



The Envirodel – Dubel Association



DESCRIPTION OF THE NATURAL ENVIRONMENT

and

BIODIVERSITY IMPACT ASSESSMENT

of the

PLANNED VELE COLLIERY

Musina Municipality
Vhembe District
Limpopo Province

Prepared for: COAL OF AFRICA LIMITED

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1 INTRODUCTION

Limpopo Coal Company (Pty) Ltd has acquired the prospecting rights to prospect for coal on the farms Overvlakte 125 MS (Ptn 3,4,5,6,13, RE), Bergen op Zoom 124 MS, Semple 155 MS and Voorspoed 836 MS from Zingaro Trade 39 (Pty) Ltd through a consent in terms of Section 11(1) of the Mineral and Petroleum Resources Development Act (MPRDA), 2002 (Act 28 of 2002). Coal of Africa (Pty) Ltd is planning an opencast and underground coal mine on the said properties.

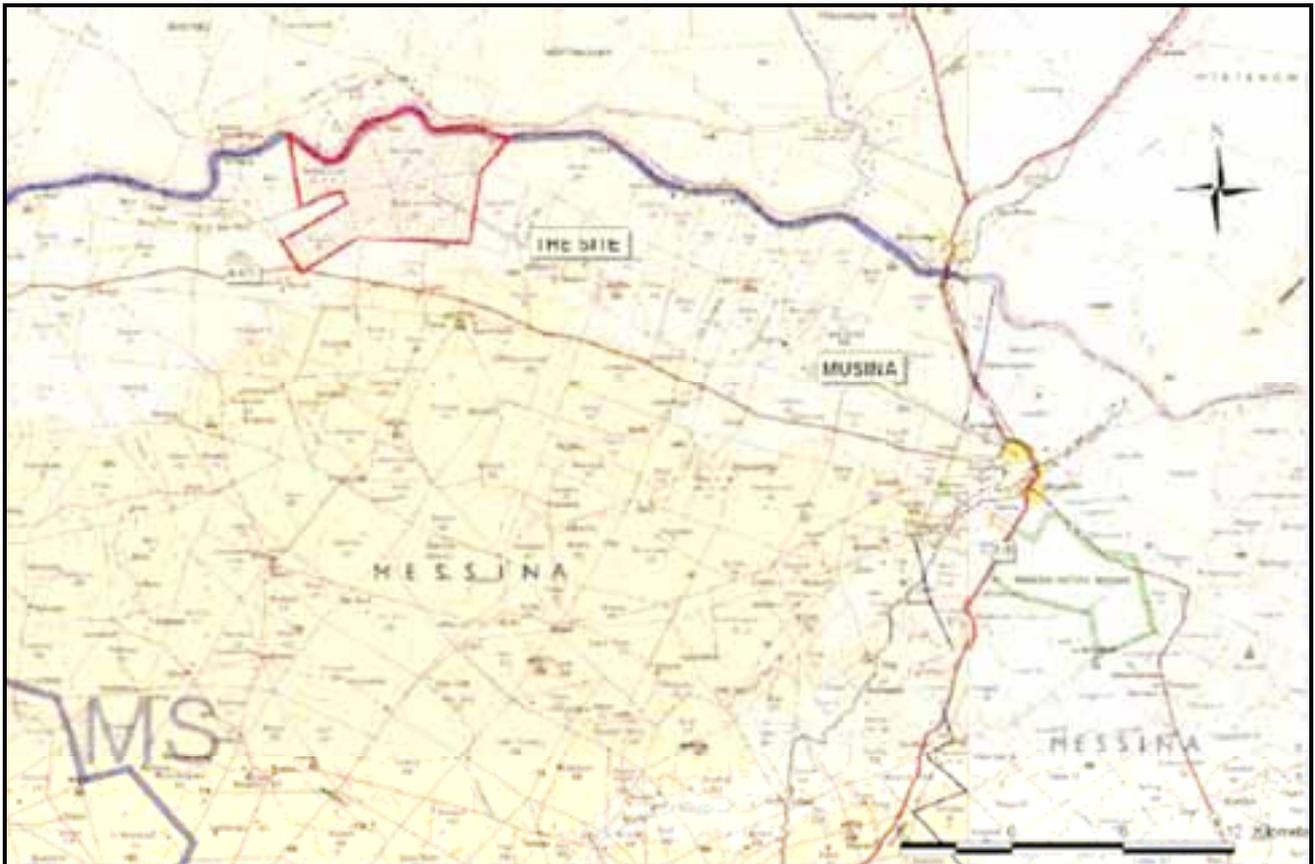
Jacana Environmentals cc has been appointed by Coal of Africa to conduct an Environmental Impact Assessment for the project. Dubel Integrated Environmental Services was appointed by Jacana Environmentals to conduct biodiversity impact studies for the proposed Vele Colliery Project.

This report contains the results of the biodiversity aspects of the environmental impact assessment. Although several potential impacts on the biodiversity are mentioned in this report, other specialists in their specialist's reports address specifics. This report therefore focuses on the flora and fauna of the study area.

2 STUDY AREA LOCATION

The study area is located on the northern border of South Africa in the Limpopo Province and borders the Limpopo River (figure 1). The study area therefore borders Zimbabwe to the north and Botswana is approximately 27 kilometres to the west at the confluence of the Shashe and Limpopo Rivers. The nearest town is Musina, approximately 48 kilometres southeast. Mapungubwe National Park and World Heritage Site is approximately 5.36 kilometres west of the study area. The area falls within longitude 29° 27' 00"E to 29° 47' 00"E and latitude 22° 5' 00"S to 22° 18' 00"S.

Figure 1: Regional setting of the Vele Colliery Project.



The study area comprise of the following farms and sizes (table 1):

Table 1: Farms included in the study area.

FARM NAME	HECTARES
Semple 155MS	942.9147
Overvlakte 125MS - 6	3554.4706
Overvlakte 125MS - 5	
Overvlakte 125MS - 4	
Overvlakte 125MS - 3	
Overvlakte 125MS - 13	
Overvlakte 125MS - 14	
Overvlakte 125MS - RE	
Bergen op Zoom 124 MS	2078.1327
Voorspoed 836 MS	2087.2216
TOTAL	8662.7396

3 METHODOLOGY

The following steps were followed:

- a. Issues that may arise as a result of the proposed development, through planning, construction, operation and decommissioning phases, were identified in consultation with specialists and interested and affected parties.
- b. A desktop baseline study and extensive literature research study was undertaken.
- c. The database of the Limpopo Valley Herb Project was made available by Me R van der Walt and incorporated into the study.
- d. Broad geological and soil occurrences (land types) and characteristics were identified.
- e. Mapping and evaluation of vegetation / habitats on aerial photographs was undertaken
- f. Site visits and surveys have been undertaken from August 2008 to January 2009 to gather and review existing information on geology, soils, fauna and flora that can be expected and do occur in the study area. Potential impacts were identified for each issue and assessed by considering the aspects below.
- g. Where the potential impacts were perceived as having a high risk or significance, alternatives, preventative and mitigation measures were considered as part of the planning process and/or recommended for relevant phases (planning, construction, operation and decommissioning).
- h. Specialist studies and surveys were commissioned to:
 - i. identify flora species
 - ii. identify vegetation communities
 - iii. identify fauna species (small mammals, reptiles, birds & large mammals) and potential habitats
identify red data species (fauna & flora) and their habitats
 - iv. evaluate the sensitivity of each plant community & red data species habitat
 - v. map vegetation communities & red data species / habitats, and
 - vi. identify medicinal, invasive and/or exotic plants that might occur.
- i. Other specialist's studies conducted as part of the EIA process was also consulted and incorporated.
- j. Potential impacts and the associated risks were then re-assessed as "actual impacts", taking into consideration alternatives, preventative and mitigation measures.
- k. The significance of each "actual impact" was then determined.
- l. To determine the broad legal requirements of potential impacts and some broad mitigation measures, a broad legal overview has been conducted.

There are three major categories of impacts on biodiversity namely:

- i. Impacts on habitat resulting in loss, degradation and / or fragmentation.
- ii. Direct impacts on fauna and flora and species, for example plants and animals that are endemic / threatened / special to a particular habitat will not be able to survive if that habitat is destroyed or altered by the development.
- iii. Impact on natural environmental processes and ecosystem functioning. This can lead to an accumulated effect on both habitat and species.

4 PROJECT DESCRIPTION

The Vele Colliery Project is located in the Tuli Basin Coalfield in Limpopo Province. The colliery will mine coal through two open cast pits (the East Pit and the West Pit) and two underground pits (the East mine and the West Mine) to produce coking coal for the metallurgical industry and a potential middling product for power generation. Process routes are virtually identical for both the underground and open cast run of mine (ROM) coal, except the latter product is subjected to rotary breaker beneficiation of the coarser coal fraction. Owing to the different washing characteristic of the underground and open cast coal, it will be treated separately, the respective products being combined. The underground sections are close to the river. The resource is estimated to contain 720.847 million tones of coal.

The surface workings will be located to the south of the mining areas on the farm Bergen op Zoom. The following surface workings are also planned:

- Topsoil stockpiles
- Overburden stockpiles
- ROM coal storage area
- ROM coal crushing plant (primary, secondary and tertiary crusher)
- Associated conveyors from the crusher to storage silos and from the washing plant to the product storage areas
- Coal washing plant
- Product stockpile areas
- Discard dump and slurry co-disposal site (potentially in-pit)
- Haul roads and service roads
- Associated workshops
- Earthmoving vehicle workshops
- Change houses and offices
- Main entrance gate security and freight area

Feasibility studies area also underway to determine the most viable option to transport the export / inland products from the mining site to the Musina Siding, and include:

- Haul trucks along existing roads (preferred option during the initial 5 years of operation)
- Overland conveyor
- Rail link

Both the inland and export coal product will be transported from Musina via existing railway.

5 DESCRIPTION OF AFFECTED ENVIRONMENT

5.1 Climate

5.1.1 Climate of the Limpopo Basin

The climate of the Limpopo Basin varies spatially from being arid in the west through semi-arid and temperate areas in central zones to semi-arid in the east, with a few sub-humid pockets in the centre. Three wind systems have a strong influence on the basin's climate. These are the tropical cyclones from the Indian Ocean, the south-easterly wind systems that bring rainfalls from the Indian Ocean and the Inter-Tropical Convergence Zone (ITCZ), which in some years moves sufficiently far southwards to influence rainfall in the northern parts of the basin.

Air temperatures across the basin show a marked seasonal cycle, with highest temperatures recorded during the early summer months and lowest temperatures during the cool, dry winter months. Rainfall is also highly seasonal, falling predominantly as intense convective thunderstorms during the warmer summer months.

The severe droughts observed during the early 1990s and the exceptional floods during 2000 in the Limpopo valley illustrate the extreme variability of rainfall and runoff in the basin. This variation has significant effects on aquifer recharge.

5.1.2 Climate of the study area

The climate of the study area is semi-arid with a mean annual rainfall ranging from 350 – 400 mm (figure 2). Rainfall is highly variable and usually falls during the summer months. Extended periods of below average rainfall occur. There is on average 10 rainy days per year. Temperatures sometimes rise to 45°C in summer. The winters are mild and frost occurs very seldom.

The mean annual rainfall of the study area is approximately 348 mm per annum. The mean annual rainfall for the Goeree (Dongolakop) weather station (0809/285 : 22° 15' S; 29° 40' E; 614 m a.m.s.l. : 30 years) is 278 mm with a potential minimum of 154 mm during dry years and a potential maximum of 451 mm per annum during wet years (table 2).

The rainy season is predominantly from November to March when about 83% of the total annual rainfall occurs. The driest months are from May to September, when less than 7 mm of rain per month is recorded. The maximum rainfall measured at the Macauville rainfall station (at the Agricultural Research Station) over a 24-hour period was 112 mm in March. The highest monthly maximum rainfall recorded was 212 mm in December (Van Rooyen 2008).

Figure 2: Mean annual precipitation in the study area.



Table 2: Rainfall data for Goeree (Dongolakop) rainfall station 0809/285).
22° 15' South; 29° 40' East; 614 m a.s.l. (30 years)

	Jan	Feb	Mch	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Max	252	180	105	65	65	47	47	47	44	72	111	127	451
9	127	121	75	36	0	17	0	0	24	43	69	115	369
8	92	88	49	24	0	10	0	0	12	31	50	89	326
7	70	68	34	17	0	4	0	0	4	24	38	72	298
6	54	53	22	11	0	0	0	0	0	18	30	60	276
5	41	41	13	7	0	0	0	0	0	14	23	49	257
4	30	31	4	2	0	0	0	0	0	10	17	40	239
3	20	21	0	0	0	0	0	0	0	5	12	32	221
2	11	12	0	0	0	0	0	0	0	0	6	24	202
1	0	0	0	0	0	0	0	0	0	0	0	15	178
Min	0	0	0	0	0	0	0	0	0	0	0	4	154
Mean	56	55	27	14	2	5	1	1	7	19	31	60	278

Max = highest rainfall recorded over 30 years

Min = lowest rainfall recorded over 30 years

First column 1 to 9: e.g. 6 means that in 6 out of 10 years the rainfall will be 54 mm or less in January; or for 6 out of 10 years the annual rainfall will be 276 mm or less (last column).

The mean annual temperature for Macauville is 22.5°C (table 3). The extreme maximum and minimum temperatures measured were 43.5°C and -3.8°C respectively. The mean daily maximum temperature for January is 33.5°C and for July 24.9°C. The mean daily minimum for January is 21.3°C and for July it is 6.9°C. Frost may occur from June to August. Evaporation from free water surfaces is in excess of 2 500 mm per year over most of the area.

Cloud cover is the highest during December, January and February, with July, August and September the sunniest months. The relative percentage air humidity at 08:00 is the highest from February to July, resulting in dew precipitation in the cool autumn mornings.

Table 3: Temperature data for Macauville weather station 0809706 X.
22° 16' S; 29° 54 O; 522 m; 29 year period

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean	27.4	26.6	25.5	22.9	19.1	15.9	15.9	18.4	21.9	24.3	25.9	26.7	22.5
Max	43.5	41.2	40.5	39.7	37.5	32.4	33	38.1	41.9	42	43	43	43.5
Min	13	12.8	10.3	5.6	1.2	-3.6	-3.4	-3.8	3.5	8.1	10.9	10.6	-3.8

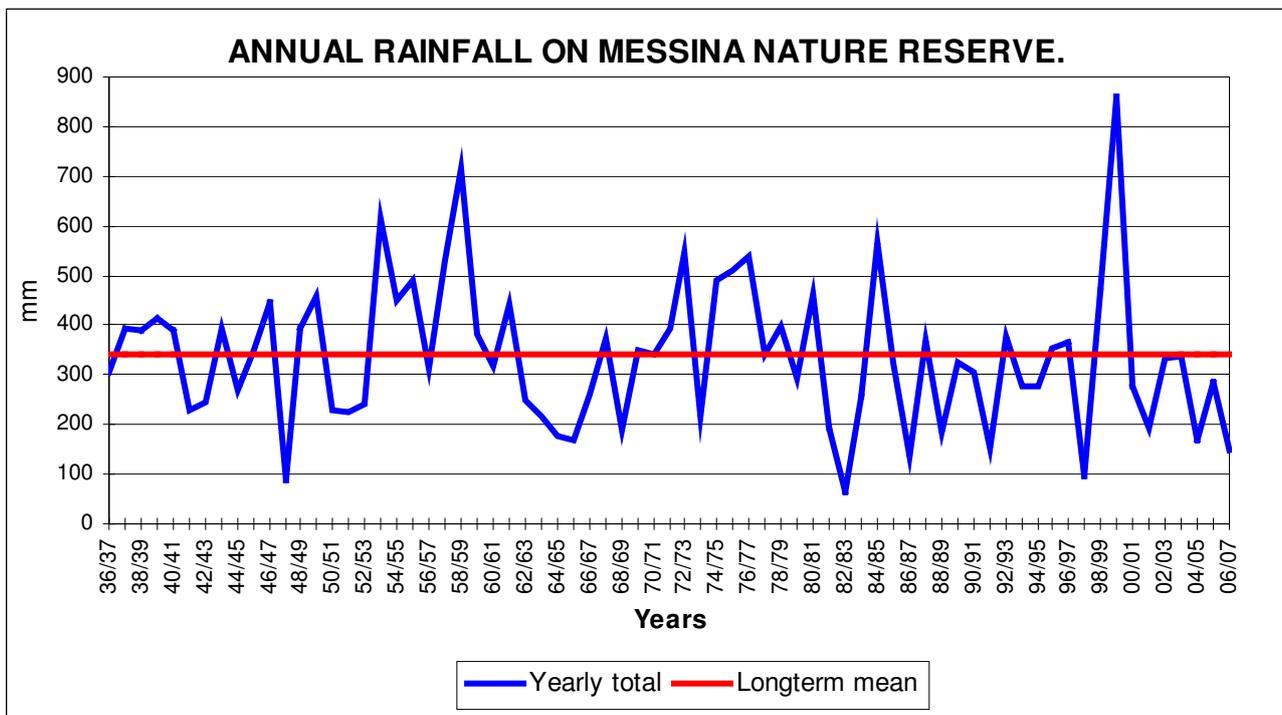
Mean = mean of maximum + minimum temperature/2

Max = extreme maximum temperature recorded

Min = extreme minimum temperature recorded

The arid climate, low rainfall with a high variability, as illustrated through the annual rainfall patterns on Messina Nature Reserve 48 kilometres to the east (figure 3), high temperatures and high evaporation rates, are together with shallow rocky soils the most important factors that determine the vegetation composition of this area. It also influences and determines, especially without active management, the success of vegetation rehabilitation programmes. The variability of the amount and time of rainfall is critical for the production of grass, the availability of grazing and thus the carrying capacity, stocking rates and survival of game and livestock. The available browse is also limited by severe droughts and low and erratic rainfall patterns, which can lead to a decrease in the amount of browse material available to game and livestock. Water is thus one of the most critical environmental factors playing a role in the ecology of the region and determines to a large extent the landuse potential and utilisation options of these arid areas.

Figure 3: Erratic rainfall on Messina Nature Reserve.



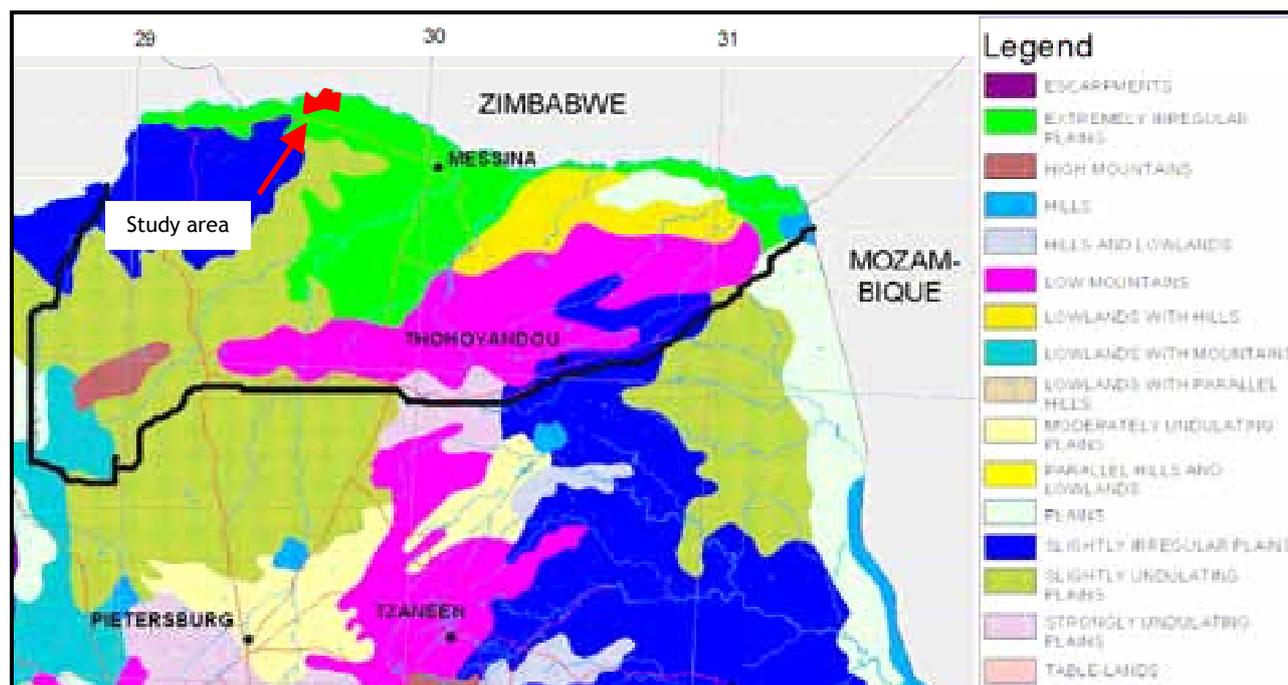
The significant influence of climate is also noticeable in the large amount of cattle farms that have been transformed to game farms in the past 2 decades in the Musina area. Game species that occurred historically

in these areas are more adapted to the climatic conditions and habitat types of these areas. Game farming and associated hunting and ecotourism activities are the most common land uses in the Musina area.

5.2 Topography

The Limpopo River valley area consists mostly of extremely irregular plains (figure 4). The altitude of the study area range from 484 m a.s.l. at the Limpopo River to 598 m a.s.l. on the undulating terrain in the south-eastern areas of the farm Bergen op Zoom, an increase of 114m over a distance of almost 7 kilometres. The topography of the study area is fairly flat in the northern, western and central areas but undulating hills and rocky outcrops is typical of the north-eastern, eastern and south-eastern areas. The highest point in the area is Dongolakop in the south-western corner of the farm Petershof (to the southwest of the study area), measuring 896 m a.s.l.

Figure 4: Topography of the study area.



Five (5) broad landscape units can be identified in the study area:

- Soft undulating landscape with plains and isolated koppies towards the western, central and northern parts.
- Limpopo River valley and associated floodplains and larger drainage lines.
- Extremely irregular undulating rocky areas with koppies and hills with fairly steep slopes to the south-eastern parts.
- The sandveld plato and steep sandstone scarp to the east.
- The eroded valley bottom on the eastern border.

Deeper sandy soils are associated with the flat topography whilst shallow rocky soils are associated with the undulating hills and rocky outcrops. Existing agricultural activities are limited to the flat areas adjacent to the Limpopo River. Some of these areas are also associated with floodplains alongside the Limpopo River. Because of the irregular undulating rocky areas, fairly steep rocky slopes, shallow rocky nature of soils and intensity of rainfall (thunderstorms), the study area is very susceptible to water erosion, especially on roads and areas denuded of vegetation or with a poor herbaceous basal cover.

5.3 Drainage

5.3.1 Eco-regions

For the purposes of river eco-classification, Kleynhans, Thirion and Moolman demarcated level one and two eco-regions across the country in 2005. Demarcation of boundaries was largely based on a Geographical Information System (GIS) approach but was confirmed through consultation with local experts. Due to the

homogeneity of habitats within rivers of an eco-region, fish and invertebrate communities (or assemblages) are also considered to be constant throughout the eco-region.

The study area is located in eco-region 1.01 of the Limpopo Plain (figure 5). Through GIS, the characteristics of the Limpopo Plain eco-region were identified by Kleynhans, Thirion & Moolman (In Angliss et.al. 2008) and are provided in table 4.

Biomonitoring in the Limpopo River system is limited to perennial tributaries of the Limpopo River and no biomonitoring is conducted in the Limpopo River itself, as it is not suitable for assessments of seasonal rivers. (M Angliss: pers. com.¹).

Figure 5: Location of the study area in eco-region 1.01.

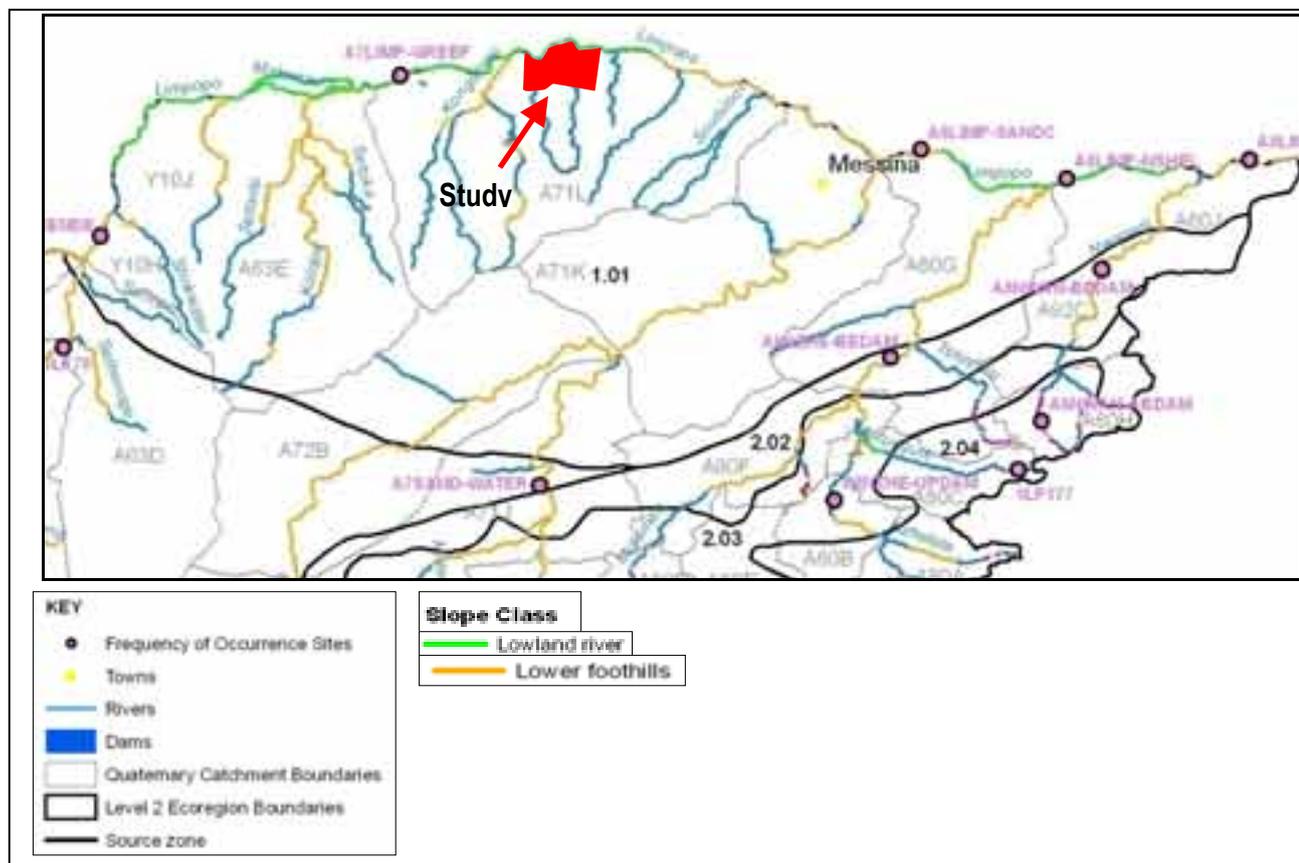


Table 4: Characteristics of eco-region 1.01 (Kleynhans, Thirion & Moolman 2005).

Main Attributes	Limpopo Plain 1.01 (dominant types in bold)
Terrain Morphology: Broad division	Plains; low relief; Plains; moderate relief; Lowlands, Hills and Mountains; moderate and high relief
Terrain Morphology	Plains; Slightly undulating plains Slight irregular plains; Extremely irregular plains (almost hilly) Lowlands with hills
Vegetation types (Primary)	Mopane Bushveld
Altitude (m a.m.s.l.)	100 to 900
MAP (mm)	200 to 400
Coefficient of variation (% of annual precipitation)	30 to 39
Rainfall concentration index	>65
Rainfall seasonality	Early to mid summer
Mean annual temp (°C)	20 to >22
Mean daily max temp (°C) February	28 to 32

¹ MK Angliss. Aquatic Specialist. Department of Economic Development, Environment and Tourism. Polokwane.

Mean daily max temp (°C) July	20 to 26
Mean daily min temp (°C) February	18 to >20
Mean daily min temp (°C) July	4 to >10
Median annual simulated runoff (mm) for quaternary catchment	<5 to 10 (10 to 40 limited)

5.3.2 Limpopo Catchment

The entire study area is part of the Limpopo River System and catchment. Several other large and small drainage lines occur in the study area. The Limpopo River catchment area is approximately 413 000 km². The average rainfall in the catchment is 530 mm per annum and range from 200 mm to 1 200 mm. Evaporation is high and range between 800 mm – 2 400 mm per annum, with an average of 1 970 mm per annum. Runoff is 5.5 x 10⁹m³ per annum or 13 mm per annum (www.arc.agric.za.)

Water is transferred into the basin under 6 separate transfer schemes. Presently approximately 244 000 ha are irrigated with a potential of 122 000 ha in selected sub-catchments. Currently overdevelopment is taken place and the area where the demand exceeds water availability is 70,000 ha. Other land uses (dry land) in the catchment include crops (234 000 ha), pastures (1 780 000 ha) and forestry (455 000 ha) (www.arc.agric.za).

The human population estimation in the catchment area is 14 million.

5.4 Geology

5.4.1 Geology of the Limpopo Basin

The prominent geological features of the Limpopo River Basin are the Limpopo Mobile Belt (where considerable mineralization has taken place), the Kalahari Craton, the Archaean Craton, the Karoo system and the Bushveld Igneous Complex (Brandl, 1981).

Consolidated quaternary age sediments are present in upstream Limpopo, not only in the form of the ubiquitous Kalahari sands which conceal much of the bedrock to varying depths, but also in the form of flood-bank alluvium. Silt, sand and gravel are present both within the river channels and adjacent to the river where broad floodplains have accumulated. Notable accumulations of coarse sand are present in the channels of the Shashe and Motloutse tributaries (www.sardc.net).

In the southern (South African) portion of the basin, the Bushveld Igneous Complex forms an extremely important geological feature, and contains a very large proportion of the region's mineral wealth. The geological features of this area consist mostly of basic mafic and ultramafic intrusive rocks, accompanied by extensive areas of acidic and intermediate intrusive rocks. At the southern and eastern periphery of this area, large dolomite and limestone formations occur, accompanied by extensive mineralization along their contact zones (www.sardc.net).

In the southern portion of the basin, the extensive, carbon rich sedimentary rocks of the Karoo system contain enormous economic reserves of coal and are the site of intensive coal-mining activities in South Africa (www.sardc.net).

The lower Limpopo Basin is characterised by extensive erosion plains, gently dipping coastward. The coastal belt is characterised by a dune area with an average width of 30 km, but extending to 100 km in some places. The lower Limpopo Basin consists largely of unconsolidated and consolidated sedimentary rocks with granitic intrusions exposed as erosion remnants in the landscape (www.sardc.net).

5.4.2 Geology of the study area

The following geological formations occur in the study area (figure 6):

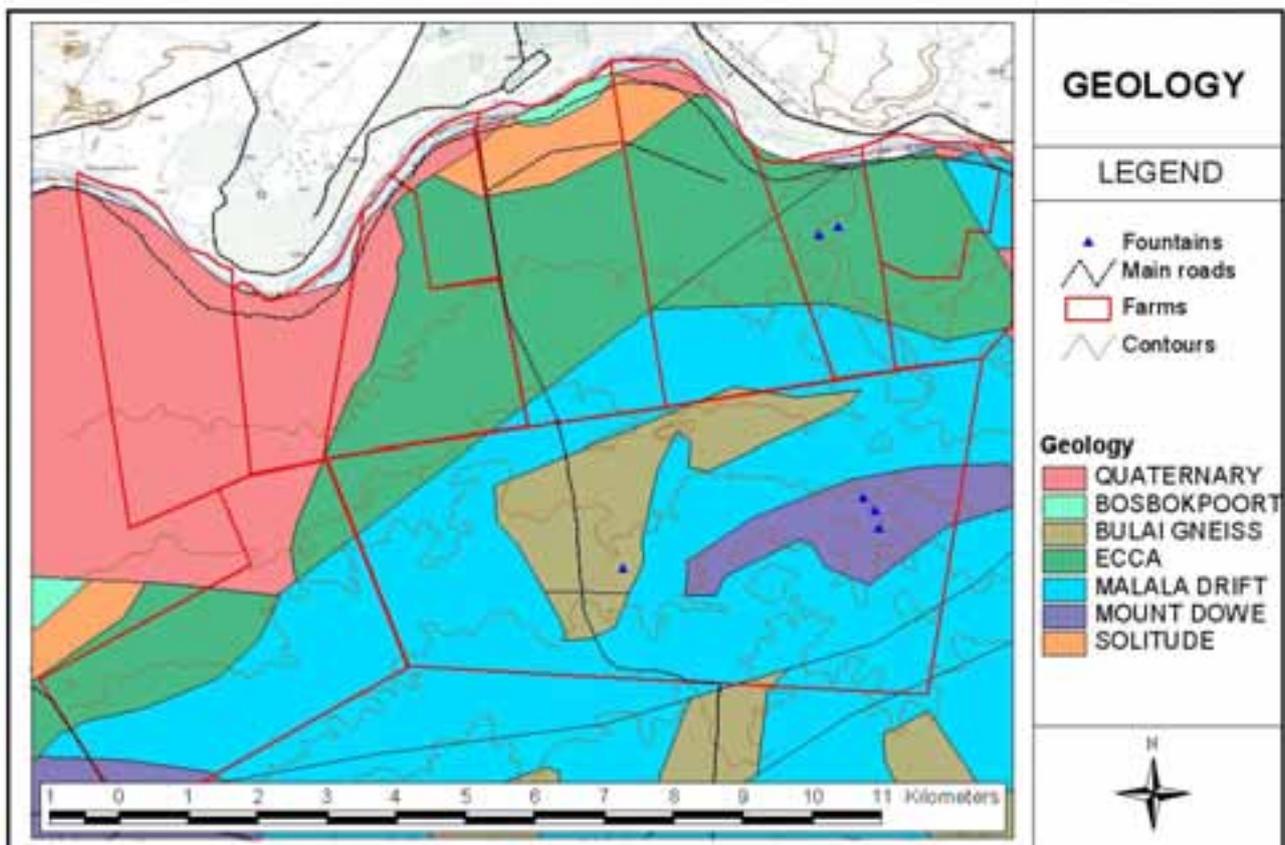
- Quaternary deposits
- Bosbokpoort Formation (Karoo Sequence)
- Solitude Formation (Karoo Sequence)
- ECCA formation (Karoo Sequence)
- Bulai Gneiss
- Mount Dowe Group (Beit Bridge Complex)

- Malala Drift Group (Beit Bridge Complex)

The farms Semple (and Almond), northern areas of Newmark and mostly alongside the Limpopo River are underlain by **Quaternary deposits** and consist of sedimentary deposits, sand and calcrete. On the northern areas of portion 5 of the farm Over Vlakte mudstones of the **Bosbokpoort Formation** (Karoo Sequence) occur. Directly south of these mudstones, and including parts of portion 6 of the farm Over Vlakte to the west and portion 4 of the farm Over Vlakte to the east, shale and mudstone of the **Solitude Formation**, also of the Karoo Sequence, occur.

Most of the remaining areas of portions 6, 5, 4, 3 and 13 of the farm Over Vlakte, north-western areas of Bergen op Zoom and the north-eastern and central western areas of Newmark consist of Arenite, shale and coal of the **ECCA formation**, also of the Karoo Sequence. It is mainly in these areas where coal deposits occur and where mining activities will be focussed on.

Figure 6: Geology of the study area.



The central areas of Bergen op Zoom is characterised by outcrops of **Bulai Gneiss**. The gneiss is a greyish, coarse-grained porphyritic rock. Bulai Gneiss intruded as an anatectic melt originating from remobilised basement rocks and is aged at 2 700 Ma.

To the east of the Bulai Gneiss, a belt of metaquartzite and to a lesser extent leucocratic gneiss of the **Mount Dowe Group** of the Beit Bridge Complex occur on the farm Bergen op Zoom. Closely associated with the metaquartzite is magnetite quartzite.

Around the Bulai Gneiss and metaquartzites of the remaining areas of the farms Bergen op Zoom and Newmark, gneisses, quartzites and pelite of the **Malala Drift Group** of the Beit Bridge Complex occur.

All the rocks of the Beit Bridge Complex were subjected to high temperatures and pressure conditions. This is a consequence of the collision of two crustal plates, the so-called Kaapvaal craton in the south and the Zimbabwe craton in the north, resulting in the Limpopo orogeny. The present-day gneisses represent the root zone of this orogeny. The Limpopo orogeny took probably place 2 000 Ma (Million years) ago (Brandl, 1981).

The Beit Bridge Complex embraces a succession of supracrustal rocks into which the Messina Suite, of anorthosites, gabbros and serpentinites, and the Bulai Gneiss intruded. The supracrustal rocks were probably deposited in a shallow basin as arkose, sandstone, shale, dolomite and volcanogenic material. During several periods of deformation and thermal events the rocks were subjected to at least one episode of high-grade

metamorphism and they are now represented mainly by metaquartzite, calc-silicate rocks, amphibolite, metapelites and various gneisses (Brandl, 1981).

The cover rocks have, on the basis of dominant lithology, been subdivided into the Mount Dowe, Malala Drift and the Gumbu Groups. The order of succession of these units is speculative. Contacts between them appear to be conformable but they are never well defined. Thus it cannot be established with certainty whether a particular layer is part of a normal succession or has been tectonically emplaced (Brandl, 1981).

5.5 Soils

Soil is the growth medium for plants that serve as food and provide habitat for a variety of living organisms. Soil in itself also provides habitat for living organisms. It is with justification that one can say that soil, as well as the geological substrate, are the backbone on which other facets of nature are built.

Different soil bodies have different characteristics. These soil characteristics, noticeable and non-noticeable but measurable, are used for classification purposes. Soil characteristics, individual and collectively, determine the intrinsic behaviour and suitability of soils for different vegetation types.

The soils present in a particular area are, among other things, directly correlated to the geological substrate, position in the landscape and climatic conditions under which it developed. One normally finds that a particular soil type will frequently occur at a particular place in the landscape. Broad soil patterns can at a recognisable level therefore be identified according to particular circumstances in particular landscapes. These broad patterns are, amongst other things, important for understanding the functioning of natural systems. This reasoning is basically the land type principle.

A second grouping can also be done. Soil forms with reconcilable characteristics can be grouped together because their intrinsic behaviour, potential and suitability will be more or less the same. Reconcilable soils are normally found within a specific terrain unit or a specific position in the landscape (terrain form). The same groupings can thus be identified in different soil patterns.

