5.6 GROUND WATER

A detailed site specific, quantitative, geohydrological investigation was conducted for the Middelbult Block 8 EMPR Addendum in 2002. The actions performed during this survey will be listed below. However, for the Shondoni Project three reserve block areas (Leeuwpan, Springbokdraai and Block 8 Northern Reserves) were added. Whereas for this study, the 2002 investigation was revisited and updated through re-measurement of ground water levels and ground water sampling and analyses, a the hydro-census for the area was extended to cover the new areas and the geohydrological interpretation of the study area was revised and expanded to include the new areas, primarily based on existing data supplemented with geological information supplied by Sasol Mining for the new areas.

The 2002 and current investigations comprised:

- Obtain, collate, verify and review existing geological, geohydrological and mining information – regional information as well as information contained in old and current EMPR's.
- Verify the existing geological information within the study area. The geological information supplied by the Sasol Geology Department was obtained from more than 600 exploration boreholes.
- Verify serviceability of existing (old) monitoring boreholes within the study area, as well as external user boreholes. Access to all existing boreholes was investigated and borehole depths and water level depths were measured. These boreholes will serve as ground water sampling and monitoring locations.
- Site and drill 30 additional boreholes (2002) within the study area for geohydrological assessment and monitoring purposes. These boreholes were drilled in pairs (one shallow (SSW-) and one deep (SDF-) borehole) and were used to determine the geohydrological differences between shallow weathered zone aquifers and deeper Karoo aquifers. Each borehole was geologically profiled according to the lithology, weathered status and physical properties of the underlying host rock that it penetrated. Borehole Logs and Site Reports have been generated for each of the 30 boreholes and are attached as APPENDIX 5.2(A) to this report.
- Compile base maps for topography, geology and geohydrology.
- Perform multi-parameter profiling of borehole water columns to assess ground water quality stratification. The Electrical Conductivity (EC) profile obtained during profiling for each of the 30 monitoring boreholes were plotted and are attached as APPENDIX 5.2(B). The EC profile represent the overall dissolved salinity distribution within the borehole water column and together with information on weathering, fracturing and water intersections, facilitate meaningful sampling horizon selection for the purposes of stratified ground water sampling.
- Take stratified ground water samples.
- Submit ground water samples to laboratory and analyse for pH, EC, TDS, Ca, Mg, Na, K, Si, F, Total Alkalinity, Cl, SO_4, NO_3, Al, Fe and Mn. The geochemistry results of the 114 water samples taken are attached as APPENDIX 5.5(A).
- Code and computerize all relevant data into computerized data base.

- Compile a comprehensive ground water base line description including the regional geohydrological setting, physical aquifer description, hydraulic aquifer description, aquifer dynamics, aquifer hydrochemistry, aquifer classification, and ground water use.

5.6.1 Regional Geohydrological Description

The regional geohydrological setting is described with reference to available published regional information for the study area. The study area include the Middelbult Reserve, Block 8 Reserve, Springbokdraai Reserve, Leeuwpan Reserve and Block 8 Northern Reserve extents. The regional geohydrological description will deal with the regional topography, meteorology, surface drainage, geology, geohydrology and historical mining, all of which will have an influence on the geohydrological setting of the study area.

5.6.1.1 Regional Topography

The study area is located within the Mpumalanga Province of South Africa. The topography of the Mpumalanga Province varies and has a distinctive mountainous north-eastern region and a flatter, expansive south-western region. The north-eastern region varies substantially in elevation (between 1500 m amsl and 2200 mamsl) and covers the transition between the "Lowveld" and the "Highveld". The study area (located by the white dot on Figure 5.6.1.1(a)) falls within the elevated flatter south-eastern to eastern region of the province.

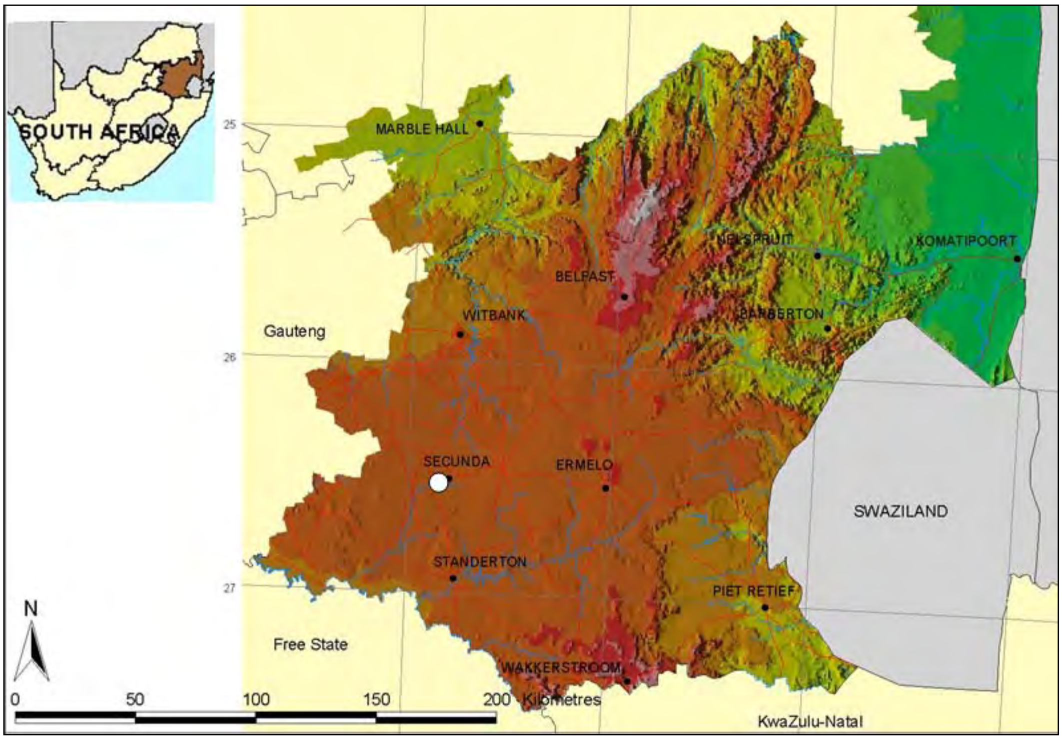
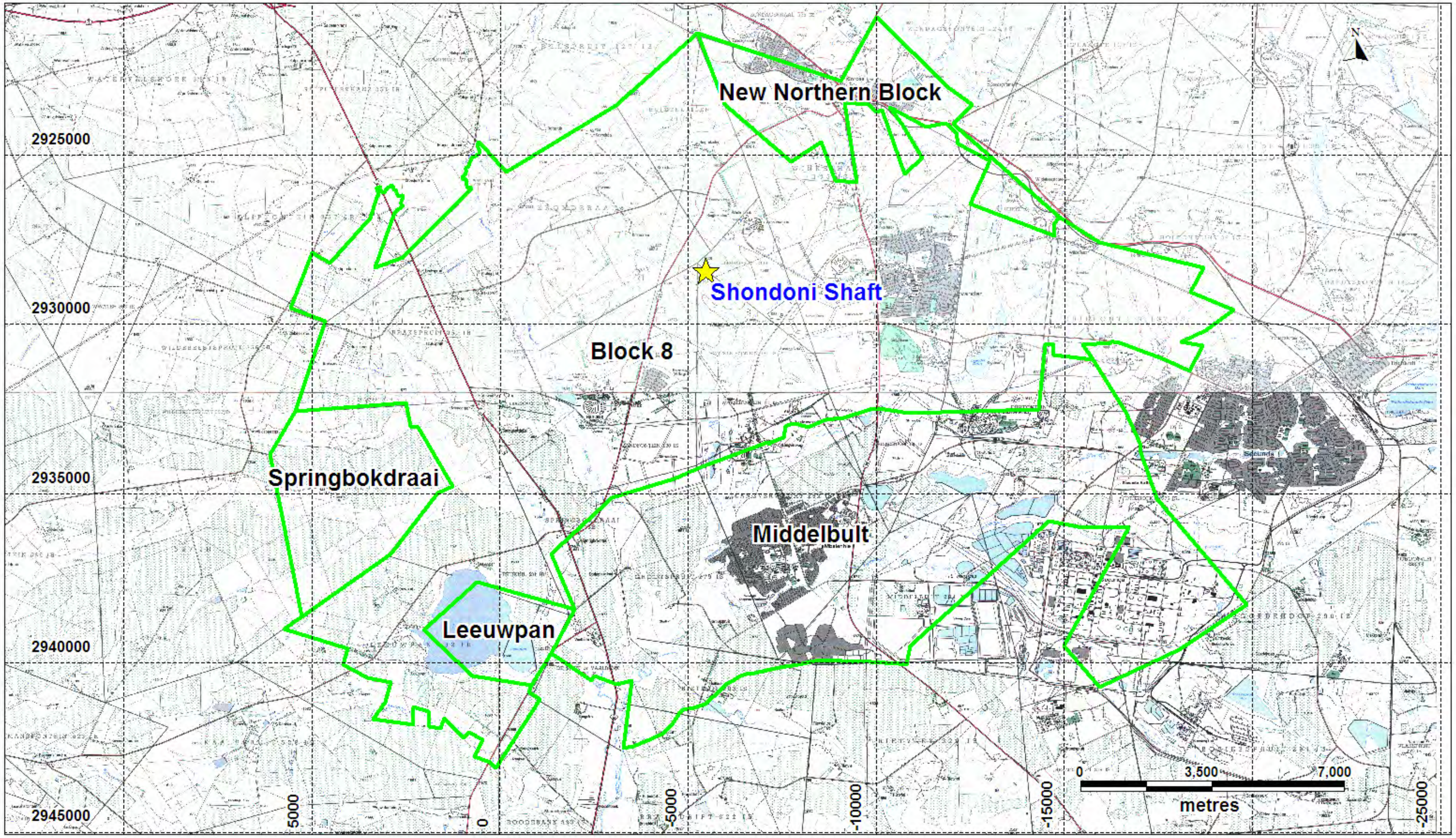


Figure 5.6.1.1(a): 3D Surface ENPAT map of Mpumalanga

Figure 5.6.1.1(a) represents a relief image obtained from the Environmental Potential Atlas for the Mpumalanga Province Series, supplied by the Department of Environmental Affairs and Tourism, 2000 and illustrates the regional surface topography of Mpumalanga.



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- Shondoni Shaft
- Reserve Extents

Figure 5.6.1.1(b): Regional Topography

The localized topography of the study area will be discussed with reference to the clipped region of the four (2628BD Leandra, 2628DB Willemsdal, 2629AC Evander and 2629CA Secunda) 1: 50 000 Topographical Maps Sheets of South Africa, displayed as Figure 5.6.1.1(b). The natural topography of the study area is flat, slightly undulating and ranges in elevation between 1600 mamsl and 1650 mamsl (meters above mean sea level). The natural surface topography has however been moderately altered as a result of the various anthropogenic and mining activities in the area. Several mine dumps, ash dumps and stockpiles, etc. are evident across the surface of the study area.

5.6.1.2 Regional Meteorology

The climate of Mpumalanga contrasts vastly between the far eastern and north-eastern "Lowveld" and the "Highveld", which covers most of the central and western extent of the province. The climate of the Lowveld is typically subtropical with hot, humid summer days in which temperatures often reach 40°C.

The average temperatures may reach up to 30°C in the summer and up to 23°C during the winter months. The average minimum temperatures range between 19°C and 6°C during the summer and winter months respectively. Rainfall predominantly occurs during the summer and autumn months (September to May), whilst the winters are mild and dry. The climate of the Highveld is typically characterized by hot summer months, between October and March and cold winters from May through to August.

The rainfall of the Highveld is highly seasonal and falls predominantly in the form of late afternoon thunder storms during the summer months. The winters are cold and dry and are often associated with vast early morning mist belts and frost.

Figure 5.6.1.2(a) is the Mean Annual Precipitation Map (per quaternary catchment) from the Environmental Potential Atlas for the Mpumalanga Province series, supplied by the Department of Environmental Affairs and Toursim, 2000 and indicates the rainfall distribution across the Mpumalanga Province. Figure 5.6.1.2(a) indicates that lowveld and low lying areas adjacent to Marble Hall have the lowest Mean Annual Precipitation (MAP) across the province (460 – 620 mm/annum).

For the western and central regions of the Highveld the MAP increases to between 620 to 750 mm/annum. The MAP progressively increases towards the east across the Highveld with the MAP reaching 1040 to 1335 mm/annum across the most eastern regions of the Highveld. The increased rainfall is closely related to the elevation of the region.

The local meteorology of the study area will be discussed with reference to the data obtained from the Bethal Monitoring Station. The summer temperatures are mild with a maximum average of 25°C and a minimum average of 12°C. Winters are cold with a maximum average of 18°C and a minimum average of 1°C.

The MAP of the study area is 711 mm which occurs as showers and thunderstorms, and falls mainly from September to April. The winter months of June, July and August are dry and their combined rainfall comprises only 3.9% of the total annual precipitation. The Mean Annual Evaporation (MAE) of the study area, as determined using the A-Pan technique, is 1729 mm/annum. The prevailing winds within the study area, are seasonal and blow from the southwest and northwest during winter months and from the east and northwest during the summer months.

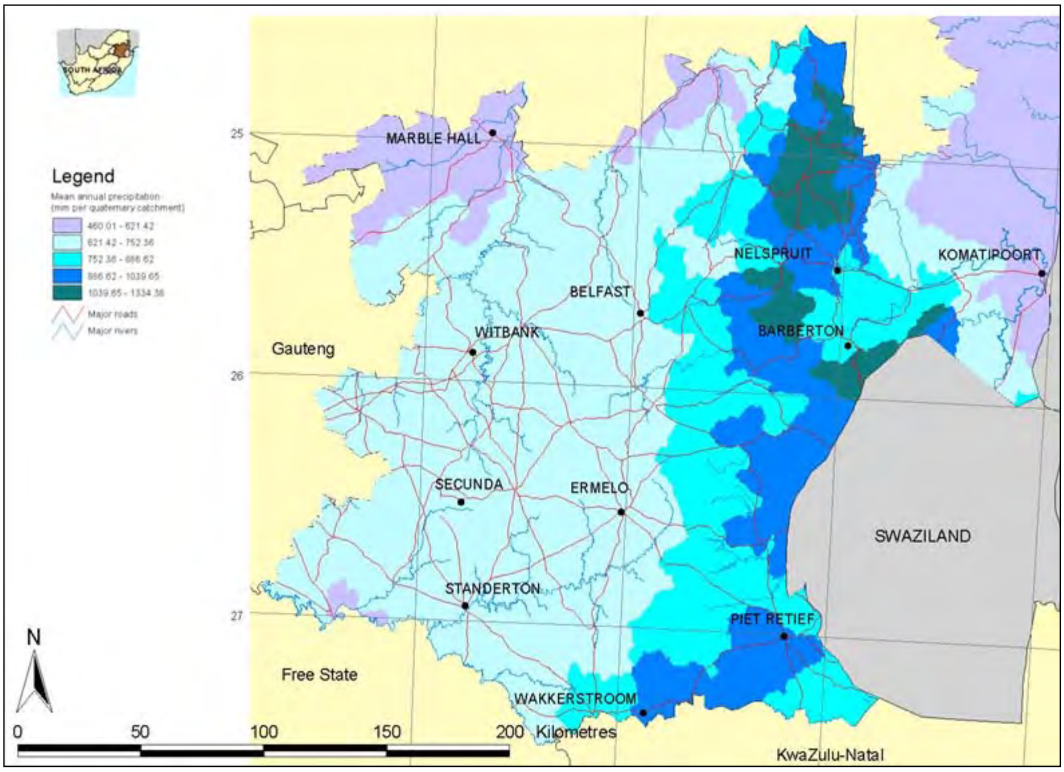


Figure 5.6.1.2(a): Regional MAP of Mpumalanga

5.6.1.3 Regional Surface Drainage

Figure 5.6.1.3(a) is map indicating the major surface water drainage systems of the Mpumalanga Province, and indicates the Mean Annual Runoff for each the quaternary catchments. It is evident from Figure 5.6.1.3(a) that there are three distinct surface water flow regimes in Mpumalanga.

The northern (Komati/Crocodile River and Olfiants River Primary Catchments) of the three drainage systems has a mean annual runoff of between 10 million m^3 and 140 million m^3, per quaternary catchment per annum.

The eastern regime (Mfolozi/Pongola River Primary Catchment) has a mean annual runoff of between 810 million m^3 and 1.6 billion m^3, per quaternary catchment per annum.

The study area is located within the western regime (Vaal River Primary Catchment) of the three drainage systems, which has a mean annual runoff of between 140 million m^3 and 280 million m^3, per quaternary catchment per annum.

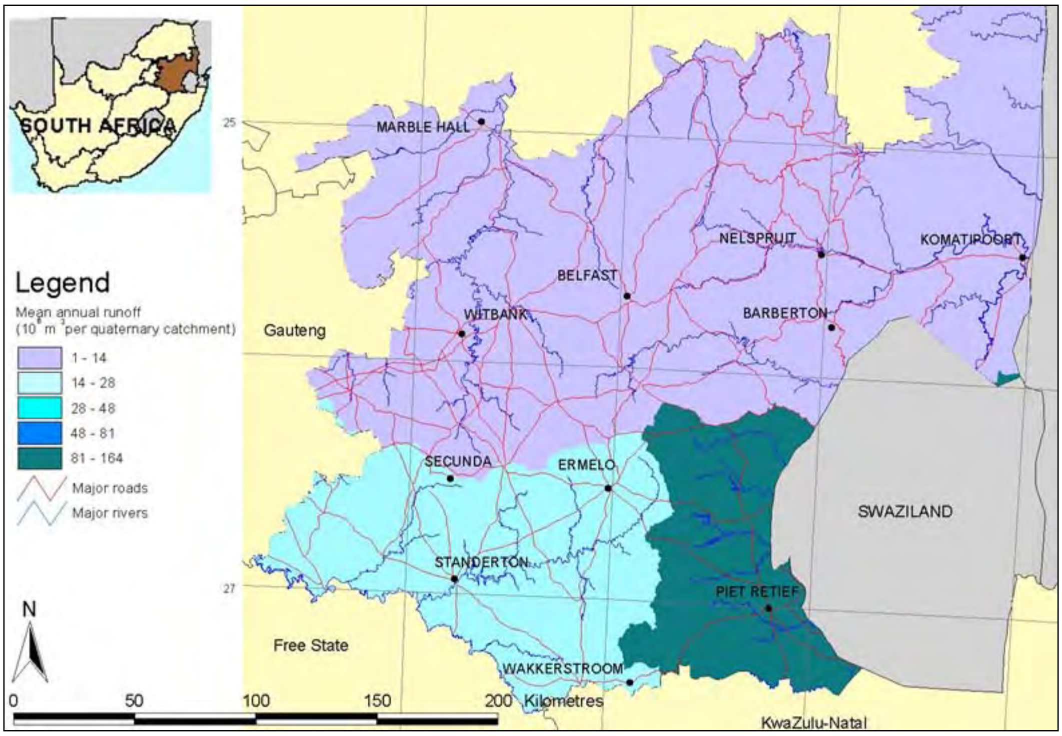


Figure 5.6.1.3(a): Regional Drainage Systems of Mpumalanga

The extent of the new Block 8 Northern Reserves lies on the watershed that separates the C12D quaternary catchment from the B11D quaternary catchment, and is in fact the boundary between the Vaal River and the Olifants River Primary Catchments.

The study area falls within the northern extent of C12D quaternary catchment, which drains in a southerly direction within the study area (Figure 5.6.1.3(b)). The major surface water drainage bodies in the study area include the Grootspruit, Trichardtspruit, Kleinspruit, Wildebeestspruit, Watervalspruit, Kaalspruit and the Waterval River.

The Grootspruit drains in a southerly to south-westerly direction across the north-eastern regins of the study area, whilst the Trichardtspruit and Kleinspruit drain in a westerly to south-westerly direction across the eastern extent of the study area. The Watervalspruit and Wildebeestspruit both drain in a south-easterly to easterly direction across the western and north-western regions of the study area.

The Kaalspruit drains in an easterly to south-easterly direction across the south-western regions of the study area. Each of the tributaries drain into the Waterval River which drains in a Southerly direction across the entire extent of the study area and ultimately drains in to the Vaal River.

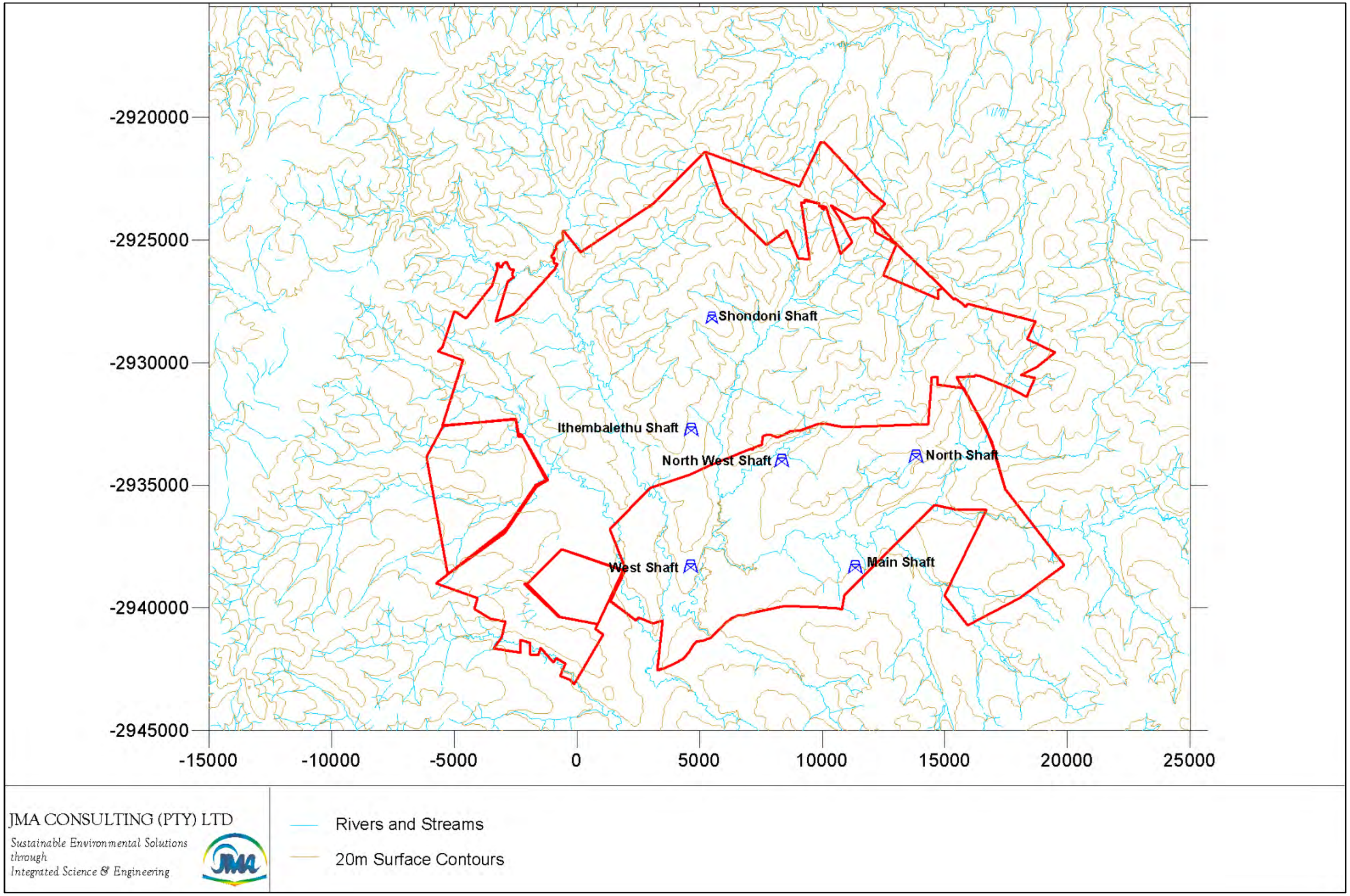


Figure 5.6.1.3(b): Major Surface Drainage Features of the Study Area

5.6.1.4 Regional Geology

The geology across the Mpumalanga Province is highly variable as indicated on the map obtained from the Environmental Potential Atlas for the Mpumalanga Province Series' Dominant Geology Map, supplied by the Department of Environmental Affairs and Toursim, 2000 (Figure 5.6.1.4(a)). This Figure indicates that the surface geology of the south-western extent of the province comprise mainly Karoo Sediments (shales, arenites, mudstones, tillite) as well as dolerite intrusions.

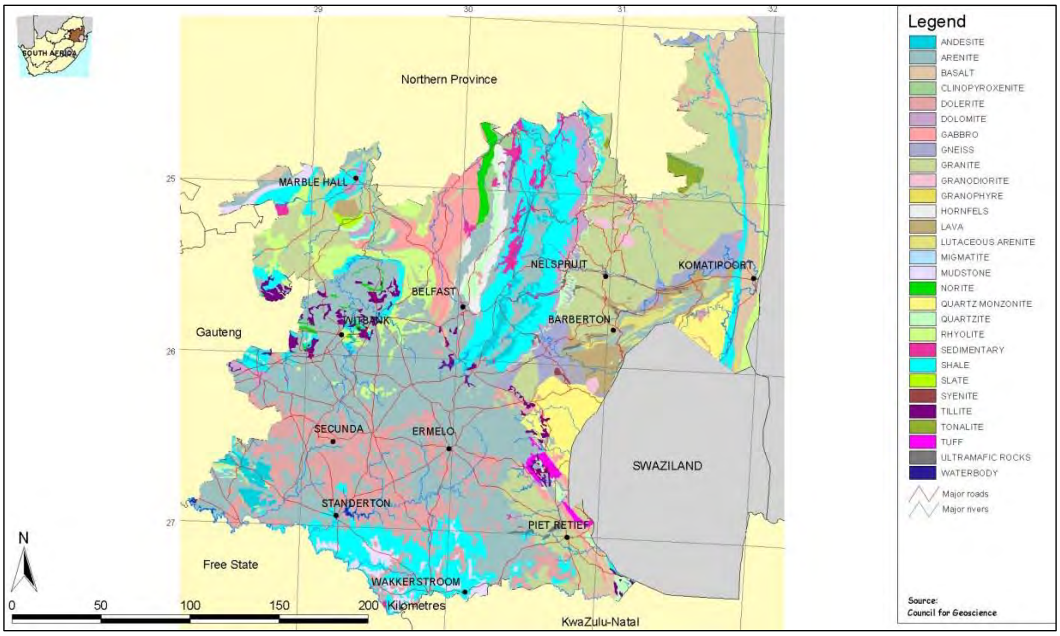
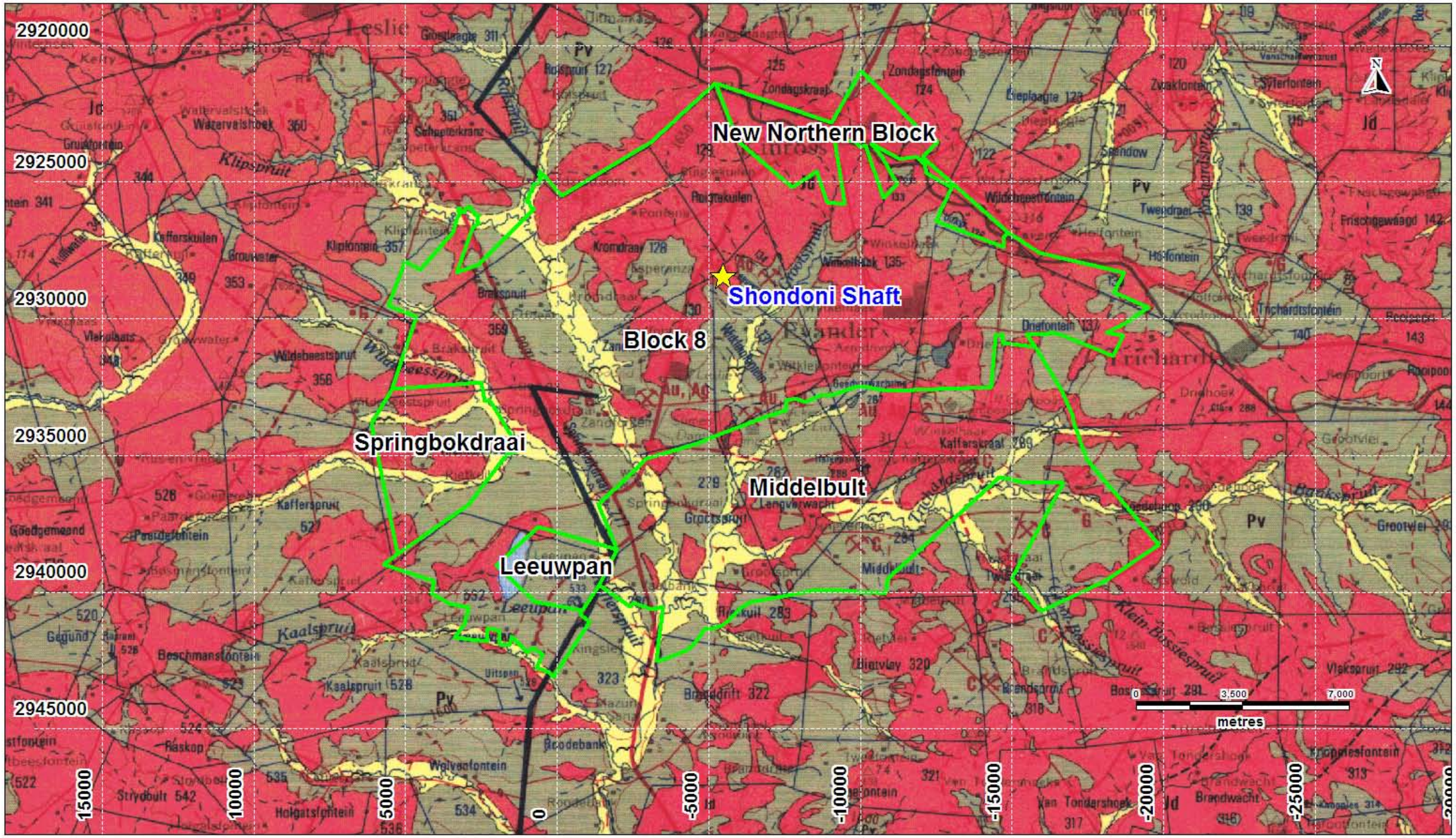


Figure 5.6.1.4(a): Mpumalanga Province Surface Geology

The occurrence and movement of ground water, as well as the ground water quality, are functions of the geological host rock in which the ground water occurs, including the alteration thereof as a result of human activities, such as mining. The regional geology of the across the extent of the study area will be discussed with reference to the clipped region of the 1:250 000 Geological Map Series of South Africa – Sheet 2628 EAST RAND, (1986), displayed as Figure 5.6.1.4(b). The Regional Geology Map depicts that the surface geology within and adjacent to the Study Area is dominated by the sedimentary rocks of the Vryheid Formation (Pv) as well as Jurassic Age Dolerite Intrusives (Jd).

The Vryheid Formation forms part of the Ecca Group of the Karroo Supergroup, and out crops extensively across the study area. The Vryheid Formation generically consists of interbedded sandstones and shale layers. Carbonaceous shale and coal layers are generally associated with the Vryheid Formation as well. The dolerite present within the study area (Jd) is younger than the Vryheid Formation and intruded into and through the sedimentary rocks of the Vryheid Formation. The dolerite intrusions typically occur as dykes and sills and are often responsible for the devolatization of the coal adjacent to the dolerite intrusions. The river beds across the study are typically associated with the deposition of tertiary and quaternary sands and sediments. Gold (Au), silver (Ag) and coal (C) has been, or is currently being mined, within the study area as well.



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- Shondoni Shaft
- Mine Lease Area

Figure 5.6.1.4(b): Regional Geology of the Study Area

5.6.1.5 Regional Geohydrology

The regional geohydrology of the study area will be discussed with reference to the available information relevant to the map extract displayed as Figure 5.6.1.5(a). This map extract was clipped from the published 1:500 000 Hydrological Map Series of the Republic of South Africa, Sheet 2526 Johannesburg, 1999.

The regional geohydrological attributes of the study area are clearly a function of the geological formation distribution. Two distinctly separate surface stratigraphic sequences (Pe and Jd) occur within the study area, each with their own geohydrological manifestations. Both sequences out crop extensively and interchangeably across the extent of the study area.

Geohydrological Zone 1: Permian Age Ecca Group Sediments

The surface geology within the southern extent of the study area is predominantly underlain by the argillaceous rocks (shale, mudstone and siltstone) and arenaceous (sandstone) of the Ecca Group – denoted by Pe on Figure 5.6.1.5(a).

The primary ground water occurrences within this zone are in joints and fractures associated with the contact zones, related to the heating and cooling of the country rock, caused by the intrusions of the dolerite dykes and sills. Ground water is also extensively present within the weathered zones of the Ecca Group litholgies.

The borehole yielding potential within this geohydrological zone is classified as d2, which indicates an average yield which varies between 0.1 l/s to 0.5 l/s, although much larger yields are often associated with more localized contact zones. The aquifer type is classified as intergranular and fractured, and no large scale ground water abstraction is indicated to occur from these aquifers within the bounds of the study area. The ground water potential for the western area is given as between 40 and 60%, which indicates the probability of drilling a successful borehole (yield > 0.1 l/s) whilst the probability of obtaining a yield in excess of 2 l/s is given as between 0% and 20%.

Geohydrological Zone 2: Jurassic Age Dolerite

The surface geology across the northern extent of the Block 8 Reserve as well as the new Block 8 Northern Reserve consists almost entirely of ultramafic to mafic Jurassic Age Dolerite Intrusives – denoted by Jd on Figure 5.6.1.5(a).

The primary ground water occurrences within this zone are in joints and fractures associated with the contact zones, related to the heating and cooling of the intrusive bodies as well as in the contact zones with the host rock. The borehole yielding potential within this geohydrological zone is predominantly classified as d2, which indicates an average yield which varies between 0.1 l/s to 0.5 l/s, although much larger yields are often associated with more localized contact zones. The aquifer type is classified as intergranular and fractured, and no large scale ground water abstraction is indicated to occur from these aquifers within the bounds of the study area.

There is, however, a localized area within the dolerite to the south-east of the study area, that is classified as d3, indicating that the average yield varies between 0.5 and 2.0 l/s. The aquifer type is still classified as intergranular and fractured.

The ground water potential for the western area is given as between 40 and 60%, which indicates the probability of drilling a successful borehole (yield > 0.1 l/s) whilst the probability of obtaining a yield in excess of 2 l/s is given as between 0% and 20%.

The mean annual recharge (MAR) to the ground water system within the study area is estimated to be between 25 mm and 50 mm per annum, which relates to between 3.5% and 7.0% of the mean annual precipitation (MAP). The ground water contribution to surface stream base flow is relatively low, estimated to be less than 25 mm per annum. The aquifer storativity (S) for the fractured aquifers in this part of the study area is estimated to be between 0.001 and 0.01. The saturated interstice types (storage medium) are fractures which are restricted principally to the zone directly below the ground water level. The pristine ground water quality is good with a Total Dissolved Solids (TDS) range of between 300 mg/l to 500 mg/l. The ground water is classified to be of the hydrochemical type B, with dominant cations Ca^{2+} and Mg^{2+} and dominant anion being HCO_3^-.

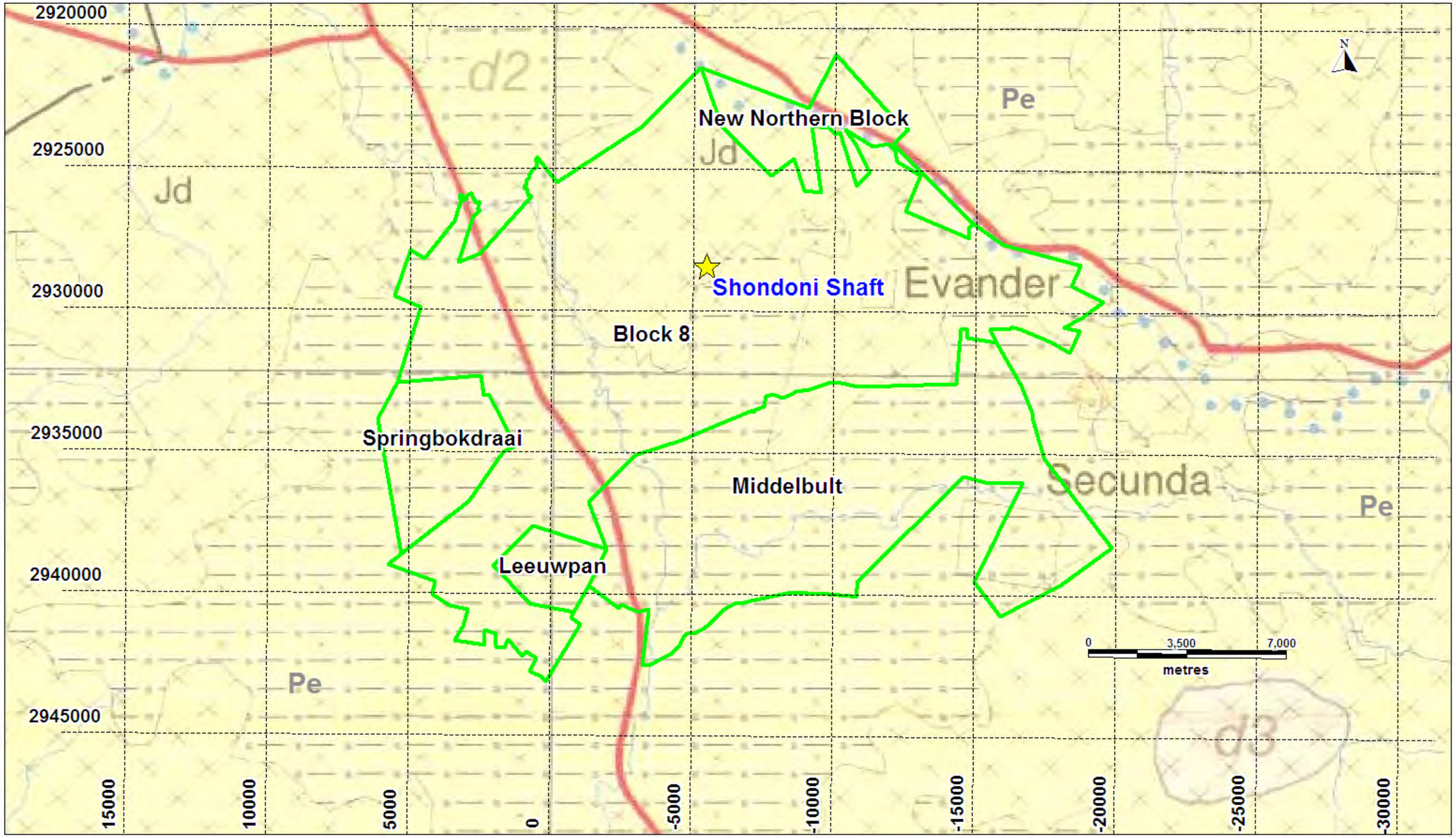
5.6.1.6 Regional Historical and Future Mining

The regional historical mining will be discussed with reference to Figure 5.6.1.6(a) and will not extend beyond the extent bound by the study area.

Figure 5.6.1.6(a) delineates the extents of the historically underground mined areas (**pink**) as well as the proposed underground mining extents of the No. 4 coal seam (**light blue**) and No. 2 coal seam (**dark blue**) respectively. The detailed mine layout and underground mining methods are discussed in the EIA and will not be addressed in this Groundwater Specialist Report. Figure 5.6.1.6(a) indicates that the entire Middelbult Reserve has been mined out as well as the southern extent of the Block 8 Reserve. The No. 4 coal seam has been historically mined by standard board and pillar underground mining methods from these reserves.

The proposed underground mine layout however depicts that both the No. 4 and No. 2 coal seams will be mined out by underground mining methods in the future. The No. 4L seam ranges in elevation between 1436.20 mamsl and 1527.14 mamsl with an average elevation of 1483.43 mamsl. The No. 2 seam occurs some 20 to 30 meters below the No. 4L seam and ranges in elevation between 1408.98 mamsl and 1493.50 mamsl with an average elevation of 1449.734 mamsl.

It is evident from the Figure 5.6.1.6(a) that the current proposed underground mining extent of the No. 4 Coal Seam is far larger than for the No. 2 coal seam. The No. 4 coal seam will be mined out by standard bord and pillar as well as high extraction underground mining methods, whilst the No. 2 seam will be entirely mined by standard bord and pillar underground mining methods.



