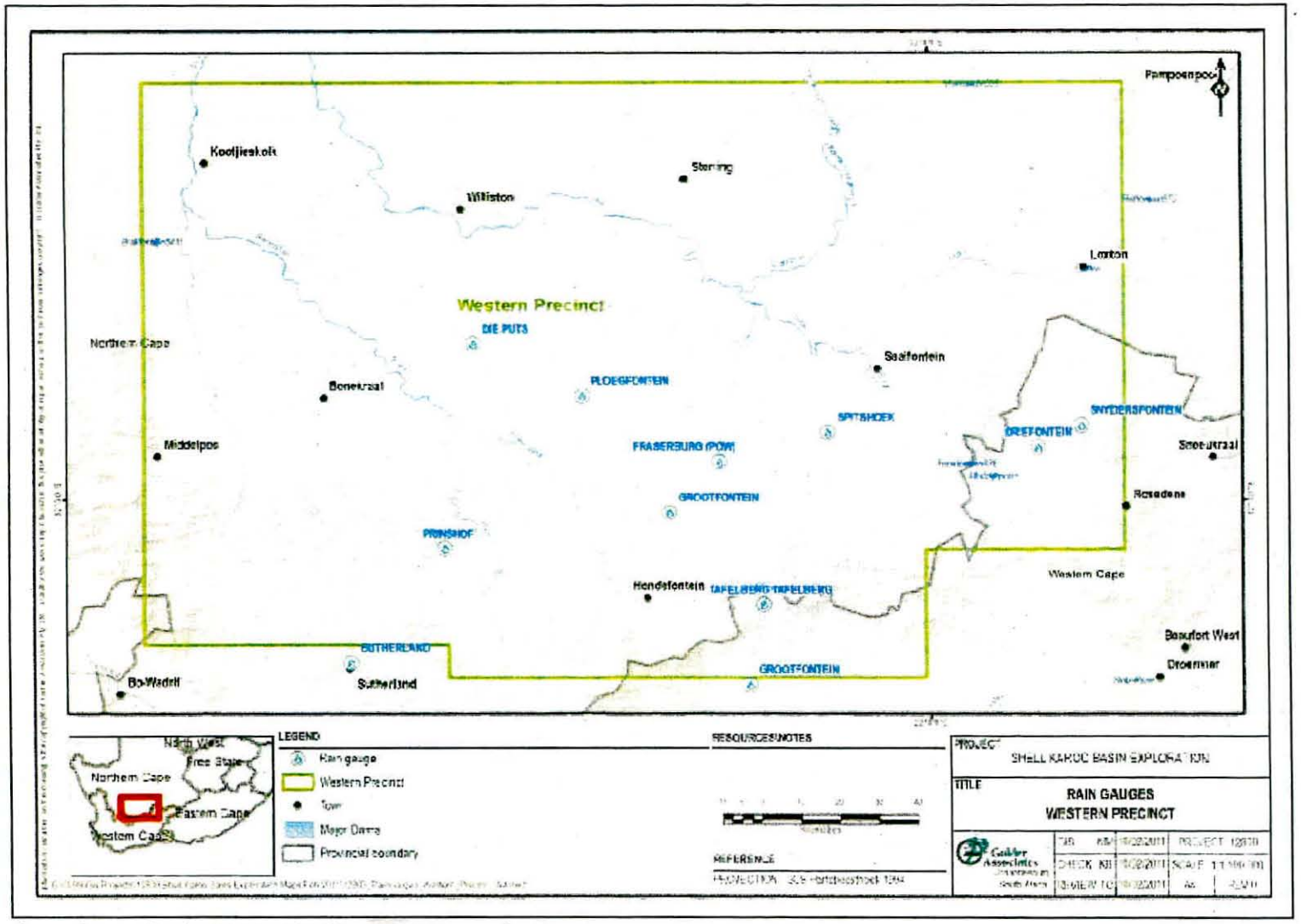


Figure 2-4: Locations of rain gauges in the western precinct

Table 2-5: The mean annual precipitation (MAP) and maximum 24-hour rainfall for a number of return periods within the six exploration areas of the Central Precinct

Rainfall Station	MAP (mm)	Return Period (years)						
		2	5	10	20	50	100	200
Victoria West 1								
Sterling (0140616_W)	243	29.8	42.1	50.8	59.6	71.7	81.4	91.4
Rheboksfontein (0141066_W)	235	38.8	54.8	66.1	77.6	93.3	105.7	118.8
Rietfontein 1								
Nelspoort (0093070_W)	226	35.1	49.3	59.4	69.6	83.5	94.6	106.2
Kampferskraal (0093074_W)	219	34.5	48.5	58.5	68.5	82.2	93.1	104.4
Ka 2								
Bakensrug (0093314_W)	218	34.5	48.6	58.5	68.5	82.3	93.2	104.5
Murraysburg (0117447_W)	257	33.3	47.0	56.5	66.2	79.4	90.0	101.0
Ossekuil 1								
Doornbosch (0095123_W)	407	45.2	63.7	76.7	89.8	107.8	122.0	137.0
Quaggasdrift (0095006_W)	411	48.4	68.1	82.1	96.0	115.3	130.5	146.4

2.3.4. Severe and Rare Phenomena

Historical weather observations in the region recorded by the SAWS (SAWS 2008) (Table 2-6) indicate frequent flood/heavy rain and tornado/strong winds events. Three tornadoes were recorded.

Table 2-6: Notable weather and weather related events in the study area

Year	Month	Day	Event	Place
1837	02	18	FLOODS	BEAUFORT WEST
1853	09	03	SNOW	GRAAFF-REINET
1856	06		FLOODS	BEAUFORT WEST
1869	10	23	FLOODS	BEAUFORT WEST
1870			FLOODS	BEAUFORT WEST
1871	02	27	FLOODS	VICTORIA WEST
1881	02		FLOODS	BEAUFORT WEST
1881	02		HAIL	BEAUFORT WEST
1886	07	11-14	SNOW	GRAAFF REINET
1905	03		FLOODS	BEAUFORT WEST
1907	01	08	TORNADO	JANSENVILLE
1918	03	14-15	FLOODS	BEAUFORT WEST
1920	02	1-4	FLOODS	BRITSTOWN
1920	02	1-4	FLOODS	DE AAR

Year	Month	Day	Event	Place
1920	02	1-4	FLOODS	PHILIPSTOWN
1921	12	28-29	FLOODS	ABERDEEN
1921	12	28-29	FLOODS	BEAUFORT WEST
1921	12	28-29	FLOODS	JANSENVILLE
1926	07	21-23	SNOW	GRAAFF-REINET
1933	08	28-29	SNOW	BEAUFORT WEST
1937	12	20	FLOODS	BEAUFORT WEST
1939	08	22-23	FLOODS	CARNARVON
1939	08	22-23	FLOODS	VICTORIA WEST
1940	02	16	FLOODS	BEAUFORT WEST
1940	02	16	FLOODS	NELSPOORT
1941	04	06	FLOODS	BEAUFORT WEST
1947	08	02	DUSTSTORM	BEAUFORT WEST
1947	08	02	DUSTSTORM	HUTCHINSON
1948	01	28	FLOODS	BEAUFORT WEST
1948	03	4	FLOODS	NELSPOORT
1950	05	12-18	FLOODS	BEAUFORT WEST
1950	05	12-18	FLOODS	VICTORIA WEST
1950	12	7	SNOW	ABERDEEN
1950	12	7	SNOW	MURRAYSBURG
1953	09	13-14	SNOW	DE AAR
1956	06	25-26	STRONG WIND	BEAUFORT WEST
1956	06	25-26	STRONG WIND	GRAAFF-REINET
1958	05	31	STRONG WIND	BEAUFORT WEST
1961	03	26-27	FLOODS	ABERDEEN
1961	03	26-27	FLOODS	JANSENVILLE
1961	03	26-27	FLOODS	LOXTON
1961	08	02	FLOODS	CARNARVON
1968	06	11-12	SNOW	JANSENVILLE
1973	08	19	SNOW	GRAAFF REINET
1974	03	07	FLOODS	GRAAFF REINET
1976	11	05	TORNADO	HANOVER
1977	05	07-08	SNOW	GRAAFF REINET
1981	08	28-29	SNOW	ABERDEEN
1981	08	28-29	SNOW	BEAUFORT WEST
1981	08	28-29	SNOW	DE AAR
1984	05	15-16	STRONG WIND	BEAUFORT WEST
1988	03	08-12	FLOODS	BRITSTOWN
1988	03	01	FLOODS	HUTCHINSON
1988	03	01	FLOODS	LOXTON
1988	03	08-12	FLOODS	LOXTON

Year	Month	Day	Event	Place
1988	03	01	FLOODS	NELSPOORT
1988	03	01	FLOODS	VICTORIA WEST
1988	03	08-12	FLOODS	VICTORIA WEST
1988	06	12	SNOW	GRAAFF REINET
1988	11	02	HAIL	PHILIPSTOWN
1989	04	22	HAIL	GRAAFF REINET
1989	07	30	STRONG WIND	GRAAFF REINET
1989	12	17	HAIL	MIDDELBURG – CAPE
1990	01	25	HAIL	JANSENVILLE
1990	01	25	STRONG WIND	JANSENVILLE
1990	10	15	SNOW	GRAAFF REINET
1990	10	18	SNOW	GRAAFF REINET
1990	10	18	SNOW	MIDDELBURG – CAPE
1991	06	06-08	SNOW	BEAUFORT WEST
1992	03	02	EXTREME COLD	MIDDELBURG – CAPE
1992	08	08-09	SNOW	ABERDEEN
1993	02	25	FLOODS	BEAUFORT WEST
1993	06	11	SNOW	DE AAR
1994	02	05-06	FLOODS	PETRUSVILLE
1994	03	04	HAIL	CARNARVON
1994	03	01	HAIL	DE AAR
1994	07	01	SNOW	BEAUFORT WEST
1995	05	21	SNOW	GRAAFF REINET
1995	07	18	SNOW	GRAAFF REINET
1996	12	27-30	FLOODS	GRAAFF REINET
2000	03	01-02	FLOODS	BEAUFORT WEST
2001	07	21	SNOW	GRAAFF REINET
2005	02	0	TORNADO	JANSENVILLE
2006	05	19	SNOW	WAPADSBERG PASS
2006	08	16	SNOW	GRAAFF REINET
2006	05	19	SNOW	LOOTSBERG PASS
2007	12	25-26	HIGH TEMPERTURES	BEAUFORT WEST
2007	12	30	HEAVY RAIN	BRITSTOWN
2007	12	30	STRONG WIND	BRITSTOWN
2007	12	30	HEAVY RAIN	DE AAR
2007	12	30	HAIL	DE AAR
2007	12	30	STRONG WIND	DE AAR
2007	12	30	HEAVY RAIN	HANOVER
2007	12	30	STRONG WIND	HANOVER
2007	12	30	HEAVY RAIN	PETRUSVILLE
2007	12	30	STRONG WIND	PETRUSVILLE

(i) Tropical Cyclones

The study area is not located on a hurricane track (i.e. between latitudes 5°S to 30°S) or adjacent to a warm ocean. Therefore it is not expected that the site will experience a hurricane, or at least there is a very low probability. However, it is important to note the difference between a hurricane and hurricane force winds. The latter refers to a wind speed scale called the Beaufort Scale, where hurricane force winds are those with speeds above 118 km/h. Exceedence of this wind speed (excluding the occurrence of tornadoes) has an estimated likelihood of about 0.1 per annum.

(ii) Tornadoes

Tornadoes in South Africa are typically associated with very hot air masses and severe thunderstorms. The most commonly method used to classify tornadoes is the 'Fujita-Pearson scale classification. This system classifies tornadoes in six intensities, ranging from F0 (no damage) to F5 (incredible damage). The intensity is based on the apparent damage to structures, the extent of the path and other descriptors from which wind speeds are then inferred.

About 65 percent of the South African tornadoes (Goliger 1997) are classified as F0 or F1 (light damage), while more than 90 percent are classified as F0, F1 or F2 (considerable damage, with maximum wind speeds of up to 70 m/s). Only about 8 percent of the documented tornadoes were F3, i.e. severe damage, with maximum wind speeds of up to 90 m/s. The tornado which occurred in Mount Ayliff in January 1999 was seemingly the most severe ever reported, with a classification of F4.

Based on an analysis of the occurrence of South African tornadoes for the period 1905 to 1997 by SAWS (Goliger *et al*, 1997), most tornadoes have been observed in Gauteng, the Free State, KwaZulu-Natal (along a line from Pietermaritzburg to Ladysmith) and the north-eastern areas of the Eastern Cape. Most of these events occur in mid-summer from November to January, although a large number of tornadoes have occurred in spring and early summer (September and October) and in the late summer and autumn (February to May). An analysis of tornado time of occurrence revealed that most events occurred in the late afternoon or early evening, typically between 16h00 and 19h00.

No evidence of tornadoes could be found for the study area. On the basis of the available tornado occurrences over a period from 1905 to 1997, Goliger *et al* (1997) estimated tornado (F1 and higher) probabilities for South Africa, as shown in Figure 2-5. According to study, the estimated tornado strike risk is about 1×10^{-5} per year per km^2 to the east, and becomes less moving towards the west of the study area.

Goliger *et al* (1997) report the highest wind speed in South Africa of 100 m/s being made during a tornado event. Furthermore, they estimate the likelihood of a tornado with a rotational wind speed of more than 90 m/s (324 km/h) would be less than 1.6 percent of all tornadoes. Given that the estimated probability of a tornado is 1×10^{-5} per year in the study area, this corresponds to a risk of about 1×10^{-7} per year.

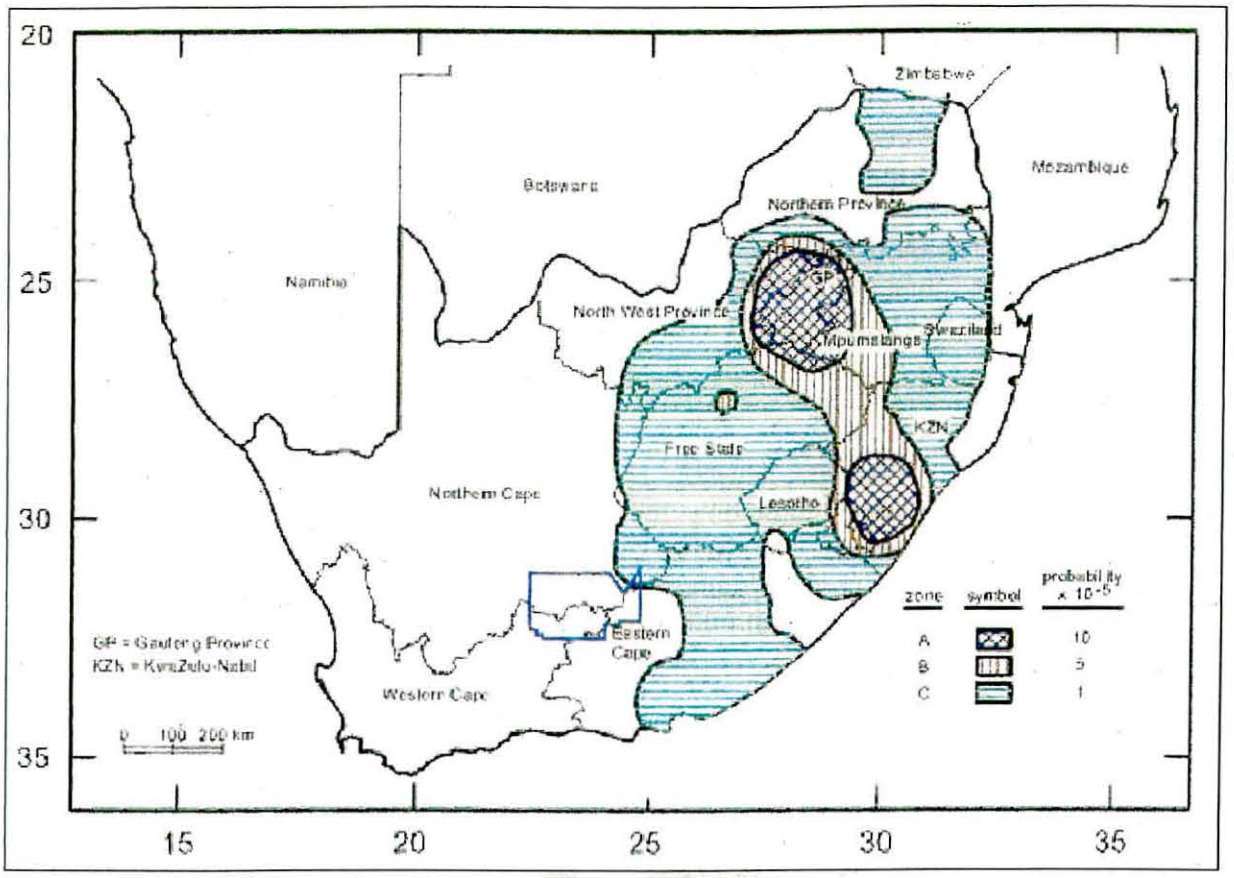


Figure 2-5: Mean annual rate of occurrence of tornadoes (excluding events with an intensity of F0 on Fujita Scale)

(iii) Hail

Formation of hail occurs as a result of very strong updrafts in convective thunderstorms of considerable vertical development. These updrafts carry hail into the uppermost ice regions of the cloud, which then fall into the supercooled layer below, which is still liquid at a temperature of less than 0°C. Very often hailstones are then lifted again by very strong updrafts back into the freezing upper part of the cloud again, where more clear ice and rime coalesce into consecutive layers on the hailstone. This vertical re-circulation may continue for some time but once the mass and weight of the hail is too great to be supported by air currents within the storm cell it falls to the ground (Geer 1996). The average number of days with hail in the study area is 1.7 per year.