A land type denotes an area that can be shown at 1:250 000 scale and that displays a marked degree of uniformity with respect to terrain form, soil patterns and climate. Land types of the study area are presented in figure 7. Five (5) land types are distinguished in the study area. Broad soil classes associated with the land types are:

<u>Land type</u>	<u>Broad soil classes</u>
• Ae266:	Red-yellow apedal freely drained soils.
• Db218:	Prismacutanic and/or pedocutanic diagnostic horizons dominant.
• Fb143:	Glenrosa and/or Mispah forms (other soils may occur).
• Ia155:	Miscellaneous land classes.
• Ib395:	Miscellaneous land classes.

The Ae Land Type consists of red-yellow, freely drained soils with a high base status and more than 300 mm deep. The "Db" Land Type indicates areas where prismacutanic, gleycutanic and/or pedocutanic diagnostic horizons are dominant and where duplex soils with red B-horizons comprise more than half of the area covered by duplex soils. The "Fb" Land Type is characterised by shallow soils dominated by Glenrosa and/or Mispah soil forms and indicates land where lime is rare or absent in the uplands but generally present in lowland soils. "Ia" refers to land types with a soil pattern difficult to accommodate, with at least 60% of which comprises pedologically youthful, deep (>1000 mm) unconsolidated deposits. Common soil forms are Dundee and Oakleaf. The rocky outcrops and ridges are included in the "Ib" Land Type, which consists of miscellaneous land classes and rocky areas with diverse soils and is associated with exposed rock (exposed rock, stones or boulders), covering 60% - 80% of the area.

Given the high levels of variability encountered during the soil surveys (see soil specialists report), the published land type information provided is too generalized (due to the scale of mapping) to be useful for mine planning purposes. However, the land type information is useful at a regional planning level.

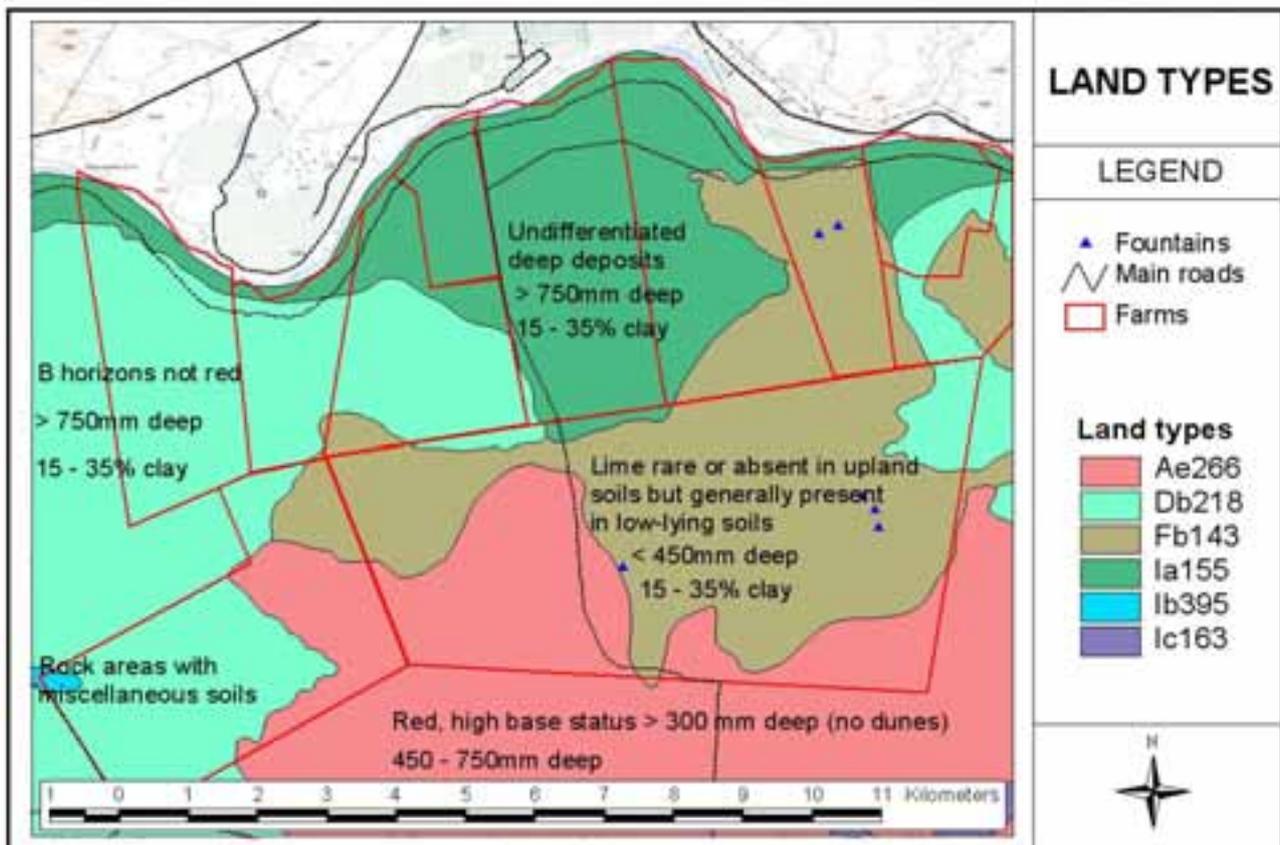
Soils derived from gneiss, quartzite and sandstone are usually sandy and leached and have a low nutrient content, whereas soils derived from diabase, dolerite, gabbro, basalt, shale, siltstone and mudstone are usually more clayey and have a higher nutrient content and water-holding capacity. Silt and clayey alluvial soils occur on flood plains along the streams.

The ecological limitations and implications of these classes are briefly discussed.

Shallow rocky soils on crests, scarps and some midslopes (Fb143, Ib395):

- Ecological potential is limited by the limited soil depth and solid to partly weathered parent material near or at the surface, as well as the leached and nutrient poor status of these soils.
- In most cases the layer of topsoil has been removed by heavy showers, which increase water run-off and erosion.
- The occurrence of lime in Mispah soils can have an influence on the vegetation composition of that area.
- Areas where rocks and Mispah soils occur are characterised by a total lack of soil or very shallow sandy soils with a low moisture content, hygroscopicity, plant basal cover and very low regeneration potential and carrying capacity.
- Mismanagement of these soils through actions such as overgrazing (exposure of topsoil), grading of roads, misplacement or no maintenance of roads result almost always in a total loss of the topsoil. This process is irreversible and currently evident in the study area.

Figure 7. Land types of the study area.



Well-drained soils on footslopes and midslopes (Ae266):

- Less leaching of clay minerals and nutrients led to a better nutrient status than the shallow rocky soils.
- There are generally no limitations in terms of water permeability and therefore root growth depth.
- These soils have a better potential for grazing and game tended to concentrate on these areas.
- Rainfall is the limiting factor to ensure sustainable grazing over time.
- Vegetation on areas where Hutton soils occur will have, because of the medium to coarse sandy nature of these soils, a more typical “sandveld” species composition.
- Hutton soils are more susceptible to wind erosion than water erosion.
- Overgrazing or other disturbances of these areas results in a removal of the plant basal cover that leads to an exposure of the A-horizon. Topsoil has already been lost in many parts of these areas due to wind erosion.

Alluvial soils in valley bottom and floodplains (Ia155, Db218):

- These areas are subjected to higher grazing pressure and periodic flash floods.
- It is in these valley bottom areas that the all-important riverine, floodplain and drainage line vegetation types occur.

- These areas are very palatable and are preferred by game. Game also utilise these areas, because of the accumulation of minerals and salts, as natural licks.
- These areas are susceptible to erosion because of their medium - coarse texture, position in the landscape and accumulation of water during normal thundershowers.

Many of the soils types that occur in the study area have rocks as a depth-limiting material. This is one of the critical limiting factors that influence the occurrence and distribution of vegetation (structural and floristic). There are however large areas in the study area (floodplains etc.) that do not have such limitation and that are currently utilised as highly productive agricultural land.

5.6 Flora

5.6.1 Biome

A biome is a broad ecological unit that represents a major life zone extending over a large natural area (Rutherford & Westfall 1994). It is the largest land community unit recognised at a continental or subcontinental level and mappable at a scale no larger than about 1:10 million (Rutherford & Westfall 1994).

The vegetation of the study area belongs to the broad vegetation group the Savannah Biome (Low and Rebelo 1996). The Savannah Biome is the largest Biome in Southern Africa, occupying 46% of its area, and over one-third the area of South Africa. It is well developed over the Lowveld and Kalahari region of South Africa and is also the dominant vegetation in Botswana, Namibia and Zimbabwe. A grassy ground layer and a distinct upper layer of woody plants (trees and shrubs) is characteristic of the Savannah Biome. Where this upper layer is near the ground (low growing) the vegetation may be referred to as Shrubveld, where it is tall and dense, as Woodland, and the intermediate stages are locally known as Bushveld.

The environmental factors delimiting the biome are complex and include (Low and Rebelo 1996):

- altitude ranges from sea level to 2 000 m;
- rainfall varies from 235 to 1 000 mm per year;
- frost may occur from 0 to 120 days per year; and
- almost every major geological and soil type occurs within the biome.

A major factor delimiting the biome is the lack of sufficient rainfall, which prevents the upper (tree and shrub) layer from dominating, coupled with fires and grazing, which keep the grass layer dominant. Summer rainfall is essential for the grass dominance, which, with its fine material, fuels near-annual fires. In fact, almost all species are adapted to survive fires, usually with less than 10% of plants, both in the grass and tree layer, killed by fire. Even with severe burning, most species can resprout from the stem bases (Low and Rebelo 1996).

The shrub-tree layer may vary from 1 to 20m in height, but in Bushveld typically varies from 3 to 7m. Soil depth is one of the critical factors that determine tree high in the biome. The shrub-tree element may come to dominate the vegetation through bush encroachment in areas that are being overgrazed (Low and Rebelo 1996).

Most of the savannah vegetation types are used for grazing, mainly by cattle or game. In the southernmost savannah types, goats are the major stock. In some types crops and subtropical fruit are cultivated. These mainly include the Clay Thorn Bushveld (14), parts of Mixed Bushveld (18), and Sweet Lowveld Bushveld (21). Urbanization is not a problem, perhaps because the hot, relatively moist climate and diseases (sleeping sickness, malaria) hindered urban development in the past.

Representation of the savannah biome in conservation areas in South Africa is good in principle, mainly due to the presence of the Kruger- and Kalahari Gemsbok National Parks within the biome. However, the large areas conserved in South Africa, belies the fact that half of savannah vegetation types are inadequately conserved, in having less than 5% of their area in reserves. However, much of the area is used for game farming and can thus be considered effectively preserved, provided that sustainable stocking rates and sound environmental practises are maintained. The importance of tourism and big game hunting in the conservation of the area must also not be underestimated.

5.6.2 Veld types / Vegetation types

According to Acocks's (1988) classification of the vegetation of South Africa, the study area falls within one recognised veld types, namely Veld Type 15 - Mopane Veld. According to the classification of Low and Rebelo (1996), there is also only one veld type present, namely Veld Type 10 – Mopane Bushveld. According to Mucina & Rutherford (2006), the study area is situated in the Musina Mopane Veld, the Limpopo Ridge Bushveld and the Subtropical Alluvial Vegetation alongside the Limpopo River. The latter vegetation type is severely modified and degraded because of agricultural practices and the security fence alongside the Limpopo River. The rocky outcrops and koppies occurring throughout the study area also fall in the Limpopo Ridge Bushveld. All of these veld types are described below.

The bulk of the proposed mining site forms part of a much broader landscape (Savanna Biome, Veldtypes Musina Mopane Bushveld and Limpopo Ridge Bushveld (Mucina and Rutherford, 2005)), and fringes along the Subtropical Alluvial Vegetation (riverine) of the Limpopo. Much of the riverine landscape, both within the proposed mining area and elsewhere, has been destroyed or altered, particularly through the establishment of crop farming – any remaining pristine habitat assumes a new and increased significance (Braack 2009). The frequent, high volume use of pesticides in these areas is also significant. Similarly, inherent abiotic factors (thus survival factors) within the mopane and ridge Bushveld (such as soil temperature and moisture properties) have been significantly altered in many parts of these veldtypes through veld-mismanagement and overgrazing (Braack 2009).

5.6.2.1 Mopane Bushveld (Low and Rebelo 1996)

Man has transformed approximately 8% of the veld type, opposed to the 38.29% that has been conserved. In South Africa, it is fairly well conserved in the Kruger National Park and Mapungubwe National Park, and many Provincial Nature Reserves such as Messina, Nwanedi, Makuya, Letaba Ranch and Hans Merensky, as well as private conservation areas and game farms. Effectiveness of conservation of veld in the private conservation areas is however determined by the level of ecologically sound management that is applied. This is questionable in many of the above mentioned conservation areas, and the amount of conservation areas mentioned by authors creates a false picture of an area well conserved, while the real conservation status is most probably much lower.

The Mopane Bushveld can mostly be found on sandy, loamy to rocky soils derived mostly from gneiss. The altitude ranges from 300 - 700m above sea level. The annual rainfall is low and erratic and between 250 – 500 mm. Very high summer temperatures occur and temperatures range from 1.5⁰C - 42.5⁰C, with an average of 22⁰C. Therefore evaporation rates are very high. Frost occurs very seldom and is, for all practical considerations, regarded as absent with no influence on the vegetation.

The tree layer is characterized by dense growth of *Colophospermum mopane* (Mopane), and mixtures of mopane and *Combretum apiculatum* (Red Bushwillow), *Acacia nigrescens* (Knobthorn), *Adansonia digitata* (Baobab), *Commiphora* spp. (Corkwood spp.), *Boscia albitrunca* (Shepherd's Tree), *Kirkia acuminata* (White Seringa), *Grewia* spp (Raisin bush spp.) and *Acacia tortilis* (Umbrella Thorn).

The shrub layer is moderately developed and individuals of *Grewia* spp., *Ochna inermis* (Stunted Plane), *Sterculia rogersii* (Common Star-Chestnut) and *Dichrostachys cinerea* (Sickle Bush).

The grass layer is poorly developed, with grasses such as *Enneapogon cenchroides* (Nine-awned Grass), *Cenchrus ciliaris* (Blue Buffalo Grass), *Stipagrostis uniplumis* (Silky Bushman Grass), *Aristida congesta* (Tassel Three-awn) and *Schmidtia pappophoroides* (Sand Quick). *A. congesta*, *E. cenchroides* and herbs are common in overgrazed and degraded areas.

Rainfall and especially grazing have always been important driving forces in this vegetation type, and certain changes in the vegetation composition and structure can be expected if these driving forces change.

The position in the landscape (crest, scarp, mid slope, valley floor) generally strongly influences the qualities of the soil and therefore the characteristics of the vegetation as well as the species composition thereof.

Currently the most common economic uses for this veld type are game and cattle farming, and ecotourism. In the study site, especially along the Limpopo River, agriculture (citrus, cotton etc.) is the most important land use.

5.6.2.2 Musina Mopane Veld (Mucina & Rutherford 2006)

The Musina Mopane Veld is characterized by undulating to very irregular plains with some hills, at an altitude of around 600m. On areas with deep sandy soils, the white seringa (*Kirkia acuminata*) is one of the dominant tree species along with *C. mopane* (Mopane), *C. apiculatum* (Red Bushwillow) and *Grewia* spp. (Raisin bushes). The herbaceous layer is poorly developed, especially where mopane occurs in dense stands. This vegetation type is classified as “Least threatened” with 2% statutorily conserved in the Mapungubwe National Park, as well as the Nwanedi, Musina and Honnet Nature Reserves to the east. About 3% is transformed, mainly by cultivation, and soil erosion is moderate to high.

The geology consists mainly of gneisses and meta-sediments of the Beit Bridge Complex, with variable soils from deep red/brown clays to deep, freely drained sandy soils, to shallower types including skeletal Glenrosa and Mispah soil forms. The mean annual precipitation varies between 300 – 400 mm and the area is generally frost-free.

Important taxa include trees such as *C. mopane* (Mopane), *A. digitata* (Baobab), *A. nigrescens* (Knobthorn), *C. apiculatum* (Red Bushwillow), *A. senegal* var. *leiorhachis* (Slender Three-hook Thorn) and *Commiphora mollis* (Velvet Corkwood). Conspicuous small trees and shrubs include *G. bicolor* (White Raisin), *G. flava* (Velvet Raisin), *B. foetida* subsp. *rehmanniana* (Stink Shepherd’s tree) and *T. prunioides* (Lowveld Cluster-leaf). The grass layer is characterized by *Aristida* spp. (Three-awn grasses), *S. uniplumis* (Silky Bushman grass), *S. pappophoroides* (Sand Quick), *B. deflexa* (False Signal grass), *E. cenchroides* (Nine-awned grass) and *U. mosambicensis* (Bushveld Signal grass).

5.6.2.3 Limpopo Ridge Bushveld (Mucina & Rutherford 2006)

This vegetation type covers the irregular hills and ridges of much of the area in the vicinity of the Limpopo River. The altitude varies from 300 m to 700 m in the east, with some hills reaching 1 000 m in the west. The vegetation structure is moderately open savannah with a poorly developed ground layer. *K. acuminata* (White Seringa) is prominent on many of the ridges along with *A. digitata* (Baobab). On shallow calcareous gravel and calc-silicate soils, the shrub *Catophractes alexandri* is dominant. Areas of sandstone of the Clarens Formation are prominent in places such as Mapungubwe National Park. Although not as prominent as at Mapungubwe National Park, sandstone ridges also occur in the study area.

The mean annual precipitation varies from 300 – 400 mm and the area is generally frost-free. Important plant species include the *A. digitata* (Baobab), *S. birrea* (Marula), *C. mopane* (Mopane), *C. glandulosa* (Tall Common Corkwood), *T. prunioides* (Lowveld Cluster-leaf), *B. albitrunca* (Shepherd’s tree) and various figs, e.g. *F. tettensis*.

This vegetation type is classified as “Least Threatened”, with some 18% statutorily conserved in the Kruger and Mapungubwe National Parks. Only about 1% is transformed, mainly by cultivation and mining.

5.6.2.4 Limpopo Riverine and floodplain vegetation (Subtropical Alluvial Vegetation)

From an ecosystem and conservation point of view, the riparian fringe and associated floodplains of the Limpopo River is of critical importance. It is normally a dense vegetation community with a closed canopy that occurs in the rich alluvial deposits along the river.

The most prominent trees in this community are *A. xanthophloea* (Fever tree), *F. albida* (Ana tree), *C. imberbe* (Leadwood), *X. zambesiaca* (Nyala tree), *F. sycomorus* (Common Cluster fig), *P. violacea* (Apple-leaf = *L. capassa*) and *C. megalobothrys* (Large Fever-berry). The Limpopo floodplain has allowed some trees to grow to massive sizes such as Nyala and Ana trees in particular.

Floodplains alongside the Limpopo River area are characterised by *Salvadora australis* bush clumps (Narrow-leaved Mustard tree), *A. tortillis* (Umbrella Thorn), *A. xanthophloea* (Fever tree), *Hyphaene coriacea* (Ilala Palm), *Balanites pedicellaris* (Small Green Thorn), *A. stuhlmannii* (Vlei Thorn), *Phaeoptilum spinosum* (Brittle-Thorn), *A. nebrownii* (Water Thorn) and *Acacia borleae* (Sticky Thorn).

The Limpopo River riparian forest and associated plant communities have been under severe pressure since 1978 (De Beer, 2006). Extensive patches of this vegetation have been cleared for cultivation, security and veterinary purposes along the length of the Limpopo River.

Elephants also had, and still have, a significant impact on the riparian and floodplain vegetation in the region. Elephants are steadily destroying closed canopy forest and the density of trees is declining drastically, even in

formally protected areas. The canopy has started opening with an increase in the creeper component such as *Combretum microphyllum* (De Beer, 2006).

Riparian vegetation, with associated closed canopy forests and floodplains, is regarded as sensitive and threatened habitats and ecosystems. These ecosystems are being destroyed, either by human interference or a lack thereof, or other natural components of the ecosystem. Degradation of these ecosystems can result in for instance a loss in biodiversity (species and numbers), degradation of the functioning of the river, forest and floodplain systems, a loss in habitat suitability for many faunal and floral species, an increase in soil erosion, and a decrease in water quality.

5.6.3 Vegetation communities of the study area

Different plant communities develop as a result of differences in geology, topography, rockiness, drainage, soil texture, soil depth, slope, and historic management. Each plant community usually represents a different habitat, has its own inherent grazing and browsing capacity and represents a specific habitat for certain types of fauna species.

The study area is dominated by tree and shrub forms of *C. mopane*, *T. prunoides*, *Commiphora*, *Grewia* species and the grasses *A. congesta*, *E. cenchroides* and *B. deflexa*. A large portion of the study area, adjacent to the Limpopo River, has totally been transformed through agricultural practises.

The diversity of plant species of the study area are summarised in table 5 and a plant species list, as compiled during surveys conducted by DUBEL, is attached as annexure A. This is not a comprehensive list because the survey period was limited to one season. A comparison with other studies on adjacent farms is also provided in table 5.

Table 5: Plant species diversity.

	Amount of species	Amount of species	Amount of species
	DUBEL 2009	Van Rooyen 2008	Van der Walt 2008
Trees	43	36	66
Shrubs	26	23	
Grasses	47	36	36
Liana	3	3	1
Palm	1	1	1
Dwarf shrubs	3	4	314 {large area: from Pontdrift (west) to Malaladrift (east) and from the northern most point of the Limpopo River (north) to approximately 22 30' in the south}
Climbers	4	4	
Forbs	23	47	
Succulents	6	4	
Geophytes		2	
Sedges	4	4	
Total	160	164	

A comprehensive species list of forbs, climbers, bulbous plants, succulents, dwarf shrubs, parasites and epiphytes, compiled over several seasons, is provided in annexure B. Me. R van der Walt² compiled this list on the Ludwigslust Game Farms as part of the Limpopo Valley Herb Project. Ludwigslust Game Farms consists of the following farms: Ludwigslust 163 MS, Wimpsh 139 MS, Matolege 133 MS, Petershof 131 MS, Chatsworth 128 MS, Amersham 127 MS, and Bergen op Zoom 124 MS (Van Rooyen 2008). The farm Bergen op Zoom is thus included in this study. This list contains 314 species. It is clear that this, the "forbs", is the richest component of the flora biodiversity in this arid area. It is also an important food source for game, especially in the dry season and in drought periods when the grass layer is depleted. Many of these plants are annuals and also do not appear every season. The importance of long-term monitoring actions / surveys are imperative to assess the true biodiversity of a specific area, especially these arid areas.

² Me R van der Walt, Limpopo Valley Herb Project, PO Box 2008, Musina. 0900

During the surveys of 2008 and 2009, DUBEL distinguished the following landscape – vegetation communities in the study area and are presented in table 6 and figure 8.

Table 6: Landscape – vegetation communities.

1	Floodplain
1a	Open <i>Salvadora australis</i> floodplain
1b	Open tree floodplain
1c	Medium height shrub <i>A. tortilis</i> floodplain
2	Limpopo riverine forest
3	Mopane
3a	Open mopane sandveld
3b	Shrub Mopane
3c	Shrub mopane on rocky slopes
3d	Shrub mopane on quartzite
3e	Mopane on limestone
3f	Dense Mopane veld
4	Mixed <i>C. mopane</i> - <i>Commiphora</i> - <i>T. prunioides</i>
5	Eroded Mopane
6	Drainage line mopane woodland
7	Drainage line woodland
8	Rocky outcrops
9	Quartzite Rocky outcrops
10	Sandstone ridge
11	Plato sandveld
12	Pans / springs
13	Old lands
14	<i>Catophractes alexandri</i> shrubveld

The species composition of each landscape – vegetation community is provided in table 7. Diagnostic and dominant species is highlighted in bold. Other characteristics of the community are provided under the name of the community and a photographic guide is provided in annexure C.

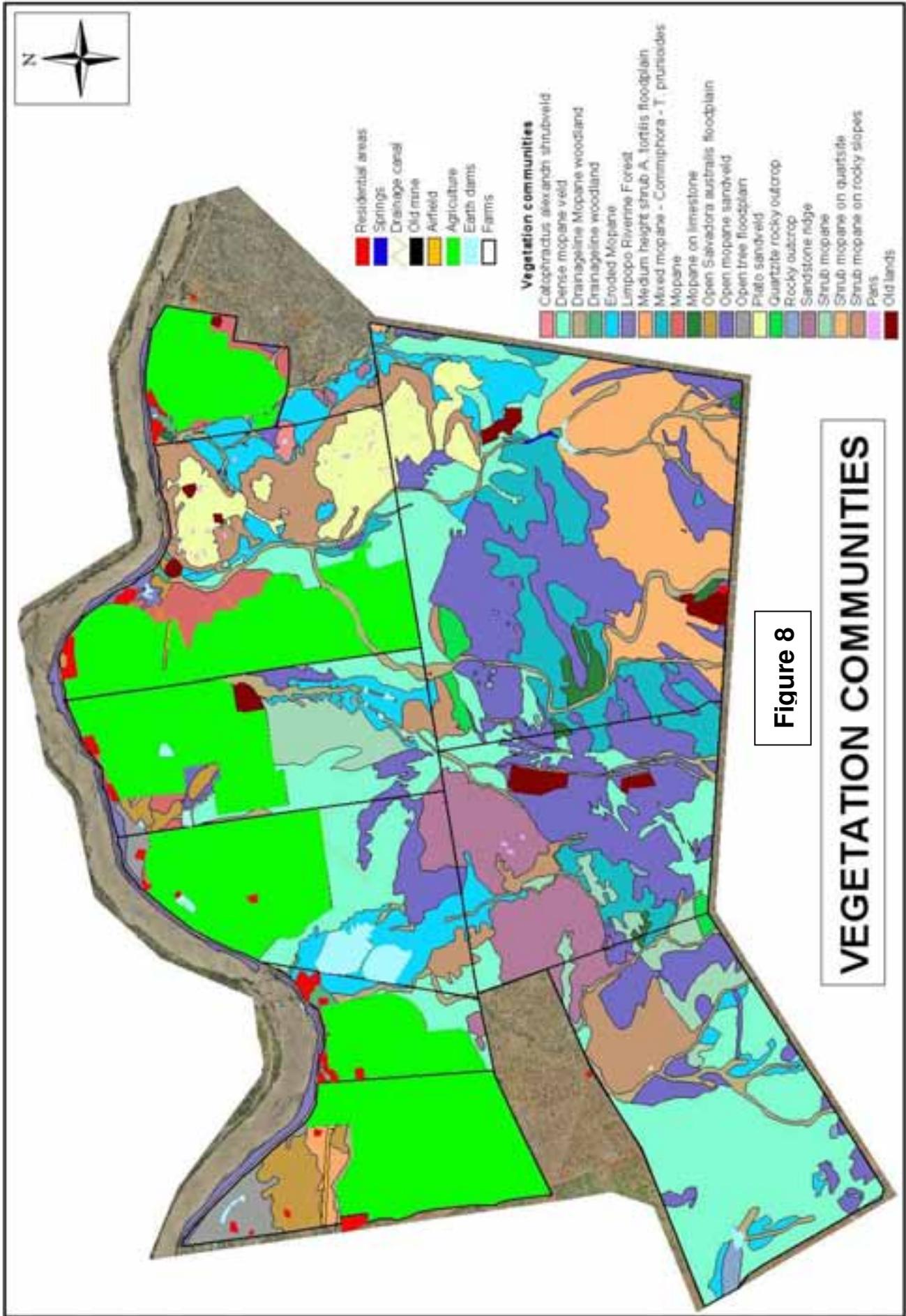


Figure 8

VEGETATION COMMUNITIES

Table 7: Species composition of each vegetation community.

1	Floodplain		
1a	Open <i>Salvadora australis</i> floodplain - <i>Salvadora</i> bush clumps - alluvial soils - < 4 m in height - sensitive area	<i>Salvadora australis</i> <i>Balanites pedicellaris</i> <i>Acacia stuhlmannii</i> <i>Phaeoptilum spinosum</i> <i>Acacia nebrownii</i> <i>Acacia borleae</i> <i>Boscia foetida</i> <i>Acacia tortilis</i> subsp. <i>heterocantha</i> <i>Acacia senegal</i> var. <i>rostrata</i> <i>Acacia grandicornuta</i> <i>Colophospermum mopane</i> <i>Terminalia prunioides</i> <i>Albizia anthelmintica</i> <i>Panicum maximum</i> <i>Sporobolus ioclados</i> <i>Eragrostis rigidior</i> <i>Eragrostis trichophora</i> <i>Sporobolus panicoides</i> <i>Tragus berteronianus</i> <i>Chloris virgata</i> <i>Eragrostis heteromera</i> <i>Solanum gigantium</i> <i>Tribilus terrestris</i>	Narrowleaved Mustard-tree Small Green Thorn Vlei thorn Brittle-thorn Water thorn Sticky Thorn Stink-bush Umbrella Thorn Bushy Three-hook Thorn Horned Thorn Mopane Lowveld Cluster-leaf Worm-bark False-thorn Guinea Grass Pan Dropseed Broad-leaved Curly Leaf Hairy Love Grass Famine Grass Common Carrot-seed Grass Feathered Chloris Bronze Love Grass Goat bitter apple
1b	Open tree floodplain - open tall tree woodland - alluvial soils - > 10 m in height - sensitive area	<i>Acacia xanthophloea</i> <i>Acacia tortilis</i> subsp. <i>heterocantha</i> <i>Xanthocercis zambesiaca</i> <i>Acacia ataxacantha</i> <i>Croton megalobotrys</i> <i>Salvadora australis</i> <i>Gymnosporia senegalensis</i> <i>Ziziphus mucronata</i> <i>Hyphaene coriacea</i> <i>Feadherbia albida</i> <i>Combretum imberbe</i> <i>Ximemia americana</i> <i>Grewia bicolor</i> <i>Terminalia prunioides</i> <i>Acacia nebrownii</i> <i>Boscia albitrunca</i> <i>Phaeoptilum spinosum</i> <i>Boscia foetida</i> <i>Grewia hexamita</i> <i>Combretum mossambicense</i> <i>Philenoptera violacea</i> <i>Cordia monoica</i> <i>Acacia nilotica</i> subsp. <i>kraussiana</i> <i>Eragrostis heteromera</i> <i>Setaria saqittifolia</i> <i>Enneapogon cenchroides</i> <i>Sporobolus panicoides</i> <i>Sporobolus ioclados</i> <i>Tragus berteronianus</i> <i>Chloris virgata</i> <i>Eragrostis lehmanniana</i> <i>Setaria verticillata</i> <i>Brachiaria deflexa</i> <i>Sporobolus africanus</i> <i>Eleusine coracana</i> <i>Eriochloa fatmensis</i> <i>Tribilus terrestris</i>	Fever Tree Umbrella Thorn Nyala Tree Flame thorn Large Fever-berry Narrowleaved Mustard-tree Red Spike-thorn Buffalo-thorn Ilala Palm Ana Tree Leadwood Blue Sourplum White Raisin Lowveld Cluster-leaf Water thorn Shepherd's Tree Brittle-thorn Stink-bush Giant Raisin Knobbly Creeper Apple-leaf Snot Berry Scented Thorn Bronze Love Grass Arrow Grass Nine-awned Grass Famine Grass Pan Dropseed Common Carrot-seed Grass Feathered Chloris Lehman's Love Grass Bur Bristle Grass False Signal Grass Ratstail Dropseed Goose Grass

1c	Medium height shrub <i>A. tortilis</i> floodplain - medium dense tree veld - < 6 m in height	<i>Acacia tortilis</i> subsp. <i>heterocantha</i>	Umbrella Thorn
		<i>Acacia stuhlmannii</i>	Vlei thorn
		<i>Albizia anthelmintica</i>	Worm-bark False-thorn
		<i>Acacia mellifera</i>	Black Thorn
		<i>Eragrostis heteromera</i>	Bronze Love Grass
		<i>Urochloa mosambicensis</i>	Bushveld Signal Grass
		<i>Eragrostis heteromera</i>	Bronze Love Grass
		<i>Sporobolus ioclados</i>	Pan Dropseed
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Tribulus terrestris</i>	

2	Limpopo riverine forest - tall tree closed canopy forest - severely degraded - alluvial soils - > 10 m in height - sensitive area	<i>Acacia xanthophloea</i>	Fever Tree
		<i>Ficus sycomorus</i>	Common Cluster Fig
		<i>Xanthocercis zambesiaca</i>	Nyala Tree
		<i>Philenoptera violacea</i>	Apple-leaf
		<i>Ziziphus mucronata</i>	Buffalo-thorn
		<i>Gymnosporia senegalensis</i>	Red Spike-thorn
		<i>Schotia brachypetala</i>	Weeping Boer-bean
		<i>Combretum microphyllum</i>	Flame Creeper
		<i>Acacia ataxacantha</i>	Flame thorn
		<i>Croton megalobotrys</i>	Large Fever-berry
		<i>Acacia tortilis</i> subsp. <i>heterocantha</i>	Umbrella Thorn
		<i>Combretum mossambicense</i>	Knobbly Creeper
		<i>Capparis tomentosa</i>	WoolyCaper-bush
		<i>Acacia schweinfurthii</i>	River Climbing Thorn
		<i>Feadherbia albida</i>	Ana Tree
		<i>Acrachne racemosa</i>	
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Cenchrus ciliaris</i>	Blue Buffalo Grass
		<i>Chloris virgata</i>	Feathered Chloris
		<i>Dactyloctenium aegyptium</i>	Common Crowfoot
		<i>Digitaria velutina</i>	Flaccid Finger Grass
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Eragrostis biflora</i>	Shade Eragrostis
		<i>Eragrostis cilianensis</i>	Stink Love Grass
		<i>Eragrostis heteromera</i>	Bronze Love Grass
		<i>Panicum deustum</i>	Broad-leafed Panicum
		<i>Panicum maximum</i>	Guinea Grass
		<i>Setaria verticillata</i>	Bur Bristle Grass
		<i>Sporobolus fimbriatus</i>	Dropseed Grass
		<i>Sporobolus ioclados</i>	Pan Dropseed
		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		<i>Tribulus terrestris</i>	
		<i>Urochloa mosambicensis</i>	Bushveld Signal Grass
		<i>Urochloa oligotricha</i>	Perennial Signal Grass

3	Mopane		
3a	Open mopane sandveld - open veld - freely drained soils - > 6 m in height - fair basal cover	<i>Colophospermum mopane</i>	Mopane
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
		<i>Boscia foetida</i>	Stink-bush
		<i>Maerua parvifolia</i>	Grey-leaved Wormbush
		<i>Boscia albitrunca</i>	Shepherd's Tree
		<i>Commiphora glandulosa</i>	Tall Firethorn Corkwood
		<i>Commiphora tenuipetiolata</i>	White-stem Corkwood
		<i>Commiphora mollis</i>	Velvet Corkwood
		<i>Commiphora viminea</i>	Zebra-bark Corkwood
		<i>Sterculia rogersii</i>	Common Star-chestnut
		<i>Lannea schweinfurthii</i> var. <i>stuhlmannii</i>	False Marula
		<i>Acacia senegal</i> var. <i>leiorhachis</i>	Slender Three-hook Thorn
		<i>Sclerocarya birrea</i> subsp. <i>caffra</i>	Marula
		<i>Combretum apiculatum</i> subsp. <i>apiculatum</i>	Red Bushwillow
		<i>Acacia tortilis</i> subsp. <i>heterocantha</i>	Umbrella Thorn
		<i>Rhigozum zambesiicum</i>	Mopani Pomegranate
		<i>Grewia bicolor</i>	White Raisin

		<i>Grewia monticola</i>	Silver Raisin
		<i>Grewia tenax</i>	Small-leaved cross-berry
		<i>Grewia flavescens</i>	Sandpaper Raisin
		<i>Dichrostachys cinerea</i>	Sickle Bush
		<i>Adansonia digitata</i>	Baobab
		<i>Acacia mellifera</i>	Black Thorn
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Stipagrostis uniplumis</i>	Silky Bushman Grass
		<i>Panicum maximum</i>	Guinea Grass
		<i>Cenchrus ciliaris</i>	Blue Buffalo Grass
		<i>Aristida adscensionis</i>	Annual Three-awn
		<i>Solanum giganteum</i>	Goat bitter apple
		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		<i>Eragrostis lehmanniana</i>	Lehman's Love Gras
		<i>Microchloa caffra</i>	Pinchusion Grass
		<i>Tribulus terrestris</i>	
3b	Shrub Mopane - variable densities - also associated with erosion - poor basal cover - < 3 m in height	<i>Colophospermum mopane</i>	Mopane
		<i>Ximenia americana</i>	Blue Sourplum
		<i>Boscia foetida</i>	Stink-bush
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
		<i>Acacia tortilis</i> subsp. <i>heterocantha</i>	Umbrella Thorn
		<i>Maerua parvifolia</i>	Grey-leaved Wormbush
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Panicum maximum</i>	Guinea Grass
		<i>Adenium multiflorum</i>	Impala Lily
3c	Shrub mopane on rocky slopes - fairly dense - on slopes - > 50% rocks - shallow soils - < 3 m in height	<i>Colophospermum mopane</i>	Mopane
		<i>Gardenia resiniflua</i>	Resin Gardenia
		<i>Anisotes rogersii</i>	
		<i>Ximenia americana</i>	Blue Sourplum
		<i>Boscia foetida</i>	Stink-bush
		<i>Boscia albitrunca</i>	Shepherd's Tree
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
		<i>Acacia brevifolia</i>	Rock Albizia
		<i>Kirkia acuminata</i>	White Seringa
		<i>Grewia bicolor</i>	White Raisin
		<i>Flueggea virosa</i>	White-berry Bush
		<i>Rhigozum zambesiicum</i>	Mopani Pomegranate
		<i>Commiphora viminea</i>	Zebra-bark Corkwood
		<i>Grewia villosa</i>	Mallow Raisin
		<i>Grewia monticola</i>	Silver Raisin
		<i>Acacia grandicornuta</i>	Horned Thorn
		<i>Acacia congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Aristida adscensionis</i>	Annual Three-awn
		<i>Bothriochloa radicans</i>	Stinking Grass
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Digitaria eriantha</i>	Finger Grass
		<i>Fingerhuthia africana</i>	Thimble Grass
		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		<i>Melinis repens</i>	Natal Red Top
		<i>Microchloa caffra</i>	Pinchusion Grass
		<i>Enneapogon desvauxii</i>	Eight Day Grass
		<i>Oropetium capense</i>	Dwarf Grass
3d	Shrub mopane on quartzite - fairly dense - undulating topography - > 50% rocks - shallow soils	<i>Colophospermum mopane</i>	Mopane
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
		<i>Commiphora viminea</i>	Zebra-bark Corkwood
		<i>Albizia anthelmintica</i>	Worm-bark False-thorn
		<i>Boscia albitrunca</i>	Shepherd's Tree
		<i>Commiphora glandulosa</i>	Tall Firethorn Corkwood

