6 DESCRIPTION OF THE RECEIVING ENVIRONMENT

The purpose of this chapter is to provide a comprehensive description of the environmental status quo conditions of the Farm Bokpoort which are likely to be affected by the development of a 75 MWe CSP plant and associated infrastructure. The environment, as referred to in this context, denotes the natural, social (including cultural heritage) and economic attributes of the Farm Bokpoort, including the surrounding areas.

Determining the environmental status quo of the proposed site, this will allow for a baseline against which environmental impacts associated with the plant development can be measured to determine the extent (significance) of the perceived environmental impacts.

Chapter 6 describes the environmental status quo (baseline) in terms of the following:

- Physical environment;
- Biophysical environment, and
- Socio-economic environment.

6.1 Physical Environment

6.1.1 Locality

The study area is situated within the Siyanda District Municipality, in the Northern Cape Province adjacent to the Orange River. The Siyanda District Municipality covers an area of 103 771 square kilometres with its northern borders aligned with Botswana and Namibia. The district is traversed by the Orange River from the east to its west. Along the banks of the Orange River intensive agriculture has developed including vineyards and domestic food farms. Upington town is the main urban area for the region and serves as both an administrative and commercial centre as well as a stopover into the area's hinterland. This region attracts tourists travelling to Namibia and local reserves, such as Witsand (approximately 40km north of Bokpoort) and the Augrabies National Park west of Upington.

The N14 and the N10 are the primary roads in the region and are the main link between the economic centres of Gauteng and Namibia. The population distribution is primarily concentrated in and around the small towns along the Orange River, and specifically in Upington. Other towns/settlements in close proximity to the Farm Bokpoort are, Grootdrink (30km north west), Kalkwerf (17 km north west), Saaiskop (9km west), Groblershoop (15 km south), Wegdraai (9km south west), Stutterheim (16km south east), Skerpioenpunt (20km south east), and Boegoeberg (25km south east) – refer to Figure 49.

Figure 49: Towns/settlements located in close proximity to the Farm Bokpoort

6.1.2 Climate

Refer to *Section 6.1.8* for details on the climatic conditions of the Bokpoort site.

6.1.3 Topography

The study area is generally characterised by Dune Hills (parallel crests) and Lowlands in the northern part and Extremely Irregular Plains in the south, sloping towards the Orange River in a south-eastern direction from a high point of approximately 1,100m in the north to approximately 900m in the south at a general gradient of approximately 1.1%. Part of the Korannaberg foothills is located in the extreme northern section of the study area, comprising a small section of the site, characterized by the presence of boulders, high slopes and mountainous topography.

6.1.4 Geology

The geology of the area is generally characterised by the metamorphosed sediments and volcanics intruded by granites and is known as the Namaqualand Metamorphic Province. The proposed CSP plant site is sited on red brown windblown sands of the Gordonia Formation, Kalahari Group. Dune ridges occur in the northern portions of the site and is characterised by NNW-SSE orientation. Calcrete outcrops occur approximately 2 km west and southwest from the Garona substation (Figure 50). An anticlinal structure (upward pointing fold) causes the Groblersdal formation to be elevated in the area to the east of the site where it forms a range of hills known as the Skurweberge (Figure 50).

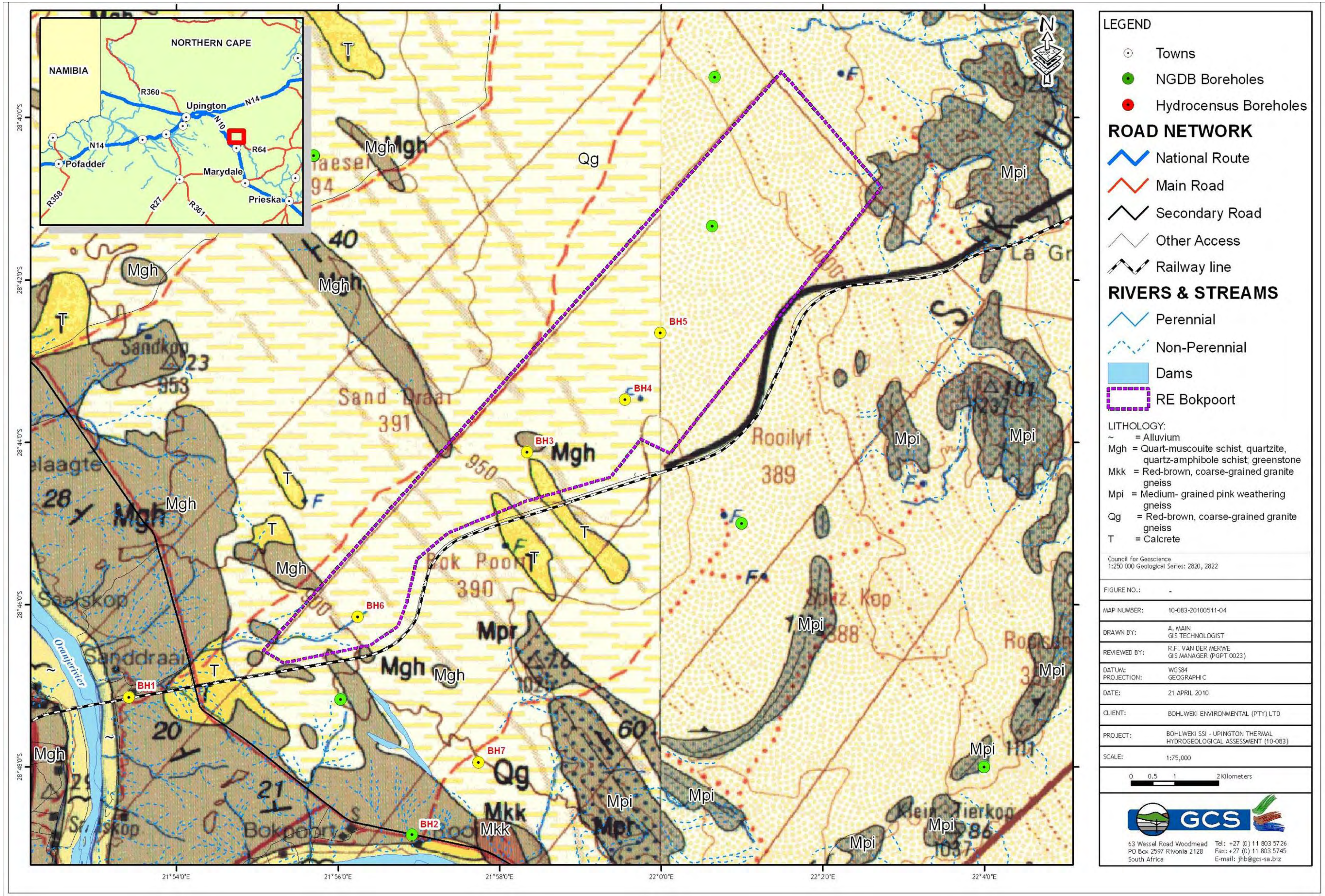


Figure 50: Site geology

In the vicinity of the site, the dip of the bedding is approximately 40 degrees towards the north east indicating that there is an intervening synclinal structure between the site and the Skurweberge anticline to the east.

6.1.5 Soils[36]

The ARC-Institute for Soil, Climate and Water (ARC-ISCW) was requested by Bohlweki-SSI to carry out a desk-top study regarding the soils, and agricultural potential aspects for a proposed CSP plant and associated infrastructure in the Northern Cape Province.

6.1.5.1 Methodology

The databases at ARC-ISCW were used to collate all available information. This was available in ArcGIS.

6.1.5.2 Regional Overview

- **Land types**

The soil information that was used to inform this study forms part of the national 1:250 000 land type survey (Eloff *et. al*, 1986). Each land type is a unique combination of soil pattern, terrain and macroclimate.

The study area comprises a total of three different land types (Figure 51 and Table 22), namely:

Table 22: General description of land types

Red, structureless, high base status soils	Ae4
Red, structureless, high base status soils (with sand dunes)	Af7
Rocky areas with very little soil	Ic4

- **Land Type Characteristics**

The main characteristics of each of the land types occurring (soils, depth, texture and occurrence), as well as agricultural potential[37], are given in Table 23.

[36] Bohlweki Environmental. 2006. *Environmental Impact Assessment for the establishment of a New Concentrating Solar Power (CSP) plant and associated infrastructure in the Northern Cape Province.*
[37] Macvicar, C.N., De Villiers, J.M., Loxton, R.F, Verster, E., Lambrechts, J.J.N., Merryweather, F.R., Le Roux, J., Van Rooyen, T.H. and Harmse, H.J. Von M. 1977. *Soil Classification: A Binomial System for South Africa. ARC-Institute for Soil, Climate and Water*, Pretoria.

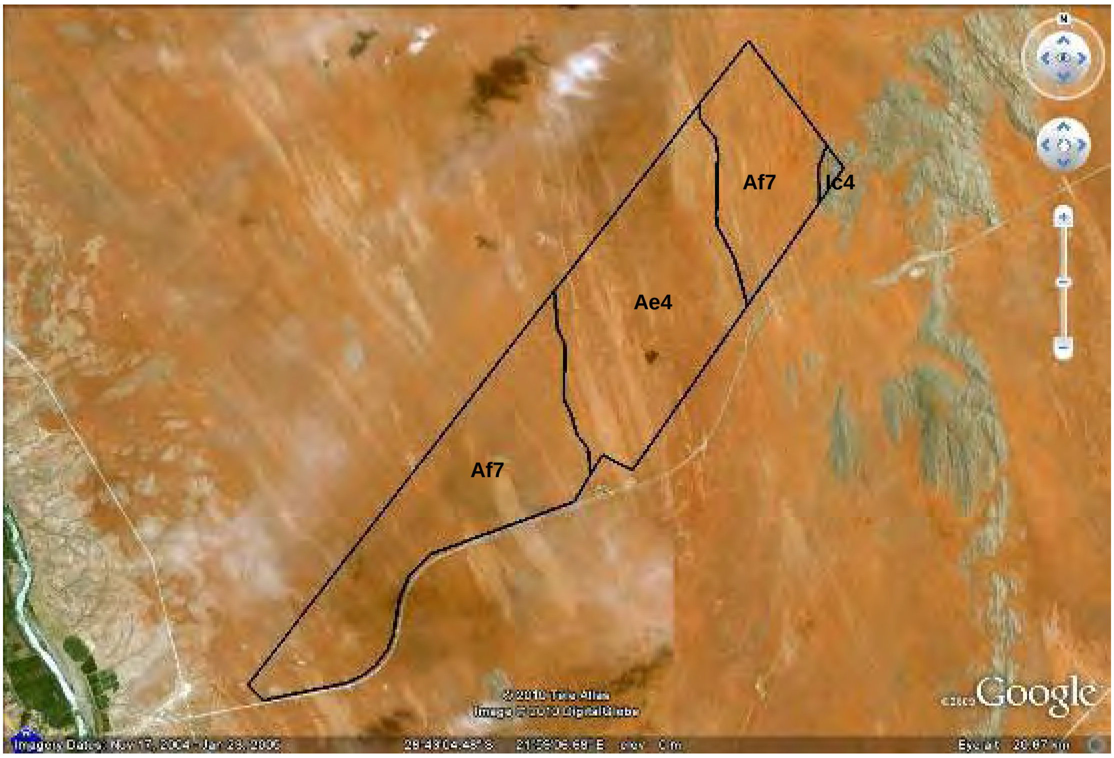


Figure 51: Land types (Bokpoort)

Table 23: Soil properties per land type

Land type	Dominant Soils	Sub-dominant Soils	Slopes	Agricultural Potential (%)
Af7	**Hu30/33/34** (600-1200 mm), Sa, 58%	***Hu30/31*** (>1200 mm), Sa (dunes), 40%	1-2%	H: 0.0 M: 58.0 L: 42.0
Ae4	**Hu33/34** (450-1000 mm), Sa, 42%	***Ms10/22*** (100-250 mm), Sa, 41%	1-2%	H: 0.0 M: 47.0 L: 53.0
Ic4	**Rock, 80%**	***Hu30/Ms10*** (50-250 mm), Sa-LmSa, 11%	4-60%	H: 0.0 M: 8.0 L: 91.0

From the above table and the related map (refer to Figure 51), it can be seen that the soils of the Farm Bokpoort mainly consist of red and yellow sands, mostly of the Hutton (Hu) form, occasionally with dunes, especially at the Bokpoort site. Smaller areas of shallow lithosols of the Mispah (Ms) and Hutton (Hu) forms, along with rock, also occur.

The only areas of high potential land that exist are the alluvial zones close to the Orange River, where irrigation may be practiced.

- **Climate**

In addition to the soil characteristics as outlined above, there are also severe climatic restrictions to agricultural potential. Rainfall is very low, generally between 260 and 340 mm per year, while evaporation is extremely high, due to the high temperatures, which can reach 35 - 40^{o}C in summer. For this reason, even the best soils are unsuited for dryland agriculture under these conditions.

- **Slope**

The dominant slopes occurring in the study area are flat, to gently sloping. Apart from a very small area in the northeast corner of the site (land type Ic4), no areas of steep topography occur.

- **Agricultural Potential**

The general agricultural potential of the soils in each land type is given in the right-hand column of Table 23.

From an agricultural potential assessment, it can be concluded that the only high potential soils in the alluvial zones occur close to the Orange River (Figure 52), with the majority of the remainder comprising low to moderate potential soils, mainly due to the rapid drainage and/or the presence of dunes.

However, it must be borne in mind that these are soil assessments only, and do not take into account any climatic restrictions as outlined above.

Figure 52: Land types (Bokpoort) - with high agricultural potential soils highlighted in yellow

6.1.6 Geohydrology (Groundwater)

Groundwater Consulting Services (Pty) Ltd (GCS) was appointed by Bohlweki-SSI to undertake a geohydrological impact assessment for the proposed CSP plant on the Farm Bokpoort. The aim of this assessment was to assess the baseline groundwater conditions for the local aquifer system and to determine the likely risks to the groundwater environment.

*Refer to **Appendix C** for the Geohydrological Report.*

6.1.6.1 Methodology

The following methodology was used for the geohydrological assessment:

- **Desk Study**

The desk study involved a review of all available geological and hydro-geological literature. This included aerial photography, and topographical, geological and hydro-geological maps. Data was requested from the DWA for existing boreholes and groundwater use in the area.

- **Hydrocensus**

A hydrocensus survey was conducted on the area within a 1km radius surrounding the site. The aim of the survey was to locate and map the groundwater users in the vicinity of the site. Various landowners in the area were consulted to determine the extent of groundwater usage from the boreholes and springs in the vicinity. Groundwater samples were also collected from several of the production boreholes located on surrounding farms.

6.1.6.2 Regional Overview

The proposed CSP site is located in an area of complex pre-Cambrian basement geology, including volcanic, igneous and metamorphic rocks. Groundwater is stored and transmitted mainly via secondary features such as fractures, although some intergranular porosity and permeability is present in certain areas. The solid strata are covered in places by Quaternary unconsolidated to weakly consolidated sediments of the Kalahari Group. To the north of the study area these sediments may yield useful quantities of groundwater. Calcretes and limestones overlie the basement rocks in places, although these are usually of low groundwater potential. Groundwater yields from the basement rocks are generally low, and groundwater quality varies from potable to saline. Naturally high concentrations of nitrate are sometimes found. The depth to groundwater in many areas is frequently in excess of 40 metres.

There is no significant groundwater usage in the study area as most water used is sourced from the Orange River. Groundwater utilisation is of importance across wide areas away from the Orange River in the arid Kalahari region where it is mainly used for rural domestic supplies, stock watering and water supplies to towns. As a result of the low rainfall, recharge of groundwater is limited and only small quantities can be abstracted on a sustainable basis. Artificial recharge of groundwater is practised in some areas where water from small dams is transferred through pipelines into boreholes located in the area of recharge of the main production boreholes.

According the Internal Strategic Perspective for the Lower Orange Water Management Area[38] the aquifer characteristics (borehole yields and storage of groundwater) are typically unfavourable because of the hard geological formation underlying most of the area.

Groundwater constitutes an important source of water for rural water supplies in the Orange River, although it is only a small proportion of the total available water. Much of the groundwater abstracted near the river is actually recharged from the river and could also be accounted for as surface water.

Fractured aquifers are more vulnerable to pollution than aquifers where the storage and transmission of groundwater is primarily intergranular, due to the higher rates of groundwater movement and lower attenuation potential. Once polluted, such aquifers are difficult and expensive to remediate. Soluble pollutants are likely to travel vertically downwards to the water table together with recharging water, and then move with the water in the direction of regional groundwater flow. Recharge mechanisms in this area are not fully understood, but are thought to be episodic, following sporadic heavy rainfall.

The quantity of water to be used for the operation of the proposed CSP plant (i.e. steam generation, cooling, the domestic needs of plant workers, and for the washing of the plant mirrors) is estimated at 859 000 cubic meters per annum for a wet-cooled plant– detailed design specifications regarding water requirements are being developed by the engineering design team. Of these stipulated quantities approximately 100 000 m^3 per annum of water will be required for mirror washing. The mirrors will be cleaned during the night, when non-functional, by a high pressure spray of demineralised water from a vehicle. The water will likely run off the mirrors onto the ground surface below. Some of the wash water might evaporate during spray-washing, although the quantity of water loss through evaporation is more than likely to be insignificant since mirror washing will be undertaken during night time. These water volumes when applied over the estimated plant area (350 ha) may increase the groundwater recharge at the site, raising the local water table and mobilising any contaminants at the site into the groundwater. There is, however, no evidence of current contaminants. As noted below, a suitable protocol for the management of any on-site potential contaminants would mitigate this risk.

The CSP technology (i.e. parabolic trough) considered by Solafrica utilises a HTF for direct steam generation. The HTF may be thermal oil or water. None of the aforementioned fluid will be deliberately discharged to, or be in direct contact with, the surrounding environment, however accidental spills or leakage of the fluid on the ground are possible and if not removed from the contaminated area could likely result in the pollution of the local groundwater resource. A suitable operational protocol to be used in the event of an accidental would mitigate this risk.

[38] Department of Water Affairs and Forestry (DWAF), 2004. Internal Strategic Perspective: Lower Orange Water Management Area. Prepared by PDNA, WRP Consulting Engineers (Pty) Ltd, WMB and Kwezi-V3 on behalf of the Directorate: National Water Resource Planning. DWAF Report No P WMA 14/000/00/0304.