(iv) Lightning

Lightning is the defining hazard of all thunderstorms and is caused by the differential between the positively charged upper section of a cloud and the negatively charged lower section. A new Lightning Detection Network (LDN) has recently (2006) been set up by the SAWS in South Africa. According to this network, the study area experiences between 1 (western portion) and 5 (north-eastern portion) lightning flashes per year per km².

2.4. Topography

Microclimates are dictated by the local topography. As shown in Figure 2-6, the most significant rise in topography is towards the southern sector. It is expected that these mountain ranges would determine the prevailing wind conditions to a great degree.

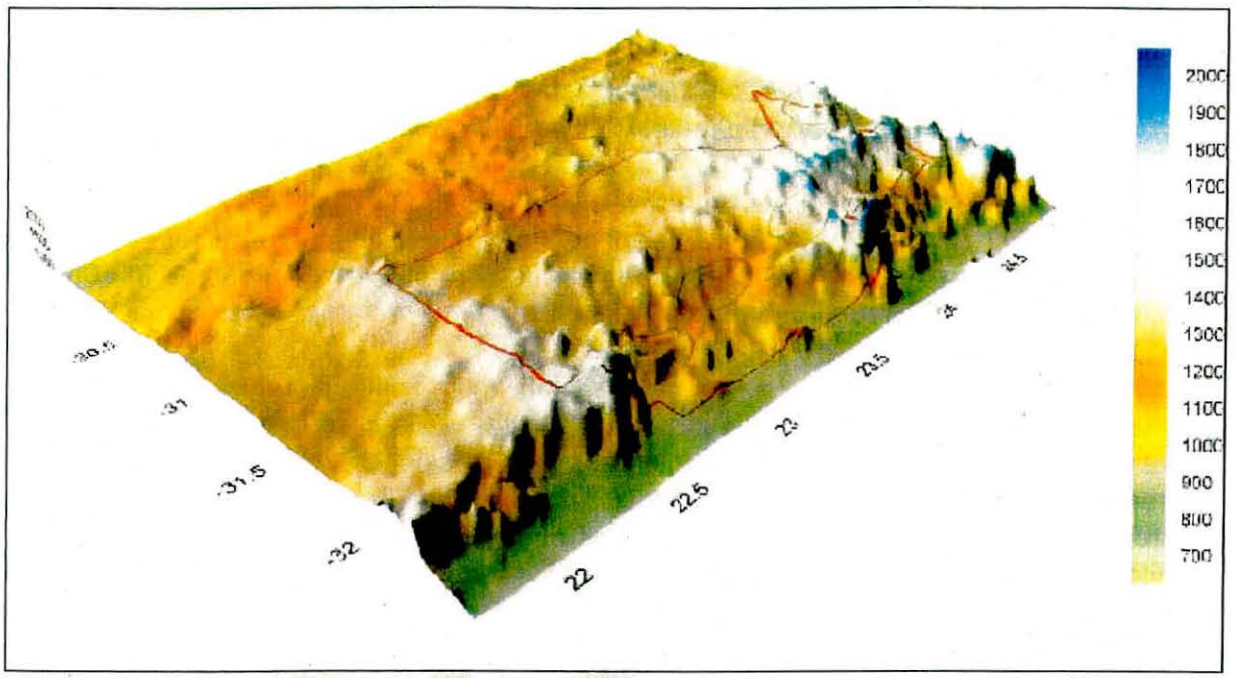


Figure 2-6: Major topographical features in the study area

2.5. Air Quality Regulations

2.5.1. Atmospheric Emissions Licence

The National Environmental Management: Air Quality Act (NEM AQA) (Act no.39 of 2004) commenced on the 11 September 2005 as published in the Government Gazette on the 9th of September 2005. Sections 21, 22, 36 to 49, 51(1)(e),51(1)(f), 51(3),60 and 61 were originally omitted, but came into effect on the 1 April 2010 (Government Gazette, 26 March 2010). The AQA was developed to reform and update air quality legislation in South Africa with the intention to reflect the overarching principles within the National Environmental Management Act. It also aims to comply with general environmental policies and to bring legislation in line with local and international good air quality management practices.

Given the specific requirements of the NEM AQA, various projects had to be initiated to ensure these requirements are met. One of these included the development of the *Listed Activities and Minimum National Emission Standards*. These standards were published on 31 March 2010 (Government Gazette No. 33064). The project aimed to establish minimum emission limits for a number of activities identified through a consultative process at several

forums. According to these standards, flares are not included under the NEM AQA. If the gas is to be used in reciprocating engines to produce electricity, the Act only comes into force if the power generation is above 50 MW (Category 1).

The operation of flares is mentioned under Category 2, and more specifically under Subcategory 2.1 Combustion installations. This category applies to the petroleum industry ("*the production of gaseous and liquid fuels as well as petrochemicals from crude oil, coal, gas or biomass*"). The discussion of the flare appears only in a footnote concerning the amount of sulphur dioxide emissions from the refinery. The note is essentially only a reminder that sulphur dioxide emissions can also come from flares and that this needs to be taken into account when the total sulphur dioxide "bubble" is calculated.

In the Act, a flare means a combustion device that uses an open flame to burn combustible gases with combustion air provided by ambient air around the flame. It further states that the combustion may be steam or air assisted. Flares may be either continuous or intermittent. This term includes both ground and elevated flares.

It may be argued that a flare is the "disposal of waste" and therefore may fall under Category 8: Disposal of hazardous and general waste. This category applies to facilities where general and hazardous waste including used oil or sludge from the treatment of used oil are incinerated (>10 kg/hour). The flare feed may perhaps be seen as the combustion of "waste" (i.e. incinerated). However, in the Act a flare is not considered as an incinerator although both involve combustions. Furthermore, the feed here is not waste, but rather the flare should be seen as a safety device. It is therefore the opinion that flares were not intended for inclusion in this category.

The last point to consider is the relatively short duration of the exploration (i.e. approximately 6 months). Under Category 2 (Petroleum Industry), it is stated that the standard excludes "test or experimental conditions", such as the exploration activities.

It is therefore concluded that the flare may not require an atmospheric emissions licence.

2.5.1. National Ambient Air Quality Standards

The National Ambient Air Quality Standards (NAAQS) was published in the Government Gazette on the 24th of December 2009. These standards were essentially based on the limit values developed originally by a technical committee and three working groups under the auspices of the South African Bureau of Standards (SABS). SABS was engaged to assist the Department of Environmental Affairs (DEA) in the facilitation of ambient air quality standards for criteria pollutants. Standards were determined based on international best practice for PM10, dustfall, SO_2, NO_2, ozone (O_3), CO, lead (Pb) and benzene (C_6H_6). These standards were first published for comment in the Government Gazette on 9 June 2007 with the revised standards published for comment on 13 March 2009. The final standards as published on 24 December 2009 are listed in Table 2-7.

Table 2-7: National Ambient Air Quality Standards (NAAQS)

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
Carbon Monoxide (CO)	1 hour	30000	26000	88	Immediate
	8 hour[a]	10000	8700	11	Immediate
Nitrogen Dioxide (NO_2)	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
PM10	24 hour	120	-	4	Immediate – 31 Dec 2014
		75	-	4	1 Jan 2015
	1 year	50	-	0	Immediate – 31 Dec 2014
		40	-	0	1 Jan 2015
Sulphur Dioxide (SO_2)	10 minutes	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hour	125	48	4	Immediate
	1 year	50	19	0	Immediate
Benzene	1 year	10	3.2	0	Immediate – 31 Dec 2014
		5	1.6	0	1 Jan 2015

2.5.2. Dust Fallout

Dust deposition is evaluated according to the criteria published by the DEA. In terms of these criteria dust deposition is classified as follows:

SLIGHT	-	less than 250 mg/m²/day
MODERATE	-	250 to 500 mg/m²/day
HEAVY	-	500 to 1200 mg/m²/day
VERY HEAVY	-	more than 1200 mg/m²/day

The Department of Minerals and Energy (DME) uses the 1 200 mg/m²/day threshold level as an action level. In the event that on-site dustfall exceeds this threshold, the specific causes of high dustfall should be investigated and remedial steps taken.

The SANS 1929:2004 proposed that dustfall rates be evaluated against a four-band scale, as presented in Table 2-8 with the target, action and alert thresholds for ambient dust deposition are given in Table 2-9.

Table 2-8: Bands of dustfall rates proposed for adoption

Band Number	Band Description Label	Dustfall Rate (*D*) (mg m^{-2} day^{-1}, 30-day average)	Comment
1	RESIDENTIAL	$D < 600$	Permissible for residential and light commercial
2	INDUSTRIAL	$600 < D < 1\,200$	Permissible for heavy commercial and industrial
3	ACTION	$1\,200 < D < 2\,400$	Requires investigation and remediation if two sequential months lie in this band, or more than three occur in a year.
4	ALERT	$2\,400 < D$	Immediate action and remediation required following the first exceedance. Incident report to be submitted to relevant authority.

Table 2-9: Target, action and alert thresholds for ambient dustfall

Level	Dustfall Rate (mg m^{-2} day^{-1}, 30-day average)	Averaging Period	Permitted Frequency of Exceedence
TARGET	300	Annual	
ACTION RESIDENTIAL	600	30 days	Three within any year, no two sequential months.
ACTION INDUSTRIAL	1 200	30 days	Three within any year, not sequential months.
ALERT THRESHOLD	2 400	30 days	None. First exceedance requires remediation and compulsory report to authorities.

According to the proposed dustfall limits, an enterprise may submit a request to the authorities to operate within the Band 3 ACTION band for a limited period, providing that this is essential in terms of the practical operation of the enterprise (for example the final removal of a tailings deposit) and provided that the best available control technology is applied for the duration. No margin of tolerance will be granted for operations that result in dustfall rates in the Band 4 ALERT.

3. TECHNICAL ASSESSMENT

Air pollutants from the exploration drilling operation may be divided into their potential impacts, namely nuisance (odours and dustfall) and toxic (irritants and carcinogenic) compounds. The significance of these impacts are determined firstly through the potential to violate relevant regulatory criteria (both ambient air and emission limits) and secondly through the comparison to health risk criteria. Since the assessment is at a qualitative level, direct comparison of absolute air concentrations are not possible. Instead, only the potential sources of air emissions and the various air pollutants will be discussed.

3.1. Exploration Activities that could Potentially Impact the Environment

Air pollution emissions are expected to occur during site preparation, exploration drilling, hydraulic fracturing and decommissioning. Since this study does not include the production phase, these emissions will not be discussed.

3.1.1. Site Preparation

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.

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 fuelled on site, the potential to emit volatile organic compounds exists.

This phase is anticipated to last for 2 to 3 weeks. The drill rig would be mobilised over a period of 2 to 4 weeks.

Approximately 10 trucks will transport the rig and a number of demountable units/caravans and other equipment to the site. The units include offices, toilets, showers and limited amount of accommodation.

Other ancillary equipment on site includes:

- Generators
- Lighting equipment (can be run off a generator or the grid)
- Storage for hazardous chemicals
- Fuel storage with bunding
- Temporary storage of explosives, radioactive sources (for logging) may be required. Storage will be provided by contractors and will only be used when use is imminent. Movement and storage will be under permit from authorities and by specialist companies which hold relevant transport and storage licenses.

3.1.2. *Exploration Drilling and Hydraulic Fracturing*

During the drilling operation, well construction and fracturing, air emissions are expected to occur from the following operations:

- Transportation
  - Activities:
    - *Constructing access roads*
    - *Drilling*
    - *Decommissioning*
  - Access and haul roads
    - Entrained dust
  - Vehicles exhaust an evaporative emissions
    - Combustion gases (sulphur dioxide, oxides of nitrogen, carbon monoxide, 1,3-butadiene, diesel particulate matter) and evaporative VOCs
- Power generators
  - Activities:
    - *Drilling*: to power the drilling rig
    - *Fracturing*: to power compressors to pressurise the well, to perforate and fracture
  - Combustion gases (sulphur dioxide, oxides of nitrogen, carbon monoxide, 1,3-butadiene, diesel particulate matter) and polycyclic aromatic hydrocarbons (PAHs)
- Compressors
  - Activities:
    - *Fracturing*: to pressurise the well, to perforate and fracture
  - Combustion gases (sulphur dioxide, oxides of nitrogen, carbon monoxide, 1,3-butadiene, diesel particulate matter)
- Open air fluid impoundments
  - Activities:
    - *Drilling*: to hold drill cuttings and fluid
    - *Fracturing*: to hold spent fracturing fluid during flow back for recycling or disposal
    - *Completion*: removal of fracturing equipment, site restoration if necessary
  - Evaporating VOCs
- Well flaring
  - Activities:
    - *Drilling unplanned events*: encounter a methane pocket
    - *Well testing*
  - Combustion gases (sulphur dioxide, oxides of nitrogen, carbon monoxide, 1,3-butadiene, diesel particulate matter)

It is anticipated that a flare pit will be constructed. A flaring rate of 2 800 to 8 500 m^3 (100 to 300 Mscf) is expected during the testing period. Flaring is seen as a safer way to manage the gas than simply allowing it to vent into the air. Flaring is also used to burn gases that would otherwise present a safety problem. It is common to flare natural gas that contains hydrogen sulphide in order to convert the highly toxic hydrogen sulphide gas into less toxic compounds.

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, and De Swardt, 1976). The likelihood of hydrogen sulphide emissions is therefore low.

Flares emit a host of air pollutants, depending on the chemical composition of the gas being burned and the efficiency and temperature of the flare. Flaring results in sulphur dioxide emissions if hydrogen sulphide is present in the natural gas. There may also be additional by-products formed if some of the chemicals used during the drilling or hydraulic fracturing process are converted to a gaseous form and are burned along with the natural gas. The full EIA would address this possibility and its significance.

Fugitive emissions are unintentional leaks of gases. This may occur from breaks or small cracks in seals, tubing, valves or pipelines, as well when lids or caps on equipment or tanks have not been properly closed or tightened. When natural gas escapes via fugitive emissions, methane as well as VOCs and any other contaminants in the gas (e.g., hydrogen sulphide) are released to the atmosphere. The full EIA would address this possibility and its significance.

3.1.3. Decommissioning

Should wells result in unsuccessful production tests, these would be decommissioned. Cement will be poured into the hole several times to ensure there is no communication between the reservoir and the surface. The steel casing will be removed from the top layers.

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.

3.1.4. Air Pollutants

The various pollutants that could potentially be emitted during exploration are discussed in this section.

Table 3-1 is a summary of the pollutants and their most likely emission location.

Table 3-1: 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		

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.

3.1.4.1. Particulate Matter

The most common sources of particulate matter from the proposed operations are dust or soil entering the air during pad construction or from traffic on access roads, and diesel exhaust from vehicles and engines used to power machinery at the facility. These emissions are the same as those from vehicles on the existing roads. It is not apparent that any dust emission controls are applied on existing farm roads. Particulate matter can also be emitted during flaring operations.

Particulate matter is essentially small particles that are suspended in the air and settle to the ground slowly. These particles may be re-suspended if disturbed. Particles small enough to be inhaled and can cause adverse health effects. These are denoted by PM_{10}, i.e. particles with a diameter less than 10 micrometers. PM_{10} is regulated by the DEA as a criteria air pollutant and published air quality standards, as provided in Table 2-7.

$PM_{2.5}$ particles (with a diameter less than 2.5 micrometers) can lodge deep within the lungs and cause serious health problems. $PM_{2.5}$ can cause respiratory ailments, painful breathing, chronic bronchitis, and premature death. Some particulates, such as diesel exhaust, are carcinogenic.
These particles are often also formed as a result of chemical reactions involving gases and other particles in the atmosphere. The most common precursor gases involved in these reactions are nitrogen oxides, sulfur dioxide, VOCs and ammonia.

Larger airborne particulates generally deposit nearby the source of emission. Crops and vegetation near unpaved roads can be covered with airborne dust, stunting their growth due

to the shading effect and clogging of the plants' pores. As a result, cattle and wildlife may avoid this vegetation. If exposed to the dust, it can also cause nuisances such as hay fever and allergies.

3.1.4.2. Hydrogen Sulphide

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, and De Swardt, 1976). The likelihood of hydrogen sulphide emissions is therefore low.

Hydrogen sulphide occurs naturally in the environment (e.g., decaying organic matter, marshes, sulphur springs and in volcanic gases). It is produced by living organisms, including human beings, through the digestion and metabolism of sulphur-containing materials. If significant amounts of hydrogen sulphide gas are contained in natural gas it is considered to be "sour". Natural gas can contain up to 28 percent hydrogen sulphide gas, consequently, it may be a significant air pollutant near the gas extraction areas.

The gas has a characteristic rotten egg odour at low concentrations. The 50 percent odour recognition threshold[1] is about 8 parts per billion (ppb) in air. More than 90 percent can smell it at levels of 50 ppb. At higher concentrations, hydrogen sulphide rapidly deadens the sense of smell. For most people, this occurs at approximately 150 parts per million (ppm).