- < 6 m in height	<i>Commiphora mollis</i>	Velvet Corkwood
	<i>Sterculia rogersii</i>	Common Star-chestnut
	<i>Rhigozum zambesiaccum</i>	Mopani Pomegranate
	<i>Combretum apiculatum</i> subsp. <i>apiculatum</i>	Red Bushwillow
	<i>Commiphora tenuipetiolata</i>	White-stem Corkwood
	<i>Acacia senegal</i> var. <i>leiorhachis</i>	Slender Three-hook Thorn
	<i>Sclerocarya birrea</i> subsp. <i>caffra</i>	Marula
	<i>Dichrostachys cinerea</i>	Sickle Bush
	<i>Grewia bicolor</i>	White Raisin
	<i>Grewia villosa</i>	Mallow Raisin
	<i>Cordia monoica</i>	Snot Berry
	<i>Adansonia digitata</i>	Baobab
	<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
	<i>Enneapogon cenchroides</i>	Nine-awned Grass
	<i>Brachiaria deflexa</i>	False Signal Grass
	<i>Stipagrostis uniplumis</i>	Silky Bushman Grass
	<i>Eragrostis lehmanniana</i>	Lehman's Love Gras
	<i>Heteropogon contortus</i>	Spear Grass
	<i>Tragus berteronianus</i>	Common Carrot-seed Grass
	<i>Aloe littoralis</i>	Mopane aloe
	<i>Bothriochloa radicans</i>	Stinking Grass
<i>Digitaria eriantha</i>	Finger Grass	
<i>Tribilus terrestris</i>		

3e	Mopane on limestone	<i>Colophospermum mopane</i>	Mopane
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
	- fairly rocky (small rocks)	<i>Acacia tortilis</i> subsp. <i>heterocantha</i>	Umbrella Thorn
	- open structure	<i>Boscia foetida</i>	Stink-bush
	- < 3 m in height	<i>Boscia albitrunca</i>	Shepherd's Tree
	- isolated areas	<i>Grewia bicolor</i>	White Raisin
		<i>Grewia flavescens</i>	Sandpaper Raisin
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Oropetium capense</i>	Dwarf Grass
		<i>Enneapogon desvauxii</i>	Eight Day Grass
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Cyprus</i> spp.	
		<i>Bothriochloa radicans</i>	Stinking Grass
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		<i>Tribilus terrestris</i>	
	<i>Solanum qiantium</i>	Goat bitter apple	

3f	Dense Mopane veld	<i>Colophospermum mopane</i>	Mopane
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
	- dense	<i>Acacia tortilis</i> subsp. <i>heterocantha</i>	Umbrella Thorn
	- on sandy soils	<i>Boscia foetida</i>	Stink-bush
	- thickets on disturbed areas	<i>Anisotes rogersii</i>	
	- associated with erosion	<i>Maerua parvifolia</i>	Grev-leaved Wormbush
	- 6m in height	<i>Dichrostachys cinerea</i>	Sickle Bush
		<i>Grewia bicolor</i>	White Raisin
		<i>Rhigozum zambesiaccum</i>	Mopani Pomegranate
		<i>Maerua angolensis</i>	Bead-bean Tree
		<i>Ximenia americana</i>	Blue Sourplum
		<i>Acacia grandicornuta</i>	Horned Thorn
		<i>Panicum maximum</i>	Guinea Grass
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Stipagrostis uniplumis</i>	Silky Bushman Grass
	<i>Tragus berteronianus</i>	Common Carrot-seed Grass	
	<i>Hoodia corrorii</i> subsp. <i>luqardii</i>		

4	Mixed mopane - Commiphora - T. prunioides	<i>Colophospermum mopane</i>	Mopane
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
		<i>Commiphora glandulosa</i>	Tall Firethorn Corkwood

	<ul style="list-style-type: none"> - open to dense - on rocky shallow soils - 6 – 8 m in height - well developed shrub layer 	<p><i>Commiphora tenuipetiolata</i> White-stem Corkwood</p> <p><i>Commiphora mollis</i> Velvet Corkwood</p> <p><i>Commiphora viminea</i> Zebra-bark Corkwood</p> <p><i>Boscia albitrunca</i> Shepherd's Tree</p> <p><i>Acacia tortilis</i> subsp. <i>heterocantha</i> Umbrella Thorn</p> <p><i>Maerua parvifolia</i> Grey-leaved Wormbush</p> <p><i>Grewia flavescens</i> Sandpaper Raisin</p> <p><i>Grewia villosa</i> Mallow Raisin</p> <p><i>Sclerocarya birrea</i> subsp. <i>caffra</i> Marula</p> <p><i>Grewia bicolor</i> White Raisin</p> <p><i>Flueggea virosa</i> White-berry Bush</p> <p><i>Sterculia rogersii</i> Common Star-chestnut</p> <p><i>Dichrostachys cinerea</i> Sickle Bush</p> <p><i>Combretum mossambicense</i> Knobbly Creeper</p> <p><i>Acacia senegal</i> var. <i>leiorhachis</i> Slender Three-hook Thorn</p> <p><i>Adansonia digitata</i> Baobab</p> <p><i>Acacia nigrescens</i> Knob Thorn</p> <p><i>Aristida congesta</i> subsp. <i>barbicolis</i> Spreading Three-awn</p> <p><i>Stipagrostis uniplumis</i> Silky Bushman Grass</p> <p><i>Tragus berteronianus</i> Common Carrot-seed Grass</p> <p><i>Panicum maximum</i> Guinea Grass</p> <p><i>Enneapogon cenchroides</i> Nine-awned Grass</p> <p><i>Brachiaria deflexa</i> False Signal Grass</p> <p><i>Protasparagus</i> spp</p> <p><i>Digitaria eriantha</i> Finger Grass</p> <p><i>Cenchrus ciliaris</i> Blue Buffalo Grass</p> <p><i>Microchloa caffra</i> Pinchusion Grass</p> <p><i>Eragrostis trichophora</i> Hairy Love Grass</p> <p><i>Eragrostis lehmanniana</i> Lehman's Love Grass</p> <p><i>Solanum gigantium</i> Goat bitter apple</p>
5	<p>Eroded Mopane</p> <ul style="list-style-type: none"> - shrubby structure - associated with drainage - poor basal cover - < 3 m in height - degraded area 	<p><i>Colophospermum mopane</i> Mopane</p> <p><i>Maerua angolensis</i> Bead-bean Tree</p> <p><i>Terminalia prunioides</i> Lowveld Cluster-leaf</p> <p><i>Maerua parvifolia</i> Grey-leaved Wormbush</p> <p><i>Acacia nebrownii</i> Water thorn</p> <p><i>Boscia foetida</i> Stink-bush</p> <p><i>Ximenia americana</i> Blue Sourplum</p> <p><i>Aristida congesta</i> subsp. <i>barbicolis</i> Spreading Three-awn</p> <p><i>Bothriochloa radicans</i> Stinking Grass</p> <p><i>Enneapogon cenchroides</i> Nine-awned Grass</p> <p><i>Brachiaria deflexa</i> False Signal Grass</p> <p><i>Cenchrus ciliaris</i> Blue Buffalo Grass</p> <p><i>Panicum maximum</i> Guinea Grass</p> <p><i>Tragus berteronianus</i> Common Carrot-seed Grass</p>
6	<p>Drainage line mopane woodland</p> <ul style="list-style-type: none"> - tall trees - > 10 m in height - in drainage lines - sensitive area 	<p><i>Colophospermum mopane</i> Mopane</p> <p><i>Balanites pedicellaris</i> Small Green Thorn</p> <p><i>Acacia erubescens</i> Blue Thorn</p> <p><i>Acacia nigrescens</i> Knob Thorn</p> <p><i>Philenoptera violacea</i> Apple-leaf</p> <p><i>Acacia tortilis</i> subsp. <i>heterocantha</i> Umbrella Thorn</p> <p><i>Combretum imberbe</i> Leadwood</p> <p><i>Acacia mellifera</i> Black Thorn</p> <p><i>Grewia bicolor</i> White Raisin</p> <p><i>Anisotes rogersii</i></p> <p><i>Maerua parvifolia</i> Grey-leaved Wormbush</p> <p><i>Adansonia digitata</i> Baobab</p> <p><i>Bothriochloa radicans</i> Stinking Grass</p> <p><i>Cenchrus ciliaris</i> Blue Buffalo Grass</p> <p><i>Panicum maximum</i> Guinea Grass</p> <p><i>Eragrostis lehmanniana</i> Lehman's Love Grass</p> <p><i>Tragus berteronianus</i> Common Carrot-seed Grass</p> <p><i>Eragrostis biflora</i> Shade Eragrostis</p> <p><i>Aristida congesta</i> subsp. <i>barbicolis</i> Spreading Three-awn</p>

		<i>Stipagrostis uniplumis</i>	Silky Bushman Grass
		<i>Aristida rhiniochloa</i>	Rough Three-awn
		<i>Chloris virgata</i>	Feathered Chloris
		<i>Digitaria velutina</i>	Flaccid Finger Grass
		<i>Setaria sagittifolia</i>	Arrow Grass

7	Drainage line woodland - tall trees - > 10 m in height - in drainage lines - resembles riverine areas - sensitive area	<i>Colophospermum mopane</i>	Mopane
		<i>Philenoptera violacea</i>	Apple-leaf
		<i>Combretum imberbe</i>	Leadwood
		<i>Xanthocercis zambesiaca</i>	Nyala Tree
		<i>Acacia nigrescens</i>	Knob Thorn
		<i>Acacia tortilis</i> subsp. <i>heterocantha</i>	Umbrella Thorn
		<i>Maerua parvifolia</i>	Grey-leaved Wormbush
		<i>Flueggea virosa</i>	White-berry Bush
		<i>Hyphaene coriacea</i>	Ilala Palm
		<i>Acacia mellifera</i>	Black Thorn
		<i>Cordia monoica</i>	Snot Berry
		<i>Berchemia discolor</i>	Brown ivory
		<i>Ficus tettensis</i>	Small-leaved Rock Fig
		<i>Grewia bicolor</i>	White Raisin
		<i>Grewia monticola</i>	Silver Raisin
		<i>Adansonia digitata</i>	Baobab
		<i>Eragrostis trichophora</i>	Hairy Love Grass
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Panicum maximum</i>	Guinea Grass
		<i>Stipagrostis uniplumis</i>	Silky Bushman Grass
		<i>Aristida adscensionis</i>	Annual Three-awn
		<i>Solanum giganteum</i>	Goat bitter apple
		<i>Eragrostis heteromera</i>	Bronze Love Grass
		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		<i>Eragrostis lehmanniana</i>	Lehman's Love Grass
		<i>Schmidtia pappophoroides</i>	Sand Quick
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Digitaria velutina</i>	Flaccid Finger Grass
		<i>Melinis repens</i>	Natal Red Top
		<i>Cynodon dactylon</i>	Couch Grass

8	Rocky outcrops - isolated outcrops - very rocky > 70% - shallow soils - shrubby structure - medium tall trees - unique habitat	<i>Combretum apiculatum</i>	Red Bushwillow
		<i>Grewia flavescens</i>	Sandpaper Raisin
		<i>Grewia bicolor</i>	White Raisin
		<i>Grewia monticola</i>	Silver Raisin
		<i>Grewia villosa</i>	Mallow Raisin
		<i>Combretum mossambicense</i>	Knobbly Creeper
		<i>Pappea capensis</i>	Jacket-plum
		<i>Acacia nigrescens</i>	Knob Thorn
		<i>Ficus tettensis</i>	Small-leaved Rock Fig
		<i>Kirkia acuminata</i>	White Seringa
		<i>Steganotaenia araliacea</i>	Carrot-tree
		<i>Boscia albitrunca</i>	Shepherd's Tree
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
		<i>Grewia tenax</i>	Small-leaved cross-berry
		<i>Balanites pedicellaris</i>	Small Green Thorn
		<i>Melinis repens</i>	Natal Red Top
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Aristida meridionalis</i>	Giant Three-awn
		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		<i>Tricholaena monachne</i>	Blue-seed Grass
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Schmidtia pappophoroides</i>	Sand Quick
		<i>Enteropogon monostachyus</i>	Mopane Grass
		<i>Panicum maximum</i>	Guinea Grass
		<i>Cenchrus ciliaris</i>	Blue Buffalo Grass
		<i>Digitaria eriantha</i>	Finger Grass
		<i>Hibiscus micranthus</i>	

9	<p>Quartzite Rocky outcrops</p> <ul style="list-style-type: none"> - isolated outcrops - rocky on slopes > 50% - shallow sandy soils - shrubby structure on slopes - medium tall trees - form a plato on top - open structure - unique habitat 	Pappea capensis	Jacket-plum
		Combretum apiculatum	Red Bushwillow
		Gardenia resiniflua	Resin Gardenia
		Acacia erubescens	Blue Thorn
		Albizia harveyi	Common False-Thorn
		<i>Anisotes rogersii</i>	
		<i>Markhamia zanzibarica</i>	Bell-bean Tree
		<i>Colophospermum mopane</i>	Mopane
		<i>Kirkia acuminata</i>	White Seringa
		<i>Cassia abbreviata</i> subsp. <i>beareana</i>	Sjambok Pod
		<i>Boscia albitrunca</i>	Shepherd's Tree
		<i>Boscia foetida</i>	Stink-bush
		<i>Commiphora mollis</i>	Velvet Corkwood
		<i>Commiphora tenuipetiolata</i>	White-stem Corkwood
		<i>Grewia flavescens</i>	Sandpaper Raisin
		<i>Combretum mossambicense</i>	Knobbly Creeper
		<i>Grewia tenax</i>	Small-leaved cross-berry
		Croton gratissimus	Lavender Fever-berry
		<i>Grewia bicolor</i>	White Raisin
		<i>Grewia monticola</i>	Silver Raisin
		<i>Grewia villosa</i>	Mallow Raisin
		<i>Commiphora viminea</i>	Zebra-bark Corkwood
		<i>Acacia erubescens</i>	Blue Thorn
		Lannea schweinfurthii var stuhmannii	False Marula
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Aristida adscensionis</i>	Annual Three-awn
		<i>Eragrostis nindensis</i>	Wether Love Grass
		<i>Melinis repens</i>	Natal Red Top
		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		Danthoniopsis dinteri	Rock Grass
		<i>Aristida rhiniochloa</i>	Rough Three-awn
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Panicum maximum</i>	Guinea Grass
		<i>Eragrostis trichophora</i>	Hairy Love Grass
		<i>Digitaria eriantha</i>	Finger Grass
		<i>Tricholaena monachne</i>	Blue-seed Grass
		<i>Oropetium capense</i>	Dwarf Grass
		<i>Enneapogon cenchroides</i>	Nine-awned Grass

10	<p>Sandstone ridae</p> <ul style="list-style-type: none"> - east – west extent - rocky on slopes > 30% - shallow sandy soils - shrubby structure on slopes - medium tall trees - form a sloping plato on top - fairly open structure - unique habitat 	<i>Colophospermum mopane</i>	Mopane
		Combretum apiculatum	Red Bushwillow
		Gardenia resiniflua	Resin Gardenia
		<i>Commiphora viminea</i>	Zebra-bark Corkwood
		<i>Ximenia americana</i>	Blue Sourplum
		Acacia erubescens	Blue Thorn
		Croton gratissimus	Lavender Fever-berry
		<i>Albizia anthelmintica</i>	Worm-bark False-thorn
		<i>Grewia bicolor</i>	White Raisin
		<i>Ehretia amoena</i>	Sandpaper-bush
		<i>Dichrostachys cinerea</i>	Sickle Bush
		Anisotes rogersii	
		Cassia abbreviata subsp. <i>beareana</i>	Sjambok Pod
		<i>Rhigozum zambesiaceum</i>	Mopani Pomegranate
		<i>Grewia tenax</i>	Small-leaved cross-berry
		<i>Commiphora glandulosa</i>	Tall Firethorn Corkwood
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
		Gyrocarpus americanus	Propeller Tree
		Antheophora pubescens	Wool Grass
		<i>Melinis repens</i>	Natal Red Top
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Digitaria eriantha</i>	Finger Grass
		<i>Aristida adscensionis</i>	Annual Three-awn
<i>Schmidtia pappophoroides</i>	Sand Quick		
<i>Tragus berteronianus</i>	Common Carrot-seed Grass		

		<i>Bothriochloa radicans</i>	Stinking Grass
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Melinis repens</i>	Natal Red Top
		<i>Eragrostis trichophora</i>	Hairy Love Grass
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Hoodia corrorii</i> subsp. <i>luqardii</i>	
11	Plato sandveld - sandy soils - sometimes rocky - medium height trees - well developed shrub layer - fairly open - unique habitat in terms of surrounding mopane veld	<i>Colophospermum mopane</i>	Mopane
		<i>Boscia albitrunca</i>	Shepherd's Tree
		<i>Acacia erubescens</i>	Blue Thorn
		<i>Combretum apiculatum</i>	Red Bushwillow
		<i>Albizia anthelmintica</i>	Worm-bark False-thorn
		<i>Commiphora viminea</i>	Zebra-bark Corkwood
		<i>Croton gratissimus</i>	Lavender Fever-berry
		<i>Grewia bicolor</i>	White Raisin
		<i>Gardenia resiniflua</i>	Resin Gardenia
		<i>Rhigozum zambesiacum</i>	Mopani Pomegranate
		<i>Ximenia americana</i>	Blue Sourplum
		<i>Anisotes rogersii</i>	
		<i>Sterculia rogersii</i>	Common Star-chestnut
		<i>Adansonia digitata</i>	Baobab
		<i>Grewia tenax</i>	Small-leaved cross-berry
		<i>Grewia villosa</i>	Mallow Raisin
		<i>Grewia flavescens</i>	Sandpaper Raisin
		<i>Combretum mossambicense</i>	Knobbly Creeper
		<i>Dichrostachys cinerea</i>	Sickle Bush
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Stipagrostis uniplumis</i>	Silky Bushman Grass
		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Melinis repens</i>	Natal Red Top
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Eragrostis rigidior</i>	Broad-leaved Curly Leaf
		<i>Schmidtia pappophoroides</i>	Sand Quick
		<i>Eragrostis lehmanniana</i>	Lehman's Love Grass
		<i>Microchloa caffra</i>	Pinchusion Grass
		<i>Digitaria eriantha</i>	Finger Grass
		<i>Bothriochloa radicans</i>	Stinking Grass
		<i>Aloe chabaudii</i>	
		<i>Euphorbia Limpopoana</i>	
12	Pans / springs - pans mainly on sandstones - isolated - sensitive areas - unique habitat - springs in drainage lines	<i>Combretum imberbe</i>	Leadwood
		<i>Schotia brachypetala</i>	Weeping Boer-bean
		<i>Colophospermum mopane</i>	Mopane
		<i>Echinochloa colona</i>	Jungle Rice
		<i>Eragrostis trichophora</i>	Hairy Love Grass
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
		<i>Digitaria eriantha</i>	Finger Grass
		<i>Eragrostis heteromera</i>	Bronze Love Grass
		<i>Setaria sagittifolia</i>	Arrow Grass
		<i>Sporobolus africanus</i>	Ratstail Dropseed
13	Old lands - disturbed areas - different stages of succession - low shrubs - < 3 in height - isolated tall trees	<i>Acacia tortilis</i> subsp. <i>heterocantha</i>	Umbrella Thorn
		<i>Colophospermum mopane</i>	Mopane
		<i>Dichrostachys cinerea</i>	Sickle Bush
		<i>Adansonia digitata</i>	Baobab
		<i>Lannea schweinfurthii</i> var. <i>stuhmannii</i>	False Marula
		<i>Sclerocarya birrea</i> subsp. <i>caffra</i>	Marula
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Brachiaria deflexa</i>	False Signal Grass
		<i>Stipagrostis uniplumis</i>	Silky Bushman Grass
		<i>Panicum maximum</i>	Guinea Grass
		<i>Cenchrus ciliaris</i>	Blue Buffalo Grass
		<i>Solanum gigantium</i>	Goat bitter apple

		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		<i>Eragrostis lehmanniana</i>	Lehman's Love Gras
		<i>Microchloa caffra</i>	Pinchusion Grass
		<i>Tribilus terrestris</i>	
		<i>Urochloa mosambicensis</i>	Bushveld Signal Grass
		<i>Enneapogon cenchroides</i>	Nine-awned Grass
14	<i>Catophractes alexandri</i> shrubveld - shrub veld - shallow rocky soils - lime present - < 2 m in height	<i>Catophractes alexandri</i>	Trumpeter Thorn
		<i>Colophospermum mopane</i>	Mopane
		<i>Ximania americana</i>	Blue Sourplum
		<i>Grewia bicolor</i>	White Raisin
		<i>Terminalia prunioides</i>	Lowveld Cluster-leaf
		<i>Grewia tenax</i>	Small-leaved cross-berry
		<i>Aristida congesta</i> subsp. <i>barbicolis</i>	Spreading Three-awn
		<i>Tragus berteronianus</i>	Common Carrot-seed Grass
		<i>Oropetium capense</i>	Dwarf Grass
		<i>Enneapogon desvauxii</i>	Eight Day Grass

Species with medicinal and poisonous properties (mostly poisonous for cattle and sheep) that occur in the study are provided in table 8 (Van Rooyen, 2008). 18 species have medicinal properties and 9 species have poisonous properties.

Table 8. Species with medicinal and poisonous properties.

Species with medicinal properties	Species with poisonous properties
<i>Acacia tortilis</i>	<i>Solanum kwebense</i>
<i>Adansonia digitata</i>	<i>Acalypha indica</i>
<i>Albizia anthelmintica</i>	<i>Geigeria burkei</i>
<i>Boscia albitrunca</i>	<i>Panicum maximum</i>
<i>Cassia abbreviata</i>	<i>Stipagrostis uniplumis</i>
<i>Combretum apiculatum</i>	<i>Adenium multiflorum</i>
<i>Euphorbia ingens</i>	<i>Euphorbia ingens</i>
<i>Lannea schweinfurthii</i>	<i>Euphorbia sp.</i>
<i>Philenoptera violacea</i>	<i>Sarcostemma viminale</i>
<i>Sclerocarya birrea</i>	
<i>Dichrostachys cinerea</i>	
<i>Ehretia rigida</i>	
<i>Flueggea virosa</i>	
<i>Gardenia resiniflua</i>	
<i>Grewia bicolor</i>	
<i>Grewia villosa</i>	
<i>Gymnosporia senegalensis</i>	
<i>Ximania americana</i>	

The floodplains, Limpopo Riverine forest, rivers, rocky outcrops, pans and springs are considered to be of high conservation value. The sandstone ridges and platos are considered as unique habitats in this mopane veld because it provides diversity and have 'n higher species diversity than other areas in the study area.

5.7 Fauna

The diversity of faunal species associated with mopane veld areas in the study area is lower than that of many other areas within the veld type and even other veld types. This is mainly because of low rainfall and shallow rocky sandy soils that result in poorer nutritional status of the veld. Habitat degradation, mainly because of agricultural practises and long-term overgrazing, also had an influence on the natural distribution patterns of many faunal species in these areas.

The development of the game farm industry over the past 30 – 40 years, especially the hunting industry, also influenced the occurrence and distribution of many faunal species in these areas, especially antelope species and predators. Many antelope species have been introduced or reintroduced, some outside of their natural distribution range, and predators have been earmarked as so-called "problem animals" and were deliberately removed on many farms for many years.

The development of the game farm industry also had secondary affects on the occurrence and distribution of faunal species. The confinement of a fairly large amount of antelope, species and numbers, on relatively small areas (farms) resulted in an increase in the availability of food (prey) for many predator species and thus a natural increase in predator numbers over time. The so-called “problem animals” therefore increased and thus also the actions to remove such animals.

Typical management actions associated with game or livestock farming, such as the provision and increase in the distribution of permanent water, resulted in an increase in the availability of water in these arid areas. A critical limiting factor that determined the occurrence and distribution of many faunal species had been eliminated as a result and habitat suitability for many species increased. This alteration of the functioning of the ecosystem did not only influence the occurrence of large mammal species, but also small mammals, reptiles, birds etc.

5.7.1 Mammals

Mammal species that were identified during the surveys, that are known to occur (according to land owners) and could possibly occur (according to literature reviews) in the study area are summarised in table 9. This however does not imply that all of these species will occur in the study area at any given time.

Table 9: Mammal species identified during surveys.
(√ = confirmed occurrence ; X = confirmed absence).

COMMON NAME	SCIENTIFIC NAME	CONFIRMED OCCURRENCE IN STUDY AREA	GENERAL DISTRIBUTION IN LARGER AREA
HEDGEHOGS			
Southern African hedgehog	<i>Atelerix frontalis</i>	√	
ELEPHANT-SHREWS			
Rock elephant-shrew	<i>Elephantulus myurus</i>	√	
BATS			
Egyptian Fruit-bat	<i>Rousettus aegyptiacus</i>		? (habitat)
Mauritian Tomb Bat	<i>Taphozous mauritanus</i>		√
Sundevall's Leaf-nosed Bat	<i>Hipposideros caffer</i>		√
Egyptian Silt-faced Bat	<i>Nycteris thebaica</i>		√
Geoffroy's Horseshoe Bat	<i>Rhinolophus clivosus</i>		√
Darling's Horseshoe Bat	<i>Rhinolophus darlingi</i>		√
Bushveld Horseshoe Bat	<i>Rhinolophus simulator</i>		√
Schreibers's Long-fingered Bat	<i>Miniopterus schreibersii</i>		√
Cape Serotine Bat	<i>Eptesicus capensis</i>		√
Temminck's Hairy Bat	<i>Myotis tricolor</i>		√
Kuhl's Pipistrelle	<i>Pipistrellus kuhlii</i>		√
Banana Bat	<i>Pipistrellus nanus</i>		√
Yellow House Bat	<i>Scotophilus danganii</i>		√
Egyptian Free-tailed Bat	<i>Tadarida aegyptiaca</i>		√
BABOONS, MONKEYS & BUSHBABIES			
Chacma baboon	<i>Papio ursinus</i>	√	
Lesser bushbaby	<i>Galago moholi</i>	√	
Thick-tailed bushbaby	<i>Otolemur crassicaudatus</i>		√
Vervet monkey	<i>Cercopithecus aethiops</i>	√	
PANGOLINS			
Pangolin	<i>Manis temminckii</i>	√	
HARES & RABBITTS			
Jameson's Red Rock Rabbit	<i>Pronolagus randensis</i>		√
Scrub hare	<i>Lepus saxatilis</i>	√	
RODENTS			
Common Molerat	<i>Cryptomys hottentotus</i>		?
Lesser Savanna Dormouse	<i>Graphiurus parvus</i>		?

Porcupine	<i>Hystrix africaeaustralis</i>	√	
Springhare	<i>Pedetes capensis</i>	√	
Tree squirrel	<i>Paraxerus cepapi</i>	√	
Woodland Dormouse	<i>Graphiurus murinus</i>		?
Pouched Mouse	<i>Saccostomus campestris</i>		?
Fat Mouse	<i>Steatomys pratensis</i>		?
Grey Climbing Mouse	<i>Dendromus melanotis</i>		? (habitat)
Large-eared Mouse	<i>Malacothrix typica</i>		?
Bushveld Gerbil	<i>Tatera leucogaster</i>		√
Spiny Mouse	<i>Acomys spinosissimus</i>		√
Namaqua Rock Mouse	<i>Aethomys namaquensis</i>		√
Red Veld Rat	<i>Aethomys Chrysophilus</i>		√
Striped Mouse	<i>Rhabdomys pumillio</i>	√	
Single-striped Mouse	<i>Lemniscomys rosalia</i>	√	
Pygmy Mouse	<i>Mus minutoides</i>		√
Thomas's Pygmy Mouse	<i>Mus sorella</i>		?
House Mouse	<i>Mus musculus (introduced)</i>	√	
Tree Mouse	<i>Thallomys paedulcus</i>		?
Natal Multimammate Mouse	<i>Mastomys natalensis</i>		?
Multimammate Mouse	<i>Mastomys coucha</i>		?
House Rat	<i>Rattus rattus (introduced)</i>	√	
Angoni Vlei Rat	<i>Otomys angoniensis</i>		? (habitat)
Vlei Rat	<i>Otomys irroratus</i>		? (habitat)

CARNIVORES

African Wild Dog	<i>Lycaon pictus</i>		√
Aardwolf	<i>Proteles cristatus</i>	√	
African wild cat	<i>Felis lybica</i>	√	
Banded mongoose	<i>Mungos mungo</i>		√
Black-backed jackal	<i>Canis mesomelas</i>	√	
Brown hyaena	<i>Hyaena brunnea</i>	√	
Spotted hyaena	<i>Crocuta crocuta</i>		√
Leopard	<i>Panthera pardus</i>	√	
Lion	<i>Panthera leo</i>	Occasionally	√
Caracal	<i>Felis caracal</i>	√	
Cerval	<i>Felis serval</i>	√	
Civet	<i>Civettictis civetta</i>	√	
Cheetah	<i>Acinonyx jubatus</i>		√
Dwarf mongoose	<i>Helogale parvula</i>		√
Honey badger	<i>Mellivora capensis</i>	√	
Large-spotted genet	<i>Genetta tigrina</i>		√
Slender mongoose	<i>Galerella sanguinea</i>		√
Small-spotted genet	<i>Genetta genetta</i>		√
Striped polecat	<i>Ictonyx striatus</i>		√

AARDVARK

Aardvark	<i>Orycteropus afer</i>	√	
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DASSIES (HYRAX)

Rock Dassie (Hyrax)	<i>Procavia capensis</i>	√	
Yellow-spotted Rock Dassie	<i>Heterohyrax brucei</i>		√

ELEPHANT

Elephant	<i>Loxodonta africana</i>	Occasionally	√
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RHINOCEROS

Square-lipped Rhinoceros	<i>Ceratotherium simum</i>	X	√
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HIPPOPOTAMUS

Hippopotamus	<i>Hippopotamus amphibius</i>	Occasionally	√
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UNGULATES

Blue wildebeest	<i>Connochaetes taurinus</i>	√	
Buffalo	<i>Syncerus caffer</i>	X	√
Burchell's zebra	<i>Equus burchellii</i>	√	

Bushbuck	<i>Tragelaphus scriptus</i>	√	
Bushpig	<i>Potamochoerus porcus</i>	√	
Common duiker	<i>Sylvicapra grimmia</i>	√	
Eland	<i>Taurotragus oryx</i>	√	
Gemsbok	<i>Oryx gazelle</i>	√	
Impala	<i>Aepyceros melampus</i>	√	
Klipspringer	<i>Oreotragus oreotragus</i>	√	
Kudu	<i>Tragelaphus strepsiceros</i>	√	
Nyala	<i>Tragelaphus angasii</i>		√
Red Hartebeest	<i>Alcelaphus buselaphus</i>		√
Reedbuck	<i>Redunca arundinum</i>	X	√
Sable	<i>Hippotragus niger</i>	X	√
Sharpe's grysbok	<i>Raphicerus sharpei</i>		√
Steenbok	<i>Raphicerus campestris</i>	√	
Warthog	<i>Phacochoerus aethiopicus</i>	√	
Giraffe	<i>Giraffa camelopardalis</i>	√	
Waterbuck	<i>Kobus ellipsiprymnus</i>	√	

5.7.2 Herpetofauna

5.7.2.1 Background

No historic data for the specific farms of the study area are available. However, some studies have been conducted on Mapungubwe National Park, Messina Nature Reserve and Maremani Nature Reserves, 55 kilometres east of the study area. These areas are very similar in habitat and climate to the study area but this does not imply that all species found in these areas will occur in the study area.

Maremani Nature Reserve covers approximately 44 000 ha of natural mopane bushveld and is described by Thomas and Christen (2002) as “a home to a phenomenally vast reptile biodiversity”. They also found that there were certain “hotspots” of reptile activity and breeding areas, all worthy of protection.

One of these hotspots was The Magdala River system, a seasonal river rich in reptile fauna and an important breeding site for reptile species. Such rivers also occur in the study area and these species would most probably also occurred here.

African Rock Python (*Python natalensis*)

Black Mamba (*Dendroaspis polylepis*)

Horned Adder (*Bitis caudalis*)

Giant plated lizard (*Gerrhosaurus validus*)

Nile Monitor Lizard (*Varanus albigularis*)

Rock Monitor Lizard (*Varanus niloticus*)

Several populations of *Scelotes limpopoensis* (Limpopo Dwarf Burrowing Skink), a rarely seen reptile and an endemic to this area, were also located on Maremani.

Other important breeding sites on Maremani occurred on koppies, where for instance a large communal group of *Gerrhosaurus validus* (Giant Plated Lizard) were located. Such habitats also occur in the study site, especially on the farm Bergen op Zoom, and it is expected that these lizards will also occur in the study site.

The following venomous snakes were also identified:

Boomslang (*Dispholidus typus*)

Vine snake (*Thelotornis capensis*)

Puff Adder (*Bitis arietans*)

Egyptian (snouted) cobra (*Naja annulifera*)

Mozambique Spitting Cobra (*Naja mossambica*)

Black mamba (*Dendroaspis polylepis*)

Shield-nose snake (*Aspidelaps scutatus*)

Burrowing Adder (*Atractaspis bibronii*)

Various garter snake species (*Elapsoidea* spp.)

Snouted Night Adder (*Causus defillippi*)

Horned Adder (*Bitis caudalis*)

5.7.2.2 Herpetological study

Dr H Braack of ABRUS Environmental Consultancy conducted literature surveys (Alexander and Marais 2007, Branch 1998, Marais 2004, Minter et al 2004, various relevant journals) and a herpetological study in the proposed mine area during January 2009 and compiled the following report (Braack 2009):

The study area was surveyed on a broad basis on foot with some emphasis placed on habitats known to have a richer or more specialised fauna (e.g. rock outcrops, deep sands, fountains, pans). The various habitats were strip/transect surveyed as far as possible. While walking the strips, movement was observed, rocks and logs were lifted and searched under, leaf litter was scratched and sifted, grass tussocks were

searched, and exposed rocks and logs were checked for basking animals. Cracks in rocks, and gaps between rocks, were investigated. Some priority was given to the granite outcrops, because of their herpetological significance as a special habitat, and the relatively undisturbed nature of their terrain. Permanent and temporary water bodies and their surrounds were investigated for amphibians. Good rains, which had recently fallen in the area, meant that many reptiles and amphibians were most likely to be active. The timing of the survey was, thus, satisfactory, though brief.

A total of forty-two (42) species of herpetofauna were recorded on the proposed Vele mining site during the survey, as listed below in table 10.

Table 10: Herpetofauna identified during the herpetological study.

Reptiles	Chelonians	<i>Kinixys spekii</i>	Speke's Hinged Tortoise
		<i>Stigmochelys pardalus</i>	Leopard Tortoise
		<i>Pelomedusa subrufa</i>	Marsh Terrapin
	Snakes	<i>Python natalensis</i> (SA RDB, ToPS)	African Rock Python
		<i>Aparallactus capensis</i>	Cape Centipede Eater
		<i>Lamprophis capensis</i>	Brown House Snake
		<i>Psammophis subtaeniatus</i>	Stripe-bellied Sand Snake
		<i>Philothamnus semivariiegatus</i>	Spotted Bush Snake
		<i>Crotaphopeltis hotamboeia</i>	Herald Snake
		<i>Dispholidus typus</i>	Boomslang
		<i>Naja annulifera</i>	Snouted Cobra
		<i>Bitis arietans</i>	Puff Adder
	Lizards	<i>Scelotes limpopoensis</i>	Limpopo Dwarf Burrowing Skink
		<i>Trachylepis quinquetaeniata</i>	Rainbow Skink
		<i>Trachylepis striata</i>	Striped Skink
		<i>Trachylepis varia</i>	Variable Skink
		<i>Heliobolus lugubris</i>	Bushveld Lizard
		<i>Pedioplanis lineocellata</i>	Spotted Sand Lizard
		<i>Gerrhosaurus flavigularis</i>	Yellow-throated Plated Lizard
		<i>Gerrhosaurus validus</i>	Giant Plated Lizard
		<i>Platysaurus intermedius</i>	Common Flat Lizard
		<i>Varanus niloticus</i>	Water Monitor
		<i>Agama armata</i>	Peter's Ground Agama
		<i>Acanthocercus atricollis</i>	Southern Tree Agama
		<i>Chamaeleo dilepis</i>	Flap-neck Chameleon
		<i>Afroedura</i> sp. cf <i>transvaalica</i>	Flat Gecko
		<i>Chondrodactylus turneri</i>	Turner's Giant Gecko
		<i>Hemidactylus mabouia</i>	Moreau's Tropical House Gecko
		<i>Homopholis wahlbergii</i>	Wahlberg's Velvet Gecko
	<i>Lygodactylus capensis</i>	Cape Dwarf Gecko	
	<i>Lygodactylus stvensoni</i>	Stevenson's Dwarf Gecko	
	Amphibia	<i>Xenopus laevis</i>	Common Platanna
		<i>Phrynomantis bifasciatus</i>	Banded Rubber Frog
<i>Hemisus marmoratus</i>		Mottled Shovel-nosed Frog	
<i>Kassina senegalensis</i>		Bubbling Kassina	
<i>Hyperolius marmoratus</i>		Painted Reed Frog	
<i>Chiromantis xerampelina</i>		Foam Nest Frog	
<i>Pyxicephalus edulis</i> (ToPs)		African Bull Frog	
<i>Tomopterna cryptotus</i>		Tremolo Sand Frog	
<i>Bufo garmani</i>		Eastern Olive Toad	
<i>Afrana angolensis</i>		Common River Frog	
<i>Ptychadena anchietae</i>		Plain Grass Frog	

Local anecdotal records include the presence of Black Mamba (*Dendroaspis polylepis*), Mozambique Spitting Cobra (*Naja mossambica*), Twig Snake (*Thelotornis capensis*), and Nile Crocodile (*Crocodylus niloticus*; SARDB).

Egan (2008) provided additional historical records for the same quarter degree grid cell (2229BA):

<i>Dasypeltis scabra</i>	Common Egg Eater
<i>Elapsoidea sunderwallii</i>	Sundevall's Garter Snake
<i>Rhinotyphlops lalandei</i>	Delalande's Beaked Blind Snake
<i>Bitis caudalis</i>	Horned Adder
<i>Pachydactylus punctatus</i>	Speckled Thick-toed Gecko

A new species of Flat Gecko, *Afroedura* sp. nov., was also listed by Egan (2008), but the locality is not known.

IUCN Red Listing of reptiles is currently under review through the South African Reptile Conservation Assessment (SARCA) project, and several research initiatives to investigate species validity are in progress. SARCA results should be available during 2009.

The current listing of herpetofauna in the ToPS document has been found, by herpetologists, to be unsatisfactory, and will be under review (2009) in conjunction with SARCA findings.

Unless conducted over a lengthy period of time, which may extend over years, few surveys of herpetofauna can be considered totally complete. What should be gauged along with the site-recorded species are the availability of habitats, which are structurally similar to on-site habitat, their accessibility, and the proximity of surrounding feeder populations of herpetofauna and their ability to access and traverse/inhabit the site. Habitats adjoining the proposed mining site are structurally similar to those on site, and should easily enable access to feeder populations for establishment and traversing.

