7 RECEIVING ENVIRONMENT

7.1 Introduction

As required in section 31(2) of the NEMA Regulations, 2010, this section includes a description of the environment that may be affected by the activity and the manner in which the biophysical, social, economic and cultural aspects of the environment may be affected by the proposed activity as well as a description of the environmental issues that were identified during the impact assessment process.

7.2 Study Area in Regional Context

7.2.1 Locality

Hendrina Power Station is located approximately 20km north of the town Hendrina in the Mpumalanga Province. The power station falls under the jurisdiction of the Nkangala District Municipality and in turn falls under the jurisdiction of the Steve Tshwete Local Municipality (**Figure 7.1**).

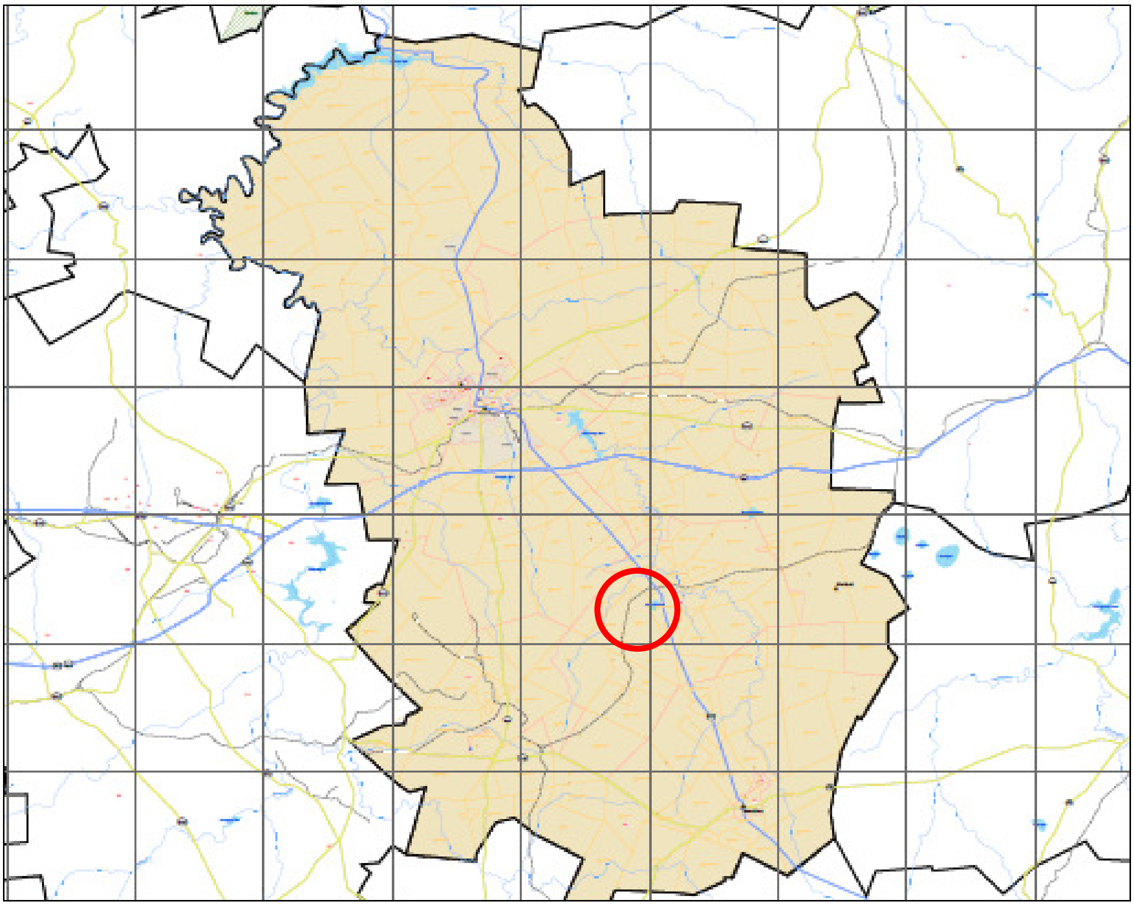

Figure 7.1: The location of the Hendrina Power Station within the Steve Tshwete Local Municipality

7.2.2 Study Area

During the Screening process 5 potential alternative sites for the new proposed wet ash disposal facility were identified within the demarcated study area (**Figure 7.2**). These 5 sites where investigated during the Scoping phase of the project and underwent both a site preference rating as well as a fatal flaw analysis (according to the DWA Minimum Requirements, 2nd ed, 1998). Through these two processes Site E was identified as the preferred site out of the 5 original sites (**Figure 7.3**).

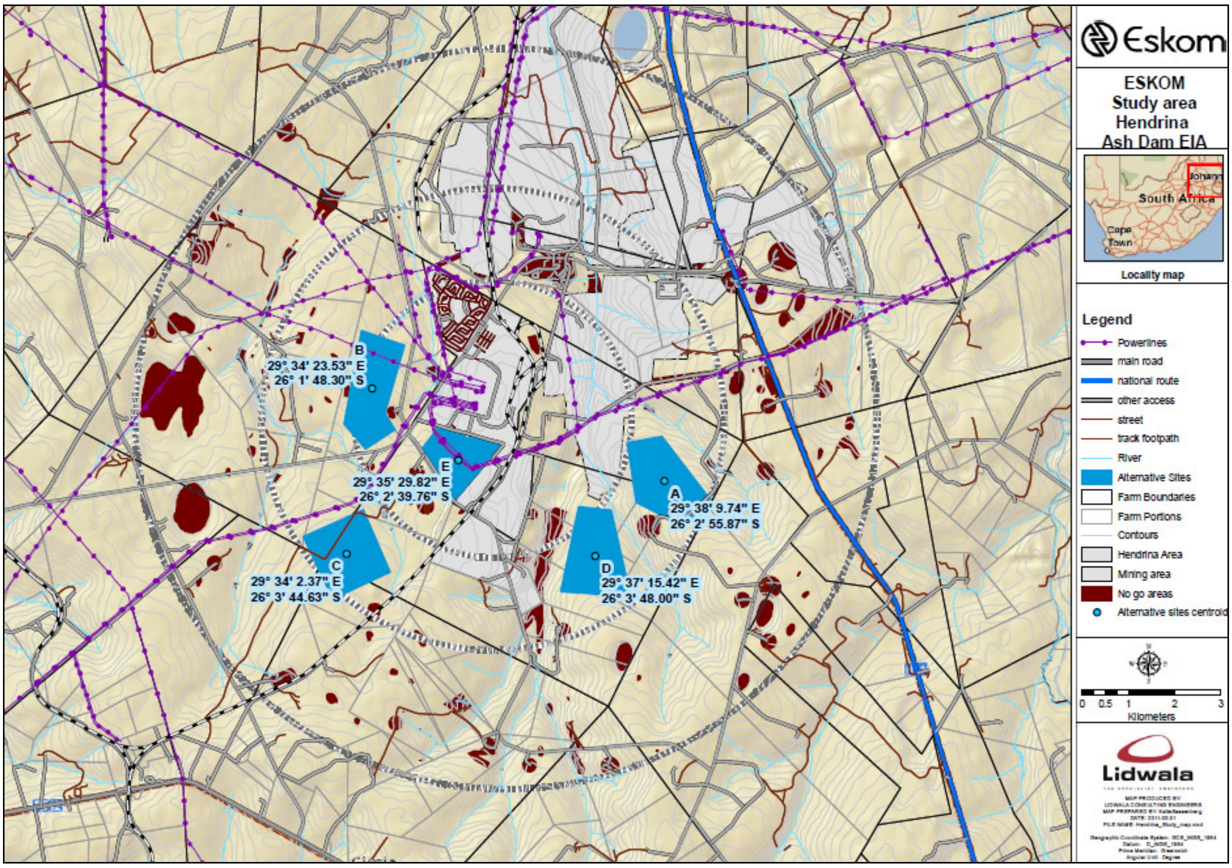

Figure 7.2: The location of the 5 alternatives identified within the demarcated study area during the screening phase

Figure 7.3: Alternative E – Preferred site identified during the Scoping Phase

Table 7.1 outlines the farms associated with preferred site – Alternative E

Table 7.1: Farm Portion associated with Alternative E

SG_CODE	FARM_NO	PORTION	FARM NAME
Alternative E			
T0IS00000000015400008	154	00008	BOSCHMANSKOP 154 IS

Due to the fact that Alternative E was identified as the preferred site, and the site has Transmission lines and a bulk water supply pipeline crossing through it, the EIA is also required to assess alternative corridor alignments for the relocation of three Transmission lines and a DWA bulk water pipeline that traverse Alternative E.

The alternatives identified for the transmission lines are shown in **Figure 7.4** and the alternative pipeline route is shown in **Figure 7.5.**

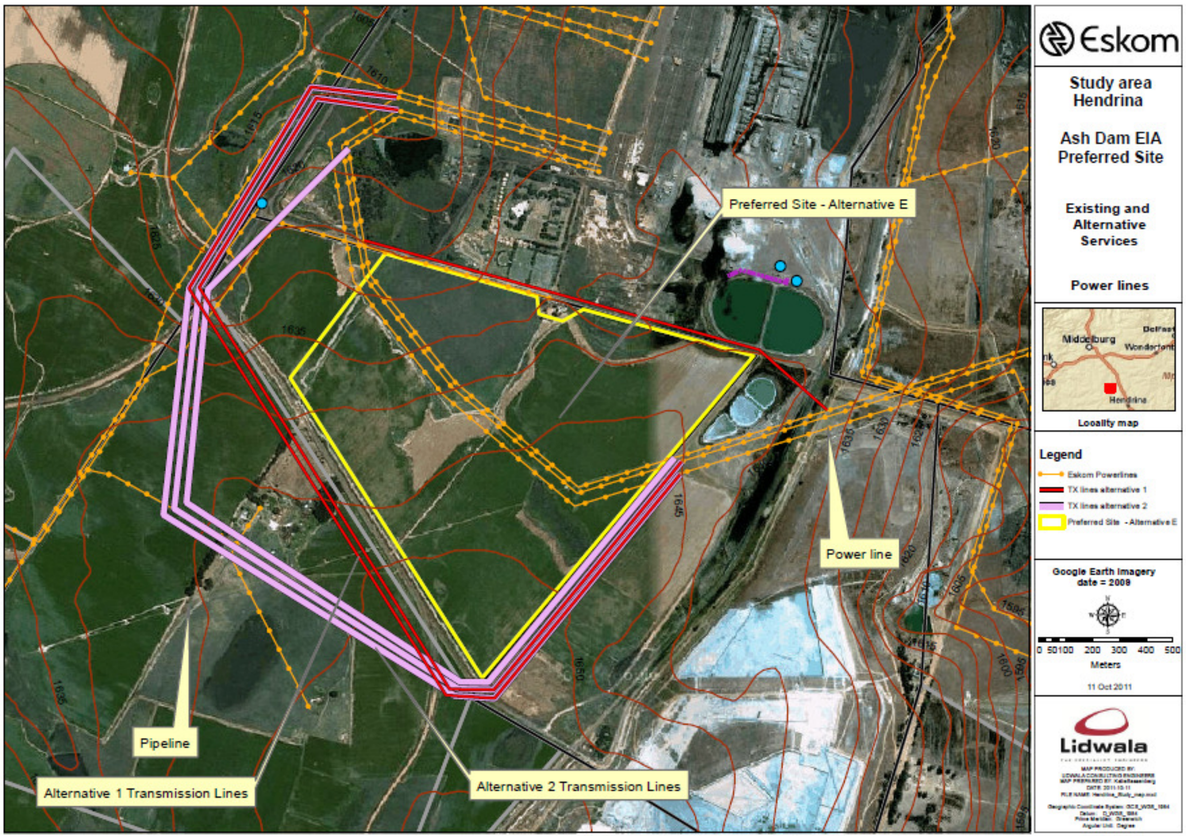

Figure 7.4: Transmission line re-alignment alternatives (Alternative 1 – thin red line, Alternative 2 – thick pink line)

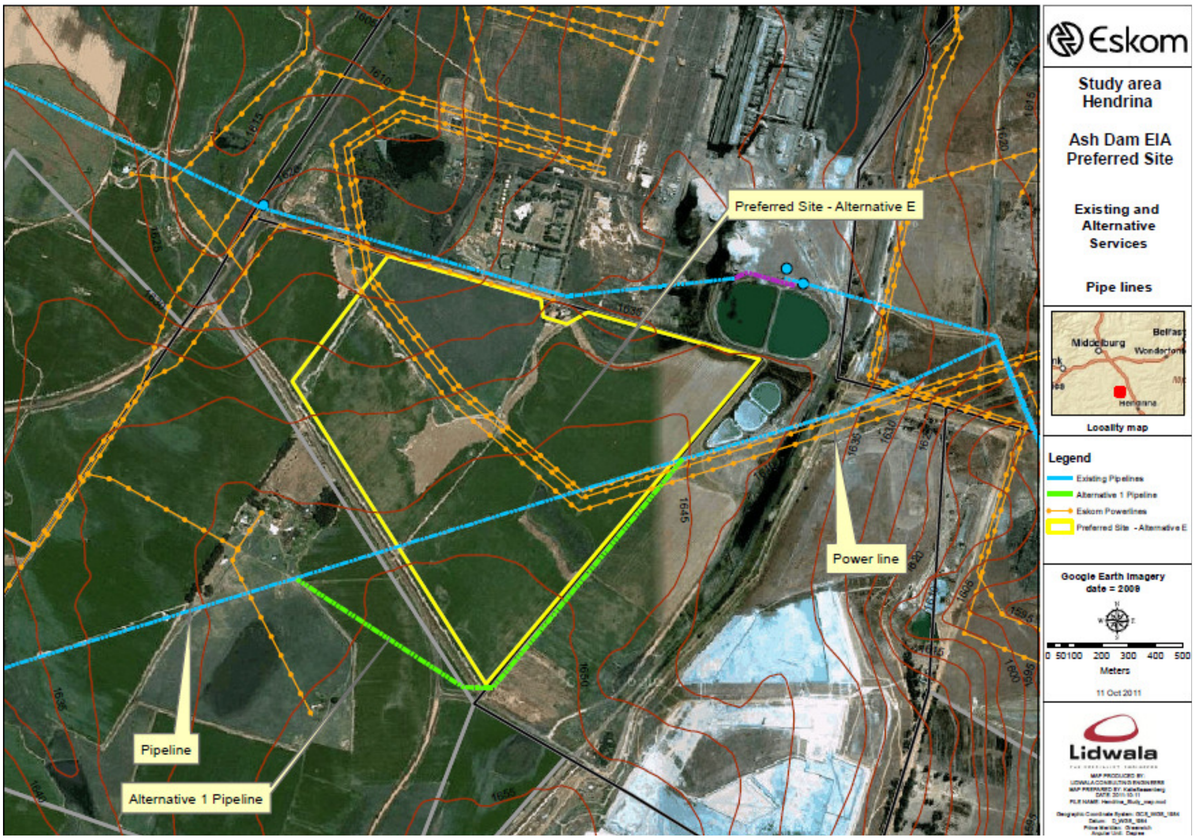

Figure 7.5: DWA Bulk water Pipeline realignment alternative (green line)

7.3 Topography

7.3.1 Description

The area within the study area is characterised by typical undulating terrain of the Mpumalanga Province. The natural topography of the greater area has been highly disturbed as a result of mining and agricultural activities.

- ***Alternative E***

Alternative E can be described as relatively flat, however it was noted that the site falls in two different directions thus effectively draining both to the east and west of the site. Alternative E's natural topography has been disturbed by agriculture, more specifically the farming of maize.

- ***Power line***

The topography of alignment for the two power line alternative corridors can be described as flat to undulating, similar to that of Alternative E, with no distinct topographical features apart from a pan to the south of the 2nd alternative alignment.

- ***Pipeline***

The topography of alignment for the two power line alternatives can be described as flat to undulating, similar to that of Alternative E, with no distinct topographical features apart from a pan to the south of the point where the proposed new alignment joins with the existing pipeline.

7.4 Climate and Air Quality

7.4.1 Description

The meteorological characteristics of a site govern the dispersion, transformation and eventual removal of pollutants from the atmosphere (Pasquill and Smith, 1983; Godish, 1990). The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth"s boundary layer. Dispersion comprises vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume „stretching". The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction and the variability in wind direction, determine the general path pollutants will follow, and the extent of cross-wind spreading (Shaw and Munn, 1971; Pasquill and Smith, 1983; Oke, 1990).

Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field. Spatial variations, and diurnal and seasonal changes in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). Atmospheric processes at macro- and meso-scales must be accounted for to accurately parameterise the atmospheric dispersion potential of a particular area. A qualitative description of the synoptic climatology of the study region is provided based on a review of the pertinent literature. The analysis of meteorological data observed for the proposed site, where available, and data for neighbouring sites will provide the basis for the parameterisation of the meso-scale ventilation potential of the site.

The analysis of at least one year of hourly average meteorological data for the study site is required to facilitate a reasonable understanding of the ventilation potential of the site. The most important meteorological parameters to be considered are: wind speed, wind direction, ambient temperature, atmospheric stability and mixing depth. Atmospheric stability and mixing depths are not routinely recorded and frequently need to be calculated from diagnostic approaches and prognostic equations, using as a basis routinely measured data, e.g. temperature, predicted solar radiation and wind speed.

No meteorological data are available for the Hendrina Power Station site and use was made of the MM5 calculated meteorological data for the proposed operations. Data for the period 1 January 2007 to 31 December 2009 were available for use in the study.

- ***Local wind field***

Figure 7.6 provides period wind roses for the proposed Hendrina wet ash disposal facility site, with **Figure 7.7** including the seasonal wind roses for the same site. The predominant wind direction is northwesterly and easterly with a >10% frequency of occurrence. Winds from the southwesterly sectors are relatively infrequent occurring <5% of the total period. Calm conditions (wind speeds < 1 m/s) occur for 11% of the time.

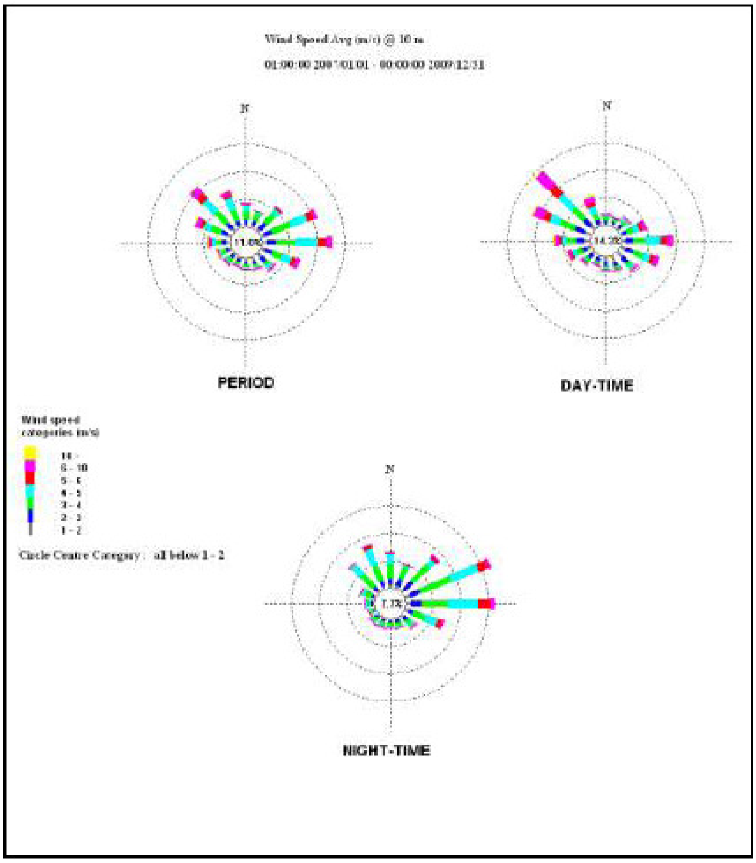

Figure 7.6: Period, day-time and night-time wind roses for Hendrina Wet Ash Disposal Facility (1 January 2007 to 31 December 2009)

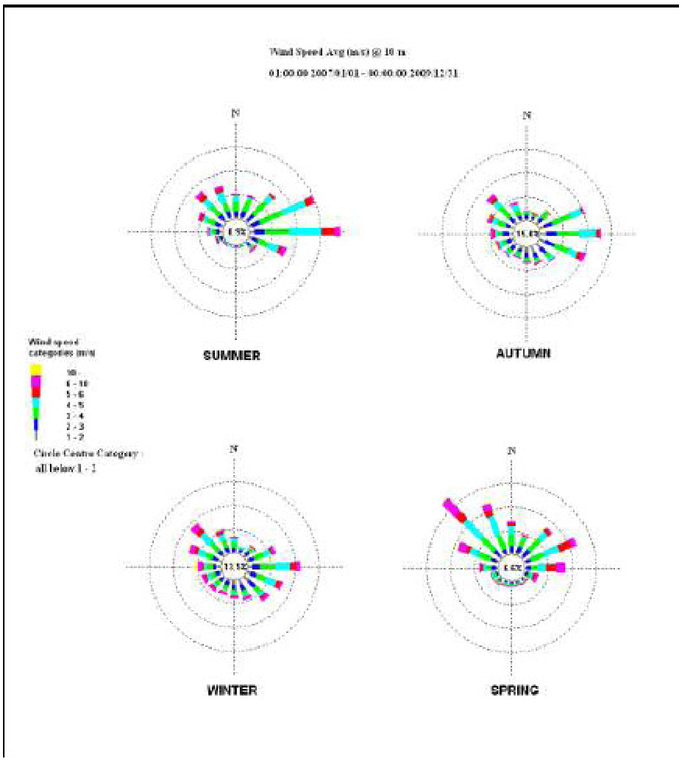

Figure 7.7: Seasonal wind roses for Hendrina Wet Ash Disposal Facility (1 January 2007 to 31 December 2009)

A frequent northwesterly flow dominates day-time conditions with ~15% frequency of occurrence. During the night-time an increase in easterly and east-northeasterly flow is observed with a decrease in northwesterly air flow. During summer months, winds from the east become more frequent, due to the strengthened influence of the tropical easterlies and the increasing frequency of occurrence of ridging anticyclones off the east coast. There is an increase in the frequency of calm periods (i.e. wind speeds <1 m/s) during the winter months of 13.5%.

Wind speeds in general range between 0 m/s and 14 m/s, with an average of 3.4 m/s.

- ***Surface Temperature***

Air temperature has important implications for the buoyancy of plumes; the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise. Temperature also provides an indication of the extent of insolation, and therefore of the rate of development and dissipation of the mixing layer.

The diurnal temperature profile for the site (2009) is given in **Figure 7.8**. Annual maximum, minimum and mean temperatures for the site are given as 25.7°C, 2.2°C and 15°C, respectively, based on the calculated MM5 data for the period 2009. Average daily maximum temperatures range from 25.7°C in December to 12.6°C in July, with daily minima ranging from 16.6°C in January to 2.2°C in July (**Figure 7.9**).

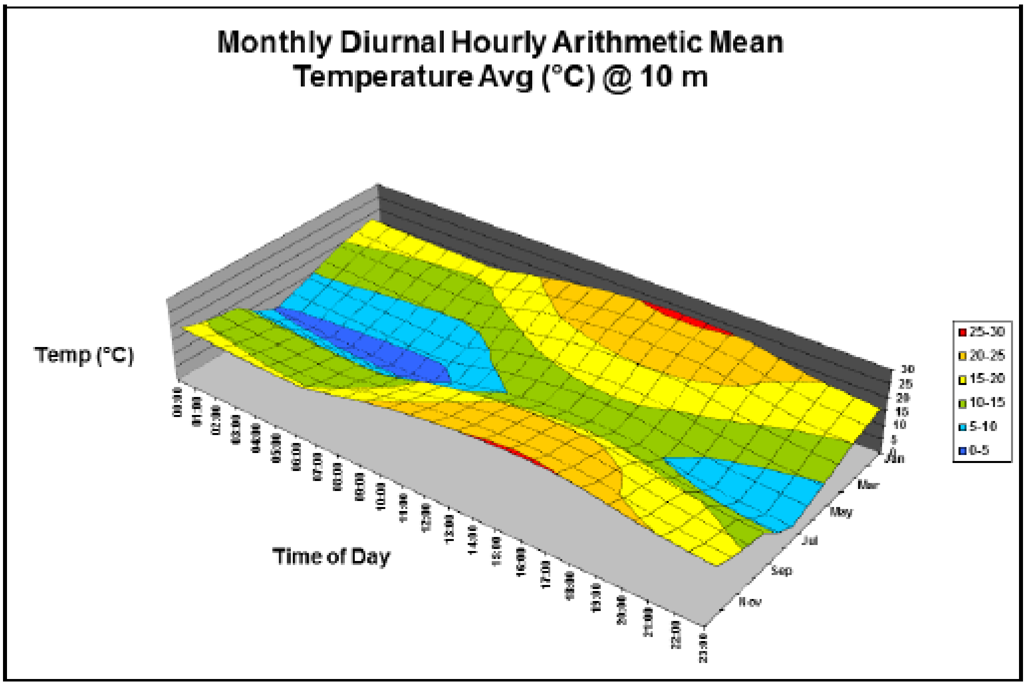

Figure 7.8: Diurnal temperature profile for the site (2009)

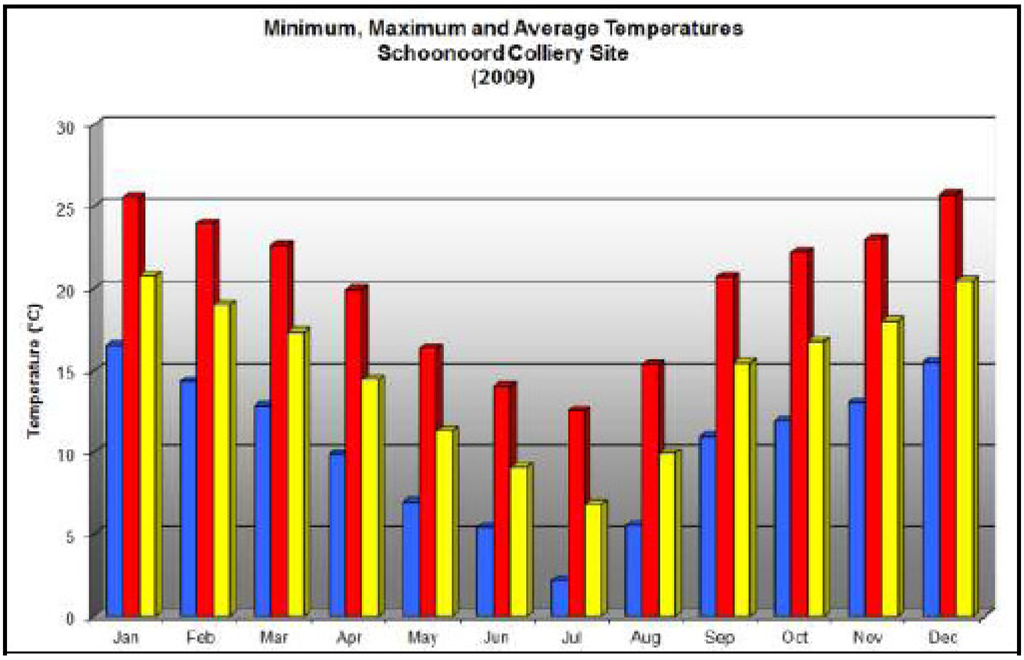

Figure 7.9: Minimum, maximum and average monthly temperatures for the site during the period 2009

- ***Precipitation***

Rainfall represents an effective removal mechanism of atmospheric pollutants and is therefore frequently considered during air pollution studies. Monthly rainfall for the site (2007 – 2009) is given in **Table 7.2**. Average monthly rainfall for this period is in the range of 306 mm. The study area falls within a summer rainfall region, with over 85% of the

annual rainfall occurring during the October to March period.

Table 7.2: Monthly average rainfall for the site for the period 2007 – 2009

Month	Average rain (mm)	Average No. hours>0.254mm	Average No. days>0.254mm
January	973	182	21
February	315	87	13
March	236	74	12
April	107	37	7
May	60	19	3
June	23	10	2
July	13	6	1
August	77	10	2
September	157	31	5
October	432	111	18
November	616	149	20
December	669	142	21

- ***Atmospheric Stability***

The vertical component of dispersion is a function of the extent of thermal turbulence and the depth of the surface mixing layer. Unfortunately, the mixing layer is not easily measured, and must therefore often be estimated using prognostic models that derive the depth from some of the other parameters that are routinely measured, e.g. solar radiation and temperature. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground based inversions and the erosion of the mixing layer. The mixing layer ranges in depth from ground level (i.e. only a stable or neutral layer exists) during night-times to the base of the lowest-level elevated inversion during unstable, day-time conditions.

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in **Table 7.3**.

Table 7.3: Atmospheric Stability Classes

A	Very unstable	Calm wind, clear skies, hot daytime conditions
B	Moderately unstable	Clear skies, daytime conditions
C	Unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong night-time inversions and a slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

For low level releases, such as due to vehicle entrainment from unpaved roads, the highest ground level concentrations will occur during weak wind speeds and stable (night-time) atmospheric conditions. Wind erosion, on the other hand, requires strong winds together with fairly stable conditions to result in high ground level concentrations i.e. neutral conditions.

- ***Ambient Air Quality within the Region***

The Department of Environmental Affairs (DEA) operates a monitoring network over the Highveld region at the residential areas of Hendrina, Ermelo, Middleburg, Secunda and eMalahleni. The closest monitoring station to the proposed operations is located at

Hendrina. The highest daily and monthly PM10 concentrations for the period 2008-2010 are given in **Figure 7.10** and **Figure 7.11** respectively.

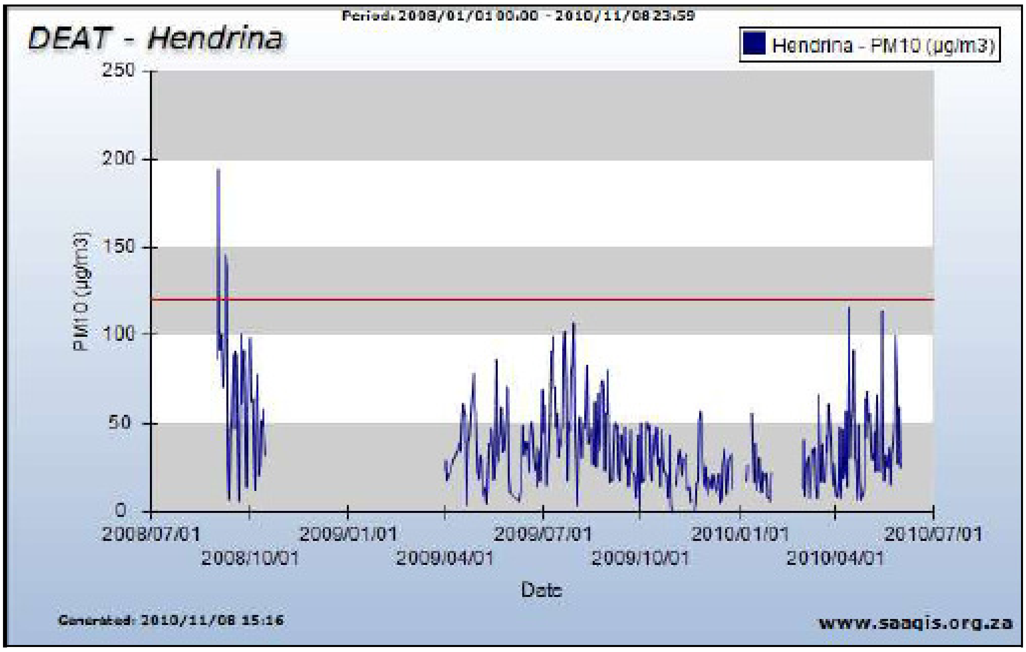

Figure 7.10: Daily measured PM_{10} ground level concentrations (µg/m³) at the Hendrina DEA monitoring station (for the period 2007-2010) (as downloaded from the SAAQIS website)

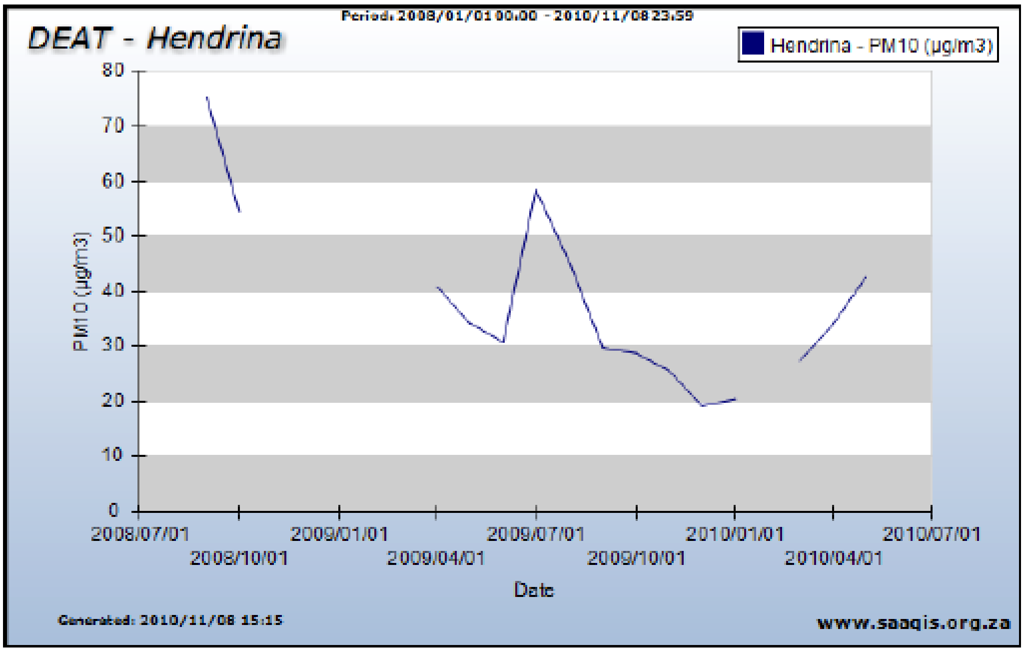

Figure 7.11: Monthly measured PM_{10} ground level concentrations (µg/m³) at the Hendrina DEA monitoring station (for the period 2007-2010) (as downloaded from the SAAQIS website)

Exceedances of SA air quality PM_{10} limits were found to occur at the Hendrina monitoring station. However, the National Ambient Air Quality Standards (NAAQS) allow 4 daily exceedances per calendar year. When compared to the NAAQS applicable immediately till 31 December 2014, the predicted PM_{10} concentrations for the period 2008 – 2010 were found to result in less than 4 allowable exceedances. For the NAAQS applicable from 1 January 2015, the predicted concentrations for the period 2008 – 2010 were found to result in more than 4 allowable exceedances for the period 2009. Annual concentrations were estimated from the monthly PM_{10} concentrations for the period April 2009 to March 2010.

High ambient particulate concentrations have been found to coincide with low ambient temperatures and low rainfall (Burger, 1994). Increases in domestic coal burning and poor atmospheric dispersion potentials, together with persistent industrial emissions, combine to produce elevated ambient concentrations during winter months. High concentrations during summer months are usually associated with increases in fugitive dust emissions. Rainfall events result in a reduction of airborne concentrations due to reductions in the potential for fugitive dust emissions and due to the removal of particulates in the atmosphere by raindrops.

7.5 Soil and Agricultural Potential

7.5.1 Description

Most parts of the site show that it was previously or is presently being cultivated. However, in the south-eastern corner there is a portion ($\pm$48 ha) that comprises disturbed soils due to excavation. There is an abandoned dwelling in the northern part (south of the power station).

Several soil map units were identified (**Figure 7.12**). A description of the most important soil characteristics of each unit, such as the dominant soil form and family, soil depth, topsoil texture and underlying material, is given in the soil legend shown in **Table 7.4**.

In general, the soils are moderately deep, yellow-brown to red, light- to medium-textured soils (**Av**, **Bv** and **Gc** map units), with no significant degree of structure. Shallower soils, with ferricrete outcrops in places, also occur (**Wa** map unit), as well as some areas of disturbance (**Ex** map unit). The soils in the lower-lying positions (**Tu** and **Ka** map units) are darker brown to black, with a slightly heavier texture and signs of wetness lower in the profile.

The map units are shown on the soil map in the Appendix as for the following example:

Av
61.72 ha

Where **Av** represents the map unit (in this case Avalon soils) and **61.72 ha** is the area.

Table 7.4: Soil map legend

Map Unit	Depth (mm)	Dominant Soil Form(s)	Sub-dominant Soil Form(s)	General description of soils occurring	Agricultural Potential
Structureless soils					
Av	500-1200	Avalon	Glencoe	Grey-brown, structureless, loamy sand to sandy loam topsoils on yellow-brown, structureless, loamy sand to sandy loam subsoils on grey, mottled, soft plinthite (**Avalon** form) or occasionally on cemented ferricrete (**Glencoe** form).	Moderate to high **(63.98 ha)**
Bv	750-1200+	Bainsvlei	Hutton	Reddish, structureless, sandy loam topsoils on red, structureless, sandy loam to sandy clay loam subsoils on grey mottled, soft plinthite (**Bainsvlei** form). Where no plinthite is present, the soils belong to the **Hutton** form.	Moderate to high **(56.37 ha)**
Gc	400-700	Glencoe	Glenrosa, Avalon	Grey-brown, structureless, loamy sand to sandy loam topsoils on yellow-brown, structureless, loamy sand to sandy loam subsoils on cemented ferricrete (**Glencoe** form).	Low to moderate **(8.40 ha)**
Wa	500-900	Wasbank	Dresden	Grey-brown, structureless to weakly structured, sandy loam topsoils on greyish, structureless, sandy loam subsoils, on hard plinthic (**Wasbank** form). Where grey subsoil horizon is absent, the soils belong to the **Dresden** form.	Low to moderate **(6.17 ha)**
Soils with signs of wetness					
Tu	500-900	Tukulu	Avalon	Dark brown, structureless to weakly structured, sandy loam to sandy clay loam topsoils on yellow-brown to dark grey, weakly structured, mottled, sandy clay loam subsoils, on grey, mottled clay (**Tukulu** form), occasionally on grey, mottled, soft plinthite (**Avalon** form).	Low **(17.91 ha)**
Ka	200-350	Katspruit	-	Brown to dark brown, weakly structured, sandy clay loam topsoils on dark brown to dark grey-black, weakly structured,	Very low **(7.08 ha)**

				sandy clay loam subsoils, often wet (**Katspruit** form).	
Miscellaneous					
Ex	-	-	-	Much topsoil removed through excavation, signs of red deep soils, but much mixing and disturbance	Very low **(48.13 ha)**
TOTAL AREA					**208.04 ha**

More detail can be found in the Soil Study included in **Appendix J**.