Since hydrogen sulphide is heavier than air, it could potentially settle in low-lying areas where, if present in high concentrations, could injure or kill livestock, wildlife, and human beings. Common symptoms of exposure to long-term, low levels of hydrogen sulphide include headache, skin complications, respiratory and mucous membrane irritation, respiratory soft tissue damage and degeneration, confusion, impairment of verbal recall, memory loss, and prolonged reaction time. Exposure to high concentrations can cause unconsciousness, known as "knockdown," and can be lethal.

The World Health Organization (WHO) has an air quality guideline of 150 $\mu g/m^3$ (10.6 ppb) averaged over a 24-hour period. This guideline is based on the avoidance of eye irritation. WHO recommends that hydrogen sulphide concentrations not exceed 0.005 ppm (5 ppb; 7 $\mu g/m^3$), over a 30-minute period, to avoid substantial complaints about odour.

3.1.4.3. Carbon Monoxide

Carbon monoxide may be emitted during inefficient flaring and from engines . It is a colourless, odourless, flammable gas produced by incomplete burning of carbon-based fuels such as oil, natural gas, coal, and even wood. Carbon monoxide is poisonous if inhaled. It inhibits the blood's ability to carry oxygen, and can cause dizziness, unconsciousness, and even death.

[1] 50 percent odour recognition threshold is the concentration at which about half of the population can identify the compound.

Carbon monoxide is regulated by the DEA as a criteria air pollutant and published air quality standards, as provided in Table 2-7.

3.1.4.4. Oxides of Nitrogen

Nitrogen oxides (NOx) denote a group of various oxidised states of nitrogen, of which nitrogen dioxide is considered a criteria pollutant by most countries; including South Africa (see air quality standards in Table 2-7). The health impacts from nitrogen dioxide include respiratory problems, heart conditions, and lung damage. NOx also contributes to the formation of photochemical smog (ground-level ozone) and to acid deposition, or acid rain.

NOx is emitted from the combustion of fossil fuels, especially at very high temperatures and can be seen, along with other particles in polluted air, as a reddish-brown haze. Vehicles and power plants are the principal emitters of NOx,

NOx is emitted at gas operations from flaring, and is part of exhaust from diesel and natural gas engines that power machinery such as compressor engines and other heavy equipment.

3.1.4.5. Sulphur Dioxide

Sulfur dioxide is formed during the combustion of fossil fuels that contain sulphur, such as oil, natural gas, and coal. Flares and machinery that runs on diesel and natural gas (containing reduced sulphurs such as hydrogen sulphide) emit sulphur dioxide. Sour gas processing plants also emit sulfur dioxide. It has a pungent odour and irritates membranes in the nose and in the respiratory system.

Sulphur dioxide reacts with other chemicals to form particulate pollution, which can damage lungs and cause respiratory illness, heart conditions, and premature death. It is regulated by the DEA as a criteria air pollutant (see air quality standards in Table 2-7), and along with nitrogen dioxide, is a principal contributor to acid rain.

3.1.4.6. Volatile Organic Compounds

Volatile organic compounds include a host of chemicals that contain carbon and evaporate easily at room temperature. VOCs include BTEX, formaldehyde, and many others. BTEX is the acronym for benzene, toluene, ethylbenzene, and xylene. Benzene is a known carcinogen, and has also been shown to cause blood disorders and to impact the central nervous system the reproductive system. Benzene is regulated by the DEA as a criteria air pollutant (see air quality standards in Table 2-7). Toluene may affect the reproductive and central nervous systems. Ethylbenzene and xylene may have respiratory and neurological effects. BTEX can be a component of both petroleum products and natural gas, with the latter in considerably lower amounts. Given the experience with natural gas, the levels of BTEX in the shale gas are considered insignificant.

VOCs are emitted during venting or flaring of natural gas, from compressors, from pits storing produced water, and are part of the exhaust from diesel and natural gas powered

engines. VOCs react with NOx to form ground-level ozone and smog, which can trigger respiratory problems such as asthma.

Most people can smell benzene when it reaches levels of approximately 1.5 - 5 parts of benzene per million parts of air (ppm). The Occupational Safety and Health Administration (OSHA) has set maximum exposure levels for workers at 1 ppm (over an 8-hour period) and 5 ppm (over a 15-minute period). At levels above 150 ppm some people may begin to experience serious and irreversible health effects.

The vapours of benzene, toluene and xylenes are heavier than air and may accumulate in low-lying areas.

3.1.4.7. Methane

Methane is a major component of natural gas. It is colourless, odourless, and flammable. Whilst it is not toxic to humans, it acts as an asphyxiant[2]. Methane is also a greenhouse gas, significantly more potent than carbon dioxide.

Methane is emitted during the venting of natural gas, and during the release of fugitive emissions. A major hazard from methane associated with gas development is that it can seep up through the ground in areas that have shallow deposits or improperly abandoned wells.

3.1.4.8. Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons are hydrocarbon compounds with multiple benzene rings. PAHs are emitted at gas operations in diesel exhaust and from pits storing produced water. Typically, PAHs are components of asphalts, crude oil, coal, coal tar pitch, fuels, and greases. Also, PAHs are formed during the incomplete burning of coal, oil, and gas.

Studies have shown that people exposed by breathing or skin contact for long periods to mixtures that contain can develop cancer. The US EPA classifies several PAHs as probable human carcinogens.

3.2. Description of the Technical Assessment Methodology

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

[2] An asphyxiant gas is a non-toxic or minimally toxic gas which dilutes or displaces the oxygen-containing atmosphere, leading to death by asphyxiation (suffocation) if breathed long enough. Toxic gases, by contrast, cause death by other mechanisms, such as competing with oxygen (e.g. carbon monoxide) or directly damaging the respiratory system (e.g. phosgene).

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

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

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

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

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

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

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

3.3. Technical Assessment

3.3.1. Site preparation

Table 3-2 below summarises those impacts directly related to site preparation, and provides a significance rating for each impact before and after mitigation.

Table 3-2: 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
1. Air Quality												
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

Technical assessment

Fugitive dust will be released during activities that require disturbing the soil.

Vehicle exhaust emissions include combustion gases (sulphur dioxide, oxides of nitrogen, carbon monoxide, 1,3-butadiene, diesel particulate matter).

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

Mitigation measures

It is customary to regulate particulate emissions from access 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.

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.

Impact significance

It is anticipated that the site preparation activities could result in significant dust emissions; however, these are confined to the site and hence of medium significance.

Gaseous emissions from vehicles are considered to be less significant and of low significance.

3.3.2. Exploration Drilling and Hydraulic Fracturing

Table 3-3 below summarises those impacts directly related to exploration drilling and hydraulic fracturing, and provides a significance rating for each impact before and after mitigation.

Table 3-3: 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
1. Air Quality												
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

Technical assessment

During the drilling operation, well construction and fracturing, air emissions are expected to occur from the following operations:

- Transportation;
- Power generators;
- Compressors;
- Drilling rig;
- Open air fluid impoundments; and

- Well flaring.

Pollutants include:

- fugitive dust from haul roads;
- sulphur dioxide, oxides of nitrogen, carbon monoxide, 1,3-butadiene, particulate matter, VOCs and PAHs from combustion sources; and
- VOC's and methane from fugitive emissions

Mitigation measures

Minimise 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.

Also, depending on the significance of impact established through the EIA, monitoring and mitigation measures that could be considered include:

- Infrared monitoring instrumentation to detect fugitive emissions.
- Installation of vapour recovery unit can eliminate most of the VOC emissions and recover valuable natural gas during flow back and well testing

Minimise surface area if open air impoundments will be used.

Impact significance

Although emissions are likely to occur, it is anticipated that the impacts will be localised. The resulting air concentration levels are expected to be of moderate magnitude, hence of medium significance.

3.3.3. Decommissioning

Table 3-4 below summarises those impacts directly related to decommissioning, and provides a significance rating for each impact before and after mitigation.

Table 3-4: 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
1. Air Quality												
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

Technical assessment

Fugitive dust will be released during activities that require disturbing the soil. Vehicle exhaust emissions include combustion gases (sulphur dioxide, oxides of nitrogen, carbon monoxide, 1,3-butadiene, diesel particulate matter). As these vehicles may be fuelled on site, the potential to emit volatile organic compounds exists.

Mitigation measures

Regular watering of haul roads, reduce vehicle speeds, minimise exposed areas prone to wind erosion, cover haul truck loads.

Impact significance

It is anticipated that the site preparation activities could result in significant dust emissions; however, these are confined to the site and hence of medium significance. Gaseous emissions from vehicles are considered to be less significant and of low significance.

3.3.4. Cumulative impacts

Since the existing air quality is considered to be very good, apart from potential airborne particulates from farming activities, the impacts from the exploration is considered to be responsible for most of the increased air pollution in the vicinity of the operation.

3.3.5. Assumptions and knowledge gaps / limitations

The final detail of the proposed exploration has not been available. The locations of emissions were therefore based on typical exploration configurations.

The anticipated power generation and compressor sizes have not been fixed. It was therefore not possible to quantify air emissions of gases and particulate matter from the equipment.

The number and types of vehicles required during the various phases are still preliminary.

The access road lengths have not been determined since the exact locations for drilling have not been identified.

It is assumed that the flare would operate continuously.

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

4. MITIGATION AND MANAGEMENT MEASURES

The following discussions will need to be developed into more detailed programmes once the detailed impact assessment has been completed.

4.1. Recommended Mitigation Measures

4.1.1. Site Preparation

The most significant impact during site prepatation would be as a result of airborne particulates from fugitive dust sources, including wheel entrainment, wind erosion of exposed surfaces, and construction activities.

It is essential to have effective dust and emission controls for every potentially dust generating activity to protect the health and safety of the workforce on site as well as reduce statutory nuisance and health risk to local residents and people in the vicinity. An emission minimisation plan is regarded essential in the situation where construction activities are conducted very close to residential and other sensitive receptors. Although the proposed exploration areas are relatively far removed from the residential areas a management plan is still recommended.

The most significant air pollution sources need to be identified during the detailed EIA phase. Experience has shown that fugitive dust emissions mostly originate from wheel entrainment on unpaved roads. It is, therefore, recommended to have the initial focus on the reduction of emissions from road surfaces. The following mitigation measures during site preparation are recommended:

- 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.
- 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. However, if topsoil handling occurs when soil is too wet, the soil structure may be compromised.

Decisions pertaining to the timing of topsoil stripping require the balancing of various aspects.

- Where it is logistically possible, control methods for unpaved roads should be utilised to reduce the re-suspension of suspended particulates. Recommended measures are
    - *Source extent reduction*: Speed and Traffic reduction - these controls limit the amount of traffic on an unpaved road or strict enforcement of speed limits.
    - *Source improvement*: Paving and Gravel surface - these controls alter the road surface. These techniques are "once-off" control methods, therefore ensuring that periodic treatments are not normally required
    - *Surface Treatment*: Watering and Chemical stabilisation - these control techniques require periodic reapplications. Water is usually applied, utilising a truck with a gravity or pressure feed. This is only a temporary measure and periodic reapplications are necessary to achieve a substantial level of control efficiency. Chemical suppressants have less frequent reapplication requirements. These are designed to alter the roadway, such as cementing loose material into a fairly impervious surface (hereby simulating a paved surface) or forming a surface which attracts and retains moisture (simulating wet suppression). The practicality of watering schedules needs to be investigated, given the general scarcity of water in the area.
- Air quality monitoring at the nearest neighbours should be initiated.
- 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.
- Dust suppression methods should be where logistically possible, implemented at all areas that may / are exposed for long periods of time.

4.1.2. Exploration Drilling and Hydraulic Fracturing

The significance of air emissions can only be quantified once the all process equipment have been specified and sized. Emission rates and subsequently, ground level air concentrations can then be calculated using a suitable atmospheric dispersion model.

However, some generic considerations include:

- Use low-sulphur fuel and efficient engines.
- Engines must be regularly maintained
- The installation of monitoring instrumentation to detect fugitive emissions.
- Installation of vapour recovery unit to minimise VOC emissions and recover valuable natural gas during flow back and well testing
- Minimise surface area if open air impoundments will be used.

sophisticated instruments would be required during site preparation, exploration drilling and hydraulic fracturing. The techniques outlined in the South African National Standards, SANS 1929:2004 would then be recommended

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.
Air pollution control should be based on the project air quality limits given in Section 2.5.

5. 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 the following key questions will need to be answered:

- What is the current air quality at the proposed sites?
- What will the impacts on air quality be due to the site preparation, exploration and decommissioning?
- What mitigation measures can be implemented to reduce the impacts to acceptable levels?

6. CONCLUSIONS

6.1. 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 the criteria pollutants of sulphur dioxide and nitrogen dioxide are 5 parts per billion (ppb). Due to the agricultural activities, 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) weather station has been identified to provide meteorological data at the level of detail which is required to use for atmospheric dispersion modelling and general climate statistics:

- Beaufort West (identification number 0092081 5)

It should be noted that Beaufort West falls just outside the study area towards the southwest. The effect of the topographical barrier that shelters the study area towards the north would not be shown by this figure. Instead, it is expected that the southerly wind components may be less pronounced. Nonetheless, it is believed that the prevailing easterly wind would be similar to the conditions in the study area. Furthermore, the strong westerly winds are also

4.2. Recommended Monitoring Programmes

A comprehensive monitoring regime which includes measurement of levels in worker areas and areas of the community sensitivity is recommended.

The monitoring regime needs to include the following:

- Parameters to be monitored;
- Monitoring locations;
- Monitoring interval;
- Data and data analysis requirements for monitoring reports; and
- Reporting interval.

It is recommended that the air quality monitoring network be established prior to site preparation, drilling and fracturing. 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

It is suggested that the sampling technique for the gaseous pollutants could initially be based on the technique of passive diffusive sampling. With this technique, the gas of concern is absorbed into a specially prepared substrate, normally over a period of two weeks. If the concentrations are very low, the tubes could be exposed for longer periods, typically one month.

Particulate monitoring would be required for both airborne concentrations and fallout dust. The former may be determined with a mini-Vol sampler, which draws a sample of air at a fixed rate over a pre-weighed filter paper over a period of 24 hours. The amount of particulates is then determined gravimetrically. Since this is a fairly labour-intensive technique, exposures could be done over three-day cycles rather than back-to-back. Alternatively, more sophisticated instruments could be utilise that does the daily sampling automatically.

The nuisance level of dust, observed as daily deposition, calculated over an exposure period of one month is the most acceptable method proposed for the project. As a minimum four "fallout buckets" should be located in the four cardinal wind directions around the identified exploration area.

On completion of the detailed environmental impact assessment, a better level of understanding the magnitude of the anticipated air concentrations would guide whether more

expected to occur in the study area. Low occurrence of calm wind conditions are also illustrated with these observations.

The region is in a dry area with Beaufort West receiving only 223 mm per annum on average.

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 about 1 x 10^{-5} per year per km^2 to the east, and becomes less moving towards the west of the study area. The average number of days with hail in the study area is 1.7 per year. It is estimated that the study area experiences between 1 (western portion) and 5 (north-eastern portion) lightning flashes per year per km^2.

6.2. Potential Air Emissions

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

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

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.

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 fuelled on site, the potential to emit volatile organic compounds exists.

During the drilling operation, well construction and fracturing, air emissions are expected to occur from the following operations:

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

The expected pollutants emanating from these different activities are summarised in Table 6-1.

Table 6-1: 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.

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.

6.3. 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?

7. REFERENCES

SAWS (2008) Caelum - A History of Notable Weather Events in South Africa 1647- 2007. Pretoria.

DEA (2004). National Environment Management: Air Quality Act. No.27318. South Africa, Government Gazette. 476: 56.

DEA (2009a). State of the Air Report 2005, National Environmental Management: Air Quality Department of Environmental Affairs. Pretoria.

DEA (2009b). National Environmental Management: Air Quality Act, 2004, National Ambient Air Quality Standards 1210. Department of Environmental Affairs, Pretoria, Government Gazette. Act 39 of 2004.

DEA (2010). National Environment Management: Air Quality Act- List of activities which may result in atmospheric emissions which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions ecological conditions or cultural heritage. No.33064. South Africa, Government Gazette. 537.

Geer, I.W. (ed.) (1996), Glossary Of Weather And Climate With Related Oceanic And Hydrologic Terms. Boston, American Meteorological Society.

Golder Associates (2011). Surface Water Technical Report in support of the EMP for the South Western Karoo Basin Gas Exploration Application Project: CENTRAL PRECINCT, Report 12800-10376-11

Goliger A.M., Milford R.V., Adam B.F. and Edwards M. (1997), Inkanyamba - Tornadoes in South Africa. Pretoria, United Litho.

Integrated Pollution Prevention and Control (IPPC) (2005). *Reference Document on Best Available Techniques for Waste Treatment Industries.*, European Commission

Integrated Pollution Prevention and Control (IPPC) (2006). *Reference Document on Best Available Techniques for Food, Drink and Milk Industries.*, European Commission

Kunz, R (2004). Daily Rainfall Data Extraction Utility, Version 1.4.

Loveday M 1995. *Clean Air Around the World. National Approaches to Air Pollution Control*, published by the International Union of Air Pollution Prevention and Environmental Protection Association, Brighton, 402 pp.

Pope III, Arden C, Schwartz, J and Ransom M R 1992. Daily Mortality and PM-10 Pollution in Utah Valley, *Archives of Environmental Health*, 42(3), 211-217.

Pope III, Arden C, Thun, M J, Namboordiri, N M, Dockery, D W, Evans J S, Speizer, F E and Heath Jr, C W 1995. Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults, *American Journal of Critical Care Medicine*, 151(3), 669-674.