The list presented above is certainly not a complete list. It does, however, give fair representation to both rare and common species, and can be considered adequate for the purposes of this assessment. Fossorial species are always a problem to find or predict.

In the context of herpetofauna, it is the structural integrity of natural elements such as soils (base), moisture (retention cycle, rain-drop impact, and run-off) and flora, which is significant. These elements have induced high levels of adaptation to survive in the natural, semi-arid environment. Destruction or alteration of these natural elements has an immediate effect on species survival, and, significantly, for the area to maintain its viability as a corridor for species and genetic flow and transfer. In this semi-arid environment, structural change to soil and flora character is likely to have an almost permanent impact, despite attempts at rehabilitation.

Within the proposed mining area, both this survey and the available older records reveal a number of interesting, habitat specific, reptile species. The records of Red listed and ToPs listed species such as *Python natalensis*, as well as *Gerrhosaurus validus*, are of interest, but are not unexpected, and both species have been found in adjacent areas. However, the record of an *Afroedura* species is of especial interest - this may be a new species, as discussed above.

The herpetological significance of the site is principally in the role that it plays as a passage to species and gene flow – it is here that each habitat type, whether rocky or sandy, provides a continuous corridor for species distribution and evolution. However, molecular studies are exposing a number of previously unknown relationships, and further study may reveal values that are currently not understood.

The long-term impact of any form of disturbance can realistically be determined with accuracy only after the surrounding areas are surveyed to assess the true extent of suitable habitat, and the distribution of species found within those habitats. In terms of herpetofauna, it is the structure of the habitat and microhabitat that is of significance, and it is that aspect which needs to be managed during mining activities and reclamation.

Current planning indicates that herpetofauna habitat will be most greatly impacted by the opencast operation, which is scheduled to endure for some twenty-five years. This will take place predominantly in Mopane Bushveld. Within this vegetation structure, the granite outcrops on the farm Bergen op Zoom present the most sensitive habitat in terms of their reptile importance. They cannot be easily replaced or recreated despite rehabilitation efforts.

The seasonal pans, and their environs, are of importance especially as breeding sites and local distribution centres of *Pyxicephalus edulis*.

The riverine and alluvial habitats within the proposed mining area have largely been destroyed through farming activities. Their significance centres principally through the corridor effect for herpetofauna along the Limpopo River and its fringe vegetation and soil structure.

If viewed in isolation, current understanding of the conservation status of herpetofauna should not be affected by the currently proposed mining activities, unless significant damage is caused to those areas beyond the envisaged opencast planning, and if rehabilitation/mitigation measures are not followed. It is, however, important to note that developments are continually fragmenting and decreasing natural habitat,

and that, if such developments continue on an uncontrolled and unplanned manner, separated and isolated populations will occur, and natural adaptive and developmental genetic processes will be halted.

From the point of view of the purpose of the survey, it is not possible to give one broad assessment which covers the entire site: the granite (on the farm Bergen op Zoom) and sandstone outcrop (koppie) habitats should be considered as highly sensitive and as units separate from the other habitats of the mining site; this is also the case with the fountains and shallow seasonal pans.

5.7.3 Avifauna

According to literature studies, a fairly high diversity is known to occur in the region and expected to occur in the study area also.

According to information from the nearby Mapungubwe National Park, over 400 bird species could occur in the area. An interesting attraction of the park is the occurrence of species typical of the arid western regions of the country (e.g. Southern Pied Babbler, Crimson-breasted Shrike and Black-faced (Black-cheeked Waxbill) alongside species associated with the moister Lowveld habitat of the Kruger National Park.

Along the Limpopo River, rare species for South Africa, such as Meve's (Longtailed) Starling, Tropical Boubou and Pel's Fishing Owl have also been spotted, while high densities of Verreaux's (Black) Eagle and other raptors are also prominent. Verreaux's (Black) Eagle nests on the cliff face in Mapungubwe National Park. Such nesting habitat does however not occur in the study area. In summer, an abundance of cuckoo species can be found, with up to eleven different species, including the rarer Common and Thick billed Cuckoos. Rarities also occur and it has been reported that Boulder Chat has been seen and when one looks at the habitat and considers the proximity to the Matopos and other known locations, it would appear a distinct possibility.

Species associated with bush and rocky environments are common and the most prominent bird is probably the Cinnamon-breasted (Rock) Bunting, but other species such as the Blue Waxbill and Black-backed Puffback are also particularly common. Other species that occur in the area are Meyer's Parrot, White-crested Helmetshrike, Meve's (Longtailed) Starling, Flycatcher species and Southern Boubou.

Birding in the riverbed varies depending on water levels in the river. White-fronted Bee-eaters breed in the riverbanks and are very prominent. African Fish Eagle is also fairly common.

Birds more associated with closed canopy forest areas are:

Yellow-bellied Greenbul	Meve's (Long-tailed) Starlings	Black-backed Puffback
Tropical Boubou	Southern Pied Babbler	Natal Spurfowl (Francolin)
Orange-breasted Bush-shrikes	Grey-headed Bush-shrikes	Grey-backed Camaroptera (Bleating Warbler)

The Limpopo floodplains in flood are a paradise for aquatic birds and species such as Grey-crowned cranes, up to 7 stork species and several wader, heron, crane and duck species will be seen in these wet times. Collared Palm Thrush has also been recorded in the stands of Lala Palms.

Nocturnal species in the area include:

Barn owl	African owl	White-faced owl
Scops owl	Verreaux's (Giant) Eagle owl	Pearl-spotted owl

Human interventions in habitats have created different habitat types with different species, for instance:

Kori Bustard	Wattled Starling (nomadic)	Ground Hornbill
Temminck's Courser	Crimson-breasted Shrike	Red-billed Buffalo Weaver
Swallows species	Chestnut-backed Sparrowlark (nomadic)	

Other special species that could occur in the area include:

Great White Pelican	White-backed Night Heron	Bat Hawk
Augur Buzzard	African Hobby	Dickinson's Kestrel
Green Sandpiper	Three-banded Courser	Blue-spotted Wood Dove
Grey-headed Parrot	Senegal Coucal	Pennantwinged Nightjar
Bluecheeked Bee-eater	Broad-billed Roller	Racket-tailed Roller
African Golden Oriole	Olive-tree Warbler	

In order to keep long-term data on avi-faunal trends on the river, the Soutpansberg-Limpopo Birding Route conduct Limpopo River Bird Counts annually or biannually. A part of this count is conducted in Mapungubwe National Park. The census is conducted following the guidelines of the Avian Demographic Unit's (ADU)

'Coordinated Waterbird Counts' (CWAC). The CWAC (Coordinated Waterbird Counts) count of January 2007 had a total of 229 birds from 20 species whilst the BIRP (Birds in Reserves) count had a total of 124 species. The same census was also conducted in December 2004. The CWAC count had a total of 420 birds from 28 species whilst the BIRP count had a total of 180 species. These lists could however not be obtained.

A species list of birds known to occur on the neighbouring Ludwigslust Game Farms is provided in table 11 (Van der Walt, 2008). According to this list, 144 species occur on these farms, of which the ostrich is not represented in the study area. Ludwigslust Game Farm does not border the Limpopo River and there would be species associated with the riparian and floodplain habitats that would not be represented on this list.

Table 11. Bird checklist for Ludwigslust Game Farms.

Roberts No.	Afrikaanse name	English names
8	Klein dobbertjie	Dabchick
58	Rietduiker	Reed Cormorant
62	Bloureier	Grey Heron
68	Geelbekwitreier	Yellowbilled Egret
71	Bosluisvoël	Cattle Egret
81	Hamerkop	Hamerkop
83	Wit ooievaar	White Stork
88	Saalbekooievaar	Saddlebilled Stork
94	Hadeda	Hadeda Ibis
99	Nonnetjie-eend	Whitefaced Duck
102	Kolgans	Egyptian Goose
115	Knobbeleend	Knobbilled Duck
116	Wilde Makou	Spurwinged Goose
122	Kransaasvoël	Cape Vulture
123	Witruugaasvoël	Whitebacked Vulture
124	Swartaasvoël	Lappetfaced Vulture
126	Geelbekwou	Yellowbilled Kite
127	Blouvalk	Blackshouldered Kite
131	Witkruisarend	Black Eagle
132	Roofarend	Tawny Eagle
135	Bruinarend	Wahlberg's Eagle
137	Grootjagarend (Afrikaanse)	African Hawk Eagle
140	Breëkoparend	Martial Eagle
143	Swartborsslangarend	Blackbreasted Snake Eagle
149	Bruinjakalsvoël	Steppe Buzzard
154	Akkedisvalk	Lizard Buzzard
161	Kleinsingvalk	Gabar Goshawk
163	Donkersingvalk	Dark Chanting Goshawk
169	Kaalwangvalk	Gymnogone
189	Bospatrys	Crested Francolin
196	Natalse Fisant	Natal Francolin
200	Afrikaanse kwartel	Common Quail
203	Gewone tarentaal	Helmeted Guineafowl
230	Gompou	Kori Bustard
237	Boskorhaan	Redchrested Korhaan
249	Driebandstrandkiewiet	Threebanded Plover
255	Kroonkiewiet	Crowned Plover
256	Kleinswartvlerkkiewiet	Lesser Blackwinged Plover
258	Bontkiewiet	Blacksmith Plover
266	Bosruiter	Wood Sandpiper
297	Dikkop	Spotted Dikkop
300	Trekdrawwertjie	Temminck's Courser
303	Bronsvlerkdrawwertjie	Bronzewinged Courser
347	Dubbelbandsandpatrys	Doublebanded Sandgrouse
349	Kransduif	Rock Pigeon
354	Gewone tortelduif	Cape Turtle Dove
355	Rooiborsduifie	Laughing Dove
356	Namakwaduijie	Namakwa Dove
358	Groenvlerkduifie	Emeraldspotted Dove
361	Papegaaiduif	Green Pigeon
364	Bosveldpapegaai	Meyer's Parrot
373	Kwêvoel	Grey Lourie
377	Piet-my-vrou	Redcrested Cuckoo
378	Swart koekoek	Black Cuckoo

382	Bontnuwejaarsvoël	Jacobin Cuckoo
385	Meitjie	Klaas's Cuckoo
391	Gewone vleioerie	Burchell's Coucal
392	Nonnetjies-uil	Barn Owl
398	Witkoluil	Pearlspotted Owl
405	Afrikaanse naguil	Fierynecked Nightjar
426	Rooiwangmuisvoël	Redfaced Mousebird
433	Bosveldvisvanger	Woodland Kingfisher
435	Bruinkopvisvanger	Brownhooded Kingfisher
438	Europese byvreter	European Bee-eater
441	Rooiborsbyvreter	Carmine Bee-eater
444	Kleinbyvreter	Little Bee-eater
446	Europese trou pant	European Roller
447	Gewone trou pant	Lilacbreasted Roller
449	Groottrou pant	Purple Roller
451	Hoep hoe	Hoophoe
452	Gewone kakelaar	Redbilled Woodhoopoe
454	Swartbekkakelaar	Scimitar billed Woodhoopoe
457	Grysneshoringvoël	Grey Hornbill
458	Rooibekneshoringvoël	Redbilled Hornbill
459	Geelbekneshoringvoël	Yellowbilled Hornbill
463	Bromvoël	Ground Hornbill
464	Rooikophoutkapper	Blackcollered Barbet
465	Bonthoutkapper	Pied Barbet
473	Kuifkophoutkapper	Crested Barbet
474	Grootheuningwyser	Greater Honeyguide
483	Goudstertspeg	Goldentailed Woodpecker
498	Sabotalewerik	Sabota Lark
518	Europese swael	European swallow
527	Kleinstreepswael	Lesser Striped Swallow
541	Mikstertbyevanger	Forktailed Drongo
543	Europese wielewaal	European Golden Oriole
545	Swartkop wielewaal	Blackheaded Oriole
548	Witborskraai	Pied Crow
554	Gewone swartmees	Southern Black Tit
560	Pylvlekkatlagter	Arrowmarked Babbler
568	Swartoogtiptol	Black-eyed Bulbul
576	Rooibeklyster	Kurrichane Thrush
580	Gevlekte lyster	Groundscraper Thrush
587	Hoëveldskaapwagter	Capped Wheateater
589	Gewone Spekvreter	Familiar Chat
593	Dassievoël	Mocking Chat
599	Heuglinse Janfrederik	Heuhlin's Robin
613	Gestreepte Wipstert	Whitebrowed Robin
621	Bosveldtjeriktik	Titbabbler
651	Bosveld stompstert	Longbilled Crombec
683	Bruinsylangstertjie	Tawnyflanked Prinia
694	Swartvlieëvanger	Southern Black Flycatcher
695	Maricovlieëvanger	Marico Flycatcher
701	Witliesbosbontrokkie	Chin spot Batis
710	Paradysvlieëvanger	Paradise Flycatcher
731	Gryslaksman	Lesser Grey Shrike
733	Rooiruglaksman	Redbacked Shrike
735	Langstertlaksman	Longtailed Shrike
739	Rooiborslaksman	Crimsonbreasted Shrike
740	Sneeubal	Puffback
751	Spookvoël	Greyheaded Bush Shrike
753	Withelmlaksman	White Helmetshrike
756	Kremetartlaksman	Whitecrowned Shrike
760	Lelspreeu	Wattled Starling
761	Witborsspreeu	Plumcoloured Starling
763	Langstertglansspreeu	Longtailed Starling
764	Kleinglansspreeu	Cape Glossy Starling
766	Klein-blouoorglansspreeu	Lesser Blue-eared Starling
769	Rooivlerkspreeu	Redwinged Starling
772	Rooibekrenostervoël	Redbilled Oxpecker
779	Maricosuikerbekkie	Marico Sunbird
787	Witpensuikerbekkie	Whitebellied Sunbird

798	Buffelwewer	Redbilled Buffalo Weaver
799	Koringvoël	Whitebrowed Sparrow-Weaver
803	Gewone mossie	Cape Sparrow
804	Gryskopmossie	Greyheaded Sparrow
806	Baardmannetjie	Scalyfeathered Finch
814	Swartkeelgeelvink	Masked Weaver
819	Rooikopwewer	Redheaded Weaver
821	Rooibekkwelea	Redbilled Quelea
834	Gewone melba	Melba Finch
842	Rooibekrobbin	Redbilled Firefinch
844	Gewone blousysie	Blue Waxbill
845	Koningblousysie	Violeteared Waxbill
847	Swartwangsysie	Blackcheeked Waxbill
855	Bandkeelvink	Cutthroat Finch
860	Koningrooibekkie	Pintailed Whydah
861	Pylstertrooibekkie	Shafttailed Whydah
862	Gewone paradysvink	Paradise Whydah
869	Geeloogkanarie	Yelloweyed Canary
884	Rooirugstreepkoppie	Goldenbreasted Bunting
886	Klipstreepkoppie	Rock Bunting

De Beer (2006) pointed out that the destruction of the riparian and flood plain vegetation, either by elephants and/or water abstraction (currently due to agricultural developments), will probably have a negative affect on habitat suitability of the region for many bird species. Species specifically mentioned by De Beer (2006) are:

Vulnerable species: habitat loss of nesting sites

Southern ground hornbill	Hooded vulture	African white backed vulture
Lappet faced vulture	White-headed vulture	Tawny eagle
Martial eagle	Southern banded snake eagle	Bateleur
Pel's fishing owl		

Near threatened species:

Secretary bird	Bat hawk	Ayre's Eagle
Crowned eagle		

5.7.4 Pisces

Fish distribution records for Limpopo Province are stored in the Limpopo Environmental Affairs Fish Distribution Data Base in Polokwane where records date back to the mid 1960's. Physical reference specimens are stored at the Southern African Institute of Aquatic Biodiversity (SAIAB) in Grahamstown. Since 1998, there have been extensive fish surveys in all perennial rivers of the province as part of the ongoing River Health Programme (RHP) initiative, coordinated by Limpopo Department of Economic Development Environment and Tourism (LEDET).

Angliss et. al. (2008) provides a list of fish species that are expected in the Limpopo River and its tributaries (eco-region 1.01) and in the vicinity of Schroda Dam, approximately 15 kilometres west of the study area (table 12).

Table 12. Scientific and English common names of indigenous and exotic (EX) fish species expected in the Limpopo River and tributaries of eco-region 1.01.

SPECIES	ENGLISH COMMON NAME
<i>Anguilla bengalensis labiata</i>	African mottled eel
<i>Anguilla marmorata</i>	Madagascar mottled eel
<i>Anguilla mossambica</i>	Longfin eel
<i>Barbus afrohamiltoni</i>	Hamilton's barb
<i>Barbus annectens</i>	Broadstriped barb
<i>Barbus mattozi</i>	Papermouth
<i>Barbus paludinosus</i>	Straightfin barb
<i>Barbus radiatus</i>	Beira barb
<i>Barbus toppini</i>	East coast barb
<i>Barbus trimaculatus</i>	Threespot barb
<i>Barbus unitaeniatus</i>	Longbeard barb
<i>Barbus viviparus</i>	Bowstripe barb
<i>Brycinus imberi</i>	Imberi

<i>Clarias gariepinus</i>	Sharptooth catfish
<i>Hydrocynus vittatus</i>	Tigerfish
<i>Labeo congoro</i>	Purple labeo
<i>Labeo cylindricus</i>	Redeye labeo
<i>Labeo molybdinus</i>	Leaden labeo
<i>Labeo rosae</i>	Rednose labeo
<i>Labeo ruddi</i>	Silver labeo
<i>Labeobarbus marequensis</i>	Largescale yellowfish
<i>Mesobola brevianalis</i>	River sardine
<i>Micralestes acutidens</i>	Silver robber
<i>Oreochromis macrochir (EX)</i>	Greenhead tilapia
<i>Oreochromis mossambicus</i>	Mozambique tilapia
<i>Oreochromis niloticus (EX)</i>	Nile tilapia
<i>Pseudocrenilabrus philander</i>	Southern mouthbrooder
<i>Schilbe intermedius</i>	Silver catfish
<i>Synodontis zambezensis</i>	Brown squeaker
<i>Tilapia rendalli</i>	Redbreast tilapia
<i>Tilapia sparmanii</i>	Banded tilapia

5.7.5 Invertebrates

No specific surveys were conducted to identify invertebrate species. Butterfly and dragonfly checklists were obtained from the Ludwigslust Game Farms and are provided in tables 13 and 14 respectively (Van der Walt, 2008).

A number of macroinvertebrate families are expected to utilise the habitat within the Limpopo River and associated streams in the study area and are provided in table 15 (Gerber, 2002; Thirion, 2007).

Table 13: Butterfly checklist of Ludwigslust Game Farms.

LUDWIGSLUST WILDPLAAS /GAME FARM
SKOENLAPPERLYS
BUTTERFLY CHECKLIST

(Die opname is deurlopend , dus sal die lys voortdurend aangevul word. Die Pennington's nommer (Tweede uitgawe , 1994) wetenskaplike naam sowel as Afrikaanse- en Engelse name word aangegee.)

(This list will be updated continuously. The Pennington's number (Second Edition , 1994) Scientific name as well as the Afrikaans and English names are indicated.)

1a	<i>Danaus chrysippus aegyptius</i>	Melkbosskoenlapper	African monarch
110	<i>Acraea eponina manjaca</i>	Klein oranjerootjie	Small orange acraea or dancing acraea
117	<i>Acraea natalica</i>	Natalse rootjie	Natal acraea
140a	<i>Charaxes varanes varanes</i>	Pêreldubbelstert	Pearl Charaxes
146a	<i>Charaxes jasius saturnus</i>	Koppiedubbelstert	Koppie Charaxes
168	<i>Charaxes phaeus</i>		Dusky Charaxes
213	<i>Byblia ilithyia</i>		Spotted Joker
219	<i>Hypolimnas misippus</i>	Blouglans	Common Diadem
235a	<i>Precis Junonia hierta cebrene</i>	Geelgesiggie	Yellow Pansy
236a	<i>P. Junonia ocnone ocnone</i>	Blougesiggie	Blue Pansy
240	<i>Vanessa cynthia cardui</i>	Sondagsrokkie	Painted Lady
314	<i>Iolaus bowkeri</i>	Bowker - stertbloutjie	Bowker's tailed blue
547	<i>Leptotes pirithous</i>	Gewone bloutjie	Common Blue
610	<i>Lepidochrysops glauca</i>		Silvery Blue
657a	<i>Pinacopteryx eriphia eriphia</i>	Kwagga	Zebra White
659	<i>Catopsilia florella</i>	Afrikaanse swerwer	African Migrant
661a	<i>Eurema brigitta brigitta</i>	Grasveldgeletjie	Broad-bordered grass yellow
672	<i>Colotis vesta</i>	Bontpuntjie	Veined Tip
676	<i>Colotis regina</i>	Koninginperspuntjie	Queen purple-tip
682a	<i>Colotis evippe omphale</i>		Smoky Orange Tip
685	<i>Colotis agoye</i>		Speckled Sulphur Tip
687	<i>Colotis eris'eris</i>	Goudpuntjie	Banded Gold Tip
691	<i>Belenois aurota</i>	Grasveldwitjie	Brown-veined White
707	<i>Mylothris agathina</i>		Common Dotted Border
715a	<i>Papilio demodocus</i>	Lemoenskoenlapper	Citrus Swallowtail
718	<i>Papilio Graphium (A) angolanus</i>		Angola White Lady
722	<i>Graphium antheus</i>		Large Striped Swordtail

Diptera	Athericidae	Snipe flies
	Ceratopogonidae	Biting midges
	Chironomidae	Midges
	Culicidae	Midges
	Dixidae	Dixid midges
	Ephydriidae	Shore flies
	Muscidae	House flies, Stable flies
	Psychodidae	Moth flies
	Simuliidae	Black flies
	Syrphidae	Rat tailed maggots
	Tabanidae	Horse flies
	Tipulidae	Crane flies

5.8 Wetlands

The word “wetland” is a family name given to a variety of ecosystems, ranging from rivers, springs, seeps and mires in the upper catchment, to midlands marshes, pans and floodplains, to coastal lakes, mangrove swamps and estuaries at the bottom of the catchment. These ecosystems all share a common primary driving force, namely water. Its prolonged presence in wetlands is a fundamental determinant of soil characteristics and plant and animal species composition. Any part of the landscape where water accumulates for long enough and often enough to influence the plants, animals and soils occurring in that area, is thus a wetland (DWAF 2005).

The National Water Act (Act No 36 of 1998) defines wetlands as those ecosystems where: “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.”

Wetlands must have one or more of the following attributes (DWAF 2005):

- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation.
- The presence, at least occasionally, of water loving plants (hydrophytes).
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50 cm of the soil.

Indicators that are used to identify the temporary zone of wetlands, and thus a wetland, are (DWAF 2005):

- The Terrain Unit Indicator: helps to identify those parts of the landscape where wetlands are more likely to occur.
- The Soil Form Indicator: identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator: identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator: identifies hydrophilic vegetation associated with frequently saturated soils.

According to the wetland definition used in the National Water Act (Act No 36 of 1998), vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps for several centuries). Despite hydrology not being one of the four indicators listed above, an understanding of the broad hydrological processes that drive the frequency of saturation substantially facilitates the delineation procedure (DWAF 2005).

Within the “wetland biome” various, but also extremely diverse biotopes, that directly relate to their biota can be identified. Six major wetland categories (Marine, Estuarine, Riverine, Lacustrine, Palustrine and Endorheic) are recognized in South Africa and each of these, with the exception of endorheic wetlands, are subdivided into subclasses based on the physiography with a further subdivision broadly based on the water level, associated hydrophytes and aquatic vegetation (Fouche 2005). Wetlands known to occur in the study area is presented in table 16.

Table 16: Examples of the wetland types in the study area and region (Fouche 2005).

Wetland type	Examples	Examples in the greater region	Study area
1. Endorheic	Flats, pans and marshes	Soutpan, farm Zoutpan Leeupan (Mapungubwe National Park)	- Small seasonal pans in the natural areas of the Limpopo floodplains - Small seasonal pans in the sandveld and mopane veld
2. Riverine	Perennial rivers	Limpopo Luvuvhu	Limpopo River
	Seasonal rivers	Sand River	- Limpopo River - Drainage line woodland - Drainage line mopane woodland
3. Palustrine	Springs and oases	Farm Scot Madimuhulu, farm Septimus Farm Potgietersrust Sand River Farm Robertson Hotsprings Evangelina Farm Sulphur Springs Tshipise Aventura Mphephu Aventura Resort	- 2 springs on the farm Bergen op Zoom - 2 springs on the farm Over Vlakte (portions 3)

5.8.1 Riparian (Riverine) wetlands

The National Water Act defines a riparian habitat as follows: "Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas" (DWA 2005).

Riparian habitats, also known as riparian areas, include plant communities adjacent to and affected by surface and subsurface hydrologic features, such as rivers, streams, lakes, or drainage ways. These areas may be a few metres wide near streams or more than a kilometre in floodplains. Both perennial and non-perennial streams support riparian vegetation. Because riparian areas represent the interface between aquatic and upland ecosystems, the vegetation in the riparian area may have characteristics of both aquatic and upland habitats. Many of the plants in the riparian area require plenty of water and are adapted to shallow water table conditions. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth rate is high and the vegetation under the trees is usually lush and includes a wide variety of shrubs, grasses, and wildflowers (DWA 2005).

Riparian areas (DWA 2005):

- are associated with a watercourse;
- contain distinctively different plant species than adjacent areas; and contain species similar to adjacent areas but exhibiting more vigorous or robust growth forms; and
- may have alluvial soils.

Most of the drainage lines in the study area, except the smaller drainage lines, can thus be classified as riparian areas and are regarded as sensitive ecosystems.

The riparian zone is the area of land adjacent to a stream or river that is, at least periodically, influenced by fluctuations of water level. The geomorphology of the river valley, the nature of the valley substratum and the hydrological regime of the river primarily define this zone, but it is manifest in a distinct longitudinal zone of vegetation, which forms the riparian wetland (Rogers 1995). The riparian wetlands in the study area can be classified into the category riparian fringes and the wetland type is described as floodplain vlei (Rogers 1995).

Three major features separate riparian ecosystems from other wetland ecosystem types (Rogers 1995).

- They have a linear form because of their proximity to rivers and they form a boundary between terrestrial and aquatic ecosystems.
In many areas along the Limpopo River, this boundary has been depleted or even totally destroyed.
- Energy and materials from the surrounding landscape converge and pass through riparian ecosystems in greater amounts per unit area than with any other ecosystem.
- They are connected hydrologically to both upstream and downstream ecosystems, at least intermittently.

Riparian wetlands are important because their position in the landscape ensures that they play direct roles in the functioning of both the river system and the terrestrial system and are one of the major centres of biodiversity in the global context. Their narrow spatial dimensions and open endedness make them highly sensitive to landscape changes, with major consequences for the river ecosystem which they buffer from terrestrial influences (Rogers 1995).

The primary determinant of the distribution and abundance of riparian biota is the hydrological regime, which is defined by the depth, seasonal timing, frequency and duration of flooding (Rogers 1995). Floodplain vleis experience short duration, shallow flooding at an annual or longer term frequency. The volume and time distribution of run-off from the catchment are the prime determinants of the hydrological regime of a river system. The geomorphological form of the channel and riparian zone create the site specific conditions of depth, duration, frequency and even timing of both surface and ground water fluctuations. The geomorphology is a function of the run-off characteristics, the volume, timing and character of sediment delivered to the river and of the geological character and history of the landscape (Rogers 1995). These interactions form a distinctive set of hydro-geomorphic processes which give rise to many different features of the riverine landscape such as oxbows, islands and terraces. Since these features will differ in terms of both substratum characteristics and hydrologic (surface & subsurface) conditions, they present a range of opportunities to riparian biota and each is characterised by a particular community of plants and animals.

Spatial vegetation of a river system is correlated to three (3) hydrogeomorphic gradients, namely lateral, vertical and longitudinal gradients. There may be distinct changes in frequency, duration and depth of flooding along these gradients. Hydrological differences lead to vegetation changes with distance from the river channel, elevation above the minimum thalweg (lowest point on the cross-sectional profile) and with distance downstream. The degree of vegetation changes is dependent on the particular hydro-geomorphic characteristics of the riparian system. The more arid the system and the longer the ratio of riparian area to catchment, the steeper will be the hydrological gradients and so vegetation changes along them (Rogers 1995). The vertical gradient of elevation change above the thalweg is the most important as it clearly reflects the decrease in frequency, duration and depth of flooding experienced on any one riparian cross-section (Rogers 1995). The impact of changes in the hydrology (water abstraction) of the Limpopo River riparian wetland is discussed under section 5.10.1.

Rogers (1995) identified four main factors that affect natural changes in these wetlands over time.

- Flood related disturbances.
High velocity floods mobilise areas of sedimentation and remove riparian vegetation. New sites for colonization are created and a process of succession is initiated. The extensive floods of 2000 and impacts described by De Beer (2006) are good examples of such an event.
- Fire.
Vegetation composition changes in response to the frequency, intensity and seasonal timing of fire, which has different effects on plant growth and seed banks.
- Animal disturbances.
Riparian wetlands have a high productivity and nutrient status and are thus favoured sites for grazing and browsing animals, especially during the dry season. Differential grazing and browsing, and destructive feeding activities by elephants such as elephants and warthog can result in vegetation changes over time. De Beer (2006) also illustrated the impact of this effect on the Limpopo riparian vegetation.
- Plant growth characteristics.
In lowland areas where flood disturbances are very low, competition between plant species becomes an important process structuring plant communities. This succession is almost entirely driven by the manner in which plant growth modifies the soil conditions and taller species that outcompete others for light. De Beer (2006) illustrated the effects of opening of the Limpopo Riverine forest canopy with an increase in the creeper component, such as *Combretum microphyllum*.

5.8.2 Landscape functions and values of riparian wetlands

Riparian wetlands represent boundaries between terrestrial and aquatic systems. In terms of system dynamics, boundaries are locations where the rates or magnitudes of ecological transfers (energy flow, nutrient exchange etc.) change abruptly in relation to those within the adjacent homogeneous systems they separate (e.g. land and water). Riparian wetlands are thus also considered to be ecotones.

The roles and functions of riparian wetlands are summarised as follows (Rogers 1995):

- a. Flow based functions.
 - i. The physical resistance of topography and vegetational characteristics reduce flow velocity thus spreading flow laterally and increasing water retention times in any one area.

- ii. Reduced flows and the binding action of plant roots on the soil markedly reduce erosion of riverbeds and banks.
 - iii. The direction of both surface and groundwater movement between the river and surrounding landscape can be markedly altered by both evapotranspiration and the physical resistance to flow offered by the high plant biomass.
- b. Physico – chemical functions
- iv. Riparian wetlands act as natural filters of diffuse nutrient and pollution transfers between the terrestrial system and river *via* both surface run-off and subsurface flow.
 - v. The change in flow characteristics caused by riparian wetlands result in increased deposition of both organic and inorganic suspended materials within that wetland.
- c. Biological functions
- vi. Many aquatic, aerial and terrestrial species utilise these wetlands during crucial parts of their life cycles. Others are confined solely to these systems. Therefore are these systems centres of very high biodiversity.
 - vii. Riparian wetlands are also an important modifier of the adjacent aquatic ecosystem in that it regulates nutrient movement from terrestrial systems (e.g. agricultural run-off), organic matter inputs (e.g. litter fall) and specific habitat conditions (e.g. cover from predators, perches for predators, reduced light and temperature from shading).
 - viii. The river corridor as a whole acts as an important migratory route for many species and forms an important biophysical link between wetlands of catchments. The state of the riparian zone is very important in this instance.
- d. Human use functions
- ix. The high biodiversity and productivity of these systems provide many food sources and other resources (wood, building materials, livestock / wildlife grazing).
 - x. These systems provide prime recreation sites of high commercial value.
 - xi. They provide an aesthetic quality to the overall landscape that contributes greatly to tourist appeal and quality of life.

The riparian wetlands in the study area are regarded as the most sensitive areas and have a unique species composition and ecosystem functioning as described above. These systems provide habitat for several amphibious, invertebrate, flora and other fauna species. The two (2) permanent springs on Bergen op Zoom also provide a critical source of drinking water for all fauna species during the dry winter months when water availability is problematic. Together with the pans, these water bodies fulfil a critical role in thermoregulation of fauna species during the hot summer months.

The functioning of these systems is closely related to the hydrology and geology of the area and their functioning might be impacted on by the proposed mine.

5.9 Threatened or protected species

During the specialist investigations, the occurrence and possible occurrence of the following listed fauna and flora species, according to different legislation, in the study area and surrounding region were identified through observations, literature reviews, information supplied by Me. Retha van der Walt and other relevant sources such as the Limpopo Environmental Management Act, (Act no. 7 of 2003), The Red Data lists of southern African plants compiled by Hilton-Taylor (1996a, 1996b, 1997) and the Southern African Plant Red Data list of Golding (2002). (Table 17).

Table 17: Fauna and flora species listed under several different Acts and regulations known to occur in the study area and immediate vicinity of the study area (SA - study area : R - region).

ACT	STATUS	SCIENTIFIC NAME	ENGLISH NAME
National Forest Act, 1998 (Act No. 84 of 1998) Government Gazette No. 29062, Notice 897, 8 September 2006	Protected Trees	<i>Adansonia digitata</i> <i>Balanites maughamii</i> <i>Boscia albitrunca</i> <i>Combretum imberbe</i> <i>Philenoptera violacea</i> <i>Sclerocarya birrea</i> subsp. <i>Caffra</i>	Baobab (Sa) Torchwood (R) Shepherd's tree (Sa) Leadwood (Sa) Apple-leaf (Sa) Marula (Sa)
Threatened or Protected Species Regulations, 2007. (TOPS) Government Gazette No. 29657, Government Notice No. R159 of 2007	Endangered Species	<i>Ehippiorhynchus senegalensis</i> <i>Gyps africanus</i> <i>Gyps coprotheres</i> <i>Scotopelia peli</i> <i>Torgos tracheliotus</i> <i>Lycaon pictus</i>	Saddlebilled stork (Sa) White-backed Vulture (Sa) Cape Vulture (Sa) Pel's Fishing Owl (R) Lappet-faced Vulture (Sa) African Wild Dog (R)

No. R152 of 23 February 2007.	Vulnerable Species	<i>Trionoceph occipitalis</i> <i>Aquila rapax</i> <i>Ardeotis kori</i> <i>Ciconia nigra</i> <i>Falco naumanni</i> <i>Falco peregrinus</i> <i>Polemaetus bellicosus</i> <i>Terathopius ecaudatus</i> <i>Acinonyx jubatus</i> <i>Manis temminckii</i> <i>Panthera leo</i> <i>Panthera pardus</i>	White-headed Vulture (R) Tawny Eagle (Sa) Kori Bustard (Sa) Black Stork (R) Lesser Kestrel (R) Peregrine Falcon (R) Martial Eagle (Sa) Bateleur (Sa) Cheetah (R) Pangolin (R) Lion (Sa) -occasionally Leopard (Sa)
	Protected Species	<i>Hydrocynus vittatus</i> <i>Pyxicephalus edulis</i> <i>Crocodylus niloticus</i> <i>Python natalensis</i> <i>Bucorvus leadbeateri</i> <i>Atelerix frontalis</i> <i>Parahyaena brunnea</i> <i>Leptailurus serval</i> <i>Loxodonta Africana</i> <i>Mellivora capensis</i> <i>Raphicerus sharpie</i> <i>Harpagophytum procumbens</i> <i>Hoodia currorii</i>	Tigerfish (R) African Bullfrog (Sa) Nile crocodile (R) African Rock Python (Sa) Southern Ground-Hornbill (Sa) South African Hedgehog (R) Brown Hyaena (Sa) Serval (R) African elephant (R) Honey Badger (R) Sharpe's Grysbok (R) Devil's Claw (Sa) Ghaap (Sa)
Limpopo Environmental Management Act, 2003.	Schedule 2: Specially Protected Wild Animals	<i>Loxodonta africana</i> <i>Orycteropus afer</i> <i>Manis temminckii</i> <i>Raphicerus sharpie</i> <i>Lycaon pictus</i> <i>Macheirhamphus alcinus</i> <i>Terathopius ecaudatus</i> <i>Ardeotis kori</i> <i>Gyps coprotheres</i> <i>Crex crex</i> <i>Aquila rapax</i> <i>Falco peregrinus</i> <i>Bucorvus leadbeateri</i> <i>Falco naumanni</i> <i>Lamprotornis mevesii</i> <i>Polemaetus bellicosus</i> <i>Scotopelia peli</i> <i>Ephippiorhynchus senegalensis</i> <i>Gyps africanus</i> <i>Torgos tracheliotus</i> <i>Trionoceph occipitalis</i> <i>Crocodylus niloticus</i>	African elephant (R) Ant bear (R) Pangolin (R) Sharpe's grysbok (R) Wild dog (R) Bat hawk (R) Bateleur (Sa) Bustard, Kori (Sa) Cape vulture (Sa) Corncrake (R) Eagle- Tawny (Sa) Falcon, Peregrine (R) Ground hornbill (Sa) Lesser Kestrel (R) Long-tailed Starling (Sa) Martial eagle (Sa) Pel's fishing owl (R) Saddlebilled stork (Sa) White-backed Vulture (Sa) Lappet-faced Vulture (Sa) White-headed Vulture (R) Nile crocodile (R)
	Schedule 3: Protected Wild Animals	<i>Proteles cristatus</i> <i>Civettictis civetta</i> <i>Galago senegalensis</i> <i>Acinonyx jubatus</i> <i>Giraffa camelopardalis</i> <i>Atelerix frontalis</i> <i>Hippopotamus amphibius</i> <i>Mellivora capensis</i> <i>Parahyaena brunnea</i> <i>Crocota crocuta</i> <i>Pronolagus randensis</i> <i>Oreotragus oreotragus</i> <i>Panthera pardus</i> <i>Paracynictis selousi selousi</i> <i>Laptailurus serval</i> <i>Raphicerus campestris</i> <i>Heterohyrax brucei</i> <i>Pyxicephalus adspersus</i> <i>Python sebae</i> All species of the Class Reptilia; excluding <i>Varanus niloticus</i> , <i>Varanus albigularis</i> and all species of the Sub Order Serpentes, except <i>Python sebae</i> , <i>Mehelya capensis</i>	Aardwolf (R) African civet (Sa) Bushbaby, Lesser (R) Cheetah (R) Giraffe (Sa) Hedgehog (R) Hippopotamus (R) Honey badger (R) Hyaena, brown (Sa) Hyaena, spotted (R) Jameson's red rock rabbit (R) Klipspringer (Sa) Leopard (Sa) Mongoose, Selous (R) Serval (R) Steenbok (Sa) Yellow-spotted rock dassie (R) Bullfrog (Sa) Python (Sa) All other species of reptiles excluding water monitor, rock monitor, and all indigenous snakes not listed in this Schedule

	and <i>Mehelya nyassae</i>	
Schedule 12. Protected plants	<i>Adansonia digitata</i> <i>Adenium multiflorum</i> <i>Aloe littoralis</i> <i>Hoodia corrorii</i> subsp. <i>lugardii</i> <i>Stapelia spp (all species)</i> <i>Tavaresia spp (all species)</i> <i>Huernia spp (all species)</i> <i>Orbea spp (all species)</i> <i>Peristrophe cliffordii</i> <i>Peristrophe gillilandiorum</i>	Baobab (Sa) Impala lily (Sa) <i>Aloe littoralis</i> (Sa) Ghaap (Sa) <i>Stapelia spp</i> (Sa) Ghaap (R) – adjacent farms Huernia (R) – adjacent farms Orbea (R) – adjacent farms Peristrophe (Sa) Peristrophe (Sa)

Information obtained from Limpopo Valley Herb Project (Van der Walt, 2008) indicated that the following red data flora species (table 18) occur in the study area and adjacent farms.