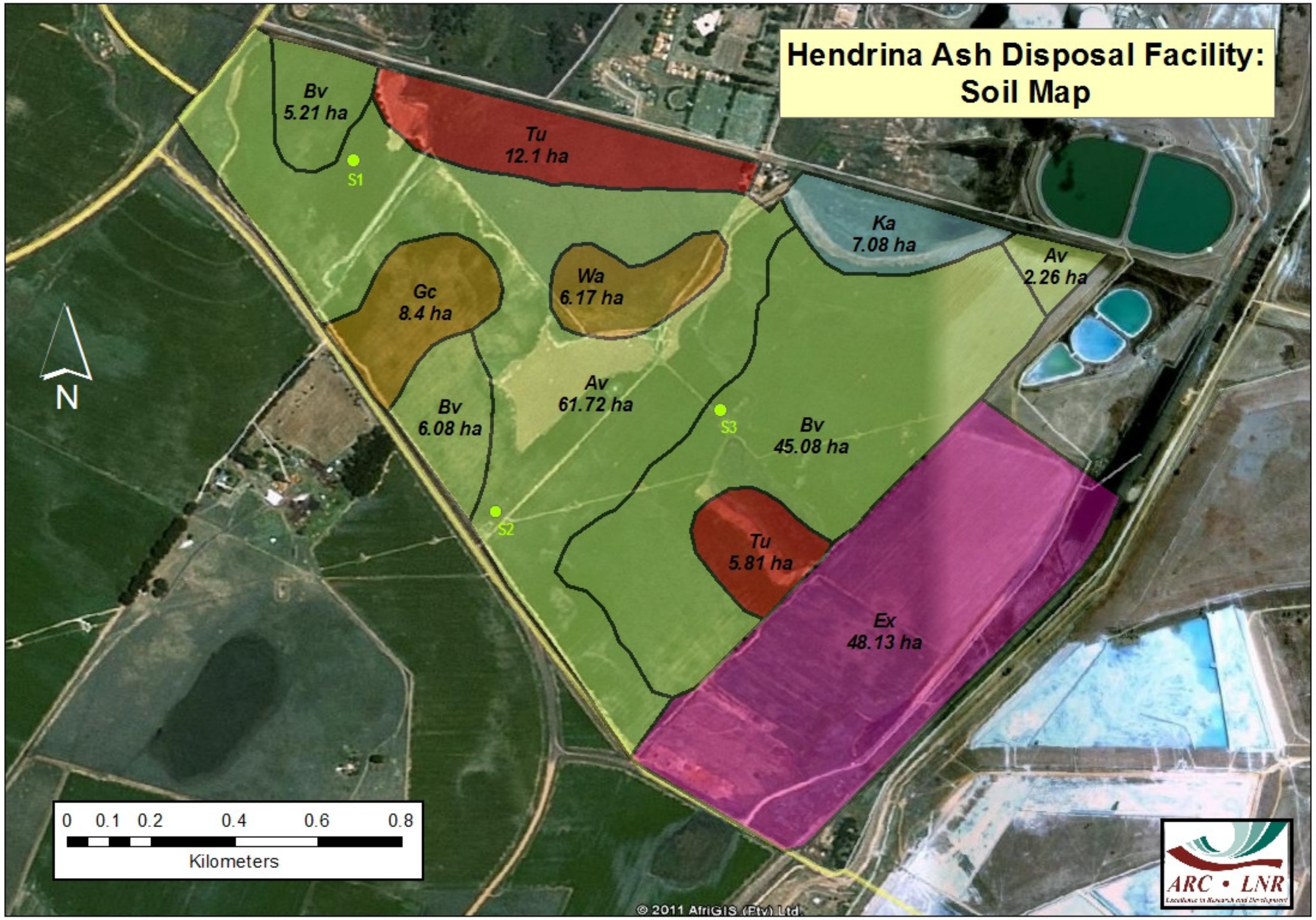

Figure 7.12: Soil Map for Alternative E

7.6 Geology

7.6.1 Description

Hendrina power station and surrounds is located on coal-bearing rocks of the Vryheid Formation, part of the Ecca Group of the lower Karoo Supergroup. These rocks are principally deltaic and fluvial siltstones and mudstones, with subordinate sandstones (Johnson et al, 2006). The coal seams originated as peat swamps, or similar environments. Where the Dwyka Group is absent (suspected in the study area) the Vryheid Formation has been deposited directly onto rugged pre-Karoo topography and the thickness of the Formation can be quite variable as a result. The Vryheid Formation rocks are well lithified (hard) and have little primary porosity. The geological map (Figure 3-1) also identifies outcrops of volcanic rocks (Rooiberg Group) within the catchment area. Immediately to the south-west of the current wet ash disposal facilitys there is a large outcrop of the Rooiberg Formation which consists predominantly of flow-banded rhyolite. Another outcrop lies to the north-west of the existing ash disposal facility. Volcanic rocks of the Kwaggasnek Formation outcrop along the lower reaches (within the catchment area) of the Woes-Allen Spruit (West) and typically consist of flow-banded rhyolite with quartzite xenoliths. The geological map also identifies a small area of quaternary deposits along the course of the Woes-Allen Spruit (West). The geology of the Hendrina area is shown in **Figure 7.13**.

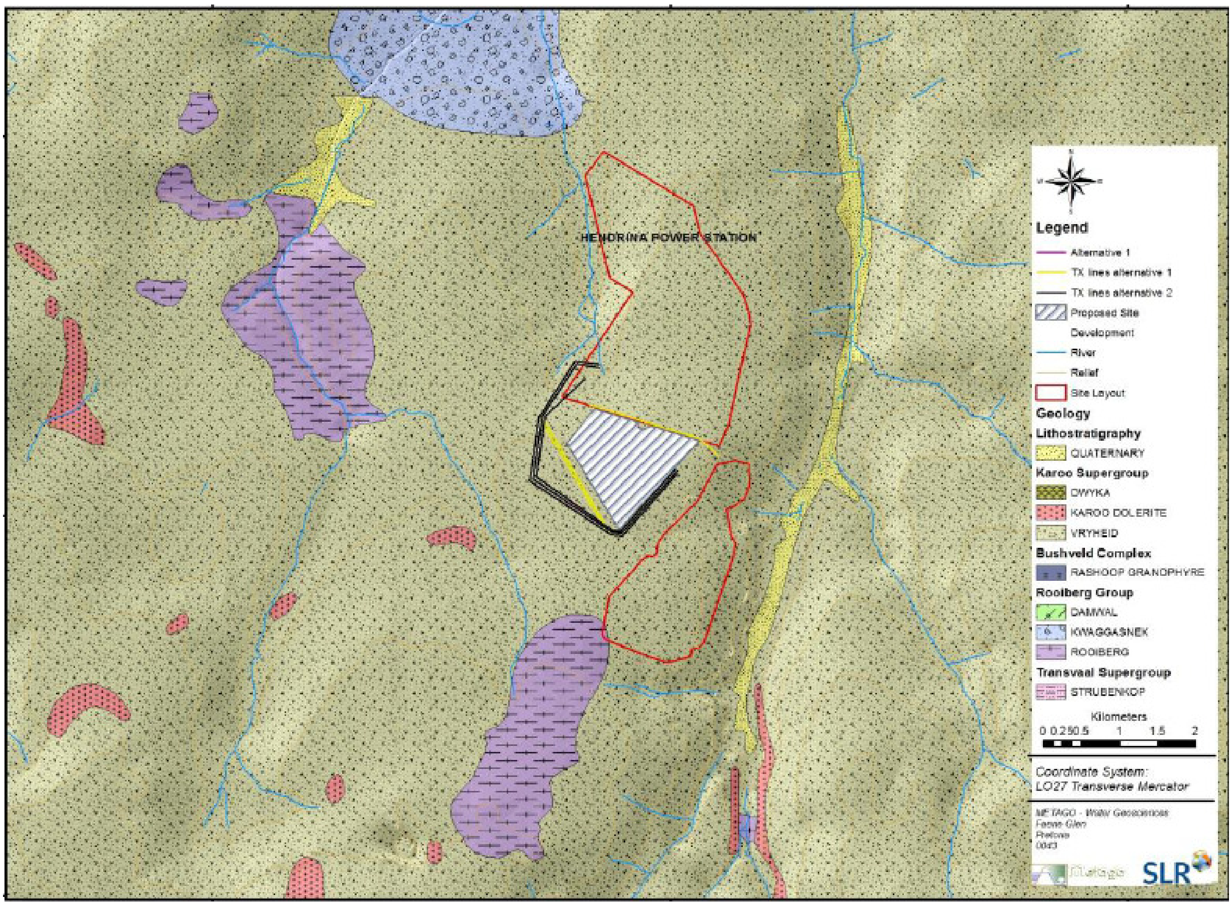

Figure 7.13: Geology of the Hendrina area

7.7 Biodiversity

7.7.1 Description - General

- **Terrestrial Biodiversity Sensitivities on a Local Scale**

The local and regional designation of Mpumalanga Terrestrial Biodiversity Conservation Categories (MBCP) is illustrated in **Figure 7.14.**

The mandate for conserving biodiversity lies with state agencies at national, provincial and local levels of government, forming part of a wider responsibility for the environment and the sustainable use of natural resources. Constitutional and national laws require these environmental issues to be dealt with in cooperative, participatory, transparent and integrated ways. The MBCP is the first spatial biodiversity plan for Mpumalanga that is based on scientifically determined and quantified biodiversity objectives. The purpose of the MBCP is to contribute to sustainable development in Mpumalanga.

The MBCP maps the distribution of Mpumalanga Province's known biodiversity into six categories. These are ranked according to ecological and biodiversity importance and their contribution to meeting the quantitative targets set for each biodiversity feature. The categories are:

1 Protected areas - already protected and managed for conservation;
2 Irreplaceable areas - no other options available to meet targets––protection crucial;
3 Highly Significant areas - protection needed, very limited choice for meeting targets;
4 Important and Necessary areas - protection needed, greater choice in meeting targets;
5 Ecological Corridors – mixed natural and transformed areas, identified for long term connectivity and biological movement;
6 Areas of Least Concern – natural areas with most choices, including for development;
7 Areas with No Natural Habitat Remaining – transformed areas that do not contribute to meeting targets.

The study area comprises two of these categories, namely:

- No Natural Habitat Remaining; and
- Least Concern.

Areas of '**No Natural Habitat Remaining**' comprise approximately 35.8% of the Province. This category has already lost most of its biodiversity and ecological functioning. In the remnants of natural habitat that occur between cultivated lands and along river lines and ridges, residual biodiversity features and ecological processes do survive, but these disconnected remnants are biologically impoverished, highly vulnerable to damage and have limited likelihood of being able to persist. The more transformed a landscape becomes; the more value is placed on these remnants of natural habitat. Areas with no natural habitat remaining are preferred sites for developments, taking the potential presence of lands with high agricultural potential into consideration.

Biodiversity assets in landscapes categorized as '**Least Concern**' contributes to natural ecosystem functioning, ensuring the maintenance of viable species populations and providing essential ecological and environmental goods and services across the landscape. This category comprises approximately 25.5% of the Mpumalanga Province and although these areas contribute the least to the achievement of biodiversity targets they have significant environmental, aesthetic and social values and should not be viewed as wastelands or carte-blanche development zones. Development options are widest in these areas. At the broad scale, these areas and those where natural habitat has been lost serve as preferred sites for all forms of development. It is still required to consider other environmental factors such as socioeconomic efficiency, aesthetics and the sense-of-place in making decisions about development. Prime agricultural land should also be avoided for all non-agricultural land uses. Land-use and administrative options for positive biodiversity outcomes include:

- Where this category of land occurs close to areas of high biodiversity value, it may provide useful ecological connectivity or ecosystem services functions, e.g. ecological buffer zones and corridors or water production. Encouragement needs to be given to biodiversity-friendly forms of management and even restoration options where appropriate;
- Develop incentives to reverse lost biodiversity for selected parcels of land where buffer zones and connectivity are potentially important;
- Standard application of EIA and other planning procedures are required; and
- These areas might serve as preferred sites for all forms of urban and industrial development (Land-Use Types 10 – 15).

- *Development Restrictions in Terms of the MBCP*

  The MBCP suggests that the categories of 'Irreplaceable' and 'Highly Significant' should remain unaltered and rather be managed for biodiversity conservation purposes. Other categories incorporate increasing options for different types of land use that should be decided by the application of EIA procedures and negotiation between stakeholders. The MBCP also recognised that 35.8% of the Province is included in the category of 'No natural habitat remaining', which has very little biodiversity value.

  The proposed development relates to 'Mining Activities' (Land Use 15 - Surface mining, dumping, dredging) and is included in the category 'Urban Industrial Land Uses' with the other development types such as Urban & Business Development, Major Development Projects, Linear Engineering Structures and Water Projects & Transfers.

These six land uses cause the greatest environmental impact and are almost completely destructive of natural vegetation and natural biodiversity. Where biodiversity persists, it is artificially maintained, generally supporting only opportunistic assemblages of plants and animals. Ecosystem processes are completely disrupted, heavily impacted or artificially maintained at high cost. These land uses not only produce the highest local impacts but also dominate the dispersed and cumulative impacts. They are the most destructive and wide-ranging, often spreading hundreds of kilometres from their source, especially along river systems. These land-use types also require special provision in land-use planning, impact assessment and mitigation.

Restrictions in terms of major developments according to the Mpumalanga Biodiversity Conservation Plan (MBCP) are illustrated in **Figure 7.15**. The proposed activity is regarded a 'Restricted' activity, but it is evident that the database does not consider smaller, localised biodiversity variations. These aspects will be addressed in the subsequent chapters.

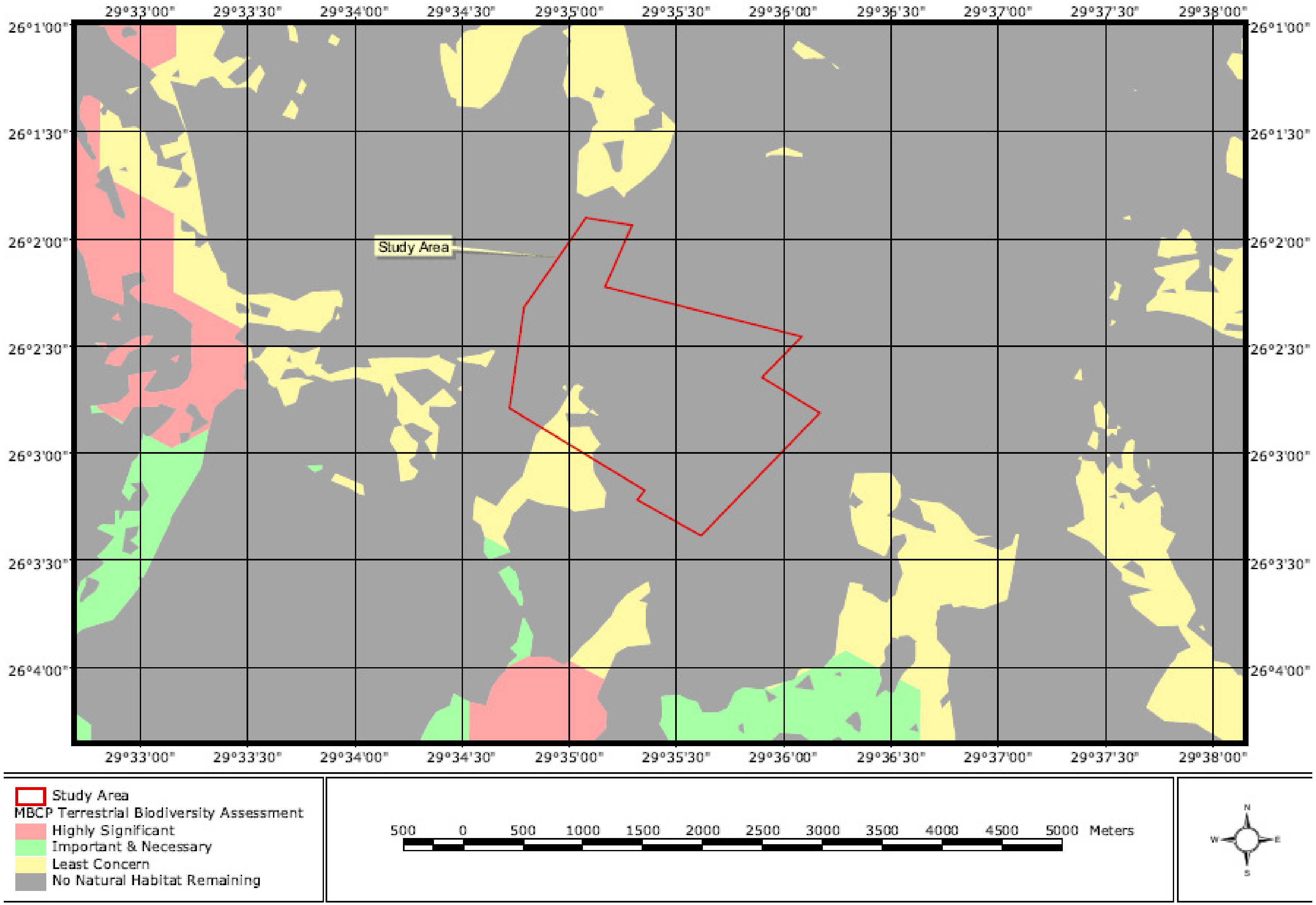

Figure 7.14: MBCP Conservation categories of the study area

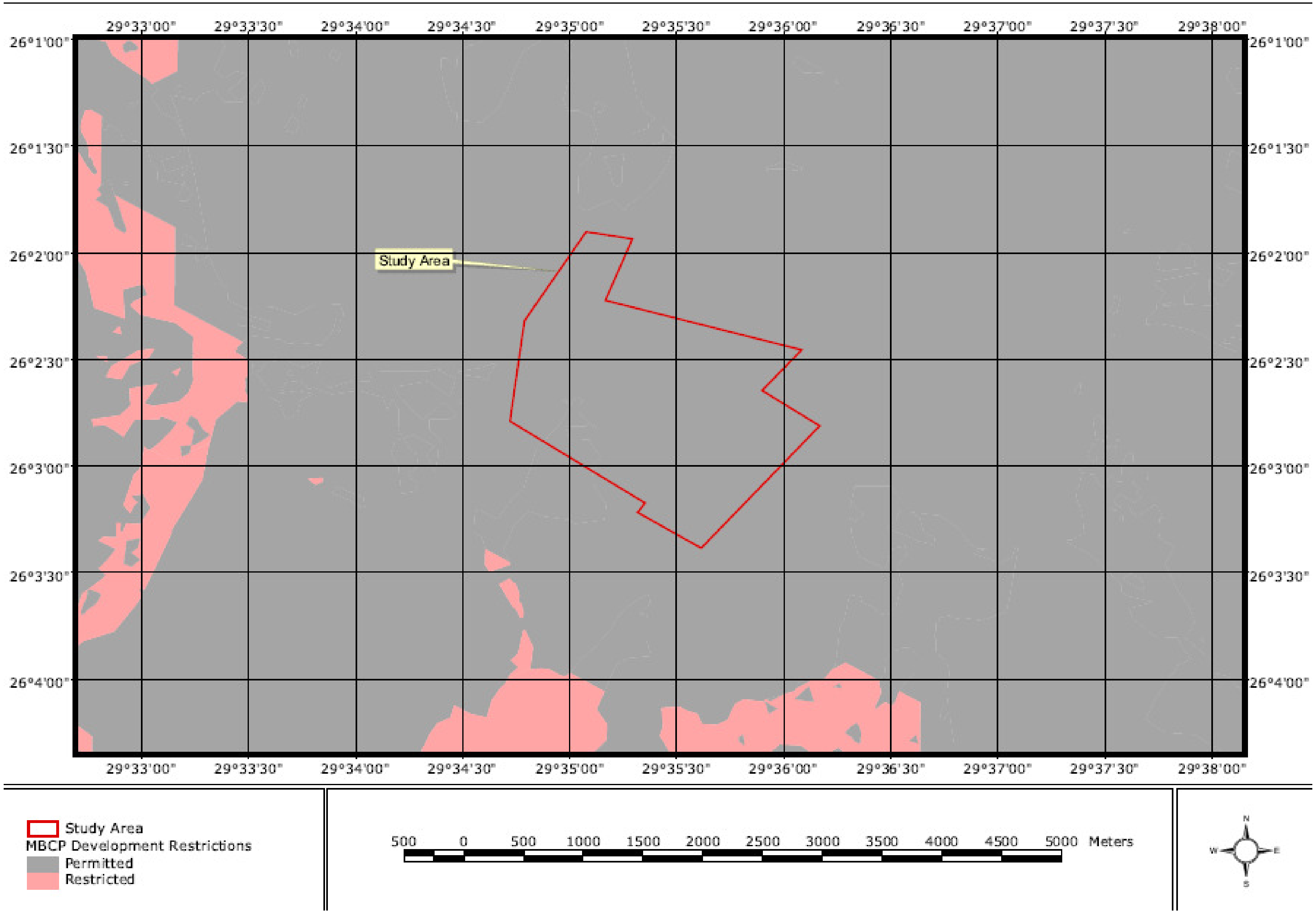

Figure 7.15: Development limitations in terms of the MBCP (Surface Mining)

7.7.2 Description - Flora

- **Regional Vegetation**

The study area is located in the Mesic Highveld Grassland Bioregion (Mucina & Rutherford, 2006), more specifically the Eastern Highveld Grassland vegetation type. This vegetation type is regarded Endangered and only very small fractions are conserved in statutory reserves. Some 44% is transformed by cultivation, plantations, mines, urbanisation and by building of dams. Cultivation may have had a more extensive impact, indicated by land cover data. The Endangered status of this vegetation type warrants a medium-high environmental sensitivity.

The vegetation is short, dense grassland dominated by the usual highveld grass composition (*Aristida, Digitaria, Eragrostis, Themeda, Tristachya*, etc.) with small, scattered rocky outcrops with wiry, sour grasses and some woody species (Acac*ia caffra, Celtis africana, Diospyros lycioides, Parinari capensis, Protea caffra, P. welwitchii* and *Searsia magalismontana*). The following species are regarded representative of the Eastern Highveld Grassland vegetation type:

- **Graminoids**
  Aristida aequiglumis, A. congesta, A. junciformis subsp*. galpinii, Brachiaria serrata, Cynodon dactylon, Digitaria monodactyla, D. tricholaenoides, Elionurus muticus, Eragrostis chloromelas, E. curvula, E. plana, E. racemosa, E. sclerantha, Heteropogon contortus, Loudetia simplex, Microchloa caffra, Monocymbium ceresiiforme, Setaria sphacelata, Sporobolus africanus, S. pectinatus, Themeda triandra, Trachypogon spicatus, Tristachya leucothrix, T. rehmannii, Alloteropsis semialata* subsp*. eckloniana, Andropogon appendiculatus, A. schirensis, Bewsia biflora, Ctenium concinnum, Diheteropogon amplectens, Eragrostis capensis, E. gummiflua, E. patentissima, Harpochloa falx, Panicum natalense, Rendlia altera, Schizachyrium sanguineum, Setaria nigrirostris* and *Urelytrum agropyroides.*

- **Herbs**
  Berkheya setifera, Haplocarpha scaposa, Justicia anagalloides, Pelargonium luridum, Acalypha angustata, Chamaecrista mimosoides, Dicoma anomala, Euryops gilfillanii, E. transvaalensis subsp*. setilobus, Helichrysum aureonitens, H. caespititium, H. callicomum, H. oreophilum, H. rugulosum, Ipomoea crassipes, Pentanisia prunelloides* subsp*. latifolia, Selago densiflora, Senecio coronatus, Vernonia oligocephala Wahlenbergia undulata, Gladiolus crassifolius, Haemanthus humilis* subsp*. hirsutus, Hypoxis rigidula* var*. pilosissima, Ledebouria ovatifolia* and *Aloe ecklonis*

- **Low Shrubs**
  Anthospermum rigidum subsp*. pumilum* and *Stoebe plumosa.*

- **Regional Diversity**

The SANBI database indicates the known presence of only 38 plant species within this particular ¼-degree grid (2629BA). This low diversity is the result of the poor floristic knowledge of the area and is not a reflection of a poor habitat and floristic diversity. The following plant species are known to occur in the region of the study area (POSA, 2010):

Table 7.5: PRECIS data for 2629BA (POSA, 2010)

Species	**Family**	**Threat**	**Growth forms**
Ceratiosicyos laevis	Achariaceae	LC	Climber, shrub
Alepidea peduncularis	Apiaceae	DDT	Herb
Asclepias gibba	Apocynaceae	LC	Herb
Aponogeton junceus	Aponogetonaceae	LC	Geophyte
Schkuhria pinnata	Asteraceae		Herb
Bryum dichotomum	Bryaceae		Bryophyte
Cyperus difformis	Cyperaceae	LC	Cyperoid
Cyperus laevigatus	Cyperaceae	LC	Cyperoid
Cyperus marginatus	Cyperaceae	LC	Cyperoid
Fimbristylis complanata	Cyperaceae	LC	Cyperoid
Isolepis costata	Cyperaceae	LC	Cyperoid
Isolepis setacea	Cyperaceae	LC	Cyperoid
Kyllinga pulchella	Cyperaceae	LC	Cyperoid
Pycreus macranthus	Cyperaceae	LC	Cyperoid
Pycreus nitidus	Cyperaceae	LC	Cyperoid
Pycreus rehmannianus	Cyperaceae	LC	Cyperoid
Eriocaulon abyssinicum	Eriocaulaceae	LC	Herb
Acalypha angustata	Euphorbiaceae	LC	Dwarf shrub
Lespedeza cuneata	Fabaceae		Dwarf shrub
Trifolium africanum var. africanum	Fabaceae	LC	Herb
Pelargonium pseudofumarioides	Geraniaceae	LC	Herb
Eucomis autumnalis subsp. clavata	Hyacinthaceae		Geophyte
Juncus dregeanus subsp. dregeanus	Juncaceae	LC	Helophyte
Linum thunbergii	Linaceae	LC	Herb
Mossia intervallaris	Mesembryanthemaceae	LC	Succulent
Alloteropsis semialata subsp. eckloniana	Poaceae	LC	Graminoid
Andropogon eucomus	Poaceae	LC	Graminoid
Digitaria ternata	Poaceae	LC	Graminoid
Eragrostis curvula	Poaceae	LC	Graminoid
Eragrostis mexicana subsp. virescens	Poaceae		Graminoid
Eragrostis patentissima	Poaceae	LC	Graminoid
Hyparrhenia hirta	Poaceae	LC	Graminoid
Panicum schinzii	Poaceae	LC	Graminoid
Sporobolus albicans	Poaceae	LC	Graminoid
Riccia cavernosa	Ricciaceae		Bryophyte
Riccia natalensis	Ricciaceae		Bryophyte
Riccia rosea	Ricciaceae		Bryophyte
Riccia stricta	Ricciaceae		Bryophyte

- **Plant Species of Conservation Importance**

No floristic species of conservation importance is known to occur in this region, according to the POSA database. Areas of natural grassland habitat and wetland habitat exhibit moderate levels of suitability for the potential presence of flora species of conservation importance, considering the current status.

- **Floristic Diversity of the Site**

The site investigation revealed the presence of approximately 71 plant species in the study area (**Appendix 1 of the Biodiversity Report in Appendix K**). The diversity of this portion of land, in spite of the degraded status of the site, is regarded relative diverse, reflecting not only on the species richness of the regional vegetation type, but also the effect of transformation and the influx of plant species not normally associated with the region, such as weeds and alien invasive species.

The grassland physiognomy of the region is indicated by the absence of woody species in areas of natural vegetation. Grasses and forbs constitute the majority of the composition (**Table 7.6**). Grasses (12 species, 17.1%) and forbs (40 species, 57.1%) dominate the species diversity (**Table 7.6**).

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Table 7.6: Growth forms of the study area

Growth Form	Number	Percentage
Climbers	1	1.43%
Forbs	40	57.14%
Geophytes	4	5.71%
Grasses	12	17.14%
Hydrophilics	4	5.71%
Sedges	4	5.71%
Shrubs	3	4.29%
Trees	2	2.86%
Total	**70**	

A total of 24 plant families are represented by the floristic diversity of the site, dominated by Asteraceae (24 species, 34.3%) and Poaceae (13 species, 18.6%) (**Table 7.7**).

Table 7.7: Plant families of the study area

Family	Number	Percentage
Amaranthaceae	1	1.43%
Anacardiaceae	1	1.43%
Apiaceae	1	1.43%
Asclepiadaceae	2	1.43%
Asteraceae	24	1.43%
Caesalpiniaceae	1	1.43%
Cyperaceae	4	1.43%
Dipsacaceae	1	1.43%
Fabaceae	4	1.43%
Hypoxidaceae	2	1.43%
Iridaceae	1	1.43%
Lobeliaceae	1	1.43%
Myrsinaceae	1	1.43%
Orchideaceae	1	1.43%
Oxalidaceae	1	2.86%
Plantaginaceae	2	2.86%
Poaceae	13	2.86%
Polygonaceae	1	2.86%
Rubiaceae	2	4.29%
Scrophulariaceae	1	5.71%
Solanaceae	1	5.71%
Thymelaeaceae	1	18.57%
Typhaceae	1	34.29%
Verbenaceae	3	1.43%

- **Flora Species of Conservation Importance**

- *Red List Species*

South Africa's Red List system is based on the IUCN Red List Categories and Criteria Version 3.1 (finalized in 2001), amended to include additional categories to indicate species that are of local conservation concern. The IUCN Red List system is designed to detect risk of extinction. Species that are at risk of extinction, also known as threatened or endangered species are those that are classified in the categories Critically Endangered (CR), Endangered (EN) and Vulnerable (VU).

The South African Red List contains three additional categories (Critically Rare, Rare and Declining) to highlight plant species that are not in danger of extinction, but are of local conservation concern because they are rare, or there are threatening processes affecting their populations. These categories have been developed to highlight those taxa classified as Least Concern according to the IUCN system, should be considered in conservation prioritization processes. It is important to emphasize that the South African categories Critically Rare, Rare and Declining are intended for use in local conservation prioritization processes only. In submission to the IUCN Red List of Threatened Species, these taxa have to be categorized according to the IUCN system and therefore their global status will be Least Concern.

No Threatened plant species were observed during the site investigation. Taking the habitat variability and status into consideration, it is regarded unlikely that species of conservation importance will occur within these parts. However, parts of the study area, endorheic pans in particular are regarded moderately suitable for the presence of Crinum bulbispermum (Declining), Nerine gracilis (Near Threatened) and Kniphofia typhoides (Near Threatened).

- *Protected Tree Species*

According the Act (National Forests Act (Act no 84 of 1998)), the Minister may declare a tree, group of trees, woodland or a species of trees as protected. The prohibitions that 'no person may cut, damage, disturb, destroy or remove any protected tree, or collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any protected tree, except under a license granted by the Minister.

No tree species that are currently included in the National Forests Act is present within the study area.

- **Alien & Invasive Plant Species**

The following invasive and weed species were noted on the study site (**Table 7.8**). Some of these species occur at densities that approximate a dominant status. The generally degraded nature of most of the site is indicated by the presence of these species, dominant species in particular.

Table 7.8: Invasive and weed plant species of the study area

Species Name	Growth Form	Family	Status/ Uses
Amaranthus hybridus	Forb	Amaranthaceae	Edible parts
Bidens formosa	Forb	Asteraceae	Weed, exotic (S. America), aesthetic uses
Cirsium vulgare	Forb	Asteraceae	Declared Invader - Category 1, weed
Conyza bonariensis	Forb	Asteraceae	Weed, indicator of disturbed areas
Crepis hypochoeridea	Forb	Asteraceae	Weed, indicator of disturbed areas
Cynodon dactylon	Grass	Poaceae	Indicator of disturbed areas, grazing potential
Datura stramonium	Forb	Solanaceae	Declared Invader - Category 1, weed
Eucalyptus species	Tree	Myrsinaceae	Declared Invader - Category 2, essential oils
Galinsoga parviflora	Forb	Asteraceae	Weed
Gomphocarpus fruticosus	Shrub	Asclepiadaceae	Medicinal uses
Hypochaeris radicata	Forb	Asteraceae	Weed
Lactuca capensis	Forb	Asteraceae	Weed
Pennisetum clandestinum	Grass	Poaceae	Invader (E. Africa), palatable grazing
Pentarrhinum insipidum	Climber	Asclepiadaceae	Edible parts
Pseudognaphalium luteo-album	Forb	Asteraceae	Weed (Europe)
Richardia brasiliensis	Forb	Rubiaceae	Weed
Schkuhria pinnata	Forb	Asteraceae	Medicinal uses, weed (S. America)
Sonchus oleraceus	Forb	Asteraceae	Edible parts
Sonchus wilmsii	Forb	Asteraceae	Weed
Stoebe vulgaris	Shrub	Asteraceae	Invasive properties
Tagetes minuta	Forb	Asteraceae	Essential oils, colours & dyes
Verbena bonariensis	Forb	Verbenaceae	Weed (S. America)
Verbena brasiliensis	Forb	Verbenaceae	Weed (S. America)
Xanthium strumarium	Shrub	Asteraceae	Category 1, weed (S. America)

- **Macro Habitat Types**

Due to the relative high levels of transformation as well as low utilisation levels and the effect of frequent burning noted across most of the site, vegetation within the study area was found to be relatively degraded. Because of intensive human activities, remaining natural vegetation within the study area is not regarded representative of the regional vegetation type, i.e. pristine. Results of the photo analysis and site investigations revealed the presence of the following habitat types (**Figure 7.16**):

- Agricultural Fields (171.6ha, 49.7%);

- Excavations (11.9ha, 3.4%);
- Exotic Trees (5.4ha, 1.6%);
- Grassland (33.6ha, 9.7%);
- Moist Grassland (13.0ha, 3.8%);
- Rehabilitated Land (31.1ha, 9.0%);
- Roads & Railways (36.1ha, 10.5%);
- Transformed Habitat (11.8ha, 3.4%);
- Unrehabilitated Land (4.9ha, 1.4%) and;
- Wetland Habitat (26.1ha, 7.6%).

o *Agricultural Fields*

Cultivation represents the major land transformation activity in the region, resulting in a mosaical pattern of agricultural fields within a natural grassland environment. These areas comprise lands that are either currently actively cultivated for crops, or fallow fields where agricultural activities has ceased some time ago, but the vegetation still reflects the impact of transformation. Fallow fields are characterised by a composition of weeds and pioneer species, representing early successional stages of vegetation. These species will continuously be replaced by species that are better adapted to changing environmental conditions. Ultimately, a new climax status will be achieved, but the species composition and physiognomy will not be similar to the original status.

Species that indicate the poor habitat status of this habitat type include Bidens formosa, Chloris virgata, Cirsium vulgare, Crepis hypochoeridea, Cynodon dactylon, Galinsoga parviflora, Pennisetum clandestinum, Plantago longissima and Tagetes minuta. The absence of species that are normally associated with pristine regional grasslands is absent, or occurs at extremely low cover abundance levels. The original grassland vegetation in these parts is entirely compromised and is unlikely to recover to a status that approximates the original status. A low floristic status is consequently ascribed to these areas. No Red Data plant species were observed within these areas. The likelihood of encountering Red Data plant species within these areas are regarded low because of habitat transformation.

o *Excavations*

Excavations represent areas where significant surface disturbances resulted from the removal of all vegetation and part of the topsoil in the area. Since these areas are mostly devoid of any vegetation, a low floristic sensitivity was ascribed to all representative areas.

o *Exotic Trees*

Small stands of exotic trees occur in the study area, the most significant being associated with the homestead that is situated in close vicinity to one of the proposed power line alignments. This habitat type comprises all areas where natural vegetation has been replaced by stands of exotic trees, mostly Eucalyptus species. A low floristic status is ascribed to these areas and it is regarded highly unlikely that these areas will be inhabited by any Red Data flora species.

- *Grassland*

The natural grassland of the study areas are characterised by a short, low cover of herbaceous species, physiognomically dominated by grasses. The floristic status of these areas is largely determined by the intensity of grazing by cattle and sheep and by the intensity and frequency of burning. In areas where high grazing pressure predominate the vegetation is dominated by the grasses Eragrostis plana, E. chloromelas, Cynodon dactylon and the forbs Cirsium vulgare and Crepis hypochoeridea. The species diversity in these parts is frequently low. No area of particularly pristine status was observed within the study area. Other species that co-dominate the vegetation of this habitat type include Chamaecrista comosa, Digitaria eriantha, Eragrostis, chloromelas, E. plana, Gazania krebsiana, Helichrysum rugulosum, Hyparrhenia hirta, Richardia brasiliensis, Scabiosa columbaria, Senecio erubescens, S. inaequidens and Verbena bonariensis.

A medium floristic status is attributed to this variation, mainly because of the poor floristic status of remaining areas of natural grassland. It should be noted that the Endangered status of the regional vegetation type was also taken into consideration in this estimation. No Red Data plant species were observed within these areas. The likelihood of encountering Red Data plant species within these areas are regarded low because of poor habitat status.

- *Moist Grassland*

Small parts of the study area comprises grassland that occur in-between terrestrial and aquatic systems, usually situated on terrain type 4 (footslopes) in close vicinity to valley bottoms (drainage lines, streams, rivers, pans). This vegetation type is generally termed 'Hydromorphic Grasslands'. Soil conditions indicate temporary inundation during times of high rain, but are generally dry for the longest part of the year. Since this community occurs in close vicinity to wetland habitat systems, it are generally regarded as sensitive, but the poor floristic status that is observed resulted in a medium-low sensitivity ascribed to these parts. Only in one case was a relative pristine status noted and a medium high status and sensitivity was ascribed. Soils are frequently high in clay content and the vegetation is therefore highly palatable; a high grazing factor subsequently contributes to the moderately degraded status or some parts.

A relative low floristic diversity is noted in these parts. The physiognomy is grassland with a well-developed and dense herbaceous layer. Moist conditions are indicated by the presence of flora species that are well adapted to moist conditions, including Cyperus species, Denekia capensis, Eragrostis gummiflua, Homeria pallida, Imperata cylindrica, Lobelia species, Scirpus burkei, Senecio erubescens and Verbena brasiliensis.

The poor floristic status of portions of this unit is indicated by the (extensive) presence of the following weeds, Amaranthus hybridus, Bidens formosa, Crepis hypochoeridea, Hyparrhenia tamba, Paspalum dilatatum and in particular the grass Pennisetum clandestinum.

Depending on the level of degradation that is noted within portions of this habitat, the floristic sensitivity varies between medium-high and medium-low.

- *Rehabilitated Land*

A portion of the property constitutes an area where previous surface disturbances were rehabilitated (presumed) and some flora species were sown in. The surface soil conditions indicate the presence of stone granules that are more commonly associated with lower soil horizons. In addition, some parts are present where surface restructuring is incomplete and remaining topsoil are present. In spite of the rehabilitated status, the vegetation was found to be relatively diverse, albeit not representative of the regional vegetation. It would appear as if these areas are not grazed and the vegetation is afforded chance to develop constantly. Further evidence of the rehabilitated status of the vegetation is the relative low basal cover of these parts.

Species that abound in this area include Chamaecrista comosa, Bidens formosa, Cirsium vulgare, Conyza bonariensis, Crepis hypochoeridea, Cynodon dactylon, Digitaria eriantha, Eragrostis chloromelas, E. curvula, E. plana, Gazania krebsiana, Gnidia microcephala, Gomphocarpus fruticosus, Helichrysum argyrosphaerum, H. caespititium, H. rugulosum, Hyparrhenia hirta, H. tamba, Indigofera species, Nemesia fruticans, Oldenlandia herbacea, Richardia brasiliensis, Schkuhria pinnata, Tagetes minuta, Tephrosia species and Zornia linearis.

A medium-low floristic status is ascribed to this habitat type because of previous degradation. It is unlikely that this habitat is suitable for any flora species of conservation importance.

- *Roads & Railways*

No natural vegetation is associated with these features and a low floristic status is ascribed to these parts of the study area.

- *Transformed Habitat*

  This habitat type represents areas where historical or recent human activities led to transformation of the natural vegetation. No natural vegetation remains in these areas and the floristic status of these areas is therefore regarded low because of the secondary vegetation that characterises this community. The likelihood of encountering Red Data species within these areas are regarded low.

- *Unrehabilitated Land*

  This portion of land is situated within close proximity to the Rehabilitated portion of land. Evidence of surface disturbances is still evident and the bare nature to the soil indicates that no revegetation activities have been undertaken. No natural vegetation remains in this area and the floristic status is regarded low because of the secondary vegetation that characterises this community. The likelihood of encountering Red Data species within these areas are therefore regarded low.

- *Wetland Habitat*

  This habitat type correspond to the endorheic pans that are present within the study area where soils are inundated or standing water are present for extensive parts of the year. In spite of rain that occurred prior to the site investigation, no water was present within these parts at the time, but soils were moist. Vegetation of these parts has not had chance to develop and the poor floristic diversity that was noted during the survey is likely an indication of the seasonality and not a true reflection of the status of these areas.