Preston-Whyte R A and Tyson P D 1988. *The Atmosphere and Weather over South Africa*, Oxford University Press, Cape Town, 374 pp.

Schulze B R 1986. *Climate of South Africa. Part 8: General Survey*, WB 28, Weather Bureau, Department of Transport, Pretoria, 330 pp.

Schwela D 1998. *Health and Air Pollution – A Developing Country's Perspective*, Paper 1A-1, Papers of the 11th World Clean Air and Environment Congress, 13-18 September 1998, Durban, South Africa.

Smithers, JC and Schulze, RE (2002). "Rainfall Statistics for Design Flood Estimation in South Africa", WRC Project K5/1060, Pretoria, South Africa.

WB 40 1984. *Climate of South Africa. Climate Statistics up to 1984*. WB40, Weather Bureau, Department of Environmental Affairs, Pretoria

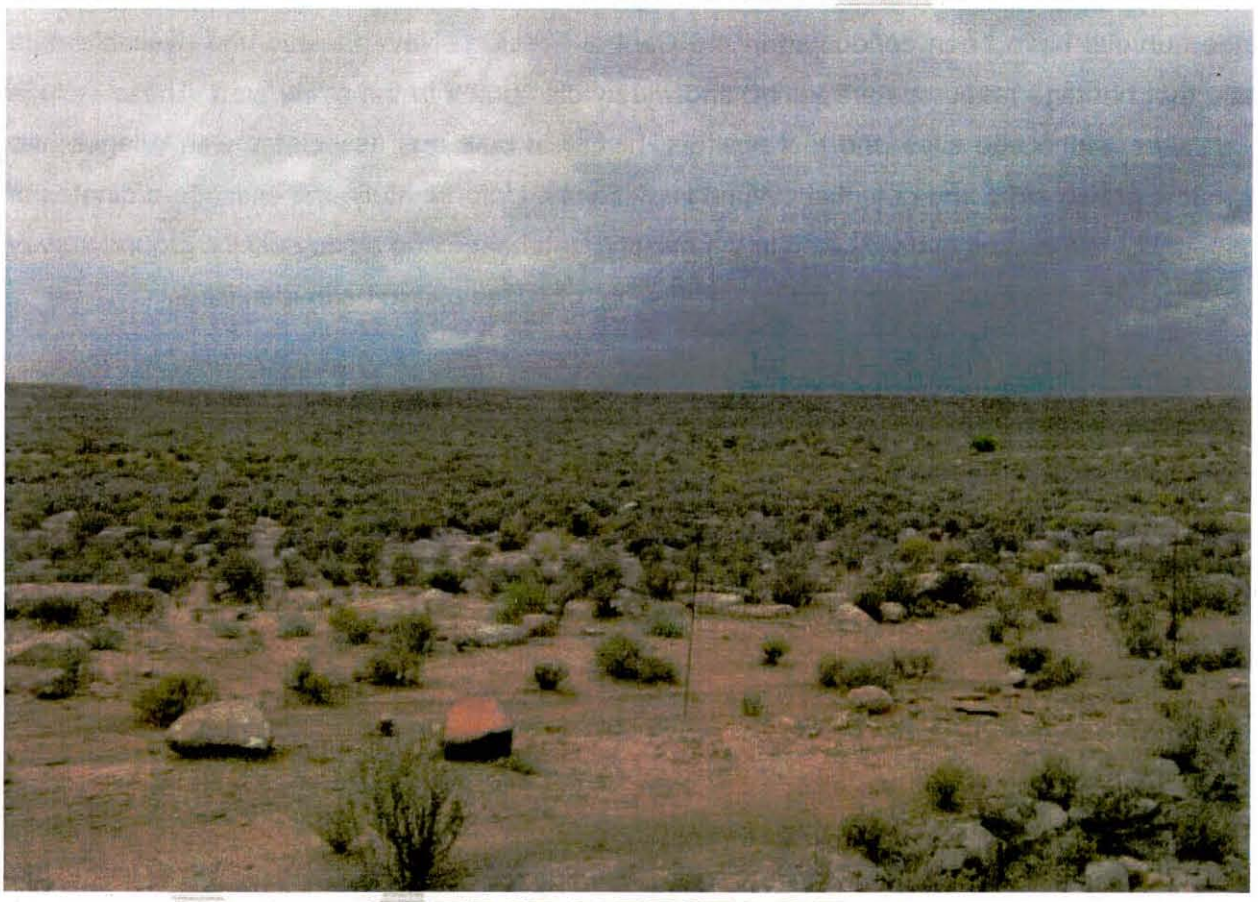
WHO 2000. *Air Quality Guidelines*, World Health Organisation, April 2000, Geneva.
WRC, 1994. Surface Water Resources of South Africa, 1990, Volume III. WRC Report No. 298/3.2/94.

WRC, 1994. Surface Water Resources of South Africa, 1990, Volume IV. WRC Report No. 298/4.2/94.

SHELL INTERNATIONAL EXPLORATION AND PRODUCTION B.V.

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

CULTURAL HERITAGE: CENTRAL PRECINCT



ACTIVE HERITAGE cc.

Frans Prins
MA (Archaeology)
P.O. Box 94

Howick

3290

feprins@gmail.com

February 2011

EXECUTIVE SUMMARY

Active Heritage cc has been appointed by Golder Associates Africa (Golder) on behalf of Shell Exploration Company B.V. (Shell), to undertake a desktop Heritage Scoping Level report, as part of the EMP process, of the proposed 30 000 square kilometre exploration area in the south western Karoo Basin referred to as the Central Precinct.

The main aim of this desktop study is to provide a synopsis of the heritage resources in the Central Precinct. The results of the desktop study indicated that available data is limited. Only a few heritage surveys have been conducted in the Central Precinct. Nevertheless, the available data indicate that heritage resources are varied and widely distributed in the study area. These include rock art sites, stone age sites and tool scatters, historical buildings associated with villages and farmsteads, graveyards, and potential cultural landscapes. Unfortunately, the exact co-ordinates of the majority of these sites are not given in the existing databases and a site specific ground survey will be required in the areas earmarked for gas drilling, once they have been identified.

ACRONYMS AND ABBREVIATIONS

ESA	Early Stone Age
HISTORIC PERIOD	Since the arrival of the white settlers - c. AD 1770 in this part of the country
IRON AGE	Early Iron Age AD 200 - AD 1000 Late Iron Age AD 1000 - AD 1830
LIA	Late Iron Age
LSA	Late Stone Age
MSA	Middle Stone Age
NEMA	National Environmental Management Act, 1998 (Act 107 of 1998) and associated regulations.
NHRA	National Heritage Resources Act, 1999 (Act No. 25 of 1999) and associated regulations (2000)
SAHRA	South African Heritage Resources Agency
STONE AGE	Early Stone Age 2 000 000 - 250 000 BP Middle Stone Age 250 000 - 25 000 BP Late Stone Age 30 000 - until c. AD 200

DEFINITIONS OF TERMINOLOGY

Archaeology: Remains resulting from human activities that are in a state of disuse and are in or on land which are older than 60 years, including artefacts, human and hominid remains, and artificial structures and features.

Early Stone Age: the archaeology of the Stone Age between 700 000 and 2500 000 years ago.

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

Holocene: the most recent geological period that commenced approximately 10 000 years ago.

Late Stone Age: The archaeology of the last 20 000 – 30 000 years associated with fully modern people.

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

Iron Age: The archaeology of the last 2000 years associated with Bantu-speaking agro-pastoralists.

National Estate: the collective heritage assets of the nation.

SAHRA: The South African Heritage Resources Agency – the compliance agency that protects national heritage.

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

Table of Contents

1.0 BRIEF OVERVIEW OF THE PROPOSED EXPLORATION APPLICATION PROJECT

Active Heritage cc has been appointed by Golder Associates Africa (Golder) on behalf of Shell Exploration Company B.V. (Shell), to undertake a desktop Heritage Scoping Level report, as part of the EMP process, of the proposed 30 000 square kilometre exploration area in the south western Karoo Basin referred to as the Central Precinct.

The precinct intersects the Eastern, Western and Northern Cape Provinces, and covers the Cacadu, Central Karoo, Chris Hani, and Pixley ka Seme District Municipalities (Figure 1).

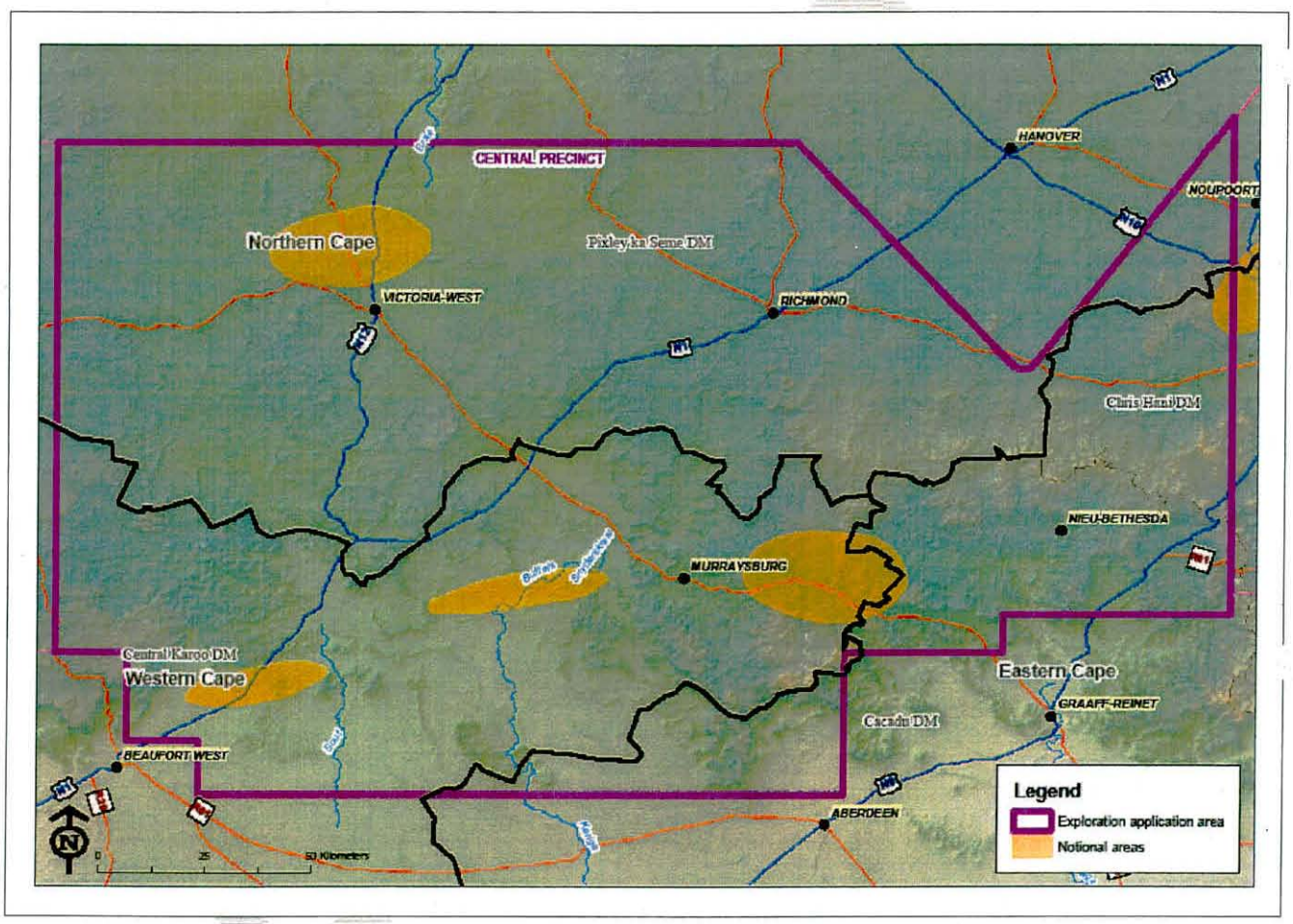


Figure 1: South Western Karoo, Central Precinct (purple line) and possible areas within which suitable well sites may be identified for future exploration drilling activities (orange polygons).

2.0 OBJECTIVES AND AIMS OF THIS STUDY

Active Heritage cc was subcontracted by Golder to undertake a desktop cultural heritage assessment for the South Western Karoo Basin, Central Precinct (Figure 1). This first phase of a cultural heritage assessment is required as a preliminary desktop exercise to identify potential heritage resources which may be impacted during site preparation, drilling and hydraulic fracturing, and decommissioning. The conclusions reached are entirely based on the available literature and the consultation of accessible heritage databases and registers. The project seeks to assess the value and significance of the known heritage resources found within the study area as well as ensure their protection and conservation. The view is promoted that development should take place in harmony with the sustainable use of heritage resources.

At this stage of the process, the heritage practitioner is required to provide:

- Description of the exploration application area in terms of cultural heritage; and
- Description of potential impacts of proposed exploration activities on heritage resources.

3.0 LEGISLATION

The National Heritage Resources Act 1999 (Act No. 25 of 1999) (NHRA) prescribes the manner in which heritage resources are assessed and managed. Section 3 (2) of this act defines South Africa's heritage resources to include:

"*a. places, buildings, structures and equipment of cultural significance;*
b. places to which oral traditions are attached or which are associated with living heritage;
c. historical settlements and townscapes;
d. landscapes and natural features of cultural significance;
e. geological sites of scientific or cultural importance;
f. archaeological and palaeontological sites;
g. graves and burial grounds, including-
i. ancestral graves;
ii. royal graves and graves of traditional leaders;
iii. graves of victims of conflict;
iv. graves of individuals designated by the Minister by notice in the Gazette;
v. historical graves and cemeteries; and
vi. other human remains which are not covered in terms of the Human Tissue Act, 1983 (Act No. 65 of 1983);

h. sites of significance relating to the history of slavery in South Africa;

i. movable objects, including-

i. objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens;

ii. objects to which oral traditions are attached or which are associated with living heritage;

iii. ethnographic art and objects;

iv. military objects;

v. objects of decorative or fine art;

vi. objects of scientific or technological interest; and

vii. books, records, documents, photographic positives and negatives, graphic, film or video material or sound recordings, excluding those that are public records as defined in section 1(xiv) of the National Archives of South Africa Act, 1996 (Act No. 43 of 1996)."

The NHRA also stipulates in Section 3 (3) that a place or object is to be considered part of the national estate if it has cultural significance or other special value because of:

"*a. its importance in the community, or pattern of South Africa's history;*

b. its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;

c. its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;

d. its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects;

e. its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;

f. its importance in demonstrating a high degree of creative or technical achievement at a particular period;

g. its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;

h. its strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa; and

i. sites of significance relating to the history of slavery in South Africa."

The NHRA also protects intangible heritage such as traditional activities, oral histories and places where significant events happened.

3.1 Relevant Authority

The relevant authority is the applicable local heritage agency; Western Cape Heritage is the relevant authority for those areas that fall within the Western Cape Province, whereas the SAHRA is the relevant authority for all other areas. The Northern Cape has a Built Environment Committee that will assess the built environment aspects of the project.

3.2 Significance rating / grading of heritage sites

Heritage resources are rated / graded in terms of significance. Heritage resources significance is determined through an assessment and grading criteria in terms of Section 7 of NHRA. In addition, in 2005, the SAHRA designed criteria (Table 1) to provide assistance and guidance for heritage resources rating and significance determination.

The SAHRA is responsible for heritage resources of national significance while the Provincial Heritage Resources Authorities are responsible for provincial heritage resources. It is important to note that the assessment of the significance of and rating of heritage resources depends on their state of conservation at the time of the assessment.

Table 1: Field rating and recommended grading of sites (SAHRA 2005)

Level	Details	Action
National (Grade I)	The site is considered to be of National Significance	Nominated to be declared by SAHRA
Provincial (Grade II)	This site is considered to be of Provincial significance	Nominated to be declared by Provincial Heritage Authority
Local Grade IIIA	This site is considered to be of HIGH significance locally	The site should be retained as a heritage site
Local Grade IIIB	This site is considered to be of HIGH significance locally	The site should be mitigated, and part retained as a heritage site
Generally Protected A	High to medium significance	Mitigation necessary before destruction
Generally Protected B	Medium significance	The site needs to be recorded before destruction
Generally Protected C	Low significance	No further recording is required before destruction

4.0 STUDY APPROACH / METHODOLOGY

This first phase heritage assessment is entirely based on a desktop study. No field surveys took place during this phase.

4.1 Desktop

3.1.1 Literature Survey

A survey of the literature pertinent to the region, including archaeological, anthropological and historical sources was conducted to assess the potential of heritage resources within the area. Past heritage impact assessment survey reports conducted within the general project provided useful data as well. Unfortunately these only covered a few selected parts of the project area and many gaps remain.

3.1.2 Databases

The SAHRA web portal for gazetted sites, objects and shipwrecks was consulted. The Heritage Register List of SAHRA was also used to shed light about heritage resources present in the area. The archaeological databases of the Albany Museum in Grahamstown and National Museum, Bloemfontein provided some information relating to archaeological resources in the study area. The SARADA database of rock art in Africa was also consulted. The latter is housed at the Rock Art Research Institute at the University of the Witwatersrand.

4.2 Restrictions and assumptions

- The available databases are incomplete. Large areas of the study area have never been surveyed from a heritage perspective. The GPS coordinates are not available for all the listed sites.
- The study area has not been subject to a field survey. This is entirely a desktop based survey and no field or ground surveys were conducted. However, these will commence furthering the next phase of project.