Table 18: Southern African Plant Red Data list species.

		STATUS	2229BA (study area)	2229AB / BB / BC (adjacent farms)
Flora: Red data listed species	Herbs	<i>Barleria holubii</i>	LC	X
		<i>Hibiscus waterbergensis</i>	LC	X
		<i>Orbea maculate ssp. maculata</i>	LC	X
		<i>Otholobium polyphyllum</i>	Rare	X
		<i>Peristrophe cliffordii</i>	Rare	X
		<i>Peristrophe gillilandiorum</i>	Rare	X
		<i>Plinthus rehmannii</i>	EN	X
		<i>Psoralea repens</i>	LC	X
	Shrubs	<i>Ochna gluca</i>	LC	X
Endemic species	Herbs	<i>Cyamopsis dentata</i>		X
		<i>Sesbania leptocarpa var. leptocarpa</i>		X
		<i>Peristrophe cliffordii</i>		X
		<i>Peristrophe gillilandiorum</i>		X
	Grass	<i>Aristida scabivalvis ssp. contracta</i>		X
EN = Endangered : VU = Vulnerable : NT = Near Threatened : LC = Least Concern : DD = Data deficient NE = Not Evaluated : STBA = Still to be Assessed				

Table 19 provides a summary of the number of species that is protected according to different legislation, categories and the IUCN red data list. More than 100 (including reptiles) species that occur in the study area are protected in legislation or are listed as red data species. Some species are however listed more than once (tables 17 & 18) within the various legislation. This implies that different processes and / or permits might be necessary to fulfil all legal requirements.

Table 19: Summary of the number of species that is protected according to different legislation, categories and the IUCN red data list.

ACT	STATUS	TAXON	SPECIES IN STUDY AREA	SPECIES IN REGION / ADJACENT AREAS
National Forest Act, 1998	Protected Species	Flora	5	1
Threatened or Protected Species Regulations, 2007 (TOPS)	Endangered Species	Avis	4	1
		Mammalia		1
	Vulnerable Species	Avis	4	4
		Mammalia	2	2
	Protected Species	<i>Amphibia</i>	1	
		<i>Pisces</i>		1
		Reptilia	1	1
		Avis	1	
Mammalia		1	5	
		Flora	2	
Limpopo Environmental Management Bill, 2003.	Schedule 2: Specially Protected Wild Animals	Reptilia		1
		Avis	10	6
		Mammalia		5
	Schedule 3: Protected Wild Animals	<i>Amphibia</i>	1	

		Reptilia	All other species of reptiles excluding; water monitor, rock monitor, and all indigenous snakes not listed in this Schedule	1 All other species of reptiles excluding; water monitor, rock monitor, and all indigenous snakes not listed in this Schedule
		Mammalia	6	11
	Schedule 12. Protected plants	Flora	7	3
Red Data		Flora	2	7
TOTAL			> 47	> 50

Table 20 provides a summary of all listed protected species. A high diversity of protected species (68), occur in and adjacent to the study area. Thirty-two (32) of these species are known and have been confirmed to occur in the study area. Only one (1) bullfrog species (*Pyxicephalus edulis*) has been confirmed to occur in the study area. The absence of *Pyxicephalus adspersus* has been confirmed and therefore has the amount of listed protected species been reduced from 33 to 32. Specimens of the two (2) *Peristrophe* species were initially collected on the farm Overvlakte. The occurrence of these species in the study area was however not confirmed during this study or through the Limpopo Valley Herb project. The reasons for this are the difficulty to identify this species and because detailed surveys for this species in the study area were not yet conducted through the Limpopo Valley herb project. These species do however occur on adjacent land and will most probably also occur in the study area.

Table 20: Protected species list.

TAXA	NAME	SPECIES IN STUDY AREA	SPECIES IN REGION/ADJACENT FARMS
Amphibia	African Bullfrog (Sa)	1	
Pisces	Tigerfish (R)		1
Reptilia	African Rock Python (Sa)	> 1	
	Nile crocodile (R)		>1
	All other species of reptiles excluding water monitor, rock monitor, and all indigenous snakes not listed in this Schedule		
Avis	Bateleur (Sa)	10	
	Cape vulture (Sa)		
	Kori Bustard (Sa)		
	Lappet-faced Vulture (Sa)		
	Long-tailed Starling (Sa)		
	Martial Eagle (Sa)		
	Saddlebilled stork (Sa)		
	Southern Ground-Hornbill (Sa)		
	Tawny Eagle (Sa)		
	White-backed Vulture (Sa)		
	Bat hawk (R)	7	
	Black Stork (R)		
	Corncrake (R)		
	Lesser Kestrel (R)		
	Pel's fishing owl (R)		
	Peregrine Falcon (R)		
	White-headed Vulture (R)		
Mammalia	African civet (Sa)	8	
	Brown Hyaena (Sa)		
	Giraffe (Sa)		
	Hyaena, brown (Sa)		
	Klipspringer (Sa)		
	Leopard (Sa)		
	Lion (Sa) -occasionally		
	Steenbok (Sa)		
	Aardwolf (R)	17	
	African elephant (R)		
	African Wild Dog (R)		
	Ant bear (R)		
	Bushbaby, Lesser (R)		
Cheetah (R)			
Hippopotamus (R)			

	Honey badger (R)				
	Hyaena, spotted (R)				
	Jameson's red rock rabbit (R)				
	Mongoose, Selous (R)				
	Pangolin (R)				
	Serval (R)				
	Sharpe's grysbok (R)				
	South African Hedgehog (R)				
	Wild dog (R)				
	Yellow-spotted rock dassie (R)				
Flora	<i>Aloe littoralis</i> (Sa)	12			
	Apple-leaf (Sa)				
	Baobab (Sa)				
	Devil's Claw (Sa)				
	<i>Hoodia corrorii</i> subsp. <i>Lugardii</i> (Sa)				
	Impala lily (Sa)				
	Leadwood (Sa)				
	Marula (Sa)				
	<i>Peristrophe cliffordii</i> (Sa)				
	<i>Peristrophe gillilandiorum</i> (Sa)				
	Shepherd's tree (Sa)				
	<i>Stapelia</i> spp (all species) (Sa)				
	<i>Barleria holubii</i> (R)				10
	<i>Hibiscus waterbergensis</i> (R)				
<i>Huernia</i> (R) – adjacent farms					
<i>Orbea</i> (R) – adjacent farms					
<i>Orbea maculate</i> ssp. <i>maculate</i> (R)					
<i>Otholobium polyphyllum</i> (R)					
<i>Plinthus rehmanni</i> (R)					
<i>Psoralea repens</i> (R)					
<i>Tavaresia</i> spp (all species) (R)					
Torchwood (R)					
TOTAL	32	36			

Thirty-six (36) protected species occur in the region / adjacent farms. Species associated with aquatic habitats do occur sporadically, depending on water levels and flooding, in the Limpopo River. Except for the Peregrine Falcon and Pel's fishing owl, the probability of occurrence of these listed bird species in the study area is high. The habitat of the study area is most probably not suitable for the Peregrine Falcon because of the degraded state of the riverine forest, while the habitat suitability for the Pel's fishing owl is also questionable, but this species might occur sporadically in the study area.

The habitat of the study area is suitable for all mammal species occurring in the region. However, species such as elephant, wild dog, cheetah and lion only occur sporadically. All these species have been sighted in this area in the past. For example, two free roaming lionesses occurred on Bergen op Zoom during October 2008 and two confirmed kills were recorded.

GPS coordinates were recoded for all protected baobab trees, *Hoodia corrorii* plants and *Aloe littoralis* populations that were encountered during the surveys and are presented in figure 9 and table 21.

A total of 116 larger baobab plants were recorded (table 21). This can however not be regarded as the total population estimate in the study area as smaller trees (<2m) have not been recorded. Baobabs occur throughout the study area on sandy soils and on shallow rocky soils. However, a higher density of plants occurs on the sandveld plato and western rocky slopes of portion 3 of the farm Overvlakte, the southern sandveld plato of portion 4 and 3 of the farm Overvlakte and northern sandveld plato of the farm Bergen op Zoom, and the open sandveld and mixed *C. mopane-Commiphora-T. prunioides* veld in the central areas of the farm Bergen op Zoom (figure 9). Portions 3 and 4 of the farm Overvlakte and the northern sandveld plato of the farm Bergen Op Zoom are earmarked as the proposed eastern pit opencast mine area. The central areas of the farm Bergen op Zoom are earmarked for the proposed plant infrastructure.

Figure 9: Locations of Baobab trees, *Hoodia corrorii* plants and *A. littoralis*

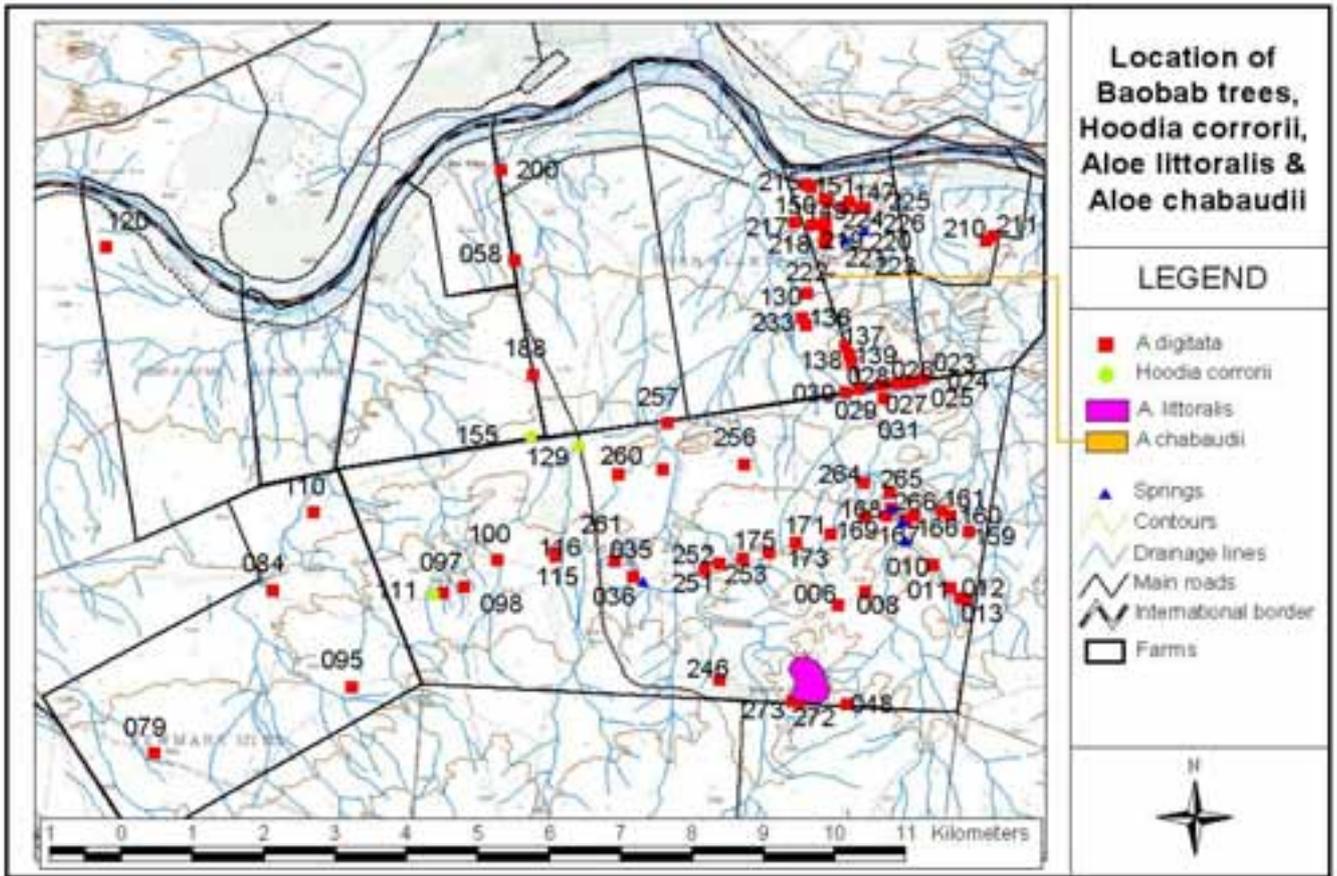


Table 21: GPS coordinates of baobab trees and *Hoodia corrorii* plants

Baobab:

ID	LAT	LONG	REMARKS		
188	-22.16529611	29.64003361			
200	-22.13918438	29.63588247			
210	-22.14818948	29.69706835			
211	-22.14757274	29.69798676			
215	-22.14109764	29.67435214			
217	-22.14589946	29.67292805			
218	-22.14624387	29.67513199	1 x L	3 x S	
219	-22.14613566	29.67573825			
220	-22.14585789	29.67677183			
221	-22.14708659	29.67691826			
222	-22.14829392	29.67679353			
223	-22.14846239	29.67669278			
224	-22.14407606	29.67922579	x 9		
225	-22.14404387	29.68123217	1 x L east	1 x L west	
226	-22.14398570	29.68184941			
233	-22.15801349	29.67384612			
246	-22.20406509	29.66340755			
251	-22.18999196	29.66163109			
252	-22.18930389	29.66339389			
253	-22.18870215	29.66641280			
256	-22.17664269	29.66657482	1 x L	1 x S west	1 x L 400m west
257	-22.17144834	29.65687931			
260	-22.17722372	29.65630431			
261	-22.17797373	29.65070696			
264	-22.17900882	29.68172721	x 2 south		
265	-22.18020122	29.68497880			
266	-22.18234339	29.68505323			
272	-22.20678686	29.67358293			
273	-22.20672676	29.67259982			
006	-22.19450519	29.67836003	200 m north		

008	-22.19281641	29.68188269			
010	-22.18947169	29.69041388			
011	-22.19242766	29.69253181			
012	-22.19358570	29.69380771			
013	-22.19386909	29.69453098			
023	-22.16574278	29.68911292	50 m south		
024	-22.16611586	29.68758599	50 m south	50 m north	
025	-22.16625156	29.68658058	x 2 S 50 m south		
026	-22.16630956	29.68619660	X 1 S 4 m south		
027	-22.16643093	29.68568288	x 3 S 50 m south	1 x S 30 m north	
028	-22.16662070	29.68371246	x 4 S		
029	-22.16708212	29.68101131	1 x S & 1 x M south	1 x S & 1 x M north	
030	-22.16749082	29.67940944	1 x S	x 2 in drainage line	
031	-22.16831896	29.68410775	x 2 S	x 1 southwest	x 1 northwest
035	-22.18900952	29.65027261	x 1 L 100 m north		
036	-22.19100676	29.65263236	x 1 L 50 m east		
048	-22.20718039	29.67943735	x 1 L 150 m north		
058	-22.15076633	29.63764720	X 1 50 m east		
079	-22.21345047	29.59221854	south of road		
084	-22.19264634	29.60709600	x 1 L		
095	-22.20490756	29.61706367			
097	-22.19303526	29.62862098	x 1 M		
098	-22.19224434	29.63132406	x 1 S		
100	-22.18880173	29.63554678	x 1 L 50 m west		
110	-22.18277556	29.61230066	x 1 S		
115	-22.18840753	29.64276695	x 1 S		
116	-22.18786036	29.64272311	x 1 L		
120	-22.14898249	29.58621156	x 3		
130	-22.15487078	29.67457166	x 1 S		
136	-22.15893307	29.67441450	x 1 S		
137	-22.16159818	29.67927550	x 2 S west		
138	-22.16267031	29.67975930	x 1 S 100 m east	x 1 M 200 m east	
139	-22.16356172	29.68012811	x 1 S west	x 1 M west	
147	-22.14316780	29.67983952	x 1 S		
149	-22.14323854	29.67711850	50 m north		
150	-22.14295372	29.67665389	x 1 S 20 m west		
151	-22.14140626	29.67504733	x 1 S	x 1 L	
159	-22.18520790	29.69491286	x 1 S		
160	-22.18328074	29.69250399	x 1 M 100 m south		
161	-22.18255503	29.69144083	x 1 M 100 m south		
166	-22.18315233	29.68807071	x 1 L 50 m east	x 1 S 50 m east	
167	-22.18360277	29.68692985	x 1 S		
168	-22.18314252	29.68449466	x 2 S		
169	-22.18342599	29.68182636	x 2 L		
171	-22.18549565	29.67748462	x 1 L 150 m east		
173	-22.18669578	29.67305143	x 1 L		
175	-22.18787620	29.66971535	x 1 L		
S = small M = medium L = large x = times the amount					116

Hoodia corrorii

IDENT	LAT	LONG	REMARKS
111	-22.19316451	29.62741356	x 1
129	-22.17428184	29.64576725	x 1
155	-22.17304568	29.63967151	x 3
			5

Five (5) *Hoodia corrorii* plants were observed during the surveys. Three (3) plants were observed in the sandstone ridge areas on the south-eastern corner of portion 6 of the farm Overvlakte. One (1) plant was located in the dense mopane areas of the north-eastern corner (next to the dirt road) of the farm Voorspoed, and one plant (1) was located in the Mixed *C. mopane-Commiphora-T. prunioides* veld of the central western areas of the farm Voorspoed. These areas are earmarked as the west pit opencast mine area and the proposed mine will therefore also have a direct impact on this species.

A population of *A. littoralis* occur in the south-eastern areas near the old mine (copper) on the farm Bergen op Zoom (figure 9). This area will not be utilised for the proposed plant and the proposed mine will therefore not have a direct impact on this species.

5.10 Ecosystems and ecosystem processes

Broad ecosystem delineation is limited to the terrestrial mopane veld areas, the Limpopo riverine forest and floodplains, large drainage lines and springs. The seasonal pans and rocky outcrops are special habitats but form part of the terrestrial mopane veld.

The Limpopo riverine forest and floodplains would be important dry season refuge areas for many fauna species in their natural state. It is also a centre of floral diversity. These areas are however due to historic developments, severely degraded within the study area and to a very large extent excluded from the terrestrial mopane veld areas by the security and veterinary fence. Riparian areas have been identified as important dry season refuge areas for a variety of large mammal species ranging from warthog to elephant. The Limpopo River also provides a source of water, particularly in below average rainfall years, while the deeper alluvial soils may provide better forage than areas inland of the riparian zone. The impacts on the sensitive riparian ecosystems, regardless of the source, need to be restricted to a minimum and rehabilitation should be considered. Impacts on this system include erosion, habitat loss and degradation and the associated impacts on faunal and floral diversity, dewatering of marshes and wetlands, excessive water abstraction as well as increased sedimentation (SANParks 2003). Continued impacts on the riverine ecosystems may also ultimately reduce the capacity of this system to absorb dramatic flooding events.

The ephemeral rivers in the area may also provide refuge for a number of fish species and could therefore be critical to their survival. Here groundwater extraction may be problematic as it may lower the water table to the extent that even species adapted to survival in small mud pools, such as sharptooth catfish, may no longer survive (SANParks, 2003). Other species such as tilapia and carp are more susceptible to desiccation as the pools dry out. Perhaps of greater importance to the survival of the fish diversity of the Limpopo is the threat of competition from exotic species. A number of fish species exotic to the Shashe/Limpopo system have been introduced into the Shashe dam, and some of these have been recorded in the Limpopo River downstream of the confluence (Kleynhans & Hoffman, 1992: In SANParks 2003). The full extent of the impact of these exotic species is undetermined but this could present a major problem for the indigenous biota in the future.

SANParks (2003) identified important ecosystem processes in the Mapungubwe cultural landscape. These processes also apply in the study area and especially the first 4 are of importance.

5.10.1 Biodiversity maintenance

De Beer (2006) conducted studies on various trees in the riverine forest that were either subjected to elephant damage or to water abstraction as a result of agricultural practises. Areas containing *Croton megalobothrys* are strongly correlated with areas that are not subjected to increased water use (De Beer, 2006). Tree density decreased as trees are subjected to increased agricultural activities where large quantities of water are abstracted. Areas directly adjacent to increased agricultural development also showed a decline of *Croton megalobothrys*. This correlation of decrease in density has been found to be even stronger for *Ficus sycomorus* and *Faidherbia albida*.

A significant decline (40%) in the number of riparian trees occurred from 1999 to 2004 (De Beer, 2006). This was not only attributed to elephants because damage to areas where no elephants are present also occurred. This damage was attributed to water abstraction, creepers and flood damage. Results are summarised in table 22.

Table 22. The influence of water abstraction on 5 prominent riparian tree species.

Species	Density	Natural areas	Before development	After development
<i>C. megalobothrys</i>	Less on soils derived from granite than on alluvial soils.		Natural areas and developed areas contained the same density of trees.	Density decreased with high water abstraction since 1980's.
<i>A xanthophloea</i>	Higher on soils derived from granite than on alluvial soils	Significant decline in densities in areas with elephants / because of floods and washed away	No significant difference in densities in natural areas and areas adjacent to agriculture developments.	Slight decline in densities in agricultural areas.
<i>F. albida</i>	Less on soils		Same densities in	Decrease in density

	derived from granite than on alluvial soils		natural and developed areas.	opposite agricultural areas – because of water abstraction.
<i>F. sycamores</i>	Higher on soils derived from granite than on alluvial soils	Floods destroyed 50% of trees in eastern areas.	No significant difference between densities in natural and agricultural areas.	Decline in densities in natural and developed areas from 1999 - 2004.
<i>H. coriacea</i>		Elephants destroyed large communities.		Agricultural development destroyed large communities.

As illustrated above, developments and impacts to natural components and processes of ecosystems can influence the biodiversity of such systems. To maintain the biodiversity of an area, a fine balance is needed between all components of such ecosystems and developments within such ecosystems. Of critical importance are specific long-term monitoring actions and an adaptive management system that can identify vectors of change and incorporate and implement the necessary mitigation actions at an early stage.

5.10.2 Nutrient cycling (effects of plant composition and diversity on such processes).

The movement of elements and inorganic compounds that are essential to the functioning of the ecosystem is referred to as the nutrient cycle. These elements and compounds tend to circulate in ecosystems in characteristic pathways called biogeochemical cycles that can be characterised into sedimentary and gaseous types. The rate of exchange is an important parameter that ensures the appropriate functioning of the ecosystem (SANParks, 2003).

According to SANParks (2003), important aspects to consider and that can be influenced by the proposed mining activities are:

- Accumulation of organic vegetative material.
- Deforestation / degradation of the riverine forest and its associated floodplain.
- Recycling pathways, which include the pathways via primary animal excretion, via microbial decomposition of detritus and the direct cycling via symbiotic micro-organisms.

5.10.3 Water cycles (inclusive of natural and artificial provision, flooding, soil deposition).

The Limpopo River riparian forest and associated plant communities have been under severe pressure from agricultural and infrastructure development since 1978, and the riparian forests and associated plant communities have been identified as an endangered plant community (De Beer, 2006). Historical data of Coombes and Kemper (1992: In De Beer 2006) show that changes in the water regime of the Limpopo River will have, and will continue to have serious implications on the present and future condition of the riparian forest, and the water limitation in the Limpopo River basin is showing the negative effects of high water pumping activities (compare table 22).

5.10.4 Other

Other important processes are:

- i. Carbon sequestration (important in both terrestrial and aquatic environments).
- ii. Faunal migration and associated seasonal effects of such migration (inclusive of the Caftan security fence on the southern bank of the Limpopo River).
- iii. Predator-prey interactions.
- iv. Plant-herbivore interactions (inclusive of potential carrying capacity to maintain biodiversity).

6 SCIENTIFIC AND CONSERVATION PROJECTS IN THE STUDY AREA AND REGION

6.1 Limpopo Valley Herb Project

According to PRECIS ("National Herbarium Pretoria [PRE] Computerized Information System"), the main portion of this northern region, including the study area, is under collected and therefore poorly represented in

the National Herbarium. As such, information on the plant biodiversity and associated threatened and sensitive species in the area may be limited (Van der Walt 2008).

The Limpopo Valley Herb Project entails surveys of non-grass herbaceous plant species including creepers, succulents and bulbous plants in the Limpopo Valley, with the ultimate aim of publishing an area specific field guide. This is a private initiative that transpired from a localized survey done in 2002/2003 on the farms Ludwigslust (MS 163), Matolege (MS 133) and Wimpsh (MS 139). The aim of the survey was to compile a comprehensive list of plant species occurring in the area and to determine grazing values and ultimately the application there-of on game farm management. Due to positive feedback and interest in the project by the local farming community, environmental conservationists and SANBI, the survey area was extended. At present the defined boundaries of the main study area stretches from Pontdrift (29 10') in the west up to Malaladrift (29 35') in the east and from the most northern point of the Limpopo River in the north to approximately 22 30' in the south. The area include Mapungubwe National Park, De Beers' Venetia-Limpopo Nature Reserve, Maremani Nature Reserve, a large number of privately owned game farms as well as the proposed Limpopo Valley Game Reserve that will form part of the Limpopo-Shashe Transfrontier Conservation Area (Van der Walt 2008). The proposed mine area is thus included in the Limpopo Valley Herb Project study area.

Because of the conservation value of the project, it has been granted special collection status with SANBI. This imply that all specimens will be incorporated as part of the National Herbariums collection and that identification of the plant material are done (or confirmed) by the scientists at SANBI (South African National Biodiversity Institute). All relevant common names, endemic and conservation status as well as known distributions of plant species are done in collaboration with PRECIS and other experts such as Dr. Hugh Glen from the KwaZulu Natal Herbarium. Maremani Nature Reserve, Musina Game Study Group, Wildlife Ranching South Africa and SANBI currently support the project. Since May 2005, the project has also been registered as a scientific research project with SANParks in Mapungubwe National Park. Fully annotated herbarium specimens are collected to serve as reference for future research and detailed leaf diagrams are being prepared to serve as further identification aids in distinguishing between different species within specific genera. All relevant information regarding species, such as medicinal uses, grazing values, indicators of veld conditions, butterfly host plants etc. are also recorded (Van der Walt 2008).

The main objectives of the first phase of the project (2004-2008) was (Van der Walt 2008):

- The collection of the biggest possible variety of herbaceous species (in flower or fruit).
- To compile complete herbarium specimens as identification aids.
- To photograph species, with the emphasis on specific characteristics that are important to differentiate between species and sub-species.
- To record all relevant information which will not appear on the herbarium specimen - such as precise locality, soil type etc.
- The complete identification of species.
- To record the distribution, frequency and conservation and endemism status of species.

To date the above mentioned objectives were achieved for more than 390 species. Fully annotated herbarium specimens, photographs, descriptions and distribution maps are available at the field herbarium located at Ludwigslust Game Farm (Van der Walt 2008).

Because the flowering and fruit bearing periods of most herbaceous plant species are limited to the summer months and influenced by rainfall, a minimum period of approximately five years is required to compile a comprehensive survey. All data thus far collected is unpublished and therefore not yet available to interested parties and the general public. It can however be of great importance to decision makers in the Limpopo Valley area where planned development will have a major effect on the vegetation and inevitable lead to habitat destruction and a decrease in the biodiversity of the area (Van der Walt 2008).

In addition to the Limpopo Valley Herb Project's information database, Me. Retha van der Walt of the Ludwigslust Game Farms also compiled species lists and collected specimens during the past eight years of the following (Van der Walt 2008):

- A complete list for trees and shrubs.
- A comprehensive list of herbaceous plant species including grasses, forbs, bulbous and succulent plants.
- A bird checklist (excluding water birds to be found next to the Limpopo River).
- A species lists of the more common mammals.
- A species lists of the more common butterflies.
- A species lists of the more common dragonflies.
- A species lists of the more common reptiles.

- A species lists of the more common scorpions.

6.2 The Ground Hornbill research and conservation project

At present Southern Ground Hornbills are considered 'vulnerable' and a protected species under TOPS regulations (2007) but their numbers are still declining. In South Africa, the total population is estimated at approximately 1500 birds, of which half is in the Kruger National Park. Groups consist of 2-9 birds, of which there is only 1 breeding female from which an average of only 1 chick is raised to adulthood every 9 years.

Over 70% of this species natural habitat has been lost due to farming / agriculture and cattle over the past 50 years. Indirect poisoning, indirect trapping and snaring, loss of large nesting trees, the trade in exotic birds, an increase in ancient cultural uses and electrocution on power transformer boxes are some reasons provided for the decline in numbers.

The Mabula Ground Hornbill Research and Conservation Project are addressing these issues by:

- Harvesting and hand-rearing of second hatched chicks which die of starvation in the nests.
- Re-introduction and augmentation of non-viable groups in the wild.
- Provision of artificial nests for wild groups without nests.
- Research on behaviour and other important unanswered questions.
- Awareness Campaigns to educate the general public to:
 - Unintentional poisoning
 - Trade in ground hornbills
 - Secondary trapping and snaring

In conjunction with the Musina Game Study Group, artificial nest boxes are being supplied to compensate for the lack of suitable nesting trees in the Musina area. No nest boxes were observed during the surveys.

6.3 Importance of research and conservation projects

The importance and value of established registered projects and other available information in the study area are:

- An area specific comprehensive database is available (although not published).
- A field herbarium, representing several taxa, is available in close proximity of the proposed development.
- The official registration and widespread support of the project, especially from PRECIS, SANBI and SANParks, provides credibility to the information.
- The occurrence of endemic, red data as well as TOPS species in the area is known and confirmed.
- It contributes to the scientific knowledge and information of the specific area and region.
- It provides a base for future research concerning all aspects of the vegetation, and other taxa, of the area.
- It contributes to the conservation of the biodiversity and ecosystems in the area and region.
- It provides a reference database that can contribute to mitigation and rehabilitation measures to ensure that the impacts of proposed land uses and developments are minimized and executed in the most responsible manner.

6.4 Formal Conservation initiatives in the region

6.4.1 Dongola Wildlife Sanctuary (1947)

Mapungubwe was rediscovered in 1932 and in 1947 a former Prime Minister (General Jan Smuts) realized the unique conservation value of the area when the Dongola Wildlife Sanctuary, consisting of 39 farms (including Semple, Almond, Newmark, Overvlakte and Bergen op Zoom) and 92 000 ha, were proclaimed. However, a year later the park was disbanded.

6.4.2 Mapungubwe National Park (2004) and World Heritage Site (2003)

The most eastern border of Mapungubwe National Park and World Heritage Site is approximately 5.36 kilometres to the west of the study area.

The cultural resources of the Limpopo-Shashe basin are generally associated with Iron Age settlements of around 1200 AD. The similarity of ivory objects, pottery remains and imported glass beads excavated at

different sites that spread across the modern international borders of Botswana, South Africa and Zimbabwe attests to the cultural affinity of the people that lived in the Limpopo-Shashe basin during the Iron Age.

The Iron Age archaeological sites of Mapungubwe, K2, Leokwe and the Schroda site in the Mapungubwe National Park in South Africa, and the Mmamagwe site in Botswana are amongst the best-studied Iron Age sites in southern Africa. They represent the Zhizo, K2 and Mapungubwe Iron Age cultures that existed in this region roughly between 600 AD and 1300 AD. Small Iron Age sites postdating this period have also been recorded in the area, including stonewalled sites on hilltops and Khami-type ruins.

Mapungubwe is renowned for the golden rhino and is believed to be the precursor of Great Zimbabwe, the most remarkable Iron Age site in southern Africa. Other important archaeological sites are at Toutswe Mogala and Mmamagwe in Botswana. Several sites are also situated on Sentinel Ranch and Mapela Hill in Zimbabwe.

Additional features of cultural importance in the Limpopo valley are the numerous San rock paintings and engravings (*petroglyphs*), fossilised dinosaur footprints and skeletal remains of the dinosaur *Massospondylus carinatus* that became extinct approximately 65 million years ago.

What makes Mapungubwe a World Heritage Site and a place of pilgrimage for Africans is the amazing history of Mapungubwe Hill and its surroundings. The people that inhabited this area were cattle and crop farmers who extensively participated in the Indian Ocean trade with Egypt, India and China. Their wealth and the physical division between the sacred leader and the commoners were a first for Southern Africa. It is because of this uniqueness that the Mapungubwe landscape was proclaimed a World Heritage Site in July 2003.

Mapungubwe also speaks of earlier times of human habitation. The San and their forebears roamed the area for the last 5 000 years. They left over 150 (documented) rock art sites in the Limpopo/Shashe confluence area, a rich library of painted and engraved images that provide insight into the world and beliefs of these hunter-gatherers. Depiction of kudu is very typical for the rock art shelters in this area.

The numerous habitat types have also resulted in high species diversity in the Park. There are at least 24 *Acacia* species and 8 *Commiphora* species, amongst other. Other vegetation of the area is a typically short fairly dense growth of shrubby Mopane trees, generally associated with a number of other trees and shrubs and a somewhat sparse and tufted grassveld. From a conservation point of view, the riparian fringe of the Limpopo is of prime importance. It is in a natural state a dense vegetation community with a closed canopy, which occurs in the rich alluvial deposits along the river.

According to SANParks, Mapungubwe and its recent declaration as a World Heritage Site have helped to highlight the significance of cultural heritage within SANParks. The inextricable links between people, biodiversity conservation and cultural heritage have become more evident through Mapungubwe. A number of initiatives have now come up within SANParks to enable a more dedicated focus on cultural heritage and community participation.

According to SANParks, the Mapungubwe National Park also provides unparalleled opportunities for the development of cultural resources as a sustainable component in the overall park development and management. Significantly, the story of Mapungubwe and its importance in the overall history of the sub-continent has been incorporated into the national schools' curricula. This means that the site itself is increasingly becoming a focus for educational tours, with many primary and secondary schools as well as students from tertiary institutions visiting the park.

SANParks is also of the opinion that the formation of the park at a time when issues of landownership and restitution has come to the fore throughout southern Africa, also provides an opportune moment for the park authorities to implement models of outreach to local communities. The park now regularly hosts communities from Botswana and Zimbabwe who, for almost more than 100 years were cut off from ancestral land of which their ancestors once were an integral part. In this way the park is reaching out to a broader Southern-African community. Initiatives that, it is hoped, will eventually culminate in the formation of a Transfrontier Conservation Area.

The ICOMOS (International Council on Monuments and Sites) evaluation documentation named the heritage site as the "Mapungubwe Cultural Landscape" of which the core site covers nearly 30 000 ha (ICOMOS 2003). It is also mentioned under section 2: "The Property - boundaries, that that this core area is supported by a buffer zone of around 100 000 ha but that no marked maps were supplied to the evaluation authority". It further stated that the nominated site contains substantial areas of 'natural' landscape of very high quality that borders the rivers in the north and to the south the boundary cuts across geometrical citrus farms, which in time will be taken out of agriculture.

The evaluation documentation further states that the proposed boundaries correspond with those of the Vhembe-Dongola National Park (which was then in the process of being established), but that no clear buffer zone was also indicated on the maps supplied.

Specific mentioning is also made of the Trilateral Memorandum of Understanding (MoU) that has been drawn up with the objective of establishing the Limpopo-Shashe Transfrontier Conservation Area (TFCA) of 5,040 km². On 22 June 2006, the MoU signaling the three nations' intent to establish and develop this transfrontier conservation area was signed by Mr Kitso Mokaila, Botswana's Minister of Environment, Wildlife and Tourism, Mr Marthinus van Schalkwyk, South Africa's Minister of Environmental Affairs and Tourism and Mr Francis Nhema, Zimbabwe's Minister of Environment and Tourism. According to ICOMOS (2003), this area "will, when established as a TFCA, constitute a very effective buffer zone". It seems thus that establishment of the TFCA has, at least as one of the objectives according to ICOSMOS, to serve as a buffer zone for the Mapungubwe Cultural Landscape. The Integrated Management Plan of the VHEMBE/DONGOLA NATIONAL PARK (2003) stated that the buffer area will be taken to be the same as the TFCA, and boundaries will change as the TFCA becomes established and grows.

During a meeting with Sanparks, Peace Parks Foundation, DEAT and SAHRA on 23 January 2008, it was established that the tri-lateral MoU for the TFCA that was signed in 2006 only refers to three of the areas, namely the Mapungubwe National Park in SA, the Northern Tuli Game Reserve (Notugre) in Botswana and the Tuli Circle Safari Area. It seems thus that the proposed mining area falls outside of any of the above current conservation initiative boundaries.