  The floristic status of these areas is generally regarded medium-high and few impacts other than grazing and trampling, which are significant impacts on their own, were noted. Impacts on this habitat type include trampling of the topsoil by cattle, peripheral infestation by terrestrial species that abound in agricultural fields, cultivation and roads and other linear developments.

  In a pristine status, these areas would be dominated by a dense grass layer and diverse herbaceous composition. The vegetation composition is likely to be dominated by hydrophilic species or grass and forb species that are adapted to permanent or temporary inundation with water. Soils in these areas are frequently high in clay content and a significant humic layer is present. The vegetation that characterise these parts are therefore highly palatable and normally targeted by cattle, resulting in frequent degradation.

  In a pristine condition, the grass Leersia hexandra is likely to dominate, with Helictotrichon turgidulum, Paspalum species, Juncus oxycarpus and Kyllinga pulchella. Forbs, herbs and bulbs are normally not abundant, but those that frequently do occur in this type of habitat include Persicaria attenuata, Verbena bonariensis, Cycnium tubulosum, Lobelia erinus, Helichrysum rugulosum and H. coriaceum. Species that were observed during this assessment include Berula erecta, Cyperus species, Denekia capensis, Homeria pallida, Imperata cylindrica, Leersia hexandra, Lobelia species, Oxalis species, Paspalum dilatatum, Rumex species, Senecio achilleifolius, S. erubescens, Typha capensis, Phragmites australis and Persicaria species.

Many of the pans in the region are in relatively good condition, despite existing impacts of agriculture. This habitat type is therefore ascribed a medium-high floristic status and, because several flora species of conservation importance are likely to occur within these areas, a high floristic sensitivity resulted for the following reasons:

- they perform an important ecological function, e.g. maintaining water purity and supply and reducing soil erosion;
- they provide habitats for various wild animal and bird populations and contain many plant species that are restricted to this habitat;
- they have been transformed or are under threat by various factors in many parts of the country; and
- Red or Orange List plant species that could potentially occur within this vegetation unit include Crinum bulbispermum (Declining), Nerine gracilis (Near Threatened) and Kniphofia typhoides (Near Threatened).

Parts of the study area also comprises wetland habitat that developed from the accumulation of runoff water from infrastructure, impounded alongside the road in the southern part of the study area. The vegetation of this part comprises mostly flora species that indicate poor habitat conditions. A medium-low status is ascribed to these parts and it is regarded unlikely that flora species of conservation importance will occur within these areas.

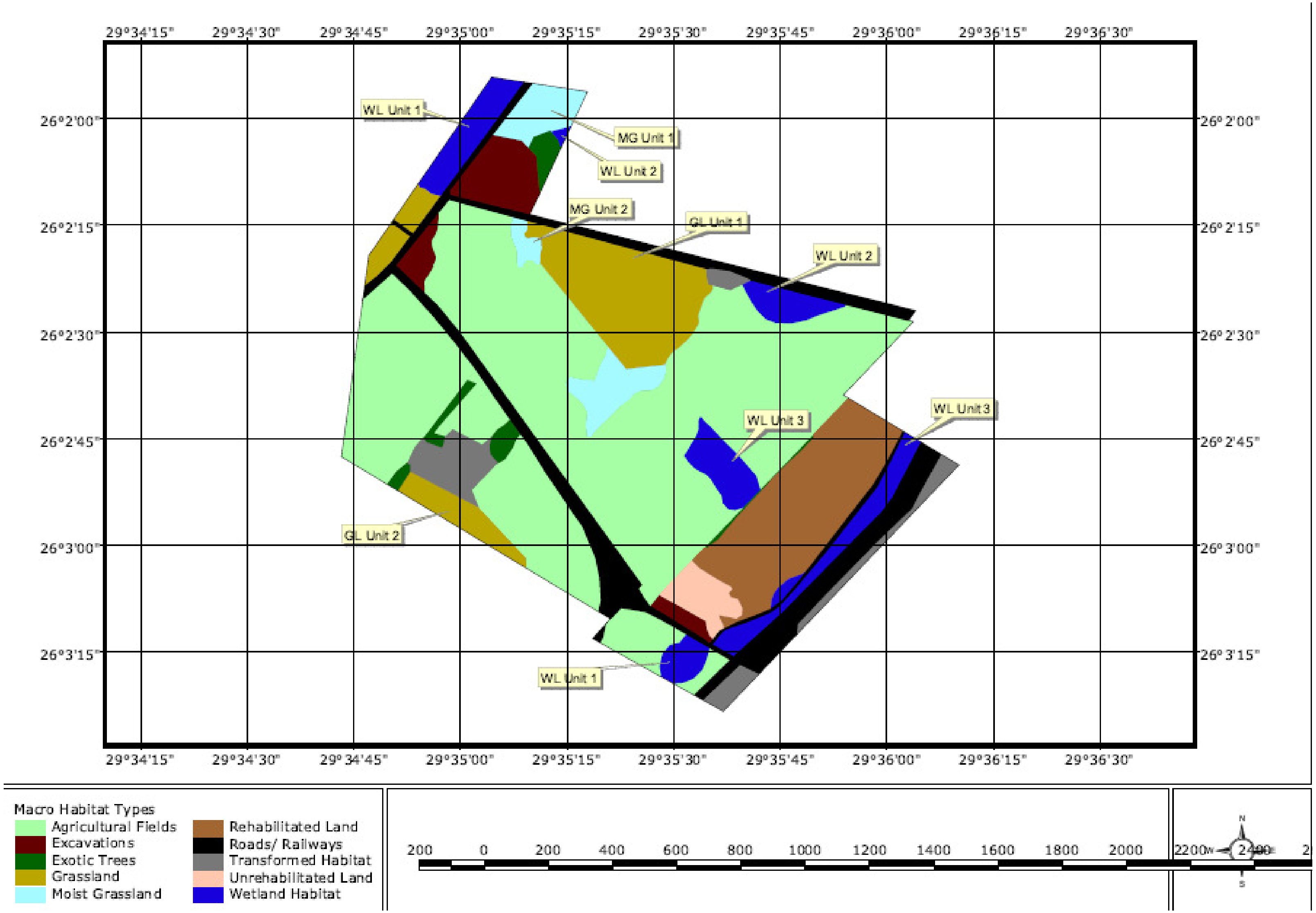


Figure 7.16: Floristic habitat types of Alternative E

- **Floristic Sensitivity**

Floristic sensitivity calculations are presented in **Table 7.8** and illustrated in **Figure 7.17**.

Table 7.8: *Floristic sensitivity estimations for the respective habitat types*

Criteria	RD species	Landscape sensitivity	Status	Species diversity	Functionality/ fragmentation	TOTAL	SENSITIVITY INDEX	SENSITIVITY CLASS
Community	**Criteria Ranking**							
Agricultural Fields	1	0	1	2	2	32	10%	low
Excavations	0	0	0	0	0	0	0%	low
Exotic Trees	1	1	1	1	2	35	11%	low
Grassland – Unit 1	4	8	6	7	8	199	62%	medium-high
Grassland – Unit 2	3	6	2	6	7	141	44%	medium
Moist Grassland - Unit 1	6	7	5	6	6	194	61%	medium-high
Moist Grassland - Unit 2	1	6	1	2	2	80	25%	medium-low
Rehabilitated Land	1	2	2	3	4	65	20%	medium-low
Roads/ Railways	0	0	0	0	0	0	0%	low
Transformed Habitat	0	0	0	0	0	0	0%	low
Unrehabilitated Land	1	1	1	1	2	35	11%	low
Wetland Habitat - Unit 1	6	10	8	8	9	255	80%	high
Wetland Habitat - Unit 2	6	10	6	6	6	224	70%	medium-high
Wetland Habitat - Unit 3	3	5	4	4	6	132	41%	medium

The extent of habitat sensitivities within the respective alternatives is presented in **Table 7.9**.

Table 7.9: *Extent of floristic habitat sensitivities within the study area*

Habitat Sensitivity	Extent	Percentage
High	8.9ha	2.6%
Medium-high	14.8ha	4.3%
Medium	41.4ha	12.0%
Medium-low	38.7ha	11.2%
Low	241.7ha	70.0%

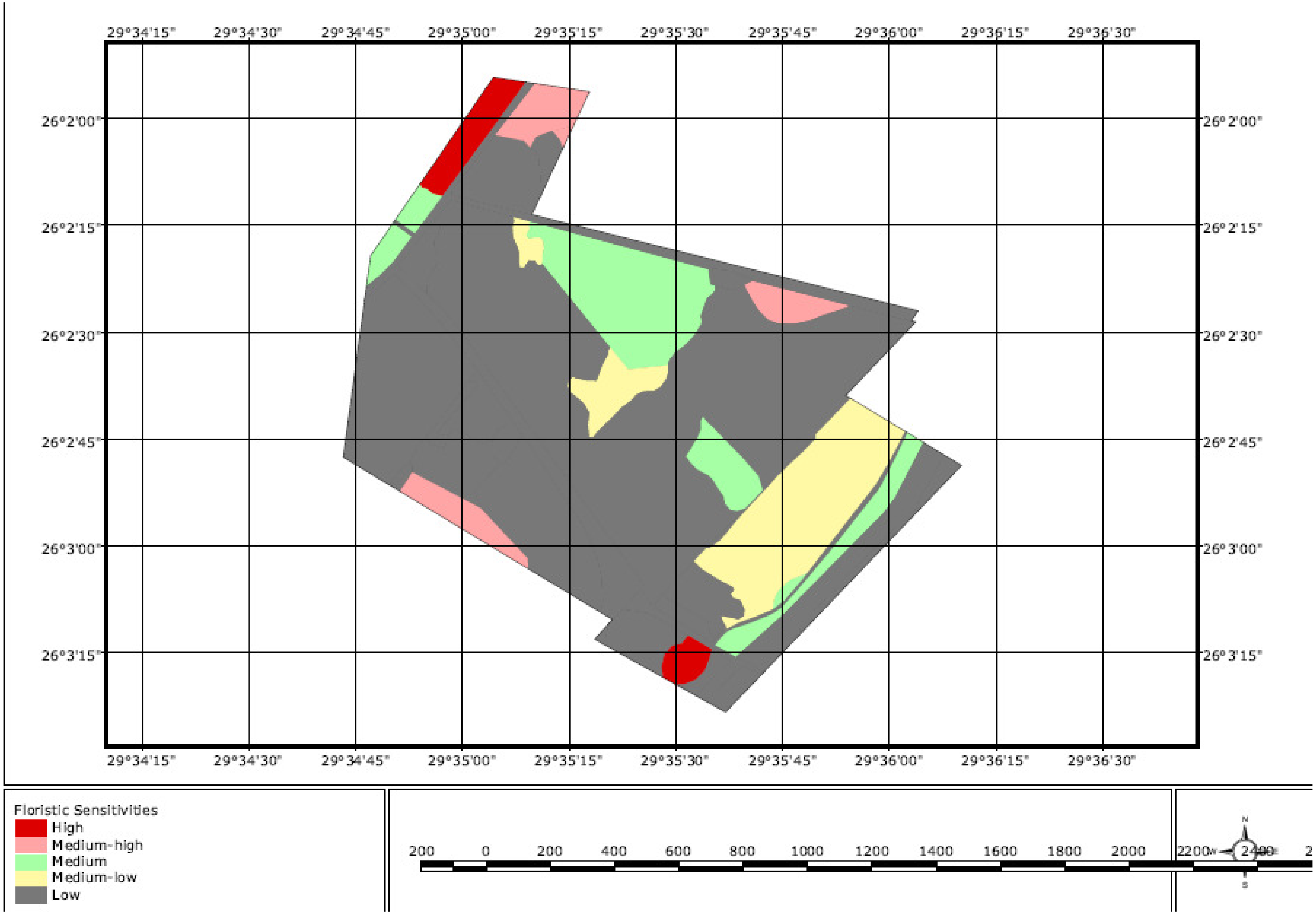


Figure 7.17: Flora habitat sensitivities of Alternative E

- **Discussion**

The vegetation of the study area exhibits the expected signs of continued and long-term impacts resulting from agriculture, severe grazing pressure in the remaining parts of natural grassland and effects of indirect and direct mining and agricultural impacts on the wetland habitat. On a regional scale, these impacts are the main causes resulting in the Endangered status that is ascribed to the Eastern Highveld Grassland, of which only 55% remains of the original 1.27 million hectares. On a local scale, the level of impacts on the natural vegetation is regarded severe and irreversible and therefore any remaining parts of natural/ pristine vegetation should be regarded as highly sensitive and conserved at all costs.

Extremely little untransformed grassland remains in the study area, these portions are furthermore degraded due to severe and prolonged grazing pressure; to the extent that much of the flora species generally associated with this vegetation type, no longer occur, particularly forb and herb species. Wetland habitat types are similarly severely impacted due to, in particular, trampling and severe grazing pressure from cattle, but also from species changes that result from infestation from nearby agricultural fields, seeds that are imported by cattle droppings as well as poor quality water entering from nearby agricultural fields and mining areas.

The result of these long-term direct and indirect impacts is that only selected portions of the study area exhibit floristic characteristics of medium-high and high sensitivity. The location of areas of higher sensitivity categories are such that generic mitigation measures (exclusion) will likely result in preservation of these areas, although significant mitigation measures should be implemented in order to conserve/ improve the current status of these areas. For this purpose, the reader should refer to the wetland report. In the case of unavoidable impacts, it is recommended that a biodiversity offset programme be initiated that will target a nearby wetland/ endorheic pan. The details of such an offset programme (offset ratios, area identification and management options) should be addressed by the wetland ecologist.

Remaining portions of the study area are mostly low in floristic sensitivity and the loss of these areas is not expected to result in significant impacts on a local or regional scale. No species of conservation importance are likely to occur within these areas and no relocation is recommended for any plant species that might occur in the site.

7.7.3 Description - Fauna

- **Regional Faunal Diversity**

Only specific faunal groups are used during the species-specific element of this faunal assessment because of restrictions concerning database availability. Data on the Q-degree level is available for the following faunal groups:

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

Animals known to be present in the Q-grid of the study area are considered potential inhabitants of the study area (all species known from the Mpumalanga Province were included to minimize the effect of sampling bias). The likelihood of each species' presence in the study areas was estimated based on known ecological requirements of species; these requirements were compared to the ecological conditions found in the study area and surrounding faunal habitat.

- **Faunal Diversity of the Site**

The presence of 30 animal species was confirmed during the site investigation (**Table 7.10**), by means of visual sightings, tracts, faecal droppings, burrows and characteristic behaviour patterns. Signs of, or individuals of, four insects, one frog, twenty birds and five mammals were confirmed for the study area. None of the species found is considered to be under threat (IUCN Red Data, CITES or TOPS). This diversity of animals confirmed to occur in the study area are regarded typical of an area the size of the study site in this part of the Grassland Biome, given the mixture of habitat types present in the study area.

Table 7.10: Faunal species observed in the study area

Class	Order	Family	Biological Name	English Name
Insecta	Coleoptera	Coccinellidae	*Cheilomenes lunata*	Lunate Ladybird
	Lepidoptera	Nymphalidae	*Danaus chrysippus orientis*	African Monarch
			Vanessa cardui	Painted Lady
	Hymenoptera	Apidae	*Apis mellifera*	Honey Bee
Amphibia	Anura	Pyxicephalidae	*Strongylopus grayii*	Clicking Stream Frog
Aves	Galliformes	Numididae	*Numida meleagris*	Helmeted Guineafowl
		Phasianidae	*Pternistis swainsonii*	Swainson's Spurfowl
	Ciconiiformes	Threskiornithidae	*Bostrychia hagedash*	Hadeda Ibis
		Ardeidae	*Ardea cinerea*	Grey Heron
	Falconiformes	Accipitridae	*Elanus caeruleus*	Black-winged Kite
	Charadriiformes	Charadriidae	*Vanellus coronatus*	Crowned Lapwing
	Columbiformes	Columbidae	*Streptopelia capicola*	Ring-necked Dove
			Spilopelia senegalensis	Laughing Dove
	Strigiformes	Strigidae	*Asio capensis*	Marsh Owl
	Passeriformes	Laniidae	*Lanius collaris*	Common Fiscal
		Hirundinidae	*Cecropis cucullata*	Greater Striped Swallow
		Cisticolidae	*Cisticola tinniens*	Levaillant's Cisticola
			Cisticola cinnamomeus	Pale-crowned Cisticola

Class	Order	Family	Biological Name	English Name
		Passeridae	*Passer melanurus*	Cape Sparrow
			Passer diffusus	Southern Grey-headed Sparrow
		Ploceidae	*Ploceus velatus*	Southern Masked Weaver
			Quelea quelea	Red-billed Quelea
		Estrildidae	*Estrilda astrild*	Common Waxbill
		Viduidae	*Vidua macroura*	Pin-tailed Whydah
		Motacillidae	*Macronyx capensis*	Cape Longclaw
Mammalia	Lagomorpha	Leporidae	*Lepus saxatilis*	Scrub Hare
	Rodentia	Muridae	*Tatera brantsii*	Highveld Gerbil
	Carnivora	Herpestidae	*Cynictis penicillata*	Yellow Mongoose
		Canidae	*Canis mesomelas*	Black-backed Jackal
	Artiodactyla	Bovidae	*Sylvicapra grimmia*	Common Duiker

In addition to species that were identified to species level, nine invertebrate families were identified during the field investigation (**Table 7.11**).

Table 7.11: Invertebrate Families of the study area

Class	Order	Family	English Name
Insecta	Odonata	Coenagrionidae	Pond Damsels
		Libellulidae	Skimmers
	Dermaptera	Labiduridae	Long-horned Earwigs
	Orthoptera	Acrididae	Short-horned Grasshoppers
	Phasmatodea	Phasmatidae	Walking Sticks
	Coleoptera	Coccinellidae	Ladybirds
	Diptera	Tipulidae	Craneflies
		Muscidae	House Flies
		Calliphoridae	Bluebottles

- **Red Data Fauna Assessment**

Eighty-two Red Data animals are known to occur in the Mpumalanga Province (mammals, reptiles, amphibians and invertebrates) (**Table 7.12**). Of these 25 are listed as Data Deficient (DD), 28 as Near Threatened (NT), 20 as Vulnerable (VU), 7 as Endangered (EN) and 2 as Critically Endangered (CR). It is estimated that 79 of the 82 species have a low probability of occurring in the study area; two have a moderate-low probability and one species a high probability.

This Red Data Probability Assessment is based on:

- the size of the study area;
- the location of the study area within a largely untransformed environment; and
- the presence of relatively pristine habitat such as those associated with grassland, woodland, wetlands and outcrops.

Table 7.12: Red Data fauna assessment of the study area

Biological Name	English Name	Status	Probability
Butterflies			
Aloeides barbarae	Barbara's Copper	Vulnerable	low
Aloeides nubilus	Cloud Copper	Vulnerable	low
Aloeides rossouwi	Rossouw's Copper	Endangered	low
Chrysoritis aureus	Golden Opal	Near Threatened	low
Chrysoritis phosphor	Scarce Scarlet	Vulnerable	low
Lepidochrysops jefferyi	Jeffery's Blue	Vulnerable	low
Lepidochrysops swanepoeli	Swanepoel's Blue	Vulnerable	low
Metisella meninx	Marsh Sylph	Vulnerable	high
Pseudonympha swanepoeli	Swanepoel's Brown	Vulnerable	low
Amphibians			
Breviceps sopranus	Whistling Rain Frog	Data Deficient	low
Hemisus guttatus	Spotted Shovel-nosed Frog	Vulnerable	low
Strongylopus wageri	Plain Stream Frog	Near Threatened	low
Reptiles			
Cordylus giganteus	Giant Girdled Lizard	Vulnerable	low
Homoroselaps dorsalis	Striped Harlequin Snake	Near Threatened	low
Kinixys natalensis	Natal Hinge-back Tortoise	Near Threatened	low
Lamprophis fuscus	Yellow-bellied House Snake	Near Threatened	low
Lamprophis swazicus	Swazi Rock Snake	Near Threatened	low
Tetradactylus breyeri	Breyer's Long-tailed Seps	Vulnerable	low
Mammals			
Acinonyx jubatus	Cheetah	Vulnerable	low
Amblysomus hottentotus	Hottentot's Golden Mole	Data Deficient	low
Amblysomus robustus	Robust Golden Mole	Endangered	low
Amblysomus septentrionalis	Higveld Golden Mole	Near Threatened	low
Atelerix frontalis	South African Hedgehog	Near Threatened	low
Canis adustus	Side-striped Jackal	Near Threatened	low
Cercopithecus mitis	Samango Monkey	Vulnerable	low
Cercopithecus mitis labiatus	Samango Monkey	Endangered	low
Chrysospalax villosus	Rough-haired Golden Mole	Critically Rare	low
Cloeotis percivali	Short-eared Trident Bat	Critically Rare	low
Crocidura cyanea	Reddish-grey Musk Shrew	Data Deficient	mod-low
Crocidura flavescens	Greater Musk Shrew	Data Deficient	low
Crocidura fuscomurina	Tiny Musk Shrew	Data Deficient	low
Crocidura hirta	Lesser Red Musk Shrew	Data Deficient	low
Crocidura maquassiensis	Maquassie Musk Shrew	Vulnerable	low
Crocidura mariquensis	Swamp Musk Shrew	Data Deficient	low
Crocidura silacea	Lesser Grey-brown Musk Shrew	Data Deficient	low
Crocuta crocuta	Spotted Hyaena	Near Threatened	low
Damaliscus lunatus lunatus	Tsessebe	Endangered	low
Dasymys incomtus	Water Rat	Near Threatened	low
Diceros bicornis minor	Black Rhinoceros	Vulnerable	low
Elephantulus brachyrhynchus	Short-snouted Elephant-shrew	Data Deficient	low
Epomophorus gambianus	Gambian Epauletted Fruit Bat	Data Deficient	low
Grammomys dolichurus	Woodland Mouse	Data Deficient	low
Graphiurus platyops	Rock Dormouse	Data Deficient	low
Hipposideros caffer	Sundevall's Leaf-nosed Bat	Data Deficient	low
Hippotragus equinus	Roan Antelope	Vulnerable	low
Hippotragus niger niger	Sable Antelope	Vulnerable	low
Hyaena brunnea	Brown Hyaena	Near Threatened	low
Kerivoula lanosa	Lesser Woolly Bat	Near Threatened	low
Lemniscomys rosalia	Single-striped Mouse	Data Deficient	low
Leptailurus serval	Serval	Near Threatened	low
Lutra maculicollis	Spotted-necked Otter	Near Threatened	low

Biological Name	English Name	Status	Probability
Lycaon pictus	African Wild Dog	Endangered	low
Manis temminckii	Pangolin	Vulnerable	low
Mellivora capensis	Honey Badger	Near Threatened	low
Miniopterus fraterculus	Lesser Long-fingered Bat	Near Threatened	low
Miniopterus schreibersii	Schreiber's Long-fingered Bat	Near Threatened	low
Myosorex cafer	Dark-footed Forest Shrew	Data Deficient	low
Myosorex varius	Forest Shrew	Data Deficient	mod-low
Myotis bocagei	Rufous Hairy Bat	Data Deficient	low
Myotis tricolor	Temminck's Hairy Bat	Near Threatened	low
Myotis welwitschii	Welwitsch's Hairy Bat	Near Threatened	low
Mystromys albicaudatus	White-tailed Rat	Endangered	low
Neamblysomus juliane	Juliana's Golden Mole	Vulnerable	low
Otomys slogetti	Sloggett's Rat	Data Deficient	low
Ourebia ourebi	Oribi	Endangered	low
Panthera leo	Lion	Vulnerable	low
Paracynictis selousi	Selous' Mongoose	Data Deficient	low
Pipistrellus anchietae	Anchieta's Pipistrelle	Near Threatened	low
Pipistrellus rusticus	Rusty Bat	Near Threatened	low
Poecilogale albinucha	African Weasel	Data Deficient	low
Raphicerus sharpei	Sharp's Grysbok	Near Threatened	low
Rhinolophus blasii	Peak-saddle Horseshoe Bat	Vulnerable	low
Rhinolophus clivosus	Geoffroy's Horseshoe Bat	Near Threatened	low
Rhinolophus darlingi	Darling's Horseshoe Bat	Near Threatened	low
Rhinolophus fumigatus	Ruppel's Horseshoe Bat	Near Threatened	low
Rhinolophus hildebrantii	Hildebrant's Horseshoe Bat	Near Threatened	low
Rhinolophus landeri	Lander's Horseshoe Bat	Near Threatened	low
Rhynchogale melleri	Meller's Mongoose	Data Deficient	low
Suncus infinitesimus	Least Dwarf Shrew	Data Deficient	low
Suncus lixus	Greater Dwarf Shrew	Data Deficient	low
Suncus varilla	Lesser Dwarf Shrew	Data Deficient	low
Tatera leucogaster	Bushveld Gerbil	Data Deficient	low

All of the animals observed in the study area (**Tables 7.10 & 7.11**) are commonly found in the grasslands and wetlands of central Mpumalanga (pers. obs.). None of these animals indicates the presence of scarce or threatened faunal habitats of habitat characteristics within the study area, as they are generally associated with abundant habitat, such as that found in the study area. The faunal assemblages of the study area support the observation that the natural faunal habitats of the study area are degraded, fragmented and isolated. This observation is reflected in **Table 7.12**. Only three of the 82 Red Data species listed for Mpumalanga are not considered to have a low probability of occurring in the study area. This is a direct result of the poor status of the remaining habitat found in the study area (that is, for the species that are known from the general area in which the study area is located within Mpumalanga – within the Q-degree or Q-catchment).

Only one species is considered to have a high probability of occurring in the study area, namely the Marsh Sylph (*Metisella meninx,* Hesperiidae: Heteropterinae). This species is restricted to the wet vleis of highveld grassland in KZN, Mpumalanga, FS, Gauteng and the North West Province. The species is known to feed on *Leersia hexandra* (Poaceae – larval host) and is well represented in the wetlands of the general region in which the study area is located (pers. obs.).

- **Faunal Habitat Sensitivity Assessment**

During the field assessment, the study area was investigated and assessed in terms of the following biodiversity attributes (**Table 7.13**):

- Habitat status: level of habitat transformation and degradation vs. pristine faunal habitat;
- Habitat diversity: the number of different faunal habitat types (both on micro- and macro-scale) found within the proposed site and bordering areas;
- Habitat linkage: the degree to which the faunal habitat of the proposed site is linked to other natural areas enabling movement of animals to and from the habitat found on site;
- Red Data species: the degree to which suitable habitat for the red data species likely to be found in the study area (larger study area) is located on each site; and
- Sensitive faunal habitat: the relative presence of faunal sensitive habitat type elements such as surface rock associated with outcrops and hills as well as wetland elements.

In order to allow for a parallel comparison between floristic and faunal sensitivities, the floristic units are used as an indication of the faunal communities. Faunal sensitivities are illustrated in **Figure 7.18**.

Table 7.13: Faunal Habitat Sensitivities for the study area

Community	Status	Diversity	Linkage	RD Likelihood	Habitat Sensitivity	Average	Sensitivity Class
Agricultural Fields	2	2	3	1	1	18%	low
Excavations	0	2	1	0	0	6%	low
Exotic Trees	2	3	1	2	1	18%	low
Grassland – Unit 1	3	3	4	3	4	34%	medium-low
Grassland – Unit 2	6	6	5	8	10	70%	medium-high
Moist Grassland - Unit 1	4	5	4	7	5	50%	medium
Moist Grassland - Unit 2	3	3	3	6	5	40%	medium
Rehabilitated Land	3	4	3	1	2	26%	medium-low
Roads/ Railways	0	0	0	0	0	0%	low
Transformed Habitat	1	2	2	1	0	12%	low
Unrehabilitated Land	0	1	1	0	0	4%	low
Wetland Habitat - Unit 1	8	7	8	8	10	82%	high
Wetland Habitat - Unit 2	4	6	5	8	10	66%	medium-high
Wetland Habitat - Unit 3	4	4	4	4	5	42%	medium

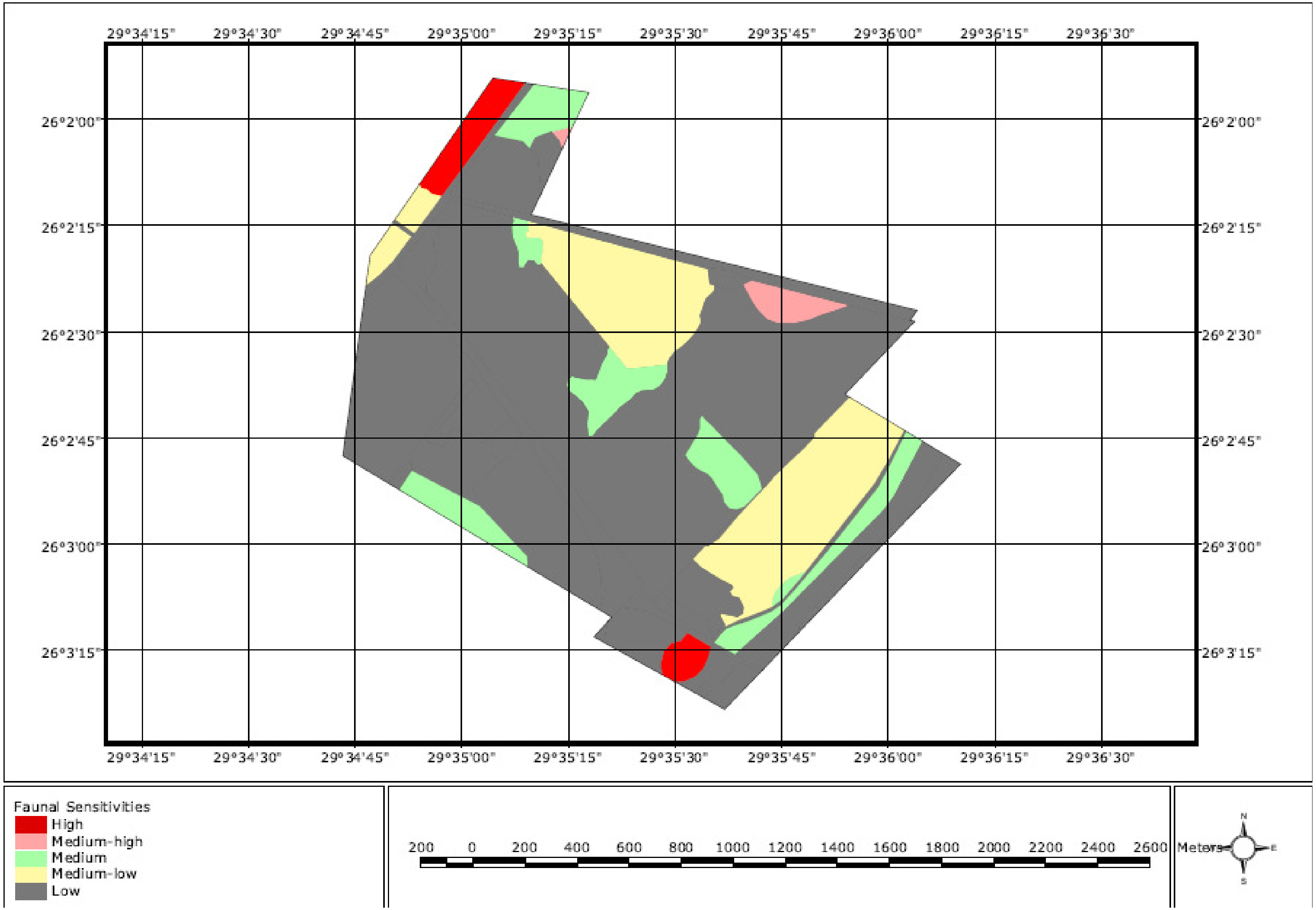


Figure 7.18: Faunal sensitivities of Alternative E

- **Discussion**

The study area is situated in an environment that comprehends extensive transformed habitats that resulted from crop agriculture and opencast coal mining. Similarly, the study area exhibits characteristics of severe transformation and degradation, comprising only small fragments of natural faunal habitat; most of these areas are wetland related with very little terrestrial faunal habitat remaining.

The faunal diversity of the study area that comprises 30 animal species and 9 invertebrate families are common to the region and none of these taxa is considered to be under any threat.

The only Red Data species listed for Mpumalanga that are considered to have a high probability of occurring in the study area is the Marsh Sylph (*Metisella meninx*). This species is commonly found in wetlands where the larval host plant, *Leersia hexandra*, abounds; as is the case within the wetlands of the study area.

None of the potential impacts associated with the proposed project for the wet ash disposal facility at Site E, pipeline alternatives routes 1 and 2 and transmission line corridors 1 and 2 are considered high for any of the project phases – construction, operational or decommissioning (including cumulative impacts).

7.7.4 Description – Ecological Interpretation

Results of the respective floristic- and faunal habitat sensitivity assessments are interpreted to present an estimation (**Table 7.14**) that would reflect the expected impact of the construction and operation of the required infrastructure on the biological environment. While the estimations of habitat sensitivity, as presented in preceding chapters do provide an indication in terms of the extent and locality of important habitat, an interpretation of the surrounding habitat sensitivity is also implemented in these estimations.

Table 7.14: Ecological Sensitivity of the study area

Community	Floristic Sensitivity	Faunal Sensitivity	Ecological Sensitivity
Agricultural Fields	low	low	**Low**
Excavations	low	low	**Low**
Exotic Trees	low	low	**Low**
Grassland – Unit 1	medium-high	medium-low	**Medium-high**
Grassland – Unit 2	medium	medium-high	**Medium-high**
Moist Grassland - Unit 1	medium-high	medium	**Medium-high**
Moist Grassland - Unit 2	medium-low	medium	**Medium-low**
Rehabilitated Land	medium-low	medium-low	**Medium-low**
Roads/ Railways	low	low	**Low**
Transformed Habitat	low	low	**Low**
Unrehabilitated Land	low	low	**Low**

Wetland Habitat - Unit 1	high	high	**High**
Wetland Habitat - Unit 2	medium-high	medium-high	**Medium-high**
Wetland Habitat - Unit 3	medium	medium	**Medium**

The extent of ecological sensitivities is illustrated in **Figure 7.19**. Estimated sensitivities reflect the separate floristic and faunal sensitivities and furthermore provide evidence of a highly degraded and transformed habitat that is characterised by the presence of mosaical remnants of natural habitat that are largely isolated.

The status of these portions generally also reflects the severity of current impacts resulting from the dominant land uses, including mining and agriculture (grazing and cultivation). While selected portions of habitat exhibit characteristics of medium-high and high ecological sensitivity, the remainder of the proposed site is regarded low in ecological sensitivity. The loss of these areas is not regarded significant on a local or regional scale. Remaining portions of higher sensitivity categories could effectively be protected by the implementation of generic mitigation measures.

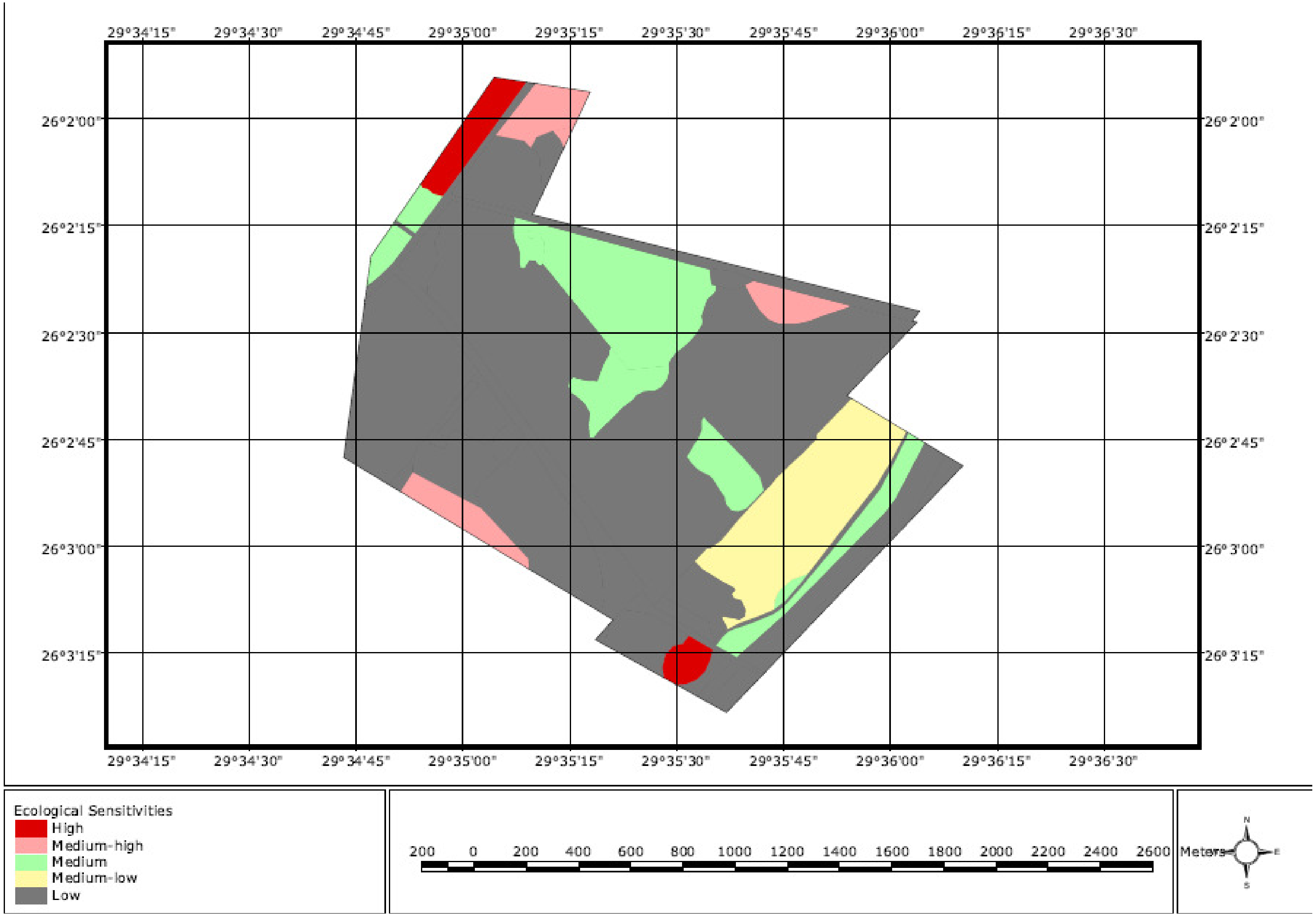


Figure 7.19: Ecological sensitivities of Alternative E

7.8 Avifauna

7.8.1 Description

Data on the bird species that could occur in the study area and their abundance was obtained from the Southern African Bird Atlas Project (Harrison *et al*, 1997). This data provided an indication of the bird species that were recorded in the quarter Degree Square within which this proposed project falls, i.e. 2629BA, and a nearby QDGS, 2529DC.

Table 7.15: Red Listed bird species recorded in the quarter degree squares (2629BA and 2529DC) within which the study area is located (Harrison *et al*, 1997). Report rates are percentages of the number of times a species was recorded by the number of times the square was counted. Conservation status is classified according to Barnes (2000).

Total Cards		66	64
Total Species		193	221
Total Breeding Species		44	27
Name	**Conservation status**	**2629BA report rate**	**2529DC report rate**
Botha's Lark	EN	2	-
Southern Bald Ibis	VU	5	14
African Marsh-Harrier	VU	2	-
Lesser Kestrel	VU	3	13
African Grass Owl	VU	2	2
Denham's Bustard	VU	-	2
White-bellied Korhaan	VU	-	2
Yellow-billed Stork	NT	3	-
Greater Flamingo	NT	27	36
Lesser Flamingo	NT	8	17
Secretarybird	NT	3	5
Black Harrier	NT	2	-
Pallid Harrier	NT	-	2
Blue Korhaan	NT	3	2
Black-winged Pratincole	NT	5	2
Black Stork	NT	-	5
White Stork	Bonn	11	14

EN=Endangered; VU=Vulnerable; NT=Near-threatened; Bonn=Protected Internationally under the Bonn Convention on Migratory Species.