5.0 STUDY RESULTS / BASELINE DESCRIPTION OF THE STUDY AREA

5.1 Desktop

4.1.1. Pre-colonial Archaeology

Large portions of the Northern Cape Province have been thoroughly surveyed for heritage sites by the Archaeology Department of the McGregor Museum in Kimberley (Beaumont *et al.*, 1990). However, most of these areas occur to the north of the Central Precinct. Dr Janette Deacon, formerly of the National Monuments Council, surveyed the area to the immediate northwest of the

Central Precinct in her research on /Xam San archaeology and symbolic use of landscape (Deacon, 1986 and 1988; Deacon and Dowson 1996; Deacon and Foster 2005). The Archaeology Department of the Albany Museum, Grahamstown conducted a small survey in the Camdeboo National Park, near the south-eastern border of the Central Precinct, in the 1980's. Smaller sporadic visits to rock art sites were conducted by various researchers in the area in the last 20 years, notably by archaeology staff of the National Museum Bloemfontein, the Rock Art Research Institute, and the McGregor Museum, Kimberley. Some heritage impact assessments have been conducted at substations near Victoria-West, and Beaufort-West. The extensive Gamma Grassridge transmission line that runs from Port Elizabeth to near Victoria-West cuts through a large section of the Central Precinct. The heritage survey conducted along the proposed route gives a good indication of the type of heritage site to be expected in the southern and central sections of the Central Precinct. Van Schalkwyk and Wahl (2007) reported isolated scatters of stone tools on the plains, some rock painting sites in the mountains of the Camdeboo, and freshwater shell middens containing bone, stone tools, and food remains along river banks, pans and flood plains. The most comprehensive archaeological survey in the area was conducted by Professor Garth Sampson and his students over a period of 30 years in the Upper, Middle and Lower Seacow River. Part of area surveyed cuts across the Eastern Precinct as well. More than 16 000 Stone Age sites were recorded during this period (Sampson 1985). Rock art sites occur at various localities in the Central Precinct. Perhaps the best known site is the rock engravings at Nelspoort near Beaufort–West in the south western section of the Central Precinct. This site has recently been developed for tourism purposes. The SARADA data base of rock art indicates that rock paintings and engravings occur at various localities within the Central Precinct. Rock art has been recorded on four other farms near Beaufort-West, at sixteen different localities in the greater Richmond area, at two farms near Murraysburg, at two farms near Nieu Bethesda, and at one locality near Victoria West (Van Riet-Lowe 1941).

Although the Karoo is presently more suited to the keeping of small stock, such as sheep and goats research has shown that, at about 1200 – 1400AD, a global climatic fluctuation (known as the Little Ice Age) may well have caused an increased rainfall in the Central Karoo resulting in the area being more suitable for the grazing by cattle and occupation by Khoekhoen pastoralists. Archaeological of pastoralist occupation of vast areas in the Karoo are indicated by various stone kraal complexes of which several hundred have been recorded in the Zeekoe River Valley in the Central and Eastern Precinct of the study area (Sampson 1985).

4.1.2. Colonial Archaeology

The indigenous San of the Karoo waged a bitter war against colonial expansion as they gradually lost control of their traditional land. The historian Nigel Penn (2005) noted that the most determined indigenous resistance to Trekboer expansion occurred when they entered the harsh environment of the escarpment of the interior plateau (Hantam, Roggeveld and Nieuweveld Mountains). Being pastoralists themselves the Trekboers settled on the escarpment where most of the springs were found. From here they were able to exploit the grazing lands further west and north. The Trekboers were highly mobile, each had a farm in the Karoo called a legplaats. Winters were very severe and the Trekboers had to move regularly. Often farms were abandoned, not only due to the San who raided them for livestock, but also due to drought and poor grazing. Disputes over farm boundaries were intense. The first recorded loan farms in the area date to around 1770 and most of the farms in the area were surveyed by the mid to late nineteenth century.

Resistance to the Trekboer expansion from the indigenous San was particularly intense in this area. Koerikei, the bullet escaper, was the leader of the San in the vicinity of Graaff-Reinett during the 1770's – a period that saw major animosity between the San and Trekboers as the latter invaded new areas formerly only occupied by the San. Koerikei has become famous in the historiographic literature for symbolising the resistance of the San to the expansion of the colonial frontier in the eighteenth century (Penn 2005; Adhikari 2010). This period of conflict (i.e.1756-1787) has also been called the period of the Bushman Wars – a period that ultimately saw the implementation of a policy of genocide against the San in the project area. The severity of the conflict between the invading Trekboers and the nomadic San of this region has been graphically described by the historians Nigel Penn (2005) and Mohamed Adhikari (2010). Within a few decades the Trekboers, and other colonial agents, hunted all the large game of the Karoo, to near extinction. Homesteads were typically erected at springs or other water sources previously frequented by the San. The San were forced to initiate a pattern of livestock raids in order to survive but also as a method to regain their former independence of the land. The San often attacked farms at dawn, killed the livestock herders who were often Khoi or San themselves, and then chased the cattle up the mountain passes of the Sneeuberg where they would often offer fierce resistance to pursuing commandos. Literally thousands of San were killed by commando's during this period. San children and women were often captured and taken back to the farms as a form of slavery known as "inboekelinge". Captured San women were sometimes given as wives to Khoi auxiliaries who aided the Trekboers in exterminating the San. But San resistance to colonial expansion was also fierce. In fact, it halted the expansion of the north eastern frontier with almost 100 years.

When the famous traveller Robert Gordon travelled though the Camdeboo, in the southern section of the Central Precinct, many frontier farmers had abandoned their farms in the Sneeuberg Mountains out of fear for being attacked by the San. The traveller Andrew Sparman made a similar observation a few years earlier in 1772. However, by 1880 San resistance to colonial expansion in the Karoo was something of the past (Gall 2002). Those San who were not killed by colonial forces were carried of to farms as labourers where they soon intermarried with colonial Khoi, slaves as well as people of European descent to form a new population group collectively known as "coloureds" (Smith et al 2000).

From the above it can be predicted that there may be a number of old graveyards and possibly historic buildings belonging to the early Trekboer period on various farms in the area. However, none of these have been assessed. Another notable feature is the corbelled houses that developed as a vernacular architecture of the northern Karoo and "Bushmanland" districts during the nineteenth century. These have been developed to cope with a scarcity of wood as a building resource and as a measure to combat San attacks (Oberholster 1972). The majority of these occur near Williston and Carnavron in the Western Precinct. However, some do occur near Beaufort-West in the Central Precinct and one has been declared provincial heritage site (Oberholster 1972). Other declared provincial heritage sites include:

- Twelve historical buildings in Beaufort-West
- The old powder magazine at Murraysburg
- Two declared provincial heritage sites near Noupoort. These include a blockhouse from the Anglo-Boer War and a church building.
- One historical building declared as a provincial heritage site at Victoria-West. Ninety other historical sites, mostly homesteads, are listed on the SAHRA register as occurring in this town.
- Two historical buildings declared as provincial heritage sites at Richmond. Sixty three other historical sites, mostly homesteads, are listed on the SAHRA register as occurring in this town.

4.1.3. Cultural landscapes and sense of place

As no field surveys have been undertaken and descriptions of the receiving environment is based on published material and aerial maps it is difficult to establish whether specific areas could be described as cultural landscapes. Nevertheless, the landscape of the Central Precinct can be described as a remote arid landscape and its visual qualities linked to the undulating topography and undisturbed nature of the landscape. The only intrusions are existing transmission lines,

scattered homesteads, wind pumps, and access roads. These contribute to the rural landscape. "There is a perceived sense of absence of human intervention or intrusion" (Patrick et al. 2009), the vast empty expanses exemplifying the qualities of the Karoo.

The historic town of Graaff-Reinett situated to the immediate south of the Central Precinct would be an ideal candidate for nomination as a cultural landscape. This scenic town harbours almost 200 provincial heritage sites – more than any other town in South Africa (Oberholster 1972). These are mostly historic buildings belonging to the 19th century period, however, the town is also situated in the mountain shadows of the Camdeboo National Park – an area that contains various San hunter-gatherer and Khoekhoen pastoralist archaeological sites as well as rock art. The scenic natural heritage site of the "Valley of Desolation" is also situated within this Provincial Park. Various memorials and monuments relating to the Khoisan genocide, Voortrekker leaders, Anglo-Boer War, and the more recent struggle history of South Africa are located in and around this town. Although not strictly situated within the borders of the Central Precinct it does indicate the potential that may exist for similar cultural landscapes in areas less well surveyed and documented within the study area.

A possible extension of the cultural landscape of Graaf-Reinett would be the Sneeuberge (Snow Mountains) the mountainous area immediately to the north of the town and well situated within the Central and Eastern Precincts of the study area. Not only is the Sneeuberge a prominent physical marker on the landscape of the Eastern Karoo but it is an important icon in the sad history of the now extinct Karoo San. For many decades this area functioned as the last stronghold of the San. At one point San resistance here was so effective against colonial expansion that it effectively halted Trekboer movement for almost 30 years (Penn 2003; Adhikari 2010). The Sneeuberg and adjacent areas contain numerous Later Stone Age sites associated with San settlement of the central interior. The Seacow River area alone contains around 16 000 sites (Sampson 1985). This is more than any other area of comparable size in southern Africa. Here, as well as elsewhere in the larger Sneeuberg area are numerous San rock painting and engraving sites. Some spectacular examples occur on the farm Ganora not far from the little town of Nieu Bethesda, itself an interesting village filled with historical buildings and ambiance. Although not inhabited by Khoekhoen pastoralists in historical times there is archaeological evidence for their occupation of the area during wetter climatic epochs such as during the so-called Little Ice Age around 1400 AD. Old buildings and graves relating to early Trekboer history occur on various farms in the area (Van Schalkwyk & Wahl 2007). In addition, the area contains numerous palaeontological sites. However, there is a need to compile a thorough inventory of heritage sites in this area and that can only happen once ground surveys have been initiated.

4.1.4 Discussion

As the Central Precinct has only seen limited heritage surveys and investigations in the past it would be meaningless to produce a map indicating the heritage sensitive spots in this area based on the desktop survey of available data. As indicated previously, this survey needs to be supplemented by ground surveys (subsequent to site selection) in order to provide a more comprehensive picture of heritage sites and features on the landscape. Based on the available heritage data it is possible to indicate broad patterns that may assist the site selection team in avoiding heritage sites and the potential damage thereof. These are provided in Section 8.1 below.

6.0 TECHNIAL ASSESSMENT

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

Cultural heritage includes both tangible and intangible aspects. The tangible aspects of heritage such as archaeological sites, historical buildings, and to some extent cultural landscapes are for the most part non-renewable. Unlike natural resources tangible, cultural heritage cannot be renewed once damaged or destroyed. Land rehabilitation measures will have no effect on tangible cultural heritage once altered or destroyed. Exploration related activities which could potneitally damage heritage sites or structures are outlined below.

Well site preparation

- Construction of access roads and preparation of the well site could damage heritage sites and features in the immediate environs of the well site. The generation of dust could pose a threat to rock paintings in close proximity to the site.
- Transportation of exploration equipment / vehicle movement outside of existing roads. Large areas of the Karoo are flat and it would be relatively easy to drive with a high clearance vehicle over these parts. However, stone tools scatters and other heritage features may occur in these flat areas and will be at risk, if the transportation is not limited to roads.

Exploration drilling and hydraulic fracturing

- Drilling and hydraulic fracturing could damage heritage sites and features in the near environs of the well site. Excessive dust created by drilling activities could also damage certain heritage sites such as rock paintings.

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

- Explorative drilling may unearth heritage material not located during the heritage ground survey. Should any heritage site or artefacts be unearthed then all activities should stop immediately and the local heritage agencies (i.e. Western Cape Heritage and SAHRA) be contacted for further evaluation. It is recommended that a heritage awareness guide be provided to the well site preparation personnel and drilling crew to help them identify heritage resources, should they be unearthed during activities.

Decommissioning

- It is unlikely that decommissioning should have any potentially negative impact on heritage sites and features not previously addressed. However, land rehabilitation processes may have a negative impact on heritage sites in the immediate environs of the rehabilitation site.

6.2 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 operational life of the activity)
1 - Improbable	1 – Immediate
0 - None	
SCALE	**MAGNITUDE**
5 - International	10 - Very high/don't know
4 - National	8 - High
3 - Regional	6 - Moderate
2 - Local	4 - Low
1 - Site only	2 - Minor
0 - None	

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

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

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

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

6.3 Assessment

Table 2 below summarises those impacts directly related to the proposed exploration project, and provides a significance rating for each impact before and after mitigation.

Table 2: Technical Assessment Matrix for the proposed South Western Karoo Basin Gas Exploration Application Project

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	Total	SP	M	D	S	P	Total	SP
Cultural Heritage												
Construction of access roads and preparation of the well site could damage heritage sites and features in the immediate environs of the well site. The generation of dust could pose a threat to rock paintings in close proximity to the site.	6	5	2	3	60	**Mod**	2	5	2	1	16	**Low**

Construction of access roads and the well site could damage heritage sites and features in the immediate environs of the proposed well site.

Impacts of moderate significance are expected if the proposed access road is situated within the immediate environs of a heritage site (i.e. within 20 m), if the proposed well site is located within 50 m from a heritage site, and the proposed well site and/or access road are located within 100 m of rock art sites.

Should the following mitigation measures be implemented prior to site preparation and construction, impact significance will be reduced to low:

- During well site selection, no sites should be placed within 100 m of declared national and provincial heritage sites.
- Once the preliminary sites are selected, a site specific cultural heritage impact assessment will need to be conducted to identify any heritage sites and features. Based on the findings of the assessment:
    - No access roads should be constructed within 20 m of identified heritage sites and features which are rated as sites of high local significance by the South African Heritage Resources Agency (SAHRA) (see Table 1 above);
    - No well sites should be constructed within 50 m of heritage sites and features which are rated as sites of high local significance by the SAHRA; and
    - No well sites or access roads should be constructed within 100 m of rock art sites which are rated as sites of high local significance by the SAHRA.

The site specific cultural heritage impact assessment will therefore inform final site selection.

Note: the SAHRA usually allows for development to commence where heritage sites or features are rated as sites of low significance (i.e. are not of any regional or local importance and/or are duplicated in many areas).

Should heritage sites rated as sites of medium to high significance be located within the above-mentioned buffer zones in relation to the selected well sites, appropriate mitigation measures will need to be implemented, in consultation with the relevant heritage agency. Mitigation could entail rescue excavation, once a permit is granted by the SAHRA.

Should any archaeological or heritage features artefacts be uncovered during exploration, all activities must be stopped and an archaeologist accredited with the Association for Southern African Professional Archaeologist (ASAPA) approached in order to determine appropriate mitigation measures for the discovered finds, if necessary. Mitigation of heritage sites will be called for when they are rated as of medium to high significance. Mitigation could entail rescue excavation of relevant heritage sites - once a permit is granted for excavation by the SAHRA. If the relevant heritage sites include graves then the protocol provided in Section 36 of the National Heritage Resources Act, 1999 (Act 25 of 1999), regarding grave exhumation, will be followed (see APPENDIX 1).

It is recommended that a heritage awareness guide be provided to the well site preparation personnel and drilling crew to help them identify heritage resources, should they be unearthed as a result of the exploration related activities.

6.4 Assumptions and knowledge gaps / limitations

- It is assumed that the vibrations caused by the proposed drilling will not have a negative impact on sites situated more than 100 m from the 1 hectare well sites.
- It is assumed that the dust caused by the proposed drilling will not have a negative impact on rock painting sites situated more than 100 m from the 1 hectare well sites.

7.0 MITIGATION AND MANAGEMENT MEASURES

The following mitigation measures have been identified for the proposed project (Table 3).

Table 3: Environmental Management Plan for proposed South Western Karoo Basin Gas Exploration Application Project

Environmental Management Plan			Timeline and frequency	Responsible party
1. Cultural Heritage				
	Project activity:	Construction of access roads and well site preparation.	-	-
	Impact:	Damage to heritage sites and features in the immediate environs of the site.	-	-
1.1	**Mitigation measure(s):**	During well site selection, no sites should be placed within 100 m of declared national and provincial heritage sites.	Site selection	Site selection team
		A site specific heritage impact assessment will need to be conducted to identify any heritage sites and features. ■ Areas identified for access road construction should be surveyed for heritage sites on the ground. ■ The one hectare well sites must be thoroughly surveyed (i.e. ground survey) for any heritage sites or features.	As appropriate, before construction of access roads and well site preparation	Heritage practitioner
		Based on the findings of the assessment: ■ No access roads should be constructed within 20 m of identified heritage sites and features which are rated as sites of high local significance by the South African Heritage Resources Agency (SAHRA) (see Table 1); ■ No well sites should be constructed within 50 m of heritage sites and features which are rated as sites of high local significance by the SAHRA; and ■ No well sites or access roads should be constructed within 100 m of rock art sites which are rated as sites of high local significance by the SAHRA.	As appropriate, to be determined prior to well site preparation and road construction and implemented throughout exploration	Drilling Contractor / SHEC
	Mitigation measure(s):	Should heritage sites rated as sites of medium to high significance be located within the above-mentioned buffer zones in relation to the selected well sites, appropriate mitigation measures will need to be implemented, in consultation with the relevant heritage agency. Mitigation could entail rescue excavation, once a permit is granted by the SAHRA.	As appropriate, before construction of access roads and well site preparation	Heritage practitioner

Environmental Management Plan			Timeline and frequency	Responsible party
		Should any archaeological or heritage features artefacts be uncovered during exploration, all activities must be stopped and an archaeologist accredited with the Association for Southern African Professional Archaeologist (ASAPA) approached in order to determine appropriate mitigation measures for the discovered finds, if necessary. Mitigation of heritage sites will be called for when they are rated as of medium to high significance. Mitigation could entail rescue excavation of relevant heritage sites - once a permit is granted for excavation by the SAHRA. If the relevant heritage sites include graves then the protocol provided in Section 36 of the National Heritage Resources Act, 1999 (Act 25 of 1999), regarding grave exhumation, will be followed.	If necessary, throughout exploration	Drilling Contractor / SHEC
		It is recommended that a heritage awareness guide be provided to the well site preparation personnel and drilling crew to help them identify heritage resources, should they be unearthed as a result of the exploration related activities.	As appropriate, prior to access road construction, well site preparation, drilling	SHEC

7.1 Recommended monitoring programmes

Sites situated closer than 200 m from the well sites and rated as significant and fragile should be monitored on a monthly basis until such time that exploration activities cease.