6.1.6.3 Site Specific Findings

- **General Geology and Aquifer Type**

The general geology of the site mainly comprises red-brown, coarse-grained granite gneiss; and quartz-muscouite schists, quartzite, quartz-amphibole schists and greenstones of the Groblershoop formation, Brulpan group. Calcrete is also found especially on the south eastern part of the area.

The hydrogeological map of the area indicates that a fractured aquifer occurs in the area. The yield from the local aquifers range from 0.1 to 0.5 l/s. Data indicates that the area receives a mean annual rainfall 185 mm and the average annual recharge for the area is calculated at 40 million cubic meters per annum over the entire sub-catchment area.

- **Hydrocensus**

The community living in the farms relies mainly on municipal water for domestic water supply. The farms located to the south of Bokpoort uses water from the Orange River. The river water requires treatment before it is ready for domestic use. Groundwater is primarily used by farmers located further away from the river. Groundwater abstracted from surrounding farms is mainly used for domestic purpose and livestock farming (cattle and sheep). Most of the boreholes are equipped with handpumps. The data collected during the survey is presented in Table 24. Refer to Figure 53 for the location of the groundwater and springs.

Water level measurements could not be taken from the farm boreholes, however, the use of wind pumps for groundwater abstraction is indicative that the groundwater level in the area is not very deep. The pH levels ranged from 7.36 to 8.06; and the Total Dissolved Solids (TDS) ranged from 420 to 490 mg/l.

- **National Groundwater Database (NGDB)**

A request was made to the DWA for borehole and groundwater data from the NGDB. The data of six boreholes within a 2 km radius around the boundaries of the Bokpoort farm were obtained from NGDB. The NGDB data indicated that the average water level from the existing boreholes measures 41.88 m below ground level. As it was established during the hydrocensus survey, the boreholes on the surrounding farms are also equipped with wind pumps and are used for stock watering. Although the groundwater resource is generally the sole source of water to the farms, the general use is at a small scale.

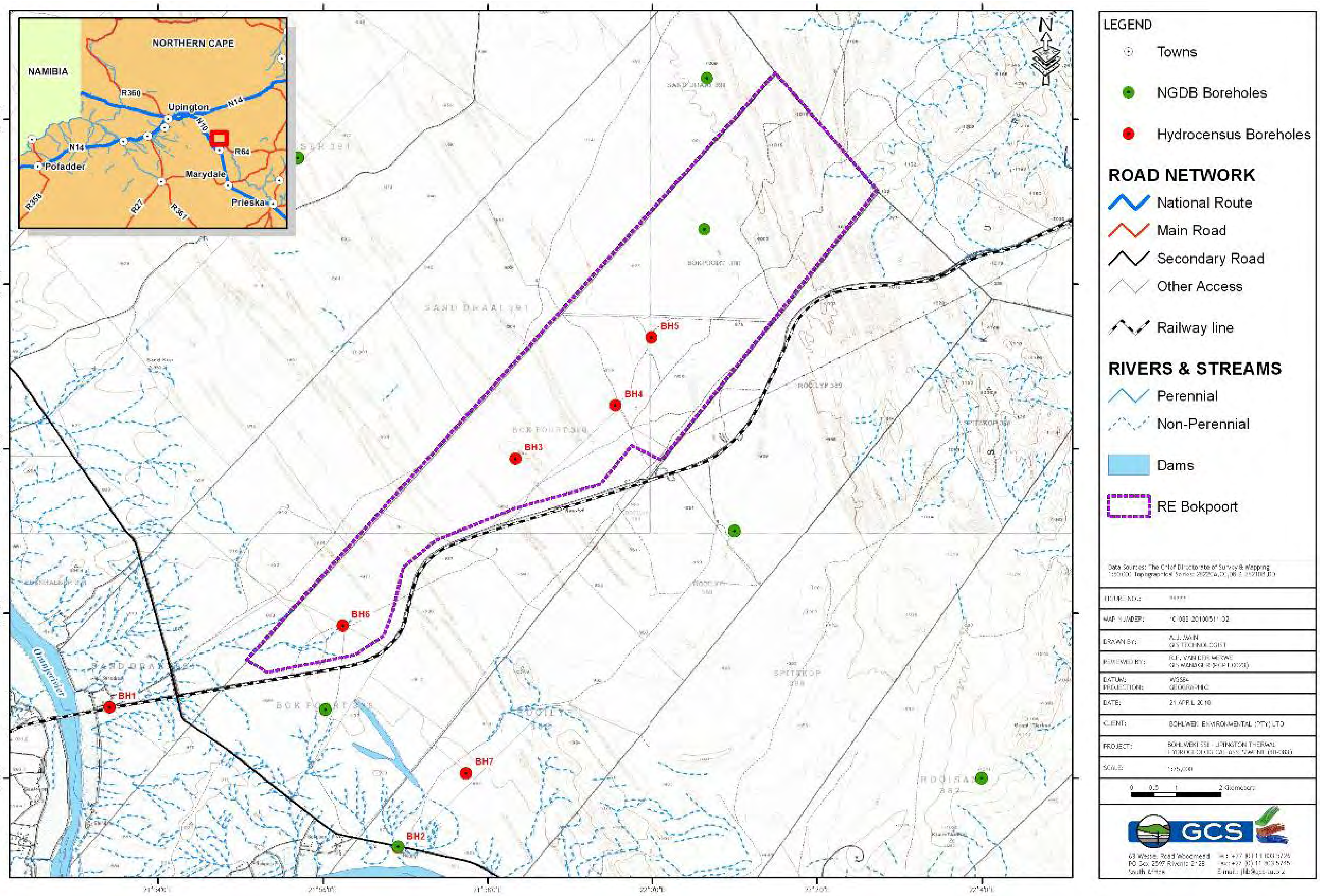


Figure 53: **Boreholes on the Farm Bokpoort and surrounding farms**

Table 24: Data obtained from hydrocensus survey

Site ID	Farm Name	Farm Owner/ Manager	Contact Details	Latitude	Longitude	Equipment	pH	TDS (mg/l)	Use	Comments
BH1		Johannes Fourie	083 785 0626	28.78569	21.89017				Unused	Borehole located next to a farm workers' house. The windpump is broken. The hole is blocked with stones.
BH2	**Rooilyf**	Hennie Jooste	083 388 5314	28.81411	21.94856	Wind pump	8.06	490	Domestic	Borehole located next a farm dwellers village along the Loop 16 gravel road.
BH3	**Bokpoort**	Chris Honiball	082 372 3467	28.73536	21.97234	Submersible pump	7.36	420	Domestic	Borehole located west of the farm house. Water is used in two farm owner's houses and in the farm workers' village.
BH4	**Bokpoort**	Chris Honiball	082 372 3467	28.72458	21.9926	Wind pump			Stock watering	Borehole located on a flat area in the wild game farm.

BH5	**Bokpoort**	Chris Honiball	082 372 3467	28.71084	21.9999	Wind pump			Stock watering	Borehole located on a flat area in a goat and sheep farm. Water is pumped into a concrete tank for stock watering.
BH6	**Bokpoort**	Chris Honiball	082 372 3467	28.7692	21.93741	Wind pump			Stock watering	Borehole located on a flat area in a sheep farm. Water is pumped into two concrete tanks for stock watering.
BH7	**Rooilyf**	Hennie Jooste	083 388 5314	28.79907	21.96237	Wind pump			Stock watering	Borehole located on a sheep farm. Currently unused because there are no sheep in the farm.

Table 25: Hydrochemical analysis results

Sample ID	Sample Date	pH	Cond	Na	K	Mg	Ca	Mn	Fe	Cl	SO4	NO3 as N	NO3	T-Alk	HCO3
HBH2	13/04/2010	7.8	243	259	3.1	82	175	<0.001	0.001	314	266	26	113	501	611
HBH3	13/04/2010	8.1	37.9	28	4	11.9	30	<0.001	<0.001	28	46	0.3	1.4	101	123
HBH5	13/04/2010	7.9	153	104	12.3	68	123	<0.001	<0.001	155	69	22	96	482	588

ID	pH	EC	Na	K	Mg	Ca	Mn	Fe	Cl	SO4	NO3 as N
Class 0 Limits	5 - 9.5	70	100	25	70	80	0.1	0.5	100	200	6
Class 1 Limits	4.5 - 10	150	200	50	100	150	0.4	1	200	400	10
Class 2 Limits	4 - 10.5	370	400	100	200	300	4	5	600	600	20
Class 3 Limits	3 -- 11	520	1000	500	400	>300	10	10	1200	1000	40
Class 4 Limits	3 -- 11	>520	>1000	>500	>400		>10.0	>10.0	>1200	>1000	>40

Quality of Domestic Water Supplies, DWA, Second Edition 1998	
Class 0	**Ideal water quality** - Suitable for lifetime use.
Class 1	**Good water quality** - Suitable for use, rare instances of negative effects.
Class 2	**Marginal water quality** - Conditionally acceptable. Negative effects may occur in some sensitive groups.
Class 3	**Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.
Class 4	**Dangerous water quality** - Totally unsuitable for use. Acute effects may occur.

South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA, First Edition 1993 & Second Edition 1996	
NR	**Target water quality range** - No risk.
IR	**Good water quality** - Insignificant risk. Suitable for use, rare instances of negative effects.
LR	**Marginal water quality** - Allowable low risk. Negative effects may occur in some sensitive groups
HR	**Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.

- **Groundwater quality**

Three groundwater samples were collected from springs in the area and submitted to the M&L Laboratory in Johannesburg for chemical analysis. GCS (Pty) Ltd established a database in AQUABASE (database system for the storage and retrieval of surface water and groundwater related data developed by VSA Earth Resources Consultants (Pty) Ltd) and Microsoft Excel in which data was captured for storage and analysis.

Results of the chemical analysis were compared with the DWA South African Water Quality Guidelines for Domestic Water Use and the SABS Standards. Table 25 below show the analysis results of groundwater samples and the limits from the DWA Guidelines. Values that exceeded the DWA limits are highlighted in colours as assigned to water quality classes by DWA.

Groundwater in the area contains elevated levels of electric conductivity. The dominant cations in two of the sampled boreholes (Borehole 2 and Borehole 5) were sodium and calcium and the dominant anions were chloride and sulphates. Furthermore, high concentrations of nitrates were recorded for these samples Borehole 3 had water of good quality with all the determinants falling in class 0 of the DWA standards. From the chemical analysis if the borehole samples it is concluded that the groundwater in the area is of $Ca/MgHCO_3$ to $CaMg/SO_4$ type.

- **Aquifer classification**

The local aquifers underlying the Bokpoort site are the sole source of potable water for the communities living in the surrounding areas. The use of groundwater resource by the farmers is, however, at a very low scale. The community living in farms located along the Orange River is dependable on water from the Orange River for domestic use.

The local aquifers can be classified as minor, according to Parsons Aquifer Classification system, due to the limited use of groundwater in the area as well as the quality of groundwater obtained from the chemical analysis results.

6.1.7 Surface Water[39]

6.1.7.1 Regional Overview

The !Kheis Local Municipality falls in the Lower Orange Water Management Area (LOWMA[40]) of South Africa. The main water resource of the LOWMA is the Orange River, which is South Africa’s biggest and most controlled watercourse. The LOWMA is characterised by an arid

[39] Bohlweki Environmental. 2006. *Environmental Impact Assessment for the establishment of a New Concentrating Solar Power (CSP) plant and associated infrastructure in the Northern Cape Province.*

[40] MS Basson and JD Rossouw. Report number PMWA 14/000/00/0203, Lower Orange Water Management Area: Overview of water resources availability and utilization. Department of Water Affairs and Forestry (DWAF), South Africa, September 2003.

climate, high temperatures and late afternoon summer thunderstorms. The evaporation rate in the LOWMA is estimate at 3000 mm which is higher than the Mean Annual Rainfall (MAR)[41].

The Orange River is the main surface water resource in the Siyanda District and !Kheis Local Municipality providing the necessary resource for the primary economic driver in the area, crop production (i.e. grapes). The river is a perennial river with a varied flow between 50 – 1 800 cubic meters per day depending on the season. The river flow is pre-dominantly controlled at the Bloemhof, Gariep and Van Der Kloof dams all situated upstream of the river (Siyanda District Municipality Integrated Development Plan, 2004). Furthermore the Orange River is regulated by a number of weirs, dams and gauging structures. The function of these structures is to regulate the flow of the river and to provide an efficient volume of water for the irrigation activities situated along the river.

The water quality of the Orange River is categorised as Class C – Moderately Transformed due to existing agricultural activities along the river banks. The major inflow of water feeds from the Vaal River which is known for its high nutrient levels and results in algal blooms from time to time. Slow water flow rates also cause siltation and turbidity of the water which leads to water quality degradation within the river.

The main water users in the LOWMA are the municipalities and the agricultural sector.

6.1.7.2 Surface Water Characteristics of Bokpoort

No area of permanent surface water is present on the site. Evidence of non-perennial drainage lines could be viewed from aerial imagery and visually in the southern part of the proposed site, but these areas are only expected to contain flowing water during periods of exceptional high rainfall.

No significant wetlands, estuaries, Ramsar Sites or major dams are present within the immediate vicinity of the study site. A seasonal pan occurs approximately 3km north of the Garona substation (see Figure 54) – a 200m buffer (no development area) has been demarcated around the pan.

The most significant impact that currently affects the status of smaller riparian systems in the region is the effect of grazing and trampling of cattle in areas where natural habitat are grazed intensively.

[41] Siyanda District Municipality EMF (2008)

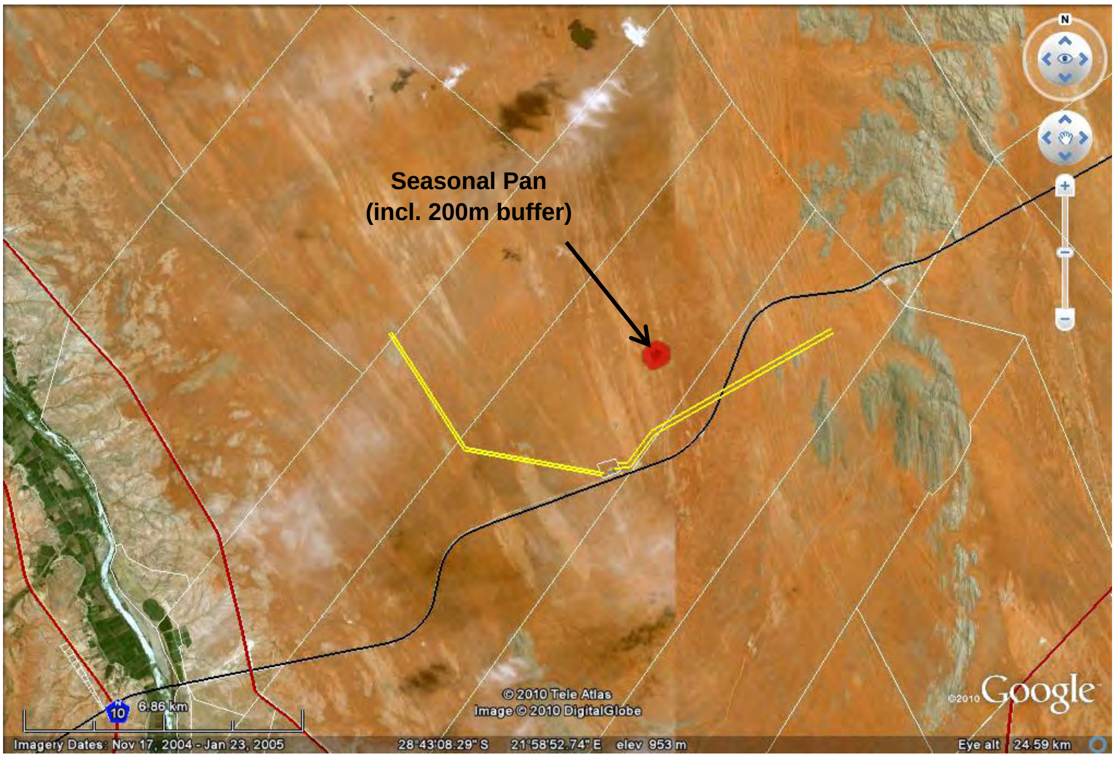


Figure 54: Seasonal pan located north of the Garona substation

6.1.7.3 Assessment Findings

The following aspects were assessed during the hydrological assessment:

- ***Rainfall***: An assessment of local rainfall events, their size, frequency and intensity and likely effects on these as a result of surface energy balance changes. Impacts were assessed using standard methodologies for estimating changes in potential evapo-transpiration and soil and ambient heat fluxes;
- ***Infiltration***: Impacts on soil water infiltration were determined by taking into account the infiltration capacity of soils and any potential changes in rainfall, rainfall interception, as well as changes in evapo-transpiration from areas surrounding the CSP plant;
- ***Surface runoff***: The capacity of the affected ground surfaces to cope with concentrated surface water was assessed in the light of soil infiltration capacity, topography, and soil erosion potential; and
- ***Streamflow***: An assessment of the impacts of the hydrological processes mentioned above on nearby streams. Impacts of streamflow were assessed in terms of total water yield, low flow yields and timing of low flows, as well as on sedimentation. Standard and acceptable hydrological process models were used for this purpose.

- **Assessment of CSP Plant on Regional Hydrology**

Water flowing in rivers in South Africa is precious, particularly in the arid regions such as the Northern Cape. The regional economy depends on the existence of the Orange River, therefore any activity which reduces flow in it is possibly an additional burden to the economy. It is estimated that 859 000 m^3.of water per annum may be required by the CSP for primarily cooling purposes and the cleaning of the plant mirrors – the exact volume of water required for the project will be dependant on the technology selected by Solafrica, and the figure provided should be considered that of a ”worst-case”. On a monthly basis this amount will be less than one five thousandth or 0.0002 of monthly flow in the Orange River at Upington (calculated for DWA measuring station D7H005 at Upington). As a proportion of river flow, this quantity is negligible and it can be concluded that the CSP will have such a small impact on river flow that the issue needs not be considered further.