The SABAP data lists 1 Endangered, 6 Vulnerable and 9 near threatened species as occurring within the study area. In addition, one species, the White Stork is protected internationally under the Bonn Convention on Migratory Species.

Two CWAC sites occur in the study area. A potential CWAC site is any body of water, other than the oceans, which supports a significant number of birds. This definition includes natural pans, vleis, marshes, lakes, rivers, estuaries and lagoons as well as the whole gamut of manmade impoundments. The two CWAC sites are Oranje Pan and Coetzeespruit

Dam. Key IUCN Listed species recorded at the CWAC sites include the Greater Flamingo and African Marsh-Harrier.

CAR route MM03 of the Mpumalanga Precinct runs in close proximity to the Study area. Southern Bald Ibis was the only key species recorded on this route during the study period.

The 2629BA QDGS also incorporates part of an Important Bird Area (IBA) - Amersfoort-bethal-carolina District. Although this IBA falls outside of the 8km study radius, it is known to hold a large proportion (>10%) of the global population of the endangered Botha's Lark (Barnes 1998). This species favors short dense, natural grassland found on plateaus and upper hill slopes. Such habitat was not observed at any of the proposed sites for this project. The majority of the study area comprised of agricultural lands, planted pastures, vleis and dams which are habitats not usually preferred by Botha's Lark. The Globally threatened Wattled Crane was listed as a vagrant to this IBA, while other key listed species recorded include Southern Bald Ibis, Lesser Kestrel, Blue Crane, African Grass Owl, Lanner Falcon and Blackwinged Lapwing. However, of these only the Southern Bald Ibis, African Grass Owl and Lesser Kestrel were recorded in the SABAP1 data from the QDGS, and the fact that the study area does not fall within the IBA, suggests that those species not recorded in SABAP1 data, are unlikely to occur on site.

- ***Southern African Bird Atlas Project 2***

SABAP 2 data was also consulted, with the two pentads in the study area, 2600_2935 and 2555_2935, recording totals of 70 and 78 species respectively. Only one card had been submitted for pentad 2600_2935, while three counts have been conducted in pentad 2555_2935 to date. This represents insufficient data to be considered an accurate indication of species present or absent. It was noted, however, that pentad 2555_2935 had report rates of 33% (i.e. 1 of 3 counts) for both Greater and Lesser Flamingoes. The preferred site alternative falls within the pentad 2600_2935, which had only been counted once, with Greater Flamingo being the only relevant species recorded. From and additional two pentads in the broader area which had been counted more than twice (2555_2935, and 2555_2930), the following species observed are relevant: Lesser Kestrel; Amur Falcon; Lesser Flamingo and Greater Flamingo.

Interestingly, 14 (which is the vast majority) of the relevant species identified in the SABAP 1 data (i.e. **Table 7.15**), have not been recorded in the SABAP 2 data for the pentads examined. This however, does not necessarily mean that these species do not occur here, or that they have moved from the area, post SABAP1, but may merely be due to the low counting effort of the pentads, or selective micro habitat counting by the SABAP2 field counters. Furthermore, one must be cautious when comparing these data sets, as the pentads represents far smaller sampling areas than the QDGS's, as well as different sampling efforts.

- ***Bird Micro-habitats***

An examination of the micro habitats available to birds was conducted. These are generally evident at a much smaller spatial scale than vegetation types, and are determined by a host of factors such as vegetation type, topography, land use and man-made infrastructure. The following micro-habitats were identified in the study area.

- *Cultivated Lands and Pasture*

Figure 7.20: Cultivated lands in the study area. This picture was taken at Alternative site E.

Figure 7.21: Cultivated land and pasture, to the west of the site. Note the centre pivot irrigation system, often favored for perching by Crane species.

Figure 7.22: A view of a portion of the proposed wet ash disposal facility site, showing cultivated pastures.

Arable or cultivated land as well as pastures, represents a significant feeding area for many bird species in any landscape for the following reasons: through opening up the soil surface, land preparation makes many insects, seeds, bulbs and other food sources readily accessible to birds and other predators; the crop or pasture plants cultivated are often eaten themselves by birds, or attract insects which are in turn eaten by birds; during the dry season arable lands often represent the only green or attractive food sources in an otherwise dry landscape. Arable lands exist in this study area, mostly planted to pasture or corn at the time of site visit. Relevant bird species that may be attracted to these areas include the Denham's Bustard, Southern Bald Ibis and White Stork.

- *Drainage Lines and Wetlands*

Figure 7.23: A drainage line, in the broader area, with evidence of erosion.

Figure 7.24: The drainage line pictured above in figure 7.23, leads to this wetland area, which was the extension of a large dam.

Drainage lines and wetlands are an important form of habitat to numerous species. Drainage lines are often surrounded by natural grasslands, which may provide habitat for species such as African Grass Owl and Botha's lark. Various waterfowl, such as ducks and geese, may make use of these areas. **Figures 7.23 and 7.24** above, were taken in the broader area, and no such large wetlands were observed on site alternative E, itself. Some small wet area, to the north of the proposed site was observed, and is shown in **figure 7.25**.

Figure 7.25: A "marshy" wetland area, between the proposed site and the Hendrina Power Station.

• *Man-made Dams*

Figure 7.26: A dam observed in the broader study area.

Artificially constructed dams have become important attractants to various bird species in the South African landscape. Various waterfowl frequent these areas and crane species often use dams to roost in communally. Birds such as flamingos and African Spoonbills may make use of these areas. Therefore dams are a key element of this study.

• *Pans*

The broader area is scattered with numerous natural pans. May of these depressions do not always fill with water, and are only obvious pans in the rainy season. Pans are important attractants to various bird species in the South African landscape. Various waterfowl frequent these areas and crane species may often use pans to roost in communally. Birds such as Coots, Grebes, Ducks, Geese, Terns, Flamingos and African Spoonbills may make use of these areas.

A medium sized pan was observed, just to the south of the study area, close to the proposed power line alternative 2. However, this pan was found to be dry on inspection during the site visit, but may have water and attract birds during, and soon after, the rainy season. A large, full pan ("Blinkpan") was observed (**see figures 7.27 and 7.28**) approximately 5km west of the proposed site, with an estimated 1000+ individual Flamingos present (both Greater and Lesser Flamingos in equal numbers).

Figure 7.27: A large natural pan observed in the broader study area, where up to 1000 flamingos were counted during the second site visit in October 2011.

Figure 7.28: Both Greater and Lesser Flamingos were observed at this pan, “Blinkpan”, approximately 5km west of the study site.

- *Open Grassland*

Figure 7.29: One of the few natural grassy areas observed in the broader study area.

Grasslands also represent a significant feeding area for many bird species, as well as possible breeding areas for others such as the African Grass Owl. Specifically, these open grassland patches typically attract the Blue Crane, Grey Crowned Crane (which have been identified in the nearby IBA discussed above) Sothern Bald Ibis, Secretarybird, White-bellied Korhaan, Denham's Bustard and White Stork. The grassland patches are also a favourite foraging area for game birds such as francolins and Helmeted Guineafowl. This in turn attracts large raptors because of both the presence and accessibility of prey. Very few patches of natural grassland are present on site.

- *Stands of Alien Trees*

Figure 7.30: Patches of alien trees were observed in the east the study area.

These areas will mostly be important to physically smaller bird species and passerines, as well as providing roosting for certain raptors and larger species such as Geese and Ibises.

Table 7.16 below shows the micro habitats that each Red Data bird typically frequents in the study area. It must be stressed that birds can and will, by virtue of their mobility, utilise almost any areas in a landscape from time to time. However, the analysis below represents each species' most preferred or normal habitats. These locations are where most of the birds of that species will spend most of their time – so logically that is where impacts on those species will be most significant. The likelihood of the species occurring (i.e. making use of the site for purposes such as foraging, feeding, hunting, nesting and breeding, or regularly flying over as part of a regular flyway) within the proposed wet ash disposal facility site, or along the proposed line alternatives, is shown below, and is merely a prediction by the author based on available information, and experience.

Table 7.16: Preferred Micro-habitats and likelihood of occurrence on site of Red Data species recorded in the relevant QDGS's.

Species	Preferred Micro-habitat	Likelihood of occurrence on site
Botha's Lark	Long, mature natural grassland	Unlikely
Southern Bald Ibis	Grassland	Likely
African Marsh-Harrier	Dams and Wetlands	Possible
Lesser Kestrel	Arable lands and Grasslands	Possible
African Grass Owl	Grasslands	Possible
Denham's Bustard	Cultivated lands and Grasslands	Possible
White-bellied Korhaan	Cultivated lands and Grasslands	Possible
Yellow-billed Stork	Cultivated lands and Grasslands	Possible
Greater Flamingo	Dams and wetlands	Possible
Lesser Flamingo	Dams and Wetlands	Possible
Secretarybird	Cultivated lands and Grasslands	Unlikely
Black Harrier	Cultivated lands and Grasslands	Possible
Pallid Harrier	Grasslands and Wetlands	Unlikely
Blue Korhaan	Cultivated lands and Grasslands	Possible
Black-winged Pratincole	Cultivated lands and Grasslands	Possible
Black Stork	Rivers and Kloofs	Unlikely
White Stork	Cultivated lands and Grasslands	Likely

- ***Personal observations***

Appendix 1 of the Avifauna Report in **Appendix L** shows the sightings list of birds observed on site and within the broader study area (i.e. within an approximate radius of 6km from the preferred wet ash disposal facility site), during the two site visits. This list is merely for indicative purposes, and this list represents incidental observations (which could be positively identified). Data from this list needs to be used with caution, as observations over such a short period, in only two seasons, cannot be taken as a true indication of the presence of all bird species in the area. In particular, the target species for this study are threatened, rare species, so the likelihood of seeing one during the site visit periods was limited. This study has therefore attached far more weight to the secondary data sources such as the bird atlas projects (SABAP1 and SABAP2) which collected data over a far longer period, and more diverse conditions. It must be noted that many “non Red Data” bird species also occur in the study area and could be impacted on by the power line. Although this impact assessment focuses on Red Data species, the impact on non Red Data species is also assessed, albeit in less detail. Furthermore, much of the mitigation recommended for Red Data species will also protect non Red Data species in the study area.

- ***Focal Species List***

Determining the focal species for this study, i.e. the most important species to be considered, is a four step process. Firstly, the micro-habitats available on site were identified. An analysis of the above existing avifaunal data represents the second step, i.e. which species occur in the area at significant abundances. The third step is to identify those species (which may be present based on the above two steps), and are more likely to be impacted upon by the wet ash disposal facility and associated power-line. This step called on the vast experience of the EWT in evaluated and investigating electrical infrastructure impacts on birds (these impacts are discussed in more detail below). In general, large, heavy flying birds are more vulnerable to collision with over-head powerlines, while perching Raptors are more vulnerable to electrocution. Smaller species and passerines are vulnerable to displacement and habitat loss. The fourth and final step was to consider the species conservation status or other reasons for protecting the species. This involved primarily consulting the Red List bird species (Barnes 2000) as in **Table 7.15**.

The resultant list of ‘target/focal species’ for this study is as follows: Greater Flamingo, Lesser Flamingo, and Grey-crowned Crane, Denham’s Bustard, Blue Korhaan, Southern Bald Ibis, and White Stork. In some cases, these species serve as surrogates for other similar species (as mitigation will be effective for both), examples being White Stork for Black Stork, and Blue Korhaan for White-bellied Korhaan. Assorted more common species will also be relevant to this study, but it is believed that the above target species will to a large extent serve as surrogates for these in terms of impact assessment and management.

7.9 Surface Water

7.9.1 Description

- ***<u>Study Area Description</u>***

o ***Ecoregion Characteristics***

The study area is located in the western parts of Mpumalanga province and falls predominantly within the Eastern Highveld grassland with isolated patches consisting of

Eastern Temperate Freshwater wetlands (**Table 7.17**). The desktop review indicated that surface water systems are located in quaternary catchment B12B (**Figure 7.31**). Landscape features for the Eastern grassland biome includes slightly to moderately undulating plains, some low hills and pan depressions, while the Temperate Freshwater wetlands are an expression of impermeable soils or erosion resistant geological features (**Table 7.17, Figure 7.32**). Mean Annual Precipitation (MAP) ranges between 600-800 mm per annum, frequently in the form of summer storms. The annual temperature in the study area is 14.7 °C for Eastern Highveld grassland and 14.9 °C for Eastern Temperate Freshwater wetlands. The Mean Annual Potential Evaporation rate (MAPE) exceeds the MAP in the area, thus a net loss in precipitation is experienced (**Table 7.17**).

Table 7.17: Environmental variables and geomorphologic description of the study area (Mucina and Rutherford, 2006).

Environmental Features	**Bioregion**	
	Eastern Highveld grassland	**Eastern Temperate Freshwater wetland**
Landscape features	Slightly to moderately undulating plains, including some low hills and pan depressions	Flat landscapes or shallow depressions filled with (temporary) water, supporting zones systems of hygrophilous vegetation
Geology and soils	Red and yellow sandy soils found on shales and sandstones	Peat soils, ranging from Champagne to Rensburg. Vleis form on impermeable soils or erosion resistant features e.g. dolerite intrusions
MAP	726 mm	704 mm
MAT	14.7 °C	14.9 °C
MFD	32 d	38 d
MAPE	1950 mm	1953 d
MASR	0.0563 m	0.0563 m
Status	E	LC
MAP: Mean Annual Precipitation; MAT: Mean Annual Temperature; MFD: Mean Frost Days; MAPE: Mean Annual Potential Evaporation; E: endangered; LC: Least Concerned		

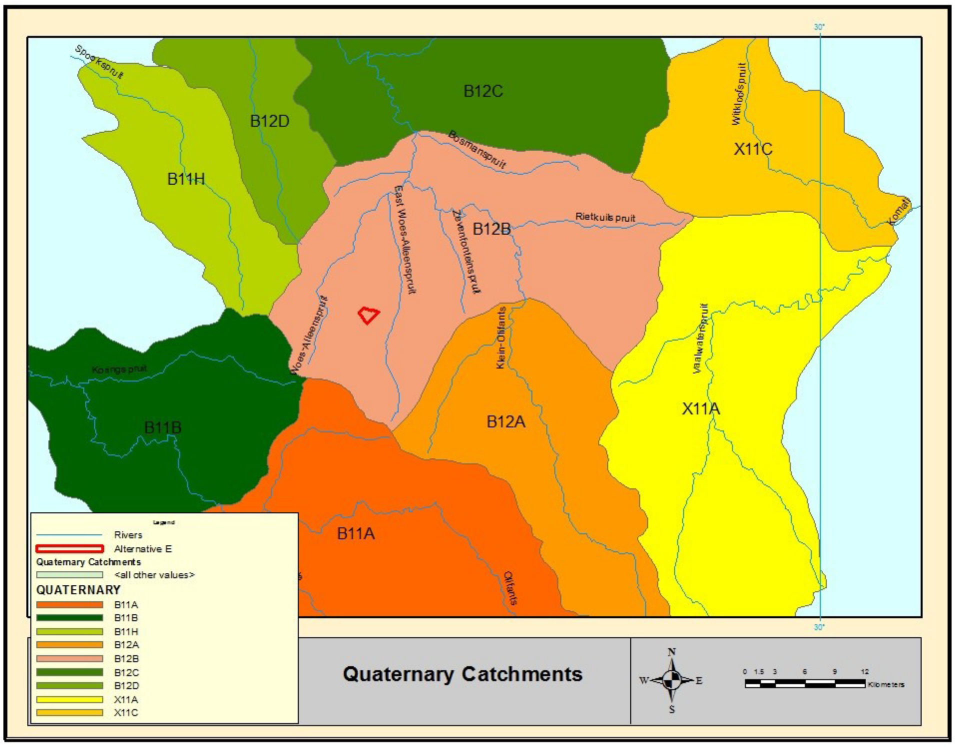


Figure 7.31: Map showing the study area and main rivers in relation with associated quaternary catchments**.**

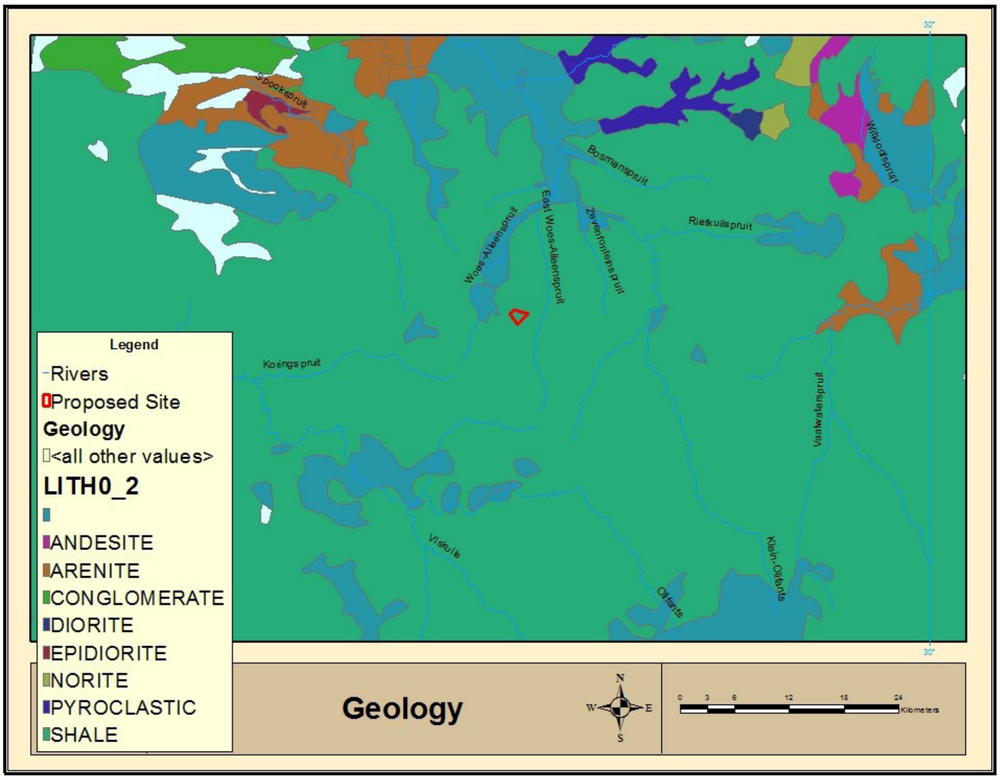


Figure 7.32: Map showing the geology of the study area and surroundings.

- ***Watercourse Characterisation***

A characterisation of watercourses in the study area reveals that the receiving Klein-Olifants River is an order three river (**Table 7.18**). Six attributes were used to obtain the PES on desktop quaternary catchment level by the NSBA (Nel *et al.*, 2004). These attributes predominantly allude to habitat integrity of instream and riparian habitat. With this in mind, the receiving Klein-Olifants River and the Woest-alleen systems according to the NSBA (Nel *et al*., 2004) fall within a D-category. This relates to a largely transformed ecosystem state (**Table 7.18**). Biological communities also reflect fair to unacceptable health in these systems (RHP, 2001). The instream habitat associated with the ecoregion in the study area reflects more degradation than adjacent ecoregions (RHP, 2001).

According to the desktop PES category from DWAF (2000), the rivers in quaternary catchment B12B fall in a C ecological category, relating to a moderately modified ecosystem with clear community modifications and some impairment of health evident. The quaternary catchment, at present, is affected by severe erosion, sedimentation, weirs, infrastructural development in the form of power stations and mines, and translocation of species (*Labeo umbratus*). The EIS (DWAF, 2000) is considered moderately sensitive due to the expected presence of flow intolerant fish species in parts of the catchment, and the system"s sensitivity to changes in flow and water quality.

Most of the surface water systems are perennial systems. Nel *et al.* (2004) lists a status of critically endangered for all the river signatures associated with the study area. The ascribed river status indicates a limited amount of intact river systems carrying the same heterogeneity signatures nationally. This implies a severe loss in aquatic ecological functioning and aquatic diversity in similar river signatures on a national scale (Nel *et al*., 2004). The Conservation Management Plan for Mpumalanga (Lötter & Ferrar, 2006) shows the proposed development falls within a sub-catchment considered to be highly significant in its contribution towards aquatic biodiversity. Factors considered in the assessment significance assessment include: migration, species richness and refuge.

Table 7.18: Desktop river characterisation of the Klein-Olifants and Woestallen system (DWA, 2000; Nel et al., 2004).

	Klein-Olifants River	**Woestalleen System**
River Order	3	1
Quaternary Catchment	B12B	B12B
Class	Perennial	Perennial
PES (NSBA)	**D**	**D**
PES (DWAF)	**C**	**C**
EIS (DWAF)	**Moderate**	**Moderate**
Conservation Status (NSBA)	Critically Endangered	Critically Endangered

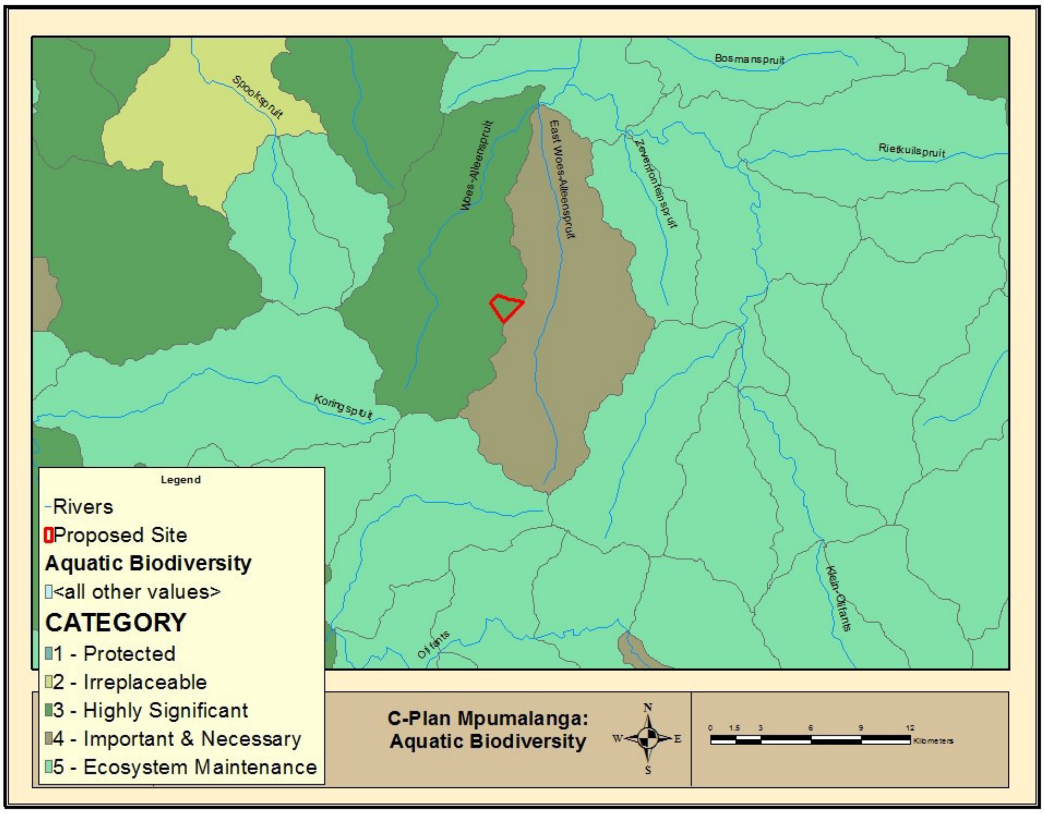


Figure 7.33: Map showing the importance of aquatic systems in supporting aquatic biodiversity in and around the study area.

- ***Catchment Drivers of Ecological Change***

The property falls within the Upper Olifants Sub-Area of the Olifants Water Management Area (WMA4). The Upper Olifants Sub-Area is the most urbanised of the 4 sub-areas in WMA4. The Upper Olifants covers an area of 11 464 km2 with a mean annual runoff of 10 780 million m3 (Midgley *et al.,* 1994). Surface runoff in this area is regulated by a number of large dams, namely Witbank, Bronkhorstspruit and the Middleburg dams (Basson *et al*., 1997). Majority of the urban population is located in Witbank and Middelburg areas, and it is projected that the population in these urban areas will grow in the near future therefore increasing the water requirement in the Sub-Area (**Table 7.19**). Extensive coal mining activities are taking place in the sub-area, both for export to other provinces and for use in the six active coal fired power stations in the sub-area. Water quality in this sub-area is therefore under threat. Mining activities in the area impact on the natural hydrological system by increasing infiltration and recharge rates of the groundwater. Approximately 62 million m3 is predicted to decant from mining activities (post closure) every year, creating a need for water quality management plans in this Sub-Area (DWAF, 2004a).

Table 7.19: Reconciliation of water requirements and availability (million m³/a) for the year 2000 in the Olifants Water Management Area (DWAF, 2004b).

Sub-area	MAR	Local yield	Transfers in	Transfer out	Local requirement	Deficit
Upper Olifants	465	238	171	96	314	1
Middle Olifants	481	210	91	3	392	94
Steelpoort	396	61	0	0	95	34
Lower Olifants	698	100	1	0	104	63

- ***Field Survey***

  - ***Water Quality***

Table 7.20 shows the *in situ* water quality constituents measured at each of the biomonitoring sites. These values were compared to benchmark criteria as set out by Kotze 2002 (**Table 7.20**). Both the pH and EC values fell within the ideal range for the protection of aquatic ecosystems (**Table 7.20**). However spatial variation in conductivity suggests different ionic composition associated with the two wetland systems and possibly different sources.

Table 7.20: In situ water quality values for sites HA1 and 2 respectively, July 2011.

Variable	Abb.	Unit	HA1	HA2
pH	pH	[H^1+ ions]	**7.48**	**7.02**
Conductivity	EC	mS-m^{-1}	**39.42**	**43.7**
Total Dissolved Solids	TDS	ppm	311.7	345.8
Temperature	Temp.	°C	8.13	8.62
Oxygen	[DO]	mg/l	**5.23**	**3.39**
Oxygen %	DO (%)	%	64.7	41.2
	Ideal			
	Acceptable			
	Tolerable			
	Unacceptable			

  - ***Habitat Assessment***

Invertebrate Habitat Assessment Score

Habitat availability is a major determinant of the overall aquatic macroinvertebrate community structure. The application of IHAS, in the context of this survey, provides a measure of habitat availability for macroinvertebrate colonisation at both sites respectively. The results obtained from the Invertebrate Habitat Assessment are shown in **Table 7.21.**

The results obtained from the IHAS assessment indicated that the habitat availability at both sites HA1 and 2 were poor reflecting IHAS scores of 28.38 and 56.76 % respectively. Site HA1 lacked stones both in and out of current, as well as gravel habitat which resulted in the low IHAS score. Site HA2 also classing as "poor" but did obtain a higher IHAS score than site HA1. The construction of the dam at site HA2 has resulted in the formation of riffles habitat directly downstream of the dam (**Figure 7.43 B**) providing more habitat for macroinvertebrate colonisation.

Table 7.21: Invertebrate Habitat Assessment version 2 (IHAS v.2) score for sites during the July 2011 survey**.**

	HA1	**HA2**
Stones in Current	0	17
Vegetation	11	14
Other Habitat	**10**	**11**
Total IHAS (%)	**28.38**	**56.76**
Class	**Poor**	**Poor**

Fish Habitat Assessment

Table 7.22 reflects fish habitat types and associated flows for sites assessed. Dominant types are highlighted and only habitat subjected to fish sampling are included when scoring available fish habitat. The dominant habitat type linked with site HA1 included overhanging vegetation and water column, associated almost entirely with a slow deep velocity class. Aquatic vegetation was absent at site HA1 at the time of sampling. Similar to that noted at site HA1, the dominant habitat type at site HA2 was overhanging vegetation and water column, however, aquatic vegetation was present at site HA2 providing potential fish habitat. On the contrary, site HA2 was dominated by both fast deep and fast shallow velocity depth classes.

Table 7.22: Fish habitat and cover ratings noted for sites HA1 and 2**.**

Habitat and velocity type	**HA1**	**HA2**
Dominant Habitat Type:		
Overhanging vegetation	35.29	23.73
Undercut banks and root wads	11.76	15.25
Substrate	17.65	13.56
Aquatic macrophytes	0.00	23.73
Water column	35.29	23.73
Velocity Depth Class %:		
Slow Deep	82.35	33.90
Slow Shallow	17.65	13.56
Fast Deep	0.00	30.51
Fast Shallow	0.00	22.03
	Dominant type	

- ***Diatom Assessment***

Table 7.23 and 7.24 show diatom index ecological descriptions and %PTV scores, and diatom species sampled at sites HA1 and 2 respectively.

A total of 62 diatom species were sampled in the July 2011 survey. No rare or endemic species were noted. Species richness for sites HA1 and HA2 was 34 and 47 species respectively (**Table 7.23**). According to the Van Dam ecological index, both sites were in a eutrophic state. Site HA1 comprised mostly of nitrogen autotrophic taxa which tolerate elevated concentrations of organically bound nitrogen, where site HA2 comprised of nitrogen heterotrophic taxa which require periodically elevated concentrations of organically bound nitrogen (Van Dam, 1994).

Table 7.23: Diatom index scores for Hendrina study sites showing %PTV and Van Dam scores.

Site	No. species	Nitrogen uptake	Trophic State	%PTV
HA1	34	Nitrogen autotrophic taxa	Eutrophic	65%
HA2	47	Nitrogen-heterotrophic taxa	Eutrophic	43.85%
PTV = Pollution Tolerant Valves				

Site HA1 showed a species composition that is characterised by pollution tolerant species that are associated with circum-neutral; eutrophic waters with low oxygen content (**Table 7.23**). Overall the water quality is poor with a high %PTV of 65% indicating that the system is impacted by organic material. As shown in **Table 7.24**, the site is dominated by the *Nitzschia* group which indicates that the system is in an impacted and degraded state (Krammer and Horst Lange-Bertalot, 2000). More specifically the dominant *Nitzschia palea*, a species found in extremely polluted waters with elevated electrolytes, nutrients and organics varifies that the system is disturbed. The presence of dominant *Nitzschia archibaldii*, and less dominant *Nitzschia nana* and *Nitzschia pura* may however suggest that pollution levels at this site tend to be more moderate, as these species are known to tolerate only moderately polluted waters.

Site HA2 comprised of diatoms that indicate a poor water quality with moderate organic content (43.8 % PTV). The diatom community is indicative of circum-neutral, low oxygenated waters with eutrophic conditions (Table 16). The presence of *Fragilaria fasciculata* and *Fragilaria pulchella* has been reported from critically polluted industrial and mining wastewaters. Other taxa recorded at this site are all extremely pollution tolerant species such *Sellaphora seminulum*, *Eolimna minima*, *Nitzschia palea, Nitzschia paleacea* and *Gomphonema parvulum*, and strongly imply that this site is severely impacted primarily from elevated electrolytes and nutrients.

Table 7.24: Dominant diatom species identified for study sites**.**

Taxa	**HA1**	**HA2**
Achnanthidium (including *A. minutissimum*) F.T. Kützing	7	5
Achnanthes J.B.M. Bory de St. Vincent	0	17
Achnanthidium exiguum (Grunow) Czarnecki	0	5
Asterionella formosa Hassall	1	0
Aulacoseira granulata (Ehr.) Simonsen var.*angustissima*	3	1
Aulacoseira granulata (Ehr.) Simonsen	1	1
Caloneis bacillum (Grunow) Cleve	1	0
Craticula halophila (Grunow ex Van Heurck) Mann	0	1
Cyclotella meneghiniana Kützing	0	6
Cocconeis C.G. Ehrenberg	0	2
Cocconeis placentula Ehrenberg var. placentula	1	1
Diatoma vulgaris Bory	1	0
Encyonema minutum (Hilse in Rabh.) D.G. Mann	2	0
Eolimna minima(Grunow) Lange-Bertalot	9	19
Fragilaria biceps (Kützing) Lange-Bertalot	0	1
Fragilaria capucina Desmazieres var.capucina	9	26
Fragilaria capucina Desmazieres var. rumpens (Kützing)	12	41
Fragilaria fasciculata (C.A. Agardh) Lange-Bertalot sensu lato	0	1
Fragilaria nanana Lange-Bertalot	1	0
Fragilaria pulchella (Ralfs ex Kütz.) Lange-Bertalot (Ctenophora)	0	4
Fragilaria H.C. Lyngbye	11	3
Fragilaria tenera (W.Smith) Lange-Bertalot	3	0
Fragilaria ulna (Nitzsch.)Lange-Bertalot var.acus (Kütz.) Lange-Berta	1	1
Fragilaria ulna (Nitzsch.) Lange-Bertalot var. ulna	0	5
Gomphonema acuminatum Ehrenberg	0	4
Gomphonema affine Kützing	0	1
Gomphonema C.G. Ehrenberg	0	4
Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	5	20
Gomphonema pseudoaugur Lange-Bertalot	0	6
Lemnicola hungarica (Grunow) Round & Basson	0	1
Mayamaea atomus var. permitis (Hustedt) Lange-Bertalot	2	1
Melosira varians Agardh	0	6
Nitzschia acicularis(Kützing) W.M.Smith	1	0
Navicula antonii Lange-Bertalot	0	5
Navicula J.B.M. Bory de St. Vincent	2	8
Nitzschia capitellata Hustedt in A.Schmidt & al.	0	12
Navicula capitatoradiata Germain	0	3
Nitzschia dissipata(Kützing)Grunow var.dissipata	0	4
Nitzschia draveillensis Coste & Ricard	39	2
Nitzschia filiformis (W.M.Smith) Van Heurck var. filiformis	0	7
Nitzschia fonticola Grunow in Cleve et Möller	0	5
Nitzschia archibaldii Lange-Bertalot	63	0
Nitzschia pura Hustedt	23	0

Nitzschia A.H. Hassall	71	40
Nitzschia linearis(Agardh) W.M.Smith var.linearis	5	2
Nitzschia linearis(Agardh) W.M.Smith var.subtilis(Grunow) Hustedt	1	0
Nitzschia nana Grunow in Van Heurck	19	0
Nitzschia paleacea (Grunow) Grunow in van Heurck	4	25
Nitzschia palea (Kützing) W.Smith	77	43
Nitzschia perspicua Cholnoky	14	0
Navicula radiosa Kützing	0	2
Navicula recens (Lange-Bertalot) Lange-Bertalot	1	0
Navicula riediana Lange-Bertalot & Rumrich	0	1
Navicula rostellata Kützing	0	5
Navicula trivialis Lange-Bertalot var. trivialis	2	4
Navicula veneta Kützing	6	4
Navicula zanoni Hustedt	0	3
Pinnularia C.G. Ehrenberg	1	0
Planothidium frequentissimum(Lange-Bertalot)Lange-Bertalot	0	1
Rhopalodia gibba (Ehr.) O.Muller var.gibba	0	2
Sellaphora seminulum (Grunow) D.G. Mann	0	39
Stenopterobia delicatissima (Lewis) Brebisson ex Van Heurck	1	0
Dominant diatom species		

- ***Aquatic Macroinvertebrates Assemblage***

The taxa that were sampled at site HA1 and 2 are reflected in **Table 7.25**. The invertebrate communities at both sites consisted mainly of highly tolerant taxa, with only a single moderately tolerant taxa sampled at both sites respectively (**Table 7.25**). Only four taxa were sampled at site HA1 compared to the 9 sampled at site HA2. A distinction between habitat induced variation or possible pollution between sites, cannot conclusively be made, but the additional flow and substrate habitat available at site HA2 is probably explaining the measured differences.

A total of 9 taxa were sampled at site HA2. The Diptera order was most represented, with 3 families sampled (Ceratopogonidae, Chironomidae and Simuliidae). High abundances (between 101 - 1000) of pollution tolerant Chironomidae and Simuliidae sampled also suggest contamination of surface water.

Both sites reflected low ASPT scores of 3.40 and 3.8 respectively as no sensitive taxa were sampled. This data will provide baseline information and may be used as comparison for future monitoring.

Table 7.25: Aquatic macroinvertebrate taxa, sensitivities and estimated abundances sampled, July 2011 survey (1 = 1 individual; A = 2 – 10; B = 11 – 100; C = 101 – 1000). * = air breathers.

Order	Taxon	Sensitivity Score (Max 15)	HA1	HA2
ANNELIDA	Oligochaeta	1	A	B
	Hirudinea	3	-	B
DIPTERA	Ceratopogonidae	5	-	A
	Chironomidae	2	A	C
	Simuliidae	5	-	C
EPHEMEROPTERA	Baetidae 1sp	4	-	A
GASTROPODA	Physidae*	3	1	-
HEMIPTERA	Corixidae*	3	B	A
ACARINA	Hydracarina	8	A	A
	Turbellaria	3	-	1
No. of Taxa			**5**	**9**
ASPT			**3.4**	**3.8**
	High tolerance to pollution			
	Moderate tolerance to pollution			
	Low tolerance to pollution			

- ***Fish Assessment***

The expected fish species list was limited to fish that have been sampled in, and immediately around or adjacent to the quaternary catchments associated with the study area. A total of 14 indigenous species representing 5 families are expected to utilise surface water systems associated with the secondary study area. **Table 7.26**, shows the expected species as well as their conservation status. No species with conservation status occur in the study area, however, *Barbus neefi* is Data Deficient (DD). *Barbus trimaculatus* has a status of Least Concern (LC), but some literature suggests that it is Vulnerable (V) in the Orange-system (Benade *et al.*, 1995). *Amphilius uranoscopus* as well as *Chiloglanis pretoriae* both have been sampled in quaternary catchment B12C but are not expected to occur in the study area (Kleynhans *et al.*, 2007) due to the lack of suitable habitat

The expected fish list also includes alien and introduced species. *Labeo umbratus* naturally occurs in the Vaal-system, but has been introduced into the Limpopo and Olifants systems. Alien species that are expected in and around the study area include *Gambusia affinis* and *Micropterus salmoides* (**Table 7.26**).

Table 7.26: Fish species expected to utilise the river systems associated with the study area, in and around the quaternary catchment (B12A, B12B and B12C) (Kleynhans, et al., 2007). Alien species are shown in orange while sensitive species are indicated in green. LC = Least Concern; DD = Data Deficient; EX = Exotic. Conservation status according to IUCN, 2011**.**

Status	**Family**	**Species**	**Status**
LC	Amphiliidae	*Amphilius uranoscopus*	Stargazer Catfish
LC	Cyprinidae	*Barbus anoplus*	Chubbyhead barb
DD	Cyprinidae	*Barbus neefi*	Sidespot barb
LC	Cyprinidae	*Barbus paludinosus*	Straightfin barb
LC -Vulnerable in Orange*	Cyprinidae	*Barbus trimaculatus*	Threespot barb
LC	Cyprinidae	*Barbus unitaeniatus*	Longbeard barb
LC	Mochokidae	*Chiloglanis pretoriae*	Shortspine rock catlet
LC	Clariidae	*Clarias gariepinus*	Sharptooth catfish
EX	Poeciliidae	*Gambusia affinis*	Mosquito fish
LC	Cyprinidae	*Labeo cylindricus*	Redeye labeo
LC	Cyprinidae	*Labeo molybdinus*	Leaden labeo
Introduced	Cyprinidae	*Labeo umbratus*	Moggel
LC	Cyprinidae	*Labeobarbus marequensis*	Largescale yellowfish
LC	Cyprinidae	*Labeobarbus polylepis*	Smallscale yellowfish
EX	Centrarchidae	*Micropterus salmoides*	Largemouth bass
LC	Cichlidae	*Pseudocrenilabrus philander*	Southern mouthbrooder
LC	Cichlidae	*Tilapia sparrmanii*	Banded tilapia
	Exotic / introduced		
	Data Deficient		
	Sensitive species		

Of the two biomonitoring sites assessed only site HA2 yielded fish (**Table 7.27**). A large population of *Barbus neefi* was sampled at this site. *Barbus neefi* has preference for slow flowing water associated with overhanging vegetation and suitable substrate. This fish is also moderately intolerant to conditions of no flow, thus testifying to the perennial nature and constant discharge linked to site HA2. *Barbus neefi* is intolerant to changes in water quality and variation in abundances or frequency of occurrences of *B. neefi* will provide a future measure for impacts associated with the proposed wet ash disposal facility.