8.0 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.

8.1 Recommended site selection criteria

The following areas need to be avoided during site selection:

- Declared national and provincial heritage sites. Twenty Provincial Heritage sites occur in the Central Precinct. These are all historical sites that relate to the heritage of white colonists.

Prior to final site selection, a ground survey should be conducted. The following areas may contain heritage sites and should be considered during the undertaking of the ground survey:

- Rock shelters in the river valleys bisecting the mountain ranges will contain rock paintings and archaeological deposit.
- Dolerite outcrops and boulders may contain rock engravings. Karoo koppies consisting of dolerite boulders are promising candidates in this regard.
- Some rock engraving sites may occur on base rock adjacent to rivers or close to water sources.
- Scatters of Early, Middle and Later Stone age artefacts may also occur near fountains and water courses.
- Stone walling, including stone walled enclosures, related the Khoekhoen pastoralist activities in this area may also be found in the southern section of the Central Precinct.
- Old farmsteads, older than 60 years and hence of heritage significance, will occur on most farms in the area. We may anticipate that these may consist of farmhouses, sheds, outbuildings, kraals and other structures.
- The characteristic corbelled houses of the Great Karoo also occur in the Beaufort-West area. One of these has been declared a Provincial Heritage sites but all of them are protected by the NHRA.

- Various historical buildings will occur in the small towns in the area. These consist of houses, churches, and block houses.
- Graves belonging to both the indigenous San as well as colonial graveyards will occur on various farms and small towns in the area. These are typically indicated by stone heaps (as in the case with San graves) or formal and informal grave stones.
- Pans and watercourses. These features were a foci of human activity in the past and prehistoric and colonial-era heritage sites may be found near its environs.

8.2 Key questions to be addressed in the EIA

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

- Are there any heritage resources or features located within or nearby (i.e. within 200 m) selected well sites and new access road alignments?
- If so, what is the significance of the heritage resource or feature (according to SAHRA rating and grading of sites)?
- Should heritage resources or features be rated as medium or high significance, what mitigation measures need to be implemented?

9.0 CONCLUSION

This preliminary Heritage Impact Assessment is based on a desktop survey of available literature and heritage databases. Only a few heritage surveys have been conducted in the Central Precinct and the available data is incomplete. Nevertheless, the available data indicate that heritage resources are varied and widely distributed in the study area. These include rock art sites, Stone Age sites and tool scatters, historical buildings associated with villages and farmsteads, graveyards, and potential cultural landscapes. Unfortunately the exact coordinates of the majority of these sites are not given in the existing data bases and a site specific ground survey will be required for those areas earmarked for gas drilling, once they have been identified.

10.0 REFERENCES

Adhikari, M. 2010. *The Anatomy of a South African Genocide: the Extermination of the Cape San Peoples.* UCT Press: Cape Town

Beaumont, P. & Morris, D. 1990. *Guide to Archaeological sites in the Northern Cape.* McGregor Museum, Kimberley.

Gaill, S, 2002. *The Bushmen of Southern Africa: Slaughter of the Innocent.* Pimlico: Great Brittain

Oberholster, J. J., 1972. *The Historical Monuments of South Africa.* Rembrandt van Rijn Foundation: Cape Town

Parkington, J, Morris, D, & Rusch, N. 2008. *Karoo Rock Engravings: Follow the San.* Creda Communications: Cape Town.

Patrick, M. 2009. *Final Scoping Heritage Impact Assessment: Gamma-Omega 765kV transmission line.* Unpublished report for PD Naidoo on behalf of Eskom Holdings.

Penn, N. 2005. *The Forgotten Frontier: Colonist and Khoisan on the Cape's Northern Frontier in the 18th century.* Ohio University Press: Athens

SAHRA, 2005. Minimum Standards for the Archaeological and the Palaeontological Components of Impact Assessment Reports, Draft version 1.4.

SAHRA. 2009. *Archaeology, Palaeontology and Meteorite Unit: Report Mapping Project.*

Sampson, C G., 1985. Atlas of Stone Age settlement in the central and upper Seacow River Valley. *Memoirs van die Nasionale Museum Bloemfontein.* No. 20.

Sampson C G., Hart, C, Wallsmith, T, Blagg, J. D. 1989. The ceramic sequence in the upper Seacow Valley; problems and implications. *South African Archaeological Bulletin* 44: 3-16

Smith, A, Malherbe, C, Guenther, M, Berens, P. 2000. *The Bushmen of Southern Africa: a foraging society in transition.* Clyson Printers: Cape Town

Van Riet-Lowe, C., 1941. *Prehistoric Art in South Africa.* Bureau of Archaeology: Archaeologicl Series no. v. Government Printers: Prertoria.

Van Schalkwyk, L & Wahl, E. 2007. *Heritage Impact Assessment of the Gamma Grassridge Powerlines and substation, Eastern, Western, and Northern Cape Provinces South Africa.* For ACER (Africa) by eThembeni Cultural Heritage. Unpublished Report.

Frans E Prins

APPENDIX 1 RELOCATION OF GRAVES

Burial grounds and graves are dealt with in Article 36 of the NHR Act, no 25 of 1999. Below follows a broad summary of how to deal with grave in the event of proposed development.

- If the graves are younger than 60 years, an undertaker can be contracted to deal with the exhumation and reburial. This will include public participation, organising cemeteries, coffins, etc. They need permits and have their own requirements that must be adhered to.
- If the graves are older than 60 years old or of undetermined age, an archaeologist must be in attendance to assist with the exhumation and documentation of the graves. This is a requirement by law.

Once it has been decided to relocate particular graves, the following steps should be taken:

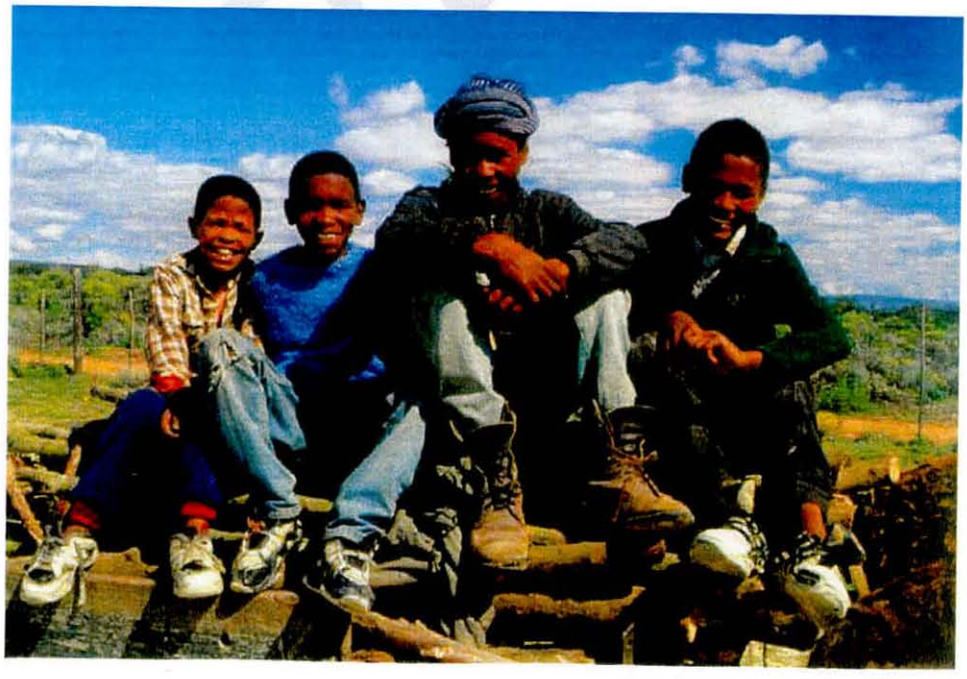
- Notices of the intention to relocate the graves need to be put up at the burial site for a period of 60 days. This should contain information where communities and family members can contact the developer/archaeologist/public-relations officer/undertaker. All information pertaining to the identification of the graves needs to be documented for the application of a SAHRA permit. The notices need to be in at least 3 languages, English, and two other languages. This is a requirement by law.
- Notices of the intention needs to be placed in at least two local newspapers and have the same information as the above point. This is a requirement by law.
- Local radio stations can also be used to try contact family members. This is not required by law, but is helpful in trying to contact family members.
- During this time (60 days) a suitable cemetery need to be identified close to the development area or otherwise one specified by the family of the deceased.
- An open day for family members should be arranged after the period of 60 days so that they can gather to discuss the way forward, and to sort out any problems. The developer needs to take the families requirements into account. This is a requirement by law.
- Once the 60 days has passed and all the information from the family members have been received, a permit can be requested from SAHRA. This is a requirement by law.
- Once the permit has been received, the graves may be exhumed and relocated.
- All headstones must be relocated with the graves as well as any items found in the grave

February 2011

DRAFT REPORT

SOCIAL TECHNICAL ASSESSMENT

South Western Karoo Basin Gas Exploration Application Project: Central Precinct



Golder Report Number. 12800-10397-17

Golder Associates

2.0 OBJECTIVES AND AIMS OF STUDY

The purpose of the assessment is to describe the social context of the proposed project and to predict potential project impacts and benefits. Specific objectives include the following:

- Describe the social conditions and trends in the area that could potentially be affected by the project; and
- Compile a high-level scope of potential social impacts.

The socio-economic assessment has been compiled based on a literature review of available documents pertaining to local planning and development; analysis of statistical data (Quantec and the Community Survey (CS) of 2007), and interview records and comments gathered during public consultations with stakeholders (the stakeholder engagement process is described in detail in a separate report).

3.0 SOCIO-ECONOMIC CONTEXT

The central precinct is the local study area (LSA) and intersects the Western Cape, Northern Cape and Eastern Cape, and falls within the Central Karoo, Pixley ka Seme, Chris Hani and Cacadu district municipalities (DM) as shown in Table 3-1.

Table 3-1: Precincts in relation to municipal boundaries

Precinct	District Municipality	Local Municipality
Central	Central Karoo, Pixley ka Seme, Cacad and, Chris Hani	Beaufort West, Ubuntu, WCDMA05, Camdeboo, and Inxuba Yethemba

The LSA falls mostly within Beaufort West LM in the Western Cape, Ubuntu LM in the Northern Cape and Camdeboo LM in the Eastern Cape as well as the Western Cape District Management Area (WCDMA05) (Figure 3-2**Error! Reference source not found.**).

District Management Areas (DMAs) are often sparsely populated and characterised by abundant natural resources. These areas fall outside the boundaries of local municipalities and municipal services are generally not provided to these areas (e.g. national parks and world heritage sites). District municipalities then assume direct responsibility for the governance, administration and management of these areas by providing a limited number of local government functions[1].

The DMA of the Central Karoo DM is a unique arid zone with a legacy left by the indigenous Khoi-San people. The DAM incorporates the town of Murraysburg, a small town primarily supported by tourists drawn by the surrounding Sneeuberg Mountains, plains and rock art sites. The fossil-rich terrain has some of the most important archaeological sites in the world – particularly near Beaufort West and Nelspoort where stone-age sites and Bushmen engravings have been found – and boasts over 9,000 plant species. Murraysburg caters to this market with a number of local crafts being produced. Beyond Murraysburg, the area is sparsely populated with a few large farms.

Beaufort West (just outside the central precinct boundary), the largest urban area in Beaufort West LM, is a typical South African "platteland" or country town adjacent to the Karoo National Park. Beaufort West was originally established as a service centre for rail- and road transport and to a lesser degree for rural agriculture. It lies in a sheltered spot, between two normally dry rivers, at the foot of the Nuweveld Mountains. During the 1970s and 1980s, 90% of the town's economically active people were employed by the SA Railways. The National Road from Cape Town to Johannesburg (N1) bisects the town, and is still responsible for generating a significant portion of the town's revenue.

Victoria West is the main town (of three urban settlements) in Ubuntu LM.

Population

Beaufort West LM has a population of just over 37,500 (64% of the total population in the DM) and is characterized by large areas of agricultural land with Beaufort West as the main urban centre. The population density is 2 per km². The majority of the population (77%) is Coloured and approximately 90% speak Afrikaans as their first language.

Figure 3-1: Landscape surrounding Beaufort West

[1] National Study of Service Delivery in District Management Areas (DMAs), Human Sciences Research Society, Final Draft, April 2005

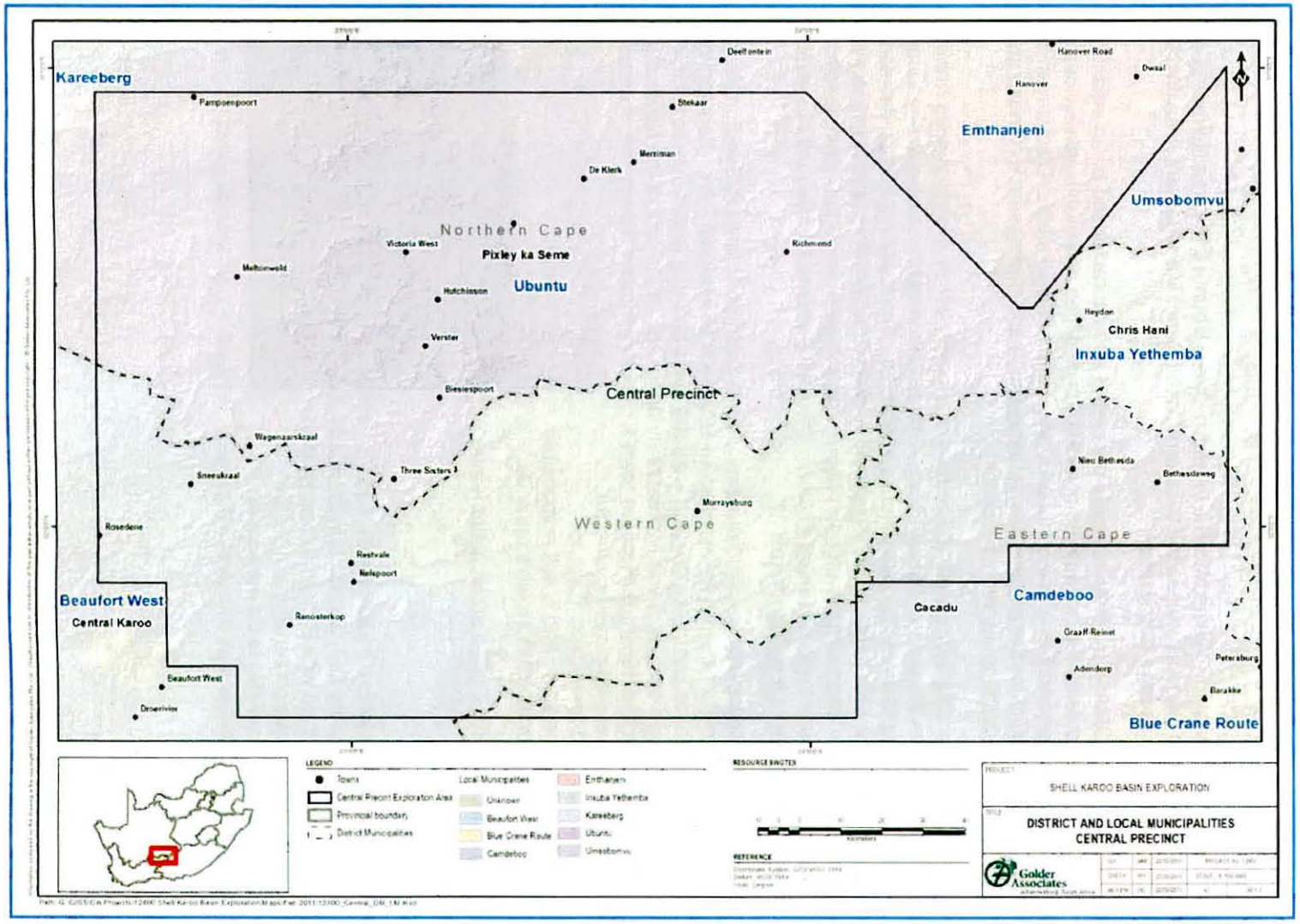


Figure 3-2: District and Local Municipalities – Central Precinct

Table 3-2: Central Precinct Population Distribution[2]

4.0	Population		Designation			
Province / Municipality	**Total**	**Per km²**	**Black**	**Coloured**	**Asian**	**White**
Western Cape	5,357,000	41	30%	50%	1%	18%
Central Karoo DM	59,000	2	10%	80%	0%	10%
Beaufort West LM	37, 600	2	14%	77%	0%	9%
Northern Cape	1,147,600	3	40%	50%	0%	10%
Pixley ka Seme DM	179,500	2	23%	67%	0%	10%
Ubuntu LM	17,600	1	13%	80%	0%	6%
Eastern Cape	**6,743,823**	**40**	**88%**	**8%**	**0%**	**4%**
Cacadu DM	369,700	6	46%	40%	0.2%	13%
Camdeboo LM	43,005	6	23%	68%	0%	10%
Chris Hani DM	812,900	22	95%	3%	0.1%	2%
Inxuba Yethemba LM	49,200	4	48%	36%	0.2%	16%

Ubuntu LM includes the towns of Victoria West (main town), Loxton (outside the central precinct boundary) and Richmond as well as two former Spoornet villages: Hutchinson and Merriman. While the population is significantly smaller in Ubuntu LM, the population profile is very similar to the rest of the central precinct (notably the Beaufort West LM). More than 80% of the local population in both municipalities is Afrikaans-speaking and designated Coloured[3].