- **Assessment of CSP Plant on Rainfall**

The question arises whether a facility like the proposed CSP could have an effect on local and regional weather and climate, particularly rainfall, by somehow affecting weather patterns and local energy budgets. To answer this question, regional controls on climate and weather are examined first, followed by the possible effects of the facility on local energy budgets and atmospheric conditions.

The average circulation of the atmosphere over southern Africa is anti-cyclonic and the daily weather is to a large degree controlled by the semi-permanent South Indian Anticyclone. A trough of low pressure across the Northern Cape and Botswana is linked to a tropical low north of Botswana[42]. This system advects moist tropical air from equatorial regions into the sub-continental region from time to time during the summer, when convection can take place and result in rainfall. However, the annual rainfall in the southern Kalahari region is more variable than anywhere else in South Africa[43]. This variability appears to be strongly linked to seasonal and inter-annual meridional (wind circulation in the east-west direction) circulation patterns[44]. Clearly, the controls on rainfall and its variability in the region lie at the much greater scales of continental, oceanic and hemispherical atmospheric circulation.

The net effect of the conversion of sunlight to electrical energy, over the area of the facility, will be a slight cooling of the ground surface and air during the daytime. Although the temperature differences will hardly be discernable, this will result in a small amount of local air subsidence over the facility during the daytime, with associated suppression of evapo-transpiration. The descending air will spread out beyond the field of heliostats/troughs, where, in contact with the hot ground surface, it will soon be heated back to air temperatures normally found close to the ground surface during the day in that region. At night, there will be a net loss of heat energy from a very localised source as power generation and air cooling of the steam cycle continues. The rising column of warmed air will dissipate rapidly in the relatively cooler and moving night air.

By way of example, the quantity of heat loss during this process will be substantially less than a so-called “six-pack” coal fired power station with its chimneys and forced-convection cooling

[42] Preston-Whyte, R.A and Tyson P.D. 1988. *The Atmosphere and Weather of Southern Africa.* Oxford University Press, Cape Town.
[43] Tyson**,** P.D.1986. *Climatic Change and Variability in South Africa*. Oxford University Press, Cape. Town.
[44] Tyson**,** P.D.1986. *Climatic Change and Variability in South Africa*. Oxford University Press, Cape. Town.

towers found on the Mpumulanga Highveld. These installations are not known for their weather-altering capabilities. The conclusion to be drawn from the above therefore is that a CSP will have no effect on local weather, particularly rainfall. Neither will the small change in the energy budget over the area of the CSP have any effect, adverse or otherwise.

- **Assessment of CSP Plant on Infiltration**

The aeolian sands that are prevalent at both the sites have high infiltration rates. These sands can have infiltration rates anywhere between 10 $mm.hr^{-1}$ and 250 $mm.hr^{-1}$. The depth of the sand over the underlying calcrete hardpan and its imperviousness would be one local control of infiltration at each site although such data is not available at present.

The installation of a CSP plant would result in some impervious areas of buildings, infrastructure and roads. This would cause local changes to infiltration at the scale of the building, but stormwater drainage will easily disperse this on site because of the high infiltration rates. The heliostats/troughs might cause small-scale ponding under individual structures should there be a very heavy storm, but it is highly unlikely that any such effect would cross site boundaries or have an effect off the site. Possibilities for management of the soil surface under the heliostats/troughs would be to either leave a bare or very short vegetation surface, or lay a surface of stone chips. In either case this would make no difference to the infiltration rate.

There are two other factors of infiltration to consider: 1) disturbance and sealing, and 2) soil crusting. Activities such as vehicular movement between the heliostats/troughs for cleaning purposes might disturb the soil surface. It is well known that agricultural activities result in soil surface sealing, which will lead to reduced infiltration. Further, vehicular activity could lead to compaction, also reducing infiltration. Sands however are particularly resistant to compaction and sealing.

Soil crusting by cyanobacteria is a phenomenon known to occur in the arid Kalahari Basin[45,46]. Biological crusts are advantageous in desert regions to those plants to which they can provide additional nutrients. However, it is not known how this crusting affects infiltration and runoff, if at all. Activity on the soil surface, such as livestock or vehicular traffic, will destroy the crusting, although the crusts can reform fairly rapidly. In the Kalahari Desert in Botswana, the presence of biological crusting is persistent even in areas with livestock movement. Such crusting is not likely to have any effect on infiltration and any of the sites.

- **Assessment of a CSP Plant on Runoff and Streamflow Generation**

Any runoff that can be generated by a soil surface and rainfall is dependent on the intensity and duration of rainfall, combined with the infiltration capacity of the soil. Given that the soils at all sites have high infiltration rates, it is highly unlikely that surface runoff will develop

[45] Dougill, A.J and Thomas, A.D. 2004. *Kalahari sand soils: Spatial heterogeneity, biological soil crusts and land degradation*. Land Degradation and Development 15: 233 – 242. DOI 10.1002/ldr.611.
[46] Berkeley, Thomas, A.D. and Dougill, A.J. 2005. *Cyanobacterial crusts and woody shrub canopies in Kalahari Ranglands*. African Journal of Ecology 43: 137 – 145.

except for long return period heavy rainfalls. The development of a CSP plant is unlikely to change that because most of the site will keep its characteristics of high infiltration rates. If runoff occurs in this arid environment, it occurs as storm flow, which quickly subsides and the stream channel reverts to its normal dry condition. Thus there is also likely to be no effect on streamflow.

Soils are similarly aeolian red sands overlying calcrete hardpans, with some dune features near boundaries of the site. The major advantage of this site is the proximity of Eskom transmission infrastructure, which would reduce some of the development costs. The area is flat, but bounded in the north east by a range of hills and in the south west by a topographic feature. No natural drainage features are evident. Surface runoff appears not to be actively generated on this site either and this is also unlikely to change with the development of a CSP plant on this site.

6.1.8 Air Quality

The Air Quality Unit at SSI Engineers and Environmental Consultants was appointed by Solafrica to undertake an Air Quality Impact Assessment for a proposed 11.5 MW boiler at two likely locations for the CSP plant – refer to Figure 55.

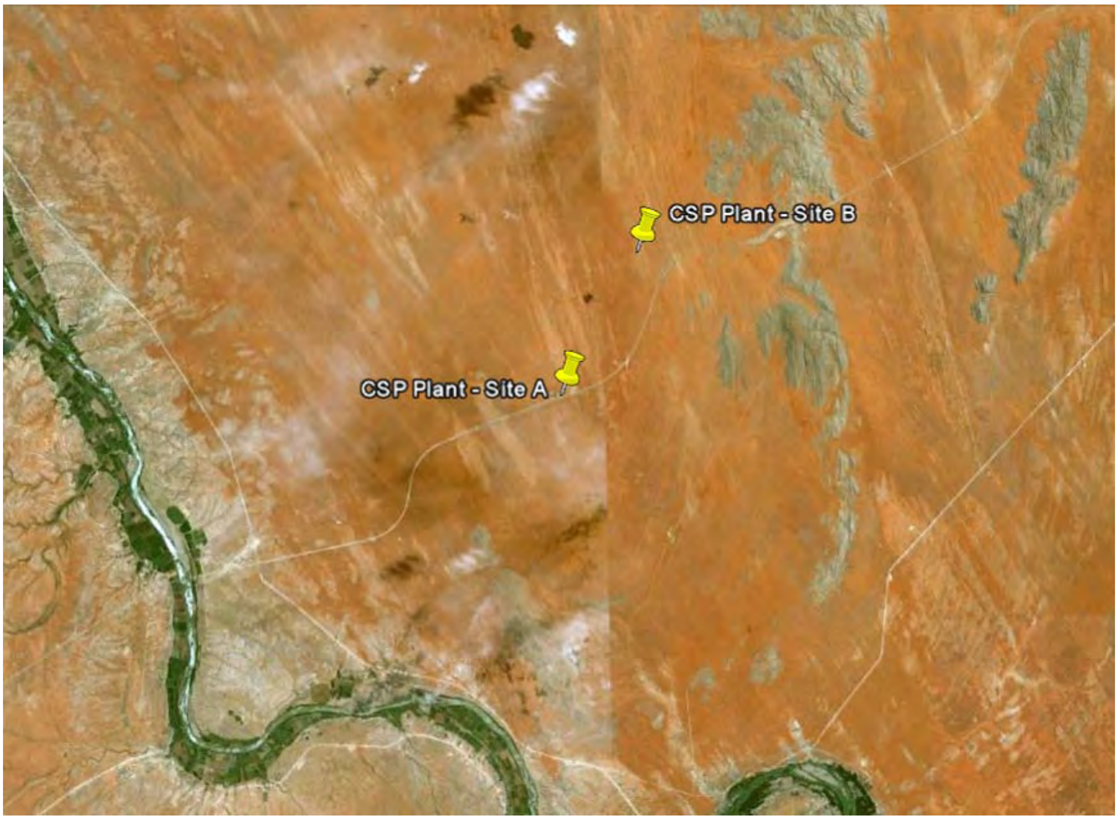


Figure 55: Plant locations assessed during the Air Quality Assessment

As part of the Air Quality Assessment for the proposed boiler, a baseline assessment was undertaken through a review of available meteorological data. The potential impact of emissions from the proposed project on the surrounding environment was evaluated through the compilation of an emissions inventory and subsequent dispersion modelling simulations using the AERMOD dispersion model. Comparison with the South African ambient air quality standards was made to determine compliance in terms of the potential health impacts for humans.

*Refer to **Appendix D** for the Air Quality Impact Assessment Report.*

6.1.8.1 Methodology

An overview of the methodological approach followed during the Air Quality Impact Assessment is outlined in the section which follows.

- **Baseline Assessment**

During the baseline assessment, a qualitative approach was used to assess the baseline conditions in the project area. Modelled meteorological data was obtained for the period January 2005 to December 2009 to determine the atmospheric dispersion potential of the area. Sensitive receptors, such as local communities, in close proximity to the site were identified using available satellite imagery.

- **Air Quality Impact Assessment**

During this phase, an emissions inventory was compiled to estimate emissions from the proposed boiler. Dispersion modelling simulations were undertaken using the AERMOD dispersion model and presented graphically as isopleths plots. Comparison with the National ambient air quality standards was made to determine compliance.

6.1.8.2 Assumptions and Limitations

Due to the unavailability of information required for the modelling studies, the following assumptions were made as part of this assessment:

- Use was made of site-specific modelled meteorological data as hourly surface observations from a nearby meteorological station was not available;
- Emissions were estimated using the USEPA AP-42 emission factors for Fuel Oil Combustion and Liquefied Petroleum Gas Combustion;
- The sulphur content of the diesel fuel was assumed to be 0.55%, as per the South African diesel specification (SABS 342);
- The composition of the LPG fuel was assumed to be 100% propane for the calculation of emission rates. The composition of the LPG to be used at the proposed site is approximately 30% butane and 70% propane;
- All particulate (PM) was modelled in the filterable fraction (PM10 and less);
- The boiler was assumed to operate for a 12 month period - as a maximum emission scenario - based on provided annual diesel and LPG consumption rates. During

normal operating conditions at the proposed site, it is anticipated that the boiler will only be operational for 6 months.

- Emissions from the proposed storage tank were not included in the dispersion simulations. Based on the design parameters provided, the storage tank is not anticipated to be a significant air pollution source and is not classified as a listed activity in terms of the Listed Activities and Associated Minimum Emission Standards (Government Gazette No 32434).

6.1.8.3 Baseline Description of the Area

- **Meso-scale Meteorology**

The nature of local climate will determine what will happen to pollution when it is released into the atmosphere (Tyson and Preston-Whyte, 2000). Pollution levels fluctuate daily and hourly, in response to changes in atmospheric stability and variations in mixing depth. Similarly, atmospheric circulation patterns will have an effect on the rate of transport and dispersion of pollution.

The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during conditions of free convection and when the mixing layer is deep (unstable atmospheric conditions). These conditions occur most frequently in summer during the daytime. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped under a surface inversion (Tyson and Preston-Whyte, 2000).

Inversion occurs under conditions of stability when a layer of warm air lies directly above a layer of cool air. This layer prevents a pollutant from diffusing freely upward, resulting in an increased pollutant concentration at or close to the earth’s surface. Surface inversions develop under conditions of clear, calm and dry conditions and often occur at night and during winter (Tyson and Preston-Whyte, 2000). Radiative loss during the night results in the development of a cold layer of air close to the earth’s surface. These surface inversions are however, usually destroyed as soon as the sun rises and warm the earth’s surface. With the absence of surface inversions, the pollutants are able to diffuse freely upward; this upward motion may however be prevented by the presence of an elevated inversion (Tyson and Preston-Whyte, 2000).

Elevated inversions occur commonly in high-pressure areas. Sinking air warms adiabatically to temperatures in excess of those in the mixed boundary layer. The interface between the upper, gently subsiding air is marked by an absolutely stable layer or an elevated subsidence inversion. This type of elevated inversion is most common over Southern Africa (Tyson and Preston-Whyte, 2000).

The climate and atmospheric dispersion potential of the interior of South Africa is determined by atmospheric conditions associated with the continental high pressure cell located over the interior. The continental high pressure present over the region in the winter months results in fine conditions with little rainfall and light winds with a northerly flow. Elevated inversions are common in such high pressure areas due to the subsidence of air. This reduces the mixing depth and suppresses the vertical dispersion of pollutants, causing increased pollutant concentrations (Tyson and Preston-Whyte, 2000).

Seasonal variations in the positions of the high pressure cells have an effect on atmospheric conditions over the region. For most of the year the tropical easterlies cause an air flow with a north-easterly to north-westerly component. In the winter months the high pressure cells move northward, displacing the tropical easterlies northward resulting in disruptions to the westerly circulation. The disruptions result in a succession of cold fronts over the area in winter with pronounced variations in wind direction, wind speeds, temperature, humidity, and surface pressure. Airflow ahead of a cold front passing over the area has a strong north-north-westerly to north-easterly component, with stable and generally cloud-free conditions. Once the front has passed, the airflow is reflected as having a dominant southerly component (Tyson and Preston-Whyte, 2000).

Easterly and westerly wave disturbances cause a southerly wind flow and tend to hinder the persistence of inversions by destroying them or increasing their altitude, thereby facilitating the dilution and dispersion of pollutants. Pre-frontal conditions tend to reduce the mixing depth. The potential for the accumulation of pollutants during pre-frontal conditions is therefore enhanced over the plateau (Tyson and Preston-Whyte, 2000).

- **Site-Specific Dispersion Potential**

Given the remote location of the proposed site, local meteorological data required for modelling purposes is not available. Use was therefore made of site-specific modelled MM5 meteorological data for the period January 2005 to December 2009 from Lakes Environmental.

Wind roses comprise of 16 spokes which represent the directions from which winds blew during the period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories.

Based on an evaluation of the meteorological data provided, winds originate predominantly from the north-north-east (10% of the time) and north (9% of the time) (Figure 56). Moderate to fast winds are generally recorded over the monitoring period. Calm wind speeds, which are designated as wind speeds less than 0.5 m/s, occur infrequently (4% of the time).

A diurnal trend in the wind field is recorded at the proposed site (Figure 57). During the day-time (06:00 – 18:00), moderate to fast winds originate predominantly from the westerly and northerly sectors. During the night-time (12:00 – 18:00), winds originate from all sectors with a shift observed to the north-north-east and north-east between 00:00 – 06:00. As would be expected, faster winds are recorded during the day-time period compared to the night-time.

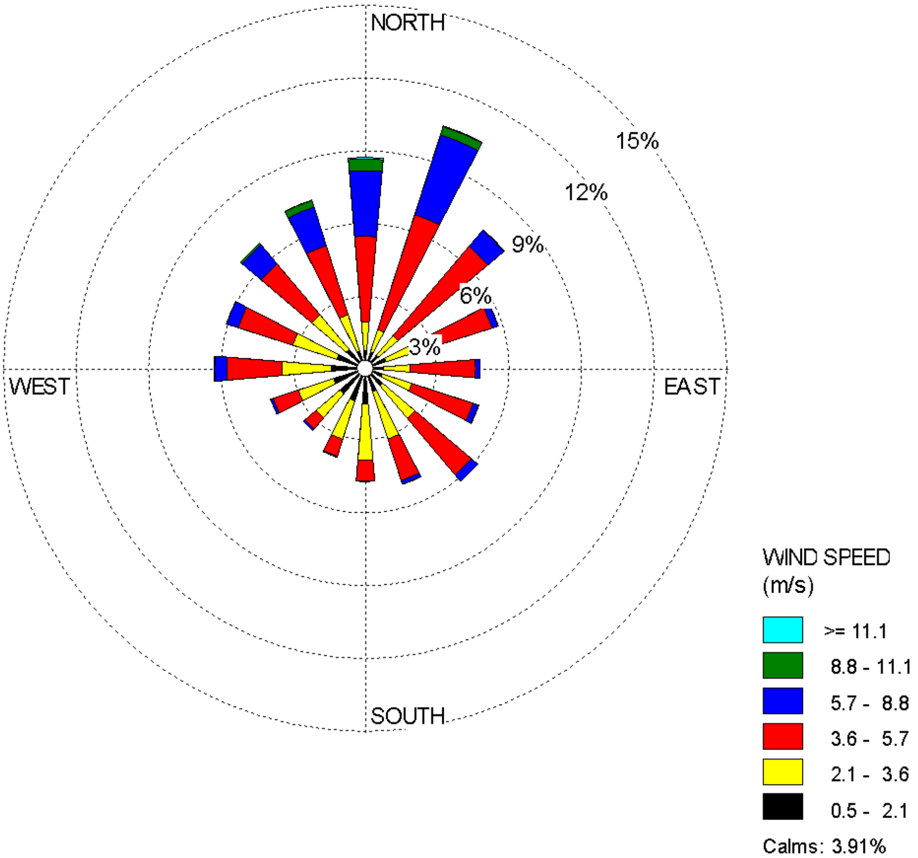
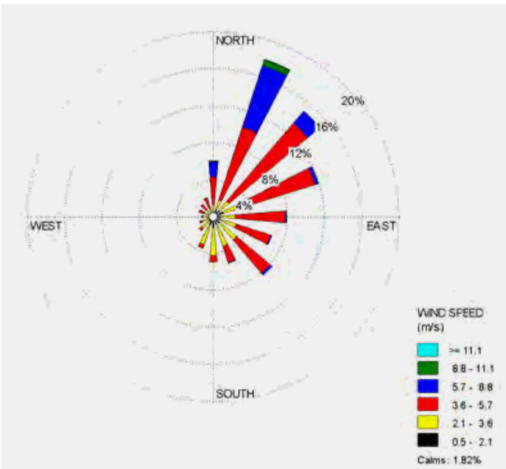
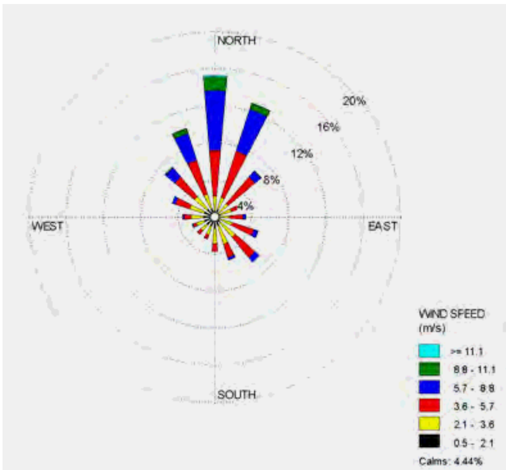


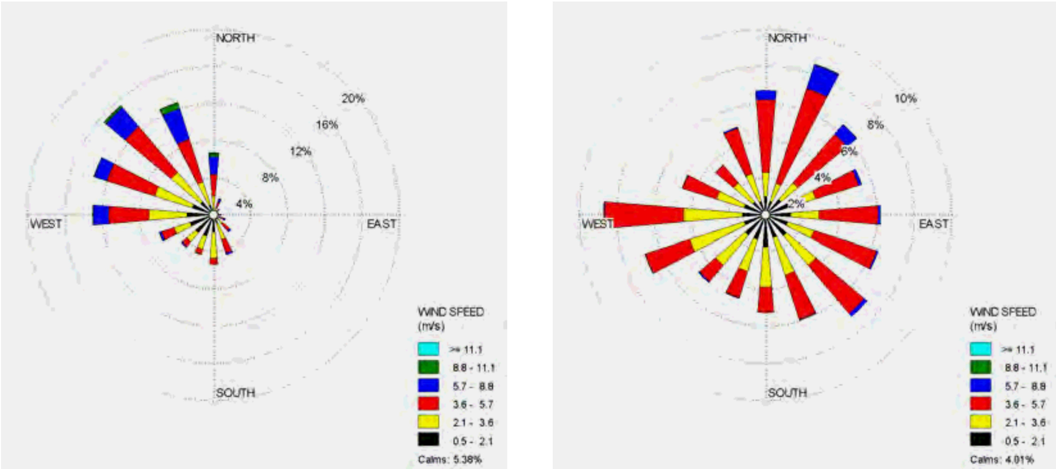
Figure 56: Period wind rose for the proposed site for the period Jan 2005 – Dec 2009



00:00 – 06:00



06:00 – 12:00

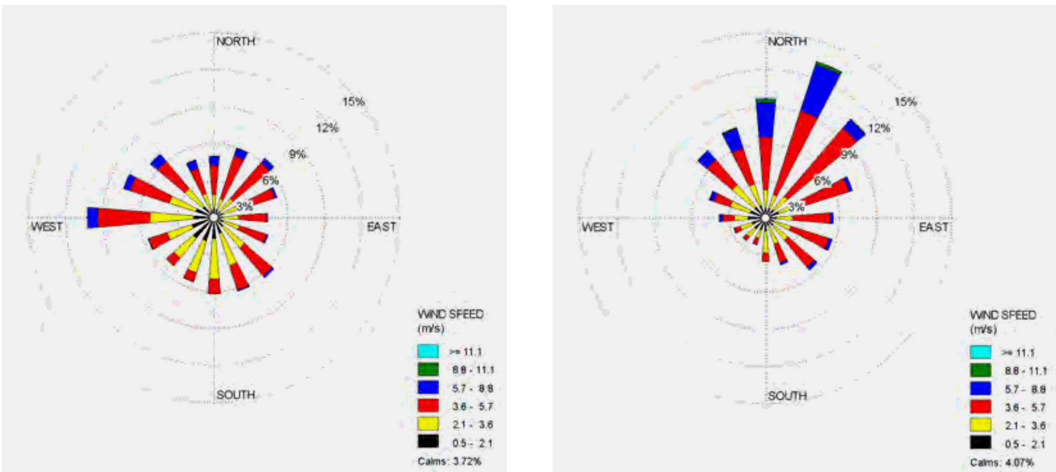


12:00 – 18:00 **12:00 – 18:00**

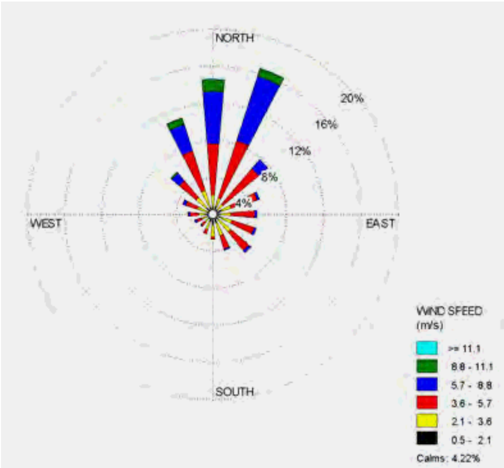
Figure 57: Diurnal wind roses for the proposed site for the period Jan 2005 – Dec 2009

The seasonal variability in the wind field at the proposed site is shown in Figure 58. During the summer months (December, January and February), winds originate predominantly from the west. During autumn (March, April and May), a shift is observed with winds originating predominantly from the north-north-east and north-east. A similar pattern to the autumn months is observed during the winter months (June, July and August). During spring (September, October and November), winds originate from all sectors, with the highest frequency recorded from the westerly sector.

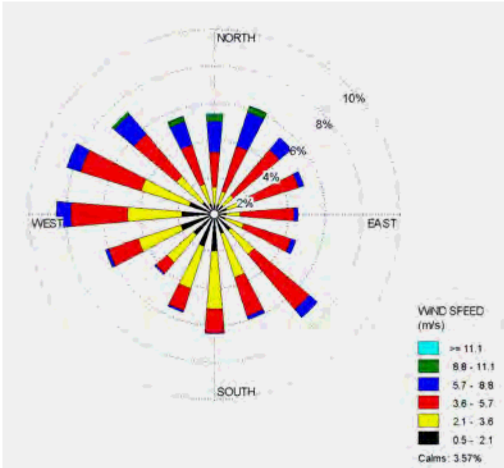
Based on the prevailing meteorological conditions for the area, emissions released from the proposed site will be transported predominantly in a south-south-westerly and southerly direction from the proposed site. The prevalence of moderate to fast winds will transport emissions several kilometres from the proposed site.



Summer **Autumn**



Winter



Spring

Figure 58: Seasonal wind roses for the proposed site for the period Jan 2005 – Dec 2009

6.1.8.4 Atmospheric Stability

Atmospheric stability is commonly categorised into six stability classes (Table 26). The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5 to 6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night-time a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

Table 26: Atmospheric stability classes

A	Very unstable	calm wind, clear skies, hot daytime conditions
B	Moderately unstable	clear skies, daytime conditions
C	Unstable	moderate wind, slightly overcast daytime conditions
D	Neutral	high winds or cloudy days and nights
E	Stable	moderate wind, slightly overcast night-time conditions
F	Very stable	low winds, clear skies, cold night-time conditions

In general, the proposed site experiences neutral (Class D) to stable (Class E) atmospheric conditions (Figure 59). This is expected given the predominance of a high-pressure anticyclone over South Africa which produces stable, clear conditions.

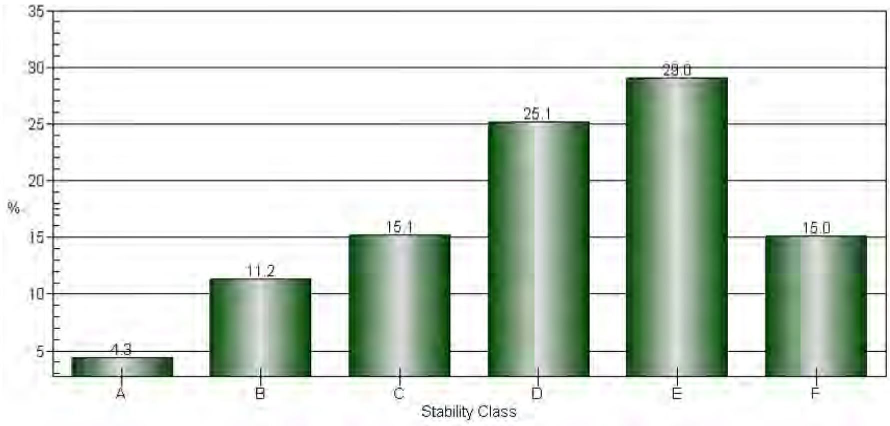


Figure 59: Stability class frequency distribution for the proposed site for the period Jan 2005 – Dec 2009

6.1.8.5 Temperature and Humidity

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella and Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles (CEPA/FPAC Working Group, 1999). This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids. Temperature also provides an indication of the rate of development and dissipation of the mixing layer.

Average monthly temperature and humidity at the proposed site for the period 2005 – 2009 is given in Figure 60. Daily average summer temperatures range between ~24 °C and ~26 °C while winter temperatures range between ~11 °C and ~13 °C. Relative humidity peaks during the winter months.

Figure 60: Average monthly temperature and humidity for the proposed site for the period 2005 – 2009

6.1.8.6 Health Risk Evaluation Criteria

South African ambient air quality standards have been issued by the Department of Environmental Affairs and will be used as a basis for comparison for this assessment. However, reference will be made to international guidelines to ensure complete compliance. The pollutants assessed during the current investigation included the criteria pollutants: inhalable particulate matter (PM), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2).

- **Particulate Matter**

Particulate matter is the collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface. PM includes dust, smoke, soot, pollen and soil particles (Kemp, 1998). PM has been linked to a range of serious respiratory and cardiovascular health problems. The key effects associated with exposure to ambient particulate matter include: premature mortality, aggravation of respiratory and cardiovascular disease, aggravated asthma, acute respiratory symptoms, chronic bronchitis, decreased lung function, and an increased risk of myocardial infarction (USEPA, 1996).

PM represents a broad class of chemically and physically diverse substances. Particles can be described by size, formation mechanism, origin, chemical composition, atmospheric behaviour and method of measurement. The concentration of particles in the air varies across space and time, and is related to the source of the particles and the transformations that occur in the atmosphere (USEPA, 1996).

PM can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions (USEPA, 1996):

- PM10 (generally defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung);
- PM2.5, also known as fine fraction particles (generally defined as those particles with an aerodynamic diameter of 2.5 microns or less)
- PM10-2.5, also known as coarse fraction particles (generally defined as those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns); and
- Ultra fine particles generally defined as those less than 0.1 microns.

Fine and coarse particles are distinct in terms of the emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters. Fine particles are directly emitted from combustion sources and are also formed secondarily from gaseous precursors such as sulphur dioxide, nitrogen oxides, or organic compounds. Fine particles are generally composed of sulphate, nitrate, chloride and ammonium compounds, organic and elemental carbon, and metals.

Table 34 outlines the various international health risk criteria used for the assessment of inhalable particulate matter (PM10). Guidelines and standards are provided for a 24-hour exposure and annual average exposure period respectively.

Table 27: Ambient air quality guidelines and standards for particulate matter

Origin	24-Hour Exposure (µg/m³)	Annual Average Exposure (µg/m³)	Number of exceedance allowed per year
South Africa[(1)]	120	50	4 daily exceedance
World Bank[(6)]	500	100	NA
EU[(3)]	50	30 20[(2)]	25 daily exceedance By 2010 only 7 daily exceedance
USEPA[(4)]	150	50[(5)]	1 daily exceedance
UK[(6)]	50	40	35 daily exceedance
WHO[(7) (8) (9)]	50	20	NA

Notes:

(1) Standard laid out in the National Environment Management: Air Quality Act. No 39 of 2004.

(2) Compliance by 1 January 2010.

(3) World Bank Air Quality Standards summary obtainable at URL http://www.worldbank.org/html/fpd/em/power/standards/airqstd.stm#paq.

(4) European Union Air Quality Standards summary obtainable at URL http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=Directive&an_doc=1999&nu_doc=30.

(5) United States Environmental Protection Agencies National Air quality Standards obtainable at URL http://www.epa.gov/air/criteria.html

(6) To attain this standard, the 3-year average of the weighted annual mean PM_{10} concentration at each monitor within an area must not exceed 50 ug/m^3.

(7) United Kingdom Air Quality Standards and objectives obtainable at URL http://www.airquality.co.uk/archive/standards.php

(8) WHO = World Health Organisation.

(9) Guidance on the concentrations at which increasing, and specified mortality responses due to PM are expected based on current scientific insights (WHO, 2005).

(10) Air quality guideline.

- **Oxides of Nitrogen**

Air quality guidelines and standards issued by most other countries and organisations tend to be given exclusively for NO_2 concentrations as NO_2 is the most important species from a human health point of view. International and South African standards for NO_2 are presented in Table 28.

Table 28: Ambient air quality guidelines and standards for nitrogen dioxide

Averaging Period	South Africa		WHO		EC		Australia	
	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm
Annual Ave	40	0.021	40	0.021	40$^{(2)}$	0.021$^{(2)}$	57$^{(4)}$	0.03$^{(4)}$
Max. 1-hr	200	0.10	200	0.10	200$^{(3)}$	0.10$^{(3)}$	240$^{(5)}$	0.12$^{(5)}$

Notes:

(1) Annual arithmetic mean.

(2) Annual limit value for the protection of human health, to be complied with by 1 January 2010.

(3) Averaging times represent 98th percentile of averaging periods; calculated from mean values per hour or per period of less than an hour taken through out year; not to be exceeded more than 8 times per year. This limit is to be complied with by 1 January 2010.

(4) Standard set in June 1998. Goal within 10 years given as being no exceedances.

(5) Standard set in June 1998. Goal within 10 years given as maximum allowable exceedances of 1 day a year.

NO is one of the primary pollutants emitted by aircraft and motor vehicle exhausts. As discussed previously, NO_2 is formed through oxidation of these oxides once released in the air. NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. The most adverse health effect occurs at the junction of the conducting airway and the gas exchange region of the lungs. The upper airways are less affected because NO_2 is not very soluble in aqueous surfaces. Exposure to NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function.

Available data from animal toxicology experiments indicate that acute exposure to NO_2 concentrations of less than 1 880 $\mu g/m^3$ (1 ppm) rarely produces observable effects (WHO, 2000). Normal healthy humans, exposed at rest or with light exercise for less than two hours to concentrations above 4 700 $\mu g/m^3$ (2.5 ppm), experience pronounced decreases in pulmonary function; generally, normal subjects are not affected by concentrations less than 1 880 $\mu g/m^3$ (1.0 ppm). One study showed that the lung function of subjects with chronic obstructive pulmonary disease is slightly affected by a 3.75-hour exposure to 560 µg/m3 (0.3 ppm) (WHO, 2000).

Asthmatics are likely to be the most sensitive subjects, although uncertainties exist in the health database. The lowest concentration causing effects on pulmonary function was reported from two laboratories that exposed mild asthmatics for 30 to 110 minutes to 565 µg/m3 (0.3 ppm) NO_2 during intermittent exercise. However, neither of these laboratories was able to replicate these responses with a larger group of asthmatic subjects. NO_2 increases bronchial reactivity, as measured by the response of normal and asthmatic subjects following exposure to pharmacological bronchoconstrictor agents, even at levels that do not affect pulmonary function directly in the absence of a bronchoconstrictor. Some, but not all, studies show increased responsiveness to bronchoconstrictors at NO_2 levels as low as 376-565 $\mu g/m^3$ (0.2 to 0.3 ppm); in other studies, higher levels had no such effect. Because the actual mechanisms of effect are not fully defined and NO_2 studies with allergen challenges showed no effects at the lowest concentration tested (188 $\mu g/m^3$; 0.1 ppm), full evaluation of the health consequences of the increased responsiveness to bronchoconstrictors is not yet possible.

Studies with animals have clearly shown that several weeks to months of exposure to NO_2 concentrations of less than 1 880 µg/ m^3 (1ppm) causes a range of effects, primarily in the lung, but also in other organs such as the spleen and liver, and in blood. Both reversible and irreversible lung effects have been observed. Structural changes range from a change in cell type in the tracheobronchial and pulmonary regions (at a lowest reported level of 640 µg/m^3), to emphysema-like effects. Biochemical changes often reflect cellular alterations, with the lowest effective NO_2 concentrations in several studies ranging from 380-750µg/m^3. NO_2 levels of about 940 µg/m^3 (0.5 ppm) also increase susceptibility to bacterial and viral infection of the lung. Children of between 5 to12 years old are estimated to have a 20% increased risk for respiratory symptoms and disease for each increase of 28 µg/m^3 NO_2 (2-week average), where the weekly average concentrations are in the range of 15-128 µg/m^3 or possibly higher. However, the observed effects cannot clearly be attributed to either the repeated short-term high-level peak, or to long-term exposures in the range of the stated weekly averages (or possibly both). The results of outdoor studies consistently indicate that children with long-term ambient NO_2 exposures exhibit increased respiratory symptoms that are of longer duration, and show a decrease in lung function.

- **Sulphur Dioxide**

SO_2 is an irritant that is absorbed in the nose and aqueous surfaces of the upper respiratory tract, and is associated with reduced lung function and increased risk of mortality and morbidity. Adverse health effects of SO_2 include coughing, phlegm, chest discomfort and bronchitis.

Short-period exposures (less than 24 hours): Most information on the acute effects of SO_2 comes from controlled chamber experiments on volunteers exposed to SO_2 for periods ranging from a few minutes up to one hour (WHO, 2000). Acute responses occur within the first few minutes after commencement of inhalation. Further exposure does not increase effects. Effects include reductions in the mean forced expiratory volume over one second (FEV1), increases in specific airway resistance, and symptoms such as wheezing or shortness of breath. These effects are enhanced by exercise that increases the volume of air inspired, as it allows SO_2 to penetrate further into the respiratory tract. A wide range of sensitivity has been demonstrated, both among normal subjects and among those with asthma. People with asthma are the most sensitive group in the community. Continuous exposure-response relationships, without any clearly defined threshold, are evident.