This species has a divided distribution range, with some populations occurring in the upper Zambezi and Southern Zaire, as well as south occurring populations in tributaries of the Olifants and Limpopo systems (Skelton, 2001). The divided nature of the distribution as well as the limited southern distribution of this species ascribes a conservation importance. Minnows are also, usually, characterised by extensive genetic variation between populations, but a study done by Engelbrecht *et al.* (2002) confirmed that *B. neefi* populations in headwater streams have less genetic diversity than populations further downstream. This leaves headwater populations prone to genetic drift and inbreeding. Thus, if unidirectional genetic flow is important to maintain the genetic diversity from populations situated lower down in the river-system, it illustrates the importance of conserving headstream populations as they may provide novel alleles that will increase genetic diversity of downstream populations (Engelbrecht, *et al.,* 2002).

The absence of fish, despite suitable habitat, at site HA1 possibly indicated water quality, flow or migration impacts.

Table 7.27: Fish species sampled at sites HA1 and 2 respectively, July 2011.

Species	Common name	HA1	HA2
Barbus neefi	Sidespot Barb	-	58

- ***Wetland Classification and Delineation***

o ***Wetland Classification***

The arrangement of the wetland classification system is hierarchical, and organised according to landform (Hydrogeomorphic unit as described by Kotze *et al.*, 2005) and hydrological characteristics as the primary determinants of ecological character and functionality of associated wetlands (Ewart-Smith *et al.,* 2006). The hierarchy progresses from Level 1 (at the most general level) through to Level 5, at increased finer levels **(Figure 7.34**). Accordingly 6 respective wetlands were identified in the study area (**Figure 7.35**). A total of 13 functional units were identified, three of which are located within the primary study area (**Figure 7.36**).

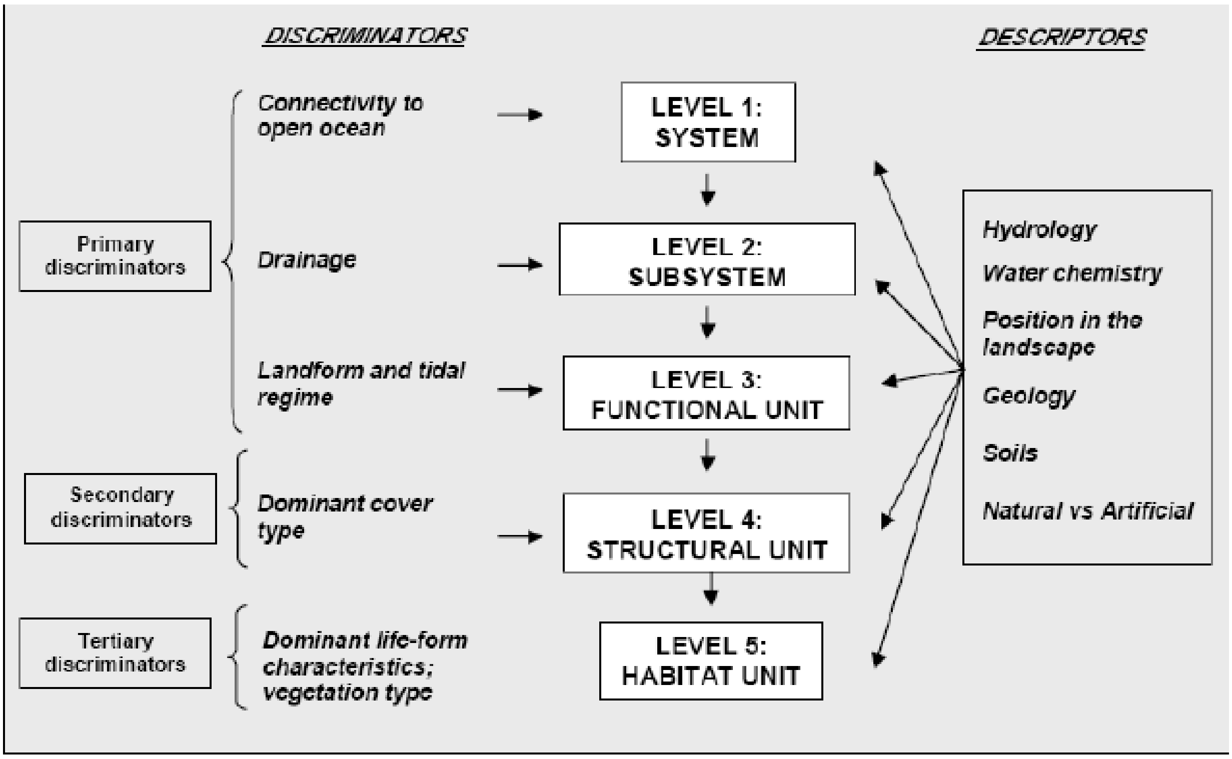


Figure 7.34: Adopted from Ewart-Smith et al. (2006), showing the basic structure of the wetland classification system. The role and hierarchy of specific discriminators are indicated.

- ***Soils***

The study area consist of moderately deep, yellow brown to red, light to medium textured soils, with no significant degree of structure. Shallower soils with ferricrete outcrop also occur (Patterson & Seabi, 2011). Within the primary study area HGM1 (of Wetland 1), and Wetland 4 are characterised by Tukulu form, while Wetland 3 is characterised by Katspruit form. Seasonal zones are generally represented by Avalon forms. The dominance of Plinthic soil in the primary study area is indicative of fluctuating perch water associated with the seasonal nature of the study area. The hydrological conductivity of the soil is relatively high; water thus drains easily to less permeable underlying geology, from where it flows as perched water. Perched water is expressed as permanent surface wetness in the lower lying areas and seasonal wetness upslope of permanent/semi-permanent areas identified.

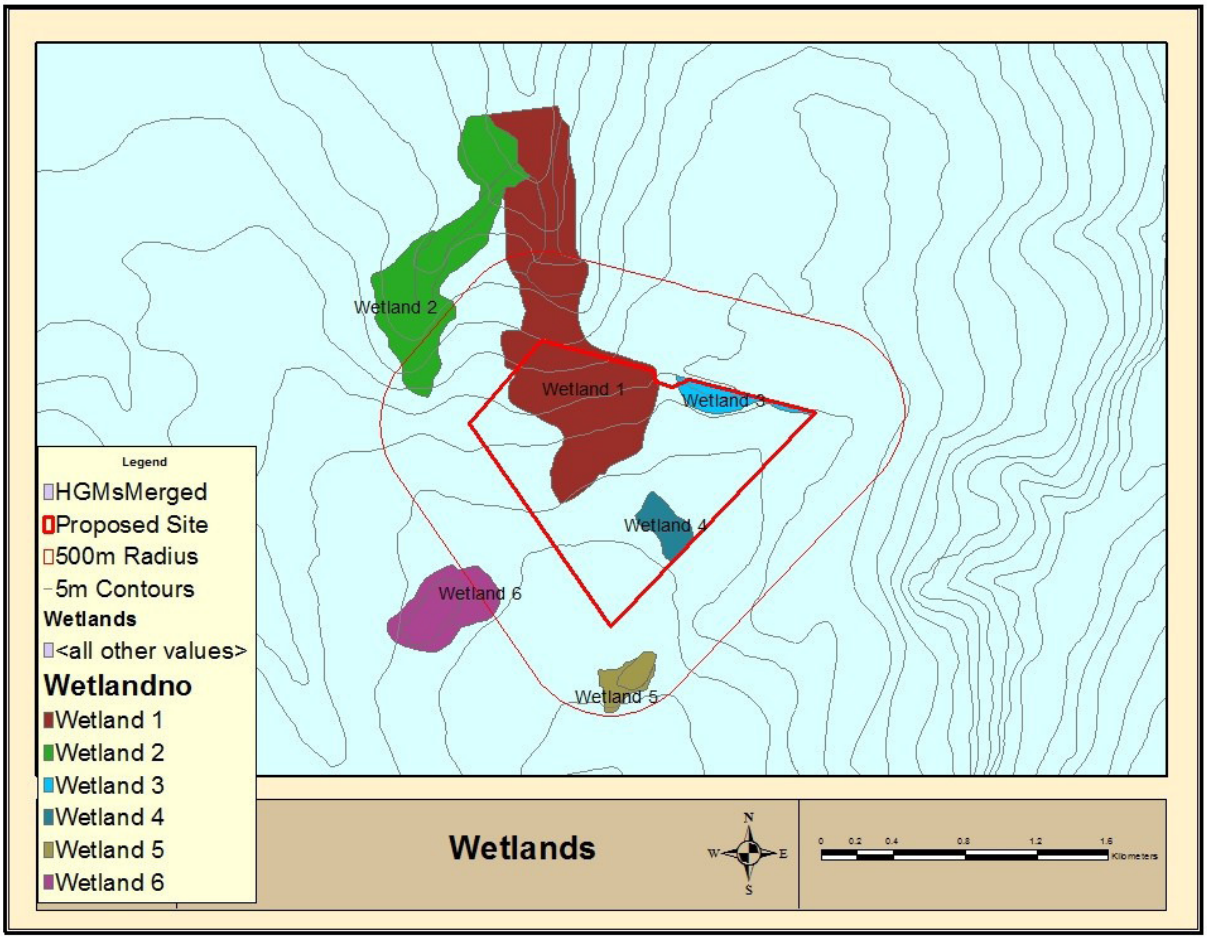


Figure 7.35: Map showing the different wetlands associated with the study area.

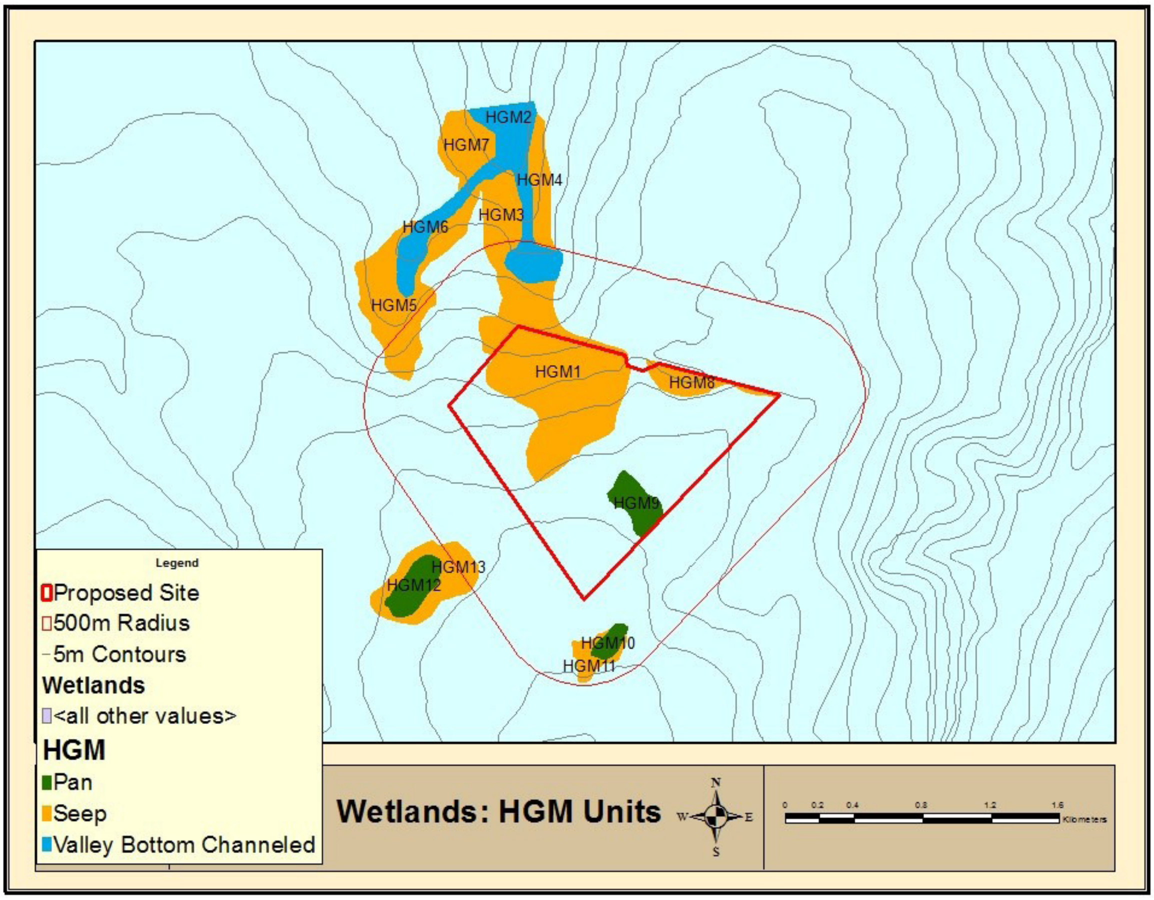


Figure 7.36: Map showing different HGM units and respective geomorphological classification.

Wetland 1 and 2 drain/or receive drainage from the North and North-western sections of the proposed footprint. These wetlands are important as they are most likely to receive runoff from the wet ash disposal facility during construction and operational phases. Clear variation in longitudinal slope associated with both wetlands warranted differentiation between higher lying seeps (with a steeper slope) abutting into channel valley bottom systems with a noted decrease in slope (**Figure 7.37 and 7.38**). Similarly both channel valley bottom systems (HGM2 and 6) notably receive substantial lateral flows from surrounding hillslope seeps (HGM units 3, 4, 5 and 7) (**Figure 7.37 and 7.38**).

Wetland 1 composed of four structural units; three seeps and one channelled valley bottom system. Wetland 2 consists of three HGM units: two seeps abutting into a channelled valley bottom system. Wetland 3 is a seep located just east of Wetland 1 and appears to be part of a remnant pan system, however due to access restriction during the field assessment this ambiguity remains unresolved. Wetland 4 consists of a seasonal pan fringing on the eastern boundary of the proposed footprint. Both wetlands 5 and 6 are seasonal pan systems with associated seeps (**Figure 7.35**). Three of the HGM units are within the boundaries of the proposed footprint (HGM 1, 8 and 9) (**Figure 7.36).** Of which HGM1 is considered the most important as it is the largest and drains into Wetland 1.

Both Wetlands 1 and 2 are drained by channel valley bottom systems receiving water from adjacent seeps. In both cases, the valley bottom systems are dammed extensively.

Headwater seeps (HGM1 and 5) both drain into dams, while HGM6 also has its confluence with HGM2 prior to flowing into a third dam. It is estimated that the three dams can contain approximately 70% of the mean annual runoff in their combined catchments.
Jointly, seeps make up the majority of wetlands in the study area. This is largely due to deep sandy soils (with high permeability) overlying a less permeable feature subsequently resulting in perch water with lateral movement. Hydrochemical characterisation of surface water sampled at HGM1, associated with the proposed footprint, was compared to that of ground water sampled, but possible ground water discharge could not conclusively be eliminated (refer to hydrological report). However, the geographical setting suggests surface runoff expressed as perched water. Seeps within the study area are mostly seasonal but do express small isolated areas of permanent or mostly permanent zones. The dryer peripheries of most seeps have been cultivated in most instances, subsequently resulting in a complete loss of wetland habitat in affected areas.

Three seasonal pans have been identified in the study area; one of which falls within the primary study area. The other two pans (and their abutting seeps) falls within, or are intercepted, by the 500 m line marking the secondary study area.

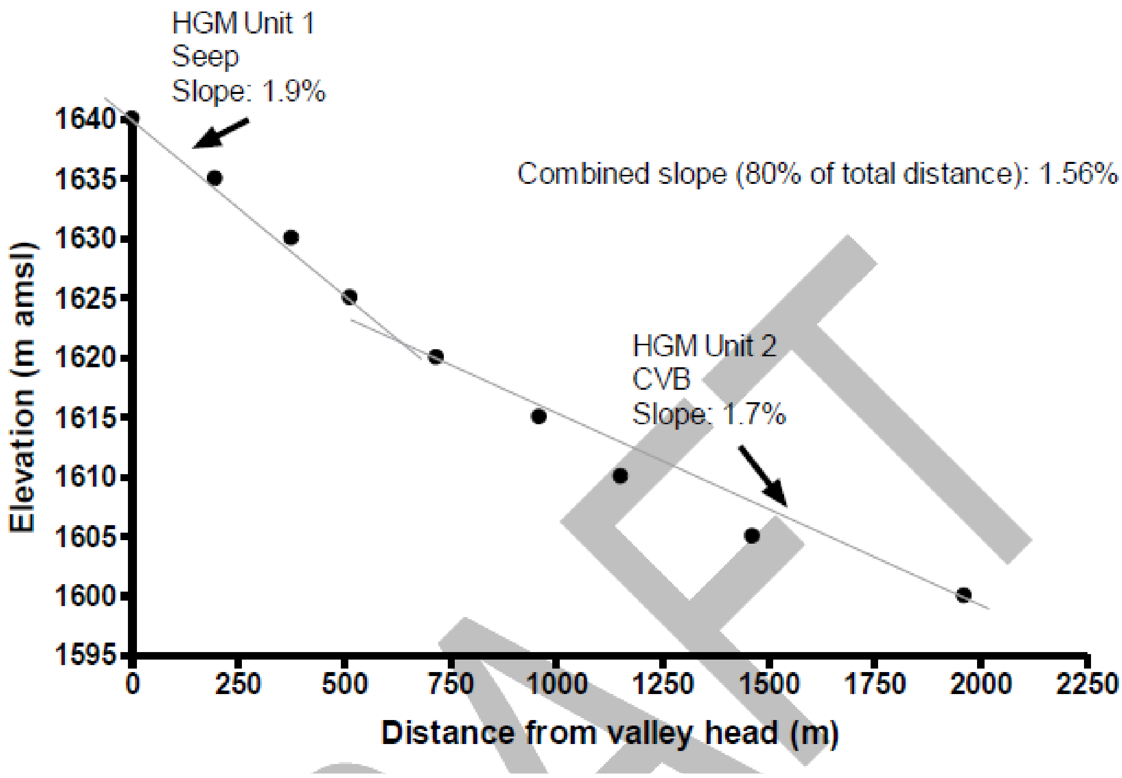


Figure 7.37: Longitudinal profile of HGM units in wetland 1, showing different slopes between HGM1 (seep) and HGM2 (channelled valley bottom).

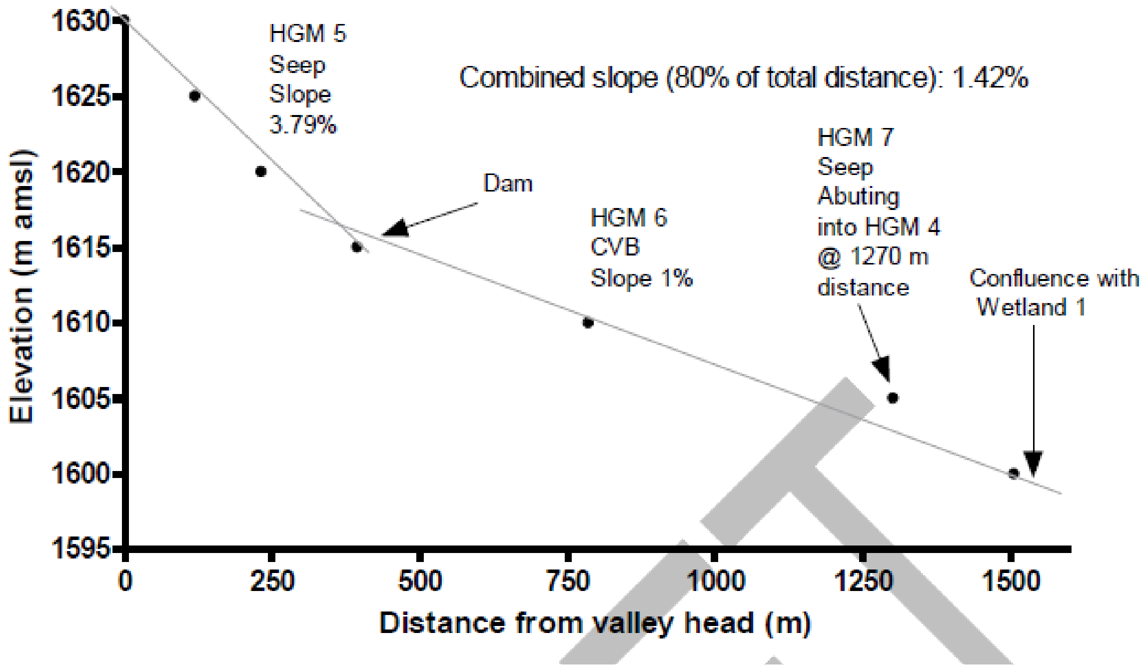


Figure 7.38: Longitudinal profile of HGM units in wetland 2, showing different slopes for HGM5 (seep) draining into HGM6 (channel valley bottom). The abutment of HGM7 (seep) into HGM6 is also noted on the diagram.

Table 7.28 and 7.29 reflects the approximate size and longitudinal slope associated with respective HGM units assessed. Respective catchment sizes are also reflected. Catchments of the two channeled valley bottom systems included those of abutting seeps. While the total catchment for Wetland 1 includes that of Wetland 2. Thus the catchment is approximately 750 hectares of which approximately 145 hectares are wetlands. Approximately 48 hectares of the proposed 140 hectare footprint is wetland.

Table 7.28: Approximate size and slope of Wetlands 1, 2 and 3, their respective HGM units and catchments associated with the study area.

	Wetland 1				Wetland 2			Wetland 3
	HGM1	HGM2	HGM3	HGM4	HGM5	HGM6	HGM7	HGM8
Catchment (ha)	88.30	639.20	9.70	117.30	181.80	190.30	51.80	102.30
HGM size (ha)	49.70	17.00	8.30	6.40	22.20	8.50	8.50	23.10
HGM slope (%)	1.90	1.70	1.47	2.57	3.79	1.00	2.20	2.68

Table 7.29: Approximate size of Wetlands 4, 5 and 6, their respective HGM units and catchments associated with the study area

	. Wetland 4	Wetland 5		Wetland 6	
	HGM9	HGM10	HGM11	HGM12	HGM13
Catchment (ha)	36.80	37.00	34.70	51.10	45.00
HGM size (ha)	5.30	2.30	2.70	6.10	10.00
HGM slope (%)	Pan	Pan	Pan	Pan	Pan

- ***Present Ecological State of Wetlands***

Wetland health may be seen as the degree of similarity between reference conditions and the Present Ecological State (PES). The PES expressed here is a combination of alteration measured on desktop and field investigation for hydrology, vegetation and geomorphology. It should be noted that field work efforts were mostly concentrated on wetlands falling within the proposed footprint of the wet ash disposal facility, while other wetlands were less extensively verified.

The hydrology of wetlands in the study area are influenced, in varying degrees, by catchment utilisation and by direct wetland modification which alter the quantity and distribution of water within each HGM unit identified. The ratio between mean annual precipitation (MAP) and potential evaporation (PE) rates provide a measure for assessing the hydrological vulnerability of wetlands to changes in water quantity. The MAP:PE ratio for the study area was calculated at 0.36, highlighting the dependence of wetlands on upstream catchment for water input. The hydrological vulnerability factor is incorporated in the PES assessment to calculate impact intensity associated with landuse activities within the respective catchments.

Similarly the vulnerability of identified HGM units to geomorphological alteration was ascertained by considering the variation from the equilibrium slope expected for a given size HGM and the actual slope measured (**Figure 7.39**). It follows that most HGM units assessed are over their equilibrium slope and is vulnerable to erosion. HGM units 1, 5 and 8 obtained the highest vulnerability scores.

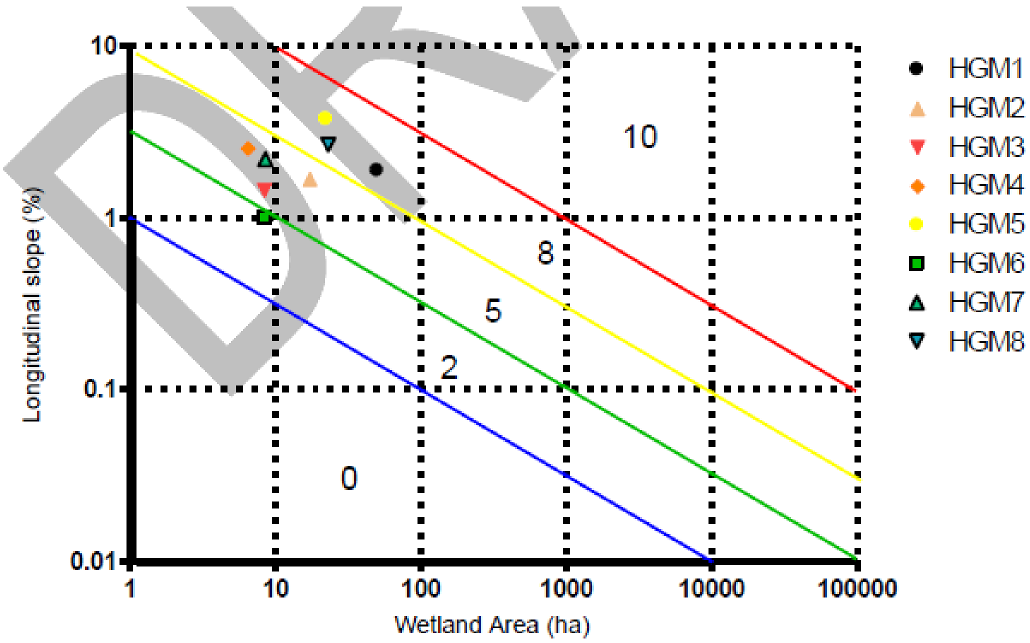


Figure 7.39: Vulnerability of HGM units to geomorphological impacts based on the wetland size and wetland longitudinal slope. The green line between 2 and 5 approximates the equilibrium slope for a wetland of a given size.

The overall PES associated for each HGM unit is illustrated in **Figure 7.40**. Seeps associated with Wetland 1 (HGM1, 3 and 4) and Wetland 2 (HGM5, 7) fell in a C category and relate to a modified state. Receiving channelled valley bottom systems (HGM2 and 6) fell in a D-category and relate to a largely modified state. HGM8, 10 and 11 also classed in a D category. The seasonal pan system (HGM12 and 13), marginally infringed on by the 500 m line, falls in an A category and even though some impacts were identified, the extent and intensity were limited. The following provides a brief summary of impacts associated with individual HGM units and their respective catchments.

- HGM1 (**Figure 7.41 A-F**): Catchment mostly impacted on by agricultural activities, which attempted to drain the upper part of the seep (**Figure 7.41 A**). Most of the temporary zones and some seasonal areas are ploughed and have been under cultivation historically. The catchment contains a number of dirt roads and a tar road acts as an impending structure as it crosses the wetland without providing hydrological continuity (**Figure 7.41 B**). This subsequently resulted in lateral extension of the HGM upstream from the tar road crossing. Power lines and linked servitude also run along most of the upper part of the seep (**Figure 7.41 C**).
- HGM2 (**Figure 7.42 A**) have two dams at both ends, some dirt roads and a tar road crossing facilitating flow, through flumes. The upper dam (**Figure 7.42 B**) receives discharge from waste water treatment facility, while the channel between the two dams has been straightened in sections. The abutting seep on the left hill (HGM3) (**Figure 7.42 C and D**) are mostly impacted on by road infrastructure, agricultural activity and isolated patches of alien vegetation, while the right hill seep (HGM4) drains runoff from the power station area **(Figure 7.42 E**).
- HGM5 is the valley head seep associated with Wetland 2 and also drains into a farm dam (**Figure 7.43 A**) which marked the start of the second valley bottom system (HGM6) (**Figure 7.43 B-E**). The unit is subject to a number of dirt roads and a tar road crossing. The entire temporary zone is under cultivation rendering the functional wetland smaller than what is naturally expected. The diatom assessment revealed industrial pollution in the system, whilst the discharge at the breached dam wall was not consisted with the seasonal nature of the upstream catchment (**Figure 7.43 B**). The system has to deal with a notable increase in water volume.
- Thus HGM6 is mostly impacted on by additional longitudinal discharge and agricultural infringement. HGM6 joins HGM2 prior to flowing into another farm dam. HGM7 is a seep abutting into a valley bottom (HGM6) the hydrological contribution of this seep is thought to be substantial as a change in slope was measured after its confluence with HGM6 (refer back to **Figure 7.36**). HGM7 drains a small catchment, largely isolated from surrounding activities. These factors constitute the B ecological category for HGM7.
- HGM8, much like HGM1, falls within the direct footprint of the proposed development. The wetland is substantially altered from natural conditions with large parts of its catchment and functional unit infringed on by industrial and agricultural activity (**Figure 7.44 A-E**). The wetland is traversed by a tar road. Low permeable fencing also restricts the movement of wetland fauna.

- HGM 9 also located on the direct footprint, is a seasonal pan system completely surrounded by agricultural activity (**Figure 7.45 A-E**).
- HGM10 and 11 comprise of a pan and seeps. The direct catchment is almost entirely under ploughed field. The wetland is also impacted on by road and railway infrastructure (**Figure 7.46 A-E**)
- HGM12 and 13 (a larger pan and seeps to the south of Alternative E) are only marginally infringed on by the 500 m line reflecting the secondary study area. The pan is seasonal and whilst some impacts have been noted (**Figure 7.47 A-C**) in the unit and its associated catchment, their extent and/or intensity are largely limited.

The general state of wetlands within the study area is impaired largely due to hydrological, geomorphological and habitat alteration induced by dam and road structures, while the agricultural activity, in most instances, have infringed on wetland habitat subsequently prohibiting ecological and hydrological functioning.

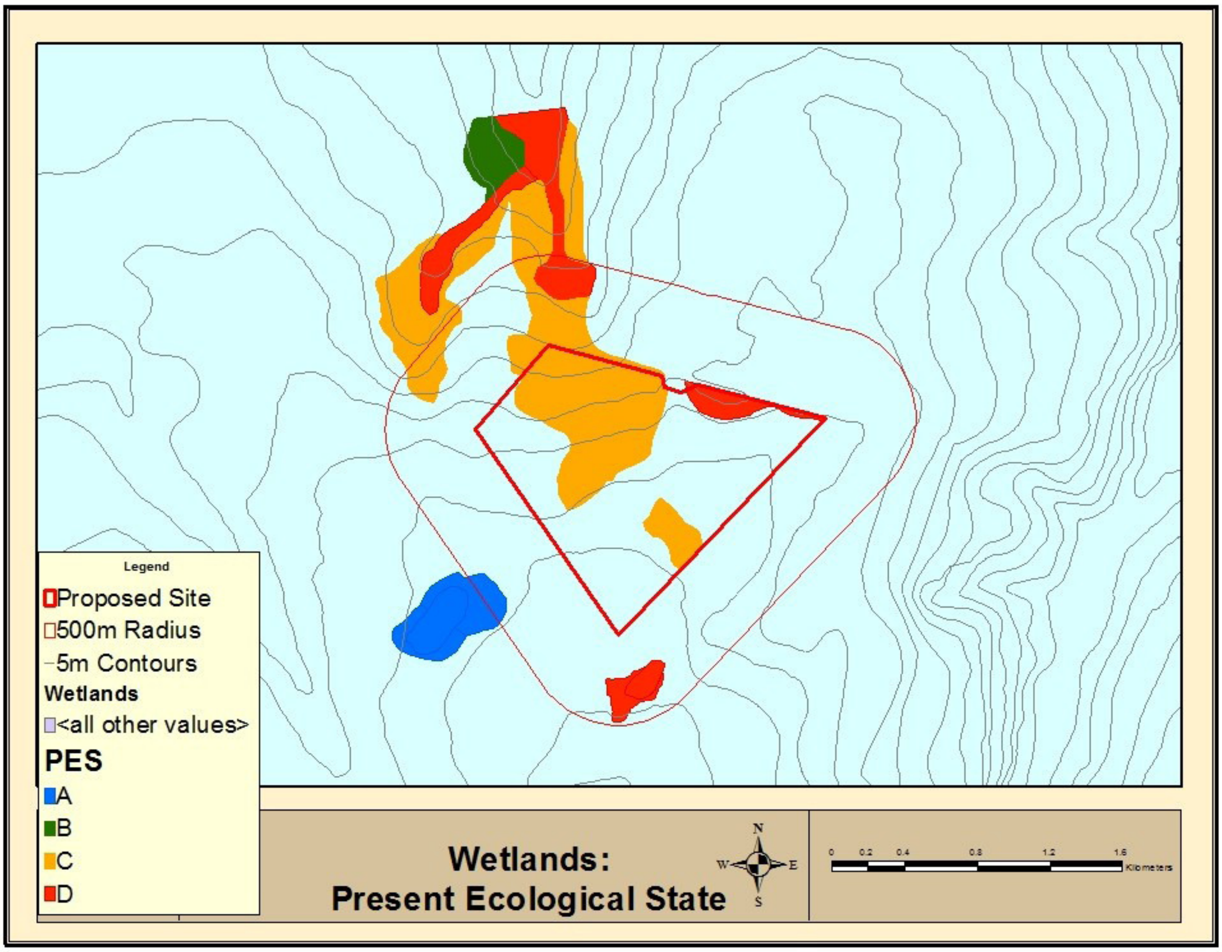


Figure 7.40: Map showing the Present Ecological State associated with respective wetlands on Alternative E.

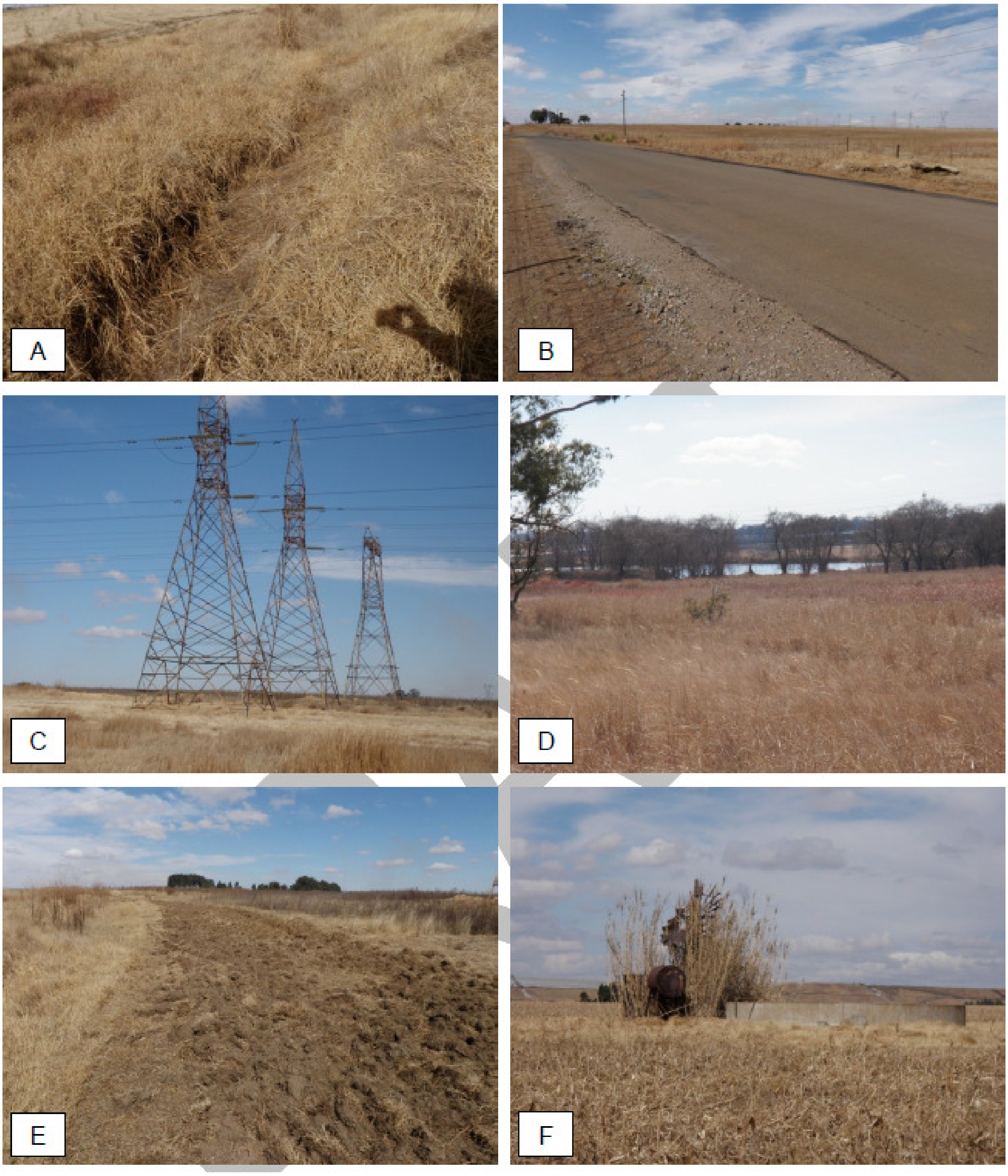


Figure 7.41: HGM1 is situated in the north-western portion of Alternative E reflecting exciting impacts which include: (A) retention dam, (B) road, (C) power line pylons, (D) furrow (E) a fire break and (F) a small dam.

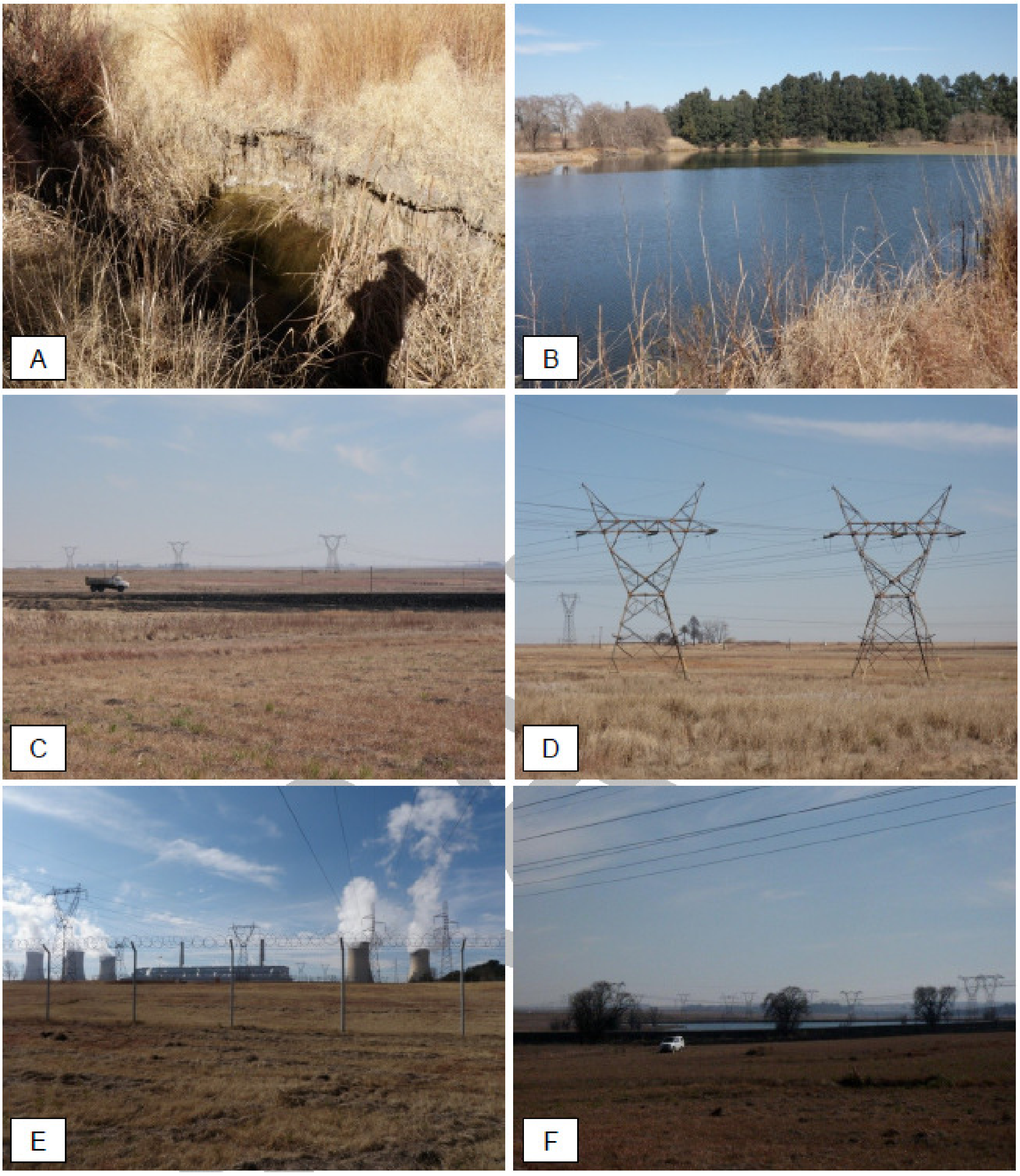


Figure 7.42: Exciting impacts associated with HGM 2, 3 and 4 include: (A) (B) large dams, (C) Hendrina Power Station, (D) severe canalisation, (E) power line pylons and (F) a road.