The Camdeboo LM is one of nine LMs in the Cacadu district and represents approximately 12% of the total population in the district. Main urban centres in the LM include Graaff-Reinet (which falls outside the central precinct boundary) and Nieu-Bethesda which are surrounded predominantly by livestock and game farms. With reference to the socio-economic landscape, the changing social character of the region was summarised as follows[4]:

> *"During the last fifty years, extensive livestock farms have grown even larger, and shed a great deal of labour. Many of these unemployed farm workers have drifted to the small towns, to join the ranks of the urban unemployed. The recent advent of game farming has contributed to this trend, although opportunities in agri-tourism and eco-tourism are beginning to create scope for new and more sophisticated types of employment in the tourism sector."*

In a Quality of Life survey conducted in 2008, one of the main reasons for people leaving the Camdeboo LM was to find employment and approximately 26% of the population between 18 and 65 years was 'unemployment and looking for work'. Pensions and social grants constituted the main sources of income for the majority of respondents.

---

2 Community Survey 2007, Statistics South Africa 2007, sourced at www.statssa.gov.za on 11.02.2011

3 In South African context, the term Coloured (also known as *Bruinmense*, *Kleurlinge* or *Bruin Afrikaners* in Afrikaans) refers or referred to an ethnic group of mixed-race people who possess some sub-Saharan African ancestry, but not enough to be considered Black under the former law of South Africa. They are mixed race and often possess substantial ancestry from Europe, Indonesia, Madagascar, Malaya, Mozambique, Mauritius, Saint Helena and Southern Africa. The extensive combining of these diverse heritages in the Western Cape developed into a distinctive 'Cape Coloured' and affiliated Cape Malay culture.

4 D.Atkinson, 2008. Towards "Soft Boundaries" Pro-poor Tourism and Cross-border Collaboration in the Arid Areas of Southern Africa.

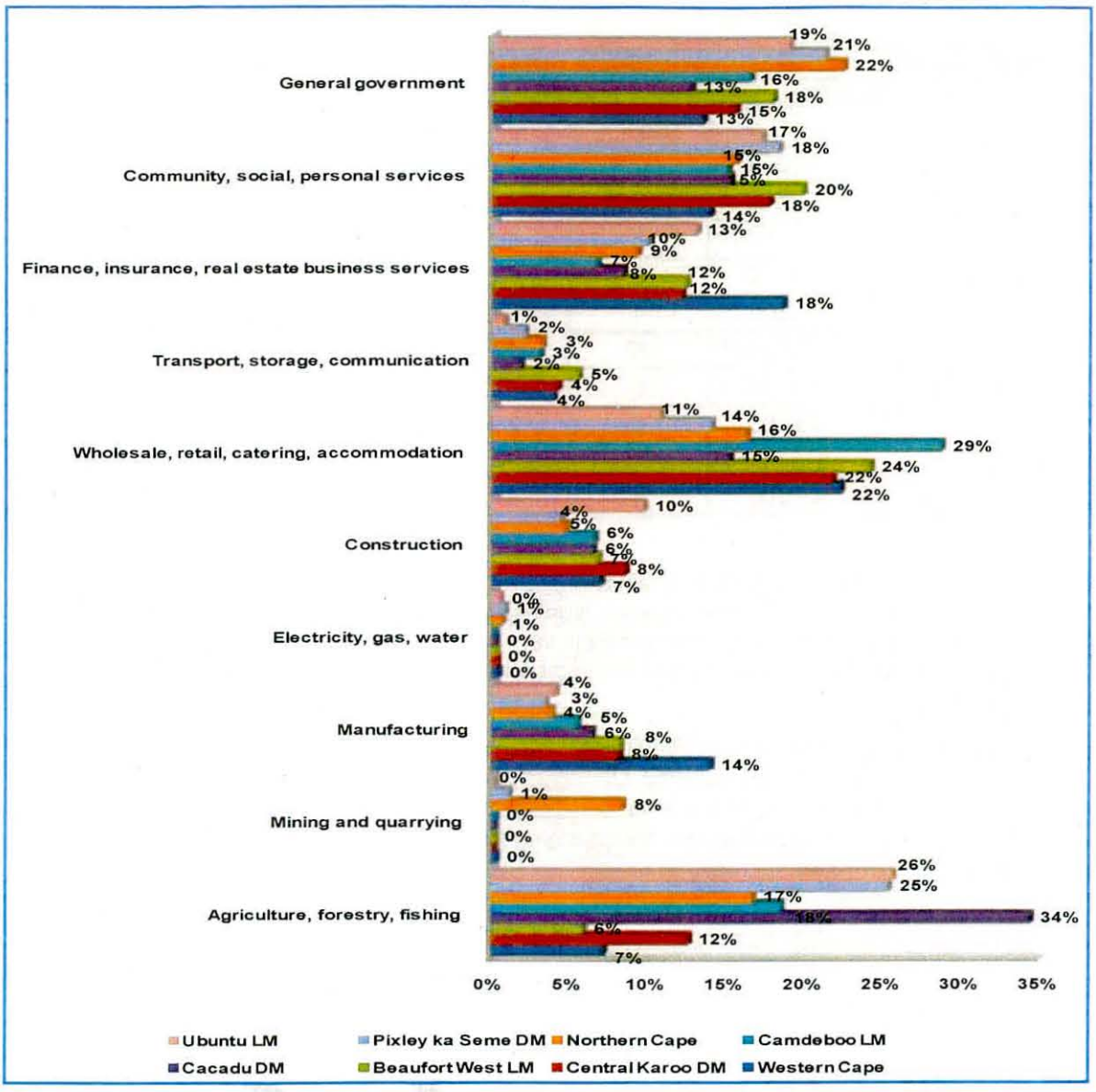


Figure 3-3: Central Precinct Employment Distribution by Sector, 2009

The Capacity Assessment report (2008) (an annual assessment by Government of municipal capacity to perform the municipal powers and functions for which it is authorised) compiled annually by the Municipal Demarcation Board (MDB)[5] indicated a negative population growth rate of 13%, 1.4% and 6.7% in Beaufort West LM, Ubuntu LM and Camdeboo LM respectively between 2001 and 2007. The declining population in Beaufort West LM and Camdeboo LM is significant and could be linked to the declining contribution of the agricultural sector to the Gross Value Added (GVA) indicator from 8% in 2004 to 5% in 2009 in Beaufort West LM and from 6% to 3% in Camdeboo LM. The natural arid climate compounded by the pressing drought in the region will have contributed to the out-migration.

Social Services and Infrastructure

There are 18 schools, 3 hospital and 10 clinics/health centres in the Beaufort West LM, 12 schools, 2 hospitals and 3 clinics in Ubuntu LM and 13 schools, 2 hospitals and 6 clinics in the Camdeboo LM. The

5 Namakwa District Municipality (DC6), Northern Cape, Assessment of Capacity for the 2008/9 Period, Municipal Demarcation Board, November 2008

Water Services Development Plan (WSDP) (a municipal planning document compiled annually for municipal water and sanitation services) for Beaufort West LM 14 urban settlements where municipal services are delivered which includes 291 businesses. The WSDP for Ubuntu LM states that the municipality has three urban settlements with 85 businesses and 123 homesteads 'scattered' in the rural region of the municipality, while the Camdeboo LM has 3 urban settlements where services are delivered including 207 businesses.

Water services in Beaufort West LM are supplied from 32 groundwater and 2 surface water sources while Ubuntu LM supplies water through reticulated systems from 17 groundwater sources. The Camdeboo LM supplies water services from 5 groundwater sources and 1 surface water source. The population is thus solely dependent on local water sources.

Tourism

Tourism has been considered a developmental opportunity for the Karoo region evidenced by the tourism conference held at the end of 2009 with the theme "creative tourism in the Karoo – implications for 2010 and beyond"[6]. Several presentations were made about the tourism potential that is seemingly locked up in the history, natural resources and heritage of the region. These experiential features are also referred to as the 'sense of place' of the area and relate to what has been referred to by stakeholders as the aesthetic value. Aesthetic value of an area is the emotional response derived from the experience of the environment with its particular natural and cultural attributes and includes atmosphere, landscape character and sense of place (Schapper, 1993).

The local economic situation is typically characterized by small towns with small local economies and a migration towards the east and coastal regions which are also the focus of tourism development. Tourism is described in various planning documents as having the potential to generate income and reduce poverty:

> *The Western Cape highlights the eco-tourism, historical culture, agri-tourism, hiking, stargazing, bird watching etc. (Western Cape Government 2002). The Cacadu Tourism Spatial Development Plan refers to the attractions of the open plains; mountains and valleys; rivers; nature reserves and wilderness areas; private game lodges; hunting and birding; hiking; biking; and horse riding. In the Northern Cape, the 2005 White Paper on Tourism refers to the parks, game reserves and conservancies, offering abundant wildlife and floral diversity. There are also many cultural and heritage resources, including museums, historical sites, and monuments. There are archaeological and rock art sites, arts and cultural festivals, prominent historical figures. There are also unique and endangered cultures, such as the San communities, the Griquas, and the Namas. Another potential area for tourism development is the game farming industry which has expanded massively in southern Africa.*[7]

The Karoo tourism initiative highlights the economic potential inherent in the ecological and historical heritage of the region.

Economy and Employment

The Central Karoo district is a designated development node as part of the Integrated Sustainable Rural Development Strategy and Beaufort West has been linked to the opportunities resulting from its position along national transportation routes (notably the N1). The IDP highlights that Beaufort West is strategically situated approximately 450 kilometres northwest from Cape Town along the N1 route, which connects Cape Town with cities like Bloemfontein and Johannesburg and is also situated on the stretch of the N1 where the N12 converges with the route, adding to the town transport potentials. Agri-business development initiatives that have been pursued over the past five years include the manufacturing of essential oils and a hydroponic project.

[6] Karoo Tourism Conference: Creative Tourism in the Karoo – Implications for 2010 and Beyond

[7] D.Atkinson. 2008. Towards "Soft Boundaries" Pro-poor Tourism and Cross-border Collaboration in the Arid Areas of Southern Africa.

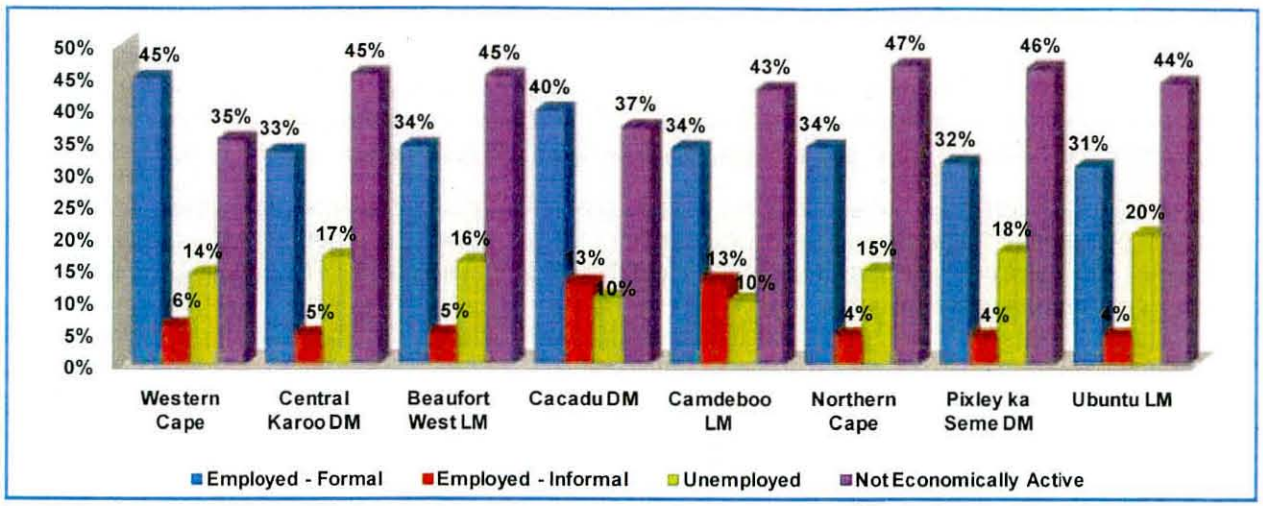


Figure 3-4: Central Precinct Employment, 2009

Formal employment levels are approximately 34% in the Central Karoo DM, over 10% lower than employment figures for the Western Cape Province (Figure 3-4). The wholesale and retail industry sector (including catering and accommodation) is the largest employer in the local municipality, accounting for 24% of employment, and contributing 14% of the local municipality GVA (Table 3-3). The largest contributor to GVA is the financial, insurance, business and real estate sector at 29%. Agriculture accounts for only 6% of employment and 5% of GVA sector contribution. However, the Beaufort West LM identifies the sector as one of importance and with opportunities for growth and employment creation despite the harsh climate and poor carrying capacity of the veld. Agri-processing, particularly related to mohair and deciduous fruit, is seemingly offering new prospects for the future. Game farming is also developing as an economically viable option.

According to a "Broad Socio-Economic Profile" report for the Cacadu DM[8] the district experienced a higher growth rate (1.1%) than the larger province. Camdeboo LM contributed 13% to the district's GVA in 2007, preceded by Kouga (22%) and Makana (24%). Agriculture is the greatest employer in the district (34%) while Camdeboo LM experienced the greatest contribution to employment in the wholesale and retail sector (Figure 3-3). The rate of employment (formal and informal) in the district is approximately 53% and approximately 47% in Camdeboo LM.

In the Ubuntu LM, agriculture and government services are the largest contributors to the economy (Table 3-3) and employ the largest number of people (Figure 3-3).

Table 3-3: GVA per Sector 2009

Sector	Western Cape	Central Karoo DM	Beaufort West LM	Cacadu DM	Camdeboo LM	Northern Cape	Pixley ka Seme DM	Ubuntu LM
Agriculture, forestry and fishing	4%	9%	5%	6%	3%	7%	15%	**21%**
Mining and quarrying	0%	0%	0%	0%	0%	**27%**	5%	0%
Manufacturing	17%	11%	10%	13%	9%	4%	3%	4%
Electricity, gas and water	2%	1%	1%	2%	1%	2%	3%	2%
Construction	5%	6%	5%	4%	3%	1%	2%	7%
Wholesale and retail trade,	14%	14%	**14%**	12%	**19%**	12%	14%	11%

[8] Cacadu District Municipality, 2008. Broad Socio-Economic Profile.

Sector	Western Cape	Central Karoo DM	Beaufort West LM	Cacadu DM	Camdeboo LM	Northern Cape	Pixley ka Seme DM	Ubuntu LM
catering and accommodation								
Transport, storage and communication	10%	12%	**14%**	5%	7%	10%	10%	5%
Finance, insurance, real estate and business services	**33%**	**27%**	**29%**	**23%**	**19%**	14%	**18%**	17%
Community, social and personal services	5%	7%	8%	13%	10%	10%	12%	12%
General government	10%	13%	**14%**	**23%**	**28%**	14%	**18%**	**21%**

It is evident from this brief description that the local economy in the central precinct is driven by the services sector with limited contributions from the construction and manufacturing sectors and no contribution from the mining sector.

Community Health and Safety

Community safety is measured by the number of incidents reported at local police stations. Crimes are typically categorised into violent and non-violent crimes, under the following headings: contact crimes (including murder and grievous bodily harm (GBH)); contact related crime (arson); property related (theft and burglary); firearms and drug related crime; other serious crime and other unspecified crime (Table 3-4).

The total number of crimes reported between April 2008 and March 2009 for the affected towns in the central precinct is 7,525. Several areas recorded an overall decrease in incidents. The increase in incidents in Beaufort West LM has been attributed to liquor abuse amplified by illegal shebeens, domestic violence and money lenders.