Sub-chronic exposure over a 24-hour period: Information on the effects of exposure averaged over a 24-hour period is derived mainly from epidemiological studies in which the effects of SO_2, suspended particulate matter and other associated pollutants are considered. Exacerbation of symptoms among panels of selected sensitive patients seems to arise in a consistent manner when the concentration of SO_2 exceeds 250 µg/m^3 in the presence of suspended particulate matter. Several more recent studies in Europe have involved mixed industrial and vehicular emissions now common in ambient air. At low levels of exposure (mean annual levels below 50 $\mu g/m^3$; daily levels usually not exceeding 125 $\mu g/m^3$) effects on mortality (total, cardiovascular and respiratory) and on hospital emergency admissions for total respiratory causes and chronic obstructive pulmonary disease (COPD), have been consistently demonstrated. These results have been shown, in some instances, to persist when black smoke and suspended particulate matter levels were controlled for, while in others no attempts have been made to separate the pollutant effects. In these studies no obvious threshold levels for SO_2 has been identified.

Long-term exposure: Earlier assessments, using data from the coal-burning era in Europe judged the lowest-observed-adverse-effect level of SO_2 to be at an annual average of 100 $\mu g/m^3$, when present with suspended particulate matter. More recent studies related to industrial sources of SO_2, or to the changed urban mixture of air pollutants, have shown adverse effects below this level. There is, however, some difficulty in finding this value.

Based upon controlled studies with asthmatics exposed to SO_2 for short periods, the WHO (WHO, 2000) recommends that a value of 500 $\mu g/m^3$ (0.175 ppm) should not be exceeded over averaging periods of 10 minutes. Because exposure to sharp peaks depends on the nature of local sources, no single factor can be applied to estimate corresponding guideline values over longer periods, such as an hour. Day-to-day changes in mortality, morbidity, or lung function related to 24-hour average concentrations of SO_2 are necessarily based on epidemiological studies, in which people are in general exposed to a mixture of pollutants; and guideline values for SO_2 have previously been linked with corresponding values for suspended particulate matter. This approach led to a previous guideline 24-hour average value of 125 $\mu g/m^3$ (0.04 ppm) for SO_2, after applying an uncertainty factor of two to the lowest-observed-adverse-effect level. In more recent studies, adverse effects with significant public health importance have been observed at much lower levels of exposure. However, there is still a large uncertainty with this and hence no concrete basis for numerical changes of the 1987-guideline values for SO_2.

The EC's air quality criteria represent standards to be achieved by the year 2005, and would supersede the EU standards. The ambient air quality standards of the USEPA are based on clinical and epidemiological evidence. These standards were established by determining concentrations with the lowest-observed-adverse effect, adjusted by an arbitrary margin of safety factor to allow for uncertainties in extrapolating from animals to humans and from small groups of humans to larger populations. The standards of the USEPA also reflect the technological feasibility of attainment.

Ambient air quality guidelines and standards issued for various countries and organisations for SO_2 are given in Table 29.

Table 29: Ambient air quality guidelines and standards for sulphur dioxide

Country	Annual Average (µg/m³)	Maximum 24-hour Ave (µg/m³)	Maximum 1-hour Ave (µg/m³)	<1-hour Maximum (µg/m³)
RSA	50	125	350	500 (10 min average)
WHO	50[(1)] 10-30[(2)]	125[(1)]	-	500[(1)] (10 min average)
EC	20[(3)]	125[(4)]	350[(5)]	
UK	20[(6)]	125[(7)]	350[(8)]	266[(9)] (15 min mean)
World Bank	50[(10)]	125[(10)]	-	-
USEPA	80	365	-	-
Australia	53[(11)]	209[(12)]	520[(13)]	-

Notes:

(1) Air quality guidelines (issued by the WHO for Europe) for the protection of human health (WHO, 2000).

(2) Represents the critical level for ecotoxic effects (issued by the WHO for Europe); a range is given to account for different sensitivities of vegetation types.

(3) Limit value to protect ecosystems. Applicable two years from entry into force of the Air Quality Framework Directive 96/62/EC.

(4) Limit to protect health, to be complied with by 1 January 2005. (Not to be exceeded more than 3 times per calendar year.)

(5) Limit to protect health, to be complied with by 1 January 2005. (Not to be exceeded more than 4 times per calendar year.)

(6) Given as annual and winter (1 Oct to 31 March) mean, to be complied with by 31 December 2000.

(7) 24-hour mean, not to be exceeded more than 24 times a year. Compliance required by 31 December 2004.

(8) 1-hour mean, not to be exceeded more than 24 times a year. Compliance required by 31 December 2004

(9) 15-minute mean, not to be exceeded more than 35 times a year. Compliance required by 31 December 2005.

(10) Ambient air concentration permissible at property boundary.

(11) Standard set in June 1998 as 0.02 ppm. Goal within 10 years is to have no exceedances.

(12) Standard set in June 1998 as 0.08 ppm. Goal within 10 years is to have maximum allowable exceedances of 1 day per year.

(13) Standard set in June 1998 as 0.20 ppm. Goal within 10 years is to have maximum allowable exceedances of 1 day per year.

(14) 90% of hourly observation to be less than 300 µg/m³

- **Identified Sensitive Receptors**

A sensitive receptor for the purposes of the current investigation is defined as a person or place where involuntary exposure to pollutants released by the proposed project could take place. Receptors surrounding the proposed sites (Sites A and B) were identified from satellite images of the area (Table 30). The residential areas of Groblershoop, Sutterheim and Wegdraai are the closest residential areas to the proposed sites. The town of Upington is located approximately 80 km to the west-north-west of the proposed sites. A neighbouring farmhouse is located in close proximity (approximately 2 km) to the proposed sites.

Table 30: Identified receptors surrounding the proposed site (as determined from Site A)

Receptor	Distance (km)	Direction from Site
Wegdraai	~ 17 km	SW
Groblershoop	~ 18 km	S
Stutterheim	~ 19 km	S
Boegoberg	~ 24 km	SSE
Upington	~ 80 km	WNW

- **Existing Sources of Air Pollution**

Based on satellite imagery and a site description of the area, the following surrounding sources of air pollution have been identified in the area:

- Agriculture;
- Domestic fuel burning; and
- Veld fires.

A qualitative discussion of each identified sources is provided in the subsections below. The aim is to highlight the potential contribution of surrounding sources to the overall ambient air quality situation in the area. These sources have not been quantified as part of this assessment.

<u>Agriculture</u>

Agricultural activity can be considered a significant contributor to particulate emissions, although tilling, harvesting and other activities associated with field preparation are seasonally based.

The main focus internationally with respect to emissions generated due to agricultural activity is related to animal husbandry, with special reference to malodours generated as a result of the feeding and cleaning of animal. The types of livestock assessed included pigs, sheep, goats and chickens. Emissions assessed include ammonia and hydrogen sulphide (USEPA, 1996).

Little information is available with respect to the emissions generated due to the growing of crops. The activities responsible for the release of particulates and gases to atmosphere would however include:

- Particulate emissions generated due to wind erosion from exposed areas;
- Particulate emissions generated due to the mechanical action of equipment used for tilling and harvesting operations;
- Vehicle entrained dust on paved and unpaved road surfaces;
- Gaseous and particulate emissions due to fertilizer treatment; and
- Gaseous emissions due to the application of herbicides and pesticides.

Land-use along the Orange River is predominantly agricultural with crops such as grapes and raisins grown in the flood plains of the Orange River. Agricultural activities along the Orange River would likely contribute to the ambient particulate and gaseous pollutant concentrations in the area.

Domestic Fuel Burning

Due to the close proximity of residential developments it is anticipated that low income households in the area are likely to use coal and wood for space heating and/ or cooking purpose. Exposure to indoor air pollution (IAP) from the combustion of solid fuels is an important cause of morbidity and mortality in developing countries. Biomass and coal smoke contain a large number of pollutants and known health hazards, including particulate matter, carbon monoxide, nitrogen dioxide, sulphur oxides (mainly from coal), formaldehyde, and polycyclic organic matter, including carcinogens such as benzo[a]pyrene (Ezzati and Kammen, 2002).

Exposure to indoor air pollution (IAP) from the combustion of solid fuels has been implicated, with varying degrees of evidence, as a causal agent of several diseases in developing countries, including acute respiratory infections (ARI) and otitis media (middle ear infection), chronic obstructive pulmonary disease (COPD), lung cancer (from coal smoke), asthma, cancer of the nasopharynx and larynx, tuberculosis, perinatal conditions and low birth weight, and diseases of the eye such as cataract and blindness (Ezzati and Kammen, 2002).

Monitoring of pollution and personal exposures in biomass-burning households has shown concentrations are many times higher than those in industrialized countries. The latest International Ambient Air Quality Standards, for instance, required the daily average concentration of PM10 to be < 180 µg/m^3 (annual average < 60 µg/m^3). In contrast, a typical 24-hr average concentration of PM10 in homes using bio fuels may range from 200 to 5 000 µg/m^3 or more throughout the year, depending on the type of fuel, stove, and housing. Concentration levels, of course, depend on where and when monitoring takes place, because significant temporal and spatial variations may occur within a house. Field measurements, for example, recorded peak concentrations of > 50 000 $\mu g/m^3$ in the immediate vicinity of the fire, with concentrations falling significantly with increasing distance from the fire. Overall, it has been estimated that approximately 80% of total global exposure to airborne particulate matter occurs indoors in developing nations. Levels of CO and other pollutants also often exceed international guidelines (Ezzati and Kammen, 2002).

Given the remote location of the area, the burning of domestic fuels such as coal, wood and paraffin for heating and cooking purposes is likely to occur in surrounding residential areas such as Wegdraai, Groblershoop, Stutterheim and Boegoberg.

Veld Fires

A veld fire is a large-scale natural combustion process that consumes various ages, sizes, and types of flora growing outdoors in a geographical area. Consequently, veld fires are potential sources of large amounts of air pollutants that should be considered when attempting to relate emissions to air quality. The size and intensity, even the occurrence, of a veld fires depend directly on such variables as meteorological conditions, the species of vegetation involved and their moisture content, and the weight of consumable fuel per hectare (available fuel loading).

Once a fire begins, the dry combustible material is consumed first. If the energy released is large and of sufficient duration, the drying of green, live material occurs, with subsequent burning of this material as well. Under suitable environmental and fuel conditions, this process may initiate a chain reaction that results in a widespread conflagration. It has been hypothesized, but not proven, that the nature and amounts of air pollutant emissions are directly related to the intensity and direction (relative to the wind) of the veld fire, and are indirectly related to the rate at which the fire spreads. The factors that affect the rate of spread are (1) weather (wind velocity, ambient temperature, relative humidity); (2) fuels (fuel type, fuel bed array, moisture content, fuel size); and (3) topography (slope and profile). However, logistical problems (such as size of the burning area) and difficulties in safely situating personnel and equipment close to the fire have prevented the collection of any reliable emissions data on actual veld fires, so that it is not possible to verify or disprove the hypothesis.

The major pollutants from veld burning are particulate matter, carbon monoxide, and volatile organics. Nitrogen oxides are emitted at rates of from 1 to 4 g/kg burned, depending on combustion temperatures. Emissions of sulphur oxides are negligible (USEPA, 1996). A study of biomass burning in the African savannah estimated that the annual flux of particulate carbon into the atmosphere is estimated to be of the order of 8 Tg C, which rivals particulate carbon emissions from anthropogenic activities in temperate regions (Cachier *et al*, 1995).

6.1.8.7 Impact Assessment

This section outlines the potential ambient air quality impacts associated with the proposed CSP plant. A detailed emissions inventory was compiled as part of this assessment to determine emissions released from the proposed boiler. Dispersion modelling simulations were undertaken using the AERMOD dispersion model and presented graphically as isopleths plots.

- **Construction Phase**

During the construction assessment phase it is expected that the main sources of impact will result due to the construction of new infrastructure associated with the proposed plant. These predicted impacts cannot be directly quantified, primarily due to the lack of detailed information related to scheduling and positioning of construction related activities. Instead a qualitative description of the impacts will be provided. This will involve the identification of possible sources of emissions and the provision of details related to their impacts.

Construction is commonly of a temporary nature with a definite beginning and end. Construction usually consists of a series of different operations, each with its own duration and potential for dust generation. Dust emission will vary from day to day depending on the phase of construction, the level of activity, and the prevailing meteorological conditions (USEPA, 1996).

The following possible sources of fugitive dust have been identified as activities which could potentially generate dust during construction operations at the site:

- Vehicle activities associated with the transport of equipment to the site;
- Preparation of the surface areas which will be required prior to the set up of new infrastructure; and
- The removal of construction equipment from site after the set up of new infrastructure.

- **Operational Phase**

<u>Model Overview</u>

AERMOD, a state-of-the-art Planetary Boundary Layer (PBL) air dispersion model, was developed by the American Meteorological Society and USEPA Regulatory Model Improvement Committee (AERMIC). AERMOD utilizes a similar input and output structure to ISCST3 and shares many of the same features, as well as offering additional features. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain effects, and advanced meteorological turbulence calculations.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources;
- A meteorological data pre-processor (AERMET) for surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux; and
- A terrain pre-processor (AERMAP) which provides a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

Model Requirements

Given the remote location of the proposed site, local meteorological data is not available. Use was therefore made of site-specific modelled meteorological data (MM5) for the period January 2005 to December 2009 and includes hourly observations of wind speed, wind direction, temperature and humidity. Source and emission parameters for the model are given in the section below.

- **Emissions Inventory**

Sources of emissions identified as occurring due to the proposed project and which need to be addressed from an air quality perspective are summarized as follows:

Proposed Boiler

Source parameters and fuel consumption values for the proposed boiler were provided by Hatch for the purpose of this assessment (Table 31). It is proposed that either diesel or LPG will be used to fuel the boiler. The boiler will operate for a total of 6 months per year. Emission rates for the proposed boiler were calculated using the USEPA AP-42 emission factors for Fuel Oil Combustion and LPG Combustion (Table 32).

Table 31: Source parameters for the Proposed Boiler

Site	Latitude (°S)	Longitude (°E)	Stack height (m)	Stack diameter (m)	Exit velocity (m/s)	Temp (° C)
Site A	28° 44’ 22.28”	21° 59’ 51.00”	30	1.5	6	180
Site B	28° 42’ 04.73”	22° 01’ 16.65”	30	1.5	6	180

Table 32: Emission rates for the Proposed Boiler

Fuel Type	Fuel Usage (m^3/yr)	Emission rate (g/s)		
		PM10	SO_2	NO_2
Diesel	3100	0.024	0.838	0.236
LPG	2900	0.002	0.001	0.143

- **Impact Assessment**

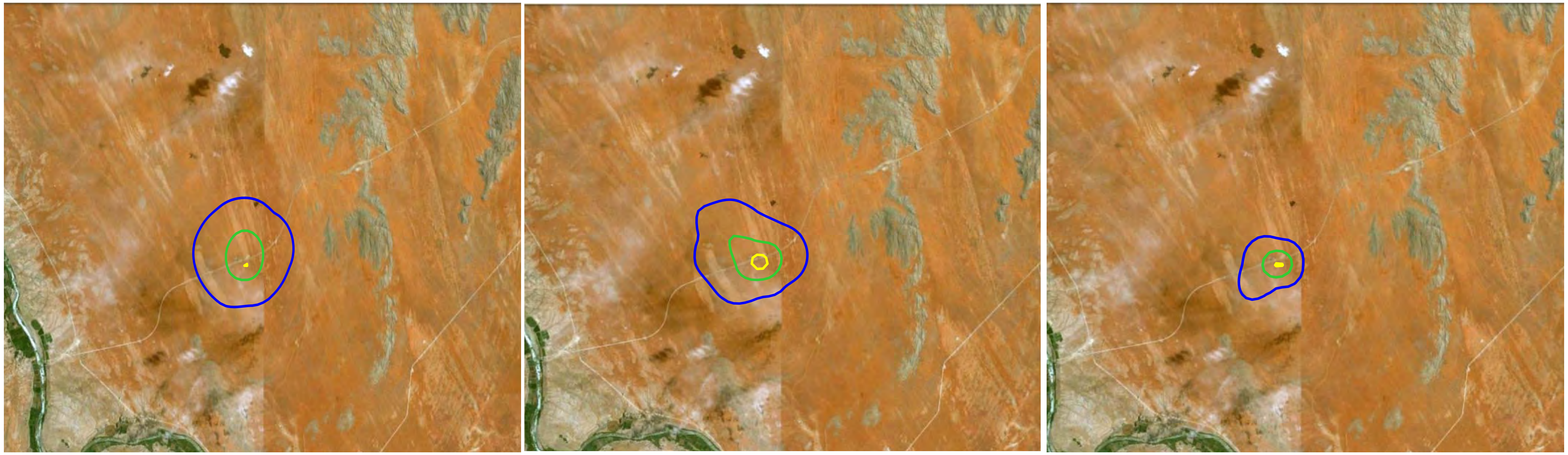
Dispersion modelling simulations were undertaken to determine the potential air quality impacts associated with emissions from the proposed boiler. Dispersion modelling simulations were undertaken for each proposed site (Site A and Site B). Results are presented graphically as isopleth plots in the figures below. Isopleth plots reflect gridded contours which represent zones of impact at various distances from the contributing sources. The patterns generated by the contours are representative of the maximum predicted ground level concentrations for the averaging period being represented. Maximum hourly, daily and annual average concentrations for PM10, SO_2 and NO_2 are represented in Figure 61 to Figure 62.

Proposed Site A

Predicted maximum hourly, daily and annual average concentrations due to emissions from the proposed boiler are low and fall well below the National standards for all modelled pollutants (Figure 61). The neighbouring farmhouse will not be influenced by elevated pollutant concentrations due to emissions from the boiler. Although higher concentrations are predicted when using diesel as compared to LPG, concentrations remain very low.