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- Shondoni Shaft
- Mine Lease Area
- Primary Catchment Boundary

Figure 5.6.1.5(a): Regional Geohydrology of the Study Area

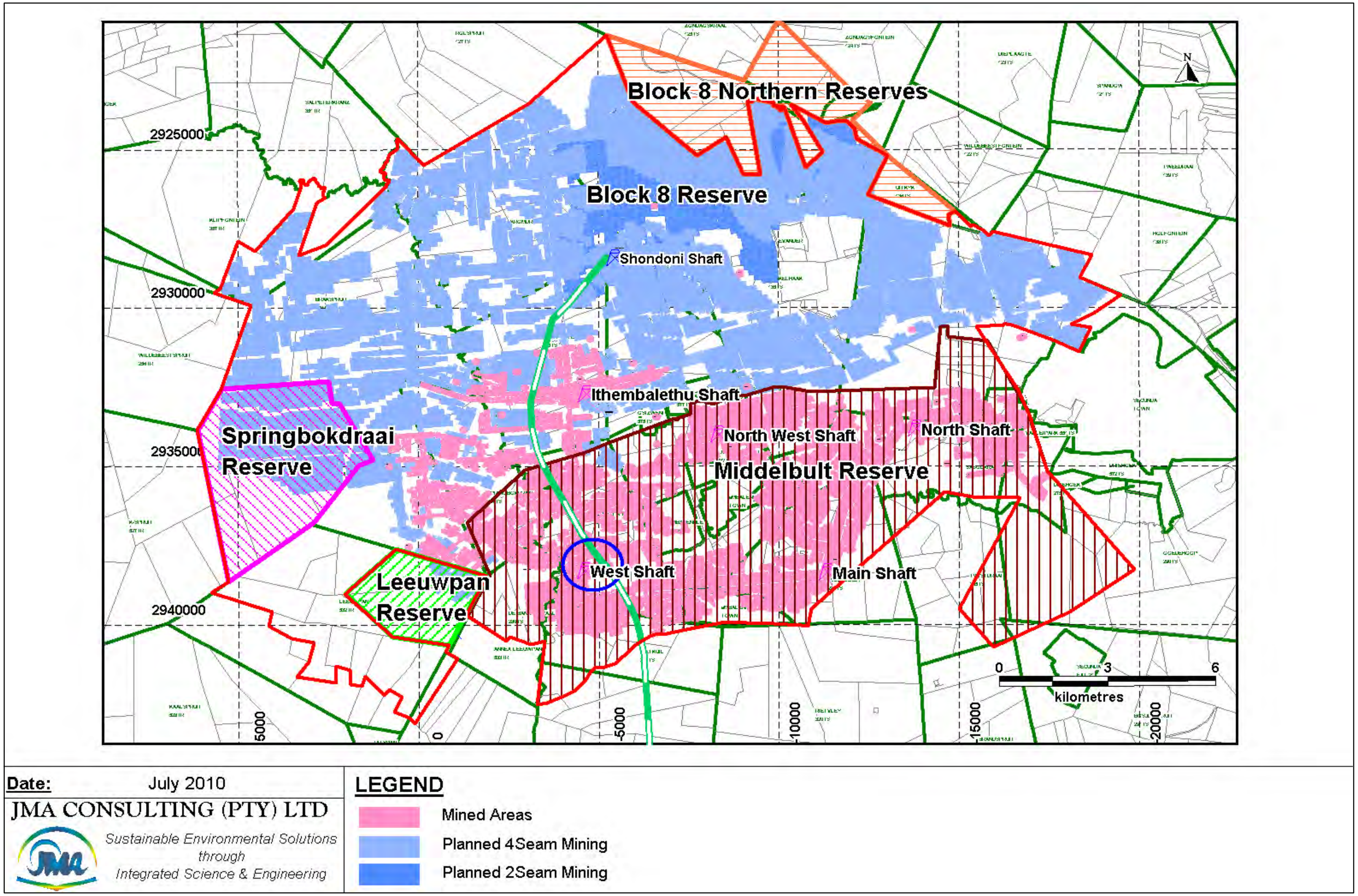

Figure 5.6.1.6(a): Regional Historical and Future Mining

5.6.2 Physical Aquifer Description of Study Area

During the 2002 geohydrological investigation for Block 8, a total of 30 monitoring boreholes were drilled specifically for geohydrological purposes. The boreholes were drilled in pairs, one shallow borehole (SSW-) of 30 m deep to investigate the shallow weathered zone aquifer(s), and one deep borehole (SDF-) ranging in depth between 80 - 150 m, to investigate the deep fractured aquifer. The shallow weathered zone aquifer(s) were sealed off in the deep boreholes (SDF-) with 30 m solid steel casing and sealed with cement and bentonite at the surface. The solid casing installed in the shallow boreholes (SSW-) ranged in depth between 2 m and 12 m, averaging at 6 m. The borehole logs and site reports as well as multi-parameter profiles, for these boreholes were recorded and are attached as APPENDIX 5.2(A) and 5.2(B) of the Ground Water Specialist Report respectively.

The boreholes were sited using geophysical (magnetic) methods with the aim of intersecting the following geological structures:

- Four boreholes pairs (SSW- & SDF- 4, -7, -10 & -13) were sited to intersect the large east-west orientated normal fault that stretches over a distance of roughly 16 km between Brandspruit 359 IR in the west and the town of Evander in the east. This large feature also intersects the Kinross Mines Ltd Slimes Dams to the west of Evander.

- One pair of boreholes (SSW- & SDF-2) were sited to intersect the smaller normal fault that stretches over a distance of roughly 4 km between Witkleifontein 131 IS in the west and Evander's Sewage Works and the Winkelhaak Mines Slimes Dams in the east.

- Two pairs of boreholes (SSW- & SDF-6 & -9) were sited to penetrate the two dykes intersecting both the Kinross Mines Ltd Slimes Dams and the Leslie Gold Mines Ltd Slimes Dams.

- One pair of boreholes (SSW- & SDF-3) was sited to intersect the 7 m thick sub-vertical rising B8 dolerite sill that compartmentalizes or separate most of the Block 8 reserve from the Middelbult underground workings.

In addition to information obtained from these boreholes, geohydrological and hydrochemical information from over 170 external user's boreholes (inclusive of 28 monitoring boreholes used for observation purposes by Kinross, Winkelhaak and Leslie Gold Mines Ltd), 1 dug well and 16 fountains were obtained during the various hydro-census'. The locations of the monitoring boreholes, external user boreholes, as well as the exploration boreholes are indicated in Figure 5.6.2(a). The locations of these boreholes and fountains, as well as their respective numbers are indicated on the Map attached as APPENDIX 5.2(C) of the Ground Water Specialist Report.

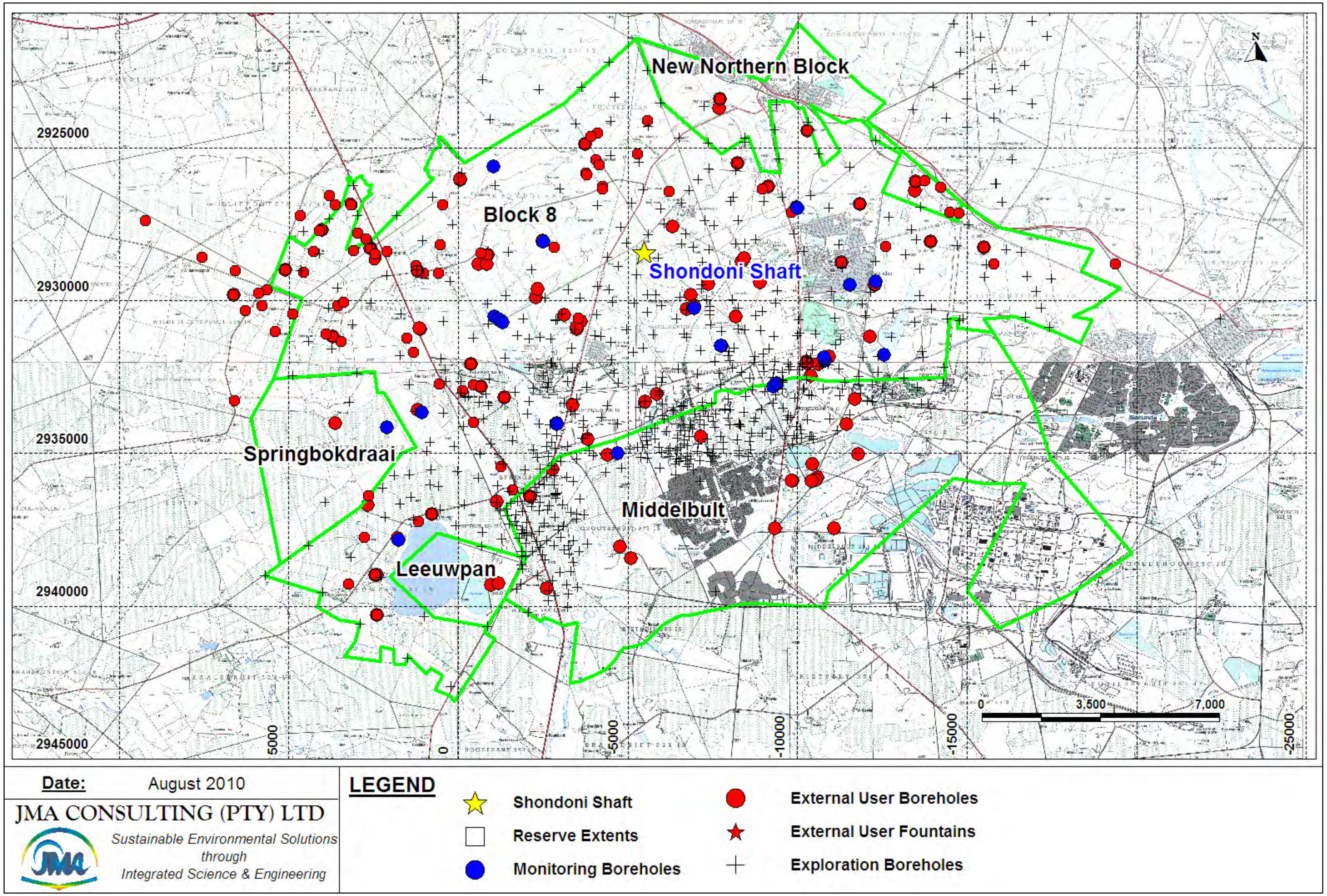

Figure 5.6.2(a): Borehole and Fountain Locations

5.6.2.1 Aquifer Matrix (Soil and Geological Matrix)

The surface of the study area consists predominantly of overburden and a dark brown to black, sandy clay layer, with an average thickness of between 1 and 2 meters thick. The clay layer is quite extensive across the extent of the study area and formed due to the weathering of the underlying lithologies. The nature of the clay layer is therefore dependant on the underlying host rock lithologies.

The host rock within the study area consists of sedimentary lithologies of the Vryheid Formation as well as Jurassic Aged dolerite intrusions. The Vryheid Formation forms part of the Ecca Group of the Karroo Supergroup, and consists of interbedded sandstone, mudstone and shale layers. Carbonaceous shale and coal layers are generally associated with the Vryheid Formation as well. The dolerite present within the study area is younger than the Vryheid Formation and intruded into and through the sedimentary rocks of the Vryheid Formation. The dolerite intrusions typically occur as dykes and sills and are often responsible for the devolatilization of the coal adjacent to the dolerite intrusions.

The general lithological profile of the study area, up to, and including the No. 2 coal seam, comprises of:

- Soft overburden consisting of soils and weathered sandstone and some occasional highly weathered dolerite
- Hard overburden consisting of fresh to slightly weathered dolerite, sandstone and shale units
- No.5 coal seam (only present in some areas)
- Inter burden units of sandstone
- No.4H and/or 4L coal seam with a thin layer of sandstone in between if both are present
- Karoo Sediments
- No. 2 coal seam

5.6.2.2 Aquifer Types (Primary, Weathered, Fractured, Karst)

There are three major aquifer types present within the extent of the study area, namely:

- shallow weathered zone perched aquifers
- shallow weathered zone Karoo aquifers
- deep fractured Karoo aquifers (zone below the weathered zone)

The shallow perched aquifers are essentially restricted to the soil (soft overburden) horizon and have a very limited vertical depth. These aquifers are however laterally very extensive and are exposed to unconfined atmospheric conditions.

The host rocks of the other two aquifer types are the Karoo sediments as well as the dolerite intrusions. The nature and physical parameters of these aquifers are dependent on the occurrence, geometry, size, spatial extent as well as the fracturing status (of both the dolerite and Karoo lithologies) associated with the intrusions.

For example, dolerite dykes and sills may form aquifer boundaries or act as ground water conduits, depending on their size as well as their weathering and fracturing conditions. In essence, the characteristics of all three aquifer systems may vary depending on the localized conditions.

It is important to note, that due to the complex nature of these dolerite intrusion, many different aquifer units or compartments exist. All these units are different, not only in terms of physical properties, but also in terms of geometry and size. This also implies that it is not always possible to unilaterally classify an aquifer zone, into any of the three categories listed above.

It is a known fact that different piezometric pressures exist both at depth, and for different aquifer units. The perched aquifer usually displays unconfined conditions, whilst the shallow weathered zone aquifer displays unconfined to semi-unconfined conditions, and the deep aquifer predominantly confined conditions. It is typical for Karoo type aquifers (both shallow weathered zone and deep) that the shallow part of an aquifer exists with a higher potential for exploitation, than the deeper aquifers.

Ground water flow in all three aquifer types is essentially horizontal, however, interconnection between the aquifer types, can introduce non-horizontal flow components. The ground water flow within the aquifers occurs primarily as a result of advection caused by gravity. Ground water flow in underground sections, which are not fully flooded, is also gravitational and therefore controlled by the mine floor contours, and only become pressure controlled when fully flooded.

5.6.2.3 Aquifer Zones (Unsaturated, Saturated)

The thickness of the unsaturated zone is taken as the distance from the surface down to the ground water level, whilst the thickness of the saturated zone is taken as the distance from the ground water level down the interface between the weathered/fractured zone and the fresh lithologies. The weathering and fracture status of the geology penetrated, was recorded during the drilling programme and is included in the borehole logs and site reports, attached as APPENDIX 5.2(A) of the Ground Water Specialist Report.

With reference to the available geological information from exploration boreholes, supplemented with data obtained during drilling of the geohydrological monitoring boreholes, the physical thicknesses for the three different aquifer types, are summarized in Table 5.6.2.3(a).

Table 5.6.2.3(a): Aquifer Zone Thickness'

Aquifer Type	Aquifer Depths (mbgl)	Saturated Thickness (m)
Shallow Perched Aquifer	0 m to 6.4 m	-
Shallow Weathered Zone Aquifer	6.4 m to 15.2 m	3.9 m to 15 m
Deep Karoo Aquifer	15.2 m to 165 m	74 m to 108 m

Table 5.6.2.3(a) indicates that depths below the surface at which each of the aquifers occur. It is evident from the table that shallow perched aquifer is underlain by the shallow weathered zone aquifer which is further underlain by the deeper Karoo aquifer.

The thickness of these aquifers is dependent on the water levels as well as the depth of the interface between the weathered/fractured zones and the fresh host rock lithologies.

In each instance where an impact on an aquifer is assessed, the potential and/or sensitivity of the aquifer(s) impacted on, will contribute towards the impact assessment made. It is therefore important to arrive at an overall aquifer classification, based on the baseline information generated. The overall classifications of the aquifers present within the study area are therefore classified as medium potential aquifers, as these aquifers have a viable exploitation potential for small scale domestic and stock-watering purposes. The aquifers will, however, not support formal irrigation or water provision for extensive areas or communities.

5.6.2.4 Lateral Aquifer Boundaries (Physical, Hydraulic, Arbitrary)

The lateral extent of the ground water zones within the study area is severely complex. The lateral extent of the perched aquifers is usually finite and varies as a function of the lateral extent of soil and clay lenses at the surface.

Due to the scale of the investigation as well as the interconnectivity of the underground mining activities, the physical extent of the Karoo aquifers can be taken as infinite. Their lateral extent within the study area would naturally be highly dependent on the distribution and interconnectivity of the dolerite dykes and sills. In certain areas across the extent of the study area, these intrusive features intersect one another and would have compartmentalized the adjacent aquifers. The degree and extent of compartmentalization prior to mining would have been very localized and is currently undetermined, as these compartments have since been be affected to various degrees as a result of the underground mining activities.

In addition to the geological features, the maximum natural lateral extent of the ground water zone (prior to mining) within the study area is limited by hydraulic boundaries. These include those boundaries formed by the major rivers and streams which act as ground water discharge boundaries, topographical water sheds which act as no-flow boundaries and surface infiltration sources (tailings dams) which usually represent constant head influx boundaries. Several of the natural hydraulic boundaries identified are delineated in Figure 5.6.2.4(a).

However, when mining activities impact on the ground water level distribution, these hydraulic boundaries become dynamic, resulting in an induced hydraulic boundary, usually manifesting as a cone of de-watering. It is important to realize from the discussion above, that aquifer boundaries are both physical and hydraulic in nature, both of which become dynamic in the mining environment.

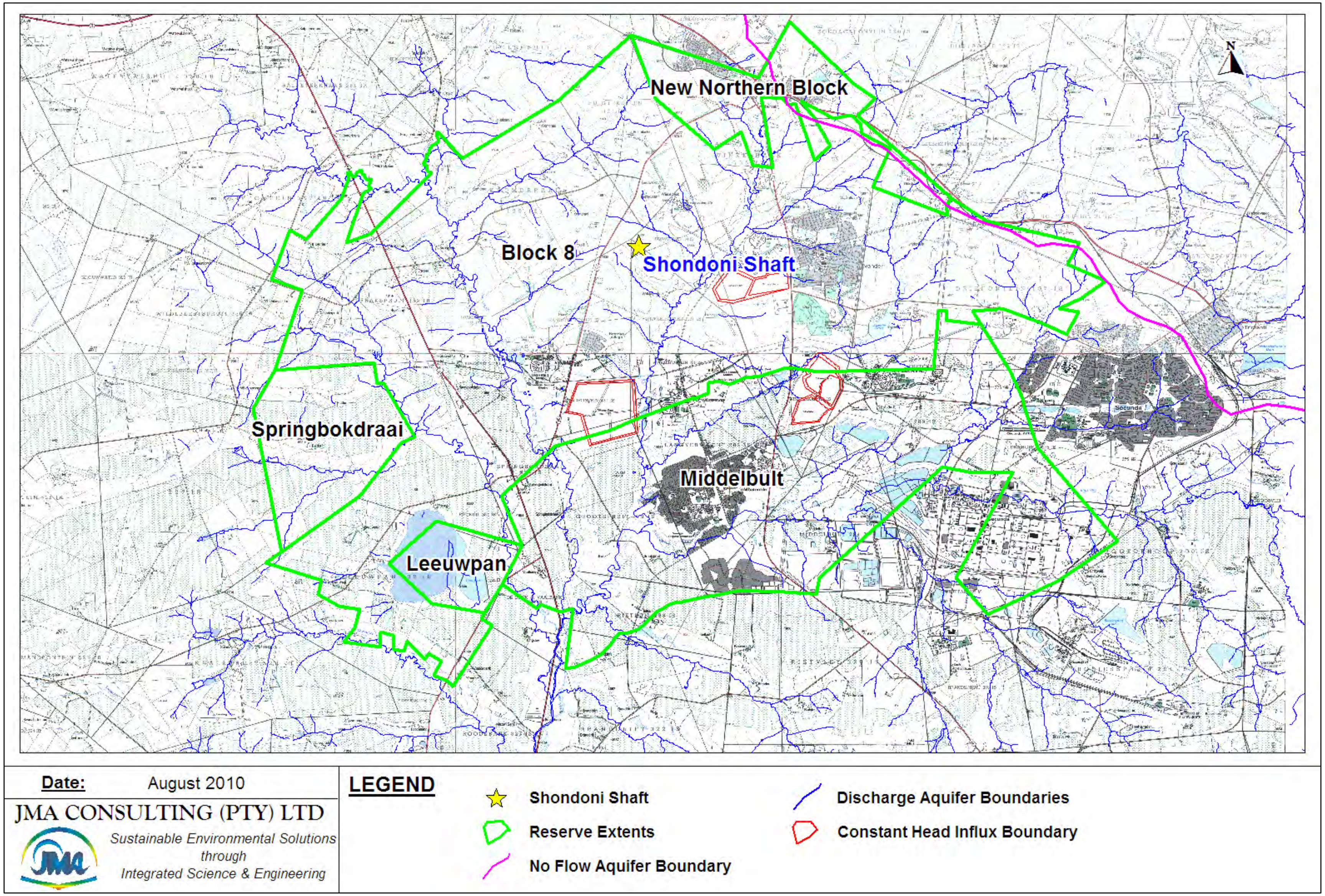

Figure 5.6.2.4(a): Natural Hydraulic Aquifer Boundaries (Including Slimes Dams)

5.6.2.5 Preferential Ground Water Flow Zones

In order to make an assessment of the ground water flow directions within the study area, the ground water level elevations in boreholes were used. Due to the nature of shallow weathered zone aquifers, the ground water contours essentially mimic those of the surface topography. It can therefore be stated that the natural regional ground water flow directions (in areas not impacted by mining), will be perpendicular to the surface topography contour lines and down towards the spruits and rivers.

The presence of the dolerite intrusions as well as the underground mining activities, do however effect the ground water flow of the area. During underground mining operations, ground water is removed from the aquifers and ultimately lowers the ground water level of the aquifer. This is known as "dewatering" and may have a significant impact on the ground water flow directions as well as the ground water flow velocities.

The degree of impact is related to the volume of ground water extracted, the extent to which as well as the depth at which the dewatering takes place. Due to the scale of the study area as well as the impacts of the underground mining activities and dewatering, detailed ground water flow directions and flow velocities will not be defined for the purpose of the ground water baseline report.

The effect that the natural geological features may have on the ground water flow zone will however be discussed. The dolerite intrusions present within the study area may act as ground water flow barriers and may in fact cause preferential ground water flow zone, or both. Fresh dolerite is impermeable and if the extent thereof is sufficiently continuous, ground water will not be able to pass through and the dolerite features may form ground water barriers. The interconnectivity of these impermeable dolerite intrusions may result in the compartmentalization of the adjacent aquifers.

It is important to note here that due to the impact of the underground mining activities, the extents and degree of the compartmentalization cannot be determined. The highly fractured zone adjacent to the dolerite intrusions and country rock (Karoo Sediments), known as the contact zone, generally has a high secondary porosity and may form a preferential ground water flow zone. The degree of fracturing as well as the interconnectivity of the fractures in this zone determines the effect that it may have as a preferential ground water flow zone.

5.6.3 Hydraulic Aquifer Description of Study Area

The hydraulic aquifer description relates to the parameters which determine the hydraulic ground water properties, such as the occurrence, availability, storage and movement of the ground water within the shallow weathered zone aquifer systems present within the study area. The hydraulic aquifer description will be based on the borehole yield information and geological logs obtained during drilling of the geohydrological boreholes, as well as from information generated during the profiling, sampling and aquifer testing conducted at the 30 monitoring boreholes. The borehole logs and site information reports as well as the EC profiles measured at the 30 monitoring boreholes are attached as APPENDIX 5.2(A) and 5.2(B) of the Ground Water Specialist Report respectively.

5.6.3.1 Borehole Yields

Four pairs of boreholes (SSW- & SDF-4, -7, -10 and -13) were sited to intersect the large east-west striking normal fault. This fault was possibly intersected in boreholes SSW-7, SDF-7 and SDF-10. Major water strikes were encountered in boreholes SSW-7 and SDF-7, both located some 800 m west of the Kinross Mines Ltd Slimes Dams. Large calcified fracture planes with pyrite mineralisation, yielding ± 22 l/s were intersected, in the overlying B4 dolerite at a depth of 17-18 m, in borehole SSW-7. Borehole SDF-7, situated some 10 m south of borehole SSW-7, recorded a water strike of ± 19 l/s, also at a depth of 17-18 m, in highly fractured B4 dolerite (no calcification observed).

A further 10 l/s were measured at a depth of 41-43 m, along a fracture in a fresh sandstone/shale succession. Boreholes SSW- & SDF-2 were sited to intersect the smaller normal fault to the south of the larger one discussed above. There was however no evidence recorded that this structure was intersect by either of the two boreholes. In conclusion it can be stated that out of the 10 boreholes geophysically sited to intersect these two faults, only three intersections (of which only two were water bearing), were recorded with some degree of confidence.

Two borehole pairs (SSW- & SDF-6 and -9) were sited to penetrate the two dykes individually intersecting both the Kinross Mines Ltd Slimes Dams and the Leslie Mines Slimes Dams. No dolerite was intersected in borehole SSW-6, whilst borehole SDF-6, sited on the dyke intersecting the Kinross Mines Ltd Slimes Dam, penetrated the dyke at a depth of 5-15 m below the surface. Although this intersection was recorded as highly weathered between 5-8 m and weathered, fractured between 8-12 m, no water strike was encountered. No dolerite was intersected in borehole SSW-9, whilst borehole SDF-9, sited to intersect the dyke indicated to cut across the Leslie Mines Slimes Dam, some 420 m east of the dam, penetrated a B12 dolerite sill at a depth of 41-42 m below the surface. No water strike was encountered along this intersection.

One borehole pair (SSW- & SDF-3) was sited to intersect the 7 m thick sub-vertical rising B8 dolerite sill that compartmentalizes or separate most of the Block 8 reserve from the Middelbult reserve. Borehole SSW-3 intersected the B8 dolerite at depths of 1-7 m and 8-17 m below the surface. A water strike of ± 0.10 l/s was recorded between 15-16 m.

Borehole SDF-3 intersected B8 dolerite at a depth of 1-13 m below the surface. A water strike of ± 0.30 l/s was recorded between 8-9 m. Another water strike of ± 2.40 l/s was recorded between 17-20 m, along a slightly weathered, fractured shale intersection, probably attributable to this dolerite intrusion.

Twenty-three dolerite intersections were recorded in twenty of the thirty newly drilled geohydrological boreholes. Thirteen water strikes, associated with host rock contacts as well as the contact between weathered and fresh dolerite, were recorded along these intersections. Three of these water strikes were recorded below the limit of weathering.

Six water strikes, ranging in depth between 6 m and 18 m were recorded in five of the fifteen newly drilled shallow weathered zone (SSW-Group) boreholes. Their estimated yields ranged between 0.1 l/s and 23 l/s, averaging at 4.25 l/s. Discarding the outlier associated with borehole SSW-7, the average estimated yield calculates to 0.70 l/s.

Only one water strike with an estimated yield of 0.40 l/s was recorded at a depth of 27-28 m, some 13 m below the limit of weathering in borehole SSW-8. Eight water strikes were recorded at depth below the limit of weathering in seven of the fifteen newly drilled deep Karoo aquifer (SDF-Group) boreholes. The water strikes ranged in depth between 27 m and 80 m and their estimated yields ranged between 0.10 l/s and 10 l/s, averaging at 1.51 l/s. Discarding the outlier associated with borehole SDF-7 and including the water strike recorded below the limit of weathering in borehole SSW-8, the average estimated yield calculates to 0.31 l/s.

Eight water strikes were recorded within the limit of weathering in five of the deep boreholes. They ranged in depth between 5 m and 33 m and their yields ranged between 0.1 l/s and 19 l/s, averaging at 4.1 l/s. Discarding the outlier associated with borehole SSW-7, the average estimated yield calculates to 1.99 l/s.

Analyses of the water strike information indicates that 81 % of the water strikes occurred at depths between 11 m and 33 m, while their reported yields ranged between 0.16 l/s and 6.11 l/s, averaging at 1.33 l/s. 19% of the strikes ranged in depth between 40 m and 80 m, while their reported yields ranged roughly between 0.25 l/s and 1.66 l/s, averaging at 0.93 l/s.

The 96 reported yields for the external user's boreholes ranged between 0.01 l/s and 8.3 l/s, averaging at 1.27 l/s. Statistical analyses of all water yielding borehole data - considered to represent the shallow weathered zone aquifer - calculates to an average yield of roughly 1.36 l/s. Analyses of all the water yielding borehole data considered representing the deep Karoo aquifer calculates to an average yield of roughly 0.62 l/s.

5.6.3.2 Aquifer Permeability and Transmissivity

The hydraulic conductivity or permeability (k) of an aquifer is a measure of the ease with which ground water can pass through the aquifer system. The permeability is defined as the volume of water discharged from a unit area of an aquifer under a unit hydraulic gradient per unit time (expressed as m/day).

The permeability of the aquifer was determined by analyzing the rate of change in the water level of the shallow weathered zone aquifer during a permeability (slug) test.

Slug tests were performed in 13 of the shallow boreholes (SSW-Group) and 14 of the deep boreholes (SDF-Group), ranging in depth between 80 - 150 m, to determine the hydraulic conductivity distribution within the saturated Karoo aquifers.

The aquifer permeability distribution across the study area is depicted in Figure 5.6.3.2(a). A statistical summary of the permeability's for the Shallow Weathered Zone Aquifers and Deep Karoo Aquifers are listed in Tables 5.6.3.2(a) and 5.6.3.2(b) respectively.

Table 5.6.3.2(a): Shallow Weathered Zone Aquifers Permeability

Description of Statistical Analyses	Hydraulic Conductivity (m/day)
Minimum Value	0.0003 m/day
Maximum Value	6.250 m/day (fault zone)
Arithmetic Mean	0.060 m/day
Geometric Mean	0.018 m/day
Harmonic Mean	0.003 m/day
Chosen for Shallow Weathered Zone Aquifer	**0.015 m/day**

Table 5.6.3.2(b): Deep Karoo Aquifers Permeability

Description of Statistical Analyses	Hydraulic Conductivity (m/day)
Minimum Value	0.001 m/day
Maximum Value	5.819 m/day (fault zone)
Arithmetic Mean	0.023 m/day
Geometric Mean	0.007 m/day
Harmonic Mean	0.002 m/day
Chosen for Deep Karoo Aquifer	**0.004 m/day**

Table 5.6.3.2(a) indicates that the calculated permeability values for the Shallow Weathered Zone Aquifers varied substantially between 0.0003 m/day and 6.250 m/day. Table 5.6.3.2(b) indicates that the calculated permeability values for the Deep Karoo Aquifers varied between 0.001 m/day and 5.819 m/day. The permeabilities assigned to the two aquifer systems were 0.015 m/day and 0.004 m/day for the Shallow Weathered Zone Aquifers and the Deep Karoo Aquifers respectively.

Additionally, statistical analyses of packer tests, conducted at different depths in 3 of the deep boreholes indicated the following:

- A mean hydraulic conductivity of 0.0043 m/day was calculated for fresh sandstone/siltstone intervals.
- A hydraulic conductivity of 0.0156 m/day was calculated for the 4 m fresh to slightly jointed B4 dolerite test section (30-34 m) in borehole SDF-11.

- A hydraulic conductivity of 0.573 m/day was calculated for the 4 m (fine grained sandstone) test section (60-64 m) across a water intersection roughly yielding 0.90 l/s in borehole SDF-14.

Hydraulic conductivities calculated from falling head tests, conducted in 2 of the deep boreholes (SDF-Group) compared well with the values obtained from the slug tests performed in the same holes. Statistical assessment of hydraulic conductivities in South African hard rock aquifers, indicate the actual k-values to lie somewhere between the geometric and harmonic mean. A k-value of 0.015 m/day is therefore proposed as realistic value for the shallow weathered zone aquifers within the study area, while a value of 0.004 m/day, is proposed for the deep Karoo aquifers.

5.6.3.3 Aquifer Storativity

The storativity (S) of an aquifer is defined as the volume of water that an aquifer releases from, or takes into storage, per unit surface area of the aquifer per unit change in hydraulic head.

The storativity of the Karoo Aquifers within the study area was obtained from literature and is taken to be approximately 0.0001. The saturated interstice types or storage medium of the aquifer are the interstices and fractures present below the ground water level, as a result of weathering and the weathering related fractures of the host rock and dolerite intrusions.

5.6.3.4 Aquifer Porosity

The porosity of an aquifer is the ratio of the void space to the total volume of the aquifer. The porosity gives is an indication of the amount of water in the subsurface, but does not represent the volume that can be released from or taken into storage. The ratio between the volume of water that can be drained from the aquifer and the total volume of the aquifer is referred to as the effective porosity.

A total of 20 samples of the main sandstone units of the study area, were submitted to MATROLAB Civil Engineering Services for porosity testing. The saturation and buoyancy method - according to the SABS 0259 protocol (1990). The results obtained from the laboratory are summarized in Table 5.6.3.4(a).

Table 5.6.3.4(a): Summary of the Aquifer Porosity within the Study Area

Lithological Unit	Minimum	Maximum	Average
Fine Grained Sandstone	0.3%	9.9%	**4.1%**
Medium to Coarse Grained Sandstone	7.7%	14.4%	**10.1%**
Total Aquifer Average	0.3%	14.4%	**5.8%**

The large range in calculated porosity between the fine and medium grained sandstone is a function of the degree of pore-cementation and on the extent (depth) of weathering as well. The difference in porosity between the different grain-size sandstones is evident in Table 5.6.3.4(a). Based on the data obtained from MATROLAB, an average effective porosity for the shallow weathered zone is taken as 3.6 %, whilst the average effective porosity for the deep Karoo aquifer zone is taken as 0.58 %.

5.6.4 Aquifer Dynamics of Study Area

5.6.4.1 Rainfall Recharge

The mean annual precipitation (MAP) across the study area as recorded from the Bethal Monitoring Station is 711 mm per annum. The recharge to the shallow weathered zone aquifers within the study area will occur primarily through infiltration of the rain water and surface water bodies. The natural recharge to the Karoo aquifers within the study area has been influenced to varying degrees as a result of the underground mining activities. The recharge values obtained from the "SASOL MINE WATER MANAGEMENT TOOL" will be used and are summarized in Table 5.6.4.1(a) below.

Table 5.6.4.1(a): Recharge values obtained from the "Sasol Mine Water Management Tool"

Type of Mining	Thick Soils		Alluvium		Rocky Outcrops & Shallow Soils	
	Range	Ave	Range	Ave	Range	Ave
Board & Pillar Mining (Mining > 80 m deep)	1-2 %	1.5 %	1.5-3 %	2.0 %	2.5-3.5 %	3.0 %
Board & Pillar Mining (Mining < 80 m deep)	1-3 %	2.0 %	2-4 %	3.0 %	4-6 %	5.0 %
Board & Pillar Mining (Along major faults & dykes)	1-3 %	2.5 %	2-4 %	3.5 %	4-6 %	5.0 %
High Extraction Mining (free draining)	2-3.5 %	3.0 %	5-12 %	9.0 %	7-15 %	12 %
High Extraction Mining (non-free draining)	7-12 %	10 %	10-20 %	15 %	15-25 %	20 %

The thick soils represent areas with low recharge values, the alluvium represents areas with medium recharge values and the rocky outcrops and shallow soils represent surface areas with high recharge potentials. Table 5.6.4.1(a) indicates that the different underground mining methods influence the recharge of surface water to the ground water to varying degrees as well. It is evident from Table 5.6.4.1(a) that areas where High Extraction Mining will take place will ultimately result in higher recharge figures than in areas that will be mined by Bord and Pillar methods.

5.6.4.2 Ground Water Level Depths and Fluctuations

Ground water levels were recorded at 151 boreholes within the study area. A map, depicting the depth to water table distribution for the study area, is included at as Figure 5.6.4.2(a). The ground water level data is attached as APPENDIX 5.4(A) of the Ground Water Specialist Report. The ground water level depths have not altered significantly over the past ten years, except for the areas that have been directly affected by aquifer dewatering associated with the underground mining activities.

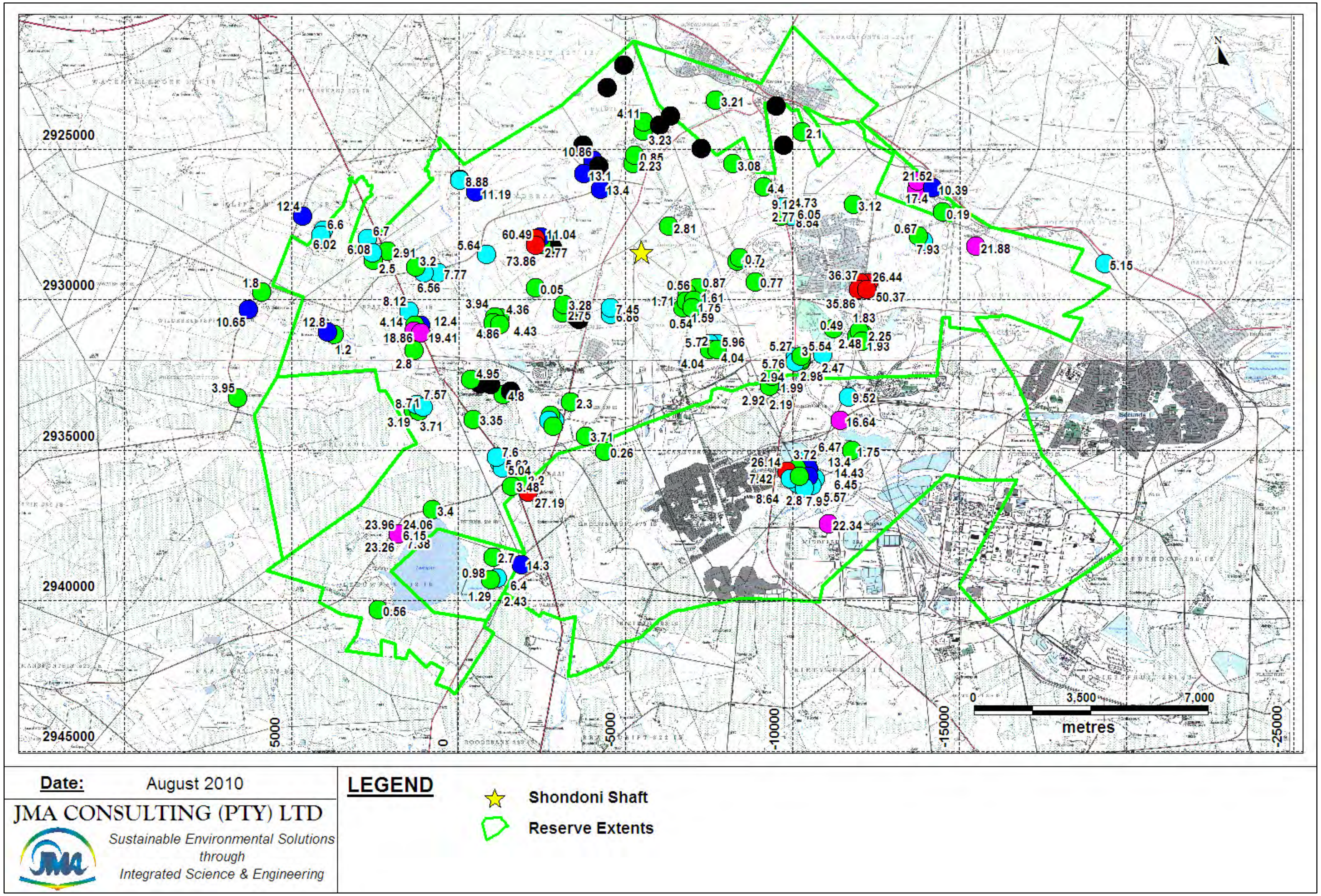

Figure 5.6.4.2(a): Ground Water Level Depth Distribution

The following observations are important regarding the depth to ground water tables:

- The depth to ground water level observed, varied between 0.05 m and 73.86 m, with a mean of 8.04 m.
- The depth to water level observed in the shallow weathered zone (SSW-) boreholes, varied between 0.27 m and 26.44 m, with a mean of 6.49 m.
- The depth to water level observed in the deep Karoo aquifer (SDF-) boreholes, varied between 0.24 m and 73.86 m, with a mean of 14.56 m
- The depth to water level observed in 74 external user's boreholes ranged between 0.05 m and 27.19 m, with an average depth of 6.23 m.
- The areas in which the water levels have been affected by dewatering are related to the panels of high extraction of underground mining activities.
- Figure 5.4.2(a) indicates that the water levels are in fact erratic across the study area and no distinct linear trend is observed. There is also no definite step in the observed depth to water table on either side of the major fault zones.
- Due to the nature of shallow weathered zone aquifers, the ground water contours essentially mimic those of the surface topography. It can therefore be stated that the natural regional ground water flow directions (in areas not impacted by mining), will be perpendicular to the surface topography contour lines and down towards the spruits and rivers.

5.6.5 Aquifer Hydrochemistry of Study Area

A total of 114 water samples were collected throughout the extent of the study area, which included 109 ground water samples. The aquifer hydrochemistry will be discussed with reference to the 104 ground water samples that were sampled from the various boreholes and wells. The locations of the ground water sampling points are indicated on Figure 5.6.5(a), whilst the geochemistry data is attached as APPENDIX 5.5(A) of the Ground Water Specialist Report.

5.6.5.1 Background Ground Water Quality

The assessment of the background ground water quality was based on data obtained from the water samples collected from the newly drilled geohydrological monitoring boreholes, as well as from the external users' boreholes. The ground water samples were analyzed for the following parameters: pH, EC, TDS, Ca, Mg, Na, K, Si, F, Total Alkalinity, Cl, SO_4, NO_3, Al, Fe and Mn. The concentrations of each of the elements in the ground water were then classified for compliance according to the SANS 241:2006 Drinking Water Standard (Table 5.6.5.1(a).

Table 5.6.5.1(a): Ground Water Quality Compliance (SANS 241:2006)

BH No.	pH	EC	TDS	Ca	Mg	Na	K	Cl	SO_4	NO_3	F	Al	Fe	Mn
GSS-1	7.44	61	367	47	27	51.5	7.5	40	86	6.26	0.41	0.04	0.10	0.01
GSS-2	7.50	60	338	40	23	65.6	5.1	70	42	0.26	0.43	0.06	0.12	0.01
GST-1	7.30	61	342	48	16	53.3	34.7	21	31	7.71	0.26	0.03	0.10	0.02
GWE-1	7.70	24	138	21	11	14.0	3.2	13	15	0.50	0.20	0.10	0.03	0.03
GWE-101	7.30	118	724	108	29	95.0	8.8	177	25	0.20	0.60	1.38	2.67	0.18
GWE-105	7.60	63	388	44	24	60.0	13.7	13	16	2.60	0.20	0.10	1.42	0.03
GWE-112	7.40	54	338	24	11	87.0	1.7	30	7	0.50	0.20	0.10	0.14	0.03
GWE-115	7.50	76	472	62	26	68.0	4.0	40	14	2.60	0.20	0.10	0.03	0.03
GWE-124	7.50	58	368	74	13	28.0	8.8	9	21	6.50	0.20	0.10	0.17	0.03
GWE-130	7.70	97	598	69	28	102.0	2.8	91	76	0.80	0.20	0.10	0.03	0.03
GWE-14	8.40	93	598	26	19	169.0	1.0	55	30	0.30	0.80	0.10	0.06	0.07
GWE-143	7.60	94	642	83	44	53.0	6.5	46	9	12.00	0.50	0.10	0.03	0.03
GWE-145	8.00	74	504	98	22	13.0	10.6	68	14	13.00	0.20	0.10	0.11	0.03
GWE-15	7.60	80	532	70	42	33.0	14.4	27	52	5.70	0.30	0.10	0.05	0.03
GWE-150	7.00	187	1300	204	108	65.0	8.7	265	147	31.00	0.40	0.10	0.03	0.03
GWE-159	7.70	49	306	28	10	73.0	1.9	22	5	0.80	0.50	0.10	0.22	0.14
GWE-168	7.80	65	400	60	25	47.0	4.9	39	46	1.10	0.20	0.10	0.03	0.05
GWE-17	8.50	73	512	30	30	51.0	44.0	40	75	5.60	0.40	0.10	0.03	0.03
GWE-19	7.60	76	496	47	22	97.0	2.3	24	27	0.40	0.60	0.10	0.03	0.03
GWE-22	8.00	93	584	19	6	173.0	2.0	99	26	0.50	3.20	0.10	0.03	0.03
GWE-25	7.60	84	580	82	49	30.0	1.1	12	114	8.00	0.30	0.10	0.25	0.03
GWE-31	7.70	78	514	28	14	141.0	2.2	15	13	0.70	0.30	0.16	0.57	0.04
GWE-48	8.00	77	500	58	36	44.0	27.0	16	5	0.40	0.50	0.44	6.79	0.06
GWE-54	8.20	56	334	21	38	37.0	4.9	36	5	0.20	0.20	0.10	1.96	0.03
GWE-56	7.60	89	504	69	44	55.0	2.7	55	5	2.40	0.30	0.10	0.03	0.03
GWE-6	7.70	89	604	80	43	53.0	5.1	37	81	1.80	0.40	0.10	0.30	0.03
GWE-7	7.50	113	734	96	67	69.0	1.0	30	107	2.80	0.50	0.10	0.19	0.03
GWE-70	7.80	133	868	62	62	122.0	3.4	233	43	1.80	0.40	0.21	0.61	0.03
GWE-73	7.40	176	1344	132	86	93.0	3.4	328	68	1.40	0.80	0.16	0.45	0.17
GWE-77	7.50	251	1760	95	108	290.0	2.7	576	110	0.60	1.30	7.71	15.00	0.52
GWE-78	7.40	98	608	48	30	129.0	2.0	64	5	0.20	0.60	0.61	1.48	0.12
GWE-79	7.30	77	486	72	36	52.0	1.0	18	6	3.30	0.40	0.23	0.40	0.03
GWE-85	7.20	304	2688	263	161	136.0	11.2	705	229	0.20	0.90	29.00	83.00	1.36
GWE-88	7.50	352	1982	16	5	702.0	3.4	913	242	0.20	0.40	0.30	0.49	0.08
GWE-9	7.30	125	884	124	77	50.0	1.1	57	139	10.00	0.30	0.75	3.01	0.07
GWE-90	7.10	1517	10650	543	979	935.0	9.8	2991	2717	0.20	0.20	0.14	14.00	5.63
GWE-92	7.30	127	1026	132	47	53.0	11.5	238	54	1.30	0.60	0.42	0.76	0.03
GWE-93	6.90	306	2528	273	165	65.0	10.3	870	77	0.80	0.20	0.10	0.50	0.03
GWE-95	6.90	334	2930	252	147	184.0	5.3	903	129	0.20	0.80	0.42	4.88	0.28
GWE-98	8.10	61	372	56	22	45.0	4.8	27	46	0.20	0.40	0.10	0.03	0.03
GWE-99	7.80	52	344	60	18	29.0	7.8	14	18	2.30	0.30	0.10	0.03	0.03

BH No.	pH	EC	TDS	Ca	Mg	Na	K	Cl	SO_4	NO_3	F	Al	Fe	Mn
HP-7-1 D	7.78	394	2720	140	89	708.0	8.3	1000	590	2.70	0.50	0.03	0.10	0.01
HP-7-2 D	7.76	227	1329	153	139	109.0	1.9	466	266	4.93	0.41	0.03	0.10	0.01
HP-7-2 S	7.60	81	502	85	59	24.3	0.7	21	109	5.12	0.51	0.03	0.10	0.01
KB-12	7.38	633	3241	248	271	607.0	0.7	1483	251	2.26	0.48	0.02	0.12	0.02
KB-13	7.75	133	747	61	33	176.0	4.3	207	38	0.31	0.65	0.03	0.16	0.02
KB-15	6.90	68	361	48	27	50.9	4.7	72	46	0.88	0.33	0.03	0.17	0.01
KB-16	7.70	76	425	33	29	97.6	2.2	25	18	0.63	0.64	0.02	0.12	0.01
KB-5	7.43	395	2105	259	227	195.0	5.2	1013	263	0.79	0.23	0.02	0.11	0.01
KB-7	7.32	404	2176	226	138	375.0	2.7	1053	170	0.96	0.44	0.02	0.12	0.20
KD-1	7.57	93	604	102	64	38.2	1.7	41	94	14.00	0.22	0.03	0.10	0.01
KD-2	7.17	120	697	61	25	156.0	7.0	35	134	4.26	0.51	0.03	0.15	0.08
KD-F1	7.54	72	406	52	40	61.8	0.9	19	24	0.36	0.30	0.06	0.11	0.01
KSS-1	7.38	68	425	53	31	58.8	7.0	38	114	6.15	0.52	0.04	0.11	0.01
LB-2	7.34	169	904	184	57	81.4	18.3	376	72	1.27	0.08	0.03	0.10	0.01
LB-3	7.24	407	2135	365	205	90.6	14.0	1210	139	0.93	0.07	0.01	0.11	0.02
LM-9	7.20	25	141	18	13	17.5	4.6	9	21	0.29	0.21	0.38	0.42	0.05
LPB-4	7.64	50	276	55	18	30.9	9.2	13	21	1.29	0.16	0.03	0.10	0.01
LPB-5	7.18	683	4536	853	212	411.0	15.1	2664	198	0.29	0.35	0.02	0.10	0.17
LPB-6	7.54	141	784	154	42	89.2	12.1	279	24	4.31	0.49	0.03	0.10	0.04
LSS-1	7.35	53	314	40	23	45.8	7.3	41	53	5.24	0.33	0.07	0.13	0.01
LSS-2	7.05	64	393	49	26	58.7	9.8	49	58	13.00	0.33	0.04	0.10	0.01
REGM-120	7.65	84	474	62	60	28.3	1.4	38	82	2.41	0.55	0.02	0.12	0.01
REGM-122	7.64	841	5167	668	496	504.0	7.1	2037	1368	4.65	0.56	0.01	0.14	0.02
REGM-133	8.00	64	380	4	1	150.0	1.9	47	18	2.05	0.60	0.03	0.12	0.01
REGM-190	7.80	189	1108	74	143	146.0	0.6	177	162	0.32	5.50	0.02	0.46	0.22
REGM-194	7.58	89	513	36	54	87.9	1.8	9	32	1.38	0.73	0.02	0.12	0.37
REGM-197	5.73	1576	10797	1770	1100	767.0	2.9	5474	1654	0.01	0.11	0.03	0.26	1.34
RKL-7	8.35	87	530	86	44	64.5	0.9	72	62	3.47	0.26	0.03	0.10	0.02
RKL-8	7.40	48	268	40	13	52.9	5.1	17	1	0.21	0.08	0.03	0.74	0.03
SDF-1	7.50	77	468	44	22	84.0	2.4	40	17	0.20	0.30	1.68	18.00	0.12
SDF-10	7.80	64	404	43	24	58.0	2.7	11	33	0.20	0.20	2.68	27.00	0.27
SDF-11	8.20	234	1348	3	2	563.0	1.9	347	12	0.20	4.60	2.14	6.17	0.06
SDF-12	7.70	68	432	44	29	71.0	5.4	18	17	0.20	0.40	0.58	17.00	0.15
SDF-13	8.00	110	662	32	20	209.0	5.8	18	78	0.20	0.60	0.90	9.49	0.12
SDF-14	8.20	69	422	6	2	159.0	3.3	16	5	0.20	0.50	0.54	0.97	0.03
SDF-15	9.80	76	418	2	2	168.0	4.1	27	20	1.00	0.60	0.83	5.31	0.05
SDF-2	7.60	73	448	50	48	34.0	1.0	8	15	0.20	0.50	1.06	11.00	0.05
SDF-3	7.80	158	916	32	20	262.0	3.9	228	74	0.20	1.20	1.62	9.58	0.27
SDF-4	9.90	167	1156	2	2	380.0	5.2	120	33	1.10	12.00	7.96	7.38	0.06
SDF-5	8.10	68	406	20	10	113.0	2.4	56	5	0.20	1.40	1.23	2.85	0.05
SDF-6	8.00	85	516	22	10	147.0	2.8	53	17	0.20	0.30	3.93	11.00	0.09
SDF-7	7.70	73	460	37	27	81.0	1.9	16	5	0.20	1.00	0.56	4.94	0.07
SDF-8	7.80	277	1568	47	16	469.0	5.1	665	136	0.20	0.30	0.19	4.96	0.06
SDF-9	7.60	61	394	22	10	95.0	3.2	45	14	0.20	0.30	0.99	14.00	0.13
SSW 4	8.60	300	2162	13	7	659.0	0.0	104	1035	0.00	0.00	0.00	0.00	0.00
SSW-1	8.50	55	364	21	10	85.0	3.4	30	5	0.20	0.90	3.74	5.67	0.32
SSW-10	7.80	68	466	36	22	87.0	3.2	11	10	0.20	0.40	3.32	8.05	0.14
SSW-11	7.90	117	716	38	20	187.0	11.7	152	86	0.20	0.20	0.63	0.75	0.10
SSW-12	7.50	74	592	47	29	78.0	5.6	18	18	0.20	0.30	0.58	1.18	0.03
SSW-13	7.70	115	868	88	65	83.0	14.1	9	72	2.80	0.70	0.24	2.17	0.23
SSW-14	7.60	77	548	51	42	64.0	3.3	13	74	0.20	0.40	0.24	6.35	0.03
SSW-15	7.90	88	596	16	10	187.0	7.3	20	14	1.00	0.60	0.36	4.40	0.03
SSW-2	7.88	92	542	53	58	94.3	1.3	14	34	0.24	0.50	0.05	0.32	0.14
SSW-3	7.80	257	1776	141	112	207.0	6.1	444	200	0.20	0.50	2.28	5.53	0.27
SSW-5	8.00	85	508	16	8	170.0	2.6	80	5	0.20	1.30	2.55	10.00	0.10
SSW-6	8.10	79	492	30	16	121.0	3.9	45	19	0.20	0.40	0.64	4.18	0.06
SSW-7	8.00	73	462	35	28	83.0	2.4	16	5	0.20	1.10	0.25	2.03	0.03
SSW-8	7.70	313	1934	79	42	491.0	7.3	723	150	0.20	0.20	0.36	0.67	0.03
SSW-9	8.00	63	396	24	12	96.0	4.2	41	9	0.20	0.40	0.33	2.87	0.04
UTK-1	7.83	117	676	98	67	68.5	5.4	136	84	2.58	0.25	0.04	0.10	0.01
WB-4	7.68	352	2199	36	2	864.0	3.3	1015	208	0.50	0.17	0.05	0.10	0.01
WB-5	7.68	187	1289	68	57	313.0	8.8	305	393	0.20	0.20	0.04	0.10	0.01
WB-6	7.28	237	1648	154	126	233.0	7.7	503	560	0.26	0.48	0.03	0.11	0.01
WKH-10	7.63	79	456	73	47	38.4	19.0	23	58	4.05	0.20	0.04	0.10	0.01
WVR-1	7.22	26	156	19	13	19.2	4.4	10	34	0.32	0.22	0.69	0.80	0.02
ZFT-1	7.49	45	243	36	21	14.9	11.1	28	47	8.18	0.02	0.02	0.12	0.02

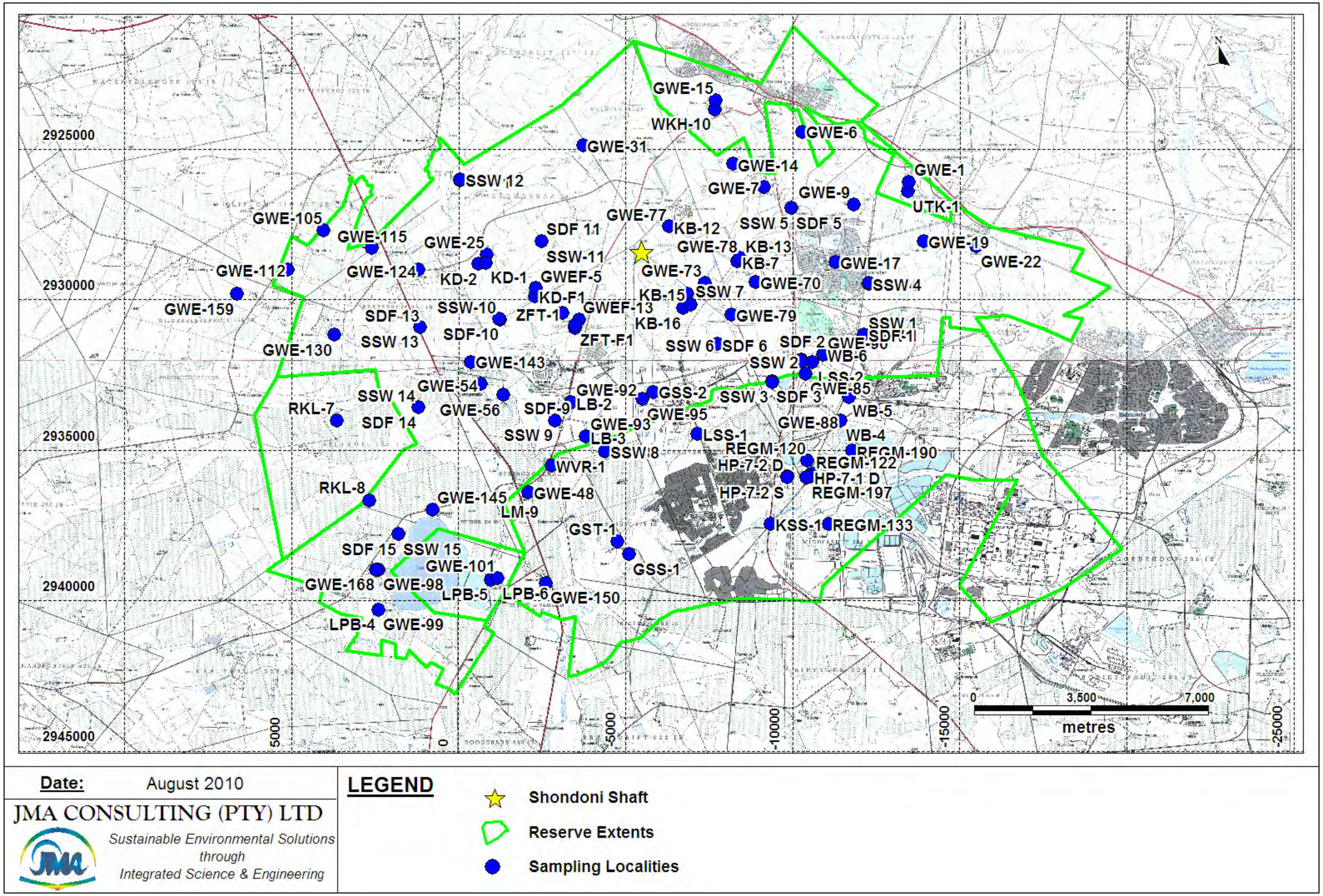

Figure 5.6.5.1(a): Ground Water Sampling Localities

The SANS Standard specifies two compliance classes namely Class I (Recommended) and Class II (Maximum Allowable). The colour coding for ground water quality used throughout this report interprets compliance with Class I as Full Compliance (green) and compliance with Class II as Marginal Compliance (orange). Exceedance of the Class II standard is interpreted as Non-Compliance (red).

The ground water geochemistry listed in Table 5.6.5.1(a) was determined from the ground water samples collected across the entire extent of the study area (Figure 5.6.5.1(a)). Due to the nature of the environment adjacent to several of the boreholes, the geochemistry of several boreholes was not used as the ground water quality at these boreholes had been affected by anthropogenic activities and do therefore not represent the background ground water quality.

Hydro-chemical imaging was used as a first screening tool , to eliminate boreholes, possibly influenced by any pollution source. This also meant that boreholes close to pollution sources (surface and sub-surface) were carefully scrutinised and discarded from this study group, if deemed necessary. After a statistical evaluation of Electrical Conductivity (EC) values, all boreholes with EC values in excess of 100 mS/m were discarded. Ground water samples are affected by mining-related pollution have lower pH values, and ground water samples that were classified as having non-compliant or marginally compliant pH values were therefore discarded as well.

Elevated SO_4 and Fe concentrations are also indicators of possible mining-related contamination of the ground water. It should however be noted that the due to the nature of aquifer and associated host geology (naturally occurring Fe in the Karoo aquifers, as well as the weathering of dolerite dykes and sills), Fe is in fact naturally elevated in the ground water systems within the study area as well.

Because of this, only SO_4 was used as a further screening tool, discarding all boreholes with SO_4 values exceeding 20 mg/l. Indicators, including NO_3 and Cl, were used to assess possible agricultural related influences, on external users' boreholes and springs. Some influences from agricultural activities were found, in the form of elevated NO_3 levels.

The remainder of the samples (33) where then screened to determine whether any individual outliers occurred for each of the individual parameters. Where the natural background value of any constituent was present at a natural elevated value (like F, Mn, Al and Fe), it was included in the background chemistry group.

Through this screening process of elimination, a distinctive background image emerged, both in terms of hydro-chemical image, as well as water quality ranges, for the different water quality variables. A summary of the background ground water quality is listed in Table 5.6.5.1(b).

Table 5.6.5.1(b): Background Ground Water Quality Summary

Element / Parameter	Min Value	Mean Value	Max Value	Range
pH	7.30	7.78	8.50	1.20
EC (mS/m)	24	69	98	74
TDS (mg/l)	138	433	608	470
Ca (mg/l)	4.3	34.9	72.0	67.7
Mg (mg/l)	1.3	20.5	48.0	46.7
Na (mg/l)	14	90	187	173
K (mg/l)	1	4	27	26
Cl (mg/l)	8	3	80	72
SO_4 (mg/l)	1.47	10.69	19.00	17.53
NO_3 (mg/l)	0.20	0.75	3.30	3.10
F (mg/l)	0.08	0.49	1.40	1.32
Al (mg/l)	0.02	0.80	3.93	3.91
Fe (mg/l)	0.03	4.26	18.00	17.98
Mn (mg/l)	0.01	0.06	0.32	0.31

Table 5.6.5.1(b) indicates that the average background ground water quality has fully compliant concentrations for the elements pH, E, TDS, Ca, Mg, Na, K, Cl, SO_4, NO_3, F and Mn, whilst the average Al and Fe concentrations have non compliant qualities. The majority of the samples had fully compliant concentrations for each element analyzed for. Al and Fe had the most elevated concentrations in the background ground water samples, followed by NO_3 and Mn.

Hydrochemical imaging was performed for the samples that were used to determine the background ground water quality and composition within the study area. Piper and Durov diagrams were compiled using the macro chemistry variables pH, EC, Ca, Mg, Na, K, Total Alkalinity, Cl, SO_4 and NO_3. The resulting Piper and Durov Diagrams depicting the background ground water hydrochemical image are shown in Figure 5.6.5.1(a) and Figure 5.6.5.1(b) respectively.

The Piper and Durov Diagrams indicate that the ground water is classified as having a Type B and Type C hydrochemical facies. The dominant cation is variable, with most samples being dominant in Na + K. Interesting to note is that the ratio between the equivalent Ca and Mg concentrations remains constant for most of the background ground water samples collected. The dominant anion is clearly bicarbonate (T.Alk). Several of the background ground water samples had elevated NO_3 concentrations (not seen on the Piper or Durov Diagrams), indicating sporadic influences as a result of agricultural activities within the study area. Fe and Al values have elevated concentrations as well, which predominantly result from the influence of the adjacent host rocks.

The pH of the background ground water is slightly alkaline and ranges between 7.3 and 8.5 with an average pH of 7.78. The EC of the background ground water samples ranges between 24 mS/m and 98 mS/m, with an average EC value of 69 mS/m. The majority of the background ground water samples have EC values greater than 70 mS/m.

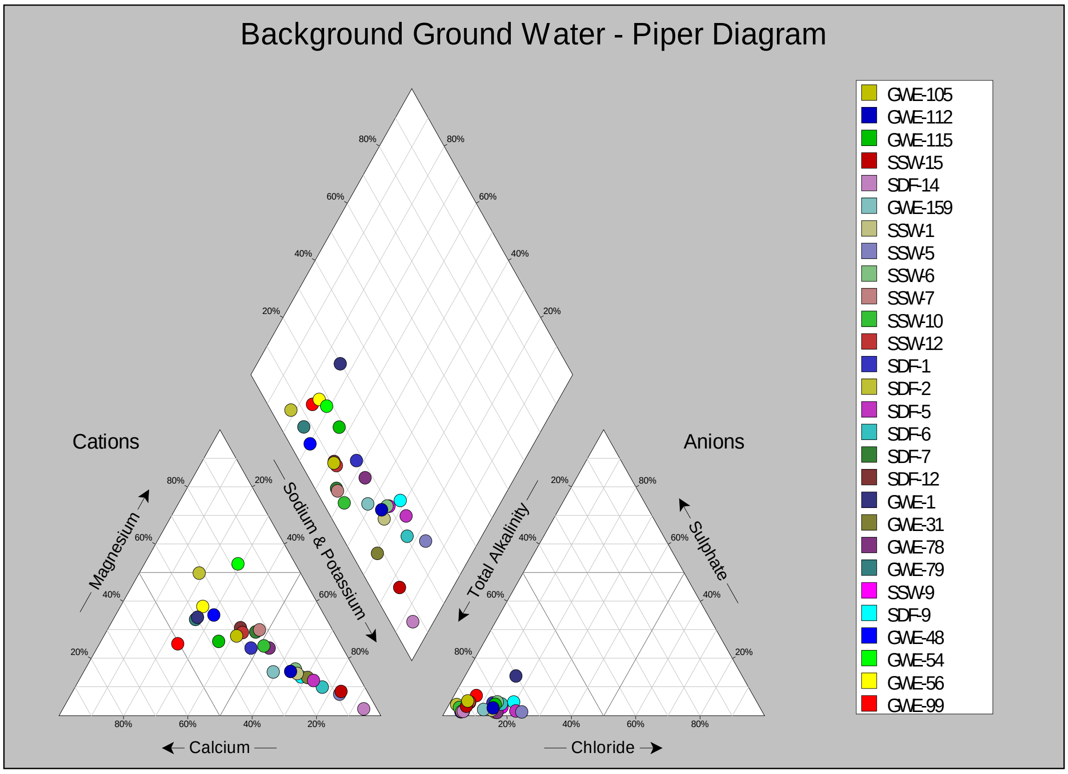

Figure 5.6.5.1(a): Background Ground Water Piper Diagram

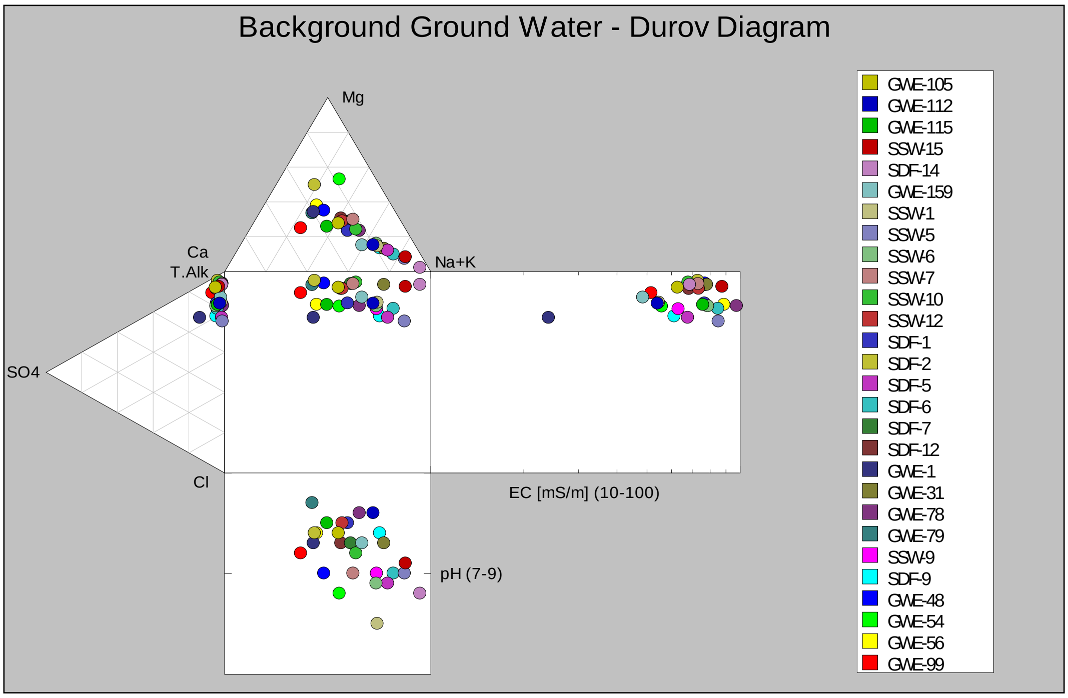

Figure 5.6.5.1(b): Background Ground Water Durov Diagram

The background ground water quality, including the possible influences from the agricultural activities, remains of a very good quality and plots as "recent and unpolluted" ground water. This further supports the statement that water in the area emanating from springs and external user's boreholes are probably not from deep circulation, but rather from the saturation of the shallow weathered zone and/or perched aquifers. Any mining related impacts on the ground water are expected to result in a decrease in the pH, as well as an increase in the TDS and SO_4 concentrations.

5.6.5.2 Current Site Specific Ground Water Quality

The assessment of the status of the ground water quality within the study area is based on the water quality data generated from samples taken at the 30 monitoring boreholes. The quality of the ground water sampled at the monitoring boreholes was assessed according to the SANS 241:2006 Drinking Water Standard and is depicted in Table 5.6.5.2(a).

Table 5.6.5.2(a): Monitoring Borehole Compliance – SANS 241:2006

BH No.	pH	EC	TDS	Ca	Mg	Na	K	Cl	SO4	NO3	F	Al	Fe	Mn
SSW-1	8.50	55	364	21	10	85.0	3.4	30	5	0.20	0.90	3.74	5.67	0.32
SSW-2	7.88	92	542	53	58	94.3	1.3	14	34	0.24	0.50	0.05	0.32	0.14
SSW-3	7.80	257	1776	141	112	207.0	6.1	444	200	0.20	0.50	2.28	5.53	0.27
SSW 4	8.60	300	2162	13	7	659.0	0.0	104	1035	0.00	0.00	0.00	0.00	0.00
SSW-5	8.00	85	508	16	8	170.0	2.6	80	5	0.20	1.30	2.55	10.00	0.10
SSW-6	8.10	79	492	30	16	121.0	3.9	45	19	0.20	0.40	0.64	4.18	0.06
SSW-7	8.00	73	462	35	28	83.0	2.4	16	5	0.20	1.10	0.25	2.03	0.03
SSW-8	7.70	313	1934	79	42	491.0	7.3	723	150	0.20	0.20	0.36	0.67	0.03
SSW-9	8.00	63	396	24	12	96.0	4.2	41	9	0.20	0.40	0.33	2.87	0.04
SSW-10	7.80	68	466	36	22	87.0	3.2	11	10	0.20	0.40	3.32	8.05	0.14
SSW-11	7.90	117	716	38	20	187.0	11.7	152	86	0.20	0.20	0.63	0.75	0.10
SSW-12	7.50	74	592	47	29	78.0	5.6	18	18	0.20	0.30	0.58	1.18	0.03
SSW-13	7.70	115	868	88	65	83.0	14.1	9	72	2.80	0.70	0.24	2.17	0.23
SSW-14	7.60	77	548	51	42	64.0	3.3	13	74	0.20	0.40	0.24	6.35	0.03
SSW-15	7.90	88	596	16	10	187.0	7.3	20	14	1.00	0.60	0.36	4.40	0.03
SDF-1	7.50	77	468	44	22	84.0	2.4	40	17	0.20	0.30	1.68	18.00	0.12
SDF-2	7.60	73	448	50	48	34.0	1.0	8	15	0.20	0.50	1.06	11.00	0.05
SDF-3	7.80	158	916	32	20	262.0	3.9	228	74	0.20	1.20	1.62	9.58	0.27
SDF-4	9.90	167	1156	2	2	380.0	5.2	120	33	1.10	12.00	7.96	7.38	0.06
SDF-5	8.10	68	406	20	10	113.0	2.4	56	5	0.20	1.40	1.23	2.85	0.05
SDF-6	8.00	85	516	22	10	147.0	2.8	53	17	0.20	0.30	3.93	11.00	0.09
SDF-7	7.70	73	460	37	27	81.0	1.9	16	5	0.20	1.00	0.56	4.94	0.07
SDF-8	7.80	277	1568	47	16	469.0	5.1	665	136	0.20	0.30	0.19	4.96	0.06
SDF-9	7.60	61	394	22	10	95.0	3.2	45	14	0.20	0.30	0.99	14.00	0.13
SDF-10	7.80	64	404	43	24	58.0	2.7	11	33	0.20	0.20	2.68	27.00	0.27
SDF-11	8.20	234	1348	3	2	563.0	1.9	347	12	0.20	4.60	2.14	6.17	0.06
SDF-12	7.70	68	432	44	29	71.0	5.4	18	17	0.20	0.40	0.58	17.00	0.15
SDF-13	8.00	110	662	32	20	209.0	5.8	18	78	0.20	0.60	0.90	9.49	0.12
SDF-14	8.20	69	422	6	2	159.0	3.3	16	5	0.20	0.50	0.54	0.97	0.03
SDF-15	9.80	76	418	2	2	168.0	4.1	27	20	1.00	0.60	0.83	5.31	0.05

Table 5.6.5.2(a) indicates that in addition to Al and Fe (which were naturally elevated in the ground water), Mg, Na, Cl, SO_4 and F had elevated concentrations with several samples having "non-compliant" concentrations. Several of the pH values were more alkaline and were classified as "marginally compliant" with regards to the SANS 241:2006 Drinking Water Standard. The EC, TDS and Mn also had slightly more elevated concentrations and several of the samples were classified as having "marginally compliant" concentrations.

A summary of the ground water geochemistry within the study area is listed in Table 5.6.5.2(b). The Table summarises the geochemistry of the ground water sampled from SSW- and SDF- monitoring boreholes. The data given in Table 5.6.5.2(b) has been classified according to the SANS 241:2006 Drinking Water Standard.

Table 5.6.5.2(b): SSW- and SDF- Ground Water Quality Summary

Element / Parameter	SSW-Samples			SDF-Samples		
	Min Value	Mean Value	Max Value	Min Value	Mean Value	Max Value
pH	7.50	7.93	8.6	7.5	8.11	9.9
EC (mS/m)	55	124	313	61	111	277
TDS (mg/l)	364	828	2162	394	668	1568
Ca (mg/l)	13	46	141	2	27	50
Mg (mg/l)	7	32	112	2	16	48
Na (mg/l)	64	179	659	34	193	563
K (mg/l)	ND	5.09	14.1	1	3.41	5.8
Cl (mg/l)	9	115	723	8	111	665
SO_4 (mg/l)	5	116	1035	5	32	136
NO_3 (mg/l)	ND	0.42	2.8	0.2	0.31	1.1
F (mg/l)	ND	0.53	1.3	0.2	1.61	12
Al (mg/l)	ND	1.04	3.74	0.19	1.79	7.96
Fe (mg/l)	ND	3.61	10	0.97	9.98	27
Mn (mg/l)	ND	0.10	0.32	0.03	0.11	0.27

Table 5.6.5.2(b) indicates that the average quality of the ground water within the study area sampled from the SSW-boreholes has the same compliance as the background ground water quality, with the exception of Mn. The average Mn concentration was classified as "fully compliant" in the background ground water quality but has an average "marginal compliance" quality in the SSW boreholes. The SDF samples displayed a similar situation, except that the average F concentration was elevated to a "non-compliant" quality.

Table 5.6.5.2(b) indicates that several samples sampled from both the SSW- and SDF- boreholes had non-compliant Na and Cl concentrations. Mg and SO_4 were also elevated to non compliant concentrations in the SSW- samples and may indicate a possible mining related impact on the ground water quality. Table 5.6.5.2(b) also indicates that the SSW- ground water samples had a poorer quality than the SDF- ground water samples, which further indicates that possible anthropogenic surface or mining related activities may have had an effect on the ground water quality within the study area.

The geochemistry of the ground water sampled from the 30 monitoring boreholes within the study area was then assessed and compared to the geochemistry of the background ground water, in order to determine whether impacts could be determined. Piper and Durov diagrams were again compiled using the macro chemistry variables pH, EC, Ca, Mg, Na, K, Total Alkalinity, Cl, SO_4 and NO_3. The resulting Piper and Durov Diagrams depicting the hydrochemical image of the ground water in the study area are shown in Figure 5.6.5.2(a) and Figure 5.6.5.2(b) respectively.

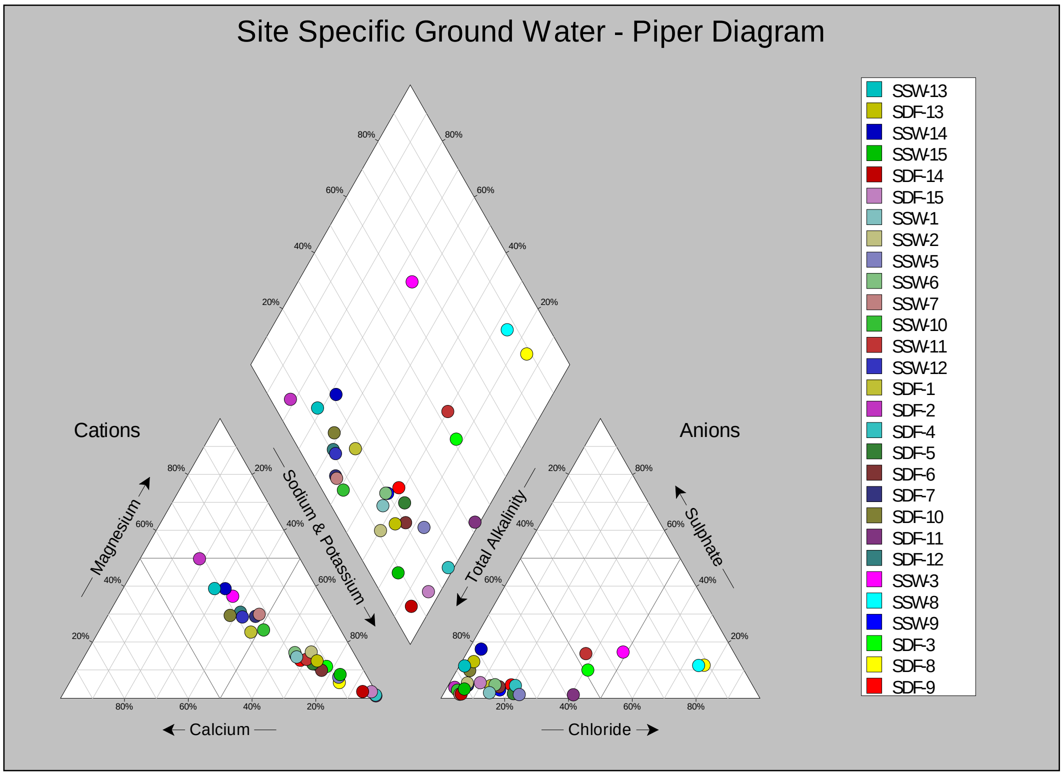

Figure 5.6.5.2(a): Study Area Ground Water Piper Diagram

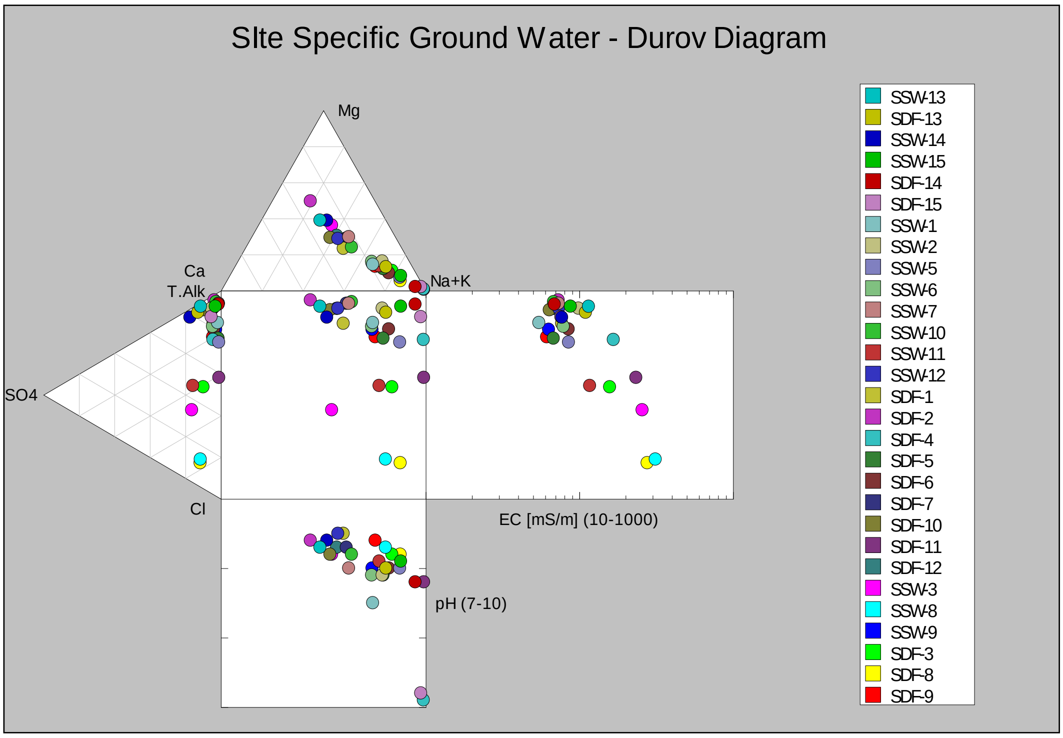

Figure 5.6.5.2(b): Study Area Ground Water Durov Diagram

It is evident from Figures 5.6.5.2(a) and 5.6.5.2(b) that there has been a distinct shift in the hydrochemical image in several of the ground water samples taken from the monitoring boreholes, when compared to the background ground water. The most notable of these include the ground water samples taken from SSW-3, SSW-8, SSW-11, SDF-3 and SDF-8.

The equivalent major/cation concentration distribution remained relatively similar to the background ground water quality, and the relative Ca:Mg ratio remained constant as well. The equivalent major anion concentration distribution, however, had altered significantly with several of the samples having significantly higher equivalent Cl concentrations. Several samples had higher equivalent SO_4 concentrations as well.

Based on the shift in the geochemistry signature of several ground water samples, predominantly SSW- samples, it is concluded that several localized anthropogenic surface and mining related activities have had an impact on, and altered the ground water geochemistry to varying degrees within the study area.

5.6.5.3 Multi Parameter Profiling

Multi-parameter profiles at each of the 30 monitoring boreholes were performed. These profiles are attached as APPENDIX 5.2(B) of the Ground Water Specialist Report and include the following:

- Temperature (ºC)
- Conductivity (mS/m)
- Dissolved Oxygen Concentration (mg/l)
- pH
- ORP (Oxidation-Reduction Potential) (mV)

The following observations are made regarding the profiles, and specific reference is made to ground water where pyrite is present:

- The temperature of mine ground water in a geohydrological borehole is generally in the range between 16 and 19ºC. Locally elevated temperatures observed in the profiles occur as a result of the exothermic oxidation of pyrite, and are the product of bacteriological workings. The bacteria are optimal at a temperature of about 30ºC.
- For the oxidation process of pyrite by oxygen, bacteria needs oxygen, thus the higher the dissolved oxygen, the more the oxidation of pyrite and the lower the pH becomes. In reducing environments, no oxidation of pyrite will occur and some microbes will even produce pyrite in anoxic-sulfidic conditions. Pyrite oxidation may still occur just above the water table in the unsaturated zone (where more oxygen is present) if pyrite is present. The dissolved oxygen in rainwater is 8 mg/l. Most boreholes show elevated dissolved oxygen at the top because of the contact with the atmosphere.
- The temperature at the top of the boreholes is often elevated because of the naturally warmer water of the unsaturated zone that travels down the borehole as well as the result of naturally warmer air in contact with the surface of the boreholes.
- The results of the profiles for the each of the parameters profiled in the boreholes complement each other directly or indirectly. These profiles are used to aid in the interpretation of the geohydrology of the sub-surface as well.

SDF-9 and SDF-6

- Boreholes SDF-9 and SDF-6 were drilled into the deeper Karoo aquifer and the multi-parameter profiles were done from about 5 m to a depth of about 75 m in the deeper boreholes.
- The boreholes have a constant temperature around 18ºC for the first 40 m. SDF-6 does show a slight elevation in temperature at the top. After 40 m the temperature starts rising slowly to about 19ºC.
- The dissolved oxygen is at about 8 mg/l at the top of the boreholes and decrease to about 2 mg/l at 19 m and to nearly 0 mg/l deeper down.
- The Electrical Conductivity is constant in the boreholes for the first 60 m, in borehole SDF-9 at about 105 mS/m, in borehole SDF-6 around 150 mS/m. At the interval of the profile from about 60 to 75 m, the conductivity rises in SDF-9 to 165 mS/m and in SDF-6 to 175 mS/m.
- The pH also stays around 7.4 in both boreholes but at the same interval mentioned above, 60 to 75 m, the pH starts rising to 8.4 in SDF-9 and to 9.3 in SDF-6.
- Both profiles show a slight increase in reducing conditions in the profiles but after the interval from 60 to 75 m, much more stronger reducing conditions are present.
- The increase of pH and Conductivity, with the strong decrease in reducing conditions at the interval from about 60 to 75 m are very evident and show definite stratification deep in the borehole. The ground water samples of both boreholes were taken in this interval and are very similar in the sense that the same parameters are elevated or reduced.
- Boreholes indicating similar profiles are boreholes SDF-13, SDF-12, SDF-14 that are also drilled into the deeper Karoo aquifer. Shallower boreholes with similar profiles are SSW-2 and SSW-11.

SDF-8 and SDF-13

- Borehole SDF-8 was drilled into the deep Karoo aquifer and SSW-7, SSW-9 and SSW-13 were drilled into the shallow weathered zone aquifer. The multi-parameter profiles were performed from the top of the water level to about 30 m in the shallow boreholes; and to about 80 m in SDF-8.
- All the boreholes show significantly elevated temperatures at the top and the maximum temperatures are much higher than that of other profiles done within the study area. SDF-8 and SSW-13 show maximum temperatures elevated just above 28ºC and SSW-7 and SSW-9 just above 23ºC. Because of this significant elevation one could expect bacteriological working and, because it is in an oxygen-rich environment, the oxidation of pyrite.
- In borehole SDF-8 the conductivity is slightly elevated at the top and then decline constantly deeper down the borehole. Boreholes SSW-7 and SSW-9 show a rise in conductivity in the first few meters until 4 m and 7 m respectively, after which it stays about constant deeper down.
- In boreholes SDF-8 and SSW-13 the dissolved oxygen starts to decline after a few meters to just above 0 mg/l. Boreholes SSW-7 and SSW-9 show very similar profiles. What is evident in all four boreholes is the slight depletion in dissolved oxygen at the top. This may be because the bacteria that show their presence with the elevated temperature at the top, are using oxygen and thus give rise to a slight depletion in oxygen at the top.

- Contrasting to the above, the pH stays relatively high in all four boreholes. This indicates no bacterial working but rather that enough alkalinity is present in the surrounding rocks to neutralize any acid produced.
- The important indicator of pyrite oxidation is elevated SO4. In the ground water samples of SDF-8 and SSW-13, SO4 values are elevated at 136 and 72 mg/l, higher than the maximum background SO4 value of 20 mg/l.
- Microbiological activity is clear in boreholes SDF-8 and SSW-13. Although elevated temperature occurs in SSW-7 and SSW-9, not enough evidence is present to justify significant oxidation of pyrite. The deeper borehole SDF-7 near SSW-7 also shows slightly elevated temperature (nearly 22ºC) at the top, but no indication of contamination of the water is present.
- Borehole SDF-8 is drilled close to an old gold mine dump and confirms the presence of ground water contamination. The geology of the borehole consists mostly of sandstone and shale layers throughout the borehole. Dolerite is present from 18 to 45 m and carbonaceous shale and a thin coal layer at 72 to 74 m.

SDF-1, SDF-2, SDF-3, SDF-10, SSW-1, SSW-3, SSW-6, SSW-14 and SSW-15

- All boreholes show slightly elevated temperatures at the top, but the temperature is seldom higher than 20ºC. This indicates no or insignificant pyrite oxidation.
- There is a lower electrical conductivity at the top, which may be due to water that falls constantly from above and dilute the water at the top of the borehole.
- All boreholes show high dissolved oxygen at the top of about 8.26 mg/l. The oxygen decreases further down the borehole to nearly 0 mg/l.
- The pH profile also starts a bit higher and decline further down the borehole and in most boreholes starts rising slightly again deeper down.
- In all boreholes, except SSW-15, the conditions become more reducing deeper down which may also indicate that the deeper water are not circulated very often and are older. No drastic variation in any parameter indicates any sharp stratification.

SDF-4, SDF-5, SDF-11, SSW-5 and SSW-12

- SDF-4, SDF-5 and SSW-12 show slight elevation in temperature at the top, which may be because of natural reasons as discussed above but boreholes SDF-11 and SSW-5 show constant temperatures from top to bottom.
- SDF-4, SDF-5 and SSW-12 show elevated pH that decline further down the boreholes. Boreholes SDF-4 and 11 show slight declined pH at the top but the pH's stay about constant deeper down the boreholes.
- SDF-4 and SSW-12 show more oxidizing conditions downwards and SDF-5, SDF-11 and SSW-5 becomes more reducing downwards. No drastic variation in any parameter indicates any sharp stratification.

5.6.6 Aquifer Classification for Study Area

The aquifer classification is done in accordance with the formal DWAF protocol "South African Aquifer System Management Classification, December 1995." Special attributes of aquifers related to structural features (such as fracturing along dyke/fault contact zones, or karst development, or mining influences) have been incorporated into the classification through the "Second Variable Classification". Classification is done in accordance with the following definitions for Aquifer System Management Classes:

Sole Aquifer System:

An aquifer which is used to supply 50 per cent or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.

Major Aquifer System:

Highly permeable formations, usually with a known, or probable, presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (less than 150 mS/m Electrical Conductivity).

Minor Aquifer System:

These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.

Non-Aquifer System:

These are formations with negligible permeability that are regarded as not containing ground water in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, ground water flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Aquifer System Management and Second Variable Classifications

Aquifer System Management Classification		
Class	**Points**	**Karoo Aquifers**
Sole Source Aquifer System:	6	-
Major Aquifer System:	4	-
Minor Aquifer System:	2	2
Non-Aquifer System:	0	-
Special Aquifer System:	0 – 6	-
Second Variable Classification – Mining Related Dewatering		
Class	**Points**	**Karoo Aquifers**
High:	3	-
Medium:	2	-
Low:	1	1

The Karoo Aquifers present within the study area appear to have been locally impacted by underground mining operations as a result of dewatering. This is observed by the localized drop in the water levels across the study area.

<u>Aquifer System Management Classification Points = 1 * 2 = 2</u>

Ground Water Quality Management Classification

Aquifer System Management Classification		
Class	**Points**	**Karoo Aquifers**
Sole Source Aquifer System:	6	-
Major Aquifer System:	4	-
Minor Aquifer System:	2	2
Non-Aquifer System:	0	-
Special Aquifer System:	0 – 6	-
Aquifer Vulnerability Classification		
Class	**Points**	**Karoo Aquifers**
High:	3	-
Medium:	2	2
Low:	1	-

<u>Aquifer VulnerabilityClassification Points = 2 * 2 = 4</u>

The indicated level of ground water protection is derived from the Ground Water Quality Management Index (GQM Index).

GQM Index = Aquifer System Management Classification x Aquifer Vulnerability Classification
= *2 x 4*
= *8*

Indicated Level of Ground Water Protection

GQM Index	*Level of Protection*	*Karoo Aquifers*
<1	*Limited*	-
1 - 3	*Low Level*	-
3 - 6	*Medium Level*	-
6 - 10	*High Level*	*8*
>10	*Strictly Non-Degradation*	-

<u>Aquifer Protection Classification</u>

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Ground Water Quality Management Index of 8 for the Karoo Aquifers within the study area, indicating that **High Level** of ground water protection is required.

5.6.7 Ground Water Use in Study Area

A borehole and spring hydro-census, was performed within a one km radius of the study area. A total of 170 boreholes, 1 dug well and 16 fountains were identified. The localities of these boreholes, well and fountains are located in Figure 5.6.7(a). These localities as well as their borehole/well/fountain numbers are indicated on the map attached as APPENDIX 5.2(C) to the Ground Water Specialist Report.

98 of the boreholes surveyed, including one dug well, were found to be in use, while 17 were found to have been destroyed. As far as the application status and use of the boreholes are concerned, the following information was gathered:

- 17 boreholes are used solely for domestic purposes.
- 33 boreholes are used for agricultural and domestic purposes.
- 18 boreholes are used solely for stock watering.
- 2 boreholes are used solely for domestic garden purposes.
- 28 monitoring boreholes are used for observation purposes by Kinross, Winkelhaak and Leslie Gold Mines Ltd.

The above boreholes supply roughly 721 people, 38 gardens, one nursery, 5 862 large stock units, 6 dairies, 965 small stock units, 27 050 poultry units and water to irrigate roughly 7 hectares.

Four (4) of the 16 fountains surveyed are in use. As far as the application status of the fountains is concerned, 2 fountains are used solely for stock watering and the other two are used for agricultural and domestic purposes. The fountains supply water to 10 people, 325 large stock units and 150 small stock units.

The following observations, related to geohydrological aspects, have relevance to the information obtained:

- The reported depths for the external user's boreholes ranged between 13 m and 150 m, averaging at 55 m.
- The depths of water strikes for the external user's boreholes ranged between 11 m and 100 m, averaging at 32 m.
- The reported yields for the external user's boreholes ranged between 0.01 l/s and 8.30 l/s, averaging at 1.27 l/s.
- The estimated yields for the external user's fountains ranged between 0.05 l/s and 2.00 l/s, averaging at 0.47 l/s.
- The depth to water level observed for the external user's boreholes and fountains ranged between 0 m and 27.19 m, averaging at 4.75 m.

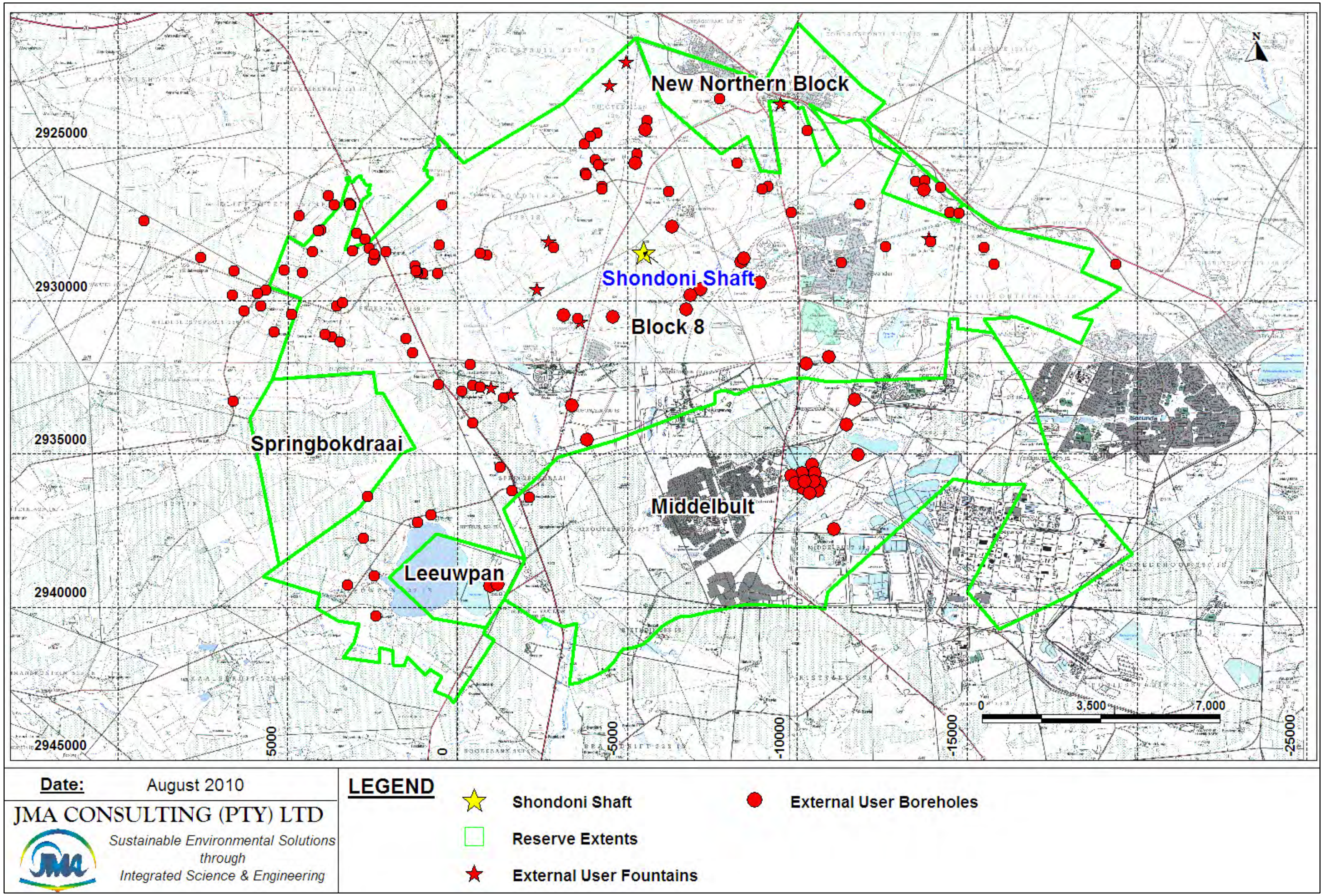

Figure 5.6.7(a): Hydro-census Sampling Localities

5.7 SURFACE WATER

This section defines the quantity and quality of the baseline surface water. Water quality sampling on the Middelbult/Block 8/Shondoni area was undertaken by Jones & Wagener in October 2002. On the southern section of the mining area, existing data from Sasol's monitoring programme was used.

5.7.1 Surface Water Quantity

This section details the baseline surface water information related to water quantity, being rainfall, flood events and stream flow, in essence, the hydrology.

The drainage density of the total Middelbult/Block 8/ Shondoni mining area is given below. The values given are based on the mining area outlined on the locality plan in Figure 5.7.1(a).

Length of drainage paths	=	293.00 km
Proposed total mining area	=	463.01 km^2
Drainage density	=	0.63 km/km^2

5.7.1.1 Catchment Boundaries

The Middelbult/Block 8/ Shondoni mining area is located in the Waterval River catchment within quaternary sub-catchment C12D of the Vaal Primary Drainage region – see Figure 5.7.1.1(b) taken from *"Surface Water Resources of South Africa – 1990"* Vol II (*Midgley, Pitman & Middleton, 1995*) (WR90)). The Waterval river catchment forms part of the Upper Vaal Water management Area (WMA) number 10. This can be seen in Figure 5.7.1.1(a) below.

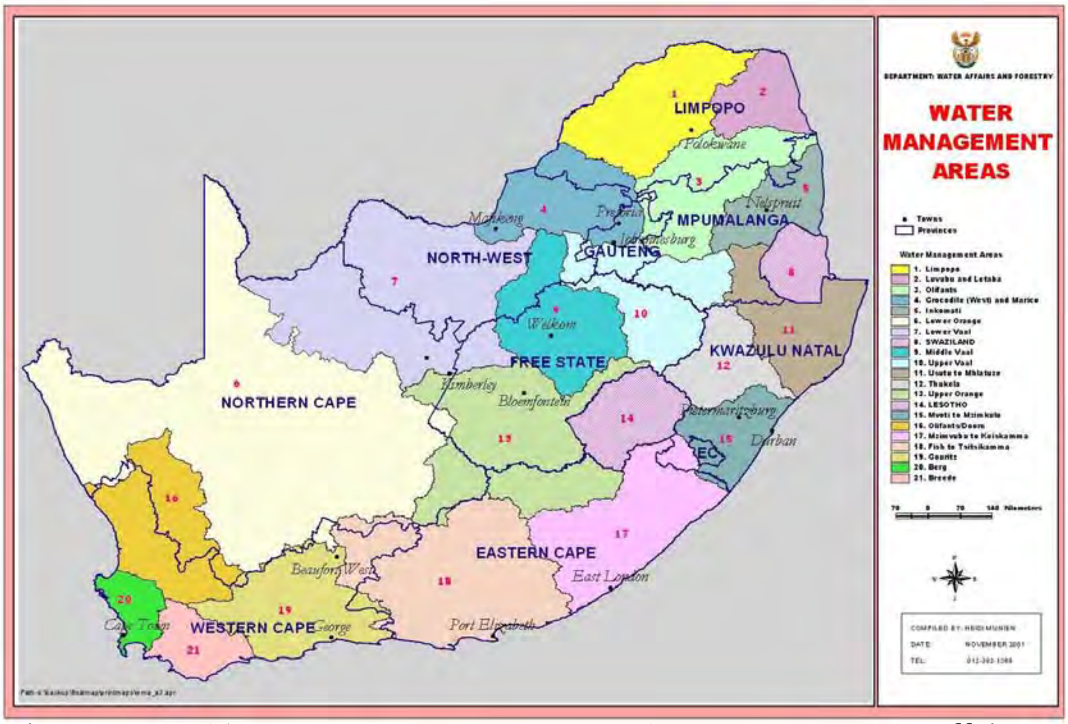

Figure 5.7.1.1 (a) Water Management Areas (Department Water Affairs : Water Quality Status Report: Upper Vaal Management Area, 2000-2005, R.Munnik)

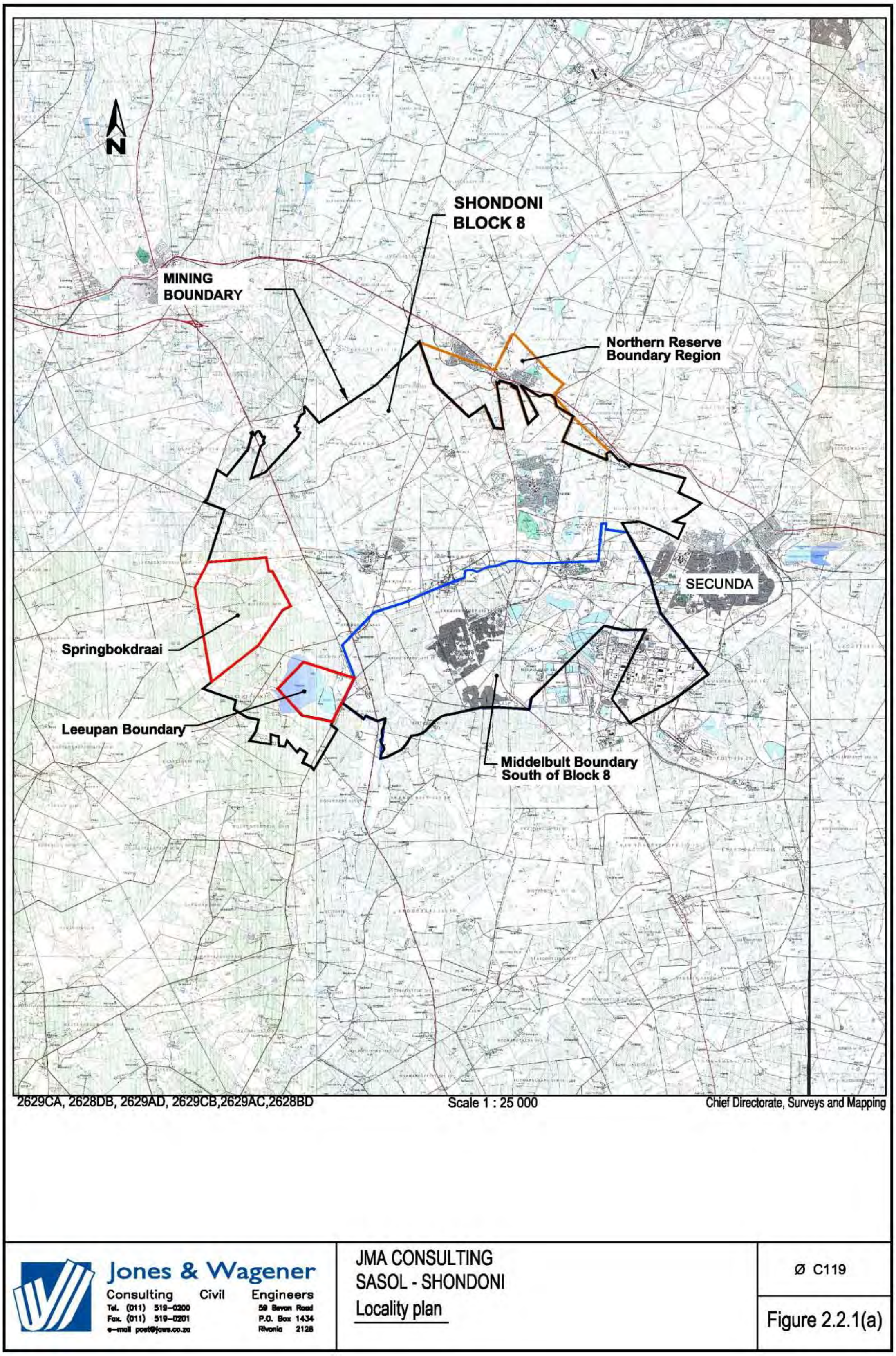

Figure 5.7.1(a) Locality Plan showing Mining Area

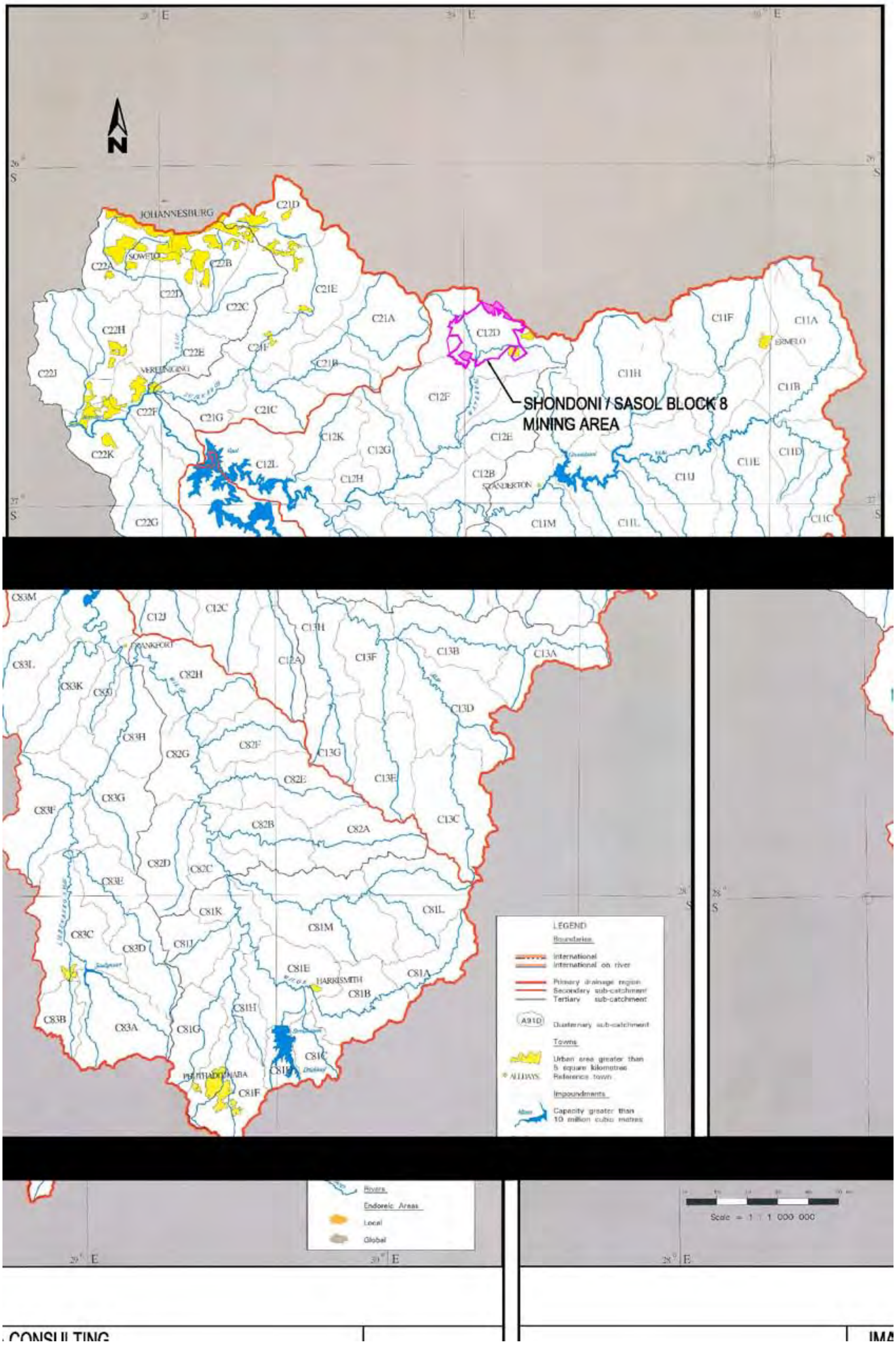

Figure 5.7.1.1(b) Quaternary Sub-catchments and Boundaries

The mining area is drained by the Rolspruit, Grootspruit, Winkelhaakspruit, and Trichardtspruit, which join the Waterval River upstream of the confluence with the upper Kaalspruit. The Waterval River eventually drains to the Vaal River upstream of the Vaal Dam, from where the stream flows in a westerly direction to the Vaal Barrage, Bloemhof Dam, eventually joining the Orange River, which flows into the Atlantic Ocean on the west coast of South Africa.

5.7.1.2 Receiving Water Body

In terms of the catchment description, the receiving water body is an important concept. The receiving water body is the point below which the mine's impact on the catchment is considered to be negligible. This implies that aspects such as surface water users need only be defined down to the receiving water body.

The receiving water body for the assessment of potential surface water quality impacts of the mine is taken as the Vaal River at the confluence with the Waterval river some 110 km downstream of the mining area.

The use of this location is motivated on the basis that:

- By implication, potential impacts on the Vaal Dam will also be included in the impact assessment.
- Further, by the time the water reaches the receiving water body, it is required to be suitable for use for all of the expected uses (drinking water, agricultural, industrial and aquatic ecosystems). Thus, by achieving compliance in terms of these, no additional impacts are expected downstream of the receiving water body. The receiving water body is relevant only in so far as it defines the aerial extent of the catchment to be considered in the impact assessment, and described in the baseline study.
- Beyond the Receiving Water Body the potential impact of the mine becomes extremely small due to the water volumes in the catchment and dilution effects.
- In terms of impact assessment, the total mining area is small compared to the receiving water body catchment. The mining area is estimated at some 463 km^2, compared to a catchment of approximately 18406 km^2 for the Vaal River to the confluence with the Waterval River (or some 2.5% of the catchment area).

The MAR for the Vaal River at the Waterval River confluence is 1055.5 x 10^6 m^3, while the MAR for the mine area is estimated at 27.05 x 10^6 m^3.

5.7.1.3 Mean Annual Runoff (MAR)

The MAR for the various sub-catchments was computed using the WRSM90 synthetic streamflow generation model. This software utilises rainfall and evaporation data, together with a number of parameters that characterise the catchment, to compute synthetic monthly streamflow data from monthly rainfall data. The Langsloot rainfall station (0478292) was used in the simulations. The catchment parameters, as published in WR90 were used in the computations.

The results of the modelling are shown in Table 5.7.1.3(a). The catchments and nodes are shown in Figure 5.7.1.3(a).

Table 5.7.1.3(a) Mean Annual Runoff (MAR) for the Middelbult/Block 8/Shondoni Mining Area

Catchment		Catchment Area (km^2)	MAR ($x10^6 m^3$)	% of MAR at Vaal River
Area A Western portion of the mining area (Wildebeestspruit, Rietkull and Brakspruit).	Node A1	153.7	8.98	0.85
	Node A3	72	4.22	0.40
	Node A8	28.1	1.65	0.16
	Node A15	3.9	0.23	0.02
	Node A17	27.9	1.63	0.15
	Node A18	69	4.04	0.38
Area B Slightly west of the main mining area in the confluence of Brakspruit and Springbokdraai.	Node B1	221.3	12.92	1.22
	Node B22	67.7	3.97	0.38
	Node B23	81.5	4.78	0.45
	Node B45	1.7	0.1	0.01
Area C Central mining area on Zandfontein and Brakspruit.	Node C1	109.4	6.39	0.61
	Node C2	66.4	3.89	0.37
	Node C23	7.3	0.43	0.04
	Node C33	2.7	0.16	0.02
	Node C44	42.2	2.47	0.23
Area D Easterly extreme of the Block 8 mining area.	Node D1	12.9	0.74	0.07
	Node D2	3.7	0.21	0.02
	Node D6	1.4	0.08	0.01
Area E South west catchment downstream of mining area on the Leeuwpan.	Node E1	53.5	3.12	0.30
	Node E2	2.5	0.15	0.01
	Node E3	24.3	1.43	0.14
Area F North west of the mining area on Trichardspruit	Node F1	191.93	11.23	1.06
	Node F2	154.6	9.04	0.86
	Node F3	37.33	2.18	0.21
	Node F4	2.7	0.16	0.02
	Node F5	141.78	8.29	0.79
	Node F7	5.96	0.35	0.03
	Node F8	17.64	1.03	0.10

Catchment		Catchment Area (km^2)	MAR ($x10^6m^3$)	% of MAR at Vaal River
Area G South east of the mining area	Node G1	65.2	3.81	0.36
	Node G2	21.9	1.28	0.12
	Node G3	9.51	0.56	0.05
Area H Southern tip of the mining area	Node H1	28.28	1.65	0.16
Area I Northern Tip of the mining area	Node I1	2.48	0.15	0.01
On the Southern tip of the watervalrivier just out side the mining area	Node WR1	864.72	50.58	4.79
	Node WR2	157.38	9.21	0.87
Entire Mine Boundary		463.01	27.05	2.56

5.7.1.4 Dry Weather Flow

In the absence of any streamflow monitoring, the conventional approach to compute the dry weather flow (also often termed "normal flow") is to analyse the long term synthetic monthly streamflow time series in order to develop a flow-duration relationship. An accepted definition of the dry weather flow in a stream is that flow in the stream that is equalled or exceeded for 70% of the time, a value which can readily be ascertained from an analysis of the flow-duration relationship. The WRSM90 Model was used to determine monthly flows for the associated catchments for the Middelbult/Block 8 /Shondoni area. Again, the Langsloot rain gauge (0478292) was used for the runoff simulations. The monthly flow exceeded in 70% of all months modelled is shown in Table 4.7.1.4(a). The catchments and nodes are shown in Figure 5.7.1.4(a).

Table 5.7.1.4(a) Computed dry weather flows for the Middelbult/Block 8/Shondoni Mining Area

River	Point of Measurement (nodes)	Computed monthly flow exceeded in 70% of months modelled (x 10^6 m^3/s)	Computed DWF (l/s average over month)
Wildebeestspruit	A1	0.02	7.72
Waterval	B1	0.03	11.57
Grootspruit	C1	0.01	3.86
Trichardtspruit	D1	0.00*	0.00
Kaalspruit	E1	0.01	3.86
Klipspruit	F1	0.02	7.72
Waterval River	WR1	0.07	27.00

Note: * denotes DWF less than 0.01 X 10^6m^3 per month

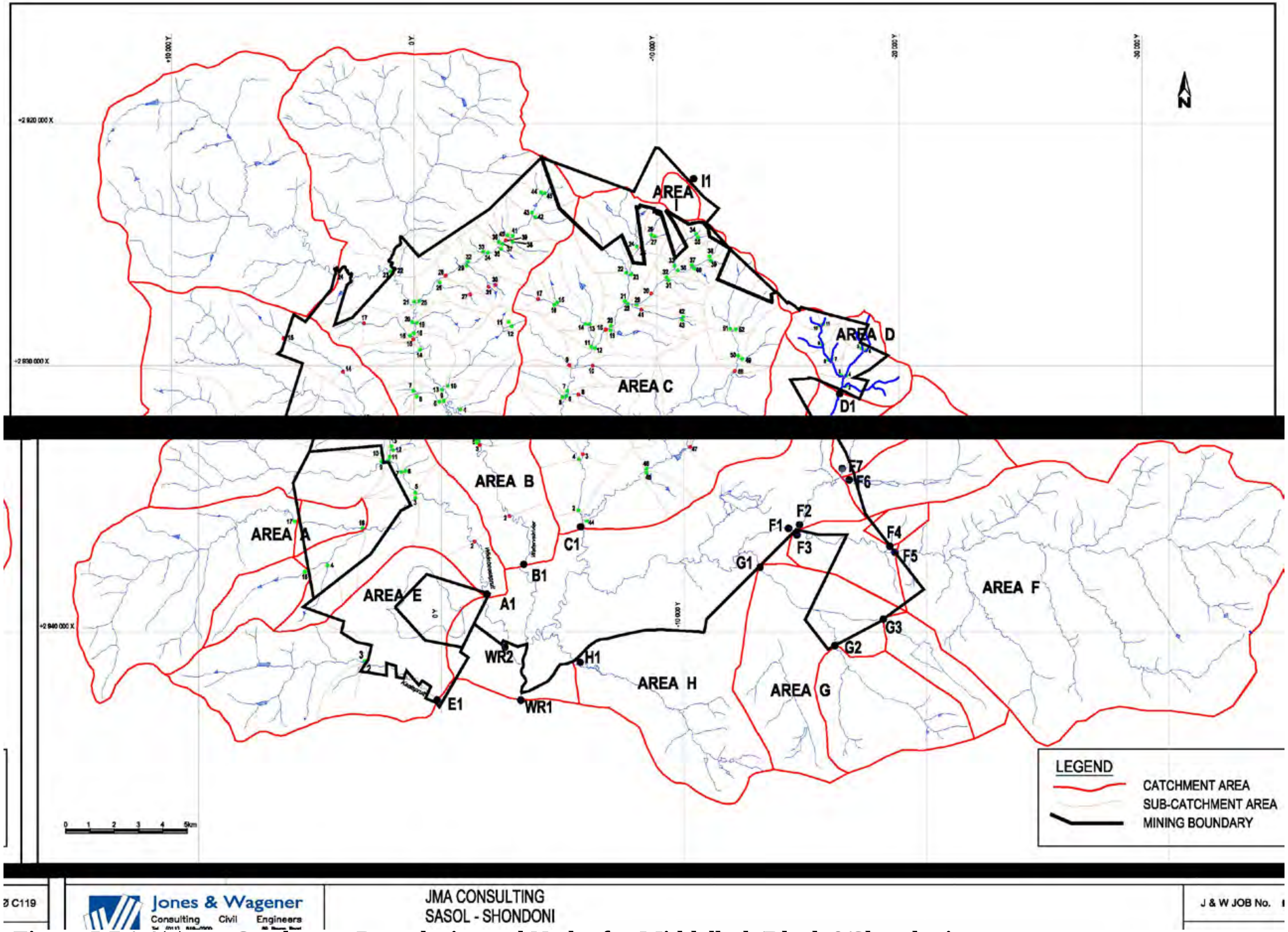

Figure 5.7.1.4(a): Catchment Boundaries and Nodes for Middelbult/Block 8/Shondoni

5.7.1.5 Flood Peaks and Volumes

Several points of interest, or nodes, were identified for peak flow calculations. These were located where streams enter and exit the mining area, and are indicated on Figure 5.7.1.4(a). Catchment areas and slopes were determined from the 1:50 000 topograpical map, published by the chief directorate, surveys and mapping. The reference numbers for the maps are 2628DB, 2628DB,2629AC, 2629CB, 2629CA and 2629AD.

There are a multitude of methods available for the determination of peak flows. The methods used were the Rational Method, the Standard Design Flood (SDF) Method (Alexander, 2002), the Regional Maximum Flood (RMF) Method (Kovacs, 1988) and the Direct Run-off Hydrograph (DRU) Method.

The peak flows calculated using each method were evaluated for each node and a representative value adopted. The computed peak flows and volumes are given in Table 5.7.1.5(a).

Table 5.7.1.5(a) Flood Peaks and Flood Volumes for Middelbult/Block 8/Shondoni Mining Area

Catchment	Nodes	Area (km^2)	Recurrence Interval	Flood Peaks (m^3/s)	Flood Volumes (m^3x10^6)
A Western portion of the mining area (Wildebeestspruit, Rietkuil).	A1	153.7	20 year	169	6.3
			50 year	221	8.2
			100 year	308	11.5
			RMF	726	27
	A3	72	20 year	119	2.9
			50 year	159	3.9
			100 year	220	5.5
			RMF	508	12.6
	A8	28.1	20 year	77	1.07
			50 year	105	1.46
			100 year	145	2.02
			RMF	355	4.95
	A15	3.9	20 year	31	0.127
			50 year	45	0.184
			100 year	61	0.25
			RMF	168	0.69
	A17	27.9	20 year	77	1.06
			50 year	113	1.56
			100 year	142	1.96
			RMF	354	4.89
	A18	69	20 year	122	2.96
			50 year	176	4.27
			100 year	222	5.38
			RMF	500	12.12

Catchment	Nodes	Area (km^2)	Recurrence Interval	Flood Peaks (m^3/s)	Flood Volumes (m^3x10^6)
B Slightly west of the main mining area in the confluence of Brakspruit and Springbok-draai.	B1	221.3	20 year	200	8.8
			50 year	251	11.05
			100 year	361	15.8
			RMF	884	38.91
	B22	67.7	20 year	116	2.78
			50 year	154	3.70
			100 year	214	5.14
			RMF	496	11.9
	B23	81.5	20 year	126	3.40
			50 year	167	4.50
			100 year	232	6.25
			RMF	532	14.34
	B45	1.7	20 year	21	0.051
			50 year	31	0.076
			100 year	42	0.1
			RMF	123	0.3
C Central mining area on Zandfontein and Brakspruit.	C1	109.4	20 year	145	4.61
			50 year	190	6.04
			100 year	265	8.42
			RMF	605	19.23
	C1	109.4	20 year	145	4.61
			50 year	190	6.04
			100 year	265	8.42
			RMF	605	19.23
	C2	66.4	20 year	115	2.72
			50 year	153	3.62
			100 year	212	5.02
			RMF	493	11.67
	C23	7.3	20 year	42	0.25
			50 year	59	0.36
			100 year	80	0.48
			RMF	213	1.29
	C33	2.7	20 year	26	0.08
			50 year	38	0.125
			100 year	51	0.167
			RMF	146	0.48
	C44	42.2	20 year	93	1.66
			50 year	126	2.25
			100 year	174	3.11
			RMF	414	7.41
D Easterly extreme of the Shondoni mining area.	D1	12.9	20 year	54	0.46
			50 year	75	0.64
			100 year	103	0.88
			RMF	264	2.28
	D2	3.7	20 year	30	0.115
			50 year	43	0.165

Catchment	Nodes	Area (km^2)	Recurrence Interval	Flood Peaks (m^3/s)	Flood Volumes (m^3x10^6)
			100 year	59	0.23
			RMF	164	0.63
	D6	1.4	20 year	20	0.042
			50 year	29	0.06
			100 year	39	0.081
			RMF	115	0.24
E Southwest catchment downstream of mining area on Leeuwpan.	E1	53.5	20 year	104	2.15
			50 year	139	2.87
			100 year	193	3.99
			RMF	454	9.39
	E2	2.5	20 year	26	0.08
			50 year	37	0.12
			100 year	50	0.158
			RMF	142	0.45
	E3	24.3	20 year	72	0.92
			50 year	99	1.26
			100 year	136	1.74
			RMF	336	4.29
F North west of the mining area on Trichardspruit	F1	191.9	20 year	207	8.52
			50 year	298	12.26
			100 year	378	15.55
			RMF	819	33.69
	F2	154.6	20 year	170	6.32
			50 year	243	9.04
			100 year	308	11.46
			RMF	729	27.12
	F3	37.3	20 year	104	1.72
			50 year	157	2.59
			100 year	198	3.27
			RMF	396	6.54
	F4	2.7	20 year	25	0.08
			50 year	38	0.12
			100 year	48	0.16
			RMF	146	0.48
	F5	141.8	20 year	181	6.48
			50 year	258	9.23
			100 year	327	11.70
			RMF	695	24.87
	F7	5.96	20 year	36	0.30
			50 year	53	0.45
			100 year	68	0.58
			RMF	124	1.05
	F8	17.6	20 year	78	0.81
			50 year	121	1.25
			100 year	157	1.63
			RMF	298	3.09

Catchment	Nodes	Area (km^2)	Recurrence Interval	Flood Peaks (m^3/s)	Flood Volumes (m^3x10^6)
G South west of the mining area	G1	65.2	20 year	145	3.39
			50 year	205	4.79
			100 year	257	6.01
			RMF	489	11.43
	G2	21.9	20 year	81	0.96
			50 year	117	1.39
			100 year	147	1.75
			RMF	323	3.84
	G3	9.51	20 year	37	0.26
			50 year	57	0.41
			100 year	71	0.51
			RMF	235	1.68
H Southern tip of the mining area	H1	28.3	20 year	82	1.14
			50 year	120	1.67
			100 year	151	2.10
			RMF	356	4.95
I Northern Tip of the mining area	I1	28.3	20 year	28	0.09
			50 year	45	0.14
			100 year	57	0.18
			RMF	141	0.45
WR On the Southern tip of the Waterval Rivier just out-side the mining area	WR1	864.7	20 year	482	39.62
			50 year	706	58.03
			100 year	889	73.08
			RMF	1846	151.74
	WR2	157.4	20 year	157	5.89
			50 year	227	8.52
			100 year	286	10.74
			RMF	736	27.63

Note: The values given in the tables above were determined using Regional Maximum Flood factored as per Kovacs (TR 137). In order to determine the flood volumes, the floods were factored down from the Regional Maximum Flood (RMF). It was assumed that this flood would have a volume of the order of 2 to 3 times the MAR.

5.7.1.6 Floodlines

1:50 and 1: 100 year Floodlines were determined for the Middelbult/Block 8/Shondoni mining area in October 2002, Report No.: JW98/02/8068. These can be seen in Figure 5.7.1.6(a) through to Figure 5.7.1.6(g).

5.7.1.7 Watercourse Alterations

No physical watercourse alterations have been planned. The proposed mine plan indicates that some streams will be undermined and therefore an exemption will be required in terms of GN704 for undermining of streams.

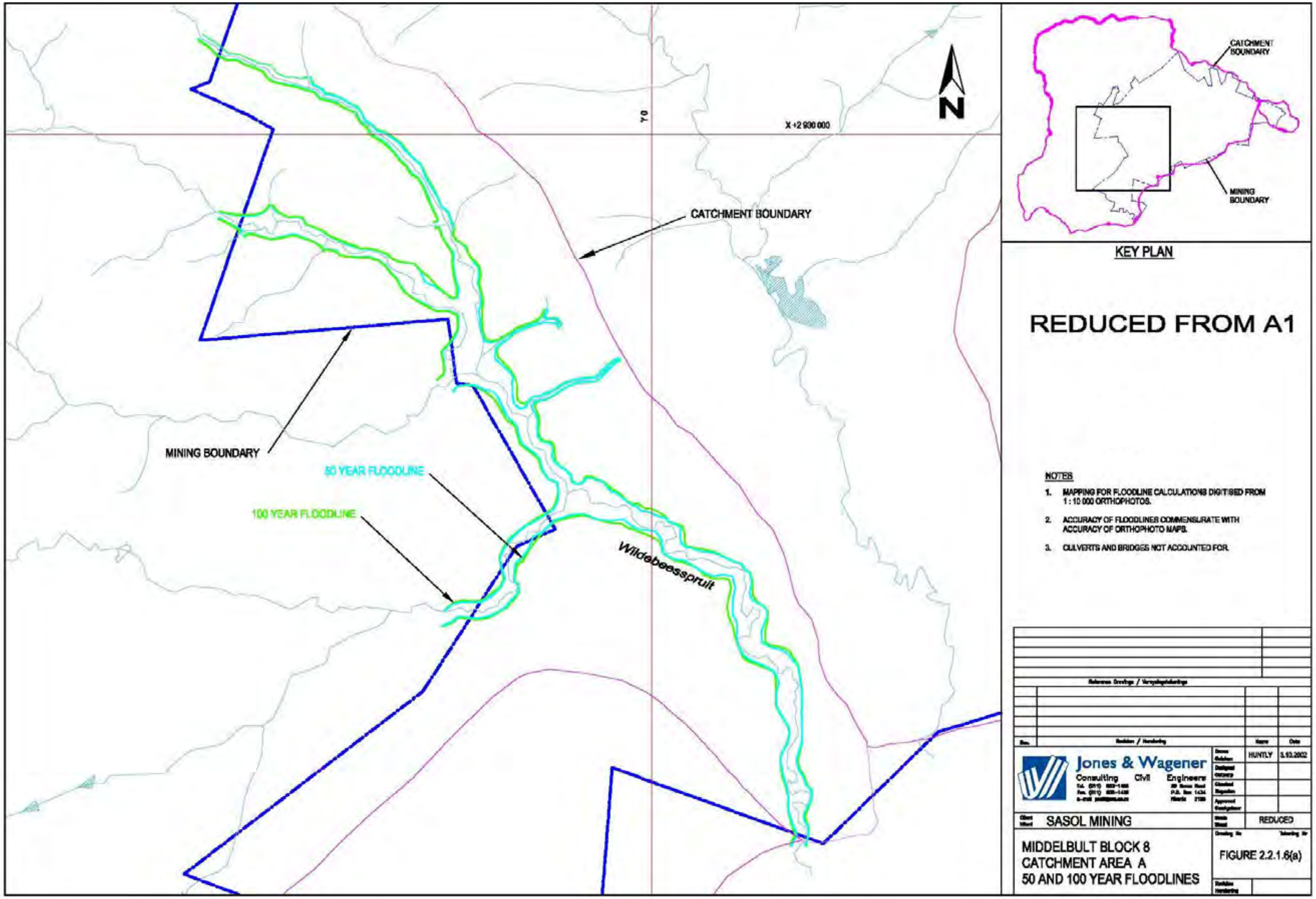

Figure 5.7.1.6(a): Middelbult/Block 8/Shondoni Floodlines: Catchment Area A

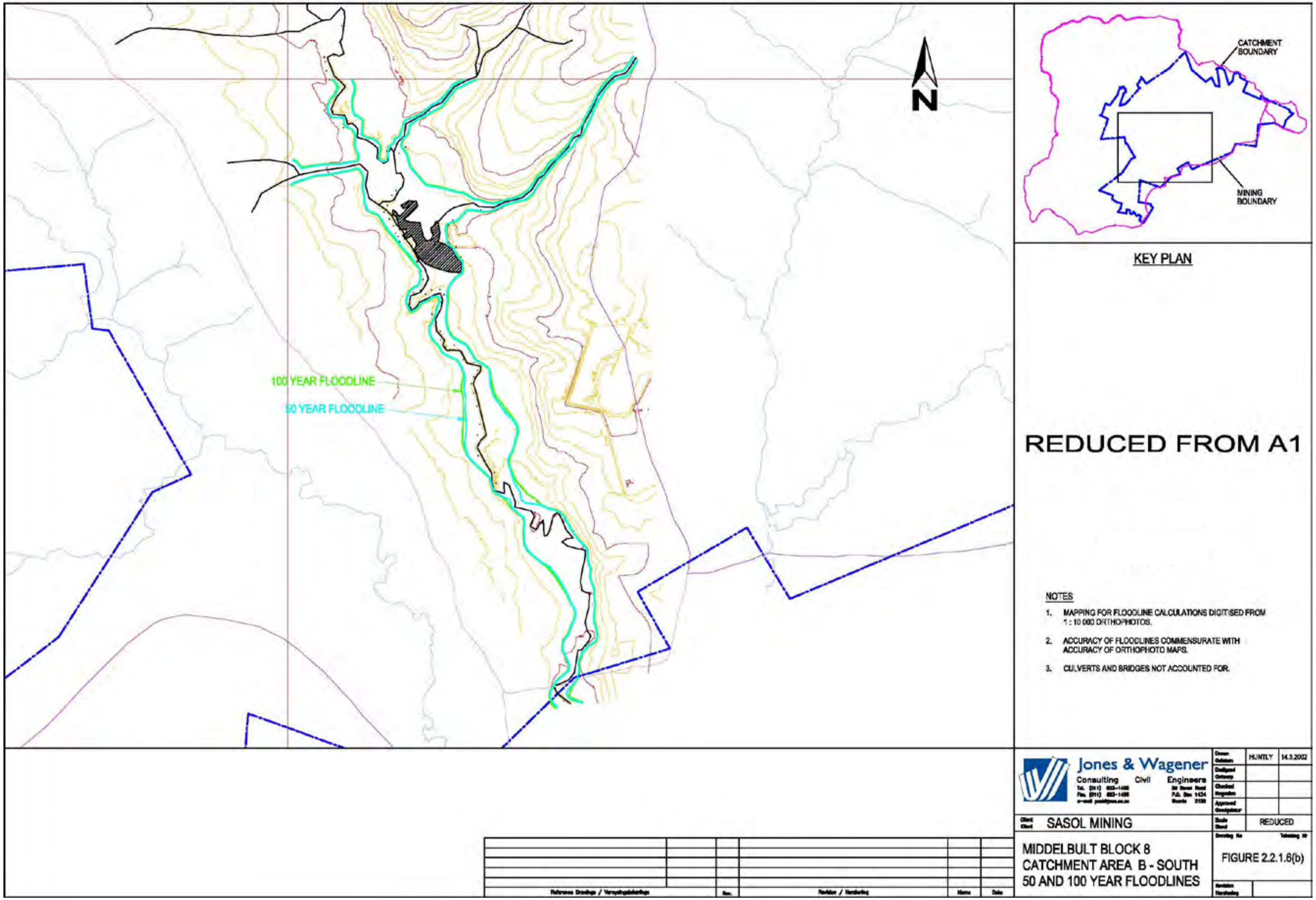

Figure 5.7.1.6(b): Middelbult/Block 8/Shondoni Floodlines: Catchment Area B South

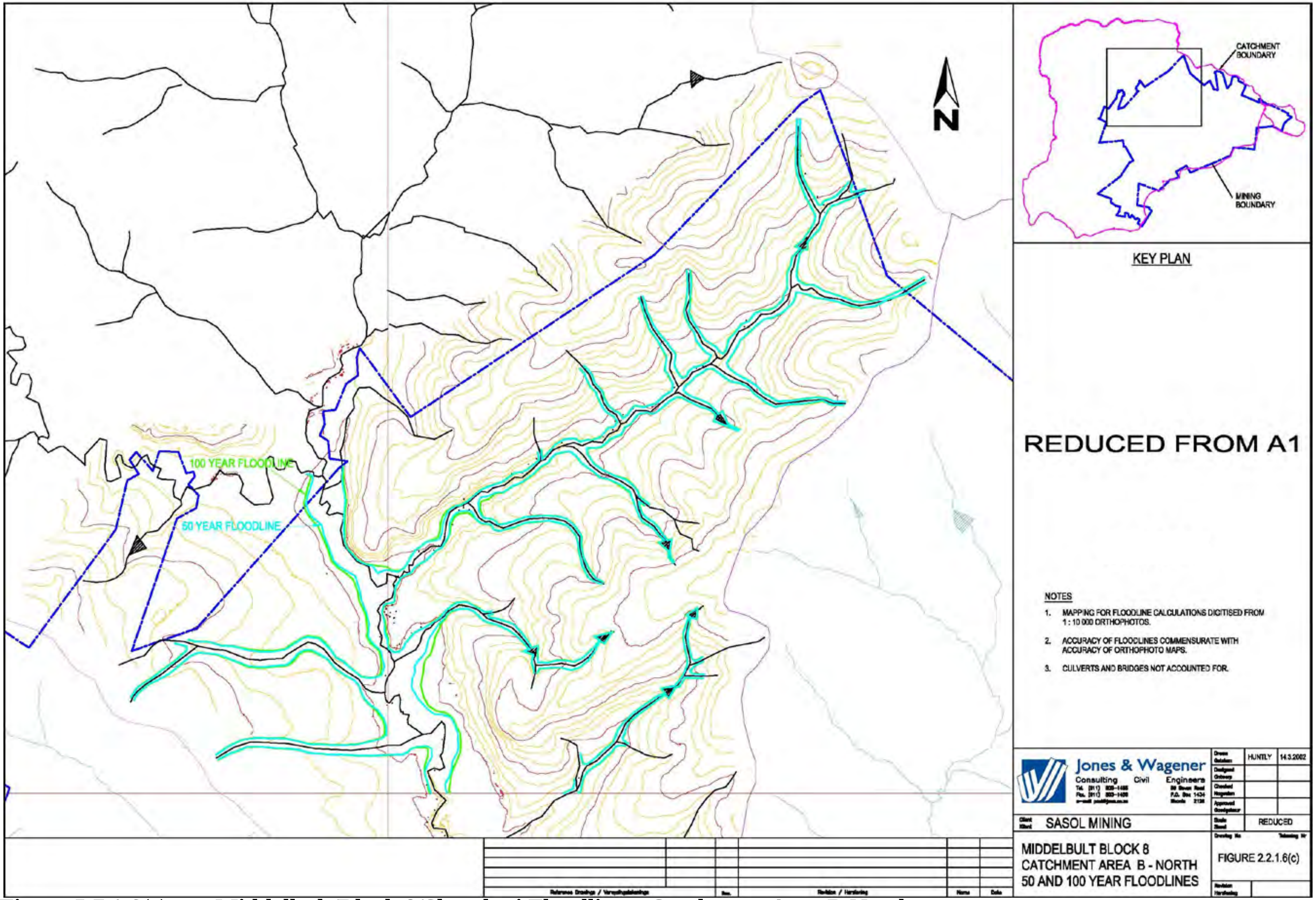

Figure 5.7.1.6(c): Middelbult/Block 8/Shondoni Floodlines: Catchment Area B North

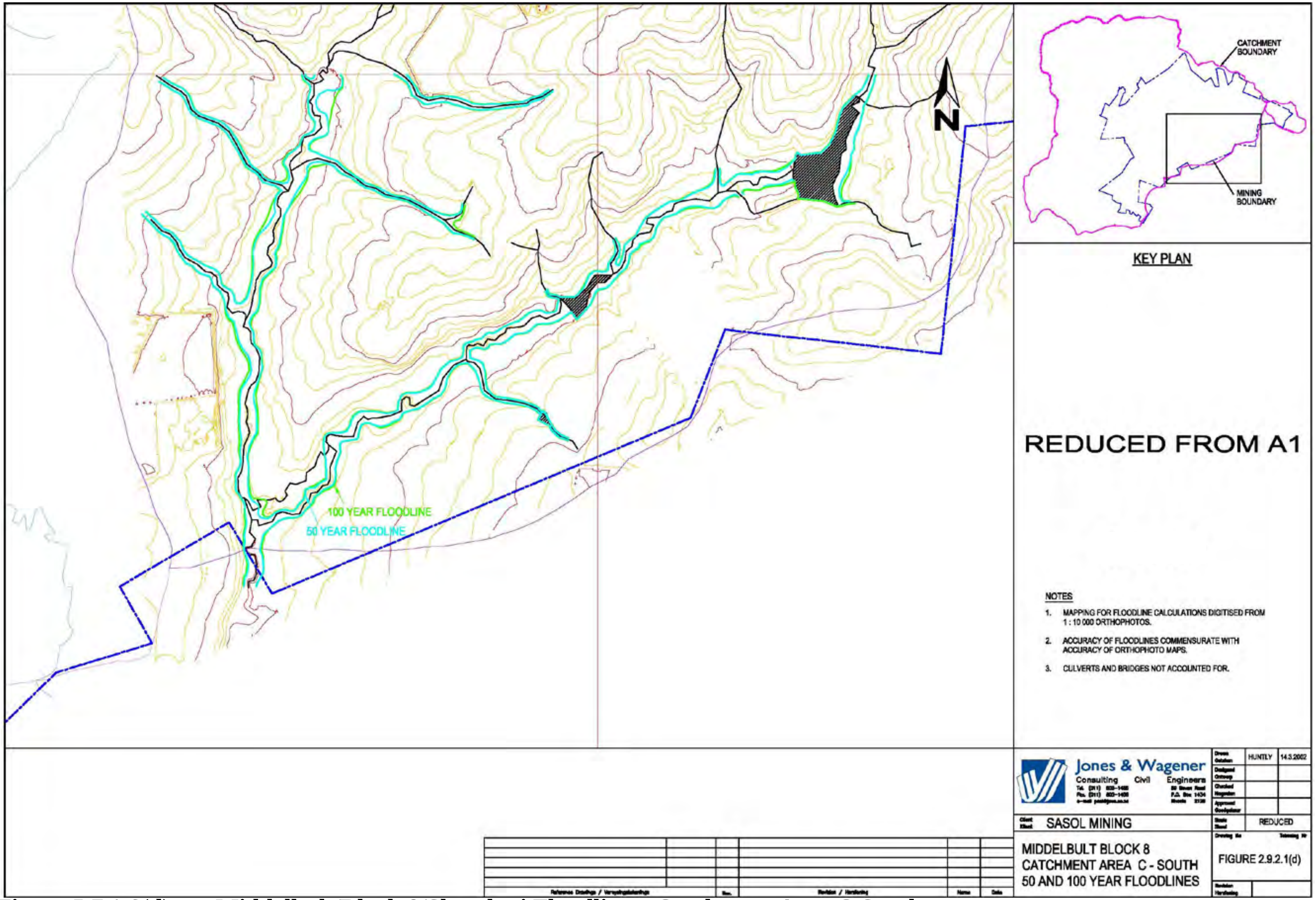

Figure 5.7.1.6(d): Middelbult/Block 8/Shondoni Floodlines: Catchment Area C South

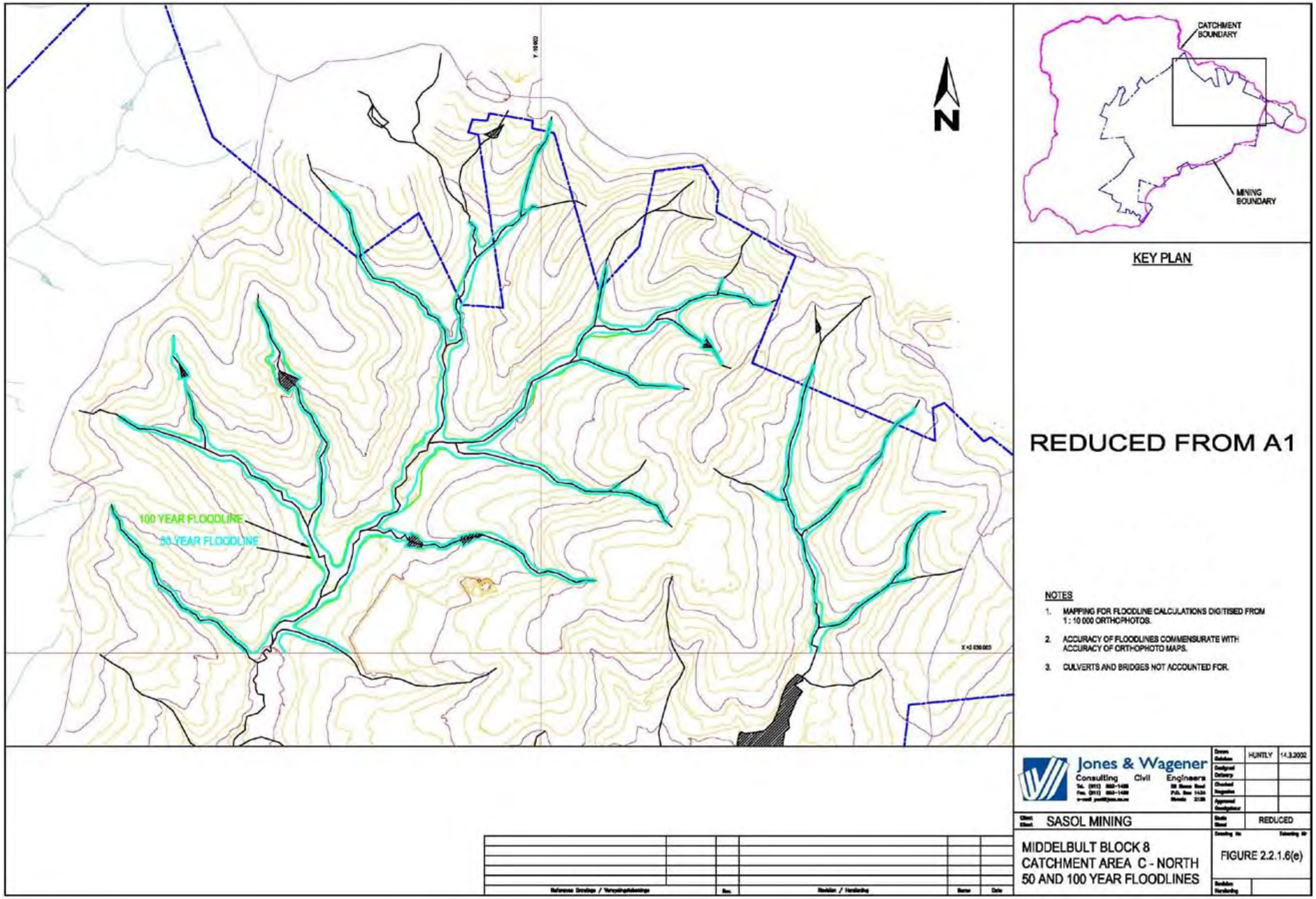

Figure 5.7.1.6(e): Middelbult/Block 8/Shondoni Floodlines: Catchment Area C North

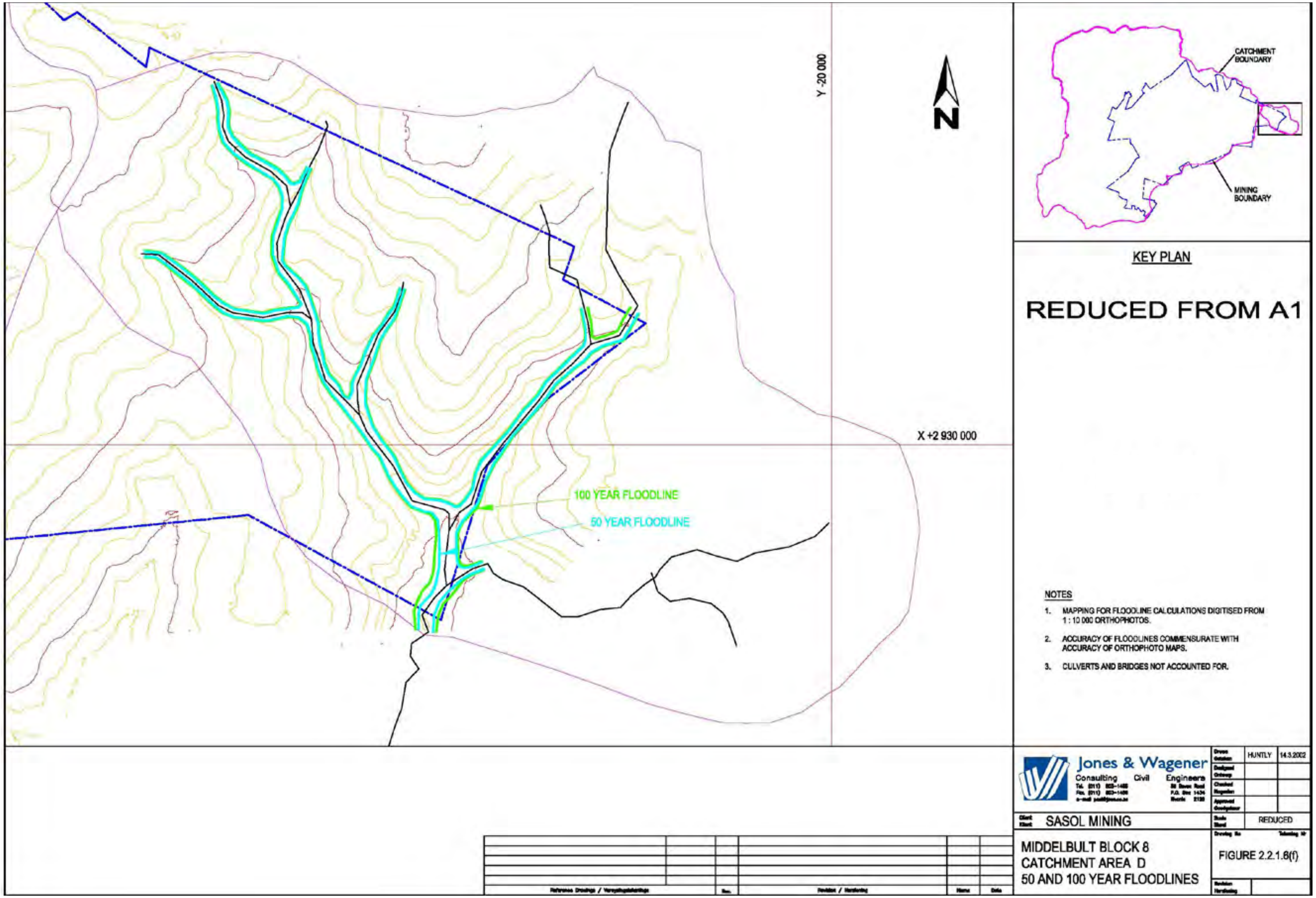

Figure 5.7.1.6(f): Middelbult/Block 8/Shondoni Floodlines: Catchment Area D

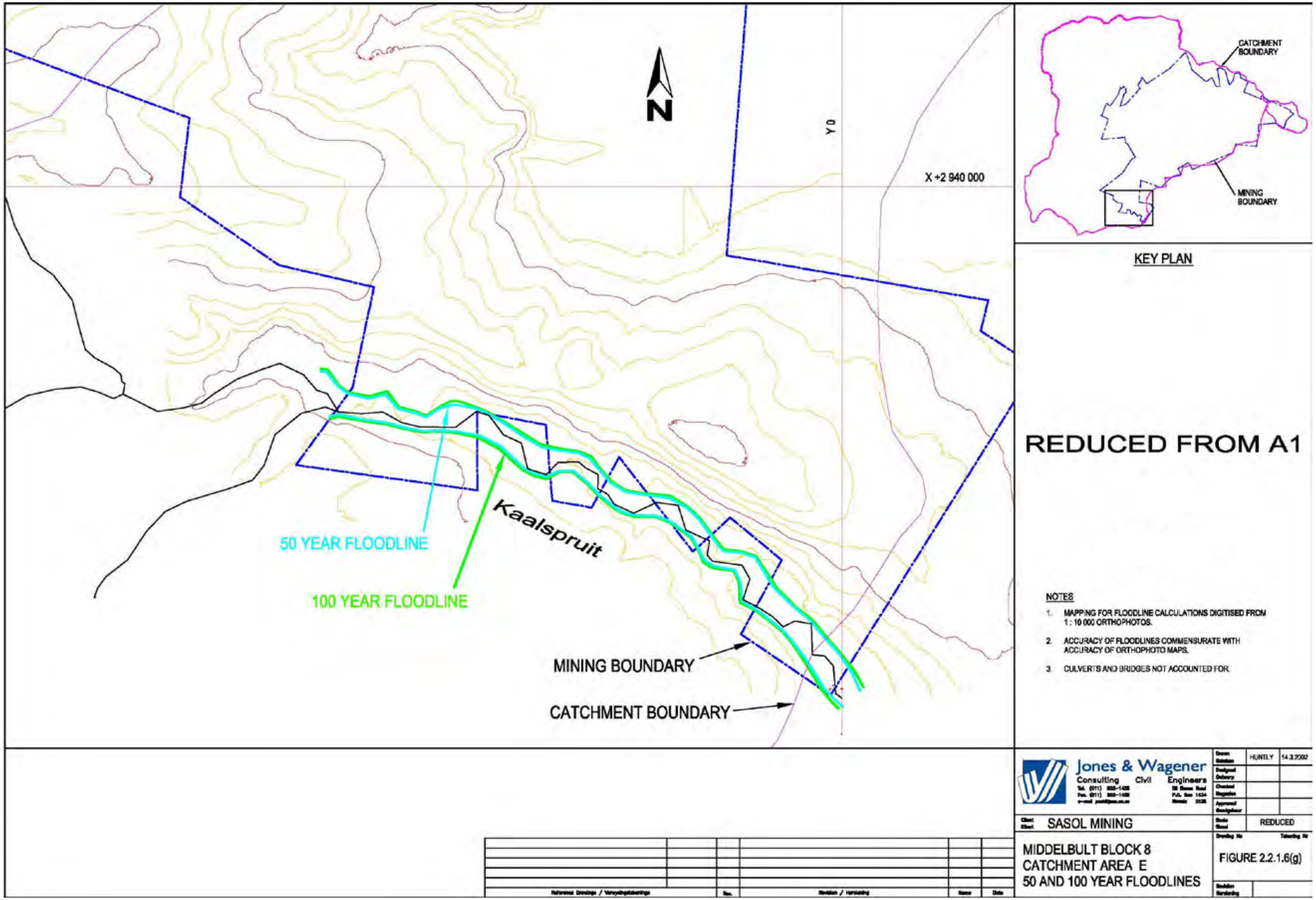

Figure 5.7.1.6(g): Middelbult/Block 8/Shondoni Floodlines: Catchment Area E

5.7.2 Surface Water Quality

Water quality sampling for the Middelbult/Block 8 /Shondoni mining area was undertaken by Jones & Wagener in October 2002 at the following locations:

- In the Kaalspruit, downstream of the mining area and upstream of the confluence with the Watervalrivier on the farm Roodebank 323 IS (sampling location B1)
- In the Watervalrivier, downstream of the mining area and upstream of the confluence with the Kaalspruit on the farm Vaalbank 280 IS. (sampling location B2)
- In the Kaalspruit immediately upstream of the mining area on the farm Kaalspruit 528 JR. (sampling location B3)
- In a tributary of the Wildebeestspruit, upstream of the mining area on the farm 527 IR(sampling location B4)
- In the Wildebeestspruit, upstream of the mining area on the farm Wildebeestspruit 356 IR. (sampling location B5)
- In the tributary to the south of the Wildebeestspruit, draining into the Wildebeestspruit, upstream of the mining area on the farm Wildebeestspruit 356 IR. (sampling location B6)

Surface water sampling is also undertaken by Sasol Chemical Industries, DWA and active mines in the area at the following locations:

- In the Kleinspruit downstream of the Sasol Secunda Industrial and Mining Complex. (sampling location RESM1)
- In the Trichardspruit downstream of Secunda. (sampling location RESM5)
- Upstream of the Bossiespruit Dam(sampling location RESM 20)
- In the Waterval river downstream of the confluence with the Kaalspruit and downstream of the mining area. (sampling location LM2,LM4,KM 6, KM4)
- In the Grootspruit to the west of Evander. (sampling location KM6)
- In the Waterval River, both upstream and downstream of Leslie Gold Mine. In the Winkelhaakspruit, downstream of the Evander Sewage treatment works. (sampling location LM 4, LM2)

The sampling locations are shown in Figure 5.7.2 (a).

5.7.2.1 Base Line Surface Water Quality

The results for the pre-mining background water quality, as shown in Table 5.7.2.1(c) were compared to the South African Water Quality Guidelines and catchment objectives (DWAF, 1996a) as presented in Table 5.7.2.1(a). In addition, the Water Quality Guideline values (DWAF, 1998) are included in Table 5.7.2.1(b) also for comparison.

However, due to the location of the site falling within the Vaal Dam sub-catchment area, as defined by DWAF (1999), *catchment specific* water quality objectives for certain constituents, namely EC and TDS are available and results have been compared with these values as seen in Table 5.7.2.1(b).

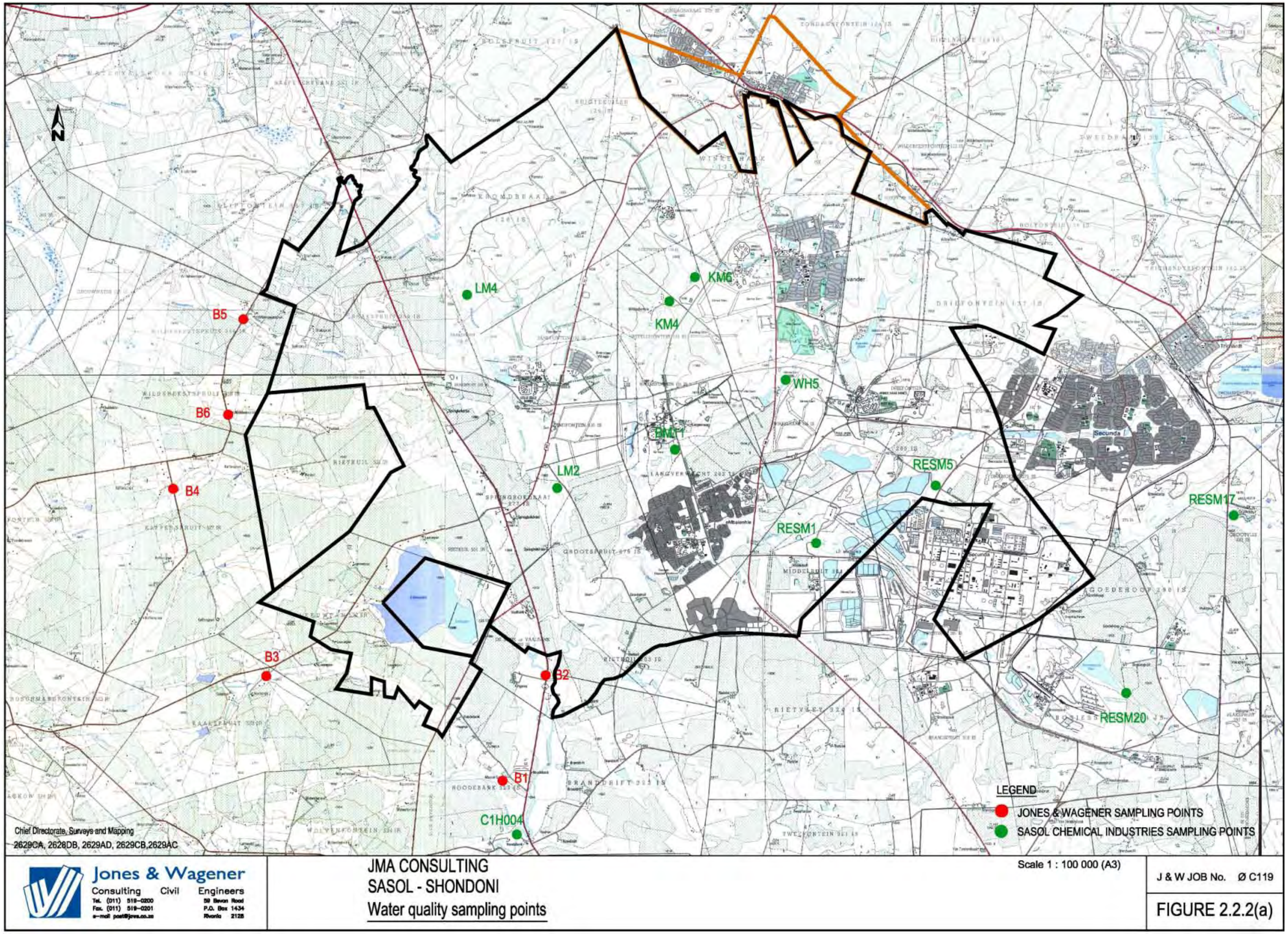

Figure 5.7.2(a): Surface Water Sampling Locations

The catchment specific water quality guidelines are similar to the South African Water Quality Guidelines; they differ in that, the *catchment specific* water quality guidelines are more stringent for particular constituents than the DWAF Domestic water quality guidelines. Compare Table 5.7.2.1(a) and Table 5.7.2.1(b).

The analyses indicates that: -

- The water draining up stream of the Block 8 mining complex in the confluence of Wildebeestspruit and the Kaalspruit contains elevated iron and manganese (even after filtering) and this may affect sensitive groups. The variation in the upstream concentrations compared to the downstream concentrations is small.
- The water draining southwards is considered fit for aquatic use.
- The pH value of the drainage basin shows a slightly high value of 7.7 to 8.3, probably due to the elevated levels of calcium.
- Sampling also indicated aluminium (Al) and Iron (Fe) to be above the limit required for drinking purposes according to Water Quality Guideline values (DWAF, 1998).
- TDS values in the area are generally above the target levels for the catchment.
- EC values in the area above the target levels as indicated in Table 5.7.2.1(b).

Table 5.7.2.1(a) South African Water Quality Guidelines (DWAF, 1996)

Constituent	Water Quality Guideline Value For:					
	Aquatic Ecosystems	Domestic	Recreation (Full Contact)	Industry (Cat. 3)	Agriculture	
					Livestock	Irrigation
pH	within 5% or 0.5 units of background	6 - 9	6.5 - 8.5	6.5 - 8.0	NA	6.5 - 8.4
EC (mS/m)**	-	-	-	-	-	-
SO_4	NA	0 - 200	NA	0 - 200	0 - 1000	NA
TDS	within 1 5% of background	0 - 450	NA	0 - 450	0 – 1000 *	< 40
V	NA	0 - 0.1	NA	NA	0 - 1	0 - 0.10
Cl	NA	0 - 100	NA	0 - 100	0 – 1500 *	0 - 1.00
Alkalinity	NA	NA	NA	0 - 300	NA	NA
Ca	NA	0 - 32	NA	NA	0 - 1000	NA
Mg	NA	0 - 30	NA	NA	0 - 500	NA
Na	NA	0 - 100	Na	NA	0 - 2000	< 70
Fe	NA	0 - 0.1	NA	0 - 0.3	0 - 10	0 - 5
F	< 0.75	0 - 1	NA	NA	0 - 2	0 - 2
Mn	< 0.18	0 - 0.05	NA	0 - 0.2	0 - 10	0 - 0.02
K	NA	0 - 50	NA	NA	NA	NA

Table 5.7.2.1(b) South African Water Quality Guidelines (DWAF, 1999)

Constituent	Water Quality Guideline value
TDS	160-170mg/l
EC	25mS/m

NA - Not Available

** Most stringent guideline taken (dairy, pigs and poultry)*

***The potable water standard for EC is 70mS/m (Quality of Domestic Water Supplies, 1998)*

5.7.3 Surface Water Use

Surface water use downstream of the site is used primarily for informal domestic purposes, agricultural and natural aquatic systems. There are no major dams immediately downstream of the site. The site is within the Vaal Dam catchment, which is located downstream on the Vaal River.

A full list of land owners in the Middelbult/Block 8/ Shondoni Mining Area is given in section 4.5 of this report. Details of downstream surface water users are shown in Table 5.7.3(a).

Table 5.7.2.1(c) Pre-Mining Water Quality of Rivers Draining over the Middelbult/Block 8/Shondoni Mining Area.

Sample		Guideline for domestic water use (DWAF, 1998)	B1 Downstream of mining area on the Kaalspruit	B2 Downstream of the mining area on the Watervalrivier	B3 Upstream of the mining area on the Kaalspruit	B4 Upstream of the mining area on the farm 527IR	B5 Upstream of mining area on the Wildebeestspruit	B6 Upstream of mining area on a tributary of the Wildebeestspruit
pH	**Ave**	5-9.5	7.9	7.8	7.7	8.3	8.0	8.1
	Min-Max		7.3-8.4	7.4-8.3	7.2-8.1	7.4-8.9	7.6-8.4	7.6-8.6
	Coeff of Var. (%)		7.1	5.2	4.9	7.7	4.3	6.2
EC	**(mSm) Ave**	150	39.3	40.1	35.2	46	59.7	59.7
	Min-Max		20.1-50.6	25.8-51.2	27-43.1	29.8-53.4	51.5-65.0	53.3-70.1
	Coeff of Var. (%)		35	28.8	19.9	24.1	9.7	15.2
Fe	**(mg/l)**	0.2	Filt. / Unfilt	Filt. / Unfilt	Filt. / Unfilt	Filt. / Unfilt.	Filt. / Unfilt.	Filt. / Unfilt
	Ave		0.52 / 0.89	0.15 / 1.11	0.81 / 1.97	0.34 / 0.76	0.08 / 0.37	0.34* / 0.85
	Min- Max		0.14-0.91 / 0.35-1.78	0.12-0.18 / 0.49-1.58	0.71-0.97 / 0.75-4.12	0.23-0.45 / 0.29-1.50	BDL-0.08 / 0.16-0.51	/ 0.58-1.24
	Coeff of Var. (%)		104.7 / 76.8	26.2 / 48.5	17.3 / 76.4	47.6 / 70.1	/ 44.1	/ 41.3
Alk	**(as $CaCO_3$) (mg/l) Ave**	-	152.5	165.5	150	188.8	248	273
	Min-Max		70-205	100-220	110-175	120-232	200-287	245-324
	Coeff of Var. (%)		38.5	31.3	19.8	25.5	15.6	16.2
Na	**(mg/l) Ave**	200	30	30	30.8	38.3	38.8	53.3
	Min-Max		18-34	26-35	28-33	28-45	37-40	48-61
	Coeff of Var. (%)		26.7	13.1	7.2	18.9	3.2	12.8
K	**(mg/l) Ave**	50	7.5	5.1	6.3	4.2	3.4	3.3
	Min-Max		6.5-8.4	4.6-5.7	5-8.5	3.5-4.9	3.1-3.6	2.4-4.3
	Coeff of Var. (%)		12.0	10.8	24.6	17.0	6.2	28.5
Ca	**(mg/l) Ave**	150	29.3	25.5	20.3	25.3	43.5	35.3
	Min-Max		13-39	15-30	14-23	18-35	32-58	20-54
	Coeff of Var. (%)		41.4	27.6	21.1	29.7	26.4	48.8
Mg	**(mg/l) Ave**	70	14.5	18.8	15	24	32.5	31.3
	Min-Max		7-21	11-24	8-19	14-31	28-37	26-39
	Coeff of Var. (%)		40	34.1	28.8	33.5	14.3	21.7
	Cl (mg/l) Ave	200	15	15.3	13	19.3	19.8	16.7
	Min-Max		6-22	6-20	8-19	7-27	14-24	12-21

Sample	Guideline for domestic water use (DWAF, 1998)	B1 Downstream of mining area on the Kaalspruit		B2 Downstream of the mining area on the Watervalrivier		B3 Upstream of the mining area on the Kaalspruit		B4 Upstream of the mining area on the farm 527IR		B5 Upstream of mining area on the Wildebeestspruit		B6 Upstream of mining area on a tributary of the Wildebeestspruit	
Coeff of Var. (%)		47.1		43.3		35.0		45.0		25.6		27.1	
SO_4 (mg/l) Ave **Min-Max** **Coeff of Var. (%)**	400	21.5 15-34 39.9		27.3 20-40 32.5		12.8 10-18 29.6		32.3 20-48 36.5		50.8 43-61 15.0		32.7 22-46 37.4	
Mn (mg/l) Ave **Min- Max** **Coeff of Var. (%)**	0.5	Filt. 0.09 0.06-0.13 54.4	Unfilt 0.18 0.06-0.26 48.2	Filt. 0.09 0.06-0.12 47.1	Unfilt 0.48 0.36-0.60 26.8	Filt. 0.10 0.03-0.23 122.3	Unfilt 0.80 0.11-2.55 147.6	Filt. 0.16 0.13-0.18 24.2	Unfilt. 0.24 0.06-0.56 93.9	Filt. 0.26 0.12-0.40 76.2	Unfilt. 0.42 0.36-0.49 13.8	Filt. 0.07*	Unfilt 0.40 0.12-0.89 108.1
Al (mg/l) Ave **Min- Max** **Coeff of Var. (%)**	0.3	Filt. 0.79 BDL-0.79	Unfilt 0.98 0.20-2.51 106.9	Filt. 0.16 BDL-0.16	Unfilt 0.86 0.63-1.31 35.2	Filt. 0.1 BDL-0.1	Unfilt 0.18 0.08-0.29 59.2	Filt. 0.38 BDL-0.38	Unfilt. 0.59 0.16-1.29 84.8	Filt. BLD	Unfilt. 0.36 0.24-0.46 25.6	Filt. 0.45*	Unfilt 0.55 0.33-0.81 44.8

Note: Fe, Mn, Al, and Zn samples were all filtered, BDL = below detection limit, Filt = Filtered samples, *Only 1 sample was taken

Table 5.7.3(a) Downstream Surface Water Users

Name of owner	Farm Name	Farm Portion	Usage		
			Irrigation	Livestock	Domestic
Anderson, Hendrik J	Klipfontein 621 IR	5			
Badenhorst, H	Wolvenfontein 534 IR	2			
Bierman, Gerhard	Paardefontein 584 IR	7		✓	✓
	Paardefontein 584 IR	18		✓	✓
	Klipdrift 324 IS	0	✓	✓	✓
	Klipdrift 324 IS	1	✓	✓	✓
	Klipdrift 324 IS	2	✓	✓	✓
	Paardefontein 584 IR	21	✓	✓	✓
	Paardekuil 583 IR	0	✓	✓	✓
Bowker, Rodney Miles	Poortjesfontein 398 IS	2		✓	
Cronje, AH	Zandbaken 585 IR	5		✓	✓
De Witt, Wynand	Paardefontein 584 IR	12		✓	✓
	Paardefontein 584 IR	17		✓	✓
Jankowitz, JA	Klipdrift 324 IS	5		✓	✓
	Klipdrift 324 IS	6		✓	✓
	Klipdrift 324 IS	7		✓	✓
J van Vuuren, Anna M	Poortjesfontein 398 IS	13			
J van Rensburg, Stephanus, Johannes	Klipfontein 621 IR	19			
Kerslake, Dick	Paardefontein 584 IR	10		✓	✓
	Sandbaken 363 IS	0		✓	✓
	Sandbaken 363 IS	4		✓	✓
Kruger, Albertus JA	Groenvley 590 IR	4			
	Groenvley 590 IR	8			
	Groenvley 590 IR	10			
Kruger, Martha EA	Groenvley 590 IR	9			
Kruger, Pik	Greonvlei	1			
Lamplough, Pamela Mary	Oudehoutspruit 586 IR	0			
Louwrens, Koos	Kaalspruit 528 IR	0		✓	✓
	Kaalspruit 528 IR	2		✓	✓
Pistorius, Tinus	Kaalspruit 528 IR	13		✓	✓
Pistorius, Willem	Paardefontein 584 IR	1		✓	✓
	Paardefontein 584 IR	3		✓	✓
	Paardefontein 584 IR	4		✓	✓
	Paardefontein 584 IR	13		✓	✓
	Paardefontein 584 IR	16		✓	✓
	Paardefontein 584 IR	9		✓	✓
	Paardefontein 584 IR	20		✓	✓
Shabangu, Thandiwe	Oudehoutspruit 586 IR	1			
	Oudehoutspruit 586 IR	2			
	Oudehoutspruit 586 IR	17			
	Oudehoutspruit 586 IR	22			
	Oudehoutspruit 586 IR	23			
Spies, L P A	Klipdrift 324 IS	8		✓	✓

Name of owner	Farm Name	Farm Portion	Usage		
			Irrigation	Livestock	Domestic
	Kromdraai 325 IS	8		✓	✓
Urquhart, AA	Kaalspruit 528 IR	6	✓	✓	✓
Urquhart, AA	Kaalspruit 528 IR	9	✓	✓	✓
	Roodebank 323 IS	1	✓	✓	✓
	Roodebank 323 IS	13	✓	✓	✓
	Roodebank 323 IS	20	✓	✓	✓
Wessels, AH	Klipdrift 324 IS	3		✓	✓
	Klipdrift 324 IS	4		✓	✓
	Roodebank 323 IS	6		✓	✓
	Roodebank 323 IS	7		✓	✓
	Roodebank 323 IS	9		✓	✓
	Roodebank 323 IS	10		✓	✓
	Roodebank 323 IS	11		✓	✓
	Roodebank 323 IS	12		✓	✓
	Roodebank 323 IS	18		✓	✓
	Roodebank 323 IS	19		✓	✓
	Groenvley 590 IR	7			
	Klipfontein 621 IR	2			
	Klipfontein 621 IR	16			
	Klipfontein 621 IR	21			
	Klipfontein 621 IR	6			
	Klipfontein 621 IR	8			
Earlybird Farm	Klipdrift 324 IS	9			✓
	Klipdrift 324 IS	10			✓
	Paardefontein 584 IR	8			
	Paardefontein 584 IR	0			
	Oudehoutspruit 586 IR	4			
	Oudehoutspruit 586 IR	21			
Terblanche, CJ	Roodebank 323 IS	00024			
Sawyer, Tom	Oudehoutspruit 586 IR				
Hatting, Phillipus W	Hartbeestdraai 620 IR	4		☐	☐
Hatting, Frank Philip	Hartbeestdraai 620 IR	5			
Kerslake, Dick	Hartbeestdraai 619 IR	0		☐	☐
	Hartbeestdraai 619 IR	2		☐	☐
	Grootspruit 617 IR	2		☐	☐
	Grootspruit 617 IR	9		☐	☐
	Grootspruit 617 IR	17		☐	☐
Kruger, Albertus JA	Groenvley 590 IR	4			
	Groenvley 590 IR	8			
	Groenvley 590 IR	10			
Kruger, Martha EA	Groenvley 590 IR	9			
Kruger, Pik	Greonvlei	1			
Moolman, Theuns	Hartbeesdraai			☐	

Name of owner	Farm Name	Farm Portion	Usage		
			Irrigation	Livestock	Domestic
Riekert, Dirk	de Pan 615 IR	0		☐	
	de Pan 615 IR	2		☐	
	de Pan 615 IR	14		☐	
	de Pan 615 IR	15		☐	
Shabangu, Thandiwe	Groenvley 589 IR	3			
Swanepoel, Pieter A	Elandslaagte 618 IR	10		☐	☐
van Dyk, Johan	Hartbeestdraai 620 IR	6			
	Hartbeestdraai 620 IR	7			
	Hartbeestdraai 620 IR	8			
	Hartbeestdraai 620 IR	0			
	Hartbeestdraai 620 IR	1			
	Hartbeestdraai 620 IR	9			
	Hartbeestdraai 620 IR	10			
	Hartbeestdraai 620 IR	11			
	Grootspruit 617 IR	3			
	Grootspruit 617 IR	10			
Lane Reynolds Trust	Grootspruit 617 IR	5		☐	☐
	Grootspruit 617 IR	11		☐	☐
	Grootspruit 617 IR	14		☐	☐
	Grootspruit 617 IR	15		☐	☐
	Grootspruit 617 IR	19		☐	☐
	Grootspruit 617 IR	18		☐	☐
	Groenvley 590 IR	1			
	Groenvley 590 IR	2			
	Groenvley 589 IR	1			
	Groenvley 589 IR	2			

5.7.4 Water Authority

The mine falls within the Department of Water Affairs Gauteng Region.

5.7.5 Wetlands

The wetlands have been addressed separately by the wetland specialist – see section 5.10.

5.7.6 Interested and Affected Parties

To be addressed as part of the Public Participation Process.

5.7.7 Aquatic Ecosystems/Biomonitoring

Aquatic Ecosystems and Biomonitoring have been assessed separately as a specialist report - see section 5.11.

5.8 TERRESTRIAL ECOLOGY (PLANT LIFE)

This section provides a baseline vegetation description of the study area by expanding on an existing study that was undertaken for a smaller part of the study area (EkoInfo cc 2004). Since the original study was completed, the study area has been expanded.

The main data collection for this project was undertaken for a previous study at the site (EkoInfo cc 2004). The results from this previous study have been used to extrapolate the existing vegetation map into the additional areas covered by the present study.

Literature surveys and Internet and Geographic Information System (GIS) reviews were completed to obtain a broad environmental overview of the area. A preliminary species list was obtained from the National Botanical Institute based on the relevant quarter degree map. This information was used to determine whether any rare or endangered species had been collected from the area. The results of this assessment were used to compile an identity kit of any rare or endangered species.

Homogenous units were delineated on the preliminary soil map of the proposed mining area. The homogenous areas were based on texture and expected soil moisture characteristics of the area. Plots were placed within homogenous units, with the aid of a Geographic Information System (GIS). The coordinates of the plots were then exported to a GPS receiver for navigation in the field. Actual location in the field was recorded within a 5 m accuracy interval.

At each plot, the following abiotic attributes were documented:

- Topography – altitude, terrain unit, percentage slope
- Soil – soil form, soil depth (mm), erosion, estimated percentage clay of A horizon
- Estimated percentage rock cover – gravel, small, medium, large

The following overall vegetation characteristics were documented:

- Vegetation cover – total, trees, shrubs, herbs, open water, rock
- Estimated average height of trees, shrubs and herbs – highest and lowest categories

A list of all species within an approximate 200 m^2 area was recorded in the following growth form categories: grasses, forbs and woodies. Cover abundance values were estimated for each species within the plot. Unknown species or potential red data species were identified using field guides (Van Oudtshoorn 1991, Van Wyk & Malan 1988), the University of Pretoria's herbarium and specialists from the National Botanical Institute.

The survey results were entered into a relational Database for record purposes and analysis of the abiotic and vegetation characteristics. The species data was entered into TURBOVEG (Hennekens 1996) and analysed with MEGATAB (Hennekens 1996). A vegetation map was compiled, based on the results of the phytosociological table and boundaries of the homogenous units.

5.8.1 Regional Description of Relevant Attributes

5.8.1.1 Location

The study area is situated to the west of the town of Secunda in the Mpumalanga Province (Figure 5.8.1.1(a). It includes portions of the original farms Driefontein 137 IS, Kinross 133 IS, Winkelhaak 135 IS, Ruigtekuilen 129 IS, Leeuwspruit 134 IS, Witkleifontein 131 IS, Kromdraai 128 IS, Zandfontein 139 IS, Springbokdraai 277 IS, Brakspruit 359 IR and Leeupan 532 IR. The study areas fall within the quarter degree squares 2628BD, 2628DB, 2629AC and 2629CA.

5.8.1.2 Topography

The landscape consists of hills, plains and lowlands. A digital terrain model based on 20 m contour intervals was used to determine slope categories. Slopes in the 5° range dominate the area.

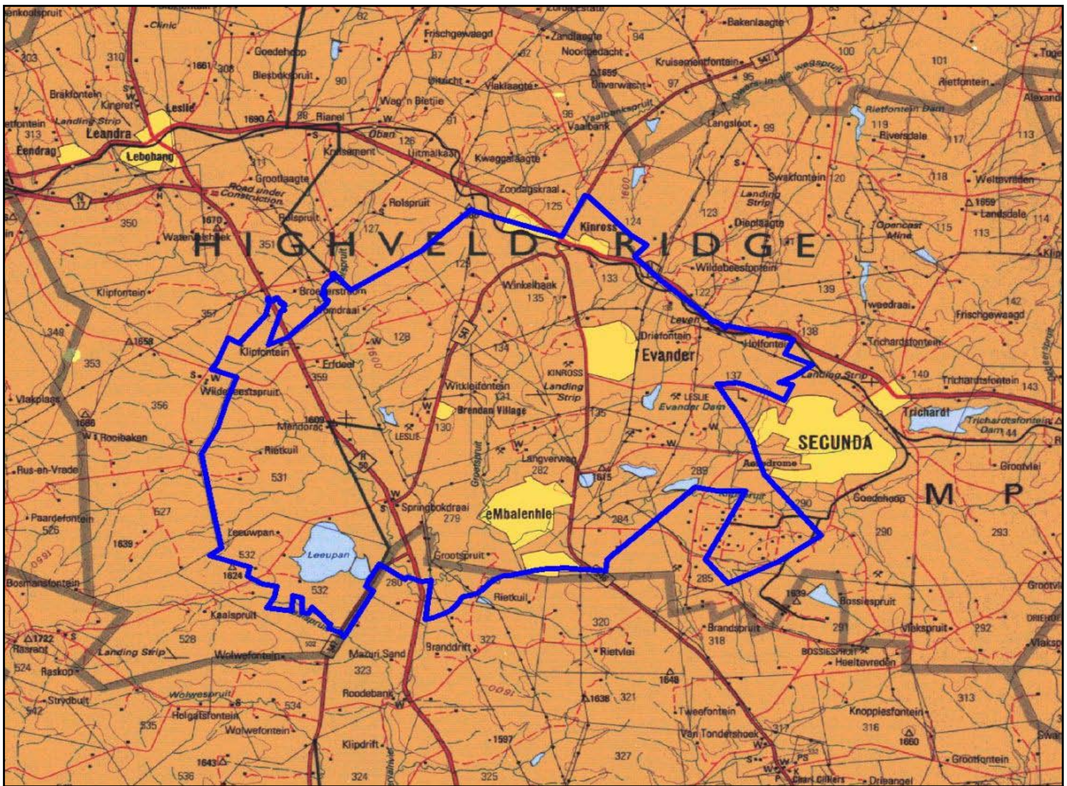

Figure 5.8.1.1(a): Location and Boundaries of Site

5.8.1.3 Geology, Soils and Rainfall

Two stratigraphic units underlay the study area, namely sedimentary arenite and shale of the Vryheid Formation within the Ecca Group of the Karoo sequence and igneous Karoo dolerites. (Figure 5.8.1.3(a)). Depending on their sequence and manner of exposure, these lithological units have an influence on the regional soil texture. Both the dolerites and shales are sources of fine textured soils. It is therefore expected that clayey soils would be common in the area.

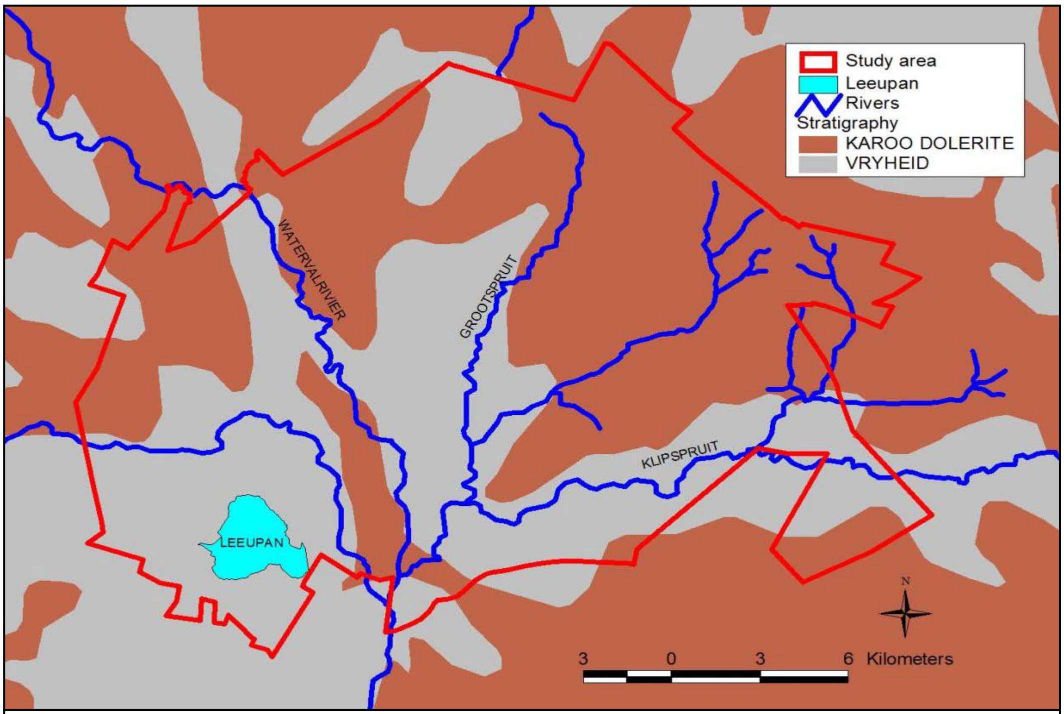

Figure 5.8.1.3(a): Lithological Units of the Study Area

The study area transects two land types (Land Type Survey Staff, 1987), the Bb and the Ea units (Figure 5.8.1.3(b)). The Ea land type refers to dark, blocky clay topsoils (often swelling clays) and/or red, structured clays. This unit covers 83% of the area. The combined presence of the clayey soil form Arcadia across the crests, midslopes and foot slopes is 70% within this Ea land type unit.

The Bb land type refers to moderately to highly leached, red soils with a plinthic catena. This unit covers only 13% of the area. In this Bb land type unit, the same clayey soils are restricted to the valley bottoms. These clayey soils (Arcadia and Rensburg) are present within 50% of this terrain unit. Sandy soil forms cover the remaining terrain units of the Bb land type.

The rainfall in the study area is approximately 700 mm per annum and occurs mainly in the summer (Dent et al. 1989).

5.8.1.4 Landuse and Landcover

A landcover map of the study area (Fairbanks *et al*. 2000) indicates that the site is within a grassland area that has been heavily impacted upon by cultivation. Mapped areas of cultivation are widespread on site on the Surveyor-General's 1:50 000 topocadastral map of the area. Mining and urbanisation have also led to significant amounts of transformation of natural vegetation. There are also various man-made and natural water-bodies on site and a few stands of alien trees.

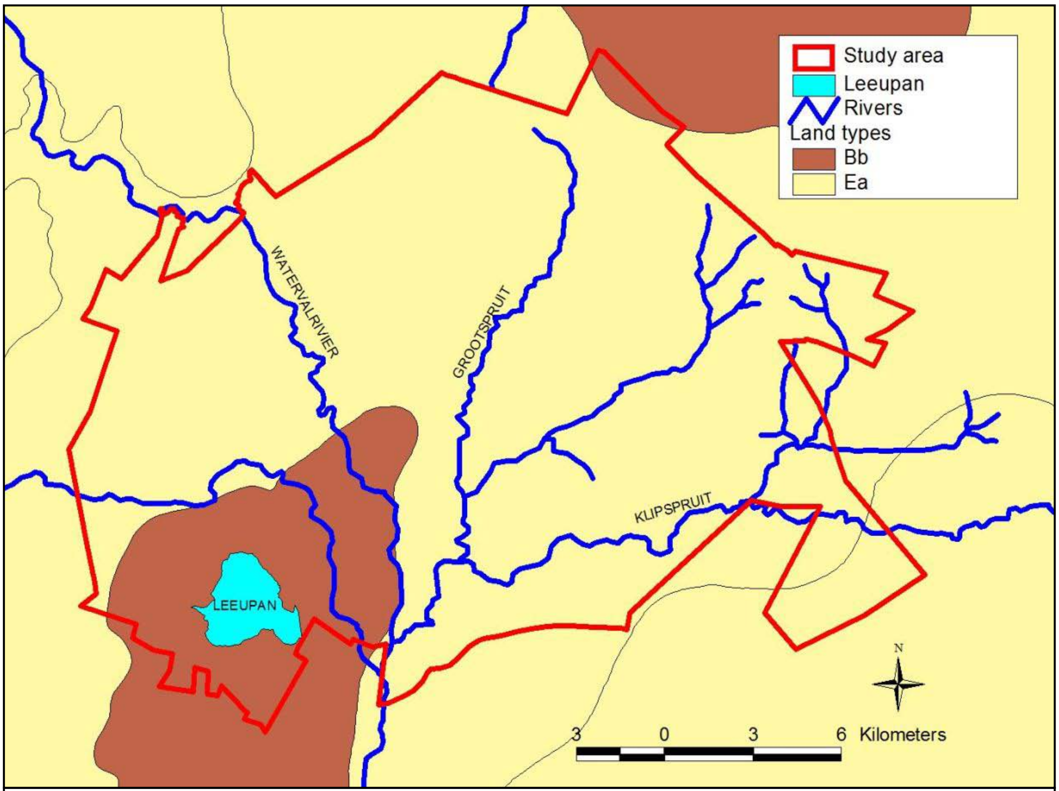

Figure 5.8.1.3(b): Land Type Units of the Study Area

5.8.2 Vegetation, Biogeography and Conservation Value

The study area is located within the grassland biome of South Africa. The grassland biome, due to agricultural and mining activities is one of the most threatened biomes in South Africa.

There are three general descriptions of the vegetation in the study area. Acocks (1953) published the first comprehensive description of the vegetation of South Africa, which was updated in 1988. This was followed by an attempted improvement (Low & Rebelo 1998) which became widely used due to the inclusion of conservation evaluations for each vegetation type, but is often less rigorous than Acocks's original publication. Recently, a more detailed map of the country was produced (Mucina *et al.*, 2005).

A companion guide to this map (Mucina & Rutherford 2006), containing up-to-date species information and a comprehensive conservation assessment of all vegetation types, has just been published. The classification of the vegetation according to the most recent publication is given below and the distribution of different vegetation types across the study area is shown in Figure 5.8.2(a).

According to this most recent vegetation map of the country the study area falls within one main vegetation type, namely Soweto Highveld Grassland. There is also a small area of Eastern Highveld Grassland and Leeupan is classified as Eastern Temperate Freshwater Wetlands.

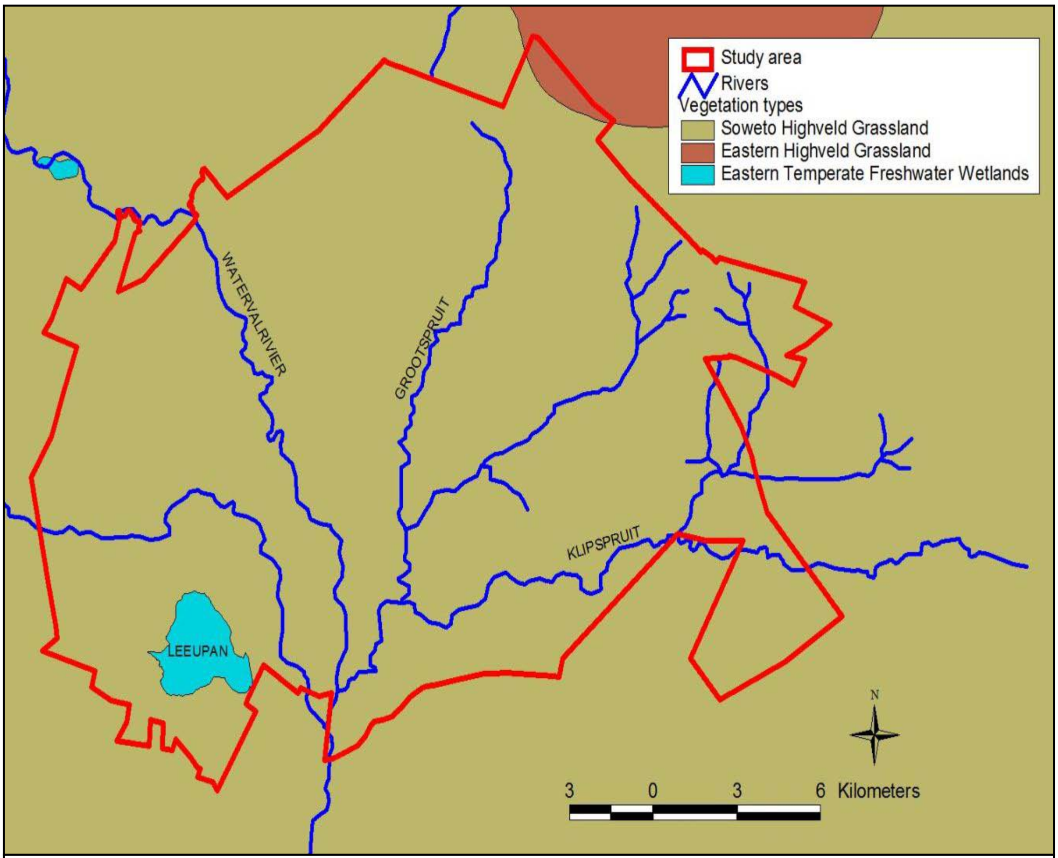

Figure 5.8.2(a): Vegetation Types of the Study Area

According to (Mucina et al., 2006), Soweto Highveld Grassland occurs on gently to moderately undulating landscapes. There is a continuous grassland cover that is only occasionally interrupted by small wetlands, narrow stream alluvia, pans and ridges or rocky outcrops. Soweto Highveld Grassland occurs on shale, sandstone or m udstone of t he M adzarawinge Formation or t he i ntrusive K aroo S uite dolerites. S oils a re de ep, r eddish on f lat pl ains a nd a re t ypically E a, Ba and B b landtypes.

The ve getation i s de scribed a s a s hort t o m edium-high, de nse, t ufted grassland dominated almost e ntirely b y *Themeda triandra* accompanied by ot her g rasses such as *Elionurus muticus*, *Eragrostis racemosa*, *Heteropogon contortus* and *Tristachya leucothrix*. A m ore c omplete l ist of expected s pecies i n undi sturbed Soweto Highveld Grassland include the following:

Graminoids (dominant): *Andropogon appendiculatus*, *Brachiaria serrata*, *Cymbopogon pospischilii*, *Cynodon dactylon*, *Elionurus muticus*, *Eragrostis capensis*, *Eragrostis chloromelas*, *Eragrostis curvula*, *Eragrostis plana*, *Eragrostis planiculmis*, *Eragrostis racemosa*, *Heteropogon contortus*, *Hyparrhenia hirta*, *Setaria nigrirostris*, *Setaria sphacelata*, *Themeda triandra*, *Tristachya leucothrix*.

Graminoids (accompanying): *Andropogon schirensis*, *Aristida adscensionis*, *Aristida bipartita*, *Aristida congesta*, *Aristida junciformis*, *Cymbopogon caesius*, *Digitaria diagonalis*, *Diheteropogon amplectens*, *Eragrostis micrantha*, *Eragrostis superba*, *Harpochloa falx*, *Michrochloa caffra*, *Paspalum dilatatum*.

Herbs: *Hermannia depressa* (d), *Acalypha angustata*, *Berkheya setifera*, *Dicoma anomala*, *Euryops gilfillanii*, *Geigeria aspera*, *Graderia subintegra*, *Haplocarpha scaposa*, *Helichrysum miciniifolium*, *Helichrysum nudifolium*, *Helichrysum rugulosum*, *Hibiscus pusillus*, *Justicia anagalloides*, *Lippia scaberrima*, *Rhynchosia effusa*, *Schistostephium crataegifolium*, *Selago densiflora*, *Senecio coronatus*, *Vernonia oligocephala*, *Wahlenbergia undulata*

Geophytes: *Haemanthus humilis*, *Haemanthus montanus*

Herbaceous climbers: *Rhynchosia totta*

Low shrubs: *Anthospermum hispidulum*, *Anthospermum rigidum* subsp. *pumilum*, *Berkheya annectens*, *Felicia muricata*, *Ziziphus zeyheriana*.

Soweto Highveld Grassland is considered to be Endangered, with none conserved and at least 45% transformed, mostly by urbanization (8%), which is spreading rapidly, and cultivation (36%) (Mucina & Rutherford, 2006). The Draft National List of Threatened Ecosystems (GN1477 of 2009), published under the National Environmental Management: Biodiversity Act (Act No. 10, 2004), lists this vegetation type as Vulnerable.

There is a very small area of Eastern Highveld Grassland on site, just to the north of Kinross. Eastern Highveld Grassland is described as occurring on slightly to moderately undulating plains including some low hills and pan depressions (Mucina *et al*., 2006). The conservation status of this vegetation type is Endangered (Driver *et al*., 2005 and Mucina *et al*., 2006), and whilst the conservation target is 24%, only a small extent is currently protected and 44% is considered to be transformed, mostly by cultivation, urbanization, forestry, building of dams and mining (Mucina & Rutherford, 2006).

The Draft National List of Threatened Ecosystems (GN1477 of 2009), published under the National Environmental Management: Biodiversity Act (Act No. 10, 2004), lists the Eastern Highveld Grassland vegetation type as Vulnerable.

The vegetation of the Ba, Bb, Ea and Ib land types in this region (just to the south of the site) has been studied in some detail (Breytenbach 1991, Breytenbach et al. 1993a, b, c), although data is not presented in a geo-referenced format. There is therefore some information that can be used to place the current study area in context (see Mucina et al. 2000), as well as the broad descriptions of Acocks (1953, 1988) and Low and Rebelo (1998) as well as the more-recently compiled national vegetation map (Mucina & Rutherford 2006).

Within the Bb land type Breytenbach (1991) identifies three plant communities:

1. The high-lying *Cynodon dactylon – Pogonarthria squarrosa* Grassland on deep (>900 mm) sandy soils;
2. the *Themeda triandra – Aristida sciurus* Grassland on shallow (<300 mm) rocky soils; and
3. the low-lying *Eragrostis curvula – Eragrostis plana* Grassland on the floodplains.

The third unit was divided by Breytenbach into four sub-communities. The environmental factors, which influence the distribution of these communities and sub-communities, are firstly soil texture and secondly soil moisture conditions. Community one is mainly associated with well-drained sandy soils, while communities two and three are associated with good to poorly drained clayey and clayey-loam soils.

During his study of the Ea land type Breytenbach (1991) distinguished between high-lying and low-lying areas, each with its own mosaic of communities and sub-communities (Breytenbach 1993). He identified the following communities within the low-lying *Themeda triandra – Eragrostis curvula* Grassland:

1. *Eragrostis curvula – Pogonarthria squarossa* Grassland
2. *Themeda triandra – Elionurus muticus* Grassland
3. *Themeda triandra – Chaetacanthus burchellii* Grassland
4. *Eragrostis curvula – Schoenoplectus decipiens* Grassland
5. *Eragrostis curvula – Eragrostis plana* Grassland

Two of these communities namely the *Themeda triandra – Elionurus muticus* Grassland and the *Themeda triandra – Chaetacanthus burchellii* Grassland were divided into seven sub-communities. The environmental factors that influence the distribution of these communities are also soil texture with four of the five associated with clayey soils, while altitude is important in terms of location and terrain unit.

Within the high-lying *Themeda triandra – Heteropogon contortus* Grassland area Breytenbach identified two communities of which one has two sub-communities:

1. *Diospyros lyciodes – Eragrostis curvula* Shrubland
2. *Themeda triandra – Elionurus muticus* Grassland

The latter was divided into two sub-communities. Altitude plays a key role in the distribution of these communities and sub-communities.

In both articles Breytenbach mentions the effects and threats of poor veld management on the environment and society and the need to improve the management and conservation of these renewable resources.

The following section provides a description of the floristic environment that may be affected by the proposed development. This description includes patterns of flora and vegetation within the study area. The results are based on the original survey undertaken for the site (EkoInfo 2004) and extrapolated to include the additions to the study area.

5.8.3 Vegetation Patterns

Two plant communities and four variations were identified during the original vegetation survey within the study area (EkoInfo 2004). These communities are:

1. *Themeda triandra – Berkheya carlinopsis* Grassland Community on clayey soils
   a. *Themeda triandra – Berkheya carlinopsis – Cirsium vulgare* Low lying variation
   b. *Themeda triandra – Berkheya carlinopsis – Elionurus muticus* High lying variation

2. *Hyparrhenia hirta – Helichrysum nudifolium* Grassland Community on sandy soils
   a. *Hyparrhenia hirta – Helichrysum nudifolium – Trichoneura grandiglumus* Over utilised variation
   b. *Hyparrhenia hirta – Helichrysum nudifolium – Commelina africana* Disturbed variation

An indication of the floristic relationship of these communities to one another and the environmental attributes that distinguish them is provided in Figure 5.8.3(a). As it was not possible to map the distribution of the four variations due to the extent of the study area and the complexity of the landscape, only the potential distribution of the two major communities were mapped based on the distribution of sandy and clayey soils (Figure 5.8.3(b)). The map also reflects the overall distribution of riparian wetlands within the area, of which only a general opinion was formed during the survey of the terrestrial vegetation and is dealt with in more detail in the wetland survey by other specialists.

Summarised descriptions of the two major plant communities are provided below. for a more detailed description, refer to the original report by EkoInfo (2004).

Themeda triandra – Berkheya carlinopsis Grassland Community on clayey soils

The *Themeda triandra – Berkheya carlinopsis* Grassland Community on clayey soils represents approximately 44% of the study area and 83% of the natural vegetation. It is associated with clayey soils of which the average estimated clay content is 48%. Common, dominant and characteristic species are provided in Appendix 1. Two variations were identified within this community during the survey of which the *Themeda triandra – Berkheya carlinopsis – Cirsium vulgare* Low lying variation is associated with the valley bottoms and low-lying areas within the study area. This community is over utilised by livestock because it is en route to water and is higher in nutrients and soil moisture and therefore more palatable to livestock than the surrounding high-lying areas. The *Themeda triandra – Berkheya carlinopsis – Elionurus muticus* High lying variation is associated with the areas above the valley bottom to the crests. It has the most extensive distribution of the two variations and reflects both natural and human influences ranging from over utilisation to high species diversity.

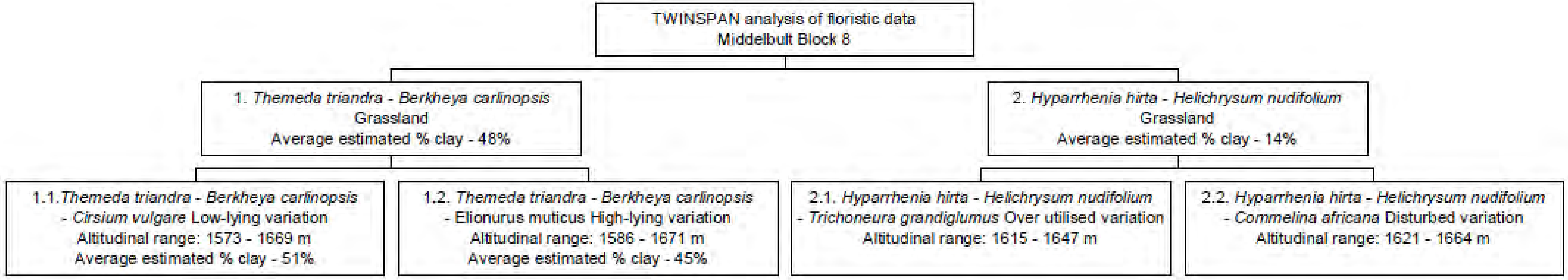

Figure 5.8.3(a): Dendrogram of Floristic Data showing four Data Clusters and their Environmental Attributes (EkoInfo 2004).

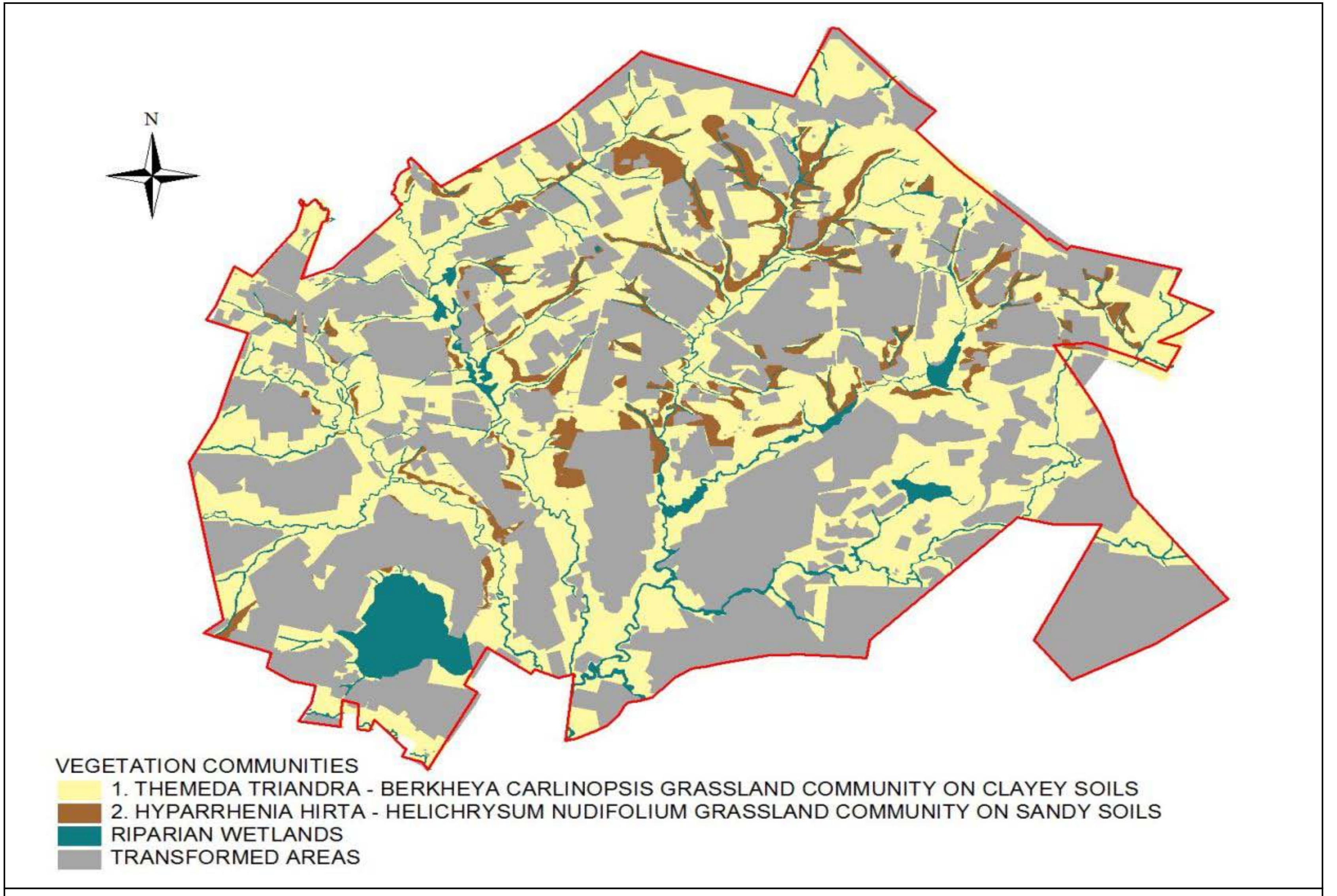

Figure 5.8.3(b): Distribution of Main Vegetation Units based on Soil Texture

***Hyparrhenia hirta – Helichrysum nudifolium* Grassland Community on sandy soils**

The *Hyparrhenia hirta – Helichrysum nudifolium* Grassland Community on sandy soils occurs as islands or stands within the larger *Themeda triandra – Berkheya carlinopsis* Grassland Community on clayey soils. It is associated with sandy soils of which the average estimated clay content is 14%. This community represents approximately 8% of the study area and 17% of the natural vegetation. This does not reflect the true distribution of the sandy soils nor the vegetation associated with the soils, as large areas of the sandy soils have been transformed for cultivation. Common, dominant and characteristic species are provided in Appendix 1. The two variations identified during the survey, reflect this trend. The *Hyparrhenia hirta – Helichrysum nudifolium – Trichoneura grandiglumus* over utilised variation represents a community which has not been mechanically disturbed, but is used for grazing and whose condition can be improved through management. The *Hyparrhenia hirta – Helichrysum nudifolium – Commelina africana* Disturbed variation represents old fields or areas on the border of cultivated fields which had been abandoned due to water logging or change in land use.

Riparian Wetlands

The riparian wetlands found within this area are representative of floodplain/vlei's. The reed, *Phragmites australis*, and bulrush, *Typha capensis*, are characteristic of the floodplain/vlei's. The species composition of the riparian fringes is similar to terrestrial vegetation up to where the streambed starts or open water is found, but may include a high number of facultative wetland species that would not ordinarily be found in terrestrial grassland. On the storage floodplains the location of the ox bow lakes are indicated by a change in vegetation from mesophytic species to hydrophytic species, especially sedges. The levees along the riparian wetland are eroded in most places and are degraded through trampling and over-utilization by livestock. Aesthetically appealing species found in the vicinity of the riparian wetlands include the shrub, *Erythrina zeyheri*, and the geophytes, *Nerine krigei* and *Haemanthus montanus*.

5.8.4 Red List Plant Species

The objective of this section was to compile a list of plant species for which there is conservation concern that may be affected by the proposed infrastructure. This includes threatened, rare, declining and protected plant species.

Lists of plant species previously recorded in the quarter degree grids in which the study area is situated were obtained from SANBI. This list contains 10 species, listed in Table 5.8.4(b) Appendix 3 together with their conservation status categories according to the IUCN Version 3.1 criteria (IUCN, 2001).

Relevant information, such as habitat, flowering time, etc., is given for all species listed. Five of these species are listed as Near Threatened and five as Declining (see Table 5.8.4(a) for explanation of IUCN categories).

Table 5.8.4(a): Explanation of IUCN Ver. 3.1 categories (IUCN, 2001), and Orange List categories (Victor & Keith, 2004)

IUCN category	Definition	Class
EX	Extinct	Extinct
CR	Critically Endangered	Threatened
EN	Endangered	Threatened
VU	Vulnerable	Threatened
NT	Near Threatened	Orange List
Declining	Least Concern, declining taxa	Orange List
Rare	Least Concern, rare	Orange List
Critically Rare	Least Concern, rare: only one subpopulation	Orange List
LC (Rare-Sparse)	Least Concern, rare: widely distributed but rare	Orange List
DDD	Data Deficient: well known but not enough information for assessment	Orange List
DDT	Data Deficient: taxonomic problems	Data Deficient
DDX	Data Deficient: unknown species	Data Deficient
LC	Least Concern	Least Concern

Of the 10 potential red data species three Declining species were recorded during the survey. They were *Boophane disticha*, *Eucomis autumnalis* subsp. *clavata* and *Hypoxis hemerocallidea*. On the basis of information, six of the remaining seven species were considered to have a high chance of occurring in the type of habitats available on site.

Table 5.8.4(b): Red Data Plant Species Recorded in the Study Area

Taxon	Latest (IUCN version 3.1) Conservation Status**	Habitat	Flowering Time	Probability of occurrence*
Boophane disticha	Declining	Dry g rassland a nd r ocky areas	October-January	**DEFINITE**, found on site
Crinum bulbispermum	Declining	Along rivers and streams or in damp depressions in black clay or sandy soil.	September-November	**HIGH**, suitable habitat on site
Eucomis autumnalis subsp. *clavata*	Declining	Open grassland, marshes.	November-April	**DEFINITE**, found on site
Gladiolus robertsoniae	Near Threatened (NT)	Moist highveld grasslands, found in rocky sites, mostly dolerite outcrops. Corms are wedged in rock crevices. Restricted to seeps and stream banks where moisture is available at the end of the dry season.	October-December	**HIGH**, suitable habitat on site
Hypoxis hemerocallidea	Declining	Grassland and mixed woodland.	January-March	**DEFINITE**, found on site
Kniphofia typhoides	Near Threatened (NT)	Low-lying wetlands and seasonally wet areas in climax Themeda triandra grasslands on heavy black clay soils, tends to disappear from degraded grasslands.	February-March	**HIGH**, suitable habitat on site
Nerine gracilis	Near Threatened (NT)	Undulating grasslands in damp, moist areas; the plants grow in full sun in damp depressions, near pans or on the edges of streams; grassland, riverbanks, vleis.	February – March	**HIGH**, suitable habitat on site
Pelargonium sidoides	Declining	Open grassland, often on shallow soils.	February – March	**MEDIUM**, marginal habitat on site
Stenostelma umbelluliferum	Near Threatened (NT)	Deep black turf soil in open woodland mainly in the vicinity of drainage lines.	September – March	**MEDIUM**, marginal habitat on site
Trachyandra erythrorrhiza	Near Threatened (NT)	Marshy areas, grassland, usually in black turf marshes.	September – November	**HIGH**, suitable habitat on site

** Conservation Status Category assessment according to IUCN Ver. 3.1 (IUCN, 2001), as indicated on SANBI website (http://sibis.sanbi.org/, accessed on 28/07/2010).

*Probability of occurrence, as follows: LOW – no suitable habitats occur on site / habitats on site do not match habitat description for species, MEDIUM – habitats on site match general habitat description for species (e.g. grassland), but microhabitat requirements are absent (e.g. rocky grassland on shallow soils overlying dolomite), HIGH – habitats on site match very strongly the general and microhabitat description for the species, DEFINITE – species found on site.

5.8.5 Protected Plant Species

All of the species from the genus *Gladiolus* and All the species from the family Orchidacea are protected in terms of the Mpumalanga Conservation Act's list of protected flora. Species previously recorded in surveys on site and within the quarter degree grid in which the study area is found are the following:

- *Bonatea speciosa*
- *Eulophia welwitschii*
- *Gladiolus crassifolius*
- *Gladiolus robertsoniae*
- *Gladiolus sericeovillosus* subsp. *calvatus*
- *Gladiolus elliotii*

5.8.6 Sensitivity assessment

The sensitivity assessment is an attempt to identify those parts of the study area that may have high conservation value or that may be sensitive to disturbance. Areas containing untransformed natural vegetation, high diversity or habitat complexity, Red List organisms or systems vital to sustaining ecological functions are considered sensitive. In contrast, any transformed area that has no importance for the functioning of ecosystems is considered to have low sensitivity.

According to the Mpumalanga C-plan version there are some sensitive features in and around the study area, as follows (Figure 5.8.6)a)):

- The eastern side of Leeupan is classified as Irreplaceable.
- Vegetation associated with the Watervalrivier and the Wildebeesspruit, as well as most of the remaining habitat along the northern third of the site and a small area of grassland to the south-west of Evander, are classified as Highly Significant.

Additional requirements, as per other environmental legislation are as follows:

- All remaining untransformed grasslands in South Africa are considered to have high sensitivity and conservation value.

The site is situated within an area that contains patches of primary grassland that occurs within the Endangered vegetation type, Soweto Highveld Grassland. There are various parts of the site that contain grassland with good species composition that is considered to be reasonably good quality Soweto Highveld Grassland.

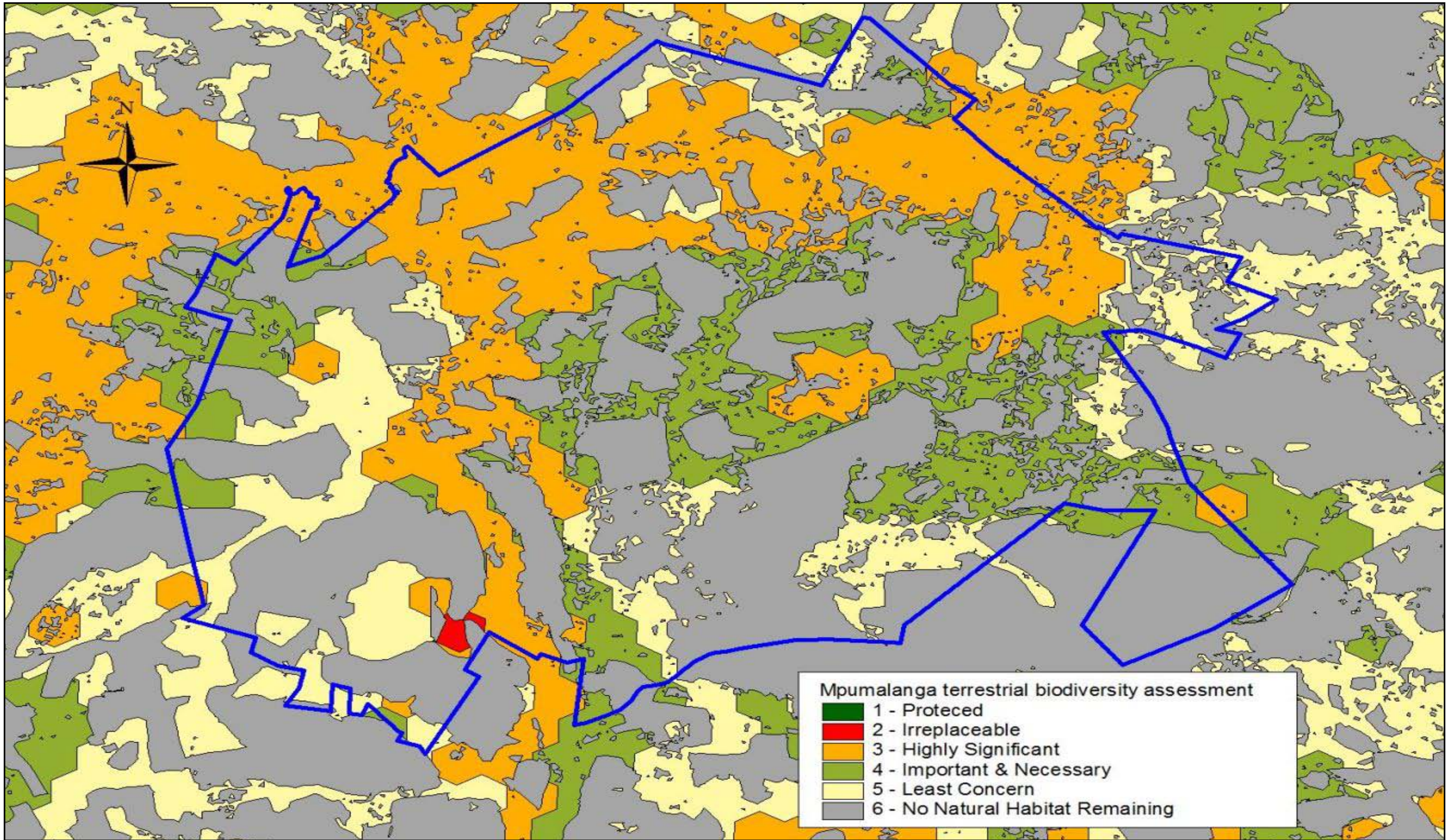

Figure 5.8.6(a): Sensitive Parts of Study Area according to Mpumalanga C-Plan

Table 5.8.6(a): Factors Contributing to Sensitivity Classification of Habitats

Vegetation/habitat type	Sensitivity	Reason
Grassland	High	• representative of an endangered vegetation type (Soweto Highveld Grassland) • protected under National Environmental Management: Biodiversity Act (draft ecosystem list)
Wetlands	High	• habitat in main drainage lines classified as wetlands (National Water Act).

5.8.7 Conclusions

The requirements of this study were to undertake a specialist study to describe the base line vegetation and flora in the study area. The vegetation study identified two major grassland plant communities as well as wetland vegetation in drainage lines. The grassland is within a grassland vegetation type called Soweto Highveld Grassland, which is classified as Endangered and listed in the Draft List of protected ecosystems (National Environmental Management: Biodiversity Act). It is a high conservation priority nationally.

All remaining areas of natural grassland are therefore considered to have high conservation value and ecological sensitivity. All wetlands are considered to be ecologically sensitive. Where natural wetland vegetation still occurs, this is considered to be an important biodiversity resource and is therefore also classified as having elevated sensitivity and conservation value. Remaining natural grasslands and all areas of wetland vegetation should be considered to have HIGH sensitivity. Remaining areas have LOW sensitivity.

5.9 TERRESTRIAL ECOLOGY (ANIMAL LIFE)

A detailed investigation of the fauna (birds and mammals) within the study area was undertaken. The aim of this investigation was to determine the faunal communities likely to occur in the study area and the relative sensitivities of the vegetation habitats which support these communities.

In order to meet the project objectives, the following tasks were performed:

- Compile species lists of all mammals and birds expected to occur within the Quarter Degree Squares (QDS) over which the study area extends based on available literature, distribution maps and previous recorded sightings;
- Groundtruth within the study area to determine the nature of the vegetation and habitats available, assess the levels of disturbance present, and attempt to confirm species presence from field signs (tracks, scats, visual sightings);
- Determine the likelihood of each species occurring within the study area based on habitat requirements, habitat availability and levels of disturbance. Particular emphasis will be placed on species of special concern (Red Data List species, CITES, etc.);
- Identify habitats which are of conservation importance for mammals and birds within the study area; and

A desktop study was conducted to determine the species potentially occurring within QDS 2629 AC, 2629CA, 2628 BD and 2628 DB based upon available information on faunal distribution ranges in southern Africa.

A field survey was then conducted over two days in June 2010 to assess the three new areas added to the study area. This assessment included identifying the types of habitat available and opportunistically surveying the site for signs of species presence (tracks, scats, skulls, visual sightings).

Using information on individual mammal species habitat requirements and the data gained during the field survey it was possible to determine the likelihood of each species occurring based on the presence or absence of important habitat features and the levels of human disturbance.

The list of bird species present within the QDS's mentioned above was obtained from the South African Bird Atlas Project (SABAP 1) conducted by the Animal Demography Unit, University of Cape Town and the South African National Biodiversity Institute.

5.9.1 Regional Description of Relevant Attributes

5.9.1.1 Location

The study area lies within the Mpumalanga Province to the west of Secunda. The towns of Evander, Kinross and eMbalenhle all lie partially or completely within the study area. The original Block 8 study area was approximately 28500 ha, but three additional land reserves have been added: Leeuwpan, Springbokdraai, and Block 8 Northern Reserve. Together, these three additional reserves add 3924.3 ha to the study area.

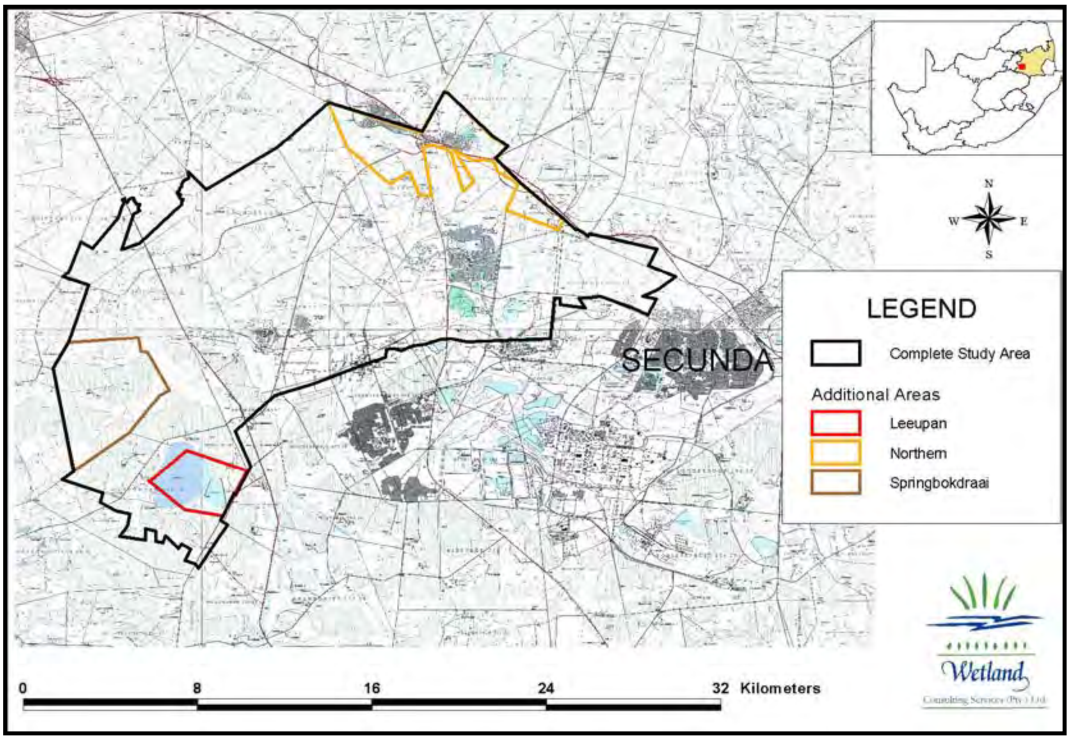

Figure 5.9.1.1(a): Location and Approximate Extent of the Study Area

5.9.1.2 Catchment Information

The study area falls within a summer-rainfall region and lies across three quaternary catchments: C12F, C12D and B11D (Figure 5.9.1.2(a). The mean annual precipitation across the site is 600 – 700 mm and the mean annual runoff is 30 – 60 mm. The rainfall and runoff values for the separate catchments are detailed in the table below (Table 5.9.1.2(a)).

Table 5.9.1.2(a): Characteristics of the Catchments within the Study Area

Quaternary Catchment	Quaternary Catchment Area (ha)	MAP - Mean Annual Precipitation (mm)	MAR - Mean Annual Runoff (mm)	Sediment Yield (1000 t/a)
C12F	75655	634.90	49.1	7
C12D	81343	666.88	59.3	7
B11D	49812	671.47	30.1	7

5.9.1.3 Geology and Soils

The geology is a mosaic of sandstone, shale and coal beds of the Vryheid Formation (Karoo Sequence), intrusive dolerites, and alluvial deposits along the larger rivers. The dolerites and shales weather to fine grained clays, whereas the alluvial deposits and sandstones will produce sandier sediments.

Gold, silver and coal have all been mined in this area in the past or present. The soils are generally expected to be moderate to deep, have a clayey texture and occur over undulating terrain. A combination of the rainfall and runoff characteristics and the nature of the soils leads to high erodibility potential in this area and high sediment yields (Table 5.9.1.2(a)).

Both vertic clay soils and sandy alluvium were observed at different points across the study area.

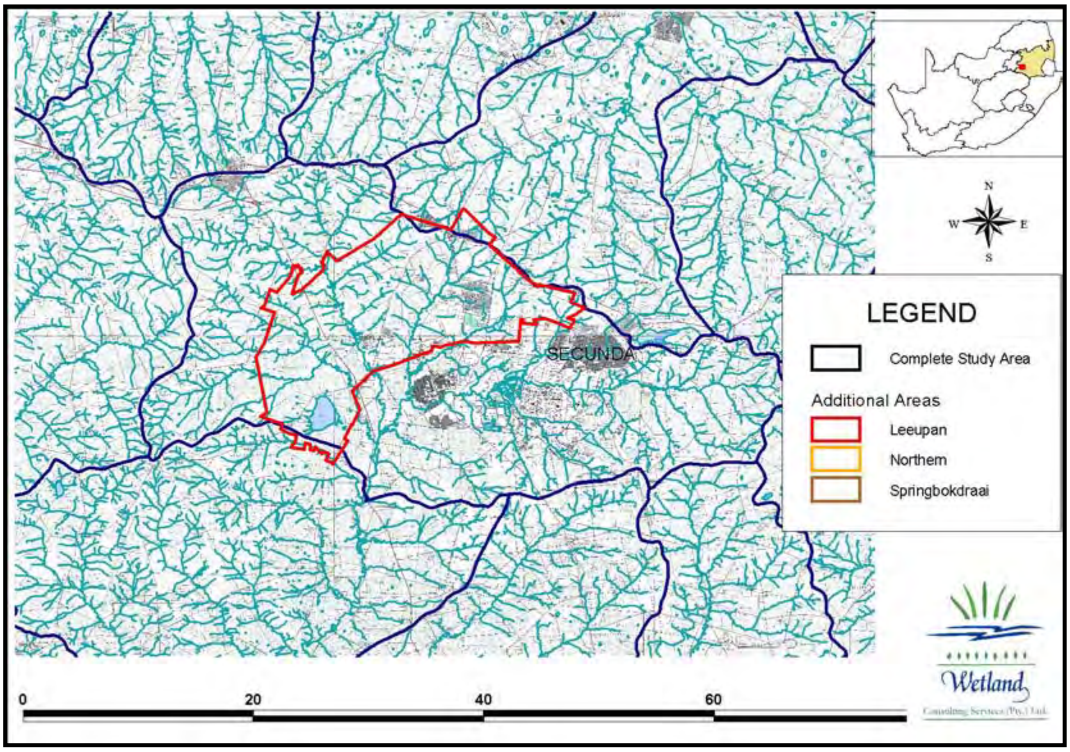

Figure 5.9.1.2(a): Study area relative to the quaternary catchments boundaries and the rivers.

5.9.1.4 Vegetation

The vegetation across the study area is of the Grassland Biome. Soweto Highveld Grassland occurs over the majority of the study area, but a small section of the new northern area is Eastern Highveld Grassland (Mucina and Rutherford 2006). Both vegetation types are considered Endangered due to limited protection in conservation areas and habitat destruction.

Soweto Highveld Grassland is characterised by short to medium-high, dense, tufted grasses dominated almost entirely by *Themeda triandra* and accompanied by such grasses as *Elionurus muticus, Eragrostis racemosa, Heteropogon contortus* and *Tristachya leucothrix*.

Eastern Highveld Grassland is characterised by short, dense grasses dominated by species of the genus's *Aristida, Digitaria, Eragrostis, Themeda* and *Tristachya*. Small, scattered rocky outcrops with wiry, sour grasses and some woody species occur within this grassland type.

T. triandra occurred extensively in those areas not exposed to heavy grazing, as did *Hyparrhenia hirta*, although they did not necessarily occur together. Along the rivers and in the wetlands *Typha capensis* was very common and formed extensive, dense stands.

The grass, *Imperata cylindrica*, also occurred frequently within areas of temporary wetness and along the river banks. Tree species, which occurred most frequently near rivers and dwellings, were mostly exotic, such as *Eucalyptus* sp. and *Salix babylonica*.

The vegetation study done across the original study area identified two vegetation communities:

- *Themeda triandra – Berkheya carlinopsis* Grassland Community on clayey soils; and
- *Hyparrhenia hirta – Helichrysum nudifolium* Grassland Community on sandy soils.

5.9.1.5 Habitat Types

Habitat selection by an animal takes into account a number of biotic and abiotic factors including: plant species present, vegetation structure, topography, pedology, climate, distance to water, presence of rocky outcrops, trees, predators and sufficient food. The level of human disturbance is also an important factor influencing habitat selection.

Within the study area the main habitat types available are short and tall mesic grasslands and riparian and wetland habitat, including floodplains, channelled and unchannelled valley bottom wetlands, and hillslope seepage wetlands. Therefore the species most likely to occur are grassland specialists, species linked to wet habitats and those with wide habitat tolerances.

Some of the habitat types observed during the field survey are shown in the photographs below (Figure 5.9.1.5(a)).

Some of the disturbances in the study area include urban settlements, roads, cultivated and cattle-grazed land and a large coal mining operation. A number of slimes dams and water impoundments are also present.

Figure 5.9.1.2(a): Series of Photographs showing Various Habitats Present

5.9.2 Fauna of the Study Area

5.9.2.1 Mammals

The results of the literature review suggest that 84 mammals species potentially occur within the study area based on their distribution ranges alone, 23 of these species being of conservation concern (Endangered, Near-threatened, Vulnerable) or Data Deficient.

No Red Data List mammal species were observed during the field survey. A list of all Red Data List mammal species recorded for the study is provided below, including their likelihood of occurrence based upon habitat suitability within the study area (Table 5.9.2.1(a)). Both the Spotted-necked otter and the Water rat (both listed as Near Threatened) are likely to occur in the study area based on their habitat requirements, the presence of suitable habitat and the levels of human disturbance.

This does not preclude the possibility of other Red Data List species occurring in the study area, they are merely less likely to occur. A list of mammal species observed in the Study Area is also included in Table 5.9.2.1(b). A complete list of all mammal species potentially occurring in the area is shown in Table 5.9.2.1(c) in Appendix I.

Table 5.9.2.1(a): Red Data List mammal species potentially occurring within QDS 2629AC, 2629CA, 2628BD and 2628DB and their likelihood of occurrence within the study area (DD = Data Deficient, EN = Endangered, NT = Near Threatened, VU = Vulnerable and (E) = Endemic)

SPECIES	COMMON NAME	CONSERVATION STATUS	LIKELYHOOD OF OCCURRENCE
Amblysomus hottentotus	Hottentot's golden mole	DD (E)	Unlikely
Crocidura cyanea	Reddish-grey musk shrew	DD	May Occur
Crocidura mariquensis	Swamp musk shrew	DD	Unlikely
Crocidura silacea	Lesser grey-brown musk shrew	DD	May Occur
Graphiurua platyops	Rock dormouse	DD	May Occur
Lemniscomys rosalia	Single-striped mouse	DD	Likely
Myosorex varius	Forest shrew	DD (E)	May Occur
Poecilogale albinucha	Striped weasel	DD	May Occur
Suncus infinitesimus	Least dwarf shrew	DD (E)	May Occur
Suncus varilla	Lesser dwarf shrew	DD	May Occur
Tatera leucogaster	Bushveld gerbil	DD	Unlikely
Mystromys albicaudatus	White-tailed mouse	EN (E)	May Occur
Ourebia ourebi	Oribi	EN	Unlikely
Amblysomus septentrionalis	Highveld golden mole	NT	May Occur
Atelerix frontalis	South African hedgehog	NT	May Occur
Dasymys incomtus	Water rat	NT	Likely
Lutra maculicollis	Spotted-necked otter	NT	Likely
Miniopterus schreibersii	Schreibers' long-fingered bat	NT	Unlikely

SPECIES	COMMON NAME	CONSERVATION STATUS	LIKELYHOOD OF OCCURRENCE
Myotis tricolor	Temminck's hairy bat	NT	Unlikely
Parahyaena brunnea	Brown hyaena	NT	Unlikely
Rhinolophus clivosus	Geoffrey's horseshoe bat	NT	Unlikely
Manis temminckii	Pangolin	VU	Unlikely
Rhinolophus blasii	Peak-saddle horseshoe bat	VU	Unlikely

Table 5.9.2.1(b): List of mammal species observed during field surveys within the study area

ORDER	SPECIES	COMMON NAME
Carnivora	*Canis mesomelas*	Black-backed jackal
Rodentia	*Otomys irroratus*	Vlei rat
Ruminantia	*Raphicerus campestris*	Steenbok
Carnivora	*Aonyx capensis*	Cape clawless otter
Carnivora	*Atilax paludinosus*	Water/Marsh mongoose
Lagomorpha	*Lepus saxatillus*	Scub hare/Savannah hare
Rodentia	*Hystrix africaeaustralis*	Porcupine
Carnivora	*Cynictis penicillata*	Yellow mongoose
Chiroptera	*Neoromicia capensis*	Cape serotine bat
Lagomorpha	*Lepus capensis*	Cape hare/Desert hare
Rodentia	*Rhabdomys pumilio*	Striped mouse

Table 5.9.2.1(c): List of mammal species potentially occurring within the study area

ORDER	*SPECIES*	*COMMON NAME*
Afrosoricida	***Amblysomus hottentotus***	***Hottentot's golden mole***
Afrosoricida	***Amblysomus septentrionalis***	***Highveld golden mole***
Carnivora	*Aonyx capensis*	*Cape clawless otter*
Carnivora	*Atilax paludinosus*	*Water/Marsh mongoose*
Carnivora	*Canis mesomelas*	*Black-backed jackal*
Carnivora	*Caracal caracal*	*Caracal*
Carnivora	*Cynictis penicillata*	*Yellow mongoose*
Carnivora	*Felis nigripes*	*Black-footed cat*
Carnivora	*Felis silvestris*	*African wild cat*
Carnivora	*Galerella sanguinea*	*Slender mongoose*
Carnivora	*Genetta genetta*	*Small-spotted genet*
Carnivora	*Genetta tigrina*	*Large-spotted genet*
Carnivora	*Ichneumia albicauda*	*White-tailed mongoose*
Carnivora	*Ictonyx striatus*	*Striped polecat*
Carnivora	***Lutra maculicollis***	***Spotted-necked otter***
Carnivora	*Mungos mungo*	*Banded mongoose*
Carnivora	***Parahyaena brunnea***	***Brown hyaena***
Carnivora	***Poecilogale albinucha***	***Striped weasel***
Carnivora	*Proteles cristatus*	*Aardwolf*
Carnivora	*Suricata suricatta*	*Suricate*
Carnivora	*Vulpes chama*	*Cape fox*
Chiroptera	*Eidolon helvum*	*Straw-coloured fruit bat*
Chiroptera	***Miniopterus schreibersii***	***Schreibers' long-fingered bat***
Chiroptera	***Myotis tricolor***	***Temminck's hairy bat***
Chiroptera	*Neoromicia capensis*	*Cape serotine bat*
Chiroptera	*Nycteris thebaica*	*Egyptian slit-faced bat*
Chiroptera	***Rhinolophus blasii***	***Peak-saddle horseshoe bat***
Chiroptera	***Rhinolophus clivosus***	***Geoffrey's horseshoe bat***
Chiroptera	*Sauromys petrophilus*	*Flat-headed free-tailed bat*
Chiroptera	*Tadarida aegyptiaca*	*Egyptian free-tailed bat*
Chiroptera	*Taphozous mauritianus*	*Tomb bat*
Eulipotyphla	***Atelerix frontalis***	***South African hedgehog***
Eulipotyphla	***Crocidura cyanea***	***Reddish-grey musk shrew***
Eulipotyphla	***Crocidura mariquensis***	***Swamp musk shrew***
Eulipotyphla	***Crocidura silacea***	***Lesser grey-brown musk shrew***
Eulipotyphla	***Myosorex varius***	***Forest shrew***
Eulipotyphla	***Suncus infinitesimus***	***Least dwarf shrew***
Eulipotyphla	***Suncus varilla***	***Lesser dwarf shrew***
Hyracoidea	*Procavia capensis*	*Rock Hyrax*
Lagomorpha	*Lepus capensis*	*Cape hare/Desert hare*
Lagomorpha	*Lepus saxatillus*	*Scub hare/Savannah hare*
Lagomorpha	*Pronolagus randensis*	*Jameson's red rock rabbit*
Lagomorpha	*Pronolagus rupestris*	*Smith's red rock rabbit*
Macroscelidea	*Elephantulus myurus*	*Rock elephant-shrew*
Pholidota	***Manis temminckii***	***Pangolin***
Primata	*Galago moholi*	*Lesser bushbaby*
Primata	*Papio ursinus*	*Chacma baboon*
Rodentia	*Aethomys chrysophilus*	*Red veld rat*
Rodentia	*Aethomys ineptus*	*Tete veld rat*
Rodentia	*Cryptomys hottentotus*	*Common mole-rat*
Rodentia	***Dasymys incomtus***	***Water rat***

ORDER	SPECIES	COMMON NAME
Rodentia	*Dendromus melanotis*	*Grey climbing mouse*
Rodentia	*Dendromus mesomelas*	*Brant's climbing mouse*
Rodentia	*Dendromus mystacalis*	*Chestnut climbing mouse*
Rodentia	***Graphiurua platyops***	***Rock dormouse***
Rodentia	*Graphiurus murinus*	*Woodland dormouse*
Rodentia	*Hystrix africaeaustralis*	*Porcupine*
Rodentia	***Lemniscomys rosalia***	***Single-striped mouse***
Rodentia	*Mastomys coucha*	*Multimammate mouse*
Rodentia	*Mastomys natalensis*	*Natal multimammate mouse*
Rodentia	*Micaelamys namaquensis*	*Namaqua rock mouse*
Rodentia	*Mus indutus*	*Desert pygmy mouse*
Rodentia	*Mus minutoides*	*Pygmy mouse*
Rodentia	***Mystromys albicaudatus***	***White-tailed mouse***
Rodentia	*Otomys angoniensis*	*Angoni vlei rat*
Rodentia	*Otomys irroratus*	*Vlei rat*
Rodentia	*Pedetes capensis*	*Springhare*
Rodentia	*Rhabdomys pumilio*	*Striped mouse*
Rodentia	*Saccostomus campestris*	*Pouched mouse*
Rodentia	*Tatera bransii*	*Highveld gerbil*
Rodentia	***Tatera leucogaster***	***Bushveld gerbil***
Rodentia	*Thallomys nigricauda*	*Black-tailed tree mouse*
Rodentia	*Thallomys paedulcus*	*Tree mouse*
Rodentia	*Xerus inauris*	*Cape Ground squirrel*
Ruminantia	*Antidorcas marsupialis*	*Springbok*
Ruminantia	*Connochaetes gnou*	*Black wildebeest*
Ruminantia	*Damaliscus pygargus phillipsi*	*Blesbok*
Ruminantia	***Ourebia ourebi***	***Oribi***
Ruminantia	*Pelea capreolus*	*Grey rhebok*
Ruminantia	*Raphicerus campestris*	*Steenbok*
Ruminantia	*Sylvicapra grimmia*	*Common duiker*
Ruminantia	*Tragelaphus oryx*	*Eland*
Suiformes	*Phacochoerus africanus*	*Common warthog*
Tubulidentata	*Orycteropus afer*	*Aardvark*

5.9.2.2 Birds

The list of bird species extracted from SABAP 1 for the four QDS's are actual recent sightings of those species by individuals and therefore constitute the actual bird species assemblage within the area (although it is recognised that it may not be a complete list). The bird species list includes 255 bird species, 25 of which are of conservation concern (Table 5.9.2.2(a)).

Four Red Data List bird species were observed during the field survey, including the Martial Eagle (*Polemaetus bellicosus*) which had not previously been recorded from this area during the SABAP 1 bird counts. Greater and Lesser Flamingo were both observed on Leeupan, a South African grass-owl was flushed from a stand of *I. cylindrica* grass along one of the watercourses in the Springbokdraai reserve, and the Martial eagle was seen just outside and to the west of the Springbokdraai reserve study area boundary.

The bulk of the species diversity is made up of grassland birds and water birds. A complete list of all bird species occurring in the area can be found in Table 5.9.2.2(b).

Table 5.9.2.2)a): Red Data List bird species occurring within QDS 2629AC, 2629CA, 2628BD and 2628DB (CR = Critically Endangered, EN = Endangered, NT = Near Threatened, VU = Vulnerable)

SPECIES	COMMON NAME	CONSERVATION STATUS	OBSERVED ON SITE
Bugeranus carunculatus	Wattled Crane	CR	
Spizocorys fringillaris	Botha's Lark	EN	
Ciconia nigra	Black Stork	NT	
Circus macrourus	Pallid Harrier	NT	
Circus maurus	Black Harrier	NT	
Eupodotis caerulescens	Blue Korhaan	NT	
Falco biarmicus	Lanner Falcon	NT	
Glareola nordmanni	Black-winged Pratincole	NT	
Mirafra cheniana	Melodious (Latakoo) Lark	NT	
Mycteria ibis	Yellow-billed Stork	NT	
Phoenicopterus minor	Lesser Flamingo	NT	X
Phoenicopterus ruber	Greater Flamingo	NT	X
Rostratula benghalensis	Greater Painted-snipe	NT	

SPECIES	COMMON NAME	CONSERVATION STATUS	OBSERVED ON SITE
Sagittarius serpentarius	Secretarybird	NT	
Sterna caspia	Caspian Tern	NT	
Anthropoides paradiseus	Blue Crane	VU	
Balearica regulorum	Grey Crowned- (Crowned) Crane	VU	
Circus ranivorus	African Marsh-Harrier	VU	
Eupodotis senegalensis	White-bellied Korhaan	VU	
Falco naumanni	Lesser Kestrel	VU	
Geronticus calvus	Southern Bald (Bald) Ibis	VU	
Neotis denham	Denham's (Stanley's) Bustard	VU	
Pelecanus rufescens	Pink-backed Pelican	VU	
Polemaetus bellicosus	**Martial Eagle**	**VU**	**X**
Tyto capensis	African Grass-Owl	VU	X

Table 5.9.2.2(b): List of bird species potentially occurring within the study area

ROBERTS NUMBER	SPECIES	COMMON NAME
1	*Struthio camelus*	Common Ostrich
6	*Podiceps cristatus*	Great Crested Grebe
7	*Podiceps nigricollis*	Black-necked Grebe
8	*Tachybaptus ruficollis*	Little Grebe (Dabchick)
50	***Pelecanus rufescens***	**Pink-backed Pelican**
55	*Phalacrocorax lucidus*	White-breasted (Great) Cormorant
58	*Phalacrocorax africanus*	Reed (Long-tailed) Cormorant
60	*Anhinga rufa*	African Darter
62	*Ardea cinerea*	Grey Heron
63	*Ardea melanocephala*	Black-headed Heron
64	*Ardea goliath*	Goliath Heron
65	*Ardea purpurea*	Purple Heron
66	*Egretta alba*	Great Egret
67	*Egretta garzetta*	Little Egret
68	*Egretta intermedia*	Yellow-billed (Intermediate) Egret
69	*Egretta ardesiaca*	Black Heron
71	*Bubulcus ibis*	Cattle Egret
72	*Ardeola ralloides*	Squacco Heron
76	*Nycticorax nycticorax*	Black-crowned Night-Heron
78	*Ixobrychus minutus*	Little Bittern
81	*Scopus umbretta*	Hamerkop
83	*Ciconia ciconia*	White Stork
84	***Ciconia nigra***	**Black Stork**
85	*Ciconia abdimii*	Abdim's Stork
90	***Mycteria ibis***	**Yellow-billed Stork**
91	*Threskiornis aethiopicus*	African Sacred (Sacred) Ibis
92	***Geronticus calvus***	**Southern Bald (Bald) Ibis**
93	*Plegadis falcinellus*	Glossy Ibis
94	*Bostrychia hagedash*	Hadeda Ibis
95	*Platalea alba*	African Spoonbill
96	***Phoenicopterus ruber***	**Greater Flamingo**
97	***Phoenicopterus minor***	**Lesser Flamingo**
99	*Dendrocygna viduata*	White-faced (Whistling-) Duck
100	*Dendrocygna bicolor*	Fulvous (Whistling) Duck
101	*Thalassornis leuconotus*	White-backed Duck
102	*Alopochen aegyptiaca*	Egyptian Goose
103	*Tadorna cana*	South African Shelduck
104	*Anas undulata*	Yellow-billed Duck
105	*Anas sparsa*	African Black Duck
106	*Anas capensis*	Cape Teal
107	*Anas hottentota*	Hottentot Teal
108	*Anas erythrorhyncha*	Red-billed Teal (Duck)
112	*Anas smithii*	Cape Shoveler
113	*Netta erythrophthalma*	Southern Pochard
115	*Sarkidiornis melanotos*	Comb (Knob-billed) Duck

ROBERTS NUMBER	SPECIES	COMMON NAME
116	*Plectropterus gambensis*	Spur-winged Goose
117	*Oxyura maccoa*	Maccoa Duck
118	***Sagittarius serpentarius***	**Secretarybird**
126	*Milvus migrans*	Black & Yellowbilled Kite (pre-split)
127	*Elanus caeruleus*	Black-shouldered (Winged) Kite
140	***Polemaetus bellicosus***	**Martial Eagle**
143	*Circaetus pectoralis*	Black-chested (Breasted) Snake-Eagle
148	*Haliaeetus vocifer*	African Fish-Eagle
149	*Buteo vulpinus*	Steppe (Common) Buzzard
152	*Buteo rufofuscus*	Jackal Buzzard
165	***Circus ranivorus***	**African Marsh-Harrier**
167	***Circus macrourus***	**Pallid Harrier**
168	***Circus maurus***	**Black Harrier**
172	***Falco biarmicus***	**Lanner Falcon**
173	*Falco subbuteo*	Eurasian Hobby
179	*Falco vespertinus*	Red-footed (Western) Falcon (Kestrel
180	*Falco amurensis*	Amur (Eastern Red-footed) Falcon (Kestrel)
181	*Falco rupicolus*	Rock Kestrel
182	*Falco rupicoloides*	Greater Kestrel
183	***Falco naumanni***	**Lesser Kestrel**
190	*Scleroptila africanus*	Grey-winged Francolin
192	*Scleroptila levaillantii*	Red-winged Francolin
193	*Scleroptila levaillantoides*	Orange River Francolin
199	*Pternistis swainsonii*	Swainson's Spurfowl (Francolin)
200	*Coturnix coturnix*	Common Quail
203	*Numida meleagris*	Helmeted Guineafowl
205	*Turnix sylvaticus*	Kurrichane (Small) Buttonquail
207	***Bugeranus carunculatus***	**Wattled Crane**
208	***Anthropoides paradiseus***	**Blue Crane**
209	***Balearica regulorum***	**Grey Crowned- (Crowned) Crane**
210	*Rallus caerulescens*	African Rail
213	*Amaurornis flavirostris*	Black Crake
217	*Sarothrura rufa*	Red-chested Flufftail
223	*Porphyrio madagascariensis*	African Purple (Purple) Swamphen (Gallinule)
226	*Gallinula chloropus*	Common Moorhen
228	*Fulica cristata*	Red-knobbed Coot
231	***Neotis denham***	**Denham's (Stanley's) Bustard**
233	***Eupodotis senegalensis***	**White-bellied Korhaan**
234	***Eupodotis caerulescens***	**Blue Korhaan**
239	*Afrotis* sp.	Black Korhaan (pre-split)
240	*Actophilornis africanus*	African Jacana
242	***Rostratula benghalensis***	**Greater Painted-snipe**
245	*Charadrius hiaticula*	Common Ringed Plover
248	*Charadrius pecuarius*	Kittlitz's Plover
249	*Charadrius tricollaris*	Three-banded Plover
255	*Vanellus coronatus*	Crowned Lapwing (Plover)
258	*Vanellus armatus*	Blacksmith Lapwing (Plover)
260	*Vanellus senegallus*	African Wattled Lapwing (Plover)

ROBERTS NUMBER	SPECIES	COMMON NAME
262	*Arenaria interpres*	Ruddy Turnstone
264	*Actitis hypoleucos*	Common Sandpiper
266	*Tringa glareola*	Wood Sandpiper
269	*Tringa stagnatilis*	Marsh Sandpiper
270	*Tringa nebularia*	Common Greenshank
272	*Calidris ferruginea*	Curlew Sandpiper
274	*Calidris minuta*	Little Stint
284	*Philomachus pugnax*	Ruff
286	*Gallinago nigripennis*	African (Ethiopian) Snipe
294	*Recurvirostra avosetta*	Pied (Avocet) Avocet
295	*Himantopus himantopus*	Black-winged Stilt
297	*Burhinus capensis*	Spotted Thick-knee (Dikkop)
305	***Glareola nordmanni***	**Black-winged Pratincole**
315	*Larus cirrocephalus*	Grey-headed Gull
322	***Sterna caspia***	**Caspian Tern**
338	*Chlidonias hybrida*	Whiskered Tern
339	*Chlidonias leucopterus*	White-winged Tern
348	*Columba livia*	Rock (Feral) Dove (Pigeon)
349	*Columba guinea*	Speckled (Rock) Pigeon
352	*Streptopelia semitorquata*	Red-eyed Dove
354	*Streptopelia capicola*	Cape Turtle (Ring-necked) Dove
355	*Streptopelia senegalensis*	Laughing (Palm) Dove
356	*Oena capensis*	Namaqua Dove
373	*Corythaixoides concolor*	Grey Go-away-bird (Lourie)
377	*Cuculus solitarius*	Red-chested Cuckoo
386	*Chrysococcyx caprius*	Dideric (Diederik) Cuckoo
392	*Tyto alba*	Barn Owl
393	***Tyto capensis***	**African Grass-Owl**
395	*Asio capensis*	Marsh Owl
401	*Bubo africanus*	Spotted Eagle-Owl
404	*Caprimulgus europaeus*	European Nightjar
411	*Apus apus*	Common (European) Swift
412	*Apus barbatus*	African Black (Black) Swift
415	*Apus caffer*	White-rumped Swift
416	*Apus horus*	Horus Swift
417	*Apus affinis*	Little Swift
421	*Cypsiurus parvus*	African Palm-Swift
424	*Colius striatus*	Speckled Mousebird
426	*Urocolius indicus*	Red-faced Mousebird
428	*Ceryle rudis*	Pied Kingfisher
429	*Megaceryle maximus*	Giant Kingfisher
431	*Alcedo cristata*	Malachite Kingfisher
446	*Coracias garrulus*	European Roller
447	*Coracias garrulus*	Lilac-breasted Roller
451	*Upupu africana*	African Hoopoe
452	*Phoeniculus purpureus*	Green (Red-billed) Wood-hoopoe
464	*Lybius torquatus*	Black-collared Barbet
465	*Tricholaema leucomelas*	Acacia Pied (Pied) Barbet

ROBERTS NUMBER	SPECIES	COMMON NAME
473	*Trachyphonus vailantii*	Crested Barbet
480	*Geocolaptes olivaceus*	Ground Woodpecker
489	*Jynx ruficollis*	Red-throated Wryneck
492	***Mirafra cheniana***	**Melodious (Latakoo) Lark**
494	*Mirafra africana*	Rufous-naped Lark
495	*Mirafra* sp.	Clapper Lark (pre-split)
498	*Calendulauda sabota*	Sabota Lark
500	*Certhilauda sp.*	Longbilled Lark (pre-split)
506	*Chersomanes albofasciata*	Spike-heeled Lark
507	*Callandrella cinerea*	Red-capped Lark
508	*Spizocorys conirostris*	Pink-billed Lark
509	***Spizocorys fringillaris***	**Botha's Lark**
515	*Eremopterix leucotis*	Chestnut-backed Sparrowlark (Finchlark)
518	*Hirundo rustica*	Barn (European) Swallow
520	*Hirundo albigularis*	White-throated Swallow
524	*Hirundo semirufa*	Red-breasted (Rufous-chested) Swallow
526	*Hirundo cucullata*	Greater Striped-Swallow
528	*Hirundo spilodera*	South African Cliff-Swallow
529	*Hirundo fuligula*	Rock Martin
530	*Delichon urbicum*	Common House-Martin
532	*Riparia riparia*	Sand Martin (Bank Swallow)
533	*Riparia paludicola*	Brown-throated (Plain) Martin
534	*Riparia cincta*	Banded Martin
543	*Oriolus oriolus*	Eurasian Golden-Oriole
545	*Oriolus larvatus*	Black-headed (Eastern) Oriole
547	*Corvus capensis*	Cape (Black) Crow
548	*Corvus albus*	Pied Crow
552	*Parus cinerascens*	Ashy Tit
567	*Pycnonotus nigricans*	African Red-eyed Bulbul
568	*Pycnonotus tricolor*	Dark-capped (Black-eyed) Bulbul
577	*Turdus olivaceus*	Olive Thrush (pre-split)
581	*Monticola rupestris*	Cape Rock-Thrush
582	*Monticola explorator*	Sentinel Rock-Thrush
586	*Oenanthe monticola*	Mountain Chat (Wheatear)
587	*Oenanthe pileata*	Capped Wheatear
589	*Cercomela familiaris*	Familiar Chat
595	*Myrmecocichla formicivora*	Ant-eating Chat
596	*Saxicola torquatus*	African (Common) Stonechat
601	*Cossypha caffra*	Cape Robin-Chat
619	*Sylvia borin*	Garden Warbler
620	*Sylvia communis*	Common (Whitethroat) Whitethroat
621	*Parisoma subcaeruleum*	Chestnut-vented Tit-Babbler
625	*Hippolais icterina*	Icterine Warbler
628	*Acrocephalus arundinaceus*	Great Reed-Warbler
631	*Acrocephalus baeticatus*	African (African Marsh-Warbler) Reed-Warbler
633	*Acrocephalus palustris*	Marsh (European Marsh) Warbler
634	*Acrocephalus schoenobaenus*	Sedge Warbler
635	*Acrocephalus gracilirostris*	Lesser Swamp- (Cape Reed) Warbler
638	*Bradypterus baboecala*	Little Rush- (African Sedge) Warbler

ROBERTS NUMBER	SPECIES	COMMON NAME
643	*Phylloscopus trochilus*	Willow Warbler
645	*Apalis thoracica*	Bar-throated Apalis
664	*Cisticola juncidis*	Zitting (Fan-tailed) Cisticola
665	*Cisticola aridulus*	Desert Cisticola
666	*Cisticola textrix*	Cloud (Tink-tink) Cisticola
667	*Cisticola ayresii*	Wing-snapping (Ayre's) Cisticola
670	*Cisticola lais*	Wailing Cisticola
677	*Cisticola tinniens*	Le Vaillant's (Tinkling) Cisticola
681	*Cisticola fulvicapilla*	Neddicky (Piping Cisticola)
683	*Prinia subflava*	Tawny-flanked Prinia
685	*Prinia flavicans*	Black-chested Prinia
689	*Muscicapa striata*	Spotted Flycatcher
698	*Sigelus silens*	Fiscal Flycatcher
706	*Stenostira scita*	Fairy Flycatcher (Warbler)
713	*Motacilla capensis*	Cape Wagtail
716	*Anthus cinnamomeus*	African (Grassveld/Grassland) Pipit
717	*Anthus similis*	Long-billed Pipit
718	*Anthus leucophrys*	Plain-backed Pipit
719	*Anthus vaalensis*	Buffy Pipit
727	*Macronyx capensis*	Cape (Orange-throated) Longclaw
731	*Lanius minor*	Lesser Grey Shrike
732	*Lanius collaris*	Common Fiscal
733	*Lanius collurio*	Red-backed Shrike
746	*Telophorus zeylonus*	Bokmakierie
758	*Acridotheres tristis*	Common Myna
759	*Spreo bicolor*	Pied (African Pied) Starling
760	*Creatophora cinerea*	Wattled Starling
764	*Lamprotornis nitens*	Cape Glossy (Glossy) Starling
769	*Onychognathus morio*	Red-winged Starling
775	*Nectarinia famosa*	Malachite Sunbird
792	*Chalcomitra amethystina*	Amethyst (Black) Sunbird
796	*Zosterops virens*	Cape White-eye (pre-split)
799	*Plocepasser mahali*	White-browed Sparrow-Weaver
801	*Passer domesticus*	House Sparrow
803	*Passer melanurus*	Cape Sparrow
804	*Passer diffusus*	Greyheaded Sparrow (pre-split)
806	*Sporopipes squamifrons*	Scaly-feathered Finch
811	*Ploceus cucullatus*	Village (Spotted-backed) Weaver
813	*Ploceus capensis*	Cape Weaver
814	*Ploceus velatus*	Southern Masked-Weaver
820	*Anomalospiza imberbis*	Cuckoo Finch (Parasitic Weaver)
821	*Quelea quelea*	Red-billed Quelea
824	*Euplectes orix*	Southern Red (Red) Bishop
826	*Euplectes afer*	Yellow-crowned (Golden) Bishop
827	*Euplectes capensis*	Yellow (Yellow-rumped) Bishop (Widow)
828	*Euplectes axillaris*	Fan-tailed (Red-shouldered) Widowbird
829	*Euplectes albonotatus*	White-winged Widowbird
831	*Euplectes ardens*	Red-collared Widowbird
832	*Euplectes progne*	Long-tailed Widowbird

ROBERTS NUMBER	SPECIES	COMMON NAME
834	*Pytilia melba*	Green-winged (Melba) Pytilia (Finch)
846	*Estrilda astrild*	Common Waxbill
852	*Ortygospiza atricollis*	African Quailfinch
854	*Sporaeginthus subflavus*	Orange-breasted (Zebra) Waxbill
856	*Amadina erythrocephala*	Red-headed Finch
860	*Vidua macroura*	Pin-tailed Whydah
862	*Vidua paradisaea*	Long-tailed (Paradise) Paradise-Whydah
869	*Crithagra mozambicus*	Yellow-fronted (eyed) Canary
870	*Crithagra atrogularis*	Black-throated Canary
872	*Serinus canicollis*	Cape (Yellow-crowned) Canary
878	*Crithagra flaviventris*	Yellow Canary
881	*Crithagra gularis*	Streaky-headed Seedeater (Canary)
885	*Emberiza capensis*	Cape Bunting
886	*Emberiza tahapisi*	Cinnamon-breasted (Rock) Bunting
888	*Milvus migrans parasitus*	Yellow-billed Kite
889	*Milvus migrans*	Black Kite

5.9.2.3 Reptiles and Amphibians

Though the study focused primarily on bird and mammal species distribution, A list of reptile and amphibian species potentially occurring in the area has been included as Table 5.9. 2.3(a). A total of 41 herpetofauna species have been reported for the study area. These results likely reflect a general lack of herpetofaunal sampling rather than low species diversity.

The distribution range of the Giant bullfrog (*Pyxicephalus adspersus*; Near Threatened) includes the study area (Du Preez & Carruthers 2009), although, according to Minter *et al.* (2004), no individuals had been recorded in the area before 2002. The Giant sungazer (*Cordylus giganteus*; Vulnerable) has been recorded from QDS 2629CD and 2629DC, some distance from the project area (Branch 1988).

Table 5.9.2.3(a): List of Reptile and Amphibian species potentially occurring within the study area

FAMILY	SPECIES	COMMON NAME	CONS STATUS
Reptiles			
Gekkonidae	*Pachydactylus c. capensis*	Cape thick-toed gecko	
Gekkonidae	*Pachydactylus vansoni*	Van Son's thick-toed gecko	
Gekkonidae	*Pachydactylus affinis*	Transvaal thick-toed gecko	
Agamidae	*Agama atra*	Southern rock agama	
Agamidae	*Agama a. distanti*	Spiny agama	
Scincidae	*Mabuya capensis*	Cape skink	
Scincidae	*Mabuya varia*	Variable skink	
Scincidae	*Mabuya striata punctatissimus*	Striped skink	
Scincidae	*Acontias g. gracilicauda*	Slendertail lance skink	
Scincidae	*Acontias breviceps*	Shorthead lance skink	
Lacertidae	*Pedioplanis burchellii*	Burchell's sand lizard	
Gerrhosauridae	*Gerrhosaurus flavigularis*	Yellow-throated plated lizard	
Cordylidae	*Chamaesaura aenea*	Transvaal grass lizard	
Cordylidae	*Pseudocordylus m. melanotus*	Drakensberg crag lizard	
Typhlopidae	*Typhlops bibronii*	South African blind snake	
Leptotyphlopidae	*Leptotyphlops c. conjunctus*	Cape thread snake	
Colubridae	*Pseudaspis cana*	Mole snake	
Colubridae	*Lycodonomorphus rufulus*	Brown water snake	
Colubridae	*Lamprophis aurora*	Aurora house snake	
Colubridae	*Lamprophis fuliginosis*	Brown house snake	
Colubridae	*Duberria l. lutrix*	Common slug-eater	
Colubridae	*Psammophylax r. rhombeatus*	Rhombic skaapsteker	
Colubridae	*Psammophis s. brevirostris*	Short-snouted grass snake	
Colubridae	*Psammophis crucifer*	Cross-marked grass snake	
Colubridae	*Aparallactus capensis*	Black-headed centipede-eater	
Colubridae	*Homoreselaps lacteus*	Spotted harlequin snake	
Colubridae	*Crotaphopeltis hotamboeia*	Herald snake	
Colubridae	*Dasypeltis scabra*	Common egg-eater	
Elapidae	*Hemachatus hemachaetus*	Rinkhals	

Amphibians			
Bufonidae	Amietophrynus gutturalis	Guttural toad	
Bufonidae	Amietophrynus maculatus	Flat-backed toad	
Bufonidae	Amietophrynus rangeri	Raucous toad	
Hyperolidae	Kassina senegalensis	Bubbling kassina	
Hyperolidae	Kassina wealii	Rattling kassina	
Phrynobatrachidae	Phrynobatrachus natalensis	Snoring puddle frog	
Pipidae	Xenopus laevis	Common platanna	
Pyxicephalidae	Amietia angolensis	Common river frog	
Pyxicephalidae	Amietia fuscigula	Cape river frog	
Pyxicephalidae	Cacosternum boettgeri	Boettger's Caco	
Pyxicephalidae	**Pyxicephalus adspersus**	**Giant bullfrog**	**NT**
Pyxicephalidae	Strongylopus fasciatus	Striped stream frog	
Pyxicephalidae	Strongylopus grayii	Clicking stream frog	
Pyxicephalidae	Tomopterna cryptotis	Tremolo sand frog	
Pyxicephalidae	Tomopterna natalensis	Natal sand frog	
Pyxicephalidae	Tomopterna tandyi	Tandy's sand frog	

5.9.2.4 Habitats of Conservation Importance

No information was provided on the conservation value of habitats within the original study area, therefore it was not possible to construct a complete sensitivity map for the entire study area (original study area and three additional reserves). Within the original study area only the wetlands previously delineated have been considered sensitive, however the extent of habitats of conservation value within the original study area are expected to be more extensive than mapped in this report. Within the additional reserve areas (Leeupan, Springbokdraai, Northern) the following habitats were considered to be sensitive and of conservation importance:

- Natural vegetation which has not been cultivated recently or heavily grazed;
- Wetlands and rivers;
- Large waterbodies (natural or artificial); and
- Any other areas known to support Red Data List species or which have the potential to do so.

Wetlands and rivers are considered sensitive habitat as they support a different range of species than the surrounding terrestrial landscape, they are an important water and food resource for many species, the transition zone (ecotone) between aquatic and terrestrial habitats is typically species-rich, and rivers form a network of (relatively) natural vegetation along which species can migrate and disperse. Many of the Red Data List species (birds and mammals) occurring or potentially occurring in the area are linked to water or wetland habitats, e.g.: African grass-owl, Greater flamingo, Lesser flamingo, water rat and Spotted-necked otter. Areas of undisturbed grassland are also of significance as they support a diverse granivore and insectivore community (both birds and mammals) which forms an essential food resource for many of the small to medium-sized carnivores, omnivores and birds of prey. Figure 5.9.2.4(a) indicates those areas of high sensitivity and conservation importance within the three additional reserves.

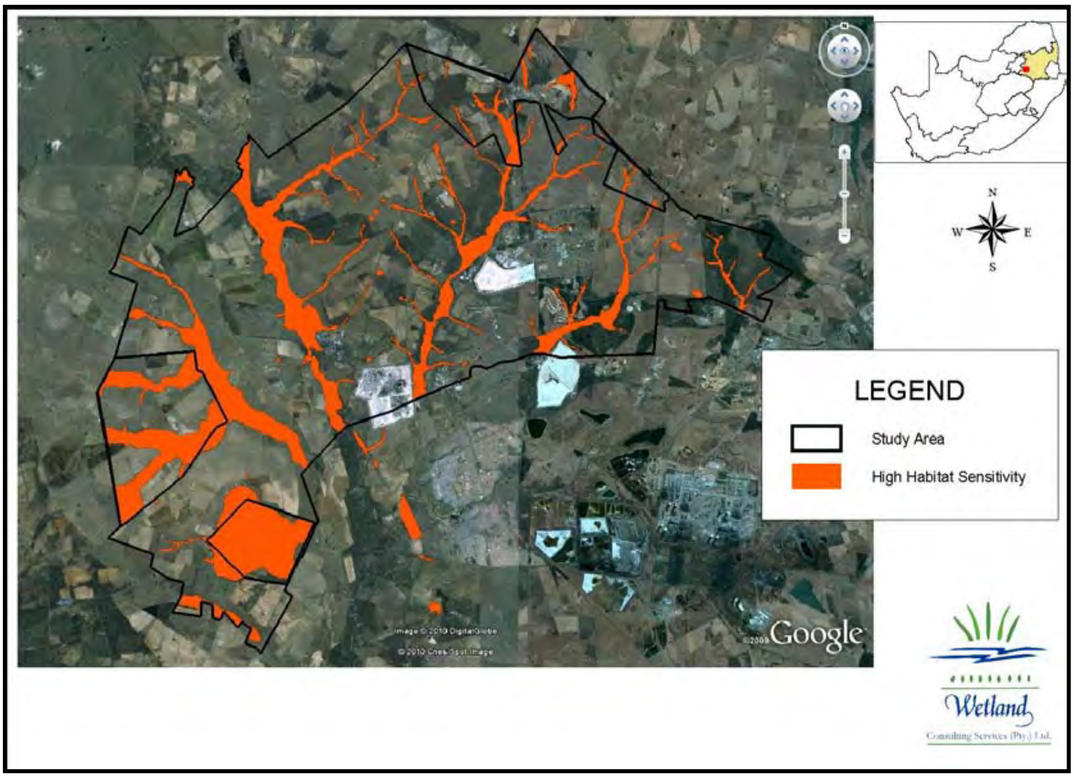

Figure 5.9.2.4(a): Habitats of Conservation Value within the Study Area

5.9.2.5 Significance of Observations

The study area includes a number of habitat types, such as Soweto Highveld Grassland, Eastern Highveld Grassland, rivers, wetlands and large open water bodies. This diversity of habitats helps to support a variety of faunal communities including a number of Red Data List species. A total of 84 mammal, 225 bird, 28 reptile and 13 amphibian species potentially occur within the study area. Of these, 37 Red Data List species could occur (not including those species considered Data Deficient) four of which were observed (all birds).

The presence of many of the species recorded is dependent on the presence of water - either in the form of large, open water bodies, streams or wetlands – and natural grassland. Therefore the continued existence of these species in and around the study area relies upon the maintenance of these habitats in a condition and to an extent sufficient to meet their habitat requirements.

5.10 AQUATIC ECOLOGY (WETLANDS)

Wetland Consulting Services (Pty) Ltd was appointed by JMA Consulting (Pty) Ltd to undertake a wetland delineation and assessment of three additional areas associated with the Sasol Mining Middelbult-Block 8-Shondoni Project, and to incorporate the findings of this study into the existing wetland study available for the area.

The original investigation formed part of the Middelbult-Block 8 EMPR Addendum for Sasol Coal. The study provided a baseline report on the wetland areas that fall within the extent of the proposed underground mining areas.

In this description the baseline information contained within the 2002 Report is extended to include the three additional areas, and then to compile one single report to cover the entire Sasol Mining Middelbult - Block 8 - Shondoni Project study area (referred to as the study area hereafter). Field work during the current study was only undertaken for the additional areas; no additional field work was undertaken in the area covered by the 2002 Report. As such, this report draws extensively from the 2002 Report, and is in many respects a duplication of the 2002 Report with some added information.

To extend the baseline information contained within the 2002 Report to include the three additional areas: Block 8 Northern Reserve, Springbokdraai Reserve and Leeuwpan Reserve, the following activities were undertaken:

- Initial desktop delineation of suspected wetland areas in the additional areas;
- Groundtruthing of the additional areas to verify extent of delineated wetland areas;
- Assessment of the current condition (PES) of the wetlands;
- Functional assessment of the wetlands;

The initial wetland assessment was based on information collected during a number of field visits undertaken during March, April and early May 2002, while the additional areas were surveyed during several site visits in June 2010. Every attempt was made to collect the types of information necessary to assist in the assessment of the status of the wetlands on site. The baseline information on the wetlands was collected using a rapid assessment technique and the wetland boundaries were field delineated to an accuracy of approximately 30 m.

An assessment of key determinants of wetland maintenance and functioning was made using soil augering, anecdotal evidence and indicators of hydric conditions. It is likely that additional plant species occur in the wetlands on site and that these were not recorded during sampling for whatever reason, including time constraints, the methods used, and the season during which sampling was undertaken. This baseline study was based on a once-off assessment of the wetland habitats and thus does not depict the seasonal variations in plant species composition and richness that may occur.

Wetland Delineation and Classification

The National Water Act, Act 36 of 1998, defines wetlands as:

Wetlands - *"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."*

For this assessment, use was made of 1:50 000 topographic maps, geo-referenced Google Earth images and aerial photographs to generate digital base maps of the study area onto which the wetland boundaries were delineated using ArcView 9.1.

The method described in Thompson et al (2002) was used to delineate wetlands at a desktop level, based on wetness signatures (darker or greenish areas) on satellite imagery and aerial photographs. All identified potential wetlands were then verified in the field.

During the current survey, wetlands were delineated according to the delineation procedure given in "A Practical Field Procedure for the Identification and Delineation of Wetlands and Riparian Areas" (DWAF 2005). Indirect indicators of prolonged saturation, namely wetland plants (hydrophytes) and wetland soils (hydromorphic soils) were used to identify wetland areas. Hydromorphic soils must display signs of wetness (mottling and gleying) within 50cm of the soil surface for an area to be classified as a wetland.

The study area was sub-divided into transects and the soil profile was examined for signs of wetness within 50 cm of the surface using a hand augur along transects. The wetland boundaries were then determined by the positions of augured holes that showed signs of wetness as well as by the presence or absence of hydrophilic vegetation.

The wetlands were subsequently classified according to their hydro-geomorphic determinants based on the system proposed in the National Wetland Classification System (SANBI, 2010) (in the case of the delineation undertaken in 2002, the classification of the wetlands was updated to align with the recently developed National Wetland Classification System – systems classified as "drainage lines" in the 2002 Report were reclassified as either channelled or unchannelled valley bottom wetlands).

The presence of wetlands in the landscape can be linked to the presence of both surface water and perched groundwater. Wetland types are differentiated based on their hydro-geomorphic (HGM) characteristics; i.e. on the position of the wetland in the landscape, as well as the way in which water moves into, through and out of the wetland systems.

5.10.1 Regional Description of Relevant Attributes

5.10.1.1 Location

The 2002 Report study area is approximately 19 300 ha in extent and is situated to the northeast and east of Secunda and south of Kinross. It includes the area surrounding Evander and the farms, or portions of the farms, Driefontein 137 IS, Kinross 133 IS, Winkelhaak 135 IS, Witkleifontein 131 IS, Leeuwspruit 134 IS, Zandfontein 130 IS, Ruigtekuilen 129 IS, Kromdraai 128 IS, Brakspruit 359 IR, Springbokdraai 377 IS, Rietkuil 531 IR, and Leeuwpan 532 IR (Figure 1). The area lies between 26024' and 26036'S and 28056' and 29011'E and is located on portions of the topographic map sheets 2628 BD Leandra, 2628 DB Willemsdal, 2629AC Evander and 2629CA Secunda (Published by the Chief Directorate: Surveys and Land Information, Mowbray).

The three areas added to the study area during the current survey constitute an additional approximately 4 000 ha, bringing the total size of the study area to 23 300 ha

The site consists of a series of drainage lines running predominantly from north to south, intersecting an undulating landscape of grassland mixed with commercial agricultural lands, mines, mine villages, and homesteads. The drainage lines and floodplains in the area form part of the Waterval River system, which is a tributary of the Vaal River.

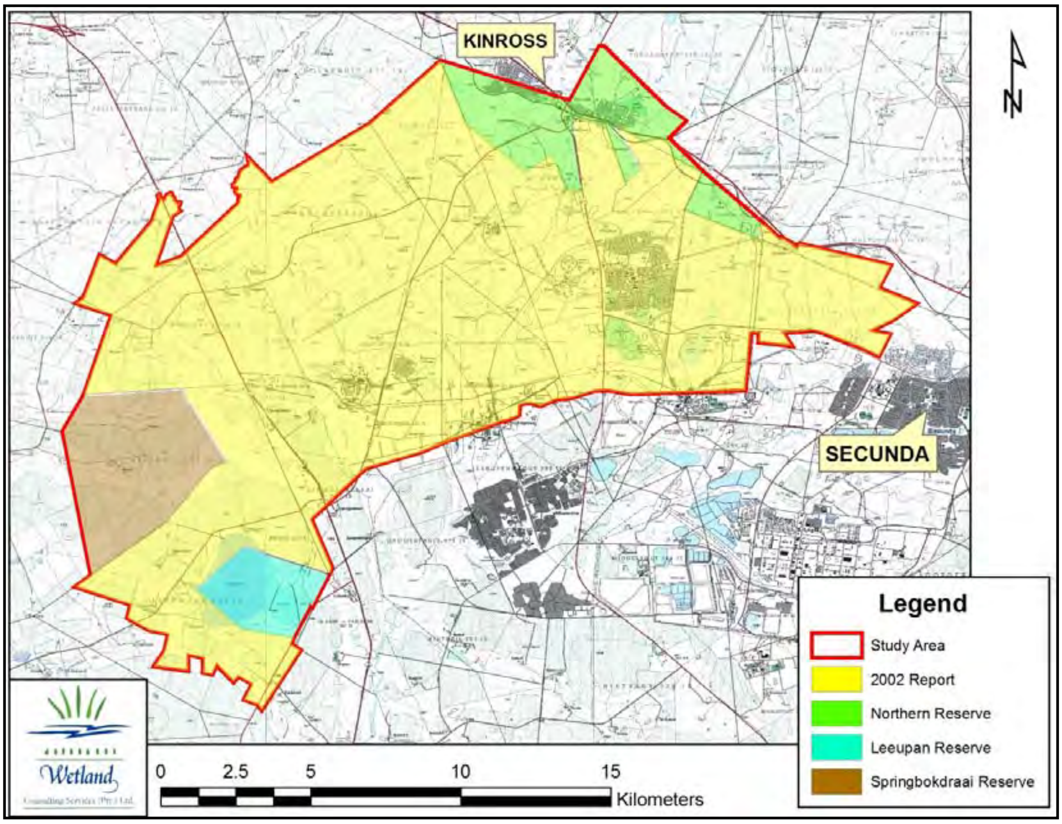

Figure 5.10.1.1(a): Map showing the extent and location of the study area. The area covered by the 2002 Report is shaded yellow, while the additional areas surveyed during the current study are shaded green, brown and blue respectively

5.10.1.2 Surface Water Catchments

The study area is located predominantly in primary catchment C, the Vaal River catchment, though with the northern most reaches of the site extending marginally into primary catchment B, the Olifants River catchment. The affected quarternary catchments include catchments C12D, in which the majority of the study area falls, and C12F, both of which are drained by the Waterval River, as well as catchment B11D, which is drained by the Steenkoolspruit. More details on the affected catchments is provided below.

Table 5.10.1.2(a): Table showing the mean annual precipitation, run-off and potential evaporation per quaternary catchment (Middleton, B.J., Midgley, D.C and Pitman, W.V., 1990).

Quaternary Catchment	Catchment Surface Area (ha)	Mean Annual Rainfall (MAP) in mm	Mean Annual Run-off (MAR) in mm	MAR as a % of MAP	Study area as % of catchment
C12D	81 343	666.9	59.3	8.9 %	29 %
C12F	75 655	634.9	49.1	7.7 %	> 0.5 %
B11D	49 812	671.5	30.1	4.5 %	1 %

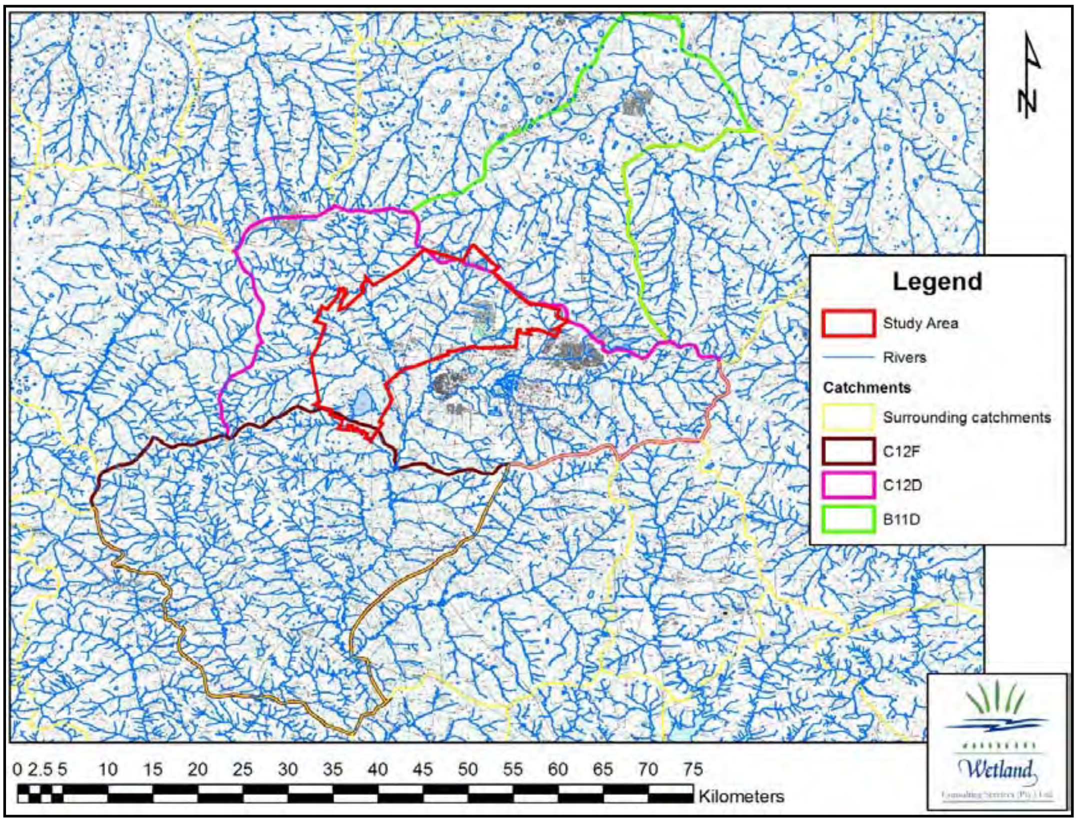

Figure 5.10.1.2(a): Map showing the study area in relation to the quaternary catchments

Of interest is the relatively high percentage of mean annual precipitation that ends up as run-off out of catchment C12D, being almost 9 %. Typically values further north on the highveld towards Witbank range from around 4-6 % (see catchment B11D).

This higher run-off value is as a result of the geology of the area (see below) and indicates that wetlands in this area are more reliant on surface flows than sub-surface flows.

It is therefore expected that wetland types such as floodplains and valley bottom wetlands would dominate in this area, with hillslope seepage wetlands being rather less common. The opposite applies to catchments further north on the highveld where infiltration of rainfall rather than run-off is the dominant driving process.

5.10.1.3 Geology and Soils

The geology of the study area is for the most part dominated by underlying dolerites, while extensive alluvial deposits occur along the floodplains associated with the larger rivers. Sandstone underlies the remaining areas of the study site, and is most common in the south west around Leeuwpan and the southern reaches of the study area.

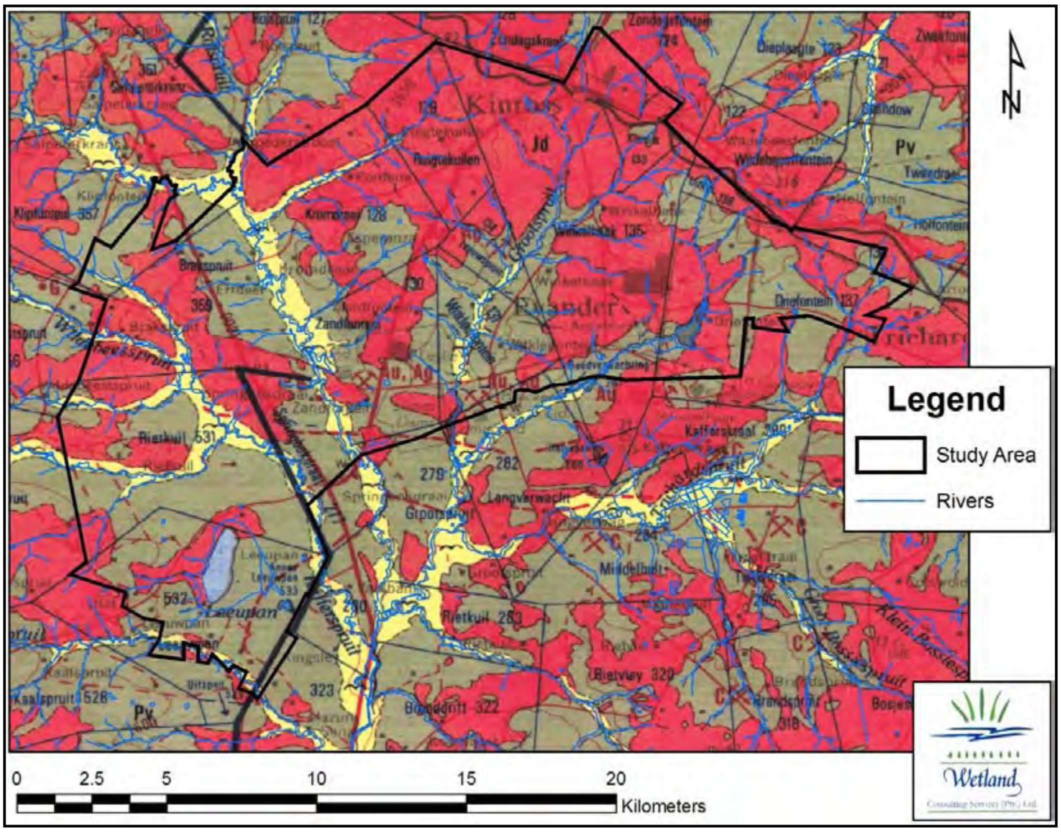

Figure 5.10.1.3(a): Map of the underlying geology – pink indicates dolerite, yellow shows alluvial deposits, and brown represents sandstone

Dolerite typically weathers to form clay rich soils, with vertic, black soils being most common in the study area.

These soils are highly expansive, showing cracking on the surface when dry, and become nearly impermeable to water when wet, resulting in a large percentage of rainfall ending up as run-off, as seen in Table 5.10.1.2(a) above.

These soils dominate the study area, with typical soils forms including:

Arcadia

In the Arcadia soil form, a vertic A horizon occurs deep into the soil profile. The A horizon has strongly developed structure and clearly visible, regularly occurring slickensides in some part of the horizon. These soils have high clay content, a dark colour, and a predominance of smectic clay minerals and possess the capacity to swell and shrink markedly in response to moisture changes. This swell-shrink potential is manifested typically by the formation of vertical cracks in the dry state and the presence at depth of slickensides (polished surface planes produced by internal movement).

Katspruit

In the Katspruit soil form an orthic A horizon overlies a G horizon which is typical moist with grey matrix colours. Mottling may or may not occur down to a depth of 50 cm. Many of the Katspruit soils associated with the floodplains in the area are not characteristically saturated at depth. This is largely the result of incision of the stream channel, which serves to drain these areas and also reduces the likelihood of overbank topping during flooding rainfall and thus reduces the frequency of flooding. The soil profile thus dries out. The G horizon may be calcareous or non calcareous.

Kroonstad

In areas where the Kroonstad soil form occurs, an orthic A horizon overlies a typical greyish E horizon with a grey matrix which in places is shallower than 50 cm. The E horizon may contain mottling or streaking with a higher chroma than that of the matrix as a result of the periodic saturation with water. Below this a typically gleyed G horizon occurs. The orthic A horizon can also range from damp in some areas to dry in others.

Rensburg

The vertic A horizon of the Rensburg soil form has clearly visible slickensides in the transition to the lower layers and is characteristically cracked when dry. The vertic A horizon ranges from moist to dry depending on the frequency and duration of wetting when the soils are flooded. The underlying G horizon is often saturated unless the system has been drained and has typical grey matrix colours often with blue or green tint with or without mottling. In places in the study area, this form was calcareous in the upper G horizon.

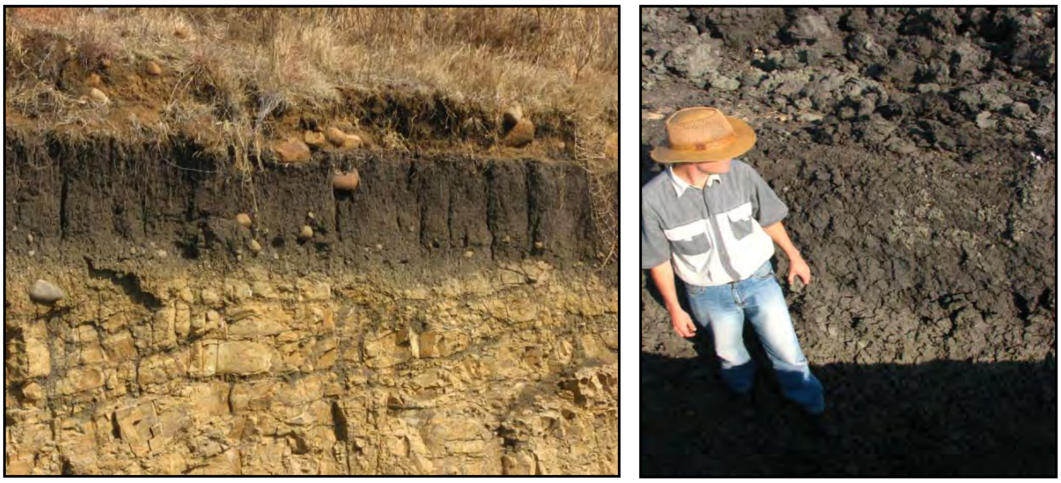

Figure 5.10.1.3(b): Photographs showing a typical Arcadia soil profile on the left and a Rensburg soil profile on the right – both photographs were taken in the Secunda area during field work conducted in June 2010

5.10.1.4 Vegetation

According to the Vegetation of South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006) the study area is located within the Grassland Biome and the Mesic Highveld Grassland Bioregion.

Three specific vegetation types occur on site, of which Soweto Highveld Grassland is dominant. Eastern Temperate Freshwater Wetland vegetation is only associated with Leeupan on site, while a small patch of Eastern Highveld Grassland is indicated as occurring in the extreme northern reaches of the study area, to the north of Kinross.

Soweto Highveld Grassland, as described by Mucina and Rutherford (2006), is found mostly in the Mpumalanga and Gauteng Provinces on the gently to moderately undulating landscape of the highveld. Intrusive dolerites feature strongly in this area.

The vegetation is typically a short to medium-high, dense, tufted grassland dominated by *Themeda triandra*. This vegetation type is considered *Endangered*, with almost 50 % already transformed by cultivation, mining, urban sprawl and building of road infrastructure.

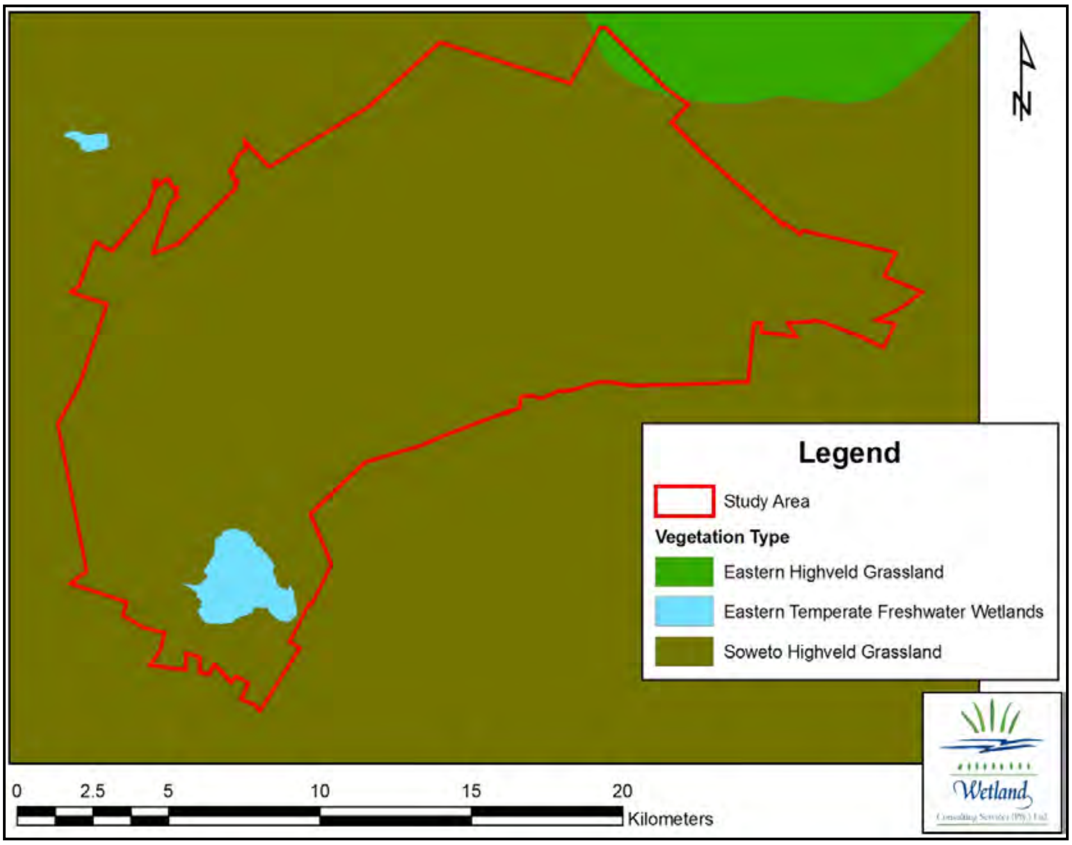

Figure 1.10.1.4(a): Vegetation map of the study area indicating the different vegetation types occurring on site (Mucina & Rutherford, 2006).

5.10.2 General Wetland Description & Classification

Five main types of natural wetland systems occur within extended study area totalling an area of 3 186 ha (13.8% of the total study area). This figure includes all the natural wetland areas, but excludes dams and water-filled quarries. The recorded wetland types are:

- Floodplain
- Channelled Valley Bottom
- Unchannelled Valley Bottom
- Depression/Pans
- Hillslope Seepage

Together with Leeuwpan (which has been classified as a pan, but currently functions more as a dam), dams form the main artificial wetland type within the study area. There are approximately 100 dams within the study area with a total area of approximately 150 ha. Of these, Evander Dam is the largest with an inundated area of approximately 45 ha. The remaining dams are mostly farm dams with a total area of 55 ha.

The large pan in the south-western part of the study area (Leeuwpan), while once a natural and much smaller pan, is now artificially maintained by "waste water" inputs from Harmony Gold Mine.

It is approximately 578 ha in extent. All the wetlands occur on clayey substrates and there is a distinct lack of sandy soils and thus hillslope seepage wetlands within the study area. Most of the seepage wetlands were located within the Leeuwpan area. All the natural wetlands and dams are maintained by surface runoff from the associated catchments and down the respective drainage lines.

Pools of standing water are restricted to pans and depressions in the drainage lines and oxbows within the floodplains. The former occur where the local relief is flat enough to allow surface water to accumulate in small depressions while the latter have developed as a result of historical natural floodplain processes.

The position and boundaries of each of these main wetland types found on site are given in Figure 5.10.2(b). A schematic diagram of how these systems are positioned in the landscape is given in Figure 5.10.2(a). The areas covered by the various wetland types are given in Table 5.10.2(a) below.

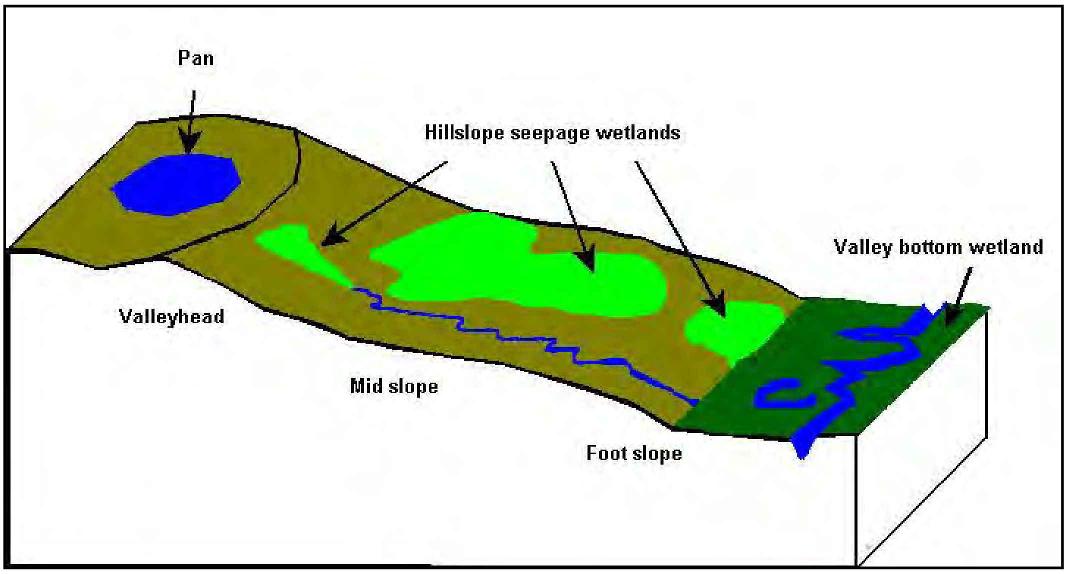

Figure 5.10.2(a): Schematic of the wetlands in the study area showing the general relationship to topography

Table 5.10.2(a): Table showing the extent of each of the different wetland types identified

Wetland Type	Area (ha)	% of wetland area
Channelled valley bottom	551.25	17.3%
Depression/Pan	586.61	18.4%
Floodplain	1914.57	60.1%
Hillslope seepage	120.22	3.8%
Unchannelled valley bottom	13.24	0.4%
TOTAL	3185.89	100.00%
Dams	124.70	n/a
Quarries	17.70	n/a

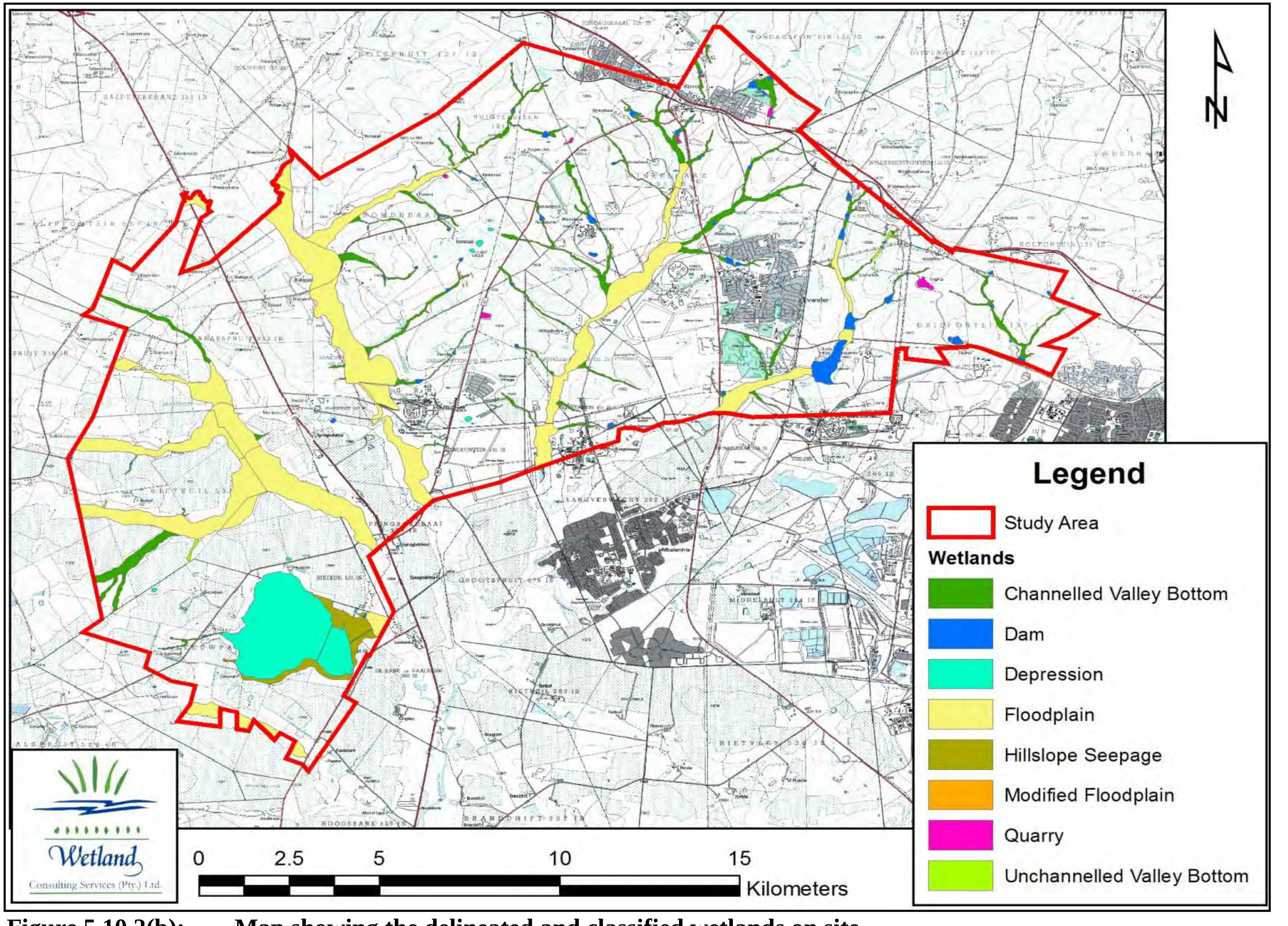

Figure 5.10.2(b): Map showing the delineated and classified wetlands on site

5.10.3 Description of the Specific Wetland Types

For the purpose of this report, wetlands have been classified according to a hydro-geomorphic (HGM) classification system based on the Level 4a classification proposed by the National Wetland Classification System (SANBI, 2009). This system uses hydrological and geomorphological characteristics to distinguish primary wetland units, and is therefore based on factors that influence how wetlands function (SANBI, 2009).

The 2002 Report classified wetlands based on a much simplified HGM classification system, and only recognised three different wetland types, namely floodplain, drainage lines and pans. To align the 2002 data with the SANBI (2009) classification system, the "drainage lines" were re-classified as either channelled or unchannelled valley bottom wetlands for the purposes of this report. The re-classification was done based on aerial photography and the presence or absence of a visible channel; no additional groundtruthing was done of these areas.

5.10.3.1 Channelled Valley Bottom Wetlands

Channelled valley bottom wetlands make up more than 17 % of the wetland area on site. The channelled valley bottom wetlands on site occur generally high up in the catchments and form tributaries of the larger floodplain wetlands. They are separated from the main floodplains in the study area based on slope and the absence of characteristic floodplain alluvial features. In most cases however, the transition from floodplain to drainage line is not as abrupt as depicted in Figure 5.10.2(b). In addition, many of the larger valley bottom wetlands function very similarly to floodplains in terms of hydrology. However, the steeper slope and the narrower valleys result in sediment export and the erosion of a channel through the wetland being the dominant processes in these systems, rather than the depositional process that dominates on typical floodplains.

Within the study area, the soils of these wetlands are characterised by vertic black clays; soils that do not display typical wetland indicators (e.g. mottling) very clearly and provide some difficulty to accurate delineation and identification of wetlands. Plant species too comprise predominantly upland species, but the presence of some facultative and facultative wetland species suggests that these areas are at least temporarily wetted. As such, it is very difficult to accurately delineate the extent of the temporarily wet zones and the boundaries of the valley bottom wetlands. Nevertheless it is felt that the delineation contained in this report represents best scientific judgement. In addition to the valley bottom wetlands, several minor preferential flow paths feeding into these wetlands also occur on site, though these do not display wetland characteristics and cannot be delineated as such. Given the clayey nature of the soils in the area and the high run-off percentage generated by these soils, it is clear that most of the valley bottom systems on site a driven by surface run-off.

Typical of all these types of systems on site, a tall emergent plant community zone dominates the lower elevations (areas that remain inundated or wet for longest). Dominant plants in the tall emergent zone include obligate hydrophytic plants such as the sedge Cyperus fastigiatus.

The bulrush Typha capensis is noticeably absent from many of these systems (with the exception of areas associated directly with dams), probably due to the highly seasonal nature of these systems. Shorter mixed grass/sedge meadows occur immediately adjacent to the tall emergent zone and the dominant plant species here include the grass Leersia hexandra and the sedges Juncus oxycarpus and Fimbristylis complanata. There is generally a rapid transition from the mixed grass/sedge zone of these more seasonally wet habitats to the more temporarily wet habitat associated with the adjacent marginally wet grasslands. These areas comprise a mixture of grasses, the dominant species being the upland grass Themeda triandