study included the description of the current atmospheric conditions in the study area, legal requirements pertaining to air pollution, predicted air impacts, mitigation and management measures, and key questions that would need to be addressed in the detailed environmental impact assessment (EIA).

Historical records of air quality, meteorological parameters and climatological behaviour were sourced and summarised to produce a succinct account of the current (baseline) conditions.

All significant sources of air emissions and associated air pollutants were identified and discussed for their significance.

BASELINE CONDITIONS

The study area has a low level of industrial activity. The only identified sources of significant air pollution are the current farming activities. These emissions are mainly airborne particulates. It is therefore expected that air concentrations of sulphur dioxide and nitrogen dioxide would be 5 parts per billion (ppb) or less. Due to agricultural activities, the daily average inhalable particulate concentrations would be about 20 $\mu g/m^3$ or less. Air concentrations of volatile organic compounds, such as benzene are expected to be very low (less than 2 ppb for benzene and less than 10 $\mu g/m^3$ for combined volatile organic compounds).

The following South African Weather Services (SAWS) automatic weather stations have been identified to provide meteorological data at the level of detail which is required to use for atmospheric dispersion modelling and general climate statistics:

- Fraserburg (identification number 0113025A2)
- Sutherland (identification number 0088293A6) [Sutherland falls just outside the study area towards the south]

A number of additional rainfall stations exist in the study area. The mean annual precipitation ranges from 137 mm (Grootfontein, 0090176_W) to 339 mm (Sutherland).

The very low temperatures (-13.6°C at Sutherland and -11.8 Fraserburg) are a clear indications of the extreme cold conditions that can be experienced in the study area.

The wind distribution at Sutherland is relatively well spread in all directions, with the prevailing wind directions from the eastern and western directions. These directions also experience most of the high wind speed conditions, with nearly equal frequencies form the east and west. The wind conditions are very different to the Sutherland observations. The most prevailing wind condition is from the west to northwesterly and southeasterly sectors. The strongest winds occur significantly more frequently from the former sector. The increased southeasterly winds may be due to night-time flows, as observed in the appropriate wind rose.

The region is clearly in a very dry area with Fraserburg receiving on average only 181 mm per annum. Sutherland's mean annual average rainfall is higher at 339 mm.

It is not expected that the site will experience a hurricane, or at least there is a very low probability. Similarly, the estimated frequency of a tornado strike risk is less than 1×10^{-5} per year. The average number of days with hail in the study area is 0.8 per year. It is estimated that the study area experiences between 1 and 2 lightning flashes per year per km².

Recommended Baseline Monitoring Programme

It is recommended that the air quality monitoring network be established prior to construction to confirm current air quality. The pollutants to include in the monitoring network include:

- Particulate monitoring (PM10 and fallout)
- Sulphur dioxide
- Nitrogen dioxide

Although its significance would only be established during the EIA, it is also suggested to include measurements of volatile organic compounds and hydrogen sulphide in the campaign.

It is suggested that the sampling technique for the gaseous pollutants could initially be based on the technique of passive diffusive sampling. On completion of the detailed environmental technical assessment, a better level of understanding of the magnitude of the anticipated air concentrations would guide whether more sophisticated instruments would be required during the construction and exploration phases. The techniques outlined in the South African National Standards, SANS 1929:2004 would then be recommended

Particulate monitoring would be required for both airborne concentrations and fallout dust.

Although monitors should be located in areas that are expected to result in elevated air concentrations, monitors should also be located in sensitive areas, e.g. at the residential boundary closest to the exploration site.

TECHNICAL ASSESSMENT

Air pollution emissions are expected to occur during site preparation, exploration drilling, hydraulic fracturing and decommissioning.

Site Preparation

Potential Air Emissions

The air pollution generated during site preparation would be the same as for any other general construction activities, with the main air pollutant being airborne dust. The various activities during site preparation require disturbing the soil to some degree through the use of construction machinery. Depending on the soil type, this could generate significant amounts of fugitive dust during the limited period of site preparation.

In addition, combustion gases (sulphur dioxide, oxides of nitrogen, carbon monoxide, 1, 3-butadiene, diesel particulate matter) will be emitted from vehicle exhausts.

As these vehicles may be also be fuelled on site, the potential to emit volatile organic compounds exists.

Predicted Impact

The air pollution impact during site preparation is expected to be *Moderate* without mitigation measures. Following mitigation, these impacts can be reduced to *Low* significance. The technical assessment ratings are summarised in Table A.

Table A: Environmental technical assessment matrix – 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
Various activities during site preparation require disturbing the soil to some degree through the use of construction machinery. Fugitive dust will be released as well as exhaust emissions	8	1	1	5	56	Moderate	4	1	1	5	28	Low

Note: M=magnitude, D=duration, S=scale, P=probability and SP=significant point.

Mitigation Measures

- It is often customary to regulate particulate emissions from haul roads employing a watering programme. However, the potential restrictive use of water may prohibit this practice. Instead chemical suppressants or tarring could be considered. The practicality of surface treatment methods need to be investigated during the EIA phase.
- Additional mitigation measures include reduced vehicle speeds and coverage of haul truck loads.
- Vegetation is to only be removed when soil stripping is required. These areas should be limited to include only those areas required for development, hereby reducing the surface area exposed to wind erosion. Adequate demarcation of these areas should be undertaken.
- The length of time where open areas are exposed should be restricted. Construction of infrastructure should not be delayed after land has been cleared and topsoil removed.
- It is also important to minimise exposed areas prone to wind erosion and to re-vegetate as soon as practically possible.
- Removed topsoil should be stored under cover to prevent wind erosion, if it is to be used for restoration, otherwise re-vegetate the surface as soon as possible.
- Control options pertaining to topsoil removal, loading and dumping are generally limited to wet suppression. The options exist in scheduling this activity to coincide with periods when soil moisture can be expected to be optimal.
- Dust suppression methods should be where logistically possible, implemented at all areas that may / are exposed for long periods of time.

Recommended Monitoring

Particulate air quality monitoring, including both air concentrations of PM_{10} and fallout must continue during the site preparation period.

Exploration Drilling and Hydraulic Fracturing

Potential Air Emissions

The air emissions expected to occur during exploration include the following operations:

- Transportation
- Compressors
- Well flaring
- Power generators
- Drilling rig
- Open air fluid impoundments

The expected pollutants emanating from these different activities are summarised in Table B.

Table B: Summary of potential sources of air emissions

Air Pollutant	Roads	Vehicle	Engines	Flare	Impoundments	Fugitives
Particulate Matter	X	X	X	X		
Sulphur dioxide		X	X	X		
Oxides of nitrogen		X	X	X		
Carbon monoxide		X	X	X		
Hydrogen sulphide[(a)]				X[(b)]		X
VOCs		X	X	X	X	X
PAHs		X	X	X		
Methane					X	X

Notes: [(a)] – hydrogen sulphide emissions will occur if there is sour gas. Early explorations done by Soekor did not encounter hydrogen sulphide (not from the drilling reports, nor core analyses). The gas composition that was measured in the past was a mix of mainly Methane (92%) , Ethane (6%) and higher hydrocarbon chains (2%) (Rowsell, D.M. and De Swardt, A.M.J., 1976, Diagenesis in Cape and Karroo sediments, South Africa, and its bearing on their hydrocarbon potential. Transactions of the Geological Society of South Africa 79 (1), 81-129)
(b) – in the unlikely event of an extinguished flare and the well not yet isolated.

Predicted Impact

The air pollution impact during exploration drilling and hydraulic fracturing is expected to be *Moderate* without mitigation measures.
Following mitigation, these impacts can be reduced to *Low* significance. The technical assessment ratings are summarised in Table C.

Table C: Environmental technical assessment matrix – 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
Routine emissions are expected from power generators and compressors. Fugitive emissions may occur at drill rig and open air fluid impoundments. Gas may be flared.	6	2	2	4	42	Moderate	4	2	2	4	28	Low

Note: M=magnitude, D=duration, S=scale, P=probability and SP=significant point.

Given the current requirements for atmospheric emission licences (AEL), the facility may not need to apply for an AEL. This will be reviewed once all equipment has been sized.

Mitigation Measures

- Mitigate particulate emissions from haul roads by reducing vehicle speed and, if possible, using regular watering. Chemical suppressants or more permanent surface treatment methods should also be considered. The practicality of surface treatment methods need to be investigated during the EIA phase.
- Use low-sulphur fuel and efficient engines. Engines must be regularly maintained
- Infrared monitoring instrumentation to detect fugitive emissions.
- Minimise surface area if open air impoundments will be used.
- In case of flaring:
    - flare to be located away from receptors (dispersion modeling to be used to assist with the location);
    - use high efficiency burners;
    - in the event that the flare fails, well must be shut to prevent venting of gas directly to air.
- Installation of vapour recovery unit can eliminate most of the VOC emissions and recover valuable natural gas during flow back and well testing

Recommended Monitoring

The pollutants to include in the monitoring network include:

- Particulate monitoring (PM10 and fallout)
- Sulphur dioxide
- Nitrogen dioxide

Although its significance would only be established during the EIA, it is also suggested to include measurements of volatile organic compounds and hydrogen sulphide in the campaign.

Unless these emissions prove to be more significant, the monitoring using passive diffusion sampling methodology would be adequate.

Decommissioning

Potential Air Emissions

Minimal emissions are expected upon closure of the exploration well, and would mainly include particulate emissions during the closure process.

Fugitive particulate matter and VOC emissions may also occur during the rehabilitation of any fluid impoundments.

Predicted Impact

The air pollution impact during decommissioning is expected to be *Low*, as shown in Table D.

Table D: Environmental technical assessment matrix – Decommissioning

POTENTIAL ENVIRONMENTAL IMPACT: DECOMMISSIONING	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	Total	SP	M	D	S	P	Total	SP
Various activities during site closure may disturb the soil to some degree through the use of clean-up machinery. Fugitive dust will be released as well as exhaust emissions	4	1	1	3	20	Low	4	1	1	3	20	Low

Note: M=magnitude, D=duration, S=scale, P=probability and SP=significant point.

Mitigation Measures

- If practical, regular watering of unpaved haul roads;
- Reduce vehicle speeds;
- Minimise exposed areas prone to wind erosion; and
- Cover haul truck loads.

Recommended Monitoring

Continuation of particulate air quality monitoring, including both air concentrations of PM_{10} and fallout must continue during the site preparation period.

KEY QUESTIONS THAT NEED TO BE ADDRESSED IN THE EIA

The next phase of work will require that a full environmental impact assessment (EIA) be undertaken. In order to assess the impacts on air quality, the following key questions will need to be answered:

- What is the current air quality at each of the selected drilling sites?
- What will the impacts (quantified) on air quality be due to the site preparation, exploration drilling, hydraulic fracturing and decommissioning activities?
- What mitigation measures can be implemented to reduce the impacts to acceptable levels?