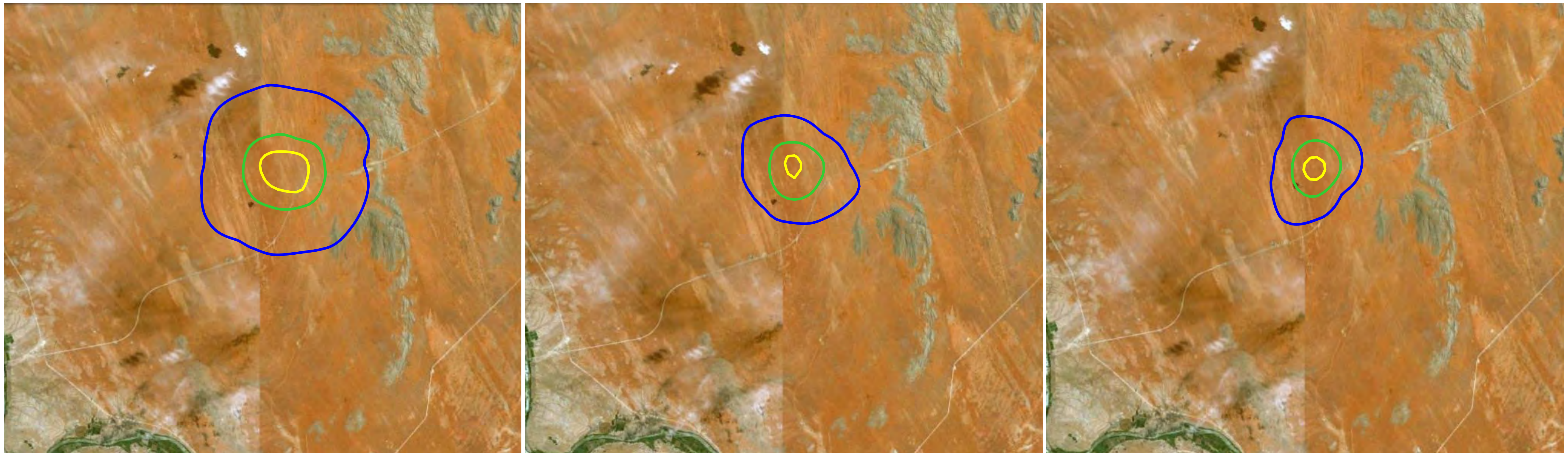
Proposed Site B

As observed at the proposed Site A, maximum hourly, daily and annual average concentrations are low and fall well below the National standards for all modelled pollutants at proposed Site B (Figure 62). The neighbouring farmhouse will not be influenced by elevated pollutant concentrations due to emissions from the boiler.



Hourly				Daily				Annual			
Diesel											
PM	0.060	0.108	0.156	PM	0.014	0.029	0.043	PM	0.002	0.005	0.007
SO_2	2.094	3.771	5.447	SO_2	0.503	1.006	1.508	SO_2	0.084	0.168	0.251
NO_2	0.590	1.062	1.534	NO_2	0.142	0.283	0.425	NO_2	0.024	0.047	0.071
LPG											
PM	0.005	0.009	0.013	PM	0.001	0.002	0.004	PM	0.0002	0.0004	0.006
SO_2	0.003	0.005	0.007	SO_2	0.0006	0.001	0.002	SO_2	0.0001	0.0002	0.0003
NO_2	0.358	0.644	0.930	NO_2	0.086	0.172	0.257	NO_2	0.014	0.029	0.043

Figure 61: Hourly, daily and annual average predicted ground level concentrations (µg/m3) from the proposed boiler at Site A



Hourly				Daily				Annual			
Diesel											
PM	0.048	0.077	0.106	PM	0.014	0.029	0.043	PM	0.001	0.003	0.004
SO_2	1.676	2.682	3.687	SO_2	0.503	1.006	1.508	SO_2	0.050	0.102	0.151
NO_2	0.472	0.755	1.038	NO_2	0.1412	0.283	0.425	NO_2	0.014	0.028	0.042
LPG											
PM	0.004	0.006	0.009	PM	0.001	0.002	0.004	PM	0.0001	0.0002	0.0004
SO_2	0.002	0.003	0.004	SO_2	0.0006	0.001	0.002	SO_2	0.00006	0.0001	0.0002
NO_2	0.286	0.458	0.629	NO_2	0.086	0.172	0.257	NO_2	0.009	0.017	0.026

Figure 62: Hourly, daily and annual average predicted ground level concentrations (µg/m3) from the proposed boiler at Site B

- **Decommissioning Phase**

The decommissioning phase is associated with activities related to the demolition of infrastructure and the rehabilitation of disturbed areas. The following activities are associated with the decommissioning phase (USEPA, 1996):

- Existing structures demolished, rubble removed and the area levelled;
- Remaining exposed excavated areas filled and levelled;
- Topsoil replaced; and
- Land and permanent waste piles prepared for re-vegetation.

Possible sources of fugitive dust emission during the closure and post-closure phase include:

- Smoothing of areas by bulldozer;
- Grading of sites;
- Transport and dumping of material for void filling;
- Infrastructure demolition;
- Infrastructure rubble piles;
- Transport and dumping of building rubble;
- Transport and dumping of topsoil; and
- Preparation of soil for re-vegetation – ploughing and addition of fertiliser, compost etc.

Exposed soil is often prone to erosion by water. The erodability of soil depends on the amount of rainfall and its intensity, soil type and structure, slope of the terrain and the amount of vegetation cover (Brady, 1974). Re-vegetation of exposed areas for long-term dust and water erosion control is commonly used and is the most cost-effective option. Plant roots bind the soil, and vegetation cover breaks the impact of falling raindrops, thus preventing wind and water erosion. Plants used for re-vegetation should be indigenous to the area, hardy, fast-growing, nitrogen-fixing, provide high plant cover, be adapted to growing on exposed and disturbed soil (pioneer plants) and should easily be propagated by seed or cuttings.

6.1.8.8 Conclusion

Predicted maximum hourly, daily and annual average concentrations due to emissions from the proposed boiler are low and fall well below the National standards for all modelled pollutants. The neighbouring farmhouse will not be influenced by elevated pollutant concentrations due to emissions from the boiler. Although higher concentrations are predicted when using diesel as compared to LPG, concentrations remain very low.

6.2 Biophysical Environment

6.2.9 Terrestrial Biodiversity

Bathusi Environmental Consultants (BEC) has been appointed as independent ecological specialists to conduct a strategic biodiversity scoping evaluation of the biological environment that will be affected by the proposed development. Dewald Kamffer (Faunal Specialists Incorporated, FSI) conducted the faunal assessment; Riaan Robbeson (BEC) conducted the floristic assessment, provided the ecological interpretation and compiled the ecological sensitivity analysis.

*Refer to **Appendix E** for the Biodiversity Assessment Report.*

6.2.9.1 Methodology

While a proper knowledge of the biodiversity of the region is not negotiable to the ultimate success of this project, an attempt was made to remove any subjective opinions that might be held on any part of the study area as far as possible. Inherent characteristics of a project of this nature implies that no method will be foolproof, mainly as a result of shortcomings in available databases and lack of site specific detail that could be obtained from limited detailed site investigations conducted over a short period of time. It is an unfortunate fact that inherent sensitivities within certain areas are likely to exist that could not be captured or illustrated during the process. This is a shortcoming of every scientific study that has ever been conducted; it simply is not possible to know everything or to consider aspects to a level of molecular detail. However, the approach followed in this study is considered effective in presenting objective comments on the comparison of biodiversity sensitivity of parts in the study area.

In order to present an objective opinion of the biodiversity sensitivity of the study area and how this relates to the suitability/ unsuitability of any area within the site in terms of the proposed development, all opinions and statements presented in this document are based on the following aspects, namely:

- A desk-top study of all available biological and biophysical data;
- Augmentation of existing knowledge by means of site specific and detailed field surveys;
- Specialist interpretation of available data, or known sensitivities of certain regional attributes;
- A GIS analysis, mapping and description of results obtained from the process, and
- An objective impact assessment process, estimating potential impacts on biological and biophysical attributes.

- **Background Information**

The overall goal of this section of the biodiversity investigation is to establish a reference point for the biophysical and biological sensitivities of the study area by means of the Ecosystem Approach or Landscape Ecology. The Ecosystem Approach is advocated by the Convention on Biological Diversity. It recognizes that people and biodiversity are part of the broader ecosystems on which they depend, and that it should thus be assessed in an integrated way. Principles of the Ecosystem Approach include the following:

- The objectives of ecosystem management are a matter of societal choice;
- Ecosystem managers should consider the effects of their activities on adjacent and other systems;
- Conservation of ecosystem structure and functioning, to maintain ecosystem services, should be a priority target;
- Ecosystems must be managed within the limits of their functioning;
- The approach must be undertaken at appropriate spatial and temporal scales;
- Objectives for ecosystem management should be set for the long-term;
- Management must recognise that change is inevitable;
- The approach should seek an appropriate balance between, and integration of, conservation and use of biodiversity;
- All forms of relevant information should be considered; and
- All relevant sectors of society and scientific disciplines should be involved.

For the purpose of this particular study a local scale was selected as suitable in terms of the size of the study area. The approach of Landscape Ecology includes the assessment of biophysical and societal causes, consequences of landscape heterogeneity and factors that causes disturbance to these attributes. In layman's terms it implies that if sensitive habitat types/ ecosystems (frequently associated with biodiversity elements of high sensitivity or conservation importance) are protected, species that are highly sensitive to changes in the environment will ultimately be protected. Species conservation is therefore largely replaced by the concept of habitat conservation. This approach is regarded effective since the protection of sensitive ecosystems will ultimately filter down to species level.

It is inevitable that the Landscape Ecology Approach will not function effectively in all cases since extremely localised and small areas of sensitivity do occur scattered in the study area, which can not always be captured on available databases or might have been missed during the site investigations. In addition to the compilation of basic species lists and the identification and description of localised ecological habitat it was also regarded important to identify areas of sensitivity on a local scale and, where possible, communities or species that are considered sensitive in terms of impacts that are likely to result from the proposed development.

This investigation therefore aims to:

- Determine the biological sensitivity of the receiving natural environment as it relates to the construction and operation of the plant and associated infrastructure in a natural environment;
- Highlight the known level of biodiversity;
- Highlight flora and fauna species of conservation importance that are likely to occur within the study area;
- Estimate the level of potential impacts of the construction and operation of proposed power generation structures on the biological resources of the study area, and

- Apply the Precautionary Principal throughout the assessment[47].

- **Assessment of Biophysical Attributes**

<u>Data Selection Process</u>

Available databases of biophysical attributes are implemented to identify regional areas of importance as it relates to biodiversity. Biophysical attributes that are known to be associated with biodiversity aspects of importance, conservation potential or natural status of the environment were implemented to compile the ecological sensitivity analysis of the study area. These attributes include the following:

- Areas of known biological importance (ENPAT);
- Areas of surface water (ENPAT);
- Degradation classes (ENPAT Land Cover Classes);
- Regional vegetation types (VEGMAP);
- Land cover categories (ENPAT), and
- Ridges and outcrops.

The first step in assessing the biophysical aspects of importance is the delineation of natural habitat, or the exclusion of transformed or degraded habitat. Areas that are transformed as a result of human activities, including agriculture, mining, urban development, etc, constitute parts of the study area where no natural habitat remains and where natural biodiversity is entirely compromised, to the extent that any recovery to a previous, pristine status is regarded impossible. These areas are generally suitable for the purpose of construction and development since impacts on important/ sensitive biological resources are regarded unlikely. Ultimately, areas that are characterised by high levels of transformation or degradation or which are characterised by low occurrences of biophysical aspects or biodiversity importance, will be considered more suitable for the proposed development, compared to areas constituting large tracts of untransformed and sensitive habitat types.

Secondly, sensitivity values are ascribed to biophysical attributes based on how these contribute to biological diversity or sensitivity. Ultimately all the information is compiled to present a holistic picture of the areas where biophysical aspects of importance occur, presenting a map that depicts regional biodiversity sensitivities based on biophysical attributes.

<u>Biophysical Sensitivities - GIS Analysis</u>

This method is believed to present a holistic overview of the biophysical sensitivity of the area, based on available data as well as the specialist's interpretation of the sensitivity of aspects that are contained in the databases. In specific cases an adjustment of sensitivity of certain areas were made based on information that was obtained from field surveys as well as information that was presented from landowners and interested parties.

[47] (www.pprinciple.net/the_precautionary_principle.html).

The GIS analysis of data was compiled in following stages, namely:

- As a first approximation an assessment was compiled during which available databases were assessed for suitability of use in this particular project. Every attempt was made to utilise the most recent available data; databases were replaced as newer information became available even during late stages of the assessment. Each database was separated into different aspects in terms of how it affects biodiversity sensitivity on a local and regional scale:

  - A biodiversity sensitivity category was ascribed to respective biophysical attributes. For example, the 'Land Cover' database was separated into respective classes in the manner in which it affects the local and regional biodiversity sensitivity, i.e. classes such as 'Agricultural', 'Urban Developments' and 'Degradation' was grouped and ascribed a LOW value;
  - Care was taken to avoid duplication between the various databases, for instance, aspects such as 'Woodland' and 'Grassland' was omitted from the 'Land Cover' database as these classes are adequately represented by the VEGMAP database;
  - Care was also taken of existing gaps of information in available databases, for example; while the ENPAT database of rivers does reflect larger rivers on a national scale, additional data is available in other databases that are not necessarily captured in the ENPAT database;
  - Where a single database contains different classes of sensitivity, these databases were split in the respective classes for layering;
  - Available databases were subsequently integrated in order to determine the maximum sensitivity of a particular parcel of land; and
  - The resultant map provided a basic assessment of the potential biophysical sensitivity on a local and regional scale.

6.2.9.2 Flora

- **Regional Diversity**

The Northern Cape Province is characterised by five biomes. Table 33 presents the area coverage and proportion of each biome within the Northern Cape Province.

Table 33: Extent of biomes within the Northern Cape Province

Biome	Area	Percentage
Fynbos	663,527 ha	1.83%
Grassland	123,837 ha	0.34%
Nama Karoo	19,593,363 ha	54.05%

Savanna	10,686,003 ha	29.48%
Succulent Karoo	5,182,370 ha	14.30%

The proposed site is mainly located within the Savanna Biome, with a small southern portion situated within the Nama Karoo Biome. The Savanna Biome is known to support more than 5,700 plant species, exceeded only by the Fynbos Ecoregion in species richness. The study sites are located within the Kalahari variation of the Savanna Biome, which although referred to as a desert, is not a true desert as it does not approximate the extreme aridity of a true desert. This area is densely covered by grasses, shrubs and trees.

The Nama Karoo Biome, the second largest biome in Southern Africa, is characterised by plains of dwarf shrubs and grasses, dotted with characteristic koppies. It is essentially a grassy, dwarf shrubland; the ration of grasses to shrubs increase progressively, until the Nama Karoo merges with the Grassland Biome. The species richness of this region is not particularly rich; only 2 147 species, of which 386 (18%) are endemic and 67 are threatened, occur.

The SANBI database indicates the presence of approximately 5 315 plant species within this province, with only 91 species within the ¼ degree grids in which the study sites are located (2821DB, DD, 2822CA). This low diversity reflects the poor floristic knowledge of the region. The species diversity comprises a diversity of growth forms, dominated by herbs (32 species, 35.2%), dwarf shrubs (24 species, 26.4%) and grasses (18 species, 19.8%). Trees and tall shrubs comprise a relatively low part of the total, reflecting on the open savanna / shrubland physiognomy of the region.

- **Diversity – Survey Results**

The species list that was compiled during the site investigation is considered moderately comprehensive. A total of 112 plant species were identified during the site investigations. The regional setting dictates the physiognomic dominance of the herbaceous component with 47 forb species (41.96%) and 24 grass species (21.43%). Trees and shrubs occur extensively throughout most of the study area (26 species 28.58%).

Taking the setting of the study area into consideration, the species composition of untransformed vegetation types is regarded representative of the regional vegetation. A total of 35 plant families are represented in the study area, dominated by Poaceae (grass family, 24 species, 21.43%), Fabaceae (16 species, 14.29%) and Asteraceae (daisy family, 12 species, 10.71%).

- **Floristic Habitat Types**

In spite of a relative homogenous appearance to much of the regional habitat, with the exception of extensive mountain ranges, a relatively obvious physiognomic variability is noted in the study area with plains alternating with parallel dunes and mountain foothills in the northern parts. It is highly likely that various smaller phytosociological differences are present within each of the identified habitat types, but for the purpose of this assessment, the observed ecological units are considered similar in major phytosociological, physiognomic and biophysical attributes. Many plant species occur across all of the habitat types, but many of the differences between units are ascribed purely on the basis of terrain morphology, soil characteristics or changes in the dominance and structure of the plant species. Surface water and rainfall in this part of the Kalahari is scarce and, together with substrate, is a major driving force of vegetation development.

Results of the photo analysis and site investigations revealed the presence of the following habitat types (Figure 63):

- Calcareous Low Shrub Plains;
- Open Shrub Duneveld;
- Open Shrub Plains;
- Quartzitic Low Shrub Plains;
- Rocky Outcrops/ Foothills;
- Transformed Areas; and
- Riparian Habitat.

The extent and coverage of habitat types within the study area is presented in Table 34.