6.4.3 Limpopo-Shashe Transfrontier Conservation Area

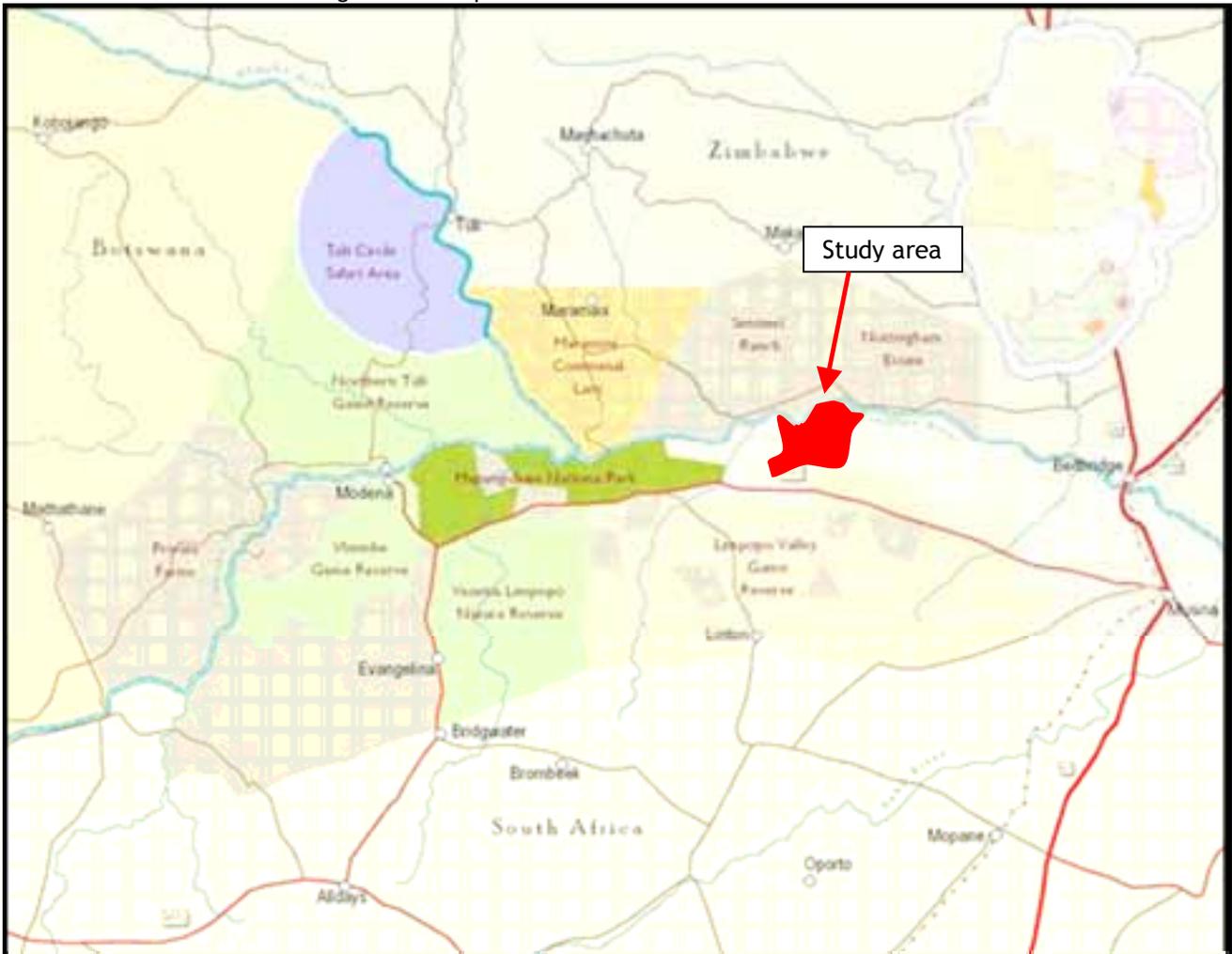
Transfrontier Conservation Areas significantly promote regional integration, greater biodiversity, environmental tourism and economic growth.

According to information obtained from the Department of Environmental Affairs and Tourism (DEAT), the concept of establishing a transfrontier conservation area around the confluence of the Limpopo and Shashe Rivers dates back to the initiative by General J C Smuts who decreed in 1922 that some farms along the banks of the Limpopo River be set aside for the Dongola Botanical Reserve. The primary aim of this reserve was to study the vegetation and assess the agricultural and pastoral potential of the area. This idea was transformed into Dongola National park in 1940s when the results of the study showed that the area was not suitable for human habitation and that it could best be used as a "wildlife sanctuary for the recreation of the nation". It was during this time that the idea of linking the sanctuary with similar conservation areas in the then Bechuanaland Protectorate and Southern Rhodesia was first mooted.

In Botswana, land to be committed to the proposed Limpopo-Shashe TFCA would encompass the Northern Tuli Game Reserve (Notugre) (figure 10). This area had its origin from an association of private landowners who have agreed to remove the fences that separate their properties and jointly manage wildlife resources. Notugre presently embraces 36 farms with a combined area of 70 000 ha. It is renowned for its Tuli elephants, the largest elephant population on private land in Africa. The establishment of this TFCA will considerably expand the range of land available to this elephant population.

On the South African side, the land to be committed to the TFCA would comprise a complex mosaic of private land, state-owned land and national parks (figure 10). South African National Parks (SANParks) with the assistance of the World Wide Fund for Nature (South Africa), De Beers Consolidated Mines Ltd, the National Parks Trust and Peace Parks Foundation, has since 1998 been involved in land purchases to create Mapungubwe National Park. This park forms the core area of South Africa 's contribution to the Limpopo-Shashe TFCA and will include 18 properties of 25 800 ha in total. A major advance in the consolidation of the core area was made in 2002 when De Beers and SANParks signed an agreement whereby properties owned by De Beers would be integrated into the core area. To date, roughly 75% of the park's core area has been consolidated by means of purchase or contract, and the Mapungubwe National parks (replacing the working name Vhembe-Dongola) was officially opened on 24 September 2004.

Figure 10: Proposed Transfrontier Conservation Area.



Establishment of the TFCA has been stipulated in the vision, mission and objectives of the Integrated Management Plan of the VHEMBE/DONGOLA NATIONAL PARK in 2003. This plan further emphasises that the ecological and cultural boundaries of the Mapungubwe Cultural Landscape extend beyond the Park boundaries and that the Trans-Frontier Conservation Area will enlarge the managed landscape to a more representative level in terms of ecological, economic and cultural viability.

The total area that could potentially be included in the proposed TFCA could be approximately 500 000 ha, with South Africa contributing 200,000 ha, Botswana 150,000 ha and Zimbabwe 150,000 ha (figure 10). The potential area that Zimbabwe can commit to the proposed TFCA is the Tuli Circle Safari Area covering an area of 41 100 ha (figure 10). This area is contiguous with the northern end of Notugre and has no physical barriers to impede the movement of wildlife. The potential also exists to incorporate portions of the Maramani Communal Land into the area of the proposed Limpopo-Shashe TFCA.

The landscape south of the Limpopo River is a flat Mopane veld with sandstone and conglomerate ridges and koppies. Nearer the Limpopo, the flat landscape changes into rugged, hilly terrain. The altitude varies from 300 to 780 m above sea level. In the Tuli Circle Safari area, the relatively flat basalt landscape gives way to the Shashe River basin running north-south to join the Limpopo River. Other major rivers that cross the proposed TFCA are the Tune and Motloutse rivers in Botswana, and Mogalakwena River in South Africa.

Three main vegetation communities are recognized in the region: riparian fringe along the Limpopo and the Shashe rivers and tributaries; the *Acacia-Salvadora* community of the Limpopo flats (including flood plains) and vlei areas, and unique baobab and Ilala palm stands and mixed western Mopane veld on ridges and flats south of the riparian fringe and floodplains. Both the riparian forest and the *Acacia-Salvadora* communities are regarded as being among the most endangered vegetation communities in South African environment. Twenty-six Red Data plant species occur within the Mapungubwe National Park.

Within the Tuli Circle Safari Area, there are three botanical reserves: Tolo River (0,44 km²), Pioneer (0,38 km²) and South Camp (0,26 km²). The region has excellent potential for a “big five” conservation area. Viable populations of lion, leopard, cheetah and spotted hyena still occur, apart from the well-known Tuli elephant. In addition, there are significant populations of ungulates within the area of a proposed TFCA, such as eland, gemsbok, duiker, impala, zebra, Sharpe's grysbok, steenbok and blue wildebeest. The habitat is also suitable for both white and black rhinoceros, which led to the release of four white rhinoceros into Mapungubwe National Park in 2004. The permanent pools in the Limpopo River offer refuge to crocodiles and hippopotamus as well as a variety indigenous fish species. De Beers recently reintroduced wild dogs, roan, tsessebe and elephant into Venetia Limpopo Nature Reserve.

This area also has great diversity of birdlife and over 350 species have been recorded to date. At least eight black eagle breeding pairs have been recorded in sandstone hills.

A large number of privately owned farms to the south and east of Mapungubwe National Park has also been earmarked to be included in the proposed Limpopo Valley Game Reserve Conservancy that will be included in the TFCA (figure 10).

The proposed mining area falls outside the current planned areas for the TFCA (figure 10). This is probably due to the fact that most of the area is currently utilised for intensive agriculture.

6.4.4 Vhembe Biosphere Reserve (VBR)

This Biosphere Reserve process started approximately 12 years ago (LEDET 2008). During the past three years, all stakeholder groups in the region have been informed of the proposed establishment of the VBR through their representatives on a steering committee and interactive consultations and work shopping process. The process has been funded, administered and guided by the Provincial Department of Economic Development, Environment and Tourism. All stakeholder groups have accepted the concept because they consider it to be the best model for the sustainable development of this unique area (LEDET 2008).

Municipal, Provincial and National Government actively support the establishment of VBR. The Department of Economic Development, Environment and Tourism has agreed to allocate funding and has the necessary staff infrastructure and expertise to assist with the future management of the proposed VBR. The concept is also enhanced by various national and international initiatives in the region such as the Global Environment Facility Project, the Integrated Sustainable Rural Development Programme, and the Expanded Public Works Programme (LEDET 2008).

Aforementioned process resulted in a submission to UNESCO to register the Vhembe Biosphere Reserve as one of the international recognized Biosphere Reserves. The nomination was forwarded by the MEC for Economic Development, Environment and Tourism (LEDET) and approved by the National Department of Environmental Affairs and Tourism in October 2008. The nomination is currently with UNESCO in France for final approval (LEDET 2008).

The reserve will include the high biodiversity of the northern part of the Kruger National Park, the Mapungubwe National Park and World Heritage site, several Provincial Nature Reserves, two recognized centres of biodiversity and endemism (the Soutpansberg and Blouberg) and the Makgabeng Plateau with more than 1000 rock art sites (figure 11). It is also a favourite destination for ecotourism, cultural tourism and hunting amongst both local and international visitors (LEDET 2008).

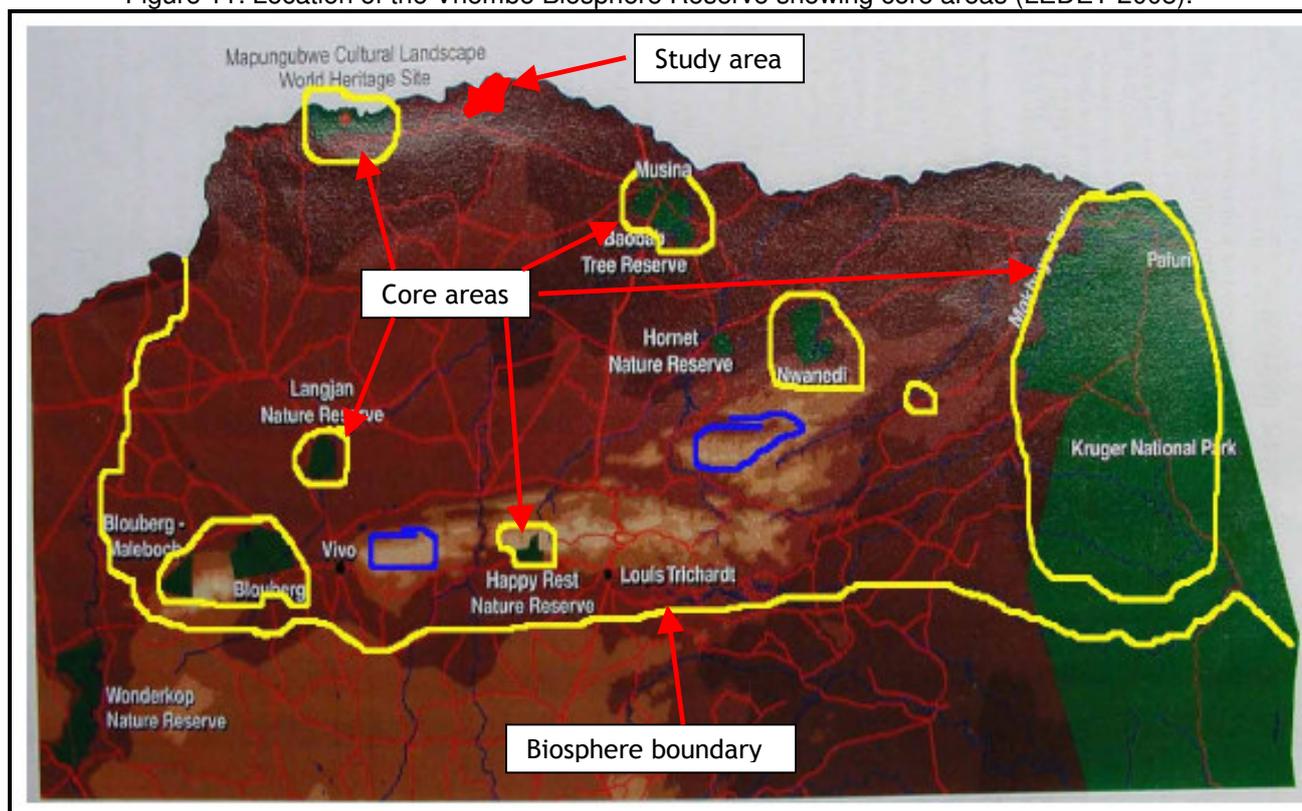
The VBR is characterised by a significant variety of physical environments, which in turn give rise to a remarkable diversity of aquatic and terrestrial species and environments (LEDET 2008). The VBR will include three (3) biomes, namely savanna, grassland, and forest, four (4) bioregions and twenty-three (23) different vegetation types or biotopes. Eight (8) of these biotopes are endemic to the VBR within the South African context. The proposed area is also a bio-geographical node, having Temperate, Kalahari, Lowveld and Tropical inputs. This creates zones of ecologically important interactions, which need to be protected to ensure conservation viability (LEDET 2008).

The objectives of a Biosphere Reserve are (LEDET 2008):

- To preserve special bio-diverse environments for future generations.
- To create and encourage a balance between conservation and economic development.
- To place a priority on encouraging local communities to become involved and to become direct beneficiaries of the benefits flowing from a Biosphere.

- To establish a social contract between all stakeholders and create an integrated ownership and management structure.

Figure 11: Location of the Vhembe Biosphere Reserve showing core areas (LEDET 2008).



Worldwide Biospheres all have three distinct zones, these being as follows (LEDET 2008);

- A legally constituted Core area or areas devoted to long-term protection, according to the conservation objectives of the Biosphere Reserve.
- A Buffer zone or zones clearly identified and surrounding or contiguous to the core areas, where only activities compatible with the conservation objectives can take place.
- An outer Transition area where sustainable resource management practices are promoted and developed.

The Soutpansberg mountain area and its surroundings naturally lend itself to the above zonation (LEDET 2008). The mountainous section will form the “Core” zone, the foothills and areas up to the Vivo/Makhado and Waterpoort Provincial roads will largely form the “Buffer” zone (there could be a few exceptions in certain specific areas where existing development has already taken place which normally would not be included within a buffer zone) and the areas from the above mentioned roads to the south and north respectively will form the “Transition” zone.

The unique biological and cultural features of the Soutpansberg and Limpopo River Valley, together with its largely underdeveloped rural population, lends itself to a sustainable development model which integrates conservation, development and logistical support as stipulated in the MaB programme (LEDET 2008).

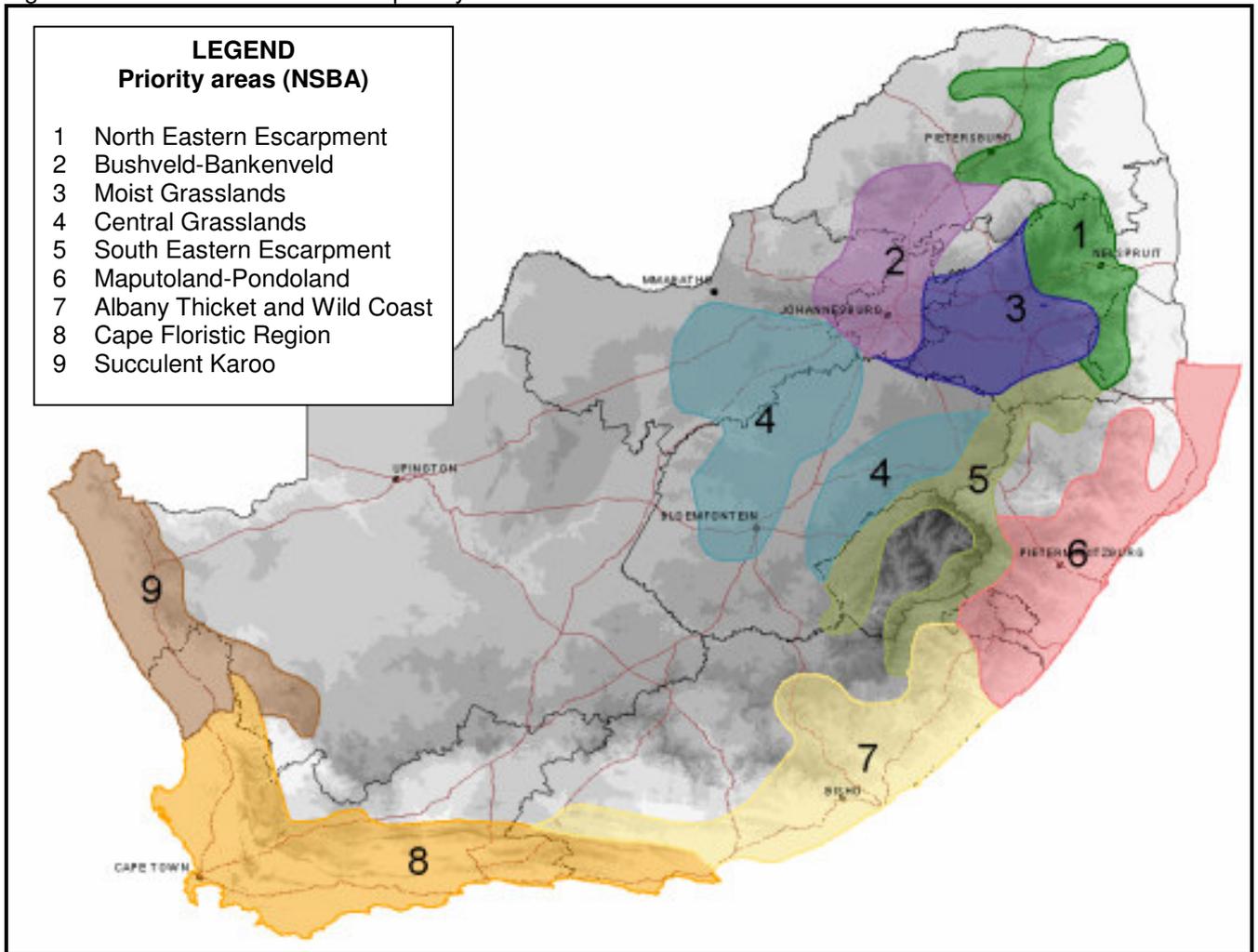
The natural environment of the Soutpansberg and Limpopo River Valley is under immense pressure due to the dependence of a largely underdeveloped rural population on natural resources. The proposed VBR, in conjunction with the Integrated Development Plan of the districts and the Environmental Management Plans of the local municipalities, should contribute significantly to creating a framework for sustainable development (LEDET 2008).

According to LEDET (2008), the VBR will in time be able to expand its functional responsibilities to South Africa’s neighbouring countries, Botswana, Zimbabwe and Mozambique through the recently established Limpopo-Shashe and Great Limpopo Transfrontier Parks.

Establishment of the Vhembe Biosphere Reserve has the support of national and regional policy framework and falls within the priority areas for conservation as determined by the National Biodiversity Assessment

2004 - Priorities for Biodiversity conservation in South Africa (figure 12) as contemplated in the National Protected Area Expansion Strategy LEDET (2008). According to this strategy, the proposed mining area falls outside priority area 1, the North Eastern Escarpment.

Figure 12: South Africa's terrestrial priority areas for conservation action.



6.4.5 Sighetti Private Nature Reserve

A signboard indicating the existence of Sighetti Private Nature Reserve is located on portion 3 of the farm Overvlakte 125 MS (photo 1). The signboard indicate “Administrasie proklamasie No 225 van 1965”. According to comments from LEDET, this reserve was proclaimed on 28/07/1965. The exact location, extend and reasons for proclamation of this private nature reserve is not known. It is assumed that the signboard will at least indicate to the immediate surrounding environment, which is portion 3 of the farm Overvlakte 125 MS. It could however also indicate to a smaller area or even a larger area that might include other portions of the farm Overvlakte 125 MS (portions 4, 5 & 6 to the west ; portions 13 & 14 to the east), or even other surrounding farms.

Portion 3 of the farm Overvlakte 125 MS is part of the planned eastern open cast pit area and consist mostly of natural areas. The remaining portions of the farm Overvlakte are intensively cultivated. The proposed mine could therefore have a direct impact on this Private Nature Reserve. However, the legal status, especially according to the National Environmental Management: Protected Areas Act, 2003 (Act No 57 of 2003), is at this stage uncertain and clarification needs to be obtained.

6.4.6 Skuldwater Ranch Nature Reserve

According to LEDET (2008), the farm Alyth 118 MS was proclaimed on 27/01/1965 as Skuldwater Ranch Nature Reserve. This farm is located to the west of the farm Semple 155 MS, which demarcate the western border of the mining area (photo 2). The farm Semple 155 MS will be part of the planned underground mine.

The farm Alyth 118 MS is located outside the planned mining area but borders directly to the west of the planned underground mining area. The reason/s for proclamation of this reserve is not known at this stage.

Photo 1: Signboard indicating Sighetti Private Nature Reserve



Photo 2: The farm Alyth 118 MS.



Except for the northern floodplain, drainage areas and riverine area, the farm Alyth has totally been transformed by agricultural practices (photo 2). The influence of this transformation on the status of the reserve is uncertain and needs to be clarified. The status of this floodplain, drainage area and riverine area is uncertain because no surveys have been conducted in this area. However, the floodplains and riverine areas on the farm Semple have been identified as sensitive areas and should not be disturbed further.

The legal status, especially according to the National Environmental Management: Protected Areas Act, 2003 (Act No 57 of 2003), is at this stage also uncertain and clarification needs to be obtained.

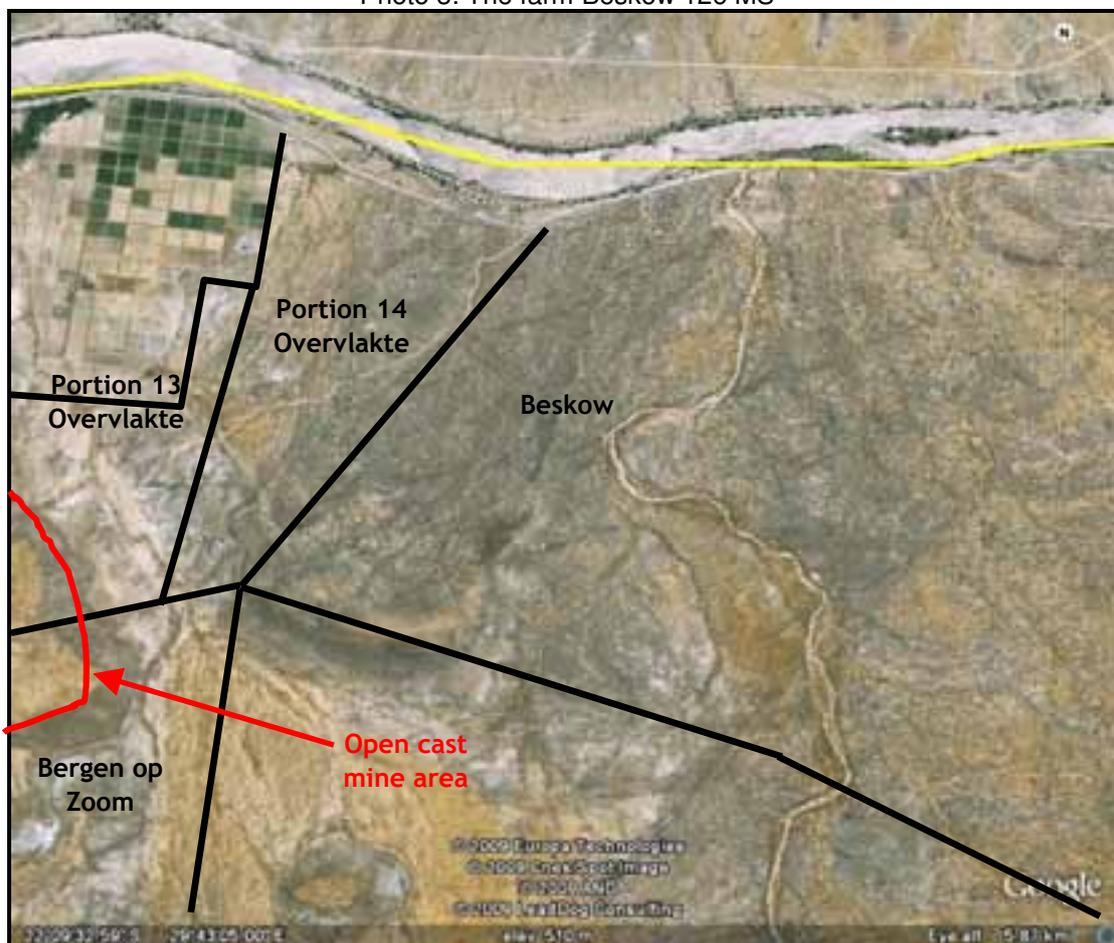
6.4.7 Vereuell Ranch Nature Reserve

According to LEDET (2008), the farm Beskow 126 MS was proclaimed in notice 281 of 13/09/1967 as Vereuell Nature Reserve. The reason/s for proclamation of this reserve is not known at this stage. This farm is located to the east of portion 14 of the farm Overvlakte 125 MS, which demarcate the eastern border of the mining area (photo 3). The farm Beskow 126 MS is located outside the planned mining area. The planned eastern open cast mine area will extent into the southern part of portion 13, but not into portion 14 of the farm Overvlakte, and is at this point approximately one (1) kilometre west of the farm Beskow's south-western border (photo 3).

No surveys have been conducted on the farm Beskow, but it seems that this farm is in a fairly natural state. The proposed mine could potentially have a direct impact on this Nature Reserve.

The legal status, especially according to the National Environmental Management: Protected Areas Act, 2003 (Act No 57 of 2003), is at this stage also uncertain and clarification needs to be obtained.

Photo 3: The farm Beskow 126 MS



6.5 Tourism and Hunting

The Limpopo-Shashe TFCA with its wealth of wildlife, beautiful scenery and unique cultural assets has the potential to become a major tourist destination in southern Africa. Existing tourists facilities are a number of privately run lodges in Botswana (which already attract about 20 000 visitors each year) and a growing number in South Africa. Mapungubwe National Park has added 100 beds to the region in the form of a rest camp with chalets, a tented camp, wilderness trails and various game-viewing facilities like a tree-top walk, hides and access roads. In Zimbabwe, the Tuli Circle Safari Area is used extensively for hunting by permit.

Except for intensive agricultural use along the Limpopo River, most of the privately owned farms in the region are used as game and/or cattle farms. Game farming (intensive or extensive), trophy hunting, recreational (“biltong”) hunting and other tourism / ecotourism activities (game drives, hiking trails etc.) are the main activities that are presented at these farms.

The hunting and tourism industry, and potential for these landuse options, largely rely on an unspoiled environment, the scenic beauty of the area (“sense of place”) and the “wilderness character” of the area. Although not always acknowledged, these landuse options also depend on intactness and proper functioning of the ecosystems.

7 ECOLOGICAL SENSITIVITY

An ecological sensitivity analysis, based on the landscape – vegetation communities, was conducted in the study area. The sensitivity of an area / community was identified through:

- literature reviews of the importance / status of a community / ecosystem,
- importance of the role in the functioning of the ecosystem,
- rare / protected species occurrences,
- uniqueness or importance of habitat for fauna species,
- uniqueness within the study area,
- uniqueness within the larger regional area,
- current degradation status,
- specialist soil classification,
- importance for rehabilitation in term of sensitive ecosystem functioning, and
- in comparison with other communities / ecosystems within the study area.

Seven (7) sensitivity classes were used that ranged from:

- 1 - high,
- 3 - medium,
- 5 - low,
- 6 - degraded but in a successional stage (old lands), and
- 7 - currently utilised as agricultural land.

The sensitivity of the study area is summarised in table 23 and a sensitivity map is attached as figure 13. Classes 1 to 5 are applicable to natural areas, although the condition or status might not be pristine. Classes 6 and 7 are applicable to currently disturbed areas where the vegetation and soils have been disturbed.

Table 23: Summary of ecological sensitivity in the study area.

Sensitivity	Landscape – vegetation community / ecosystem	Reason for sensitivity
1	Limpopo riverine forest (riparian wetland)	Endangered plant community / ecosystem
1	Rare / protected plant species	High concentrations of <i>A. digitata</i> Occurrence of <i>Hoodia corrorii</i> Occurrence of <i>Aloe littoralis</i>
1	Pans / springs	Occurrence of rare species Unique ecosystem Sensitive aquatic habitats
1	Open <i>Salvadora australis</i> floodplain	Endangered plant community / ecosystem
1	Open tree floodplain	Endangered plant community / ecosystem
1	Medium height shrub <i>A. tortilis</i> floodplain	Endangered plant community / ecosystem
1	Drainage line woodland	Endangered / sensitive plant community / ecosystem
1	Drainage line mopane woodland	Sensitive habitat & ecosystem, although well represented in region
1a	Alluvial areas - currently degraded / agriculture	Important to rehabilitation in terms of functioning of sensitive ecosystem
2	Rocky outcrops	Sensitive habitat - reptiles
2	Quartzite Rocky outcrops	Sensitive habitat - reptiles
3	Sandstone ridge	Higher diversity than normal mopane areas

3	Limited distribution of species	Occurrence of <i>Aloe chabaudii</i> in study area
4 3	Shrub mopane on rocky slopes	4 – Erosion sensitive because of slope 3 – And sensitive habitat – reptiles / mammals
4	Eroded Mopane	Erosion sensitive
4	Plato sandveld	Higher diversity than normal mopane areas
5	Open mopane sandveld	Well represented in region
5	Shrub Mopane	Well represented in region
5	Shrub mopane on quartzite	Well represented in region
5	Mopane on limestone	Well represented in region
5	Dense Mopane veld	Well represented in region
5	Mixed <i>C. mopane</i> - <i>Commiphora</i> - <i>T. prunioides</i>	Well represented in region
5	<i>Catophractes alexandri</i> shrubveld	Well represented in region
6	Old lands	Disturbed areas but in a successional stage
7	Current agricultural areas	Disturbed areas

A low sensitivity does not imply that there is no sensitivity. For instance, such areas might still be sensitive for wind or water erosion under specific circumstances and do provide habitat for flora and fauna species. Other protected plant species (*Boscia albitrunca*, *Combretum imberbe*, *Philenoptera violacea*, *Sclerocarya birrea* etc.) do occur in areas identified as of a lower sensitivity, but it is impractical to map each and every one of these plants. These areas also do provide habitat for listed protected animals.

Although currently degraded, alluvial areas (1a) in the agricultural areas can be classified and are regarded as part of the riparian wetland system. These areas are also specifically delineated in the capability soil class classification as riparian areas. These areas are important for rehabilitation in terms of functioning of the sensitive river and riparian ecosystem.

8 POTENTIAL ENVIRONMENTAL IMPACTS

This section aims to describe the environment that may be affected by the coal mining operations and the manner in which the biodiversity and associated activities/industries in an around the area may be affected by the activity. As indicated in the introduction, several potential impacts on the biodiversity are mentioned in this section but other specialists in their specialist's reports address specifics. Possible and proposed mitigation measures are provided in the EMP.

8.1 Cultural biodiversity resources / products

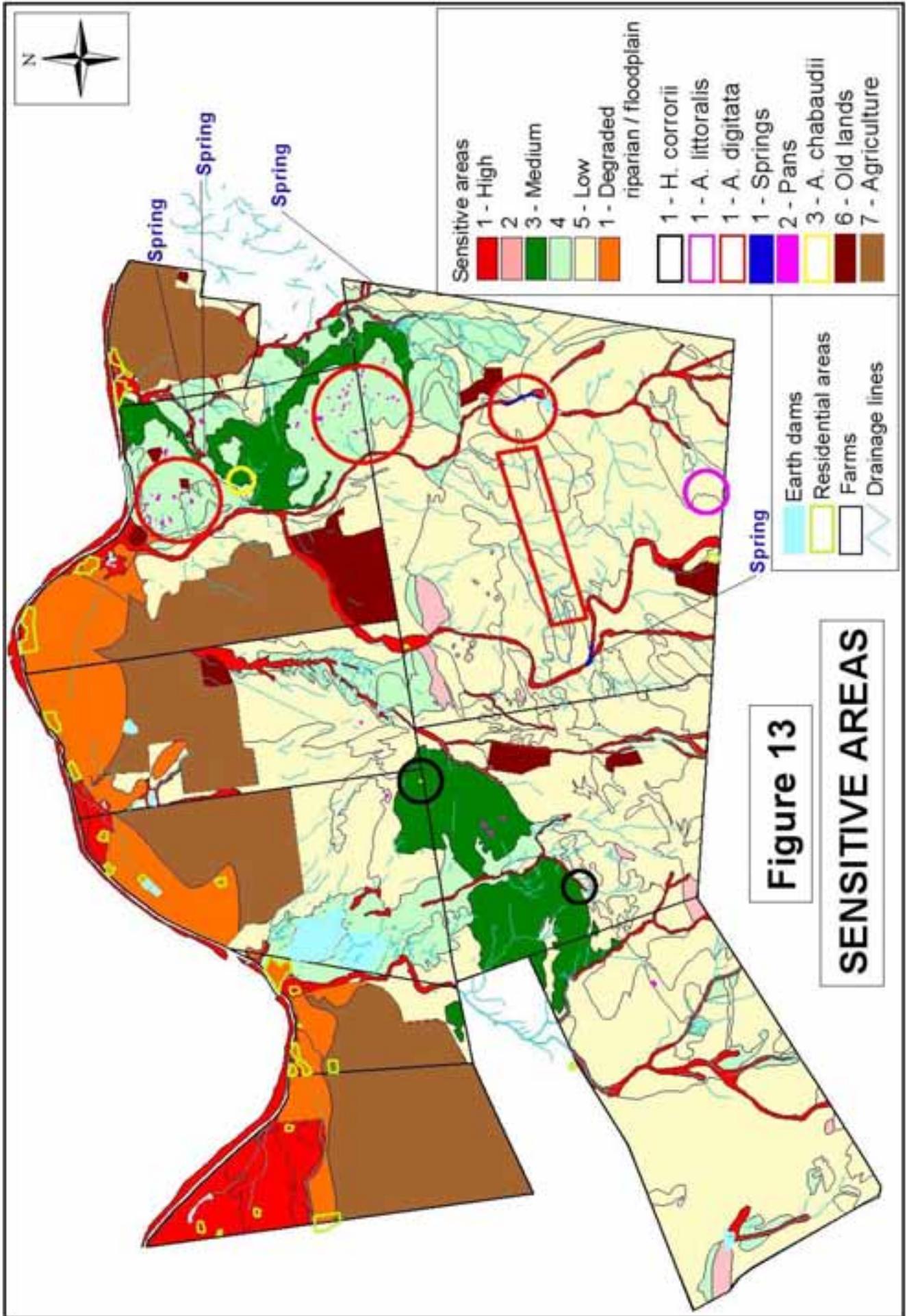
Plants and animals form an integral part of the culture of communities and as such, biodiversity cannot be separated from cultural heritage. For example, the glass beads that forms part of the heritage resources, was obtained as a result from trade in elephant and hippo ivory and animal hides. Specific trees and bushes serve as grave markers and the positions are known to family members only. Biodiversity resources are used as traditional food sources (e.g. *mashonzha* worm), in traditional healing and spiritual rituals. Conserving cultural heritage therefore also includes conserving the sense of place, associated landscape and biodiversity. This impact should as such be integrated with the cultural and heritage impact study. The general public does not have free access to the study area and the current utilisation of these resources is probably fairly low.

POTENTIAL IMPACTS:

1. Reduction in indigenous biodiversity resources / products.

8.2 Alteration of topography

Both underground and open cast coal-mining techniques have an impact on the topography and landscape by reshaping landscapes. Underground mining generally results in less surface disturbances. However, underground mines may collapse and land subsidence, particularly from longwall mining, can also destroy habitats. Surface mines or strip mining poses one of the most significant threats to terrestrial and aquatic habitats and destroys surface layers and associated plant and animal communities, impacting on ecosystem functioning and fragments habitats. According to the United States Environmental Protection Agency (2006a), the loss of vegetation and alteration of topography associated with surface mining can lead to increased soil erosion and an increased probability of flooding after rainstorms.



Research has shown that artificial slopes derived from reclaimed mining areas show some hydrological differences with respect to natural ones (Willgoose and Riley 1994; Loch and Orange 1997). One of them is characterized by the prevalence of physico-chemical control on hydrological response. Soil compaction, crusting, texture, and chemical composition; mainly control the hydrological processes, usually leading to rill system formation or intensive sheet erosion. Under such conditions, soil removal by rill and sheet erosion is very intense.

POTENTIAL IMPACTS:

2. Collapsing of underground mine.
3. Land subsidence.
4. Alteration of surface layers by opencast mining.
5. Increased soil erosion.
6. Increased flooding after rains.
7. Changes in hydrology of artificial slopes - results in rill formation and sheet erosion

8.3 Landuse potential

Mining is a temporary land use but in cases where underground mining takes place, the surface land use can often continue, depending on critical success factors for landuse, water use and management. In the event of underground mining, agricultural activities can probably continue with adjustments for the duration of the life of the mine and beyond. Conservation and eco-tourism may be less viable alternatives, especially if open cast mining takes place, because critical success factors for these land uses include scenic beauty associated with limited environmental degradation, low noise levels and pollution. Open cast mining might also influence agriculture through for instance dust pollution.

If agriculture cannot co-exist with the underground mine, these areas can be rehabilitated. Rehabilitation of especially the riparian and floodplain areas would be beneficial to the biodiversity and riparian wetland ecosystems. Kellner and Els (2008) conducted studies on the restoration of degraded, previously cultivated land in the deforested riparian areas in Mapungubwe National park. Investigations were aimed at establishment and growth of indigenous trees with and without water, enhancement of growth in “activity lines”, and the influence of browsing, soil types and temperature on restoration. Positive growth concerning “activity lines” was observed for especially *A. tortillis* and *C. imberbe* trees. Additional watering was identified as the most important factor contribution to successful establishment and growth of indigenous trees in these semi-arid areas. A multiplying effect was also demonstrated when a combination of additional watering and “activity lines” was applied. This ultimately speed up the succession process (Kellner & Els 2008).

In terms of landuse, there are very little or no short-term (during mining) mitigation measures possible for open cast mine areas. With underground mining a number of landuse options are possible. Existing and future landuse options will be affected in the proposed development area and adjacent areas as a consequence of changes in soil character and fertility resulting from soluble salts that may potentially form in the top-soil, visual impacts and potential pollution. This may be a temporary impact if rehabilitation can be done effectively. The rehabilitation potential in these arid areas is however of concern and may take many years if not actively managed.

Adjacent land uses and downstream uses can also be affected through the same means and as discussed in other sections. For instance, the proposed mine could have a direct impact on the Nature Reserves, mostly in terms of noise, light, dust pollution etc. Because Skuldwater Ranch Nature Reserve is located upstream of the planned underground mine, it is unlikely that underground water will be influenced, depending on the hydrology of the area. However, because of the proposed drainage regime changes, within the mining area, this area might be impacted upon.