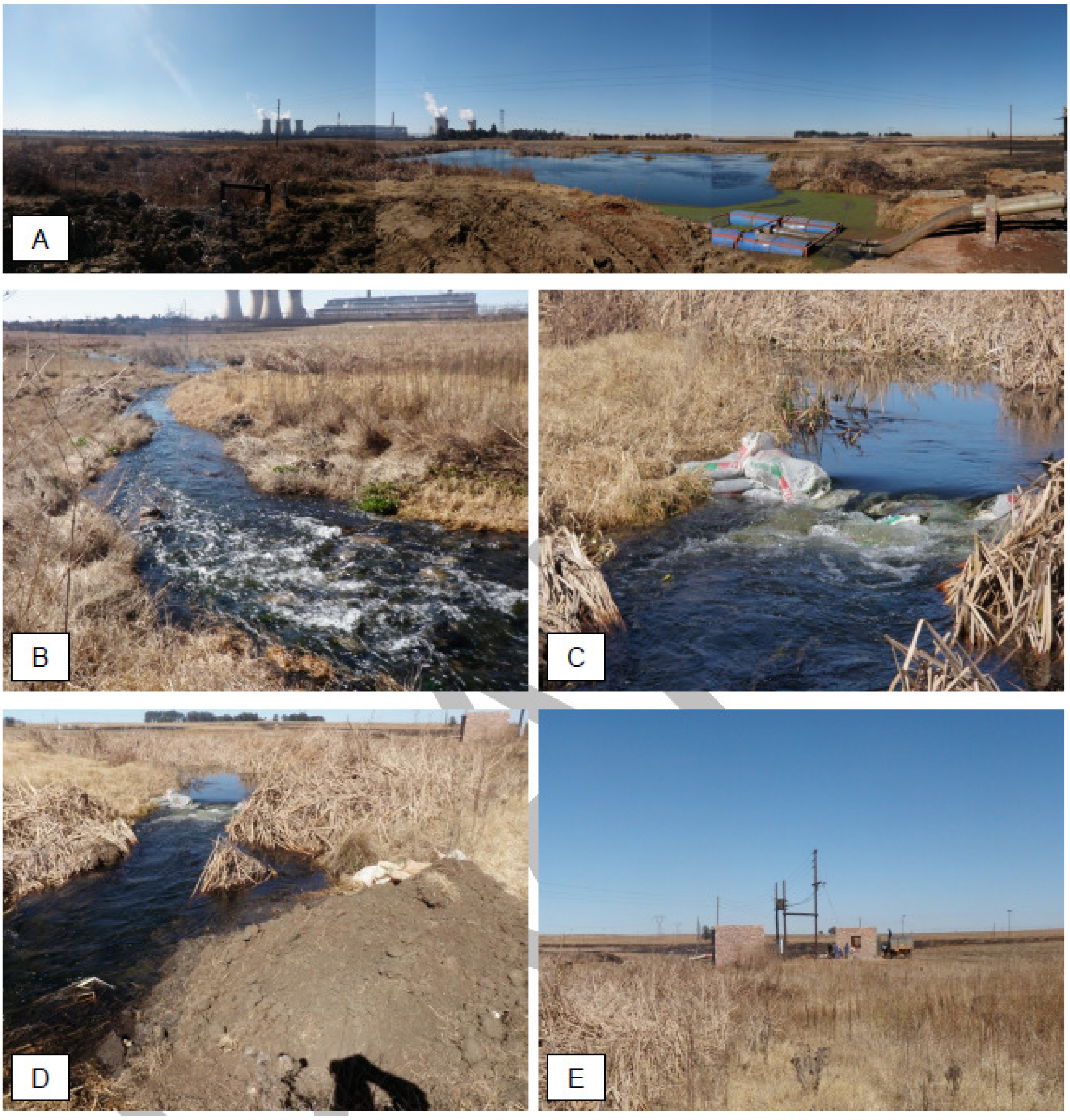


Figure 7.43: Site HA2 (monitoring site 2) is located to the north-west of Alternative E showing (A) panoramic view, (B) riffle section located downstream of the dam, (C) sand bags altering the flow, (D) loose sediment placed on the left bank, (E) construction activities.

Figure 7.44: HGM8 is situated in the north-eastern portion of Alternative E reflecting (A) panoramic view of the wetland with exciting impacts: (B) maize fields, (C) fire breaks, (D) Hendrina Power Station and (E) a farm property.

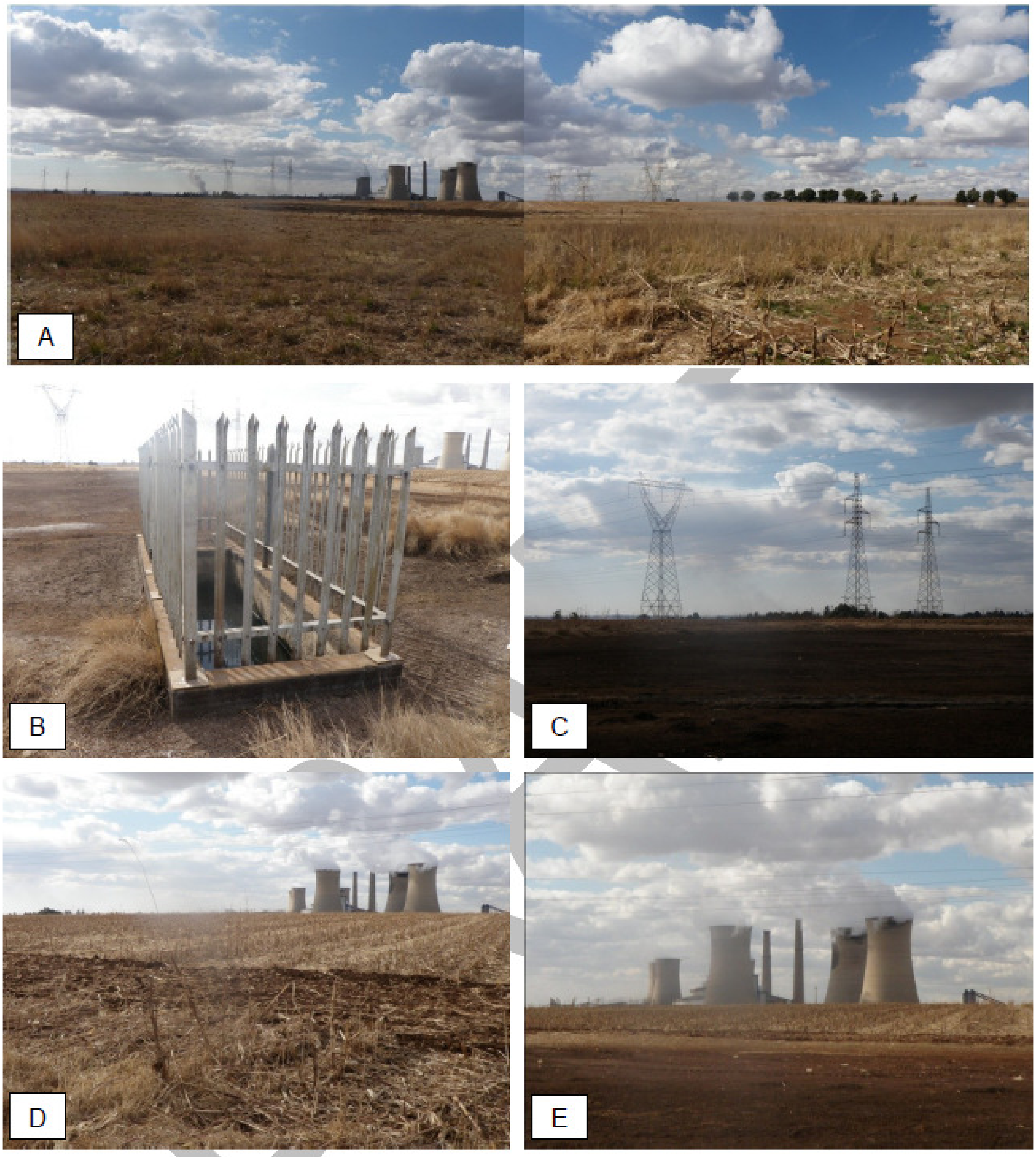


Figure 7.45: HGM9 is situated in the south-eastern portion of Alternative E reflecting (A) a panoramic view of the wetland with exciting impacts: (B) presumably a cattle dip located within the seasonal zone, (C) power line pylons, (D) maize field with a fire break (E) and Hendrina Power Station.

Figure 7.46: HGM10 and 11 are situated to the south of Alternative E reflecting (A) a panoramic view of the wetland with exciting impacts: (B) tar road and (C) exciting Hendrina wet ash disposal facility.

Figure 7.47: HGM12 and 13 are situated to the south-west of Alternative E reflecting (A) a panoramic view of the wetland with exciting impacts: (B) farm property, (C) maize husks deposited within the seasonal zone, (D) trampling via cattle and (E) power lines.

- ***<u>Wetland Functionality Assessment</u>***

Functional ecosystem services of wetlands in general include services such as flood control, nutrient cycling, erosion control, toxicant removal, carbon storage, phosphate assimilation, biodiversity maintenance, provision of food and water, cultural services and recreation. The presence of the service is subject to the potential exposure in the catchment and the HGM type. Wetlands directly implied by the footprint of the proposed development were subjected to a level 2 Wet-Ecoservices assessment and are discussed first, while a level 1 assessment was done on wetlands falling within the secondary study area.

- ***Wetlands in the Direct Study Area***

The direct catchment draining into HGM1 is largely affected by agricultural practices subsequently providing a source for nutrients and sediment. Concurrently HGM1 retains enough functionality to provide seasonal variation in reduction potential and subsequent ion exchange (**Figure 7.48**). The position of HGM1 in the landscape does not constitute a notable service in terms of flood attenuation. Similarly the stream flow regulation function provided by HGM1 is rendered obsolete due to the presence of the dam into which HGM1 flows. This notion is reinforced when considering the retention potential of the receiving dam in relation to the upstream catchment (approximate 80% of the mean annual runoff).

HGM unit 8, also a seep, retains a particular function in terms of nitrate removal (**Figure 7.49**). The wetland is largely transformed and the direct catchment does provide the opportunity for this functional service. Unlike HGM1, the connectivity of HGM8 to surface water drainage system is thought to be less. The surrounding topography suggests a possible connection to HGM2 however this could not conclusively be verified during the field assessment. Vegetation cover signified permanent wetness, suggesting a lower functional importance for flood attenuation. Loss of vegetation cover and soil disturbance, within large parts of this wetland, has also impaired wetland services associated with wetland habitat and erosion control.

HGM9, the only pan in the direct footprint of the proposed development is relatively small and largely seasonal. Due to the isolated nature of pans they have a limited function in terms of flood attenuation and stream flow regulation particularly when considering the size of the wetland in question (5.3 ha). Similarly pans are also not considered important for sediment trapping. However the immediate catchment-use does provide sources of nutrients and HGM9 is expected to provide a service in terms of mineralisation and de-nitrification (**Figure 7.50**).

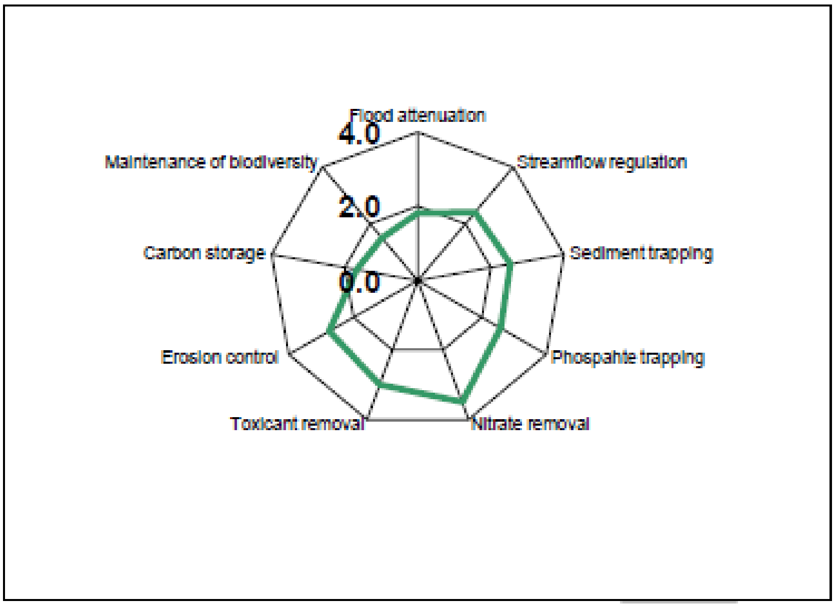


Figure 7.48: Spider diagram representing indirect services provided by HGM1**.**

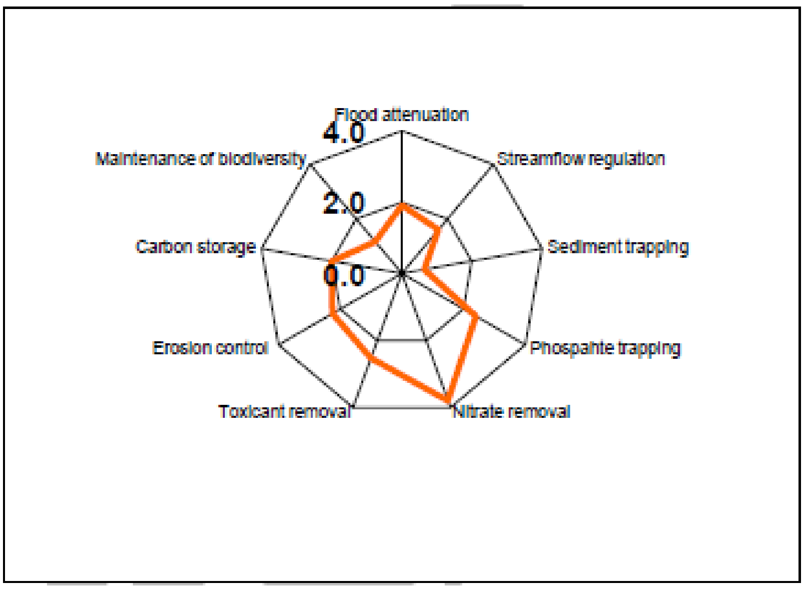


Figure 7.49: Spider diagram representing indirect services provided by HGM 8.

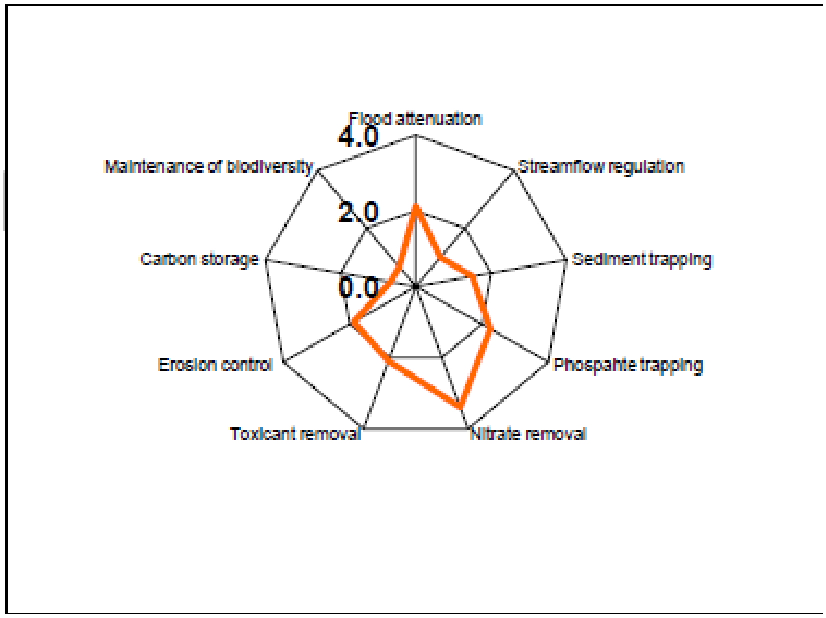


Figure 7.50: Spider diagram representing indirect services provided by HGM 9.

- ***Wetlands in the Secondary Study Area***

The secondary study area compose of a 500 m radius around the primary study area and includes two channel valley bottom systems and two pans with associated seep zones. It is important to consider the functionality associated with these systems as they will be the primary receptors of upstream impacts related to the construction and operation of the proposed wet ash disposal facility.

Channeled Valley Bottom and Associated Seeps

Channeled valley bottom systems resemble flood plain systems to a certain extent, but are generally smaller and steeper sloped with less active deposition. Wetland functions associated with flood attenuation and sediment trapping are typically less expressed in channeled valley bottom systems, moreover the presence of large farm dams located at the beginning and end of both functional units, HGM2 and 6, renders this function less important. Particular importance should be assigned to nitrate and toxicant removal associated with these systems, especially when considering the lateral input of water from adjacent hillslope seeps. Channel valley bottom systems and their seeps also consist of habitat heterogeneity induces by the gradient of wetness in the landscape, subsequently providing habitat for wetland fauna and flora. These areas are mostly limited to actual channel and wet seasonal parts, as other areas of the wetlands are under agricultural practices. Both channel valley bottom wetlands provide suitable habitat for fish under current conditions, and while the diatom assessment ascertained respective organic and industrial pollution, *Barbus neefi* was sampled in HGM6. *Barbus neefi* is semi-intolerant to degraded water quality, highlighting the importance of wetland functions associated with enhancement of water quality. The presence of *B. neefi* and the current diatom and invertebrate communities assessed should be used as monitoring instruments during the operational phase of the proposed development.

Pans and Associated Seeps

The two pans in the secondary study area are largely seasonal and vary in size. HGM10 is approximately 5 hectares, while HGM11 is roughly 16 hectares (including their abutting seeps). Their respective catchment uses are similar but differ in intensity. It follows that the services between these two pans will differ. In general, seasonal pans allow mineralisation, de-nitrification and volatilization in the case of high pHs (Allen *et al.,* 1995). Moreover, and in both cases, pans provide suitable wetland habitat for a number of wetland species. Of particular interest is the impaired state of HGM11 and 12, which provide an opportunity for offsite mitigation for HGM9, directly impacted by the placement of the proposed dam.

Table 7.30: Preliminary ratings of the hydrological benefits likely to be provided by associated wetlands

Wetland HGM	**Regulatory Benefits Potentially Provided by the Wetland**							
	Flood Attenuation			**Stream flow regulation**		**Enhancement of Water Quality**		
	Early wet season	**Late wet season**	**Stream flow regulation**	**Erosion control**	**Sediment trapping**	**Phosphates**	**Nitrates**	**Toxicants**
Channelled valley bottom (HGM2 and 6)	+	0	0	++	+	+	+	+
Hillslope seeps connected to stream channel (HGM1, 3, 4, 5, 7, 8)	+	0	+	++	0	0	++	++
Pan/Depression (HGM)10 and 12	+	+	0	0	0	0	+	+
Rating: 0 Benefit unlikely to be provided to any significant extent; + Benefit likely to be present at least to some degree; ++ Benefit very likely to be present (and often supplied to a high level)								

- ***Hectare Equivalents***

Hectare equivalents refer to the quantity of functional wetland area left considering the remaining integrity associated with the each unit (**Table 7.31**). Of the approximate 48 hectares of wetland directly affected by the proposed development about 30 hectares of hectare-equivalents remain, the majority of which play an important part in nitrification and detoxification of surface runoff in the catchment. It follows that the proposed placement of the ash dump will sterilise wetland services equivalent to approximately 30 ha. This provides a minimum-area framework for considering mitigation measures and particularly offsite mitigation plans.

Table 7.31: Hectare equivalents for respective functional units in area of study

HGM unit	Size (ha)	Hectare Equivalents (ha)
HGM1	49.70	34.8
HGM2	17.00	10.7
HGM3+4**	14.7	11.8
HGM5	22.20	15.6
HGM6	8.50	4.2
HGM7	8.50	4.9
HGM8*	5.2	2.8
HGM9	5.30	3.9
HGM10+11***	5	2.9
HGM12+13	16.1	14.8
***size of the section of the HGM directly on the primary study area** ****seeps on either side of HGM2** *****Pans and linked seeps**		

- ***Ecological Importance and Sensitivity***

The ecological importance of a wetland infers the degree to which biological diversity and ecological functioning is maintained on a particular spatial scale. Ecological sensitivity provides a measure of the ability of a wetland to resist disturbance. For the purpose of this assessment EIS scores are not expressed for individual functional units but for separate wetlands identified. Confidence ratings were higher for wetlands on the primary study area than for those on the secondary study area. **Table 7.32** provides EIS scores for respective wetlands and **Figure 7.51** shows the spatial distribution in EIS categories for each wetland.

Wetland 1 (consisting of a channelled valley bottom system and abutting seeps) scored moderate and fell into a C EIS category. Even though the functional units in this wetland are ecologically impaired it still provides potential habitat for species with conservation status and also serves as a corridor to the Woest-Alleenspruit. The risk of aquatic ecological degradation, induced by the proposed development, is highest for wetland 1 and warrants special consideration. The upper part of Wetland 1 (HGM1) will effectively be sterilised by the wet ash disposal facility. Regardless of the impaired PES of this functional unit, its downstream hydrological contribution will effectively be lost. However the severity of this is not considered substantial for three main reasons: (1) the artificial dam receiving drainage from HGM1, and marking the start of HGM2, intercepts the majority of HGM1"s hydrological contribution. (2) The presence of the dam renders flood attenuation and stream flow regulation functions of HGM1 largely obsolete. (3) The lateral contribution of seeps in Wetland 1 together with treated waste water discharge, probably contribute a substantial volume of water, mostly maintaining the permanent nature of the valley bottom system.

Wetland 2 obtained a higher EIS score mostly due to higher diversity of available habitat and the presence of *B. neefi* (which constitute a unique population). Wetland 2 will only be marginally deprived of water due to the placement of the dam. Moreover, the current discharge of this system suggests significant water input, presumable industrial effluent as indicated by the diatom response metric.

Wetland 3 and 4 fell into a D EIS category and translates into wetlands that are not ecologically important and sensitive at any scale. While the remaining pan systems (Wetlands 5 and 6) yielded moderate importance and sensitivity scores.

Table 7.32: Table reflecting the EIS assessment scores, confidence ratings and reasons.

Determinant	Wet.1	Wet.2	Wet.3	Wet.4	Wet.5	Wet.6	Confidence	Reason
PRIMARY DETERMINANTS								
1. Rare and endangered species	3	3	2	3	2	2	3	*Metisella meninx* (Marsh Sylph) - VU; African Grass Owl; African Marsh Harrier.-*Crinum bulbispermum* (Declining), *Nerine gracilis* (NT) and *Kniphofia typhoides* (NT)
2. Populations of unique species	0	2	0	0	0	0	3	Population of *Barbus neefi* sampled within HGM6, might possibly occur in Wetland 2-HGM6.
3. Species / taxon richness	3	3	0	0	2	3	3	HGM2, 6 and associated seeps provide moderate bird, invertebrate and downstream fish species richness
4. Diversity of habitat types or features	2	3	1	0	2	2	3	Gradient of wetness in most functional units are expressed in variation in vegetation cover resulting in habitat diversity. Permanent zones associated with Wetland 2 and largely natural state associated with Wetland 6 assigns a higher diversity score to these wetlands.
5. Migration/breeding and feeding site for wetland species	3	3	0	0	1	3	2	Channel valley bottom (HGM2 and 6) and respective seeps provide aquatic corridor for movement of aquatic invertebrates and fish. While HGM1 and 8 provides *Leersia hexandra* (feeding habitat for *M. Meninx*).Numerous more common wetland species (e.g. ducks, coots, geese etc) may use wetland areas for breeding and feeding.
6. Sensitivity to changes in natural hydrological regime	2	3	1	1	1	1	2	A low MAP:PE ratio for the study area suggests that wetlands are depended on upstream catchment for water input. The ratio between functional unit size and sloped revealed, for most HGM units, a vulnerability to geomorphological alteration in the providing catchment.
7. Sensitivity to water quality changes	2	3	0	1	1	1	3	Diatom response metric measured at HGM2 and 6 suggest an impaired state linked to organic and industrial pollution respectively. Similarly, low oxygen saturation was measured. However, *B. Neefi* (sampled in HGM6) is moderately intolerant to changes in water quality
8. Flood storage, energy dissipation and particulate/element removal	3	3	1	2	2	1	3	Wet-ecoservices revealed predominant functions of de-nitrification and detoxification. The degree of which are reflected in the respective scores.
Baseflow augmentation; dilution	2	2	0	1	1	1	3	Three dams in the immediate catchment supplement flood attenuation and surface water augmentation functions.
MODIFYING DETERMINANTS								
9. Protected status	1	1	1	1	1	1	2	SANBI conservation management plan for Mpumalanga assigned significance to the area for maintenance of aquatic diversity. The NSBA assigns a critically endangered status to the Woest-Alleenspruit.
10. Ecological importance (rarity of size/type/condition) – local, regional or national context	2	2	0	0	1	1	4	Mostly local importance
TOTAL	***21***	***26***	***5***	***6***	***14***	***15***		
Average	***1.9***	***2.4***	***0.5***	***0.5***	***1.3***	***1.4***		
MEDIAN	**2**	**2.5**	**0.5**	**0.5**	**1**	**1**		

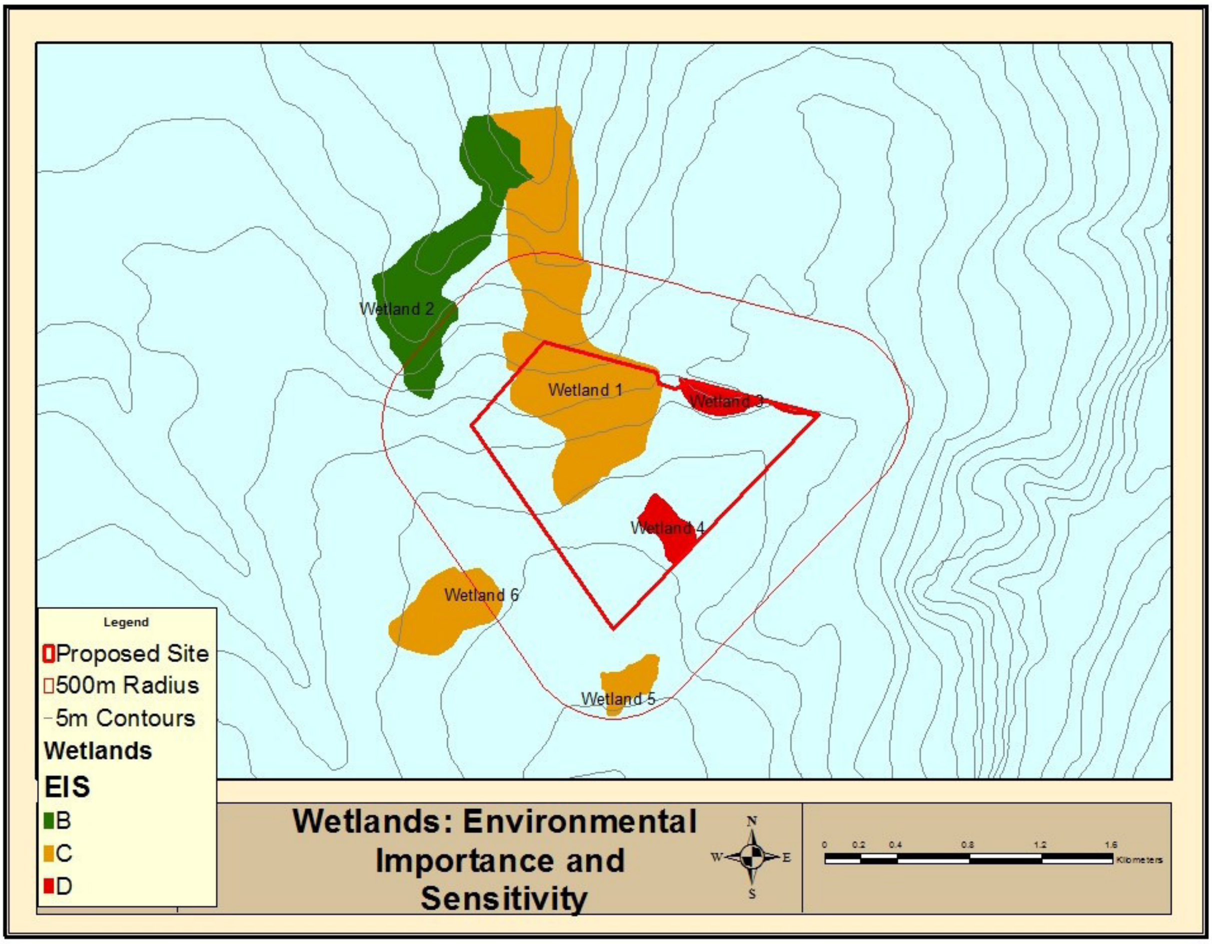


Figure 7.51: Map showing EIS categories for wetlands in the primary and secondary study area.

The Surface Water Report can be found in **Appendix M**.

7.10 Groundwater

7.10.1 Description

Based on the geology, it is considered that there are two main aquifer systems that exist in the area of interest:

- A shallow, weathered rock aquifer, referred to as the 'shallow aquifer'; and
- A deeper, hard rock fractured aquifer, referred as the 'deeper aquifer'.

Groundwater storage and transport in the unweathered Vryheid Formation is likely to be mainly via fractures, bedding planes, joints and other secondary discontinuities. The success of a water supply borehole in these rocks would depend on whether one or more of these structures are intersected by the borehole. In general the Vryheid Formation is considered to be a minor aquifer, with some abstractions of local importance. Although, groundwater may exist within fractures in the volcanic rocks, they have not been classed as a 'third aquifer' due to their limited areal extent in the study area.

The Department of Water Affairs (DWA) has produced a series of 1:500 000 scale hydrogeology maps (the General Hydrogeology Map Series), together covering the whole of South Africa. Analysis of median borehole yields and aquifer types has allowed DWA to classify the hydrogeology of the country according to an alphanumeric code incorporating aquifer type and borehole yield, shown in **Table 7.33**.

Table 7.33: General Hydrogeology Map Classification of South Africa

Aquifer Type	Borehole Yield Class (L/s)				
	Class "1" 0 - 0.1	Class "2" 0.1 - 0.5	Class "3" 0.5 - 2.0	Class "4" 2.0 - 5.0	Class "5" >5.0
Type "a": Intergranular	A1	A2	A3	A4	A5
Type "b": Fractured	B1	B2	B3	B4	B5
Type "c": Karst	C1	C2	C3	C4	C5
Type "d": Intergranular and fractured	D1	D2	D3	D4	D5

The area within an 8 km radius of the Hendrina site is almost all classified as "D2" (i.e. intergranular and fractured aquifers with median borehole yields of between 0.1 and 0.5 litres per second). The outcrop of Kwaggasnek Formation in the NW of the study area appears to be the reason for the area classified as "D3" on the general hydrogeology map series (**Figure 7.52**).

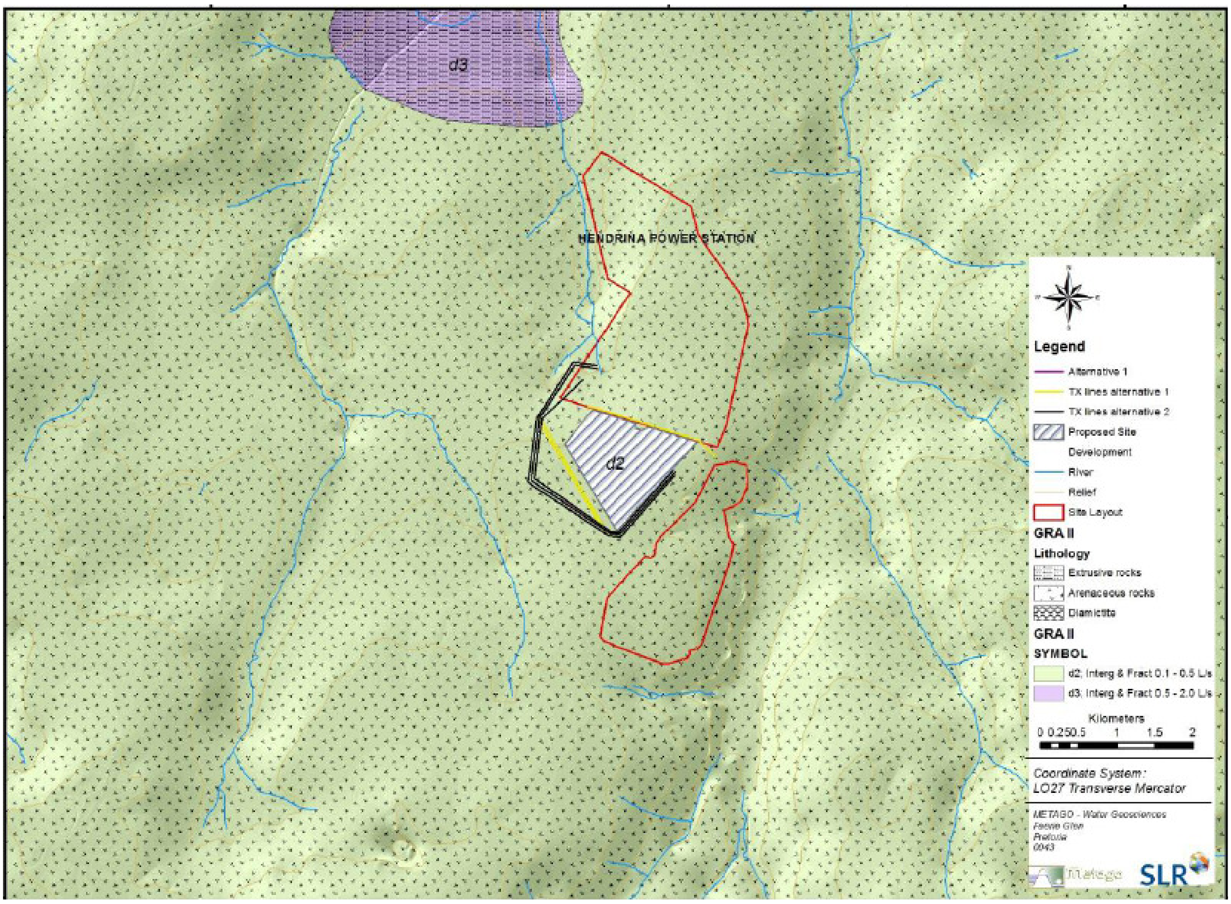


Figure 7.52: hydrogeology of the Hendrina area: DWA gra2 classification.

The study area is located in quaternary catchment B12B, within the Olifants Water Management Area. The Groundwater Harvest Potential Map of South Africa (Baron et al, 1998) classifies the study area as having an estimated groundwater harvest potential of 10 000 to 15 000 m3/km2/year (i.e. relatively low). The average borehole yield is > 0.4 litres per second (L/s), and the total dissolved solids concentration of the (unpolluted) groundwater is between 200 and 300 mg/l (i.e. relatively fresh). No major groundwater abstractions are shown on the DWA 1:500 000 scale hydrogeology map of the area (Sheet 2526 Johannesburg) in the area. The GRA2 data for the quaternary catchment B12B is summarized in **Table 7.34** below:

Table 7.34: GRA2 Data Summary for B12B

QUATERNARY CATCHMENT B12B	
Area (km2)	658.5
Average water level (metres below ground level)	8.7
Volume of water in aquifer storage (Mm3/km2)	467.7
Specific Yield	0.003
Harvest Potential (Mm3/a)	14.6
Contribution to river base flow (Mm3/a)	7.8
Utilizable groundwater exploitation potential in a wet season (Mm3/a)	9.5
Utilizable groundwater exploitation potential in a dry season (Mm3/a)	6.3

A hydrocensus was undertaken by SLR staff members in April 2011 where groundwater level monitoring data was collected from eight monitoring boreholes in the vicinity of the wet ash disposal facility. Water levels for an additional eleven boreholes were also obtained from the National Groundwater Association (NGA) database. Details of these groundwater monitoring boreholes are presented in **Table 7.35** below. A second field visit was undertaken by SLR staff in September 2011 in order to take water samples for hydrochemical analysis. The water levels at three of the boreholes visited in April 2011 were measured again during the September visit (**see Table 7.36**).

Review of groundwater level data show that groundwater in the study area is shallow (generally <10 mbgl) and is likely to be unconfined. Groundwater in the 'deeper aquifer' is likely to be confined / semi-confined.

Pumping test / hydraulic test data was not available as part of this review.