Table 34: Extent of habitat types within the study area

Habitat Type	Extent (ha)	Percentage
Calcareous Low Shrub Plains	905.73 ha	18.94%
Open Shrub Duneveld	1,538.11 ha	32.16%
Open Shrub Plains	2,168.18 ha	45.33%
Quartzitic Low Shrub Plains	71.87 ha	1.50%
Riparian Habitat	16.54 ha	0.35%
Rocky Outcrops/ Foothills	75.88 ha	1.59%
Transformed Areas	6.67 ha	0.14%

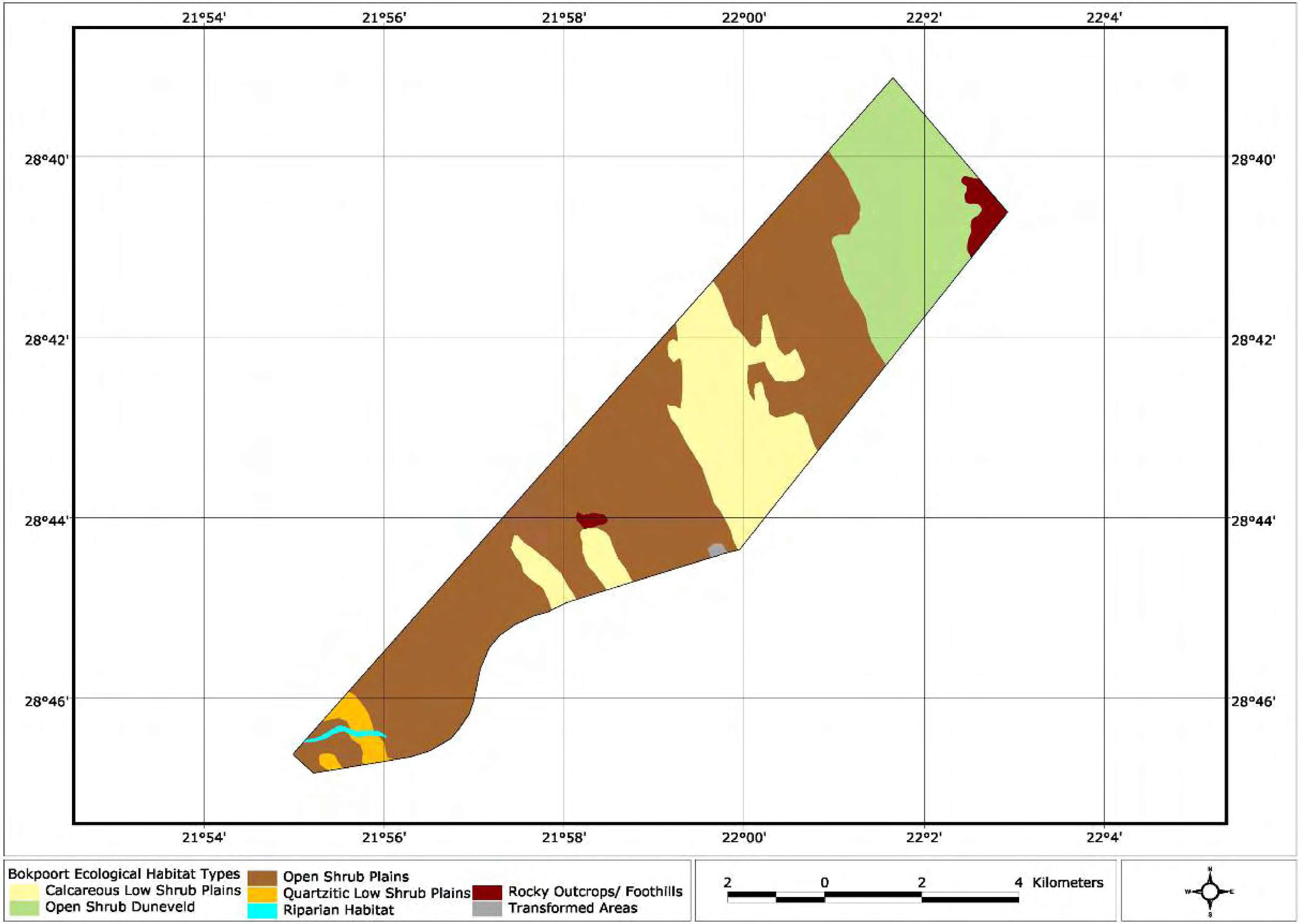


Figure 63: Ecological habitat types

Calcareous Low Shrub Plains

This unit comprises approximately 905.73 ha (18.94%) of the study area. The topography of these areas are characterised by relative flat or slightly undulating plains where the substrate comprises whitish calcareous and compact sandy soils (grey to brown, not red). The vegetation is characterised by low shrubs and grasses; tall shrubs and trees are generally absent from this unit, or occur at extremely low intervals. Prominent species include the grasses *Enneapogon desvauxii*, *Eragrostis obtusa*, *Eragrostis truncata*, *Fingerhuthia africana*, *Stipagrostis ciliata*, the shrub *Salsola etoshensis* and the forbs *Pentzia calcarea*, *Eriocephalus spinescens*, *Monechma genistifolium* subsp. *australe*, *Geigeria* species. The shrubs *Rhigozum trichotomum* and *Lycium horridum* were observed in this unit.

The status of these areas appears to be relatively degraded due to high grazing pressure and a moderate status is therefore ascribed.

Open Shrub Duneveld

This unit comprises approximately 1 538.11 ha (32.16%) of the study area. The major physiognomic attribute of this unit is the presence of low dunes with characteristic crests, slopes and streets. Each of these units could be described as a variation of this unit on the basis of distinctive habitat attributes and species composition, but for the purpose of this investigation, they are considered holistically as they always occur in association with each other.

The physiognomy conforms to an open tree savanna. Dominant species include the tree *Acacia mellifera* and the grass *Schmidtia kalahariensis*. Other prominent woody species are *Acacia haematoxylon*, *Parkinsonia africana*, *Rhigozum trichotomum*, *Boscia albitrunca* and *Acacia erioloba* and occasionally *Lycium bosciifolium*. Besides *Schmidtia kalahariensis*, the grass layer is characterised by *Eragrostis lehmanniana*, *Centropodia glauca*, *Stipagrostis amabilis*, *Brachiaria glomerata*, *Stipagrostis obtusa* and *S. ciliata*. Herbs that are found in this unit include *Hermannia tomentosa*, *Hermbstaedtia fleckii*, *Requienia sphaerosperma*, *Dicoma capensis*, *Momordica balsamina* and the climber *Pergularia daemia*.

The presence of the grass species *Schmidtia kalihariensis* is generally accepted as an indicator of high utilisation pressure. This habitat type is representative of the Gordonia Duneveld vegetation type (Mucina & Rutherford, 2006) and is in a relative good condition. A moderate status and moderate-high sensitivity is therefore ascribed to this unit due to the association with dune habitat.

Open Shrub Plains

This habitat type comprises the largest part of the study area, approximately 2,168.18 ha (45.33%). Biophysical attributes include open plains (flat or slightly undulating) with high shrubs and scattered trees on deep sandy, red soils or gravel plains and a well-developed herbaceous layer.

The species diversity is relative low; only 24 species were observed during the survey period. Prominent tall woody species in this undulating landscape are *Acacia erioloba*, *A. mellifera*, *Parkinsonia africana*, *Grewia flava* and *Boscia albitrunca*. Low shrubs include *Lebeckia linearifolia*, *Lycium bosciifolium*, *Rhigozum trichotomum* and *Salsola etoshensis*. Conspicuous grass species include *Schmidtia kalahariensis*, *Eragrostis lehmanniana* and *Stipagrostis ciliata*. Prominent forb species include *Monechma genistifolium* subsp. *genistifolium* and *Indigofera* species.

This habitat type is representative of the regional vegetation type Kalahari Karroid Shrubland (Mucina & Rutherford, 2006), which typically forms bands alternating with bands of Gordonia Duneveld. A moderate floristic status is ascribed to this unit.

Quartzitic Low Shrub Plains

This fairly unique habitat is situated in the southern part of the study area, comprising a small portion of the study area (71.87 ha, 1.50%) that is situated on plains of quartzitic stones where soils are shallow and stony. The vegetation of these areas conforms to a more succulent nature, with various succulents occurring exclusively in this habitat type. Although not noted during the survey period, the succulent *Hoodia* species, also occurs in this unit. Other succulents include *Aloe claviflora*, *Kleinia longiflora*, *Cadaba aphylla*, *Anacampseros ustilata*, *A. albidiflora* and *Euphorbia* species. Prominent grasses include *Enneapogon desvauxii*, *Eragrostis* species, *Fingerhuthia africana* and *Stipagrostis obtusa*. Woody species are generally absent with only the low shrub *Salsola etoshensis* occurring regularly.

This habitat type is not representative of the regional vegetation type and therefore represents an atypical and important variation. A high floristic status and sensitivity is therefore ascribed.

Riparian Habitat

This habitat type is situated in the southern part of the study area, comprising approximately 16.5 ha (0.35%) of the study area. It conforms to drainage lines which are mostly non-functional during most parts of the year; only flowing for short periods after significant rains has fallen. The vegetation is dominated by a prominent tree layer, consisting of *Acacia mellifera*, *Ziziphus mucronata*, *Boscia albitrunca* and the invasive species *Prosopis glandulosa*. The herbaceous layer is poorly developed with only the graminoids *Eragrostis porosa*, *Enneapogon scoparius*, *Setaria verticillata* and Cenchrus *ciliaris* occurring at relative high densities. The forb component comprises the weedy species *Pentarrhinum insipidum*, *Berkheya* species, *Flaveria* bidentis and *Kyphocarpa angustifolia*.

In spite of a poor floristic status, a high sensitivity is ascribed due to the association with riparian conditions. This habitat also frequently occurs in close vicinity to the Quartzitic Low Shrub Plains habitat type.

Rocky Outcrops/ Foothills

This habitat type occurs in the far northern section of the study area, comprising approximately 75.88 ha (1.59%) of the study area. The major physiognomic characteristic of this unit is the prevalence of rocks/ boulders, rendering the appearance of the unit extremely rugged. This unit probably forms part of the southern outliers of the Langeberg Mountain group. Soils in this unit are characteristically shallow and poor in nutrients. All other habitat types had little or nor rock cover and deeper soils. The species composition compares well to the Koranna-Langeberg Mountain Bushveld described by Mucina and Rutherford (2006). The physiognomy is an open tall shrubveld; a prominent herbaceous stratum with interspersed tall shrubs, bushes and low trees is observed.

This unit was found to be in an extremely pristine condition and, due to the association with high slopes, are generally regarded as sensitive.

A moderate species diversity was noted (27 species) with a relative equal distribution of herbs, grasses and shrubs. The shrubs *Croton gratissimus* and *Searsia burchelli* appears prominently in this unit. Prominent grasses include *Cymbopogon pospischilii*, *Aristida* species, *Digitaria eriantha*, *Enneapogon scoparius*, *Cenchrus ciliaris* and *Stipagrostis ciliata*. Prominent forbs include Asparagus species, *Geigeria* species, *Indigofera* species and *Thesium* species.

Transformed Areas

No natural vegetation remains in this area, and a low floristic status is ascribed.

- **Flora Species of Conservation Importance**

PRECIS data from SANBI indicate no Red Data flora species present within the quarter degree grids in which the study area is situated. However, the following species of conservation importance are known to occur in the region, or was observed in the study area (Table 35).

Table 35: Conservation important flora species for the region

Species	Family	Threat status
***Acacia erioloba*†**	**Fabaceae**	**Protected Tree (National Forest Act, 1998)**
***Acacia haematoxylon*†**	**Fabaceae**	**Kalahari Endemic**
Anthephora argentea*	**Poaceae**	**Regionally important (VEGMAP)**
***Boscia albitrunca*†**	**Capparaceae**	**Protected Tree (National Forest Act, 1998)**
Cucumis heptadactylus	Cucurbitaceae	SA Endemic
Digitaria polyphylla	Poaceae	Regionally important (VEGMAP)
Dinebra retroflexa	Poaceae	Regionally important (VEGMAP)
Dinteranthus pole-evansii	Mesembryanthemaceae	Regionally important

Species	Family	Threat status
		(VEGMAP)
Haworthia venosa subsp. tessellata	Asphodelaceae	SA Endemic
Helichrysum arenicola*	**Asteraceae**	**Regionally important (VEGMAP)**
Heliophila remotiflora	Brassicaceae	SA Endemic
Hyobanche sanguinea	Orobanchaceae	SA Endemic
Justicia puberula	Acanthaceae	SA Endemic, Regionally important (VEGMAP)
Justicia thymifolia	Acanthaceae	SA Endemic
Kohautia ramosissima	Rubiaceae	Regionally important (VEGMAP)
Larryleachia dinteri	Apocynaceae	Regionally important (VEGMAP)
Larryleachia marlothii	Apocynaceae	Regionally important (VEGMAP)
Lotononis oligocephala	Fabaceae	Regionally important (VEGMAP)
Megaloprotrachne albescens*	**Poaceae**	**Regionally important (VEGMAP)**
Nemesia maxii	Scrophulariaceae	Regionally important (VEGMAP)
Neuradopsis austro-africana*	**Neuradaceae**	**Regionally important (VEGMAP)**
Pharnaceum viride	Molluginaceae	SA Endemic
Ruschia kenhardtensis	Aizoaceae	Regionally important (VEGMAP)
Senecio intricatus	Asteraceae	SA Endemic
Stipagrostis amabilis [✝]	**Poaceae**	**Kalahari endemic**
Tridentea dwequensis	Asclepiadaceae	Regionally important (VEGMAP)
Zygophyllum lichtensteinianum	Zygophyllaceae	SA Endemic

*** -** Species indicated in **black bold** are regarded likely inhabitants of the study area, taking cognisance of the habitat available.

† - Species in **red bold** were observed in the study area.

- **Alien and Invasive Species**

Invading alien organisms pose the second largest threat to biodiversity after direct habitat destruction (UNEP, 2002). Invasive species are a threat to indigenous species through the following mechanisms:

- Displacement by direct competition;
- Reduction of structural diversity;
- Disruption of the prevailing vegetation dynamics;
- Impacts on fire regimes due to increases in biomass;
- Alteration of local hydrology; and
- Modification of nutrient cycling (Van Wilgen and Van Wyk, 1999).

CARA (2001) makes provision for four groups of problem plants:

- Declared weeds (Category 1 plants) – alien species prohibited on any land or water surface in South Africa; must be controlled or eradicated where possible;
- Declared invaders (Category 2 plants, commercial and utility plants) – alien species allowed only in demarcated areas providing there is a permit and that steps are taken to prevent their spread;
- Declared invaders (Category 3 plants, ornamentals) – alien species that may no longer be planted; existing plants may remain provided that all reasonable steps are taken to prevent their spread; prohibited within the floodline of watercourses and wetlands; and
- Declared indicators of bush encroachment – indigenous species that under certain circumstances e.g. overgrazing may cause bush densification.

The following species occur in the study area:

Table 36: Declared invasive and exotic flora species for the study area

Species	Threat Status
Prosopis glandulosa	Category 2 Invader
Rhigozum trichotomum	Declared indicator of encroachment
Acacia mellifera	Declared indicator of encroachment

- **Floristic Sensitivity**

Floristic sensitivity estimations are presented in Table 37 and illustrated in Figure 64.

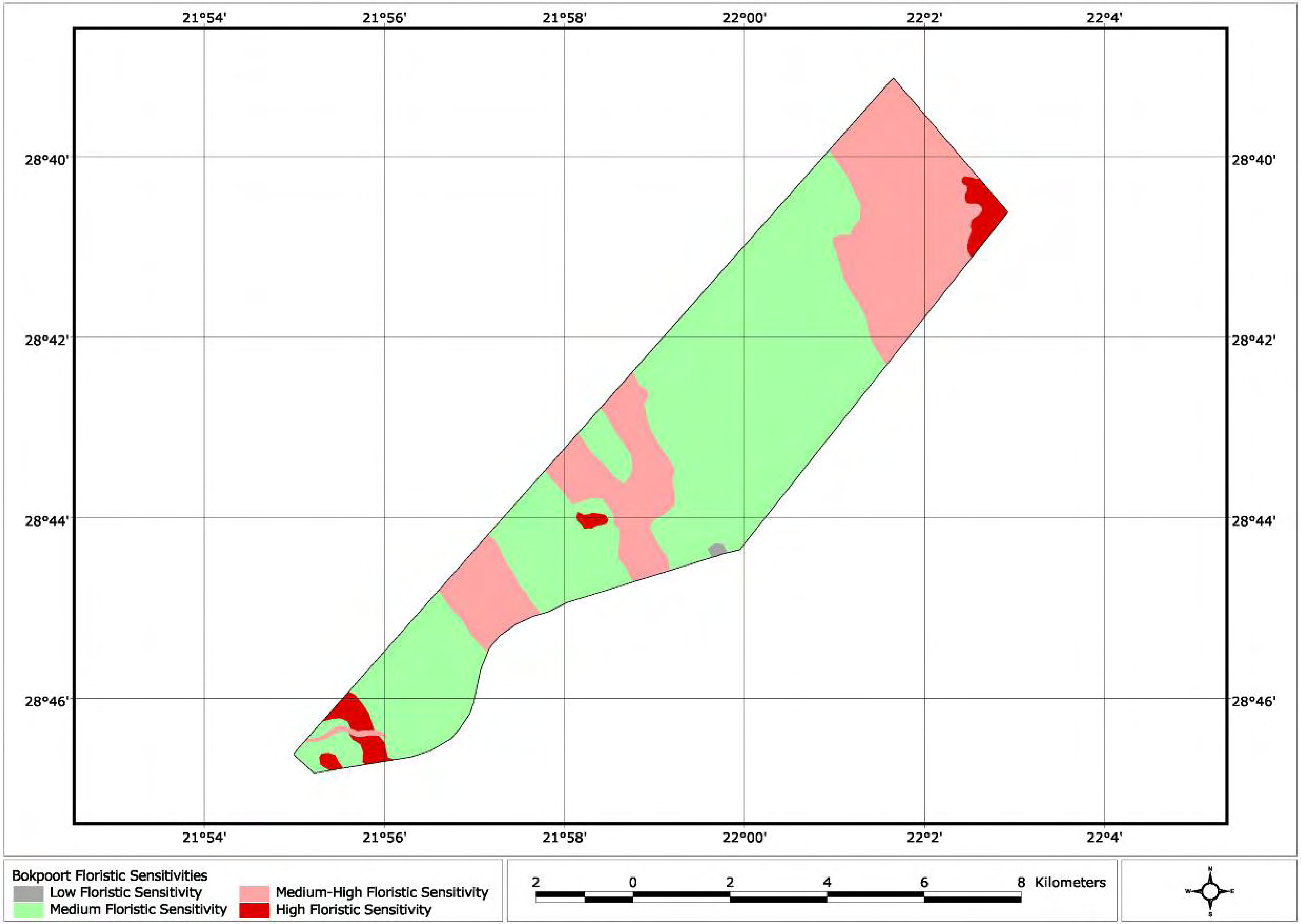


Figure 64: Floristic sensitivities of habitat types within the study area

Table 37: Floristic sensitivity for the respective habitat types

	Criteria	Sensitivity Class
Community	Calcareous Low Shrub Plains	Medium
	Open Shrub Duneveld	Medium-High
	Open Shrub Plains	Medium
	Quartzitic Low Shrub Plains	High
	Riparian Habitat	Medium-High
	Rocky Outcrops/ Foothills	High
	Transformed Areas	Low

6.2.9.3 Fauna

- **General Diversity**

Invertebrates

The invertebrates observed in the study area during the field investigation attested to a healthy, functioning ecosystem on the microhabitat as well as source-sink population dynamics scales. A total of 12 butterflies were observed in the study area; most of these species are common and widespread; if not in Southern Africa then in the drier western regions of the subcontinent.

It is highly likely that many other species will complement the observed assemblage of butterflies should the study be repeated in early summer (the only flight time of some Lepidoptera groups, notably Lycaenidae). The drier western regions of South Africa have significantly fewer butterflies than the wetter east; consequently the number of species observed during the field survey (given timing of the survey as well geographic location of the study area) confirms the untransformed and un-fragmented nature of the study area.

Herpetofauna

During the field study, the presence of eight reptiles was confirmed to occur in the study area by means of observation techniques as well as by the landowner. Species confirmed by the landowner included well-known species such as Cape Cobra and Puff Adder; these species are easily identifiable and changes of erroneous identification are unlikely. No frogs were observed during the field investigation and is regarded to reflect the combination of the dry nature of the habitat (there are far fewer species in the Northern Cape than for instance in KZN) and the timing of the field investigation (if the study is repeated after the first spring rains it is expected that at least a couple of species would prove to reside in the study area).

Mammals

A total of 25 mammals were confirmed in the study area during the field investigation. Various of the species were confirmed as residents of the study area by the landowner. It must be noted that many of the ungulate species listed for the proposed development site are a direct result of the hunting-related activities of the farm on which the study area is located; they cannot be considered free-roaming and are fenced in for hunting purposes.

Listed species that should not be considered free-roaming include Njala, Red Hartebeest, Blue Wildebeest, Waterbuck, Gemsbok and Springbok.

During the small mammal trapping (using baited small mammal live traps), the Red Data species *Tatera leucogaster* (DD), Bushveld Gerbil, was confirmed in the Open Shrub Duneveld of the study area. The species is relatively widespread in the region of the study area and sandy soils of the subcontinent.

The study area proved to have a significant number of carnivores including Bat-eared Fox, Cape Fox, Slender Mongoose, Yellow Mongoose, Suricate, Caracal, Striped Polecat and Black-backed Jackal. This is testament to the diversity and functionality of the ecosystem of which the study areas forms part of.

- **Red Data Fauna Assessment**

As a result of restrictions with regards to database availability only specific faunal groups are used during the red data aspect of this faunal assessment. Data on the Q-degree level is available for the following faunal groups:

- Invertebrates: Butterflies (South African Butterfly Conservation Assessment – http://sabca.adu.org.za);
- Amphibians: Frogs (Atlas and Red Data Book of the South Africa, Lesotho and Swaziland);
- Reptiles: Snakes and other Reptiles (South African Reptile Conservation Assessment - http://sarca.adu.org.za), and
- Mammals: Terrestrial Mammals (Red Data Book of the Mammals of South Africa: A Conservation Assessment).

Red Data fauna species known to be present in the quarter degree grids 2821DB, 2821DD and 2822CA in the above-mentioned databases were considered potential inhabitants of the study area. Additionally, species observed in the study sites during the field investigation were added to the list of species considered relevant to the study area. The likelihood of each species' presence in the study areas were estimated based on known ecological requirements of species; these requirements were compared to the ecological conditions found in the study area and surrounding faunal habitat.

- Linda's Hairtail is the only potential Red Data butterfly inhabitant of the study area. It is known from "only a few localities in Arid Savanna near Witsand, Northern Cape, near the Langeberge." There is no data on the larval host of this butterfly, but it is thought to potentially be Acacia erioloba. The species cannot be discounted as a potential inhabitant of the study area and is deemed to have at least a moderate likelihood of occurring in the study area;
- The Giant Bullfrog, *Pyxicephalus adspersus* (NT), is widespread in South Africa and is known from all nine provinces as well as Swaziland and Lesotho. It is known from the Savanna and Nama-Karoo biomes and is a potential inhabitant of the study area (it has been observed in the very dry Central Kalahari Game Reserve in Botswana – pers. obs.) and is considered to have a moderate-high probability of occurring in the study area;
- No Red Data reptiles are known from the quarter degree grids of the study area, and
- Two Red Data mammals were confirmed to occur in the study area: Bushveld Gerbil (DD) and Honey Badger (NT).

Table 38: Red Data fauna probabilities for the study area

Biological Name	English Name	Status	Probability
Lepidoptera			
Anthene lindae	Linda's Hairtail	Vulnerable	Moderate
Amphibians			
Pyxicephalus adspersus	Giant Bullfrog	Near Threatened	Moderate-High
Mammals			
Atelerix frontalis	South African Hedgehog	Near Threatened	High
Crocidura cyanea	Reddish-grey Musk Shrew	Data Deficient	Moderate
Elephantulus intufi	Bushveld Elephant-shrew	Data Deficient	High
Equus zebra hartmannae	Hartmann's Mountain Zebra	Endangered	Low
Mellivora capensis	Honey Badger	Near Threatened	Confirmed
Myosorex varius	Forest Shrew	Data Deficient	Low
Paratomys littledalei	Littledale's Whistling Rat	Near Threatened	Moderate-Low
Petromys typicus	Dassie Rat	Near Threatened	Moderate-Low
Rhinolophus darlingi	Darling's Horseshoe Bat	Near Threatened	Moderate-Low

Biological Name	English Name	Status	Probability
Rhinolophus denti	Dent's Horseshoe Bat	Near Threatened	Moderate
Tatera leucogaster	Bushveld Gerbil	Data Deficient	Confirmed

- **Faunal Habitat Sensitivities**

The close relationship between vegetation units and specific faunal composition has been noted in several scientific studies. For the purpose of this investigation the floristic units identified in the floristic assessment are considered representative of the faunal habitat types. For a description of the habitat structure and physiognomy, the reader is therefore referred to Section 8 of this document.

Faunal habitat sensitivities are subjectively estimated based on the following criteria:

- Habitat status;
- Connectivity;
- Observed species composition & RD Probabilities, and
- Functionality.

The faunal sensitivities are presented in Table 39 and Figure 65.

Table 39: Faunal habitat sensitivities for the study area

	Criteria	Sensitivity Class
Community	Calcareous Low Shrub Plains	Medium
	Open Shrub Duneveld	Medium
	Open Shrub Plains	Medium-Low
	Quartzitic Low Shrub Plains	Medium-High
	Riparian Habitat	High
	Rocky Outcrops/ Foothills	High
	Transformed Areas	Low

Habitat types that exhibit high faunal sensitivities frequently exhibit habitat characteristics that are associated with wetlands, pristine terrestrial habitat and the presence of Red Data species in these areas are generally confirmed or a high likelihood is ascribed to the potential presence of such species.

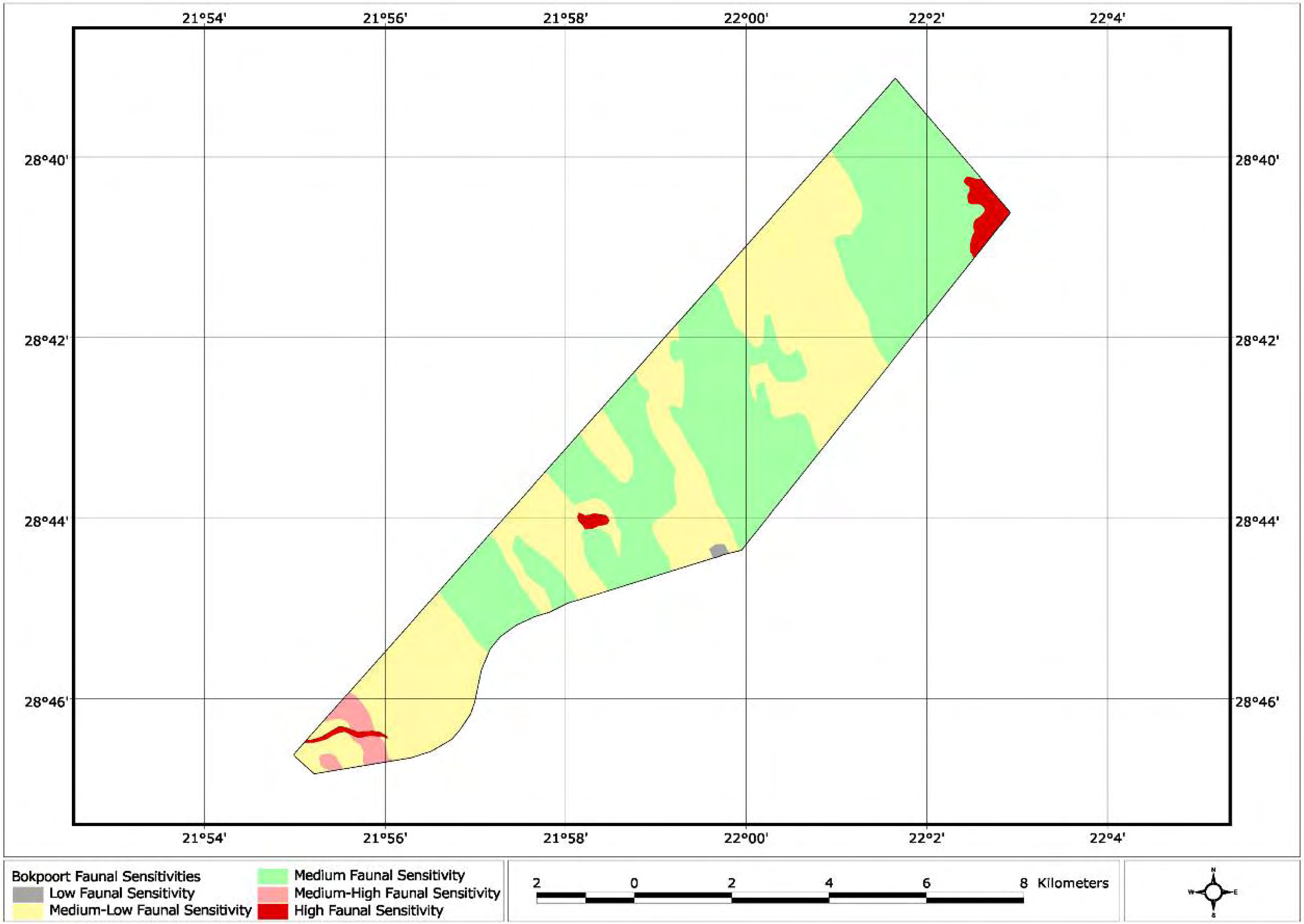


Figure 65: Faunal sensitivity of the study area

- **Discussion - Fauna**

The study area includes diverse, unfragmented faunal habitats that are natural and untransformed in nature and represent well-functioning ecosystems that are also well-connected to adjacent regions of large, natural faunal habitat characteristic of the Savanna and Nama-Karoo of the Northern Cape Province in South Africa. This is reflected in the species richness and – diversity of the animals confirmed for the study area (by personal observation and confirmation of the landowner), including five red data species (two mammals and three birds).

However, the faunal habitats of the study area represent regional vegetation communities that are largely untransformed and not considered to be under threat. The Bushmanland Arid Grassland (99.4% remaining), Gordonia Duneveld (99.8% remaining), Kalahari Karroid Shrubland (99.2% remaining) and Koranna-Langeberg Mountain Bushveld (99.9% remaining) are all listed as Least Threatened (VEGMAP, 2006). The study area investigated does not represent a significant portion of the remaining untransformed areas of any of these regional vegetation communities; indeed the larger region in which the study area is located remains largely natural and well-connected. It can be reasoned that the proposed project and associated impacts are unlikely to influence any animal species, assemblage or community significantly based on above-mentioned facts.

The relative sensitivities of the faunal habitats are based on the potential impacts of the proposed project on the faunal communities of these habitats relative to each other. For instance, it is estimated that the impacts of the proposed project are more likely to be significant with regards to the faunal assemblages limited to the riparian and ridge (rocky outcrops) habitat found in the study area than those of the Open Shrub Plains and Open Shrub Duneveld. Riparian and ridge faunal assemblages (mostly of invertebrates, birds, reptiles and frogs) are intrinsically limited in space and are therefore naturally vulnerable to habitat degradation and transformation processes. With regards to mammals, one of the most important impacts (albeit an indirect impact potentially associated with the proposed project) is the increase in road traffic volumes and associated road kills.

These habitat types are often associated with environmental features that are also generally regarded as sensitive, such as riparian zones aquatic regions and rocky outcrops.

6.2.9.4 Ecological Interpretation

Respective results of the floristic and faunal sensitivity analysis are combined to present an overview of the ecological sensitivity of the study area.

In order to present the reader with an indication of the ecological sensitivity of the respective communities, the highest sensitivity for each ecological unit is selected as being representative of the ecological sensitivity of the specific ecological unit. Results are determined in Table 40 and visually presented in Figure 66.

Table 40: Ecological sensitivity of the study area

	Criteria	Floristic	Faunal	Ecological
Community	**Calcareous Low Shrub Plains**	Medium	Medium	Medium
	Open Shrub Duneveld	Medium-High	Medium	Medium-High
	Open Shrub Plains	Medium	Medium-Low	Medium
	Quartzitic Low Shrub Plains	High	Medium-High	High
	Riparian Habitat	Medium-High	High	High
	Rocky Outcrops/ Foothills	High	High	High
	Transformed Areas	Low	Low	Low

The extent of respective sensitivity classes are presented in Table 41.

Table 41: Extent of ecological habitat sensitivities within the study area

Sensitivity Class	Extent	Percentage
Low ecological sensitivity	6.67 ha	0.14%
Medium ecological sensitivity	3073.9 ha	64.27%
Medium-High ecological sensitivity	1538.11 ha	32.16%
High ecological sensitivity	164.29 ha	3.43%

Combined results from the floristic and faunal sensitivity analysis indicate the high sensitivity of the areas associated with wetland regimes and rocky outcrops. The status of these areas is moderately pristine and are therefore considered suitable habitat for a variety of Red Listed flora and fauna species. These areas are relative small, comprising small portions of the study area. A medium-high ecological sensitivity is exhibited by the natural duneveld of the study area, particularly as a result of the likely presence of several Red Data species and the high suitability of these areas for Red Data species.

The largest extent of the study area exhibit low and medium sensitivity ecological attributes and the proposed activity is not expected to result in significant impacts in these areas.

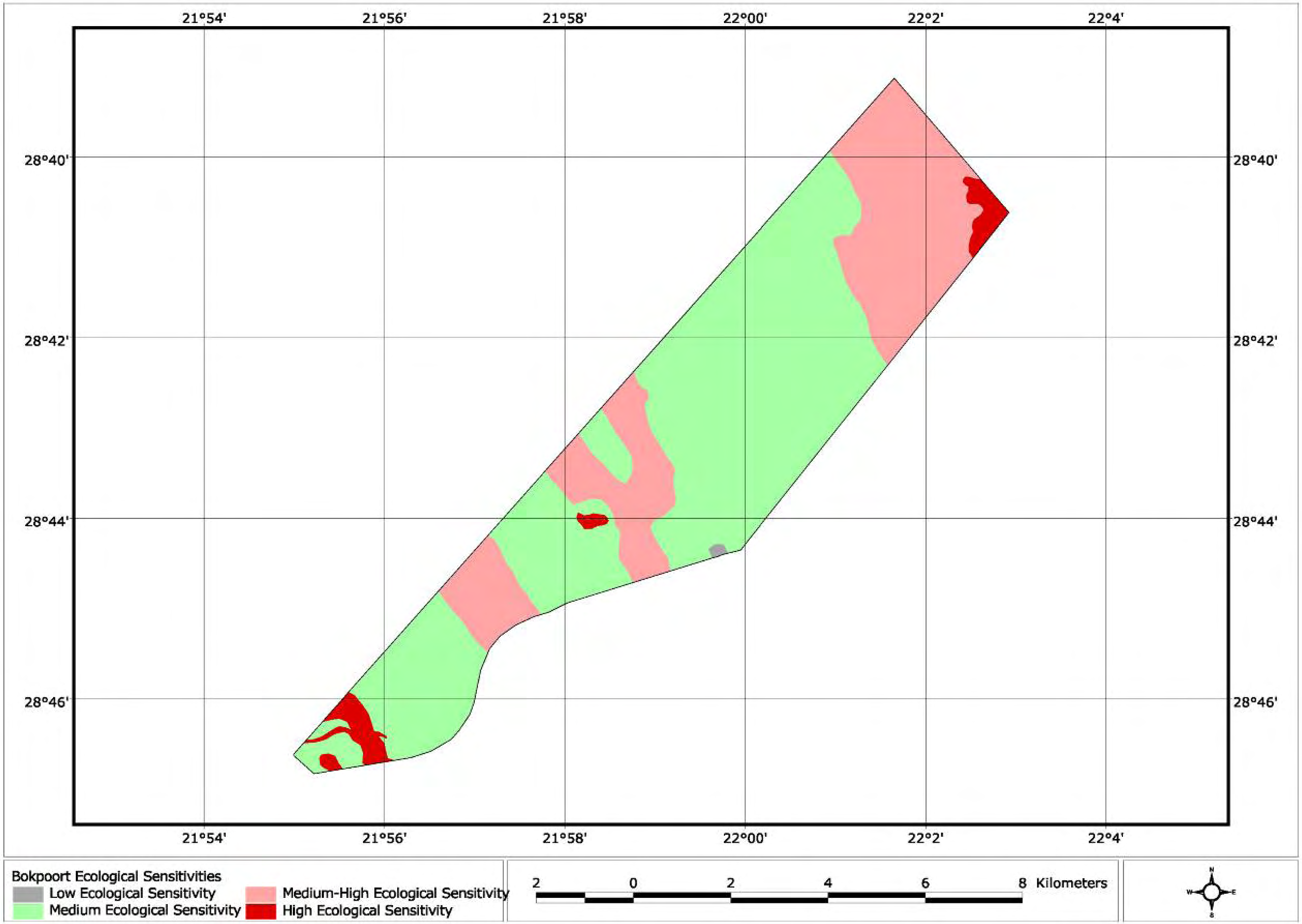


Figure 66: Ecological sensitivity of the study area