POTENTIAL IMPACTS:

8. Opencast mine areas: change in land use, which is currently mainly natural areas.
9. Underground mine: change in landuse, which is currently mainly agriculture, if co-existence is not possible.
10. Decrease land use potential of adjacent areas (including tourism and hunting).
11. Influence land use potential of downstream areas.

8.4 Habitat destruction and modification

The opencast mine and erection of infrastructure is likely to impact wildlife via two primary mechanisms: 1) through destruction / modification of habitat, and 2) by altering normal movement routes.

Destruction of habitat will be a result of the open cast mining or associated infrastructure developments in the area. Wildlife habitat within the mining area would gradually be impacted on an ongoing basis as mining activities expand over time. Approximately 937.35 ha and more than 1000 ha will be removed and altered during the eastern and western open cast mining respectively over the life of the mine. The extent of the underground mine will be approximately 2129.35 ha. All areas to be removed fall within the mopane veld type. It should be noted that from a biodiversity point of view, impacts on cultivated lands and old fields will have a lower significance than impacts on areas of natural vegetation. Of significant importance in terms of habitat, is the sensitive riparian wetland, floodplains, drainage line areas, pans and springs, and rocky outcrops.

Disturbances and removal of soil has the potential to directly and indirectly impact on vegetation in the project area. Disturbance and removal of soil and vegetation will also directly and indirectly impact wildlife by removing habitat that is used for foraging, burrowing/nesting, and breeding.

Hydrological differences between artificial slopes derived from reclaimed mining areas and natural ones result in reduced water availability for plants and because of the intense soil removal by rill and sheet erosion, plant colonization and growth results are very difficult (Nicolau, Moreno & Espigares 2005).

Research has also shown that vegetation clearing and development of electrical transmission and distribution lines may all have a negative effect on raptors and migratory birds, causing direct mortality and disrupting breeding, nesting, and foraging behaviours. In addition, nests may be disturbed during the construction phase, and less area will be available for or desirable for nesting as a result of the proposed development. Power line pilons/poles provide attractive perch, nest, and roost sites, especially where native large trees have been removed. This can have a significant negative impact on the larger raptors such as vultures as a result of electrocution and negative impacts of the electro magnetic fields on breeding success (Anderson & Hohne 2007: Fernie & Reynolds 2005: Wilson 2006.) In the case of localised red data listed species, it may even impact on species survival.

Severance can be defined as the separation of animals from parts of their habitat requirements e.g. waterholes, breeding areas, etc. The coal mining operation would require the conversion of land for transportation, either for the transportation of people or the coal itself. The mining and transportation of coal requires energy, and power lines will be erected. All of these supporting infrastructures will require removal of vegetation and it will dissect the habitat of locally occurring species and is likely to impede normal wildlife movement patterns. As a result of fragmentation of habitats through fences, roads etc., animals within these fragmented areas will at most be utilising marginal habitat and they will be isolated with limited opportunities for dispersal away from the centre of the development and associated impacts as a result of the fences to the west and the intensive agricultural activities. The result of severance is changed behaviour and distribution patterns or physical injury of animals.

Because of the size of the physical structures themselves, wildlife movement corridors may be disrupted. This may result in localized clumping and restricted dispersal among sub-populations. Over time, restricted movement and dispersal could reduce genetic diversity in the population as a whole, or could limit the ability of individual sub-populations to recolonize following random demographic or environmental events.

Habitat modification as a result of increased light, noise, air and water pollution, as well as increased human activity, may lead to distress in animals that may impact on local distribution and dispersal patterns, as well as reproductive success. The decrease in size of small islands that are left in-between developed areas is correlated with a decrease in biodiversity as the ratio of interior habitat to edge habitat decreases. This is of particular concern to certain bird and animal species that require large tracts of land for their survival. Although animals within the development footprint may either move voluntarily or be removed, mitigating the effects of the changed habitat may be a lot more difficult on adjacent land. Many animals' movement through the area are not restricted and voluntary movement away from the development may result in reduced frequency of animals on adjacent land, resulting in negative impacts on tourism and hunting.

De Beer (2006) pointed out that the destruction of the riparian and flood plain vegetation, either by elephants and/or water abstraction (currently due to agricultural developments), will probably have a negative affect on habitat suitability of the region for many bird species, including vulnerable species such as Southern ground hornbill, several (4) vulture species and eagles, and near threatened species such as Secretary birds and Crowned eagles.

Temporary soil disturbance and permanent soil removal will destroy live individuals, and may negatively impact seed sources if dead individuals are damaged or removed. Likewise, creation of manmade structures including large buildings, roads, and mines may alter natural seed dispersal patterns, which could impact recruitment success of plant species from living and dead stock. The density and diversity of vegetation

species would be modified in areas reclaimed following construction. Disturbance of natural plant communities can also lead to invasion of exotic species, which may be more likely to outcompete natives.

Increased traffic may also result in more animals being killed on roads, especially nocturnal species, as they attempt to move throughout their home range. Studies in Kwazulu Natal indicated that deaths of animals on roads could have a significant impact on numbers of especially threatened species for which numbers are already of concern.

From a herpetological perspective and in broad terms, the impact of the proposed mining and logistic activities within the underground mining areas is of little immediate significance and the impact of the opencast mining is of high immediate significance. The impact of the plant area in the southeastern region of the study area is limited and small (Braack 2009). However, all such activities require close management to reduce negative environmental impact (Braack 2009).

Braack (2009) concluded that the impact of the proposed construction and mining activities is of significance in that these will, with immediate effect, alter and/or destroy habitat and land capability. In this semi-arid environment, return to current biotic and abiotic assemblages will take many years, if, in human terms, it ever does. The duration of the impact will be temporary; it is the effect of such impact that will endure for many years.

POTENTIAL IMPACTS:

12. Disturbances and removal of soil in open cast pit, plant and other infrastructure development areas.
13. Destruction of habitat in open cast pit areas.
14. Destruction of habitat at shaft areas in underground mine area.
15. Destruction of habitat at plant and other infrastructure development areas.
16. Modification of original natural habitat after rehabilitation.
17. Alteration / disruption of normal movement routes or corridors (severance).
18. Reduced water availability on reclaimed artificial slopes reduces plant colonization and growth.
19. Alter / disturb breeding, nesting, and foraging behaviour of raptors and migratory birds.
20. Electrocution and negative impacts of the electro magnetic fields on breeding success of raptors influence species survival.
21. Distressed animals (larger mammals, raptors etc.) may change their local distribution and dispersal patterns; reproductive success may decrease.
22. Restricted dispersal among sub-populations (small mammals, reptiles etc.).
23. Reduction of genetic diversity.
24. Reduced ability of individual sub-populations to recolonize after random demographic or environmental events.
25. Damage of riparian and flood plain vegetation.
26. Seed sources may be reduced through soil disturbances / removals.
27. Alteration of natural seed dispersal patterns, which could impact on recruitment success.
28. Changes in density, structure and diversity of sensitive vegetation types.
29. Invasion of exotic species.
30. An increase in animals being killed on roads, especially nocturnal species.

8.5 Reduced water resource availability

Reduction in available underground and above ground water resources may potentially impact on individual animal/plant survival and health, as well as ecosystem functioning.

The Limpopo River bed may be defined as both a permanent wetland, and a riparian area. The riparian vegetation (large trees) on the banks of the Limpopo River is clearly discernable, both in the field as well as on aerial photographs. A further decreased water table along the Limpopo River and possible physical damage due to increased activity will impact severely on the threatened riparian forest along the Limpopo River. This plant community is listed as critically endangered (Rutherford, 2006). Relatively large areas of this vegetation community has already been damaged and degraded as a result of impacts from water abstraction, high elephant population numbers and other activities (e.g. development of infrastructure) from local farming communities and as well as the construction of the veterinary and security (cuftan) fence.

Research and bio-monitoring projects by the Department of Economic Development Environment and Tourism (LEDET) indicates that excessive abstraction of underground water results in plant moisture stress in riparian vegetation. The impact of agriculture and mining activities of Venetia mine on plant moisture stress is being monitored to mitigate impacts.

A reduction in underground water may also impact on survival of animals in the area that are dependent on water from springs and perennial pools that are maintained by underground water. In the dryer seasons, many animal species are totally reliant for their water on these water sources.

Reduction in the amount of water in the Limpopo River system may further impact on aquatic biota and food webs in the river, as river flows change, while the functioning of the river system and RAMSAR site further downstream may also be impacted on. The species composition of these wetlands is determined by amongst other aspects, water levels and duration of waterlogged periods. Not only are these wetlands sensitive habitats, but they also assist in reducing the impact of floods and assist in sustainable release of water downstream.

POTENTIAL IMPACTS:

31. Modification of hydrological processes.
32. Increase in plant moisture stress in riparian vegetation resulting in degradation / destruction.
33. Degradation / destruction of springs & pans.
34. Change / destruction of aquatic biota and food webs in the rivers.
35. Influence or change the functioning of the river system and RAMSAR site in KNP.

8.6 Water quality

In coal mining, the “overburden” (earth layers above the coal seams) is removed and deposited on the surface as waste rock. If not properly managed, erosion of these areas can result in sedimentation in streams and rivers. Coal mining of all types can also lead to increased sedimentation, which affects water chemistry and stream flow and negatively impacts aquatic habitat and impairs wetland functioning. Sediment deposited into drainage lines, streams and rivers can negatively impact aquatic plants in a number of ways. Sediment in water reduces light penetration, which can reduce the ability of plants to photosynthesize. Reduction in the ability of plants to photosynthesize can slow their growth and development. Sediment deposited in waterways can directly impact wildlife. For example, sedimentary particles can suffocate fish by clogging their gills and can also reduce respiratory efficiency of amphibians by adhering to their skin. Indirectly, sedimentation of waterways can reduce vegetation available as forage for wildlife when photosynthesis is impaired. Procedures for controlling sediment transport include berms, terraces, sediment ponds etc. and should allow water to pond and sediment to accumulate.

Coal mining, both closed underground and open-cast operations also generates large volumes of mine wastewater that have the potential to adversely affect scarce water resources in the proposed development area if not properly managed (Tanner et al. 1999; Pulles et al. 1995). The type of wastewater emanating from mines depends largely on the chemical properties of the geological materials that come into contact with the water (Thompson 1980). In both underground and surface mining, sulphur-bearing minerals common in coal mining areas are brought up to the surface in waste rock. When these minerals come in contact with precipitation and groundwater, an acidic leachate is formed. This leachate picks up heavy metals and carries these toxins into streams or groundwater. Waters affected by acid mine drainage (AMD) often exhibit increased levels of sulphate, total dissolved solids, calcium, selenium, magnesium, manganese, iron, aluminium, vanadium, conductivity, acidity, sodium, and nitrate, reflecting drastic changes in stream and groundwater chemistry with loss of aquatic life as a consequence (EPA 1994). The impact of acid mine drainage (AMD) could impact on ecosystem functioning and river health negatively and the potential for AMD must be investigated.

Chemical pollutants that accumulate in waterways adversely impact aquatic and riparian vegetation. Similar to the impacts of chemical air pollutants, chemical water pollutants can inhibit processes including photosynthesis, water regulation and respiration, which can reduce growth and development of plants. Chemical pollutants deposited in waterways can also directly impact wildlife, including aquatic species and those species that depend on aquatic species. However, the concentrations of chemical water pollutants that wildlife in the project area will be exposed to are expected to be variable and depend on location and rainfall. According to risk assessments done for coal mining and associated power plant operations in New Mexico, both mercury and selenium are of concern to endangered fish species and to fish eating birds (EES 2007). Chemical pollutants deposited in or near waterways may also indirectly affect a number of wildlife species, particularly those who depend on riparian vegetation for foraging, nesting or breeding habitat. Aquatic wildlife could be affected by the deposition of particulates or by runoff from areas impacted by deposition.

Acid mine drainage (AMD) can be neutralised by naturally occurring calcite or dolomite, or by active liming, which may be required to correct pH and precipitate out metals (Van Staden 1979). These concentrations of salts and other constituents often render such waters unsuitable for direct discharge to the river systems, except in periods of high rainfall when adequate dilution capacity is present, and controlled release is permitted by the regulatory authorities (Pulles et al. 1996). The study area has a low rainfall and dilution capacity will most probably never be present.

In many cases the mine effluent is gypsiferous, as it is dominated by calcium and sulphate ions. Some research results suggest that this water may however have the potential for irrigation, as may be required to facilitate rehabilitation in semi-arid areas, but great care should be taken in evaluating each specific situation. The gypsum is slightly soluble and concentrating the gypsiferous soil solution through crop evapotranspiration precipitates gypsum in the soil profile, removing it from the water system and reducing the potential for groundwater pollution (Tanner et.al. 1999). The impact this may have on the natural vegetation in the long term is however not yet fully researched. Other studies have found that the addition of alkaline material can increase the mobilization of both selenium and arsenic, causing these chemicals to reach the water even more rapidly (EPA).

Deposited mercury in water courses may be re-emitted to air, remain suspended or dissolve in the water, be deposited in sediments or absorbed or ingested by aquatic plants and wildlife (USFW 2005). A portion of mercury in water or sediment can be converted into methyl mercury, which is easily absorbed by aquatic organisms and accumulates in aquatic vegetation, phytoplankton and invertebrates. The emitted mercury would consist of both particulates and vapours (EES 2007).

Selenium is an essential element for both aquatic and terrestrial wildlife, but it also has the narrowest range of what is beneficial and what is detrimental to wildlife (EES 2007). Aquatic wildlife is exposed to selenium through ingesting food that contains selenium and not through direct exposure to the chemical in water. Selenium is a bioaccumulative pollutant, indicating that it accumulates in the tissues of aquatic wildlife. However, unlike mercury, concentrations of selenium do not increase significantly in animals at each level of the food chain going from prey to predator (USEPA 2004).

Accidental fuel, lubrication or other hazardous material spills, depending upon the size, has the potential to reach drainage lines and ultimately the Limpopo River and adversely impact on fish and/or downstream habitats, wetlands and the KNP.

The washing of coal further results in sludge that is normally contained in sludge impoundments which poses a potential pollution threat to the environment (Reece 2005.)

Bulk services will have to be provided, and especially sewage and other wastewater, has the potential to pollute soils and underground and surface water sources with a negative affect on ecosystems, habitats and species.

POTENTIAL IMPACTS:

36. Erosion of overburden and sedimentation in streams and rivers.
37. Acid mine drainage (AMD):
 - during operation of the open cast pits,
 - during operation of the underground mine,
 - from coal stockpiles,
 - after mine closure.
38. Pollution of soils, drainage lines and riparian wetlands through mine wastewater.
39. Washing of coal that results in sludge that is normally contained in sludge impoundments.
40. Fuel, lubrication or other hazardous material spills / incidents.
41. Pollution of the Limpopo River downstream and RAMSAR site in KNP.

8.7 Air quality

There are various sources of air pollution during the coal production process. The first is methane emissions from the mines. Methane is a powerful heat-trapping gas and is the second most significant contributor to global warming after carbon dioxide. Most of the methane emitted from underground mines escapes through ventilation systems put in place for safety measures or through other shafts and portals. The remainder is released during the handling and processing of the coal after it has been mined (DOE 2005). Methane from coal seams can however be utilised rather than released to the atmosphere with a significant environmental benefit. This is however most probably not feasible in the study area.

The second significant form of air pollution from coal mining is particulate matter (PM) emissions. Mining operations in especially arid, open, and frequently windy areas creates a significant amount of particulate matter. These wind-driven dust emissions occur during nearly every phase of coal strip mining, but the most significant sources are removal of the overburden through blasting and use of draglines (not applicable in study area), truck haulage of the overburden and mined coal, drilling, road grading, and wind erosion of reclaimed areas. The diesel trucks and equipment used in mining are also a source of PM emissions.

Particulate matter emissions are a serious health threat that can cause significant respiratory damage as well as premature death (NRDC 2007). Dust levels can be controlled by tarring of roads (access roads), spraying water on roads, stockpiles, conveyors, fitting drills with dust collection systems or utilising additional land surrounding a mine to act as a buffer zone.

Impacts from particulate matter (PM) emissions may include low viability of annual species or reduced growth rates during periods when fugitive dust is particularly high. Fugitive dust has the potential to impair respiratory functions of wildlife; however, there are few published studies that address the short or long-term implications of dust pollution on wildlife health. At high levels, fugitive dust can impair visibility, limiting the ability of predators to spot prey and, conversely, reduce the ability of prey to evade predators.

During construction, gasoline and diesel fuelled vehicles and equipment will generate gaseous and particulate exhaust emissions, including volatile organic compounds (VOCs), carbon monoxide (CO) and nitrogen oxides (NOx). In the study area, the impact of vehicle emissions on vegetation and wildlife is expected to be of localized importance near construction areas. Intensive construction is only expected to occur for less than 36 months. Emissions from construction activities are expected to have only short-term impacts on vegetation and wildlife and would be limited to the time of construction disturbance. Impacts from vehicle emissions resulting from mine operations would be low, localized and long term.

During the road transportation of coal, gaseous, particulate exhaust emissions and particulate matter (PM) emissions will also occur along the transport route. This might be fairly localized and limited to areas along the road, but could also, depending on wind speed and direction, impact on larger areas. Pending on the length of the route, the impact will be on a large area.

The type and concentrations of chemical air pollutants that plants and animals in the project area will be exposed to are expected to be variable and depend on type of processes used, location, wind direction, rainfall, and sunlight. The response of plants to chemical pollutants are also expected to be affected by other ambient conditions, such as light, humidity, temperature, and the supply of water and minerals. In general, chemical pollution that interferes with the ability of plants to photosynthesize may be indicated by changes in the physical appearance. Chemical air pollution has the potential to limit and/or reduce growth of vegetation (Zeiger et al. 2002). Wildlife can be exposed to air pollutants via inhalation of gases or small particles, consumption of particles in food or water, and/or via absorption of gasses through the skin. In general, only soft-bodied invertebrates or amphibians are affected by the absorption of air pollutants. An individual's response to a pollutant varies greatly and depends on the type of pollutant involved, the duration and time of exposure, and the amount taken up by the animal (USEPA 2006). The individual's age, sex, health, and reproductive condition also play a role in its response (USEPA 2006).

Impacts of chemical air pollution, on wildlife have the potential to be more widespread than that caused by fugitive dust, and has potential to impact wildlife further from the pollution source. Similar to atmospheric dust, compounds including O₃, SO₂ and NO₂ have particularly negative impacts on the respiratory systems of animals. Compared to other groups of animals, birds may be most susceptible to illness or injury related to airborne chemical pollutants, due to their relatively higher respiratory rates (Kimball 2006). In addition to causing respiratory problems, chemical pollutants may accumulate in the tissues of both plants and wildlife, which can lead to tissue damage, genetic mutations and other negative impacts. The accumulation of chemical pollutants in the tissues of wildlife can also have additive impacts among successively higher trophic levels, as compounds that accumulate in vegetation are consumed by herbivores, which are in turn consumed by predators, leading to "biomagnifications" (Kimball 2006).

Light pollution may also impact on wildlife, especially nocturnal species. Wildlife will avoid such areas and this might change behaviour patterns and influence feeding and survival.

POTENTIAL IMPACTS:

42. Methane emissions from:
 - the underground mine,
 - handling and processing of coal.
43. Particulate matter (PM) emissions through:
 - blasting,
 - usage of truck & shovel,
 - truck hauling of overburden,
 - truck hauling of mined coal,
 - drilling,
 - road grading,
 - usage of dirt roads,

- on reclaimed denuded areas,
 - usage of equipment,
 - during transportation on roads.
44. Generation / emission of gaseous and particulate exhaust emissions by:
- vehicles and equipment on site,
 - vehicles and equipment during transportation on roads.
45. Light pollution.

8.8 Noise

Numerous environmental factors determine the level of sound at a given point of reception. These factors include: distance from the source of sound to receptor; surrounding terrain; ambient sound level; time of day; wind direction; temperature gradient and relative humidity. There are three major categories of noise sources associated with mining. They are:

- fixed equipment or process operations (generators, pumps, conveyors, electrical equipment);
- mobile equipment or process operations (drilling, haulage, service operations); and
- transport movements of products, raw material or waste (truck traffic) (SVT 2005).

Noise research conducted at the greater Spitzkop Greenfields site indicated that the biggest noise generator is traffic in the form of coal trucks and cars. This traffic is continuous and increased during the evening reading when noise is more prominent due to climatic conditions and the surrounding noises being minimized (Digby Wells & Associates 2005).

It is expected that the noise levels generated on site will exceed the current ambient levels, resulting in a negative impact on animals. Noise may also impact on local residents and tourists who would want to experience the quietness and character of the bushveld and listen to nocturnal animal sounds such as jackal, owls etc. An increase in ambient noise levels from mining activities and blasting will reduce habitat quality for fauna and impact on the quality of the experience of tourists in the area. The distance that noise pollution will be evident can influence such experience and is discussed in detail in the noise pollution section compiled by specialists.

Variations between different species and between individuals within a single population, as well variation in the characteristics of the noise and its duration, the life history characteristics of the species, habitat type, season, activity at the time of exposure, sex and age of the individual, level of previous exposure, and whether other physical stresses such as drought are occurring around the time of exposure, complicates the assessment of the impact of noise on wildlife (Busnel 1978).

General consensus does however exist among acoustic ecologists that noise can affect an animal's physiology and behaviour, and if it becomes a chronic stress, noise can affect an animal's energy budget, reproductive success and long-term survival. Long-term studies have shown that depending on the characteristics of the noise and the species, the reaction of the animal to noise can range from mild annoyance to panic and escape behaviour (Fletcher 1980). Mild annoyance may cause wildlife to avoid or temporarily evacuate an area until the source of the noise abates. This impact will also affect the tourism activities on neighbouring properties to the proposed development area if animals that are not restricted by fences choose to avoid the area as a result of increased noise and activity levels.

Panic or escape behaviour of animals may result in accidental injury, as animals could fall, run into objects or become trampled in panic. More specifically, studies have documented a short-term increase in heart rate among ungulates (Larkin 1996), reduced ability of small mammals to detect predators (Immel 1995), and alteration of nesting and roosting sites among raptors (Larkin 1996).

Where possible, this impact must be managed and measures need to be implemented to mitigate the risk and associated environmental noise. In some cases, such as blasting, mitigation is difficult.

POTENTIAL IMPACTS:

46. Increase in ambient noise levels from:
- fixed equipment or process operations,
 - mobile equipment,
 - transport movements of products, raw material or waste on site, and
 - transport of products off site.

8.9 Human activity

The proposed development will result in a considerable increase in human presence in the project area, which is likely to impact both vegetation and wildlife. Human presence has the potential to disturb vegetation in the project area, particularly in areas where humans travel beyond the boundaries of established roads, walkways or structures. Vegetation could be directly impacted by humans trampling, damaging or removing individual plants or plant communities and could be indirectly impacted by humans disrupting soils outside of established travel routes / mining areas / plant areas that may lead to increased wind and water erosion, making it difficult for vegetation to become or remain established.

In general, wildlife tends to avoid contact or confrontation with humans. As such, wildlife may temporarily avoid areas where human disturbances are occurring, or may permanently emigrate from areas where human presence is more constant. This may result in alterations of nesting, foraging and breeding behaviour in species that are particularly sensitive to human presence (Stillman et al. 2002). Wildlife may be more sensitive to human presence during significant periods of their annual cycles, including the breeding season. If this happens tourism and hunting activities on neighbouring land may also be affected.

People will also have to travel from their residences to the mine, which will require extensive vehicle / bus travel that may increase the likelihood of collisions with wildlife, especially during the night. Vehicle strikes have the potential to adversely impact a variety of wildlife species, especially nocturnal animals and rare or endangered species.

Depending upon the activity occurring, the proximity of the activity to wildlife and the species encountered, human activity impacts would range from negligible to major. A major impact would be attributable to harm caused to wildlife, either accidentally or intentionally from human activity in the area, which could result in serious injury or death.

POTENTIAL IMPACTS:

47. Disturbances / degradation outside established mining footprint impact areas.
48. Disturbances of wildlife on adjacent areas.
49. Poaching / theft of animals or plants.

8.10 Mapungubwe National Park & World Heritage site

The proposed mine is located approximately 5.36 kilometres to the east of the most eastern point of Mapungubwe national Park and will not directly impact in the biodiversity of the Park, nor on the archaeological or heritage resources of the World Heritage Site. However, species that occur within the Park but not restricted to Park boundaries through fences (e.g. birds), might be influenced through a loss in habitat for feeding, nesting etc.

The mine could impact indirectly on the Park or specific areas in the Park on aspects such as ambience and character of the environment and wilderness quality through visibility, noise, dust, light etc. of the mine from the Park or specific areas within the Park.

Because of the remoteness of the Park, and surrounding areas, an increase in noise levels (blasting, drilling etc.) and light, even a glow in a distance, could be a disturbance and annoyance for tourists, employees and wildlife and again impact on the remote / wilderness character and experience of the Park. These potential impacts are addressed in other specialists reports.

POTENTIAL IMPACTS:

50. Loss in habitat and habitat quality for certain species.
51. Change the ambience and character of the environment.
52. Decrease the experience of the park as a tourist destination & work environment.

8.11 Limpopo – Shashe Transfrontier Conservation Area (TFCA)

SADEC protocols and a signed Memorandum of Agreement between South Africa, Botswana and Zimbabwe have initiated the process of establishment of the TFCA in 2006. The TFCA was also planned as a buffer zone for Mapungubwe National Park and World Heritage Site. Sentinel Ranch and Nottingham Estate is located in Zimbabwe just north of the proposed mining area and are, together with the proposed Limpopo Valley Game Reserve (conservancy), earmarked as private farms that could be incorporated into the TFCA. These areas falls within the phase 2 TFCA planning domain, which is a national & SADEC objective.

According to current available maps, the proposed mine area borders the northern side of the proposed Limpopo Valley Game Reserve (conservancy), and together with other agricultural areas to the west on the South African side falls outside the TFCA boundaries.

The proposed mine could however impede on the total area being incorporated into the TFCA in the future.

POTENTIAL IMPACTS:

53. Impede on Mapungubwe World heritage site buffer zone.
54. Impede on incorporation of the study area into phase 2 of the TFCA for the duration of the mine.
55. Impede on incorporation of the study area into phase 2 of the TFCA after mine closure.

8.12 Other Conservation initiatives and areas

Other conservation initiatives and areas adjacent to or in the study area are the Vhembe Biosphere Reserve, Sighetti Private Nature Reserve, Skuldwater Ranch Nature Reserve and Vereuell Nature Reserve.

A nomination to register the Vhembe Biosphere Reserve has been submitted to UNESCO in October 2008, but the outcome has not been finalised yet. Because of the large scale of a biosphere, various developments can be accommodated in the biosphere concept and the development of a coalmine within the borders of a biosphere can be accommodated, especially if it is an existing mine.

Of more importance is the landuse planning and zones within the biosphere. The planned mining area is in close proximity (5.36 km) of one of the core areas (Mapungubwe National Park and World Heritage Site) of the biosphere reserve. Because the same bufferzone was used for Mapungubwe National Park, World Heritage site and the biosphere reserve, the proposed mine falls outside the bufferzone for this core area (figure 10). It does however border directly to the north of this bufferzone on the farm Erfrust of the proposed Limpopo Valley Game Reserve. The planned mine is also located within the same aquatic ecosystem that is of primary importance for another core area and RAMSAR site 160 kilometres to the east, namely the northern Kruger National Park wetlands. Landuse planning and implementation, and management of these core and buffer areas are of international importance for the status of the biosphere.

The planned eastern open pit area is located within the Sighetti Private Nature Reserve and could therefore have a direct impact on this reserve. Skuldwater Ranch Nature Reserve and Vereuell Nature Reserve are located outside, but border the mine area, and could also directly be impacted upon. Except for the northern floodplain, drainage areas and riverine area, Skuldwater Ranch Nature Reserve has totally been transformed by agricultural practices. It is however still part of a larger ecosystem that could be influenced.

56. Impede on areas earmarked for inclusion in the Mapungubwe World heritage site & Vhembe Biosphere Reserve bufferzone. (compare impact 53).
57. Impede on the core and buffer areas of the northern Kruger National Park wetlands and thus the status of the biosphere and RAMSAR site.
58. Impede on the biodiversity and status of Sighetti Private Nature Reserve.
59. Impact on the biodiversity and status of Skuldwater Ranch and Vereuell Nature Reserves.

8.13 Cumulative impacts

The most important cumulative biodiversity impact of the proposed coalmine is probably the potential cumulative impacts of water abstraction, water quality changes, change in the hydrology, sedimentation etc. on the Limpopo River and riparian wetland and floodplain ecosystems. These systems are already under stress from extensive water abstraction in adjacent areas and the catchment and degradation and destruction of the riparian wetlands in large parts of the ecosystem.

The cumulative affect/s of an additional development such as a mine to the current agricultural developments will most probably decrease the wilderness tranquillity of the relatively unspoiled environment, the scenic beauty of the area ("sense of place") and the "wilderness character" of the area even more. Collectively seen, it could also potentially increase the pressure on the sensitive and endangered Limpopo River ecosystem and species.

The development of a coalmine in this area can facilitate the development of other related industries or developments in that area that can increase environmental pressure and impacts on the ecosystems and impede further on the "sense of place". A secondary positive effect of such a development is that it can also stimulate the growth and development of many industries, businesses and residential areas in nearby towns and thus stimulate the economy of such areas. Such developments can however also increase environmental

impacts, such as increased water requirements, sanitation, waste etc., especially if not correctly managed or if the necessary infrastructure is not available, upgraded or maintained.

POTENTIAL IMPACTS:

60. Cumulative impact on and increased pressure on sensitive riparian wetlands.
61. Decrease in the sense of place.
62. Facilitate development of other related industries in this area.
63. Increase environmental impacts in nearby towns with developments.

8.14 Listed protected species

Listed protected species could be damaged or destroyed during construction or operation of the mine. This could have an impact on the population and survival of the species.

Removal of natural vegetation in the areas where open cast mining will take place will influence various red data listed species. A total of 116 baobabs were counted of which > 70% falls within the open cast mine and plant area. The location of the plant area has been changed during the planning phase to avoid high concentrations of baobabs. There is approximately 32 red data listed and legally protected species that is confirmed to occur in the area whose habitat may be affected by the various mining activities. An additional 36 species, confirmed to occur on adjacent properties, might occur in the mining area, even though some might only occur sporadically.

Different species, or categories of species, have different legal requirements in terms of actions to be taken and permit requirements and the specific circumstances, land ownership etc. will determine the action that needs to be taken to protect such a species.

POTENTIAL IMPACTS:

64. Destroy or damage of protected species.
65. Influence on specific species population numbers and survival.

9 BIODIVERSITY RISK AND IMPACT ASSESSMENT

Risk is a combination of the probability, or frequency of occurrence of a hazard and the magnitude of the consequence of the occurrence (Nel 2002). Risk estimation (RE) is concerned with the outcome, or consequences of an intention, taking account of the probability of occurrence and can be expressed as P (probability) \times S (severity) = RE. Risk evaluation is concerned with determining significance of the estimated risks and also includes the element of risk perception. Risk assessment combines risk estimation and risk evaluation (Nel 2002).

The following steps were followed in the risk assessments of potential impacts:

- i. Issues that may arise as a result of the proposed development, through planning, construction, operation and decommissioning phases, were identified in consultation with interested and affected parties and other specialists.
- ii. Literature reviews were conducted.
- iii. Potential impacts were identified for each issue and assessed by considering criteria as outlined in table 24.
- iv. Where the potential impacts were perceived as having a high risk or significance, alternatives, preventative and mitigation measures were implemented (in planning) and recommended for all phases (planning, construction, operation and decommissioning).
- v. Where required, specialist studies were commissioned.
- vi. All specialists attended a risk assessment workshop and the integrated nature of impacts was considered collectively and comments from other specialists were included in the evaluation of the significance "with mitigation" as specialist discipline.
- vii. Potential impacts and the associated risks were then re-assessed as "actual impacts" on **biodiversity**, without implementation of mitigation measures. This approach was followed to indicate the significance of different impacts and risks on **biodiversity integrity** in the light of the risk of non-implementation of mitigation measures or failed/poorly-managed mitigation.
- viii. For land use related aspects such as conservation areas and initiatives, both biodiversity and human value added aspects such as eco-tourism were considered. This often resulted in a higher significance than when only biodiversity aspects alone were considered.
- ix. The **significance** of each impact was determined "without mitigation" and "with mitigation", taking into consideration alternatives, preventative and mitigation measures.

- x. It should be highlighted that all impacts on the aquatic ecosystem was considered as having an international extent as the Limpopo River system is, at the proposed mining area, a shared aquatic resource with Zimbabwe and downstream with Mozambique.
- xi. It should further be noted that significance in terms of biodiversity was determined considering not only the local impact, but the significance in relation to the bigger picture e.g. significance of impacts on specimens locally was also considered in terms of the impacts on the survival of the species.
- xii. Impacts identified in the biodiversity study for which the environmental management measures will be addressed by other specialists disciplines, will not be addressed in this report, other than assessing the possible impact thereof on biodiversity. The significance of such impacts “with mitigation” is only evaluated where sufficient information is available. Mitigation measures will be discussed under the different specialist disciplines.

Table 24: Environmental risk and impact assessment criteria

DURATION						
Short term	6 months	1				
Construction	36 months	2				
Life of project	25 years	3				
Post rehabilitation	Time for re-establishment of natural systems	4				
Residual	Beyond the project life	5				
EXTENT						
Site specific	Site of the proposed development	1				
Local	Farm and surrounding farms	2				
District	Musina Municipal district	3				
Regional	Vhembe region	4				
Provincial	Limpopo Province	5				
National	Republic of South Africa	6				
International	Beyond RSA borders	7				
PROBABILITY						
Almost Certain	100% probability of occurrence – is expected to occur	5				
Likely	99% - 60% probability of occurrence – will probably occur in most circumstances	4				
Possible	59% - 16% chance of occurrence – might occur at some time	3				
Unlikely	15% - 6% probability of occurrence – could occur at some time	2				
Rare	<5% probability of occurrence – may occur in exceptional circumstances	1				
SEVERITY						
Catastrophic (critical)	Total change in area of direct impact, relocation not an option, death, toxic release off-site with detrimental effects, huge financial loss	5				
Major (High)	> 50% change in area of direct impact, relocation required and possible, extensive injuries, long term loss in capabilities, off-site release with no detrimental effects, major financial implications	4				
Moderate (medium)	20 – 49% change, medium term loss in capabilities, rehabilitation / restoration / treatment required, on-site release with outside assistance, high financial impact	3				
Minor	10 – 19% change, short term impact that can be absorbed, on-site release, immediate contained, medium financial implications	2				
Insignificant (low)	< 10 % change in the area of impact, low financial implications, localised impact, a small percentage of population	1				
RISK ESTIMATION (Nel 2002)						
	SEVERITY					
PROBABILITY	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Critical (5)	
Almost certain (5)	H	H	E	E	E	
Likely (4)	M	H	H	E	E	
Possible (3)	L	M	H	E	E	
Unlikely (2)	L	L	M	H	E	
Rare (1)	L	L	M	H	H	
E	Extreme risk – immediate action required, detail considerations required in planning by specialists – alternatives to be considered					4
H	High risk – specific management plans required by specialists in planning process to determine if risk can be reduced by design and management and auditing plans in planning process, taking into consideration capacity, capabilities and desirability – if cannot, alternatives to be considered, senior management responsibility					3
M	Moderate risk – management and monitoring plans required with responsibilities outlined for implementation, middle management responsibility					2
L	Low risk – management as part of routine requirements					1
IMPACT SIGNIFICANCE						
Negligible	The impact is non-existent or insubstantial, is of no or little importance to any stakeholder and					

	can be ignored.
Low	The impact is limited in extent, even if the intensity is major; whatever its probability of occurrence, the impact will not have a significant impact considered in relation to the bigger picture; no major material effect on decisions and is unlikely to require management intervention bearing significant costs.
Moderate	The impact is significant to one or more stakeholders, and its intensity will be medium or high; therefore, the impact may materially affect the decision, and management intervention will be required.
High	The impact could render development options controversial or the entire project unacceptable if it cannot be reduced to acceptable levels; and/or the cost of management intervention will be a significant factor in project decision-making.
Very high	Usually applies to potential benefits arising from projects.

The biodiversity risk and impact assessment is provided in table 25.

Table 25: Biodiversity risk assessment.

(D = Duration ; E = Extent ; P = Probability ; S = Severity ; RE = Risk Estimation = P x S)

* Other specialist studies should also be consulted for specific impacts and mitigation measures.