Table 7.35: Summary of Groundwater Monitoring Boreholes

Borehole	UTM_X	UTM_Y	Elevation (Z) (mamsl)	Static Water Level (mbgl)	Static Water Level (mamsl)	Geological Unit Monitored
AB00001	259095.948	-2886595.931	1658.22	3.28	1654.94	Contact between Vryheid Sediments and Rooiberg
AB00003	260671.536	-2886900.137	1626.19	0.52	1625.67	Vryheid Sediments
AB00005	259748.299	-2885627.478	1640.00	0.36	1639.64	Vryheid Sediments
AB00007	260381.200	-2884282.722	1641.84	1.61	1640.23	Vryheid Sediments
AB00043	260716.727	-2886343.229	1619.55	9.53	1610.02	Vryheid Sediments

AB00044	259601.847	-2886895.431	1640.36	2.25	1638.11	Vryheid Sediments
AB00053	260264.672	-2884599.779	1640.08	1.04	1639.04	Vryheid Sediments
Unknown	260431.216	-2884537.673	1639.75	2.25	1637.50	Vryheid Sediments
BA00046	262563.262	-2894502.684	?	9.75	1688.11	Unknown
BA00041	257838.408	-2889998.641	?	4.57	1677.07	Unknown
BA00091	253910.971	-2887742.326	?	7.32	1652.00	Unknown
BA00053	262422.350	-2886241.764	?	5.33	1618.12	Unknown
BA00070	255252.560	-2884438.222	?	4.57	1635.00	Unknown
BA00021	259490.266	-2881256.813	?	8.84	1593.38	Unknown
BA00013	272292.558	-2881395.267	?	12	1607.90	Unknown
DC00045	266200.100	-2878559.169	?	12.49	1606.76	Unknown
DC00043	268456.484	-2878603.052	?	14.63	1595.73	Unknown
DC00066	264327.103	-2874668.331	?	3.65	1596.43	Unknown
DC00049	262783.141	-2871062.850	?	6.7	1553.30	Unknown

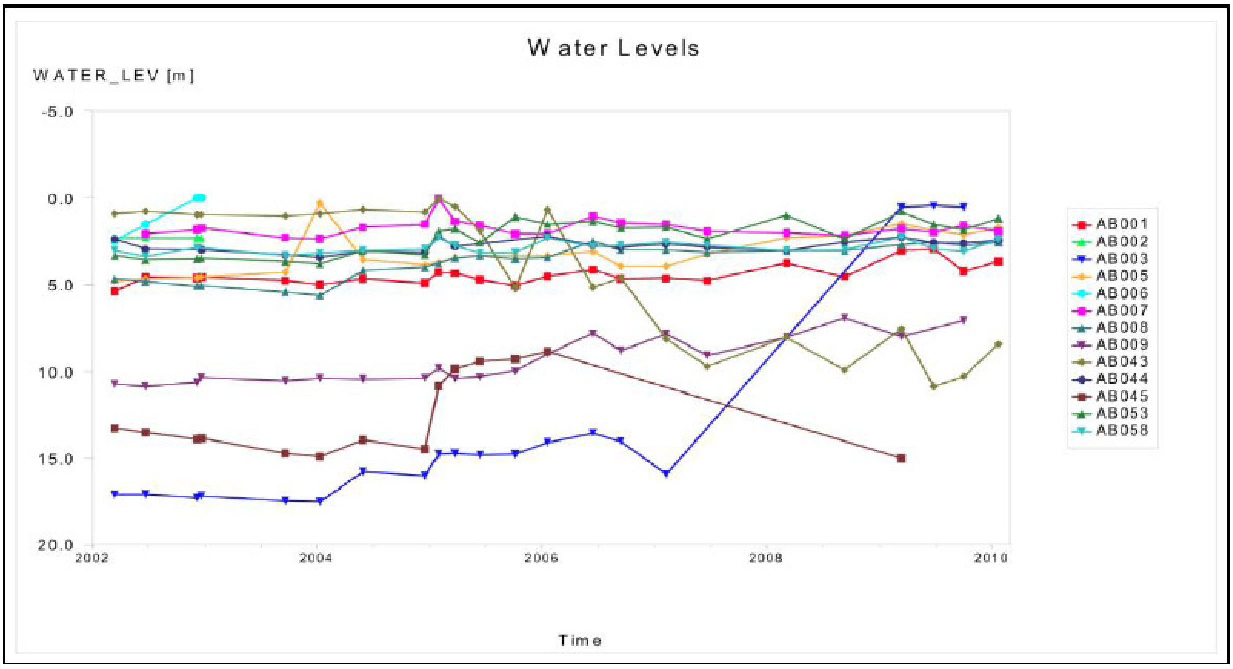


Figure 7.53: groundwater levels (mbgl) close to the hendrina wet ash disposal facility (after ght, 2010)

Several of the boreholes in the ashing area that are routinely sampled (GHT, 2010) have poor water quality, due to increased concentrations of elements such as K, Cl, Mn, SO4, or due to low pH values. Low pH can lead to increased mobility of a range of groundwater contaminants, such as trace metals. A range of conductivity values were observed in the boreholes visited, and groundwater levels (with one exception) were found to be within 5 m of the ground surface. With one or two exceptions, groundwater levels appear to be stable in the vicinity of the wet ash disposal facility (see **Figure 7.53** above). Borehole AB03, which has shown a large rise in groundwater level in the last eight years, is located close to a pumping station used for the control of water from the wet ash disposal facility, and may have been influenced by leakage or discharge from this facility.

- ***Conceptual Model of Groundwater Occurrence at Hendrina***

Recharge moving through the soil zone combines with leachate from the ash storage facility and migrates downwards through the unsaturated zone to the water table. Groundwater below the water table moves with the local groundwater gradient towards discharge zones (surface water resources such as wetlands and dams). Due to the shallow depth to groundwater in the immediate vicinity of the wet ash disposal facilities and associated infrastructure it is assumed that leakage from the base of the wet ash disposal facility occurs (i.e. a groundwater mound has formed under the wet ash disposal facility). This is supported by the poor groundwater quality in some boreholes close to the wet ash disposal facility, reported by GHT (2010). Following observations made during the field visit it is likely that any leachate from the current ash disposal area that is not intercepted by the under drain systems (or other leachate control facilities) will flow through the aquifer towards the lake or dam that is located about 1 km due east of the wet ash disposal facility. Groundwater will flow via fractures, faults, fissures and other secondary discontinuities in the rock. Locally the groundwater gradients are expected to be modified by mounding associated with the wet ash disposal facilities and other water sources.

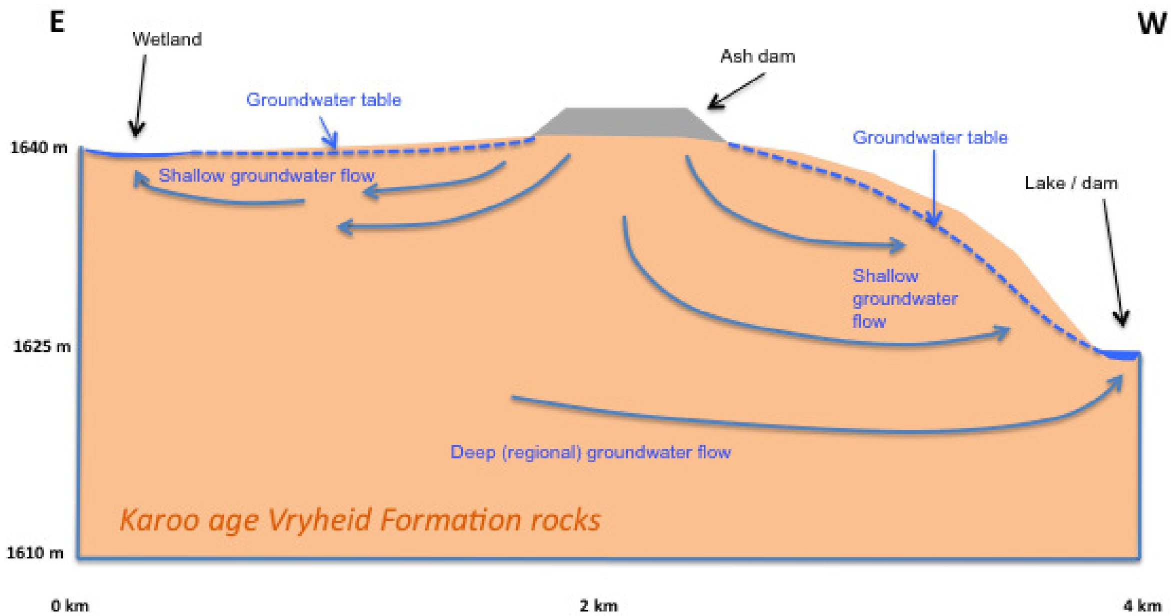


Figure 7.54: Sketch Cross-Section of Groundwater Occurrence at the Existing Hendrina Wet ash disposal facility (Note Vertical Exaggeration)

- ***Hydrologic Boundaries***

Based on the conceptual model for the Hendrina aquifers described above, groundwater flow within the shallow aquifer is likely to mimic topography on a local and regional scale. Surface water courses in the catchment area, specifically the Woes-Allen Spruit (East) adjacent to the existing ash disposal facility, appear to be deeply incised and create prominent topographic highs / lows. Locally, groundwater flow is likely to be towards, and discharge into the surface water courses; however on a catchment scale, groundwater is likely to follow the flow direction of the majority of the surface water course and flow towards the north.

- *Ponded Water / Wetland at Proposed Wet ash disposal facility Site*

During the field visit in September, SLR staff observed shallow ponded surface water in the area of the proposed new wet ash disposal facility (**Figure 7.55**), at approximately 26.04252ºE, 29.58960ºS. A sample of the water was taken (sample SLR04, see **Table 7.54** and Appendix A of the Ground Water study included in **Appendix N**), but it is not possible to say with certainty whether this water is groundwater or surface water. It is thought most likely that this is surface water resulting from rainfall supplemented by shallow perched groundwater associated with the porous laterite observed in the immediate area. It is thought unlikely that this is deep, "upwelling" groundwater, since the area is a local topographic high point. It is unfortunately not possible to say on the basis of the water analysis whether this is a wetland or not.

Figure 7.55: Shallow Ponded Water at New Wet ash disposal facility Site

- ***Hydraulic Properties***

No hydraulic testing at the site has been undertaken by SLR Consulting. Aquifer tests, in the form of slug tests were undertaken in 28 boreholes by GHT Consulting in 1997 (GHT 2010b). Methodologies for the tests and the analysis of data along with borehole installation details are unavailable. Although the depth of the borehole and associated geological unit in which the test were focused on is unknown, it is assumed that the borehole installations are shallow. A geometric mean of 0.018 m/d was calculated from the data set and is comparable with values associated with shallow sandy clay aquifers (0.1 m/d to 0.5 m/d).

No tests (e.g. core testing, de-watering analyses) have been carried out and values of storativity and porosity can only be estimated based on published values.

- ***Groundwater Quality in the Hendrina Area***

Six water samples were collected in the Hendrina Eskom site during a site visit in September 2011 (SLR01 – SLR06). Four of the samples were from boreholes, one was from the outflow of an wet ash disposal facility toe drain (SLR03), and one was from a pond at the proposed new wet ash disposal facility site (SLR04). Borehole sample SLR01 was taken at the farm of Mr Danie van Wyk, from a tap adjacent to the overhead water storage tank (it was impossible to take a sample directly from the borehole). The other borehole samples were taken using a bailer directly from boreholes surrounding the existing wet ash disposal facilities. Field parameters (T, EC, pH) were recorded at all sites, and depth to water level recorded in boreholes where access allowed. Laboratory analysis for major and minor constituents was performed by Waterlab in Pretoria, an accredited South African laboratory (results shown in Appendix A of the Ground Water Study included in **Appendix N**). Samples were kept cool between sampling and submission to the laboratory using a cooler box and ice bricks.

The accuracy of the chemical analyses was evaluated according to missing main components, plausibility of the single values as well as acceptable ion (charge) balance errors as determined by the electro-neutrality (E.N):

$$EN\,[\%] = \frac{\sum cations[meq/L] - \left|\sum anions\,[meq/L]\right|}{\sum cations[meq/L] + \left|\sum anions\,[meq/L]\right|} \cdot 100\%$$

While aqueous solutions should be electrically neutral, an error of 5 % for a sample analysis is generally considered reasonable. The criterion is relaxed to 10 % for low-mineralised samples. Interpretations based on samples with larger errors in the ion balance should be generally treated with caution. All of the samples had EN errors of 5 % or less, apart from sample SLR 04 which had an EN of 5.2 %.

- *Results*

The results of the field parameters and observations are shown in **Table 7.36** below. The full laboratory results are shown in Appendix A of the Ground Water Study included in **Appendix N.**

Table 7.36 Summary of the Water Samples Taken in September 2011

Sample ID	Source	Lat.	Long.	Field pH	Field EC (µS/cm)	Field TDS (mg/L)	Field T ºC	SWL (mbgl)
SLR01	Borehole	26.04653	29.58361	7.64	n/a	n/a	21.5	not measured
SLR02	Borehole	26.05546	29.59541	8.62	393	247	18.5	0.78
SLR03	Wet ash disposal facility toe drain	26.05542	29.59546	11.53	1284	884	21.7	n/a
SLR04	Pond	26.04252	29.58960	7.41	554	389	26	n/a
SLR05	Borehole	26.06699	29.59417	7.44	183.8	120.9	20	2.28
SLR06	Borehole	26.06419	29.58918	6.83	420	292	18.1	3.6

Borehole samples present groundwater with a Mg-Ca-HCO3 facies with exception of SLR01 which has a Ca.Mg-Cl water type. The SLR01 sample (Mr van Wyk's farm) also has elevated concentrations of Cl (247 mg/L) and NO3 (55 mg/L as N). These concentrations are higher than those found in any of the other samples, and this may indicate local pollution of the borehole rather than pollution by the wet ash disposal facility. Further work would be needed however to establish the source of high ion values at SLR01. The major ion chemistry has been plotted as a tri-linear (Piper) diagram (**Figure 7.56**), and the sample water water types are summarised in **Table 7.37**.

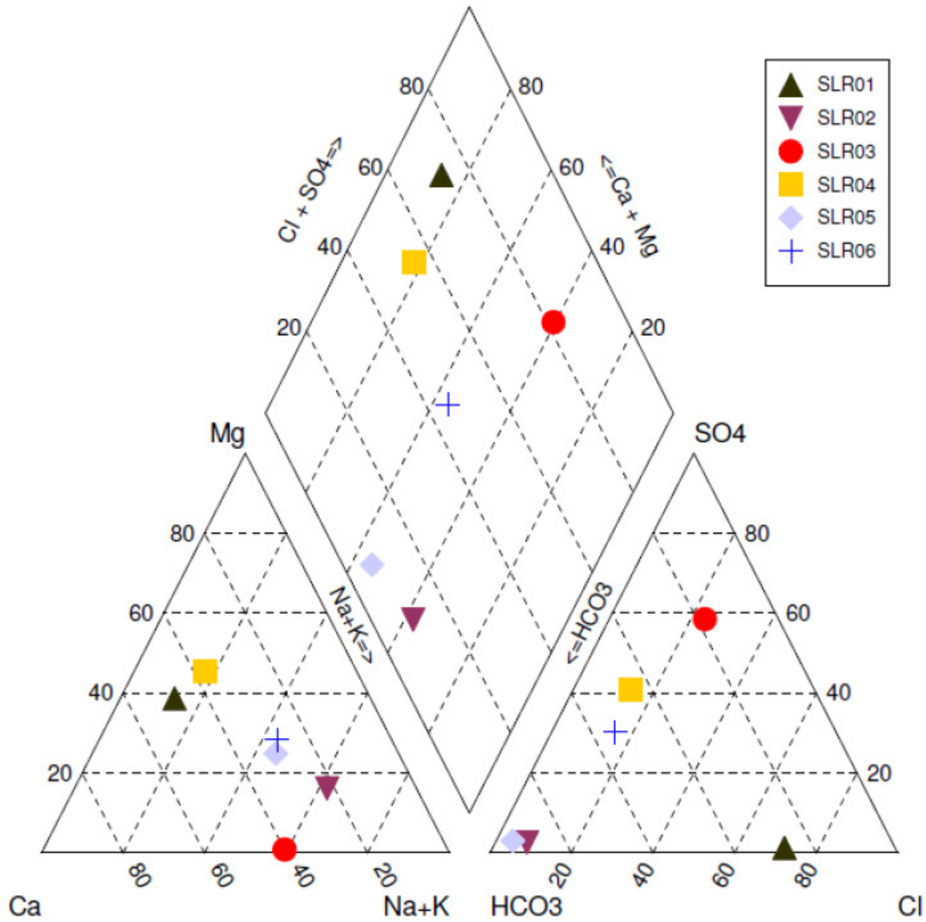


Figure 7.56 Piper Diagram Showing Water Samples Taken in September 2011

Table 7.37 Water Sample Water Types

Sample ID	TDS (mg/)	SO4 (mg/l)	Water Type	E.N.
SLR01	1 006	6	Ca-Mg-Cl-NO3	1.6
SLR02	224	5	Na-Ca-HCO3	0.5
SLR03	704	286	Na-Ca-SO4-Cl	-0.5
SLR04	324	98	Mg-Ca-HCO3-SO4	5.2
SLR05	132	<5	Na-Ca-Mg-HCO3	-1.4
SLR06	210	45	Na-Mg-Ca-HCO3-SO4	2.1

- ***Hendrina Numerical Groundwater Model***

  - *Modelling Objectives*

The project scope of work includes the development of a numerical groundwater flow and solute transport model to evaluate the growth in the potential leachate plume from the proposed wet ash disposal facility. The detailed modelling objectives were:

- To determine the flow path of the potential contaminant plume from the wet ash disposal facility;
- To determine the contaminant transport rates of the potential contaminant plume.

- *Model Function*

Despite limited site-specific groundwater level data for the Hendrina site, the numerical model is considered an important evaluation tool for potential contamination from the proposed wet ash disposal facility. Using realistic assumptions of aquifer properties and net infiltration rates for the proposed wet ash disposal facility, the model was set-up and run to evaluate the spreading of potential pollutants (plume migration) and the estimated migration time to local receptors. A review of the resulting plume allows appropriate mitigation and management procedures to be put in place to limit plume migration and potential contamination of the water environment.

- *Data Sources and Deficiencies*

The conceptual and numerical groundwater model for the Hendrina site was based on the following available information:

- Regional topographical and geological maps
- 1:500 000 scale hydrogeological maps of the Department of Water Affairs
- Digital elevation model based on spot heights
- Groundwater elevation data from field visits by SLR Consulting staff in April and September 2011, from the National Groundwater Archive (NGA), and from previous groundwater monitoring by GHT Consultants (GHT 2010b).
- Previous investigative reports and assessments completed for the site.

Recent groundwater level monitoring data for the site (hydrocensus) is limited to eight boreholes therefore the model confidence is limited by data scarcity. Critical data deficiencies include:

- Regional topographical and geological maps;
- The depth of boreholes and associated screening depth and the monitored geological unit is unknown;
- Site-specific estimates of recharge and seepage (wet ash disposal facility) rates
- No pumping tests have been undertaken and therefore values of storativity must be estimated;

The developed model should therefore be seen as an initial site model which should be refined and recalibrated once more groundwater monitoring and other data become available.

- *Model Code Description*

The conceptual groundwater model developed for the Hendrina study area was converted into a numerical groundwater model. The software code chosen for the numerical modelling work was the modular 3D finite-difference ground-water flow model MODFLOW, developed by the United States Geological Survey (USGS) (MacDonald and Harbaugh, 1988). The code was first published in 1984, and since then has undergone a number of revisions. MODFLOW is widely accepted by environmental scientists and associated professionals. MODFLOW uses the finite-difference approximation to solve the groundwater flow equation. This means that the model area or domain is divided into a number of equal-sized cells – usually by specifying the number of rows and columns across the model domain. Hydraulic properties are assumed to be uniform within each cell, and an equation is developed for each cell, based on the surrounding cells. A series of iterations are then run to solve the resulting matrix problem, and the model is said to have "converged" when errors reduce to within an acceptable range. MODFLOW is able to simulate steady and non-steady flow, in aquifers of irregular dimensions, as well as confined and unconfined flow, or a combination of the two. Different model layers with varying thicknesses are possible. The edges of the model domain, or boundaries, typically need to be carefully defined, and fall into several standard categories. Various pre- and post-processors are available for MODFLOW, aimed at making data input and 2-D and 3-D visualisation faster and simpler. In the case of the Hendrina groundwater model, the internationally accepted package GMS 8.0 (Groundwater Modelling System) was used as the software interface for the MODFLOW code.

- *Water Sources and Sinks*

Water enters the model domain as direct recharge from rainfall and as seepage from the wet ash disposal facilities. In the absence of detailed information from the design engineers, recharge (leachate infiltration) from the proposed wet ash disposal facility was estimated to be double the regional average recharge rate of 36.5 mm/a. Water leaves the model domain by evapotranspiration, groundwater outflow, and discharge to surface water courses.

- *Model Domain and Boundaries*

The model domain was vertically discretised into three model layers, representing the weathered unconsolidated zone (to include the proposed wet ash disposal facility) (20 m thick, Layer I) and the highly weathered zone (150 m thick, Layers II and III). The highly weathered zone was split into two layers (Layers II and II) for the purpose of numerical model stability only. The upper boundary of the model (Layer I) was specified as the surface topography, represented by digital elevation model (DEM) data supplied by the client.

The base of the Layer I was regionally set to 20 m below the DEM, the base of Layer II and Layer III were regionally set to 75 m and 150 m below the DEM respectively. A regular horizontal grid size of 100 m x 100 m was used.

Based on the conceptual site model, it was considered appropriate to use no flow boundaries along the northern, southern and western boundaries of the site to represent the surface water catchment area (surface water divide along the prominent topographic high). The north eastern model boundary was aligned along a watercourse, and modelled as a drain (**Figure 7.57**).

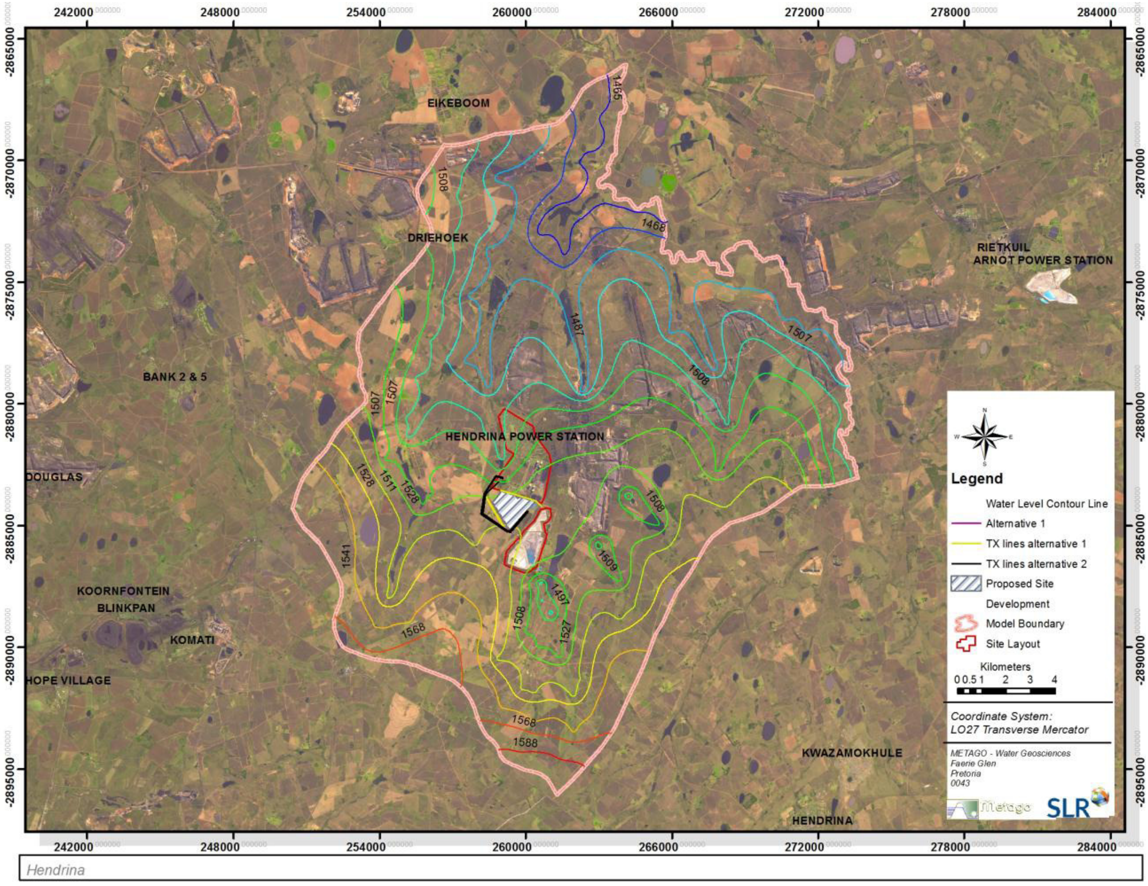


Figure 7.57 Hendrina Model Boundaries with Modelled Water Levels

- *Hydraulic Parameters*

Based on literature values, a hydraulic conductivity (K) value of 0.5 m/d was assigned to the upper weathered zone across the whole model domain, with a K value of 0.05 m/d assigned to the lower fractured aquifer across the whole model domain. Recharge of 36.5 mm/a (about 5.6 % of average rainfall) was assigned across the model area, with double that value beneath the proposed new wet ash disposal facility to account for the impact of the leachate. A constant porosity of 0.3 was assumed across the model domain.

- *Model Calibration*

The model was run with the initial parameters and boundaries as described above, and calibration yielded only marginal improvements of the model fit. The initial hydraulic parameters were therefore not changed. Using these parameters, a reasonable agreement between observed and modelled heads was achieved (R2 of 0.9663, **Figure 7.58**). The model proved sensitive to recharge rates and to K values, as expected.

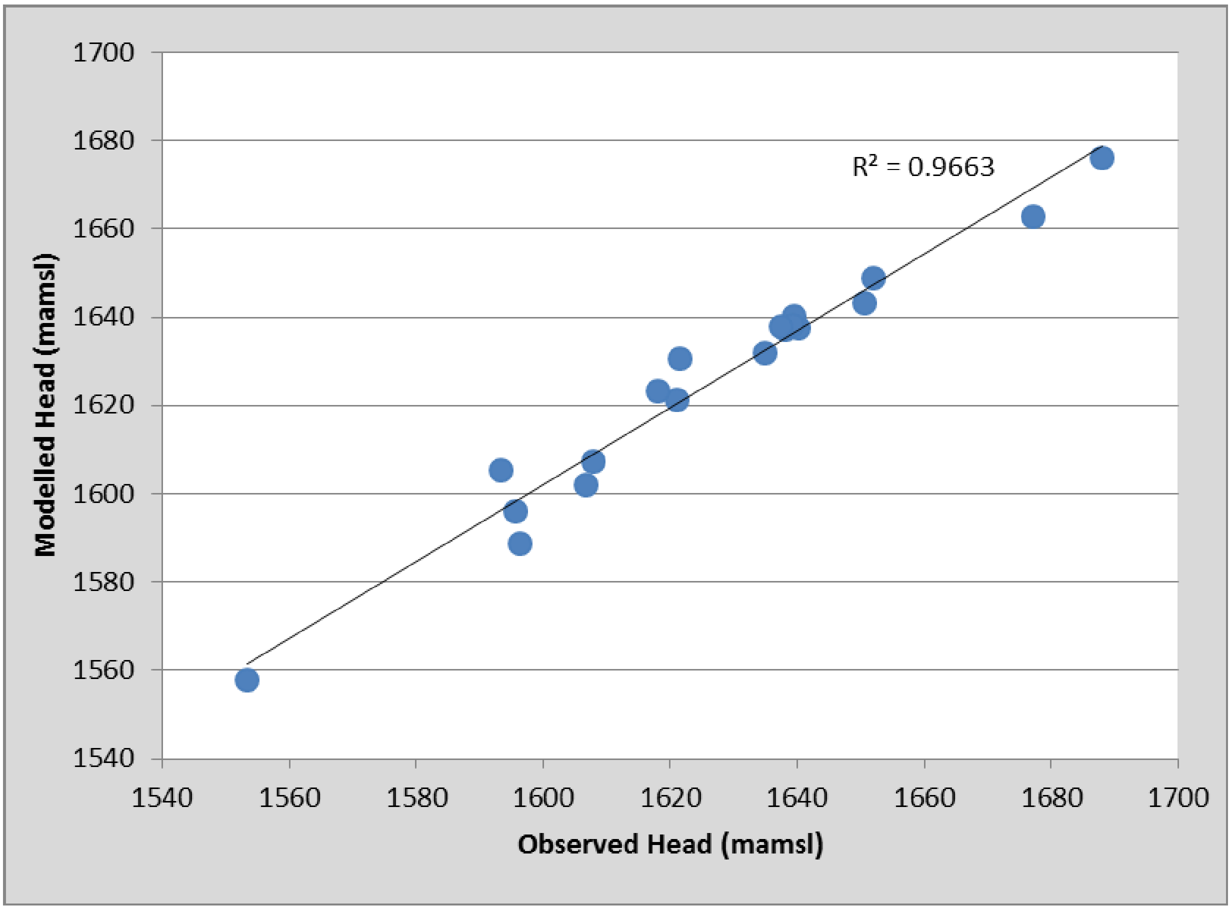


Figure 7.58: Hendrina Model Calibration

- *Model Predictive Simulations*

The calibrated steady-state groundwater flow model was used as a basis for transient contaminant transport simulations. Following the precautionary principle, only advective-dispersive (longitudinal dispersivity 75 m, porosity 0.3) transport of potential pollutants without any retardation or transformation was assumed. The impacts of potential pollution sources on the groundwater quality are therefore conservative.

The source concentration was specified as 1 (one) and the modelled plumes represent therefore fractions of the actual source concentrations. Since no element specific retardation or transformation is modelled, concentrations for individual elements of concern can be easily derived by multiplying given fractions with the respective source concentration for an element once a detailed geochemical source characterization is performed.

Model simulations for up to 150 years into the future were run. The results show a gradual movement of a contaminant plume towards the north-west, with the upper part of the watercourse to the west of the power station being the ultimate receiver of the plume. See **Figure 7.59** below. The rate of movement of the plume is obviously sensitive to the selected recharge value beneath the proposed wet ash disposal facility.

The maximum plume extent after 50 and 150 years is expected to be approximately 200 m and 500 m respectively. Estimation of breakthrough at the receiving surface water course is complicated because the location of the surface water course appears to change seasonally – however, this is expected to be around 20 years from the start of ash deposition. The maximum (unit) concentration at the surface water receiver was not reached in the 150 year model simulation period. Both of these estimates (breakthrough and maximum concentration are however highly dependent on local aquifer properties, which are not known with any degree of confidence.

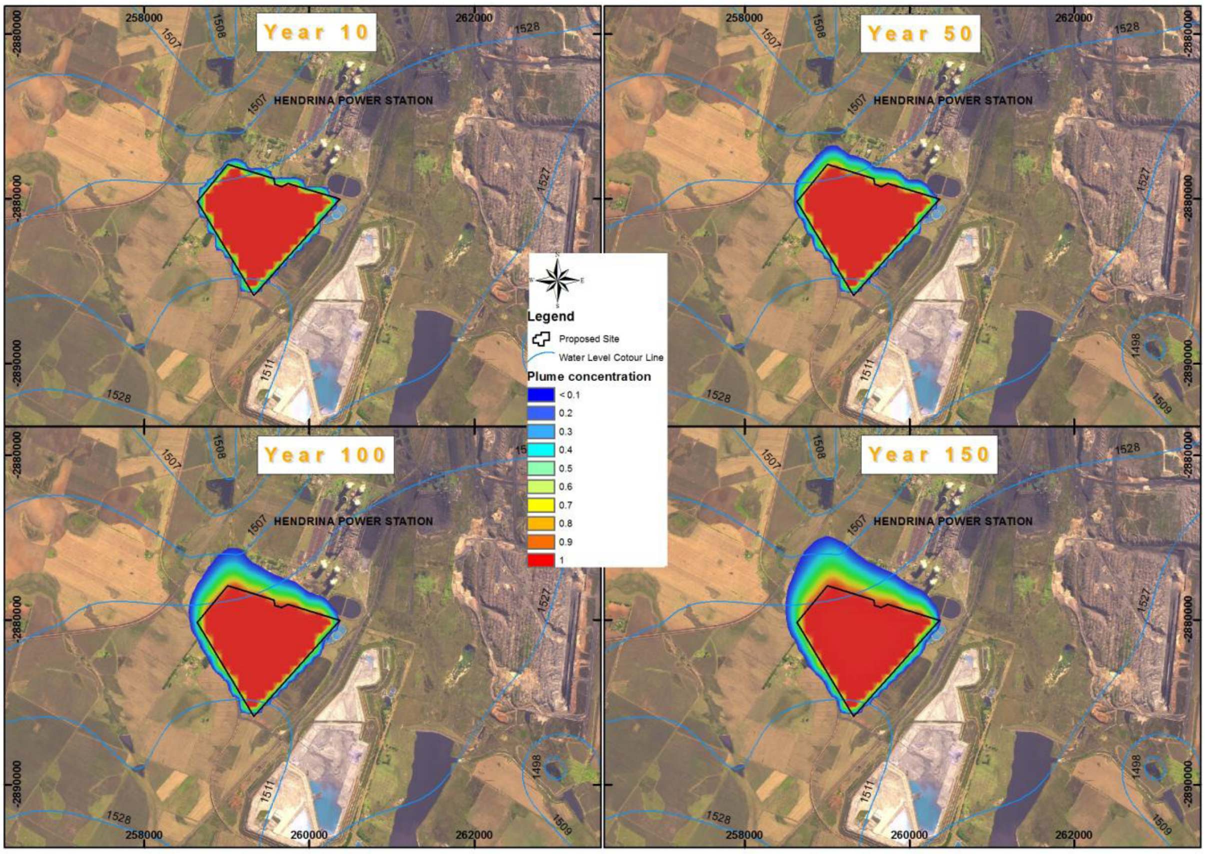


Figure 7.59 Migration of Modelled Plume at Hendrina in the Shallow Aquifer (Layer I)

- *Model Summary and Conclusions*

The numerical groundwater model was able to reasonably approximate hydrogeological conditions at the site based on the agreement between observed and modelled water levels. Non-reactive contaminant transport modelling using a unit source term suggests a slow plume migration from the proposed wet ash disposal facility site towards the north-west. The rate of migration is partly dependent on the volume of leachate percolating downwards in the model domain (modelled at twice the rate of regional groundwater recharge). The actual leachate volume will be sensitive to the efficiency of the under drain system at the proposed wet ash disposal facility, as well as any liner that is installed. Despite all efforts to account for data uncertainties, the values presented are intrinsically of low to medium confidence and should be verified once more water level measurements, hydraulic conductivities of different geological units and groundwater monitoring data become available. Predicted plume migration rates for later years of mine development can significantly be improved by observation data from earlier years and subsequent updates of the groundwater model.

7.11 Sites of Archaeological, Historical and Cultural Interest

7.11.1 Description

The cultural landscape qualities of the region essentially consist of one component. The first is a rural area in which the human occupation is made up of a pre-colonial element (Iron Age) as well as a much later colonial (farmer and industrial) component.

- *Stone Age*

Very little habitation of the highveld area took place during Stone Age times. It was only during Middle Stone Age (MSA) times (c. 150 000 – 30 000 BP), when people became more mobile, that they occupied areas formerly avoided. These are areas close to streams where cliffs and overhangs provided some shelter. No Later Stone Age (LSA) sites are known to occur in the larger region.

- *Iron Age*

Iron Age people started to settle in southern Africa c. AD 300, with one of the oldest known sites at Broederstroom south of Hartebeespoort Dam dating to AD 470. Having only had cereals (sorghum, millet) that need summer rainfall, Early Iron Age (EIA) people did not move outside this rainfall zone, and neither did they occupy the central interior highveld area. Sites dating to this period were recently excavated in the Steelpoort River valley (Van Schalkwyk 2009). Because of their specific technology and economy, Iron Age people preferred to settle on the alluvial soils near rivers for agricultural purposes, but also for firewood and water.

The occupation of the larger geographical area (including the study area) did not start much before the 1500s. By the 16th century things changed, with the climate becoming warmer and wetter, creating condition that allowed Late Iron Age (LIA) farmers to occupy areas previously unsuitable, for example the treeless plains of the Free State and the Mpumalanga highveld.

Archaeological sites identified in the region date to the Late Iron Age and it seems as if they can be divided into two distinct categories. The older of these are sites with quite high walls and are conventionally linked with the Koni-group of people that have been settled in the region since the 1600s. The second groups of sites also have stone walling but this is in most cases much less developed, in many cases making them difficult to detect. This latter group of sites probably date to a later period and can also be linked to settlement during early historic times of Ndebele- and Swazi-speakers in the region.

NHRA Category	Archaeological and palaeontological sites
Protection status	
General Protection - Section 35: Archaeology, palaeontology and meteorites	

Figure 7.60: Typical Late Iron Age stone walled sites in the region.

- *Historic period*

White settlers moved into the area during the first half of the 19th century. They were largely self-sufficient, basing their survival on cattle/sheep farming and hunting. Few towns were established and it remained an undeveloped area until the discovered of coal and later gold. The establishment of the NZASM railway line in the 1880s, linking Pretoria with Lourenço Marques (Maputo) and the world at large, brought much infra-structural and administrative development to the area. This railway line also became the scene of many battles during the Anglo-Boer War, for example at Berg-en-Dal and Signal Hill more to the east.

The town of Hendrina was founded in 1914 on the farm Grasfontein and was named after Hendrina Beukes, wife of the owner of the farm. The Hendrina Power Station came on line in 1970, making it one of Eskom's oldest operating stations.

- *Farmsteads*

Farmsteads are complex features in the landscape, being made up of different yet interconnected elements. Typically these consist of a main house, gardens, outbuildings, sheds and barns, with some distance from that labourer housing and various cemeteries. In addition roads and tracks, stock pens and wind mills complete the setup. An impact on one element therefore impacts on the whole.

NHRA Category	Buildings, structures, places and equipment of cultural significance
Protection status	
General Protection - Section 34: Structures older than 60 years	

Figure 7.61: Typical farmstead in the larger region.

- *Cemeteries*

Most of these cemeteries, irrespective of the fact that they are for land owner or farm labourers (with a few exceptions where they were integrated), are family orientated

NHRA Category	Graves, cemeteries and burial grounds
Protection status	
General Protection - Section 36: Graves or burial grounds	

Figure 7.62: Typical farm worker cemetery in the region.

7.12 Visual Aspects

7.12.1 Description

- **The Receiving Environment**

The study area for the visual assessment is located close to Hendrina in the Steve Tshwete Municipality of the Mpumalanga Province.

There are no major towns in the immediate area. Middelburg lies 40 km to the north west, and Hendrina some 16km to the south east. A number of farms and homesteads occur throughout the study area, and in close proximity to the power station. Refer to **Figure 7.67**[1].

Figure 7.63: Agricultural land use within the study area.

The N11 bypasses the site in the east and the R542 traverses a section of the study area in the south west. In addition, a number of secondary roads interconnect with the national and arterial roads, as well as with one another. A railway line traverses the study area from the south west to the north. Trains are taken to service both freight and commuters.

Mining and related activity is a prolific land use in the study area, which in combination with the existing power station results in a decidedly industrial visual character within an otherwise rural and agricultural regional setting.

This mining land use is located in close proximity to the power station, especially to the north east. In addition, transmission lines which extend to the north, west, south west and east of the power station contribute further to this existing visual intrusion. Refer to **Figure 7.68**[2].

[1] *Source:* Department of Environmental Affairs and Tourism, 2001. *Environmental Potential Atlas for Mpumalanga Province (ENPAT Mpumalanga).*

[2] *Source:* Department of Environmental Affairs and Tourism, 2001. *Environmental Potential Atlas for Mpumalanga Province (ENPAT Mpumalanga).*

Figure 7.64: Medium distance view of the existing Hendrina Power Station.
Note the transmission line infrastructure along the road.

The topography of the area is typical of the Mpumalanga Highveld, mainly a gently undulating plateau, varying between 1680m and 1600m above sea level (asl) along the Woes-Alleen Spruit. The north of the study area appears lower lying and undulating, while the south is characterised by low hills.

In addition to the above mentioned stream, a large number of dams and pans are present in the study area, although many of these have been disturbed to some extent by mining activity. The drainage lines which traverse the study area all flow north towards the Olifants River. Refer to **Figure 7.68**.

The ENPAT describes the terrain as *moderately undulating plains and pans* and the natural vegetation type as *Bankenveld.* Land cover is primarily *agricultural* interspersed with *grassland* especially along the drainage lines.

With its moderately dry subtropical climate, the study area receives between 621 and 752 mm of rainfall per annum.

No formally protected areas or conservation areas are located in close proximity to the proposed site, or within the identified study area.

The study area falls within the Mpumalanga Province, which is a particularly popular and well frequented tourist destination in South Africa. There are no known tourist facilities or destinations within the study area, but tourists en route to other parts of Mpumalanga may utilise the main regional access routes such as the N11 and the R542.

Despite the industrial nature of the existing power station and surrounds, the greater landscape of the study area is characterised by wide-open spaces and little development. Beyond the industrial complexes, the study area has a rural, agricultural character with an overall high visual quality.

Figure 7.65: Wide open spaces characterising the visual environment of the study area.

Figure 7.66: Visual character of the site for the proposed wet ash disposal facility.