Table 3-4: Central Precinct Crime Statistics, 2009

Town		Total crimes	Contact crimes against person (murder, GBH)	Contact related crime (arson)	Property related (burglary, theft)	Firearms, drug related crime	Other serious crime	Other
Murraysburg Beaufort West LM	**Total crimes**	394	117	17	103	95	32	28
	Change since 2005	2%	-31%	-39%	312%			
	Crime distribution		30%	4%	26%	24%	8%	7%
Beaufort West Beaufort West LM	**Total crimes**	4105	1285	305	753	599	934	225
	Change since 2005	21%	12%	17%	44%	37%	14%	4%
	Crime distribution		31%	7%	18%	15%	23%	5%
Richmond Ubuntu LM	**Total crimes**	283	111	23	97	20	22	9
	Change since 2005	-12%	-12%	21%	-13%	25%	-46%	50%

Town		Total crimes	Contact crimes against person (murder, GBH)	Contact related crime (arson)	Property related (burglary, theft)	Firearms, drug related crime	Other serious crime	Other
	Crime distribution		39%	8%	34%	7%	8%	3%
Victoria West Ubuntu LM	**Total crimes**	507	191	32	153	44	81	6
	Change since 2005	28%	35%	14%	76%	-41%	53%	-50%
	Crime distribution		38%	6%	30%	9%	16%	1%
Graaff Reinet Camdeboo LM	**Total crimes**	2236	673	154	572	168	594	69
	Change since 2005	-18%	-33%	-9%	-12%	29%	-5%	-50%
	Crime distribution		30%	7%	26%	8%	27%	3%

Table 3-5 refers specifically to the HIV/Aids status of the local populations in the LSA. It is evident that the percentage Aids-related deaths are significant against an infection rate of between 3-10% of the population in the range 15 and 49 years. In light of the current negative population growth rate, an increase in Aids-related deaths would further diminish the local population and reduce the ability of the local communities to reproduce their productive capacity.

Table 3-5: Central Precinct HIV/Aids, 2010

	Population HIV Positive	AIDS Deaths	Other Deaths	Percentage of Deaths related to AIDS
Central Karoo DM	3%	0.1%	0.9%	13%
Beaufort West LM	3%	0.1%	0.9%	14%
Pixley ka Seme DM	6%	0.3%	0.9%	26%
Ubuntu LM	6%	0.2%	0.9%	22%
Cacadu DM	10%	0.6%	1.1%	36%
Camdeboo LM	8%	0.4%	1.2%	24%
Chris Hani DM	11%	0.7%	1.1%	40%
Inxuba Yethemba LM	10%	0.6%	1.1%	35%

According to the IDP of Beaufort West LM, health indicators revealed that the proportion of children under the age of 1 year with first measles immunization was 93 per cent (above the national target of 90%), TB prevalence stood at 950 for every 100 000 people, with a cure rate of 74 per cent. The national target for TB cure rate of 85 per cent had not been met because of social grants, which have become a source of living for people; it implies that being cured will remove the grant. The patient nurse ratio was 31:1, better than the national target of 34:1.

During an AIDS strategy planning session in 2002, Ubuntu LM conceded that "There are only 3 clinics and 2 hospitals in the Ubuntu municipal area to deal with people who are living with AIDS. According to estimates by the District Council about 10 % of a total population of 20 000 are likely to be HIV positive and these hospitals and clinics are understaffed and under resourced and cannot provide an effective service". It appears that the general health systems are inadequate to deal with the present health conditions.

5.0 SOCIO-ECONOMIC IMPACTS

5.1 Potential Impacts

A social assessment typically considers the anticipated change in the social environment and how this will impact on the people. Change in itself is not considered an impact. Change occurs constantly and where people have control over the process, they would want to direct it towards positive change. But not all receptors will perceive change necessarily in the same way. Where change is experienced in corporeal (material) or perceptual terms, we speak of impact.

In context of an exploration project that covers an area of about 30,000km^2 in a predominantly agricultural area with a relatively small population, limited resources and significant levels of unemployment, the proposed 'change' could perhaps be described as the introduction of a diversification of economic activity into a closely knit community. The community tends to be united around the socio-ecological challenges of semi-desert environments and that values the harshness of the environment and considers their 'survival' as part of their heritage. The change that will be introduced by the exploration of shale gas is perceived by landowners as the scarring of their heritage, and by the poor and unemployed as the advent of economic development and the associated prospect of employment and improved quality of life. Survival in the Karoo, which is a delicate balance between limited ecological resources and basic human needs, is contrasted in the minds of stakeholders with 'intrusive' exploration activities of a magnitude not known in the area. The project has thus received a significant amount of public interest.

Against this descriptive background, the impact assessment is based on the review of documentation and the issues that were raised during the public consultations held across the three precincts from the end of January to early February 2011 (the stakeholder engagement process is described in detail in a separate report). Key social impacts raised during the meetings are the following:

- Disturbance of an ecological area that is associated with the local heritage;
- Water quality and quantity;
- Loss of land;
- Presence of (temporary) construction workers;
- Employment;
- Community health and safety;
- Air quality, noise and vibration; and
- Increase in traffic.

Various technical studies have been completed for the EMP, including groundwater, ecological, noise, air quality, and heritage and archaeological studies.

5.1.1 Disturbance of ecology associated with local heritage

The results from the Ecology and Heritage studies are presented in separate technical reports.

Local people have expressed their attachment to the local environment in various ways. The Karoo is often depicted as a scenic environment with a unique character that is sensitive to disturbances. This typical landscape is also traded as a tourism attraction (natural beauty, tranquillity, remoteness) and presented as cultural heritage – a way of life that is different from urban living. It was emphasised in several public meetings that disturbance of the environment due to exploration related activities could occur. For example reference was made to vehicle tyre prints in undisturbed 'veld' taking several decades to disappear. Apart from the ecological impacts, a disturbance of the environment is perceived as a cultural intrusion.

In this context, local knowledge of the environment (with specific reference to the ecology and groundwater resources) was presented with a degree of caution and respectfully qualified by a farmer in Graaff-Reinet: "our family has lived here for more than 80 years and we still do not understand the Karoo". People's lives are intricately connected with the ecological sensitivity and harsh and dry climate to the extent that the relationship between the environment and their livelihoods is presented as a constant and delicate balance. A complacent attitude to the environment (stakeholders perceive exploration to be incongruent with the ecological character of the environment) would have implications for their livelihoods.

This subjective impact of the proposed exploration activities was often expressed emotively and amplified with reference to various social risks, e.g. water contamination, danger of spills and environmental catastrophes. This impact is regional in scale, high in probability and moderate in magnitude.

5.1.2 Impacts to quality and quantity of water

The results from the Groundwater study are presented in a separate technical report.

It is common knowledge that water in the Karoo is a scarce resource. Drilling activities require smaller quantities of water than the hydraulic fracturing process. Nonetheless, the use of local sources of water for exploration related activities was raised during public consultations as a possible negative impact on the water supply to the local population and livestock on farms. Furthermore, the fear of contamination of water sources as a result of the hydraulic fracturing process has also been raised consistently by local communities throughout the regional study area as a potential negative impact on their livelihood. Associated with the perception that exploration activities potentially pose a threat to water resource security was the sense of disempowerment should an exploration incident cause the disruption of scarce water resources – the key question that was asked in several public consultation meetings was whether Shell will (be able to) repair and compensate environmental damage. Exploration activities could potentially compromise the quality and quantity of local water supply systems which will have an impact on the sustainability of local communities. If an impact occurs, the impact is local in scale but could reach regional proportion, with a low probability and moderate in magnitude.

In context of water scarcity, the identification of new groundwater sources suitable for human and livestock consumption, as part of preparatory work for the exploration activities could yield positive benefits if these were made available upon closure of exploration activities and site decommissioning.

5.1.3 Loss of land and impact on livelihood

Shell's exploration activities, starting with magneto-telluric testing, will initially require access to land and limited (menial) excavation works for the magneto-telluric testing equipment, and eventually clearing of well-pads (measuring approximately 1 ha). Access to exploration sites may be via an existing (upgraded) or new access road. Landowners will lose temporary access to these areas during exploration activities. However, if initial exploration test results indicate a feasible shale gas resource, further exploration activities may be conducted. If this leads to gas production activities under a production right, the well will be secured for future development and production. Any non-viable exploration wells will be decommissioned.

Loss of access as a result of exploration activities and associated health and safety requirements (including no-go zones) may require mitigating measures such as alternative access ways. Loss of income due to loss of production and economic resources will need to be compensated. Compensation may be provided through lease agreements.

Site selection must take cognisance of current land use in order to minimise economic displacement. The scale of impact is local with a definite probability and moderate magnitude.

5.1.4 Presence of (temporary) construction workers

Exploration is regarded as a skilled technical process that requires adherence to industry-regulated and corporate health and safety standards. During the initial exploratory drilling, it is likely that certain technologies and equipment will need to be imported and highly specialised expertise or personnel to be required. Shell will establish a team that will include international staff and contractors. During site

preparation, the team size will be 30 to 50 staff. Accommodation of teams may be in a purpose built temporary accommodation camp or in accommodation facilities in nearby urban centres.

Site preparation teams could be considered as business travellers and may stimulate the local tourism industry, especially the hospitality sector, for short periods during exploration activities. This may have an associated impact on general business in the local economy. The scale of this positive impact is local, with medium probability and moderate magnitude. No long-term housing requirements are anticipated.

In contrast, the presence of foreign exploration teams may lead to social conflict due to cultural and language differences. This impact is local in scale, low in probability and rated moderate to low in magnitude.

5.1.5 Employment

Due to the technical nature and regulated health and safety requirements, opportunities for local employment are limited to short-term positions. Influx of job-seekers and the associated increase in crime and social ills is not expected to occur due to the isolated character of the LSA and controlled access to private property in the area. At a regional scale, transportation and security requirements may lead to a limited increase (low magnitude) in employment for the duration of exploration preparation activities. The local hospitality sector may benefit from a low increase in employment opportunities.

5.1.6 Community health and safety

Exploration activities *per se* are restricted to fenced construction sites and pose no immediate risk to community health and safety. Furthermore, present controlled access to farm properties will limit the potential entry of job-seekers onto private property and no significant increase in crime associated with exploration activities is expected to occur. However, risk of contamination of water sources as a result of accidental spillage of process fluids and liquid waste are present and may have a significant impact on the health of the local population. This impact is rated under 5.1.2.

The influx of workers (including foreign teams) from outside the LSA may lead to casual, transactional and temporary sexual engagements which will increase the risk of HIV infection.

5.1.7 Air quality, noise and vibration and impact on livelihood

Air quality, noise and vibration impacts may impact indirectly on the livelihoods of affected landowners or parties. The results from the air quality and noise assessment studies are presented in separate technical reports. Increased noise levels may impact current land uses, such as game farms. With regard to air quality, 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 and growth.

5.1.8 Traffic increase

The drilling rig will be transported by standard prime mover and trailer trucks, and will be assembled on site. The construction of the temporary drilling rig typically takes between 3 and 4 weeks. Additional trailer(s) will be required to bring other portable equipment, a site office, etc. for temporary use on site. Typical traffic associated with "rig up" operations requires approximately 50 to 70 truckloads, which includes portable accommodation units and rig site offices. The frequency with which additional vehicle traffic visits a site will depend upon the phase of drilling operations. For example, on average a standard re-supply to a rig will require 2 to 4 trucks loads per day, although when pipe casing strings and mud supplies are required this may require up to 10 truckloads per day for a short period of time. Dependent upon the distance to available infrastructure, for example, a supply base or airport, additional may be required traffic once per week, plus ad hoc travel of employees to/from the site on a daily basis.

Additional traffic will increase wear and tear on the roads, increase risk of accidents, and increase noise and fugitive dust levels. Due to the number truck loads required, impact magnitude is rate moderate. In addition, since impacts could be regional. Impact significance is therefore considered to be moderate. The significance of this impact will, however, need to be confirmed subsequent to site selection, as part of the detailed environmental impact assessment.

Enforcement of Shell's corporate health and safety requirements on all contractor operations, locating well sites in close proximity to supply base or airport and, existing towns will, however, mitigate this risk.

In addition, information will be provided to local residents and police on traffic movements.

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 operational life of the activity)
1 – Improbable	1 – Immediate
0 – None	
SCALE	**MAGNITUDE**
5 – International	10 - Very high/don't know
4 – National	8 - High
3 – Regional	6 - Moderate
2 – Local	4 - Low
1 - Site only	2 - Minor
0 – None	

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

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

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

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

5.3 Technical Assessment

Table 5-1: Technical Assessment Rating

POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	Total	SP	M	D	S	P	Total	SP
Disturbance of ecology and heritage	6	2	3	4	54	Mod	4	2	2	3	28	Low
Impact to quality and quantity of water	8	2	2	2	48	Mod	4	2	2	2	24	Low
Loss of land and impact on livelihood	4	2	1	4	28	Low	2	2	1	4	14	Low
Temporary workers	2	2	2	5	18	Low	2	2	1	5	16	Low
Employment	2	2	2	1	12	Low	2	2	1	2	10	Low
Community health and safety	Same as water quality above					Mod	Same as water quality above					Low
Air quality, noise, vibration	4	2	1	4	28	Low	2	2	1	3	12	Low
Road and traffic impacts	6	2	3	4	56	Mod	4	2	2	4	32	Mod

6.0 MITIGATION AND MANAGEMENT MEASURES

6.1 Disturbance of ecology associated with local heritage

Mitigation measures proposed in the ecology assessment report must be communicated to landowners and interested and affected parties. Where possible, engagements with local stakeholders should be held to understand wildlife patterns and local heritage sites– these aspects need to be taken into account during final selection of the well sites. A local monitoring committee should be established to participate with observation status in site monitoring activities.

6.2 Water quality and quantity

Mitigation measures proposed in the Groundwater study report must be implemented.

Landowners in particular and the affected population in general must be informed of any chemical substance used during the exploration process and potential environmental, health and safety risks must be communicated to affected communities prior to its use. Efforts to maintain open and honest communication will reduce the risk of social mobilisation and amplification of risk beyond known potential impacts.

6.3 Loss of land and impact on livelihood

Land compensation and lease agreements should be entered into independently with each affected landowner or party. Where possible, engagements with local stakeholders should be held to understand grazing schedules – these aspects need to be taken into account during final selection of the well sites.

6.4 Presence of (temporary) workers

Teams will work under a strict code of conduct which requires, for example, prior permission for access, alcohol and drug polices, non-disturbance of farm activities and restoring any damages they may inadvertently cause. On-site construction camps will have controlled access and all staff will carry personal identification.

6.5 Employment

Where possible, employment opportunities should be offered to local communities before others are considered. Opportunities for skills development and training should be explored in order to maximise long-term benefits of employment.

6.6 Community health and safety

A risk communication strategy must be developed for the duration of the exploration programme (construction and operation phases) and regular stakeholder forum meetings must be held to report on health and safety monitoring and communicate health and safety risks timeously.

6.7 Air quality, noise and vibration

Mitigation measures proposed in the air quality and noise assessment studies must be implemented.

6.8 Traffic increase

Shell corporate traffic safety and operational health and safety procedures must be implemented by all staff and contractors. The implementation of safety measures such as speed limits, drivers' education, public education, and scheduling and maintenance of vehicles will reduce the impacts on all of roads used by heavy duty vehicles. In addition, information should be provided to local residents and police on traffic movements.

A traffic impact assessment should also be conducted in the detailed environmental impact assessment to follow. This assessment will identify traffic and road safety risks to local residents and users.

7.0 CONCLUSION

This assessment has considered the potential impacts of the proposed exploration activities in the central precinct on the social environment. Key impacts that have been considered are the disturbance of the ecology which is associated with the local heritage, the effects on water quality (fear of contamination) and quantity (depletion of groundwater sources) and community health and safety. The latter is a cross-cutting impact linked to water quality concerns and the perceived risk of uncontrolled spills and incidents. The overall social impact of the proposed exploration project is considered moderate to low and, with appropriate mitigation measures, could be changed to low.

A site specific social impact assessment and traffic impact assessment will be undertaken subsequent to well site selection, as part of the detailed environmental impact assessment (EIA). As part of the EIA, the following key questions will need to be addressed:

- What will the impact be of loss of land and impact on livelihood as a result of access restrictions, changes to grazing patterns, etc. on each affected landowner or party?
- What will the impact be on roads and traffic as a result of increased traffic in the vicinity of selected well sites? Traffic and road safety risks to local residents and users?
- What suitable measures can be put in place to manage/mitigate these impacts?

8.0 REFERENCES

Beaufort West Local Municipality Integrated Development Plan Review 2004/5 for Implementation 2005/6

Cacadu District Municipality, 2008. Broad Socio-Economic Profile

Camdeboo Local Municipality Local Economic Development Plan, March 2009

Camdeboo (Graff-Reinet / Nieu Bethesda / Aberdeen) – Global Quality of Life Profile and Local Economic Development Related Elements, 2008

Central Karoo District Municipality Integrated Development Plan, 2004/5

Community Survey 2007, Statistics South Africa 2007, sourced at www.statssa.gov.za on 11.02.2011

D. Atkinson. 2008. Towards "Soft Boundaries" Pro-poor Tourism and Cross-border Collaboration in the Arid Areas of Southern Africa. Sourced at http://www.aridareas.co.za/pdf_documents/U3_ATKINSON_SoftBoundaries_2008-02-20-led.pdf

Karoo Tourism Conference: Creative Tourism in the Karoo – Implications for 2010 and Beyond. Sourced at http://www.aridareas.co.za/karootourismconference.html

National Study of Service Delivery in District Management Areas (DMAs), Human Sciences Research Society, Final Draft, April 2005

RSA Regional Indicators, Quantec, 2011 Quantec Research South Africa, sourced at http://www.quantec.co.za on 11.02.2011

GOLDER ASSOCIATES AFRICA (PTY) LTD.

Frank Snijder
Social Impact Assessment Specialist

Olivia Chapman
Project Manager

FS/OC/js

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

g:\projects\12800 -service provision for shell exploration\4_reports\final reports for printing\cp\volume 2\appendix 9-social\12800-karoo(central)socialreport_rev1_sp (2).docx