Impact	D	E	P	S	RE	Impact Significance	
						Without mitigation	With mitigation
Cultural biodiversity resources / products							
Reduction in indigenous biodiversity resources / products.	4	1	5	3	4	Moderate – low Ecosystem – current utilization	Low – negligible Successful rehabilitation
Alteration of topography							
Collapsing of underground mine.	5	1	1	3	2	Moderate	Specialist discipline Correct mine planning
Land subsidence.	5	1	1	2	1	Low	Specialist discipline Positive topography with in-pit disposal, 16% bulking factor. Materials balance, free-draining final topography.
Alteration of surface layers by opencast mining.	5	1	5	4	4	High	Moderate Some species can adapt
Increased soil erosion.	3	2	3	3	3	Moderate	Specialist discipline Soil rehabilitation plan, slope design, storm water plan, stabilisation of clean water channels.
Increased flooding after rains.	2	1	3	2	2	Moderate	Specialist discipline Storm water plan
Changes in hydrology of artificial slopes - results in rill formation and sheet erosion.	4	1	3	3	3	Moderate	Specialist discipline Soil rehabilitation plan
Landuse potential							
Opencast mine areas: change in land use, which is currently mainly natural areas.	4	1	5	4	4	High	Moderate - low Successful rehabilitation
Underground mine: change in landuse, which is currently mainly agriculture, if co-existence is not possible.	4	2	5	4	4	Low (Assumption: Agriculture stop & rehabilitation improve biodiversity)	<i>Very high – positive</i> Biodiversity offset -rehabilitation of riparian wetlands. Successful rehabilitation
Decrease land use potential of adjacent areas (including tourism and hunting).	3	7	4	4	4	High	Moderate
Influence land use potential of downstream areas.	5	7	3	5	4	High	Moderate - low
Habitat destruction and modification							
Disturbances and removal of soil in open cast pits.	3	1	5	4	4	High	Low Successful rehabilitation
Destruction of habitat in open cast pit areas.	3	1	5	4	4	High	Moderate - low Change plant location in planning phase. Successful rehabilitation
Destruction of habitat at shaft areas in underground mine area.	3	1	5	1	3	Low Small area	Negligible Successful rehabilitation
Destruction of habitat at plant and other infrastructure development areas.	3	1	5	2	3	Low Small area	Negligible Successful rehabilitation
Modification of original natural habitat after rehabilitation.	5	1	4	2	3	Low	Low
Alteration / disruption of normal movement routes or corridors	3	2	4	3	3	Low (west – currently agriculture:	Negligible Successful rehabilitation

Impact	D	E	P	S	RE	Impact Significance	
						Without mitigation	With mitigation
(severance).						east – natural areas; south – plant & natural areas)	
Reduced water availability on reclaimed artificial slopes reduces plant colonization and growth.	4	1	3	3	3	Low	Negligible Successful rehabilitation
Alter / disturb breeding, nesting, and foraging behaviour of raptors and migratory birds.	3	1	3	2	2	Low	Negligible Successful rehabilitation
Electrocution and negative impacts of the electro magnetic fields on breeding success of raptors influence species survival.	4	7	3	3	3	Moderate	Low
Distressed animals (larger mammals, raptors etc.) may change their local distribution and dispersal patterns; reproductive success may decrease.	3	3	4	3	3	Moderate	Low
Restricted dispersal among sub-populations (small mammals, reptiles etc.).	4	2	5	3	4	Moderate	Low Relocation
Reduction of genetic diversity.	4	2	1	1	1	Low	Negligible Relocation
Reduced ability of individual sub-populations to recolonize after random demographic or environmental events.	4	2	1	1	1	Low	Negligible Relocation
Damage of riparian and flood plain vegetation.	5	7	4	4	4	High (Destruction of eastern drainage line & riparian area & destruction of parts of eastern & western drainage lines)	<i>Very high – positive</i> Biodiversity offset -rehabilitation of riparian wetlands. Successful rehabilitation
Seed sources may be reduced through soil disturbances / removals.	5	1	5	3	4	Moderate	Low Successful rehabilitation
Alteration of natural seed dispersal patterns, which could impact on recruitment success.	4	2	5	2	4	Low	Low Successful rehabilitation
Changes in density, structure and diversity of sensitive vegetation types.	5	1	5	4	4	High	Moderate – Low Biodiversity offset -rehabilitation of riparian wetlands
Invasion of exotic species.	3	1	3	2	2	Low	Negligible
An increase in animals being killed on roads, especially nocturnal species.	3	3	4	3	4	Moderate	Moderate – protected / rare species Low – general species
Chanced hydrology and water resource availability							
Modification of hydrological processes.	5	2	5	4	4	High	High – destruction of parts of eastern & western drainage lines Moderate – alter drainage regimes Storm water plan Biodiversity offset - rehabilitation of riparian wetlands. Create buffer zone around eastern riparian area.
Increase in plant moisture stress in riparian vegetation resulting in degradation / destruction.	3	2	3	3	3	Moderate – other areas (Assumption: current water usage will decrease)	Low Create buffer zone around eastern riparian area. Biodiversity offset - rehabilitation of riparian wetlands
Degradation / destruction of springs & pans.	5	1	5	5	4	High (Occurrence of protected and groups of species habitats)	High – Northern springs & pans destroyed. Moderate / low - plant location moved away from southern springs
Change / destruction of aquatic biota and food webs in the rivers.	5	7	5	4	4	High (Destruction of eastern drainage line & riparian area & destruction of parts of eastern & western drainage lines)	High – destruction of parts of eastern & western drainage lines Moderate – alter drainage regimes
Influence or change the functioning of the river system and RAMSAR site in KNP.	5	7	3	3	3	<i>Moderate (positive)</i> (Assumption: current water usage will decrease)	Specialist discipline: <i>Low - positive</i> Less water will be abstracted, but hydrology might change
Water quality							
Erosion of overburden and sedimentation in streams and rivers.	5	7	5	4	4	Moderate	Specialist discipline - Low Soil rehabilitation plan
Acid mine drainage (AMD): ◦ during operation of the open cast pits, ◦ during operation of the	5	7	5	5	4	High	Specialist discipline DWAF best practice guidelines

Impact	D	E	P	S	RE	Impact Significance	
						Without mitigation	With mitigation
underground mine, ◦ from of coal stockpiles, ◦ after mine closure.							
Pollution of soils, drainage lines and riparian wetlands through mine wastewater.	3	7	5	5	4	High	Specialist discipline DWAF best practice guidelines
Washing of coal that results in sludge that is normally contained in sludge impoundments.	4	7	3	3	3	Moderate	Specialist discipline DWAF best practice guidelines
Fuel, lubrication or other hazardous material spills / incidents.	4	7	3	3	3	Moderate	Specialist discipline
Pollution of the Limpopo River downstream and RAMSAR site in KNP.	5	7	3	4	4	High	Specialist discipline
Air quality							
Methane emissions from: ◦ the underground mine, ◦ handling and processing.	3	7	3	2	2	Low (Based on shallowness of coal)	Specialist discipline
Particulate matter (PM) emissions through: ◦ Blasting, ◦ usage of truck & shovel, ◦ truck hauling of overburden, ◦ truck hauling of mined coal, ◦ drilling, ◦ road grading, ◦ usage of dirt roads, ◦ on reclaimed denuded areas, ◦ usage of equipment, ◦ during transportation on roads.	4	3	5	4	4	High	Specialist discipline
Generation / emission of gaseous and particulate exhaust emissions by: ◦ vehicles and equipment on site, ◦ by vehicles and equipment during transportation on roads.	4	7	5	4	4	High	Specialist discipline (Carbon trading)
Light pollution.	3	7	5	3	4	Moderate	Specialist discipline
Noise (sources are grouped together)							
Increase in ambient noise levels from: ◦ fixed equipment or process operations, ◦ mobile equipment, ◦ transport movements of products, raw material or waste on site, ◦ blasting, and ◦ transport of products of site.	3	3	5	3	4	Moderate	Specialist discipline (translocation of fauna from site, however noise impact on adjacent areas and transport roads continue)
Human activity							
Disturbances / degradation outside established mining footprint impact areas.	3	1	3	2	2	Low	Negligible (Strict rules)
Disturbances of wildlife on adjacent areas.	3	2	3	2	2	Low	Negligible (Strict rules)
Poaching / theft of animals or plants.	3	3	3	3	3	Low	Negligible (Strict rules)
Mapungubwe National Park & World Heritage site							
Loss in habitat and habitat quality for certain species (mostly birds).	4	3	3	2	2	Moderate	Negligible Successful mitigation, rehabilitation & biodiversity offset areas
Change the ambience and character of the environment.	4	7	5	4	4	High	Moderate Successful rehabilitation
Decrease the experience of the park as a tourist destination & work environment.	4	3	3	3	3	Moderate	Moderate - low Successful rehabilitation
Limpopo – Shashe Transfrontier Conservation Area							
Impede on areas earmarked for inclusion in the Mapungubwe World heritage site & Vhembe Biosphere Reserve bufferzone.	3	7	2	2	2	Low Location is outside bufferzone	Low
Impede on incorporation of the study area into phase 2 of the TFCA for the duration of the mine.	3	7	5	4	4	High	High - Moderate Managed environmental impacts within acceptable levels & rehabilitate riparian wetlands
Impede on incorporation of the study area into phase 2 of the TFCA after mine closure.	5	7	4	4	4	High (North-south linkage)	Low Successful rehabilitation

Impact	D	E	P	S	RE	Impact Significance	
						Without mitigation	With mitigation
Other Conservation initiatives and areas							
Impede on the core and buffer areas of the northern Kruger National Park wetlands and thus the status of the biosphere and RAMSAR site.	5	7	3	5	4	High	Moderate – low Successful rehabilitation & prevention of pollution
Impede on the biodiversity and status of Sighetti Private Nature Reserve.	5	6	5	4	4	High	Moderate – low Successful rehabilitation
Impact on the biodiversity and status of Skuldwater Ranch and Vereuell Nature Reserves.	4	6	4	3	3	High	Moderate – low
Cumulative impacts							
Cumulative impact on and increased pressure on sensitive riparian wetlands.	5	7	4	4	4	High	Moderate Successful rehabilitation & prevention of pollution
Decrease in the sense of place.	4	7	5	4	4	High	Moderate Successful rehabilitation & prevention of pollution
Facilitate development of other related industries in this area.	5	7	5	4	4	High (Power plant) Other – dependent on type & size of development	High Dependent on type & size of development
Increase environmental impacts in nearby towns with new developments.	5	3	5	3	4	High - Moderate (increased water usage from Limpopo River)	Moderate
Listed protected species							
Destroy or damage of protected species.	3	1	5	2	3	Moderate	Low Rescue operations. Relocate species in off-set areas.
Influence on specific species population numbers and survival.	4	6	2	2	1	Low	Negligible

10 PROPOSED BIODIVERSITY MITIGATION MEASURES

10.1 Environmental management system

The impacts of the coal mine, especially in terms of pollution, alteration and/or destruction of habitats, land capability and wetlands, can be significant within this semi-arid environment, where biotic and abiotic assemblages will take many years to recover. The duration of impacts will be temporary to medium term (25 years) whilst its effect on biodiversity will endure for many more years (Braak, 2009). Because of the location of the mine in relation to the sensitive Limpopo riparian wetland ecosystems and international cultural and biodiversity conservation initiatives, it is important that environmental responsibility are demonstrated through the life-cycle of all activities, products and services. The environmental performance of an organization is of increasing importance to internal and external interested parties.

The ecosystems that we manage are not static – they are dynamic, both temporally and spatially. The complexity of ecosystem structure and function is well known and documented in literature. Furthermore changing socio-economic and political environments markedly impact upon conservation practices, conservation areas, management of proclaimed nature reserves and parks, developments within such areas and the sustainable utilisation of natural resources. Environmental management therefore operates in a **multidimensional decision making environment** that demands innovative approaches to management (Bestbier *et.al.*, 1996).

Because of reasons mentioned above and the nature of the proposed development, it function within international, national, provincial, and local levels and **different stakeholders** of all these sectors are involved. To address the different needs and expectations of stakeholders and for effective ecological, environmental and ecosystem management, is it necessary to incorporate an environmental management strategy and system.

An organization whose total management system incorporates an environmental management system has a strategy to **balance and integrate economic and environmental interests** and can achieve significant competitive advantages. It provides the organization with the opportunity to link environmental objectives and goals (targets) with specific financial outcomes and thus to ensure that resources are made available where they provide the most benefit in both financial and environmental terms (ISO 14000). The real value of an environmental management strategy is in the effective practical role-out its stated policy, objectives and goals

in action plans and procedures, and the measurement of the success or failure of such actions in meeting its objectives.

Such a **management system** provides order, consistency and continuity for organizations to address ecological and environmental concerns through the allocation of resources, assignment of responsibilities, and ongoing evaluation of practices, procedures and processes. Such an integrated approach helps protect human health and the environment from the potential impacts of the organisation’s activities, products or services, and assist in maintaining and improving the quality of the environment. A systematic approach or strategy to deal with the ecological and environmental aspects is therefore necessary. A management system is a tool that enables an organization of any size or type to control the impact of its activities, products or services on the natural environment. An ongoing and interactive process is therefore necessary. Such a management system also intends to establish transparency and accountability in terms of the responsibility accepted towards the sustainable management and development of its priceless assets. New developments, contracts and contractors, management activities, products, services etc. can continuously be incorporated. The management system is therefore adaptable to changes, being it environmental changes or any other. An environmental management system is that part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy, objectives and goals (ISO 14000).

The final and integrated environmental management plan should therefore rather be in the format of **management procedures** and **technical procedures** that specifically address the why, what, how, by whom and by when. These procedures should be of such a format that it is easy to understand, implement, review, adapt, and it should spell out how environmental management and monitoring should be conducted.

An **adaptive management strategy** for environmental management of the proposed mine should be based on total quality management and the PDCA series of activities, namely **plan, do, check, act**. Such a management system will address all the abovementioned criteria and aspects, short and long term needs and are adaptable to changing environments, political and social settings. It has many advantages compared to ridged formatted management plans that will not address the needs, are usually outdated by the time it is finalised and difficult to implement. Such processes, systems and procedures need to be linked with the practical implementation by senior management, personnel, contractors, advisors etc.

The process, system and procedures can only be effective if it is implemented, people are trained and informed of all aspects and somebody is tasked to make it work. Informed environmental advice/support is closely linked to the system/plan because advice is based on environmental data (historic & present) and on the ability to make predictions on the possible outcomes/impacts of management/development actions or the lack thereof. **Capacity building** is therefore an important integral part of the enrolment of the management process and system. Team building and motivation of personnel are critical for the success of management and included in capacity building.

Another important challenging characteristic of environmental management that has to be addressed is the sheer amount of aspects and information that have to be evaluated and managed. This aspect is clearly illustrated through all the specialist’s reports. Such an amount of **issue** can only be successfully addressed in a short period of time, and be managed in the long term, through the implementation of a process and management system. Implementation of an environmental management process and system also make it possible to concurrently proceed with core functions of the mine.

As previously mentioned, many impacts identified in the biodiversity study are addressed, inclusive of mitigation measures, by other specialist disciplines.

10.2 Objectives of the mitigation measures

The proposed biodiversity mitigation measures for the proposed coalmine are in essence aimed at achievement of the following:

Table 26: Objectives of the EMP.

OBJECTIVE LEVEL	OBJECTIVE
Precautionary	<ul style="list-style-type: none"> i. Establishment and implementation of a comprehensive adaptive environmental management strategy, system and process that incorporate the PDCA series of activities. ii. Detailed delineation and demarcation of sensitive areas. iii. Creation of a buffer zone for the riparian wetland.

	iv. Scientific monitoring and documentation of all environmental monitoring programmes.
Species	v. Rescue, relocation and reintroduction operations.
Ecosystem	vi. Rehabilitation of disturbed / damaged terrestrial areas. vii. Rehabilitation of currently degraded riparian wetlands / alluvial areas.
Scientific and social	viii. Establishment of a nursery. vii. Establishment of a herbarium to formalise current and future scientific information basis. viii. Contribute to the effective sharing of knowledge by make existing information available to the general public, scientific community, landowners, developers etc. through publication of a user-friendly area specific herbaceous field guide. ix. Environmental education and capacity building at all levels. x. Development of biodiversity offset programmes.

These levels and mitigation measures integrates with each other and cannot be seen in isolation.

10.3 Planning and Design Phase

Table 27: Possible impacts during the planning and design phase and mitigation measures.

Objective level	Mitigation Measures
Precautionary	<ul style="list-style-type: none"> → Qualified herpetologist and ecologist were appointed to identify rare and threatened species that do, and may potentially occur in the area. → Lists of protected species and sensitive habitats were compiled to guide development planning. → The integrated nature of impacts on biodiversity as ecosystem components and the cultural value of biodiversity were identified and will be addressed in the heritage impact management plan. → Comprehensive literature research was conducted on species that may potentially occur in the area as well as the impact of coal mining on various components of biodiversity. → Various conservationists that worked and are still working in the area were consulted. → Provision was made in the water resource use demand studies for the rehabilitation process as rehabilitation in semi-arid areas may require artificial watering regimes. → Planning and design changes were made to mitigate the impact of the development on these species and sensitive habitats where possible. → Develop, establish and implement a comprehensive adaptive environmental management strategy, system and process that incorporate the PDCA series of activities. → Detailed delineation of the wetlands and floodplain areas along the main watercourse of the Limpopo (even though severely degraded) should be done using the practical field procedure for identification and delineation of wetlands and riparian areas (DWAF, 2005) as well as underlying soils as guidance. → No excavation or further degradation of the riparian wetland zone should take place and an additional buffer zone around these sensitive habitat types should be identified and maintained. → Disturbance and building of infrastructure should be avoided within sensitive areas such as drainage lines, pans, near springs, and rocky outcrops.

10.4 Construction and Operational Phase

Table 28: Environmental management directives for both the eastern and western open pit mining areas during construction and operational phases.

Objective level	Mitigation Measures
Aquatic ecosystem	<ul style="list-style-type: none"> → As threatened wetland habitats play an important role in the hydrology and functioning of the aquatic ecosystem of the Limpopo River, these riparian wetland areas should be rehabilitated. → A rehabilitation plan for these areas should be compiled that should include at least: <ul style="list-style-type: none"> ◦ Clear objectives. ◦ Identification of the correct species & original locations.

	<ul style="list-style-type: none"> ◦ Identification of successional phase or stages of vegetation. ◦ Usage of pioneer species as “nurse plants” such as <i>A. tortilis</i> and <i>S. australis</i>. ◦ Application of a hardening period for seedlings. ◦ Exclusion of browsing / grazing. <p>→ The 1 : 100 year floodline zone should not be impeded on.</p> <p>→ The watercourses that will be diverted away from the eastern open pit, should preferably be redirected to align with the natural water courses on the western and eastern sides of the open pit to feed the sensitive downstream riparian zones.</p> <p>→ Similarly, all efforts should be made to realign the redirected watercourse at the western open pit with drainage lines to the north for the same reasons.</p>
Terrestrial ecosystem	<p>→ A detailed species rescue, relocation and re-introduction plan should be developed and implemented by a qualified person before excavations commence.</p> <p>→ This plan should at the least address the following:</p> <ul style="list-style-type: none"> ◦ Harvesting of seeds from herbaceous and woody vegetation to be used in the nursery and future rehabilitation. ◦ In tact removal of protected plant species and capture of protected faunal species under permit. <p>→ Options to be considered for the above-mentioned protected and general floral and faunal specimens:</p> <ul style="list-style-type: none"> ◦ Suitable translocation areas: e.g. protected areas such as Mapungubwe National Park, Messina Nature Reserve, Ludwigslust Game Farm. ◦ Translocation to suitable areas earmarked for restoration and rehabilitation, both on and off-site. ◦ Use of removed plants in an indigenous nursery for future restoration and rehabilitation programs. ◦ Translocation to other areas suitable for survival of the removed specimens. <p>→ Proper habitat suitability assessments before reintroductions to reduce the risk of mortalities in both source and destination populations.</p> <p>→ Rescue of as many as possible animals within, initially the eastern open cast mining areas for translocated to suitable areas.</p> <p>→ A herpetologist should be appointed during the bush-clearing phases of the operation to collect relevant study and live herpetofauna material, in particular fossorial species.</p> <p>→ Collection and further propagation of vegetation suitable for future rehabilitation and restoration in an indigenous plant nursery.</p> <p>→ Fencing of the entire designated open cast mining area to keep animals out of the area.</p> <p>→ An ongoing detailed vegetation and habitat rehabilitation plan should be implemented by a qualified person, preferably before excavations commence.</p> <p>→ Removal and stockpiling of topsoil as prescribed in the soil rehabilitation program.</p> <p>→ Cutting down and stockpiling of suitable vegetation for use (where possible) in the restoration and rehabilitation program.</p> <p>→ Removal of the above-ground vegetation layer within the strips earmarked for immediate excavation and stockpiling this organic material to be mulched and used with the topsoil as compost in the restoration and rehabilitation program.</p> <p>→ Leaving vegetation in tact in areas not earmarked for immediate excavation for as long as possible to assist in prevention of soil erosion and mitigation of noise and particle pollution.</p> <p>→ In-pit disposal of material should be done to obtain free-drainage in the final topography.</p> <p>→ Restoration of soil layers (as prescribed in the soil rehabilitation program) as soon as possible after excavation when a particular series of strips (e.g. 4 strips) is completed.</p> <p>→ Restoration of the vegetative layers immediately thereafter using the mulch, harvested seeds and plants from the indigenous plant nursery.</p> <p>→ Until the herbaceous (shorter period) and woody (longer period) vegetation layer is established, artificial watering of reclaimed areas should be applied.</p> <p>→ Water allocation for this process should be incorporated into water requirements.</p> <p>→ Implementation of the entire program must be coordinated and supervised by a suitably qualified rehabilitation officer.</p> <p>→ As the eastern open cast pit will be the first priority, and it is envisaged that excavation of the western pit will not start within the next 8 – 10 years, the above-mentioned mitigation measures should only be implemented for the western open</p>

	cast pit at that time. This will allow some time for monitoring of the success of the phase 1 mitigation and restoration process that can then inform phase 2.
Scientific and social	<ul style="list-style-type: none"> → A detailed plan/s should be developed before a nursery is established. → This plan/s should at least address the following: <ul style="list-style-type: none"> ◦ Incorporation with existing nurseries e.g. in Mapungubwe NP, Musina etc. ◦ Location ◦ Water requirements ◦ Resources ◦ Expertise ◦ Management ◦ Staff ◦ Finance (viability) ◦ Capacity building → All rescue, relocation, re-introduction and rehabilitation programmes should be properly monitored and documented for future referencing on the impacts, restoration and rehabilitation programs within semi-arid areas.

Table 29. Environmental management directives for the area earmarked for the plant and associated infrastructure and stockpiles during the construction and operational phases.

Objective level	Mitigation Measures
Aquatic ecosystem	<ul style="list-style-type: none"> → Where the access roads traverse the drainage line, care should be taken not to obstruct the flow of water and hydrology of the wetland. → Measures should be taken to ensure that no undue storm water damage and soil erosion result from the construction activities inside and outside the working areas. → Erosion protection measures should be put in place to prohibit surface storm water to concentrate and flow down cut or fill slopes or along spillway routes.
Terrestrial ecosystem	<ul style="list-style-type: none"> → All infrastructure, with the exception of the demarcated open pit mining areas and associated activities, should where possible, be concentrated in the area earmarked for the plant. → This area should be fenced to limited movement of larger animals through the area. → Before construction of infrastructure, including the proposed future railway line, all protected species must be relocated in a similar process as proposed for the open pit areas. → Corridors of natural vegetation should be left wherever possible to allow movement of smaller faunal species. → Underpasses could be constructed under access roads to allow free movement of smaller animals. → No areas should be denuded or disturbed unless crucial for construction. → Where possible, natural vegetation should be kept to reduce soil erosion. → Erosion should also be reduced through proper overall and slope design. → A detailed vegetation and habitat rehabilitation plan should be developed and implemented by a suitably qualified person, preferably before construction commences. → Rehabilitation of denuded or disturbed areas should be done as soon as activities in these areas have ceased. → Rehabilitation should be done under supervision of a suitably qualified rehabilitation officer.

Table 30. Environmental management directives for the isolated area to the east of the plant during the construction and operational phases.

Objective level	Mitigation Measures
Aquatic ecosystem	<ul style="list-style-type: none"> → The spring in the area must be protected and no abstraction of water from this, or any other spring, or pollution of these systems should take place.
Terrestrial ecosystem	<ul style="list-style-type: none"> → No boundary fence should preferably be erected on the eastern border of the farm Bergen op Zoom as this will result in fragmentation of habitat and it will impede on the dispersal of animals away from the centre of the development and associated impacts. This area can possible be included, for management purposes, into the neighbouring farms. → If a fence is to be erected, it should be erected directly adjacent (east) of the

	<p>proposed future railway line.</p> <p>→ A joint management agreement / venture should preferably be evaluated and established with the adjacent landowner of Amersham 127 MS (Ludwigslust Game Farms) to manage this isolated portion of the development area as part of the adjacent game farm.</p>
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Table 31. Environmental management directives for the area south of the western open pit area and west of the access road, as well as the underground mining area to the north of the western open pit and east of the eastern open pit.

Objective level	Mitigation Measures
Aquatic ecosystem	<p>→ Rehabilitation of degraded areas should be done, with specific emphasis to degraded wetlands and floodplain areas. This will contribute positively towards ecosystem function of the threatened riparian wetland ecosystem and associated fauna and flora. In the long-term, it may also contribute to the survival of hippos in the Limpopo River system, especially during conditions of drought when food resources for these animals are limited due to the impacts of agriculture in the area on their feeding grounds.</p> <p>→ Rehabilitation of the degraded wetlands and floodplain areas should be done under supervision of a suitably qualified person/s.</p> <p>→ Any fences on the western boundary of the development area should be permeable for small wildlife to allow for free dispersal away from the centre of the development and associated impacts.</p>
Terrestrial ecosystem	<p>→ During the excavation of the eastern open pit mining area, the wildlife in the small fenced area on portion 6 of the farm Overvlakte could be used in a research project to contribute to the expansion of the knowledge base regarding the impact of mining and associated impacts on wildlife.</p> <p>→ However, during excavation of the western open pit mining area, all game should be translocated to more suitable habitat.</p>

Table 32. General environmental management directives for the development area, excluding the open pit mining areas.

Objective level	Mitigation Measures
Precautionary	<p>→ All sensitive areas should be adequately protected and rehabilitated when damaged incidentally.</p> <p>→ Measures should be taken to ensure that no undue storm water damage and soil erosion result from the construction activities inside and outside working areas.</p> <p>→ Erosion protection measures should be put in place to prohibit surface storm water to concentrate and flow down cut or fill slopes or along spillway routes.</p> <p>→ Deep uncovered trenches outside of fenced open pit mining areas are to be discouraged as these become barriers and traps for wildlife.</p> <p>→ A speed limit of no more than 40 km/h should be instated to limit possible accidents with wildlife, especially at night.</p> <p>→ Vehicles should not be allowed to drive anywhere except on designated roads.</p> <p>→ The use of pesticides (herbicides and insecticides) for mosquito or other control should be limited to the immediate environs of office and accommodation developments.</p> <p>→ A comprehensive environmental monitoring program should be developed where strategic environmental indicators are identified across the spectrum and monitored to detect changes resulting from the proposed development. Such programme should at least include the following:</p> <ul style="list-style-type: none"> ◦ Fauna rescue operations. ◦ Fauna relocation operations. ◦ Fauna re-introduction operations. ◦ All flora and habitat rehabilitation projects and programmes. ◦ Water abstraction and the influence on specifically riverine and floodplain ecology and springs in the area (quantity & quality). ◦ Water pollution. ◦ Soil pollution. ◦ Air pollution.

	<ul style="list-style-type: none"> ◦ Noise pollution. → Part of this program should include the monitoring of plant moisture stress at water abstraction and control site/s along the Limpopo River to monitor the impact of water abstraction on riparian vegetation, similar to the program implemented by Venetia mine. This should guide the water management strategy. (It is expected that water will be abstracted from the river during high flow periods to be stored in the off channel dam for use during low flow periods.) → All other infrastructure that is needed for executing of the functions of the mine (sewage disposal, domestic waste water etc.) should comply with applicable generally accepted norms, standards and other legal requirements. → All potential pollution sources / points should be identified and appropriate containment measures should be developed and implemented.
Species	<ul style="list-style-type: none"> → No felling of trees should take place. → No burning / removal of vegetation for firewood or catching of any animals should take place unless part of the environmental management plan. → All declared exotic plants should be removed from the entire development area. → All incidents and sightings of protected species within demarcated and fenced development areas should be monitored, documented and reported to the environmental officer who will remove these animals from harms way. → Electricity pylons should be adapted according to Eskom standards to reduce the risk of electrocution for raptors.
Ecosystem	<ul style="list-style-type: none"> → No areas should be denuded or disturbed unless crucial for operations and natural vegetation should be kept to reduce soil erosion. → Rehabilitation of denuded or disturbed areas should be done as soon as activities in these areas have ceased.
Scientific & social	<ul style="list-style-type: none"> → All workers should be sensitised and environmental educational programmes should be launched to build capacity about the environmental management plan, sensitive habitats and protected species. → A penalty clause for any environmental contraventions should be included in workers' service agreements. → Biodiversity offset programs should be identified, developed and implemented, such as: <ul style="list-style-type: none"> ◦ Offset of degradation / destruction of riparian wetlands in the open cast mining areas against restoration of degraded riparian wetlands alongside the Limpopo River. ◦ Offset of terrestrial habitat destruction in open cast mine areas and influence on landuse potential, against land acquisition / co-funding / improvement of the conservation contribution of land and/or land use activities within the planned TFCA. ◦ Offset of terrestrial vegetation degradation against the development / support of an indigenous plant (including rare / protected plants) nursery and herbarium, and funding support for the Limpopo Valley Herb Project through publication of the field guide on the herbs & forbs of the region. (A herbarium, to formalise the current scientific information basis and to include future references could be established and/or supported. A specific action plan should be developed for such a herbarium. The herbarium should be incorporated into environmental education and training programmes. → Other conservation initiatives in the area, such as the Ground Hornbill Research and Conservation Project, should be supported and incorporated into the rehabilitation programmes. → Biodiversity BEE initiatives could be identified and could include aspects such as: <ul style="list-style-type: none"> ◦ Vegetation cutting. ◦ Mulching of vegetation for compost. ◦ Firewood collection ◦ Erosion control.

10.5 Mine Closure Phase

Table 33: The possible impacts of the proposed development during and after mine closure and proposed mitigation measures.

Objective level	Mitigation Measures
Levels are integrated	<ul style="list-style-type: none"> → Specific programmes should be developed for continuation of rehabilitation and monitoring actions after mine closure. → Specific programmes and actions should be developed for impacts that manifest and / or occur after mine closure. → Specific funds should be allocated to implement aforementioned programmes.

11 LEGAL FRAMEWORK

The legal framework within which the biodiversity aspects operate is fairly complex and include many acts and regulations that are also applicable on other specialist disciplines. The legal framework provided in table 34 is a summary of the most important legal aspects applicable on fauna and flora. A full legal audit of all activities, products and services has not been conducted and therefore is table 34 not a comprehensive list.

Table 34: Legal framework for fauna and flora

No	ASPECT	SECTION	REQUIRED ACTION SUMMARIZED	ISSUES AND CHALLENGES
Limpopo Environmental Management Act, 2003 (LEMA)				
1	Private Nature Reserves occurring within the proposed development area.	21(4) a & b	The MEC may withdraw the declaration on the written application by the owner of the privately owned land; or when the MEC deems it necessary.	<p>No permit can be obtained to mine in a nature reserve – it is prohibited.</p> <p>The possibility do however exist to buy these areas and apply for de-proclamation. If the NR is however of high conservation value, this will probably not be considered by LEDET. A possibility exist to consider a biodiversity offset program where the biodiversity lost as a result of the mine on a specific locality are “set-off” against conservation initiatives and other areas. This may be a reality especially in this area with international conservation initiatives.</p> <p>The implications of protected area legislation, in so far as the rights of the holder of the mining rights of land proclaimed as NR, especially when proclaimed under previous legislation where no public participation process was conducted, is uncertain.</p>
		28(1)	No person may conduct prospecting, mining or related operations within a Provincial Nature Reserve, a Protected Environment, a Private Nature Reserve or a Resource use area, except with the approval of the Executive Council, or on a site of ecological importance.	
2	Risk of killing/injure/ catch/pick-up/remove “listed/protected” animals on land owned by the client.	35(3)	No person may without a permit catch specially protected wild animals, protected wild animals, game and non-indigenous wild animals.	<p>These actions may be performed under a permit.</p> <p>Issuance of the permit will be considered based on various environmental considerations. The client will have to apply for various permits if mining is to continue, for example when animals are caught and relocated as part of a rescue operation.</p>
	Risk of killing/injure/ catch/pick-up/remove all animals on land not owned by the client.	35(5)	No person may without the written permission of the owner of the land, catch a wild or alien animal on land of which that person is not the owner.	

	Actions resulting in acquiring, possessing, conveying, keeping, selling, purchasing, donating or receiving as a gift "listed/protected" animals.	41(1) a	No person may without a permit acquire, possess, convey, keep, sell, purchase, donate or receive as a gift, any specially protected wild animal, protected wild animal, game, non-indigenous wild animal or animals referred to in Schedules 7 or 8.	species is listed in LEMA, whether or not the land on which these species occur belong to the client, and lastly the survival potential of the animals at the new destination if they are to be relocated. Because of the complexity of the matter (different species, requiring different actions and possibly different relocation strategies), it is recommended that a specialist be appointed to manage the entire process, relocation and permit applications.) A single scenario cannot be contemplated at this stage in the process.
	Convey any live wild or alien animal.	41(2)	No person may without a permit in terms of this Act or other document prescribed by other relevant legislation, convey any live wild or alien animal through the Province.	

3	Impact of mining activities on aquatic ecosystems and biota.	58 a, b & c	No person may deposit into an aquatic system any solid, liquid or gaseous substance or thing which may injure, damage or kill, or in any way be harmful to, aquatic biota: cause or allow such substance or thing to enter or percolate into an aquatic system; or carry on a business or occupation which may result in any such substance or thing entering or percolating into an aquatic system, without taking adequate precautions to prevent such substance or thing from entering or percolating into that aquatic system.	No permit can be obtained, it is prohibited actions. If the law is contravened, the polluter will be fined and may be required to pay all costs for rehabilitation and corrective action.
			In some cases, aquatic biota may be collected, etc. under a permit.	In some cases, aquatic biota may be collected, etc. under a permit.
4	Impact of mining activities on invertebrates.	61, 62 and 63	No person may without a permit conduct certain activities, only for those species listed in Schedule 10.	Permits may be applied for if necessary. None of the listed invertebrates were however recorded for the proposed development area.
5	Damaging, removal, etc of indigenous vegetation	61 (1-5)	No person may without a permit pick, be in possession of, sell, purchase, donate, receive as a gift, import into, export or remove from the Province, or convey a specially protected plant; or pick, sell, purchase, donate, receive as a gift, import into, export or collect firewood, or remove from the Province, or convey a protected plant; or pick any indigenous plant: <ul style="list-style-type: none"> – on a public road; – on land next to a public road within a distance of 100 meters measured from the centre of the road; – within an area bordering any natural water course, whether wet or dry, up to and within a distance of 50 meters from the high watermark on either side of the natural water course; or – in a Provincial Nature Reserve, a Site of Ecological Importance, a Protected Environment or a Private Nature Reserve. 	Activities are regulated under permit, and are amongst other aspects, dependent on whether a species is listed and in which category a species is listed in LEMA, whether or not the land on which these species occur belong to the client, and lastly the survival potential of the plants at the new destination if they are to be relocated. Because of the complexity of the matter (different species, requiring different actions and possibly different relocation strategies), it is recommended that a specialist be appointed to manage the entire process, relocation and permit applications.)
7	Littering	89	No person may discard, dump or leave litter on any land, water surface, street, road or site to which the public has access, except in a container or at a place which has been specially indicated, provided for or set aside for such purpose.	Prohibited activity.
8	Waste management	92	Aspects relating to waste management is regulated, including management, location,	Regulated under permit.

	management		planning and design of waste sites, disposal of waste, etc.	
9	Noise, vibration & shock	93	Aspects relating to noise, vibration & shock is regulated, including management, definition, prevention, levels, measuring, etc.	Regulated under permit and the MEC may make regulations.
National Environmental Management: Biodiversity Act. No. 10 of 2004 / Threatened or Protected Species Regulations, 2007 (TOPS)				
2,4,5	Impacts on nationally protected species of plants and animals.	All	Where a species is protected by both national and provincial legislation, a single permit application can be submitted to the provincial office as per the national requirements.	Regulated under national permit. One application process, with a permit for both provincial and national legislation.
3 and others	Impacts on threatened/protected ecosystems	All	Regulations have not been promulgated yet, and until it is done, the precautionary principle will be applied for all perceived threatened ecosystems.	The proposed development area and more especially the riparian zone, has been classified by some experts as threatened, although not listed specifically in NEMA yet and will therefore be regulated under permit of other legislation and the EIA process.
National Forest Act, 1998				
11	Impacts on protected plant species as per NFA.	All	Activities similar to the LEMA listed activities are regulated under permit. A separate permit application for species listed under environmental and forestry legislation have to be submitted, each to the relevant authority.	Regulated under permit. Two different permits, one for LEMA and one for NFA.
National Environmental Management: Protected Areas Act. 2003				
1	Mining and Nationally Protected Areas	12	A protected area which was proclaimed as a protected area or nature reserve in terms of provincial legislation for any purpose for which an area could in terms of this Act be declared as a nature reserve or protected environment, must be regarded to be a nature reserve or protected environment for the purpose of this Act.	Even though the nature reserves within the proposed development area have been proclaimed a long time ago under provincial legislation, it is considered a protected area under NEMPA.
		24	A protected area/ nature reserve may be de-proclaimed in some instances	If an area does not have national priority as a protected area, the landowner may apply for deproclamation.
		48	Despite other legislation, no person may conduct commercial prospecting or mining activities in a special nature reserve or nature reserve.	New mining Prohibited. Only where legal mining did take place before the proclamation of the Act, consideration will be given in consultation with the relevant Cabinet members.

12 CONCLUSION

The proposed coalmine is located within the mopane veld that is not regarded as an endangered or threatened veld type. However, it is partly located within a sensitive and highly threatened aquatic ecosystem, namely the Limpopo River and associated riparian wetlands and vegetation. It is also located in close proximity of Mapungubwe National Park and World Heritage Site. Furthermore, the planned Limpopo Valley Game Reserve Conservancy is situated to the south, and Sentinel Ranch and Nottingham Estate is situated in Zimbabwe to the north of the proposed mine. These areas are also earmarked for incorporation into the Limpopo-Shashe Transfrontier Conservation Area. The Limpopo River is also an international boundary with the world-renowned Kruger National Park and RAMSAR site further downstream. Impacts of the proposed mine on biodiversity should therefore not be considered in isolation, but the cumulative impacts on sustainable landuse practises such as tourism development and the impact on climate change is also of significance.

Identified impacts of the proposed coalmine can potentially impact on the terrestrial, wetland and aquatic ecosystems within the mining area, and may even extent over a much larger areas as indicated by the impact assessment. It is especially the impact of the proposed mining on the functioning of the aquatic and riparian wetland ecosystem of the Limpopo River and its associated sensitive plant communities and habitats that are of particular concern. Although several protected flora and fauna species occur, or could potentially occur in the mine area, either permanent or temporarily, the potential impacts on a species level are probably not as severe as the potential impacts on an ecosystem level. However, species is an important component of ecosystems. Impediment, alteration or disturbance of the components, processes and functioning even at localised areas in this sensitive ecosystem, can influence the functioning of the systems over a much larger area and some of the effects may only manifest over a long period of time and over long distances.

Because of their position in the landscape between terrestrial and aquatic systems, riparian wetlands play an important role in the functioning of both the river system (aquatic) and the terrestrial system. They are highly sensitive to landscape and hydrological changes, as will be the result from the proposed mining activities, with major consequences for the river ecosystem, which they buffer from terrestrial influences. The biggest potential impact of the proposed development to biodiversity in the area is however the risk of pollution that is commonly associated with coal mines.

On a species level, mitigation measures for the open cast mining areas are limited, and evolved around rescue, relocation and reintroduction operations. Because of the reasons mentioned above, mitigation measures for the proposed development and its impact on ecosystem functioning should be precautionary with design and operations following a best practise approach. Developments should be kept out of sensitive riparian areas along the Limpopo River and where disturbed, specific attention should be given to restoration of the riparian wetlands. All pollution sources / points should be identified, pollution prevention measures implemented and an early warning monitoring system implemented. Planning and design of infrastructure should be done with pollution containment and clean up in mind to ensure that even if pollution incidents do occur, it can be contained effectively and properly cleaned up and rehabilitated.

Any risk and impact assessment is but an exercise based on facts, assumptions and perceptions, and can by no means give an exact reflection of all possible scenarios. The success of proposed, and still to be developed, mitigation measures will largely depend on the commitment of the developer to its social and environmental responsibility, management of the impacts and mitigation measures and allocation of financial resources to implement such mitigation measures.

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