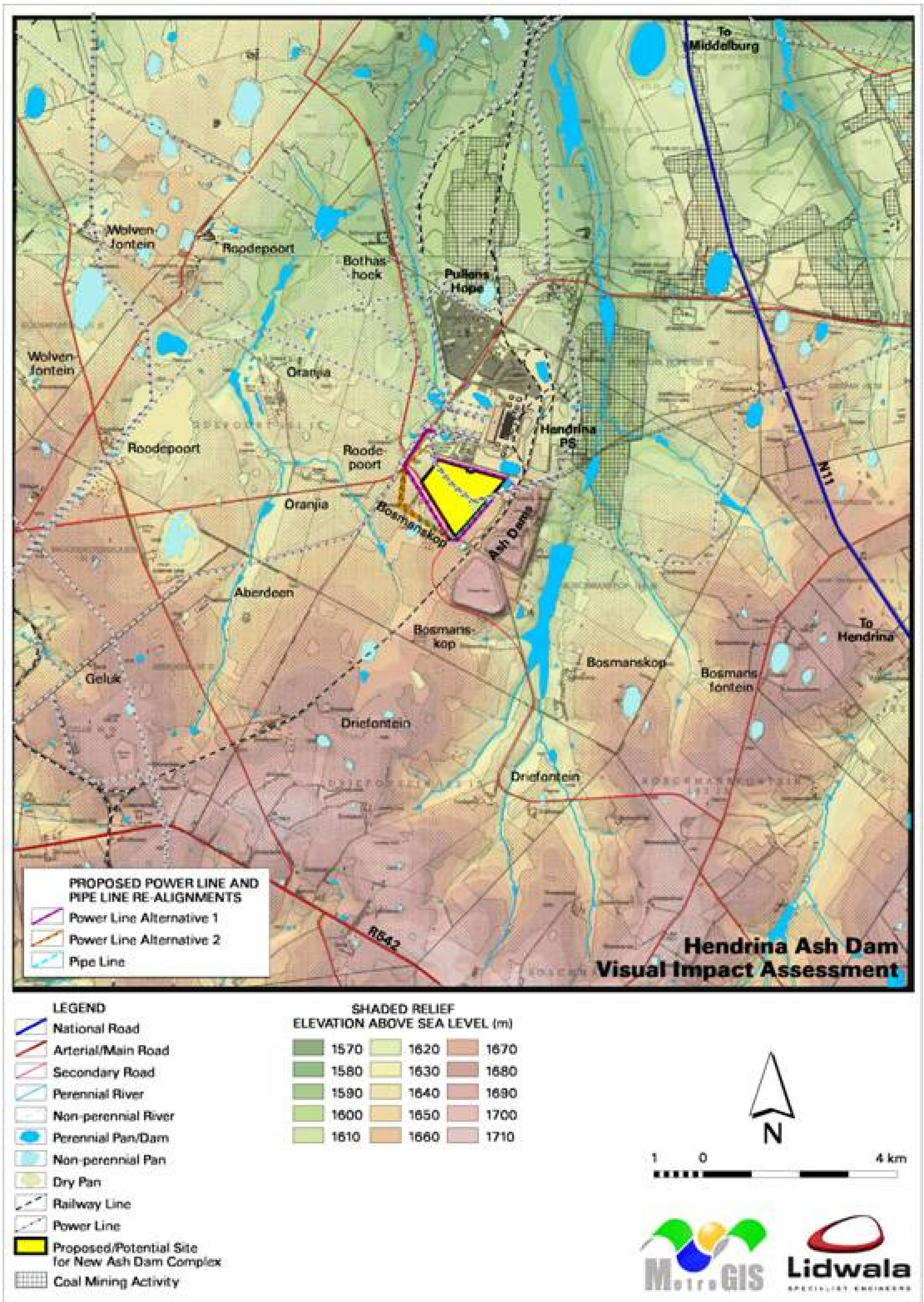


Figure 7.67: Locality and layout of the proposed wet ash disposal facility and associated infrastructure.

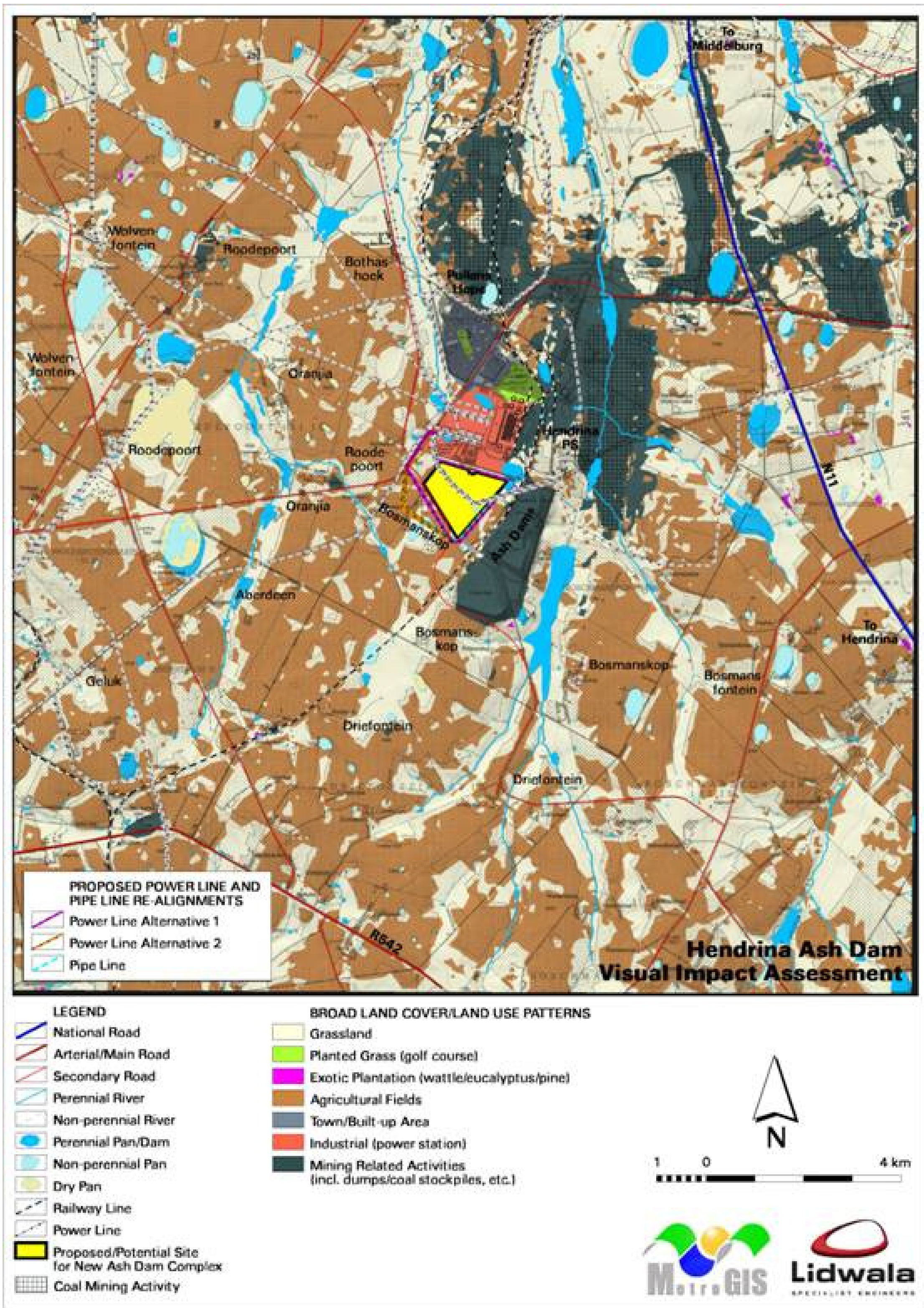


Figure 7.68: Land cover and broad land use patterns within the broader study area.

- **Potential visual exposure**

o *The proposed wet ash disposal facility*

The result of the preliminary viewshed analysis for the proposed wet ash disposal facility is shown on **Figure 7.69**.The analysis for the wet ash disposal facility was undertaken from the indicated footprint of the proposed wet ash disposal facility at an estimated height of 44m above average ground level (i.e. the approximate maximum height of the proposed wet ash disposal facility).

It must be noted that the viewshed analyses do not include the potential shielding effect of vegetation cover or existing structures on the exposure of the proposed wet ash disposal facility, and it does not take into consideration the limitations of the human eye, therefore signifying a worst-case scenario.

The total area of potential visual exposure is 188,4km². The following is evident from the viewshed analysis:

- The proposed wet ash disposal facility will have a large core area of potential visual exposure on the site itself, and within a 2,5km offset. Almost the entire area within 2,5km is likely to be visually exposed. The exception is the south east, beyond the existing wet ash disposal facilitys.

  This core area includes a number of homesteads and farms (i.e. Bosmanskop, Oranjia and Roodepoort) and a few dams and pans. In general, the drainage lines are not exposed, due to their incised topography.

  The secondary roads giving access to the north, west and south will also be exposed to potential visual impact.

- Potential visual exposure is somewhat reduced in the medium distance (i.e. between 2,5 and 5km). Areas in the west and east, along the drainage lines, will be visually screened.

  The main receptors that are likely to be exposed to potential visual impact include users of secondary roads to the north, north east and west and a number of homesteads and farms. These include Bothashoek, Oranjia, Aberdeen, Driefontein and Bosmanskop.

  A few non-perennial pans also fall within the zone of potential visual exposure.

- In the longer distance (i.e. beyond 5km), visual exposure is further reduced, interrupted by low lying areas and incised drainage lines in the far north west and north east and by the hills in the south of the study area.

Receptors exposed to potential visual exposure include the farms and homesteads of Roodepoort and Bosmansfontein. Relatively long stretches of the N11 fall within the zone of potential visual exposure, as do relatively continuous lengths of secondary roads in the west, north west and south east.

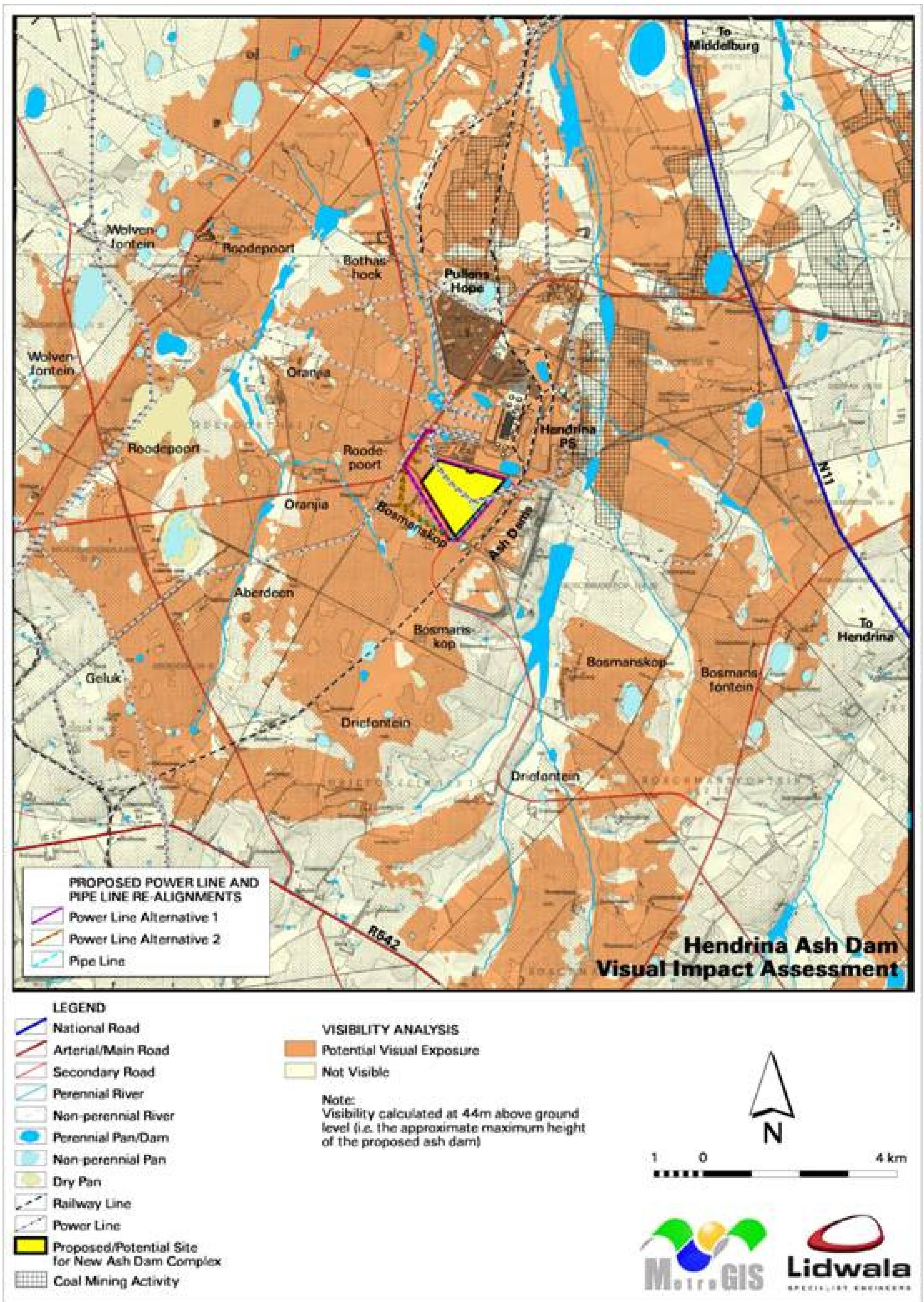


Figure 7.69: Potential visual exposure of the proposed wet ash disposal facility and associated infrastructure.

- *The proposed transmission line*

  Figure 7.70 shows the anticipated visual exposure of the proposed transmission line alternatives for a distance of 2km on either side of the proposed alignments at an offset height of 30m above ground level (i.e. the approximate maximum height of the proposed transmission lines).

  It must be noted that the viewshed analyses do not include the potential shielding effect of vegetation cover or existing structures on the exposure of the proposed wet ash disposal facility, and it does not take into consideration the limitations of the human eye, therefore signifying a worst-case scenario.

  With the exception of the area to the south east, beyond the existing wet ash disposal facilitys, the entire area within 2km of the new transmission lines will potentially experience visual impact.

  Alternative corridor 1 appears to be the shorter of the 2 alternatives, and hugs the toe-line of the proposed wet ash disposal facility in the south east, south west and north. Despite being of a different visual nature to the wet ash disposal facility, this concentration and consolidation of infrastructure is considered favourable from a visual perspective.

  Alternative corridor 2 appears to be the longer of the 2 alternatives, and extends beyond the toe-line of the proposed wet ash disposal facility in the south west. Despite being of a different visual nature to the wet ash disposal facility, the concentration and consolidation of infrastructure is considered favourable from a visual perspective, thus rendering this corridor less favourable than Alternative 1.

  Of relevance is the fact that the extent of potential visual exposure of the proposed transmission line alternatives lies within the anticipated viewshed of the proposed wet ash disposal facility. This is due to the fact that the transmission lines will be somewhat shorter than the ultimate height of the wet ash disposal facility.

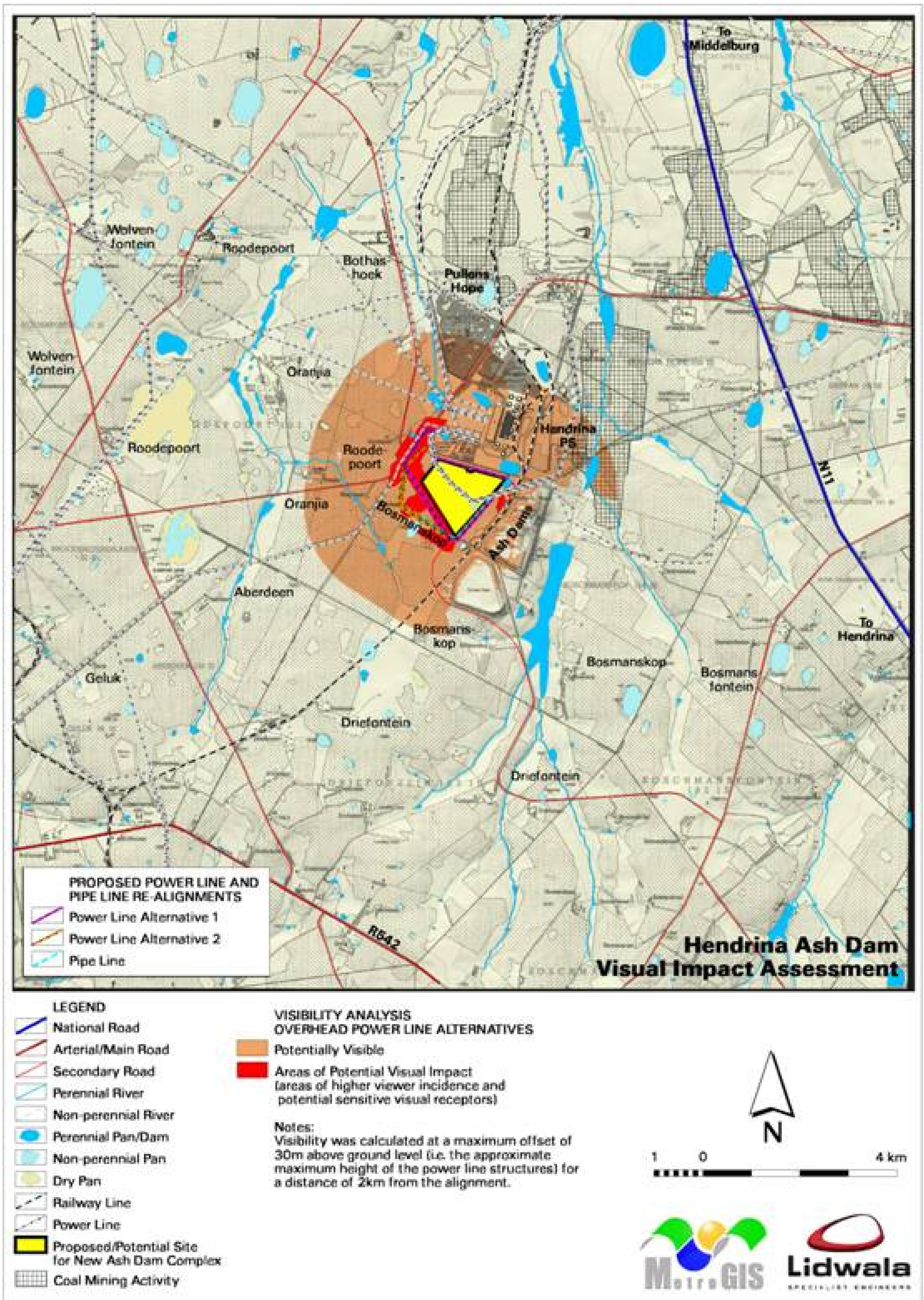


Figure 7.70: Potential visual exposure of the transmission line alternatives.

- **Visual Absorption Capacity**

The climate of the study area is moderately dry subtropical, with the study area receiving between 621 and 752 mm of rainfall per annum. Land cover is primarily *agricultural* interspersed with *grassland* especially along the drainage lines.

Overall, the Visual Absorption Capacity (VAC) of the receiving environment is low due to the nature and height of the vegetation, and the largely undeveloped state of the receiving environment.

VAC will thus not be taken into account, except within the mining and industrial complexes, where topographic disturbance, structures, infrastructure and visual clutter will absorb the visual impact of the proposed wet ash disposal facility somewhat.

- **Visual Distance / Observer Proximity**

MetroGIS determined proximity radii based on the anticipated visual experience of the observer over varying distances. The following factors are considered for the determination of appropriate proximity radii:

- The maximum cone of vision for a stationary person, which is accepted to be 60 degrees in both the vertical and the horizontal fields. This cone of vision allows for easy eye movement and no loss of focus of the object in question.
- The maximum horizontal extent or widest cross section of the proposed wet ash disposal facility that an observer will be able to perceive.
- The maximum height of the tallest infrastructure.

For an wet ash disposal facility, the horizontal extent is of most significance. In this respect, the proximity radii are calculated as a function of the critical point at which an observer will be able to perceive the full extent of the wet ash disposal facility within a maximum 60 degree cone of vision. MetroGIS developed this methodology in the absence of any known and/or acceptable standards for South African wet ash disposal facilitys.

The proximity radii used for this study (calculated from the cumulative boundary of the parks) are shown on **Figure 7.71** and are as follows:

- 0 – 1km - Short distance view where the wet ash disposal facility would dominate the frame of vision and constitute a very high visual prominence.
- 1 – 2,5km - Medium distance views where the wet ash disposal facility would be easily and comfortably visible and constitute a high visual prominence.
- 2,5 - 5km - Medium to longer distance view where the wet ash disposal facility would become part of the visual environment, but would still be visible and recognisable. This zone constitutes a medium visual prominence.

- Greater than 5 km - Long distance view where the wet ash disposal facility would still be visible though not as easily recognisable. This zone constitutes a low visual prominence for the wet ash disposal facility.

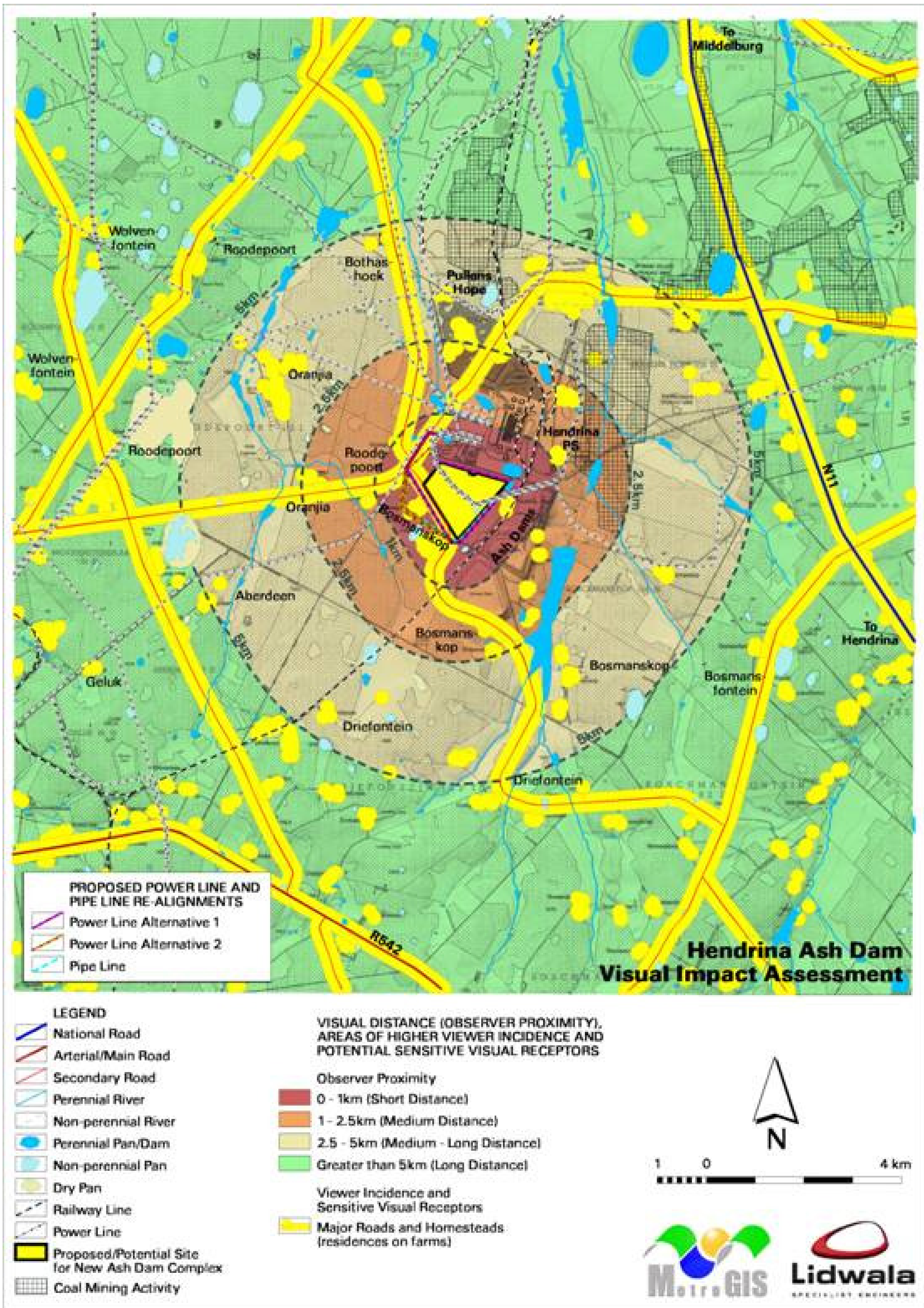


Figure 7.71: Observer proximity, areas of high viewer incidence and potential sensitive visual receptors.

- **Viewer incidence and viewer perception**

  - *Sensitive visual receptors*

Refer to **Figure 7.71**. Viewer incidence is calculated to be the highest along the roads within the study area. Commuters using the secondary roads are seen as relatively sensitive, and could be negatively impacted upon by visual exposure to the proposed wet ash disposal facility and associated infrastructure.

Commuters travelling by rail are considered less sensitive.

Other than along the roads and railway line, viewer incidence will be concentrated within the agricultural homesteads and settlements within the study area. Residents of these homesteads and settlements are considered to be sensitive to potential visual impact.

Further afield, beyond the industrial and mining hub, users of the N11 and R542 will also be sensitive to visual intrusion as these routes may carry tourists accessing and touring the scenic Mpumalanga Province.

Overall, the severity of the visual impact on visual receptors decreases with increased distance from the proposed wet ash disposal facility and associated infrastructure.

  - *Sense of place*

Sense of place refers to a unique experience of an environment by a user, based on his or her cognitive experience of the place. Visual criteria and specifically the visual character of an area (informed by a combination of aspects such as topography, level of development, vegetation, noteworthy features, cultural / historical features, etc) play a significant role.

A visual impact on the sense of place is one that alters the visual landscape to such an extent that the user experiences the environment differently, and more specifically, in a less appealing or less positive light.

Outside of the industrial and mining hub in the vicinity of the power station, the greater landscape of the study area is characterised by wide-open spaces and little development. Beyond these industrial complexes, the study area has a rural, agricultural character with an overall high visual quality.

Sensitivity to potential visual impact in this regard is ameliorated somewhat by the low incidence of visual receptors and considerable distance to tourist access routes.

7.13 Social Environment

7.13.1 Description

The Hendrina Power Station is situated in the Mpumalanga Province and within the Steve Tshwete Local Municipality area of jurisdiction.

The closest towns include Hendrina and Middleburg with the small community of Pullen's Hope situated right next to the power station.

The town of Hendrina was proclaimed on 5 June 1916 and is approximately 20 km from the power station. Hendrina is the second largest town in the municipality (after Middelburg). The main business / commercial activities in Hendrina include the OTK co-operation and a large manufacturing company.

Pullen's Hope is situated directly adjacent to the power station and is considered to be the fourth largest settlement in the municipal area. The original stands were developed by Eskom to accommodate personnel employed at the Hendrina power station. The current ownership of the community is assumed to be municipal however, this remains to be confirmed.

The socioeconomic analysis is specifically aimed at spatial related matters, i.e. demographics, employment and income and economic profile. The 2001 Census figures were used and comparisons were made with the Demarcation Board Data. The latter is based on the 1996 Census data which has been statistically manipulated to coincide with the newly demarcated study area.

- ***Demographics***

Table 7.38: Population Growth in Steve Tshwete Local Municipality

	2001	1996	% Growth	% Average Annual Growth
African	114 371	91 224	25,4	5,1
Coloured	3 547	3 530	0,5	0,1
Indian	1 313	1 900	31,0	6,2
White	23 541	37 747	38,0	7,6
Total	**142 772**	**135 412**	**5,4**	**1,08**

Source: 2001 Census data

The African population increased by 25,4% over 5 years or 5,1% on average annually. The Indian and White population decreased by 31% and 38% respectively over the 5 years or 6, 2% and 7,6% on average annually. Therefore, the need for housing in the lower income brackets, mainly subsidy linked housing has increased and will tend to increase over time.

- ***Population Estimates***

Population estimates for Steve Tshwete Municipality are reflected in **Table 7.39** below and includes the total number of people.

Table 7.39: Number and Percentage by Gender

	Male	Female	Total	Male %	Female %	Total %
Steve Tshwete	70 596	72 184	142 772	49,4	50,6	**100**
Nkangala	491 225	529 363	1 020 590	48,1	51,9	**100**
Mpumalanga	1 497 325	1 625 985	3 122 985	47,9	52,1	**100**

Source: 2001 Census data

The study area has an advantage in terms of its male population compared to that of the Nkangala District and Mpumalanga. This can mainly be attributed to more job opportunities created by the mining and industrial sectors.

- ***Level of Education***

The level of education for the population in the study area is reflected in **Table 7.40** below format with specific reference to number of people with primary, secondary and tertiary qualifications.

Table 7.40: Level of Education in Steve Tshwete Local Municipality

Persons	2001	%
None	15 769	27,8
Pre School	2 063	3,6
School	37 243	65,6
College	958	1,7
Technikon	319	0,6
University	226	0,4
Adult Education Centre	48	0,1
Other	132	0,2
Total	**56 758**	**100**

Source: 2001 Census data

- Only 3% of the population has a tertiary or higher qualification.
- 27,8% of the population have no qualification. It is noted that infants and children less than 5 years are excluded from this figure.
- Access to farm schools and the availability of schools for specially the rural population have been highlighted as part of the IDP prioritisation process. The high levels of illiteracy reflect the need for education facilities and after school learning.

- ***Population Growth Estimates***

It should be noted that population growth statistics should only be used as a guideline for future planning. These figures must be reviewed and adjusted on an ongoing basis with the availability of more relevant and specific data. Specific reference is made to the latest Census figures.

The population growth estimates are reflected for the time period 1996 to 2001 and the time period 2001 to 2006. However, the latest Census figures are disputed by Council. It was therefore suggested that the following assumptions are made for the short term as the next cycle in the Census data capturing will commence early in 2006. Any changes in the tendencies relating to population trends will then be captured.

The growth rates will be as follows for the period 2001 to 2006, namely:

- Middelburg: 3,3%
- Mhluzi: 0,0%
- Hendrina: 0,0%
- Kwazamokhule: 2,0%
- Middelburg NU: 2,3%

Table 7.41: Population Growth Rate 1996 – 2006 in Steve Tshwete Local Municipality

Area	Population Growth		Population 2001	Population Increase 2001 - 2006
	1991 - 1996	1996 - 2001		
Middelburg	1,1	3,3	42 296	49 750
Mhluzi	10,6	1,7	46 011	46 011
Hendrina	1,5	8,9	885	885
Kwazamokhule	17,9	2,0	12 843	14 180
Middelburg NU	12,0	2,3	40 737	45 642
Middelburg (MP 313)	0,7	1,1	142 772	156 468

Source: Census 2001

- The proposed population growth implies that an additional 13 696 people will reside in the study area. At a household size of approximately 3,94 people, this represents an additional 3 476 households.
- The increase in population and number of households has a significant influence on service delivery, provision of affordable housing, education, health facilities and infrastructure.
- The need for additional housing are outlined as part of the spatial analysis (refer to Chapter 2).
- A relatively high population growth rate is predicted for the urban areas with specific reference to Middelburg and Kwazamokhule. The current estimated backlog of 6 883 stands consist of 2 308 stands in Newtown accommodating 9 289 residents, whilst approximately 4 575 backyard families are residing in Mhluzi (Waste disposal survey: October 2000). In Middelburg an additional 1 500 units should be developed annually

from 2001 to 2006 to address the expected growth. The bulk of the residential units will be required to accommodate the homeless, mainly relying on government housing subsidies.
- A backlog of approximately 350 stands is present in Kwazamokhule. The development of Kwazamokhule X7 consisting of 600 residential stands will, once servicing has taken place, address the backlog sufficiently.

- **Economic:**

o *Employment and Income*

The analysis of employment and income levels in the study area are reflected as informal, formal and unemployed workforce, and average income per capita.

Table 7.42: Informal, Formal and Unemployed Workforce 2001 in Steve Tshwete Local Municipality

Area	1996	%	2001	%
Employed	47 423	80,4	41 678	64,6
Unemployment	11 574	19,6	22 798	35,4
Not economically active	-	-	31 619	-
Total labour force	**58 997**	**100**	**64 476**	**100**

Source: 2001 Census data

- The economic active population decreased by approximately 15,8% from 1996 to 2001.
- The total labour force increased by 9,3%.

o *Income*

The per capita income for the study area is provided for 1996 and 2001.

Table 7.43: Individual Monthly Income in Steve Tshwete Local Municipality

Persons	1996	%	2001	%
None	91 608	64,2	54 806	53,7
R1 - R400	6 258	4,4	3 586	3,5
R401 - R800	13 100	9,2	17 642	17,3
R801 - R1600	9 897	6,9	6 257	6,1
R1 601 – R3 200	9 888	6,9	6 057	6,0
R3 201 - R6 400	6 723	4,7	9 666	9,5
R6 401 - R12 800	3 593	2,5	2 957	2,9
R12 801 - R25 600	1 177	0,8	624	0,6
R25 601 - R51 200	278	0,2	285	0,3
R51 201 - R102 400	135	0,1	93	0,1
R102 401 - R204 800	90	0,08	**-**	**-**
Over R204 801	25	0,02	**-**	**-**
Total	**142 772**	**100**	**101 973**	**100**

Source: 2001 Census data

Table 7.43 indicates that the percentage of people with no income increased from 53,7% to 64,2% as percentage of the total in the respective census. However, the increase over the 5 years is 67%, or 13,42% on average annually. People earning between R1 and R1 600 totals 29 255 compared to 27 485 during 1996. This represents an increase of 6,4% between 1996 and 2001, or 1,2% on average annually. In total 84% of the inhabitants of Steve Tshwete Local Municipality falls within the lower income bracket.

Table 7.44: Annual Household Income in Steve Tshwete Local Municipality

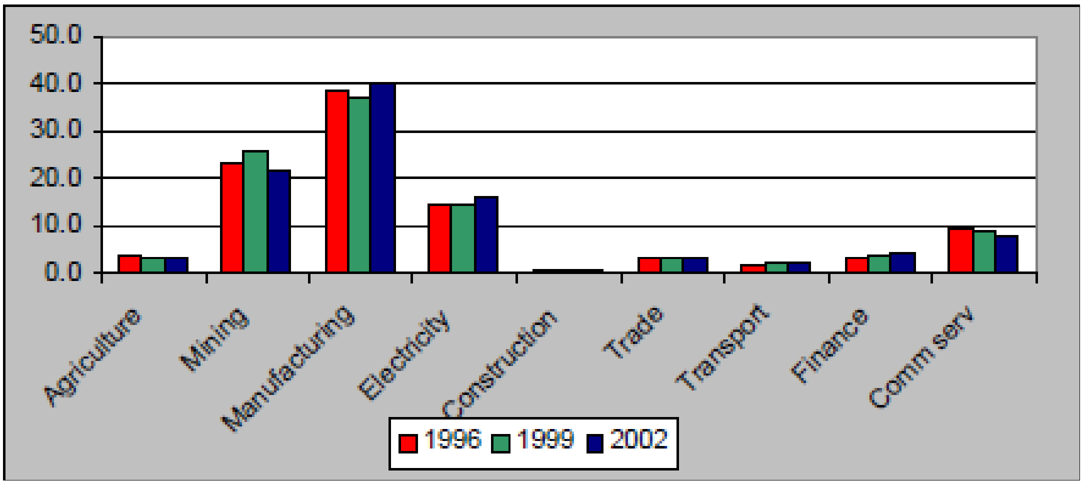
Household	1996	%	2001	%
None	5 578	15,1	1 691	7,1
R1 - R4 800	2 163	5,8	929	3,9
R4 801 - R9 600	5 068	13,7	3 122	13,1
R9 601 - R19 200	6 397	17,3	5 417	22,8
R19 201 - R38 400	6 705	18,1	4 740	19,9
R38 401 - R76 800	5 008	13,5	3 269	13,7
R76 801 - R153 600	3 604	9,7	2 947	12,4
R153 601 - R307 200	1 784	4,8	1 563	6,6
R307 201 - R614 400	479	1,3	113	0,5
R614 401 - R1 228 800	123	0,3	-	-
R1 228 801 - R2 457 600	95	0,3	-	-
Over R2 457 600	39	0,1	-	-
Total	**37 043**	**100**	**23 791**	**100**

Source: 2001 Census data

From the above mentioned table it is clear that 51,8% of the households earn less than R19 200 per year. This reflects on monthly household income of less than R1 600. This figure has increased from 46,9% during 1996 to 51,8% during 2001. Therefore, it is clear that more low income households within the lower bracket of the Governments Housing Subsidy Scheme are moving to the study area. The pressure on limited financial resources will increase which will negatively impact on service delivery. If R3 200/month or R38 400 per annum is used as the cut off point for people qualifying for Government subsidies, the percentage increase to an alarming 69,9% of the total number of households, compared to 66,8% during 1996. Household with no annual income increase from 7,1% to 15,1% from 1996 to 2001.

- *Employment and GGP Contribution to the Local Economy*

The Steve Tshwete Local Municipality is situated in the centre of the Nkangala District Municipality. The economic structure of the Steve Tshwete economy is presented graphically in **Figure 7.72** below.



Source: Global Insight Version, 1.50 (172), 2003

Figure 7.72: GGP profile by sector, 1996 to 2002

Manufacturing dominates the local economy. This is followed by the mining, electricity and community services sectors. As a result of growth in the remaining sectors, the relative importance of the manufacturing sector decreased during 1996 – 1999 but during 1999 – 2002 the relative contribution of the manufacturing sector increased to levels higher than in 1996. Conversely, the mining sectors proportional contribution increased during 1996 - 1999 and decreased to levels lower than in 1996.

The agriculture and community services sectors' proportional contribution decreased during the medium term (1996 - 2002) while the transport and finance sectors contribution increased during the same period.

The growth rates achieved by the various sectors are presented in **Table 7.45** below.

Table 7.45: Growth rates 1996 - 2002

Sectors	1996 - 1999	1999 - 2002	1996 - 2002
Agriculture	0.2	3.4	1.6
Mining	7.5	2.0	2.6
Manufacturing	2.7	7.3	5.0
Electricity	2.9	7.8	5.3
Construction	6.9	2.1	2.3
Trade	3.8	4.1	3.9
Transport	12.6	9.0	10.8
Finance	12.4	7.0	9.7
Comm. services	0.3	0.6	0.4
Total	**4.1**	**4.2**	**4.2**

Source: Global Insight Version, 1.50 (172), 2003

Transport, finance, electricity and manufacturing recorded relatively high growth rates between 1996 and 2002, whereas mining and construction declined significantly recently (1999 - 2002).

The aggregate Steve Tshwete economy recorded a relatively high growth rate for all the periods under observation. This economy grew at the second highest growth rate when compared to the other local municipalities in the Nkangala District. The above economic analysis presents the following implications for Steve Tshwete:

- Middelburg constitutes one of Nkangala's two key industrial areas. Hence, the strong growth in the manufacturing sector should be stimulated and maintained. This implies that the growth should be stimulated in specific sub-sectors to facilitate a diversification of the manufacturing base.
- The agriculture sector should be included in the development initiatives in a manner that exploits the opportunities associated with the Maputo Corridor.
- The high growth of the transport sector indicates that opportunities exist for the establishment of transport related initiatives, as well as the formation of a transport hub that serves as a link between the remainder of Mpumalanga and Gauteng.

Apart from the above mentioned implications, various initiatives should be formulated and implemented to ensure that Steve Tshwete's sectoral advantages (agriculture, mining, manufacturing, and finance) are leveraged/exploited.

During the EIA phase the latest statistics will be included in order to determine if the trend that is seen with these figures are still relevant. If major changes did occur within this local municipality it will be reflected in the EIA. It must also be investigated if these trends differ if in actual fact this will have a influence on this project from a social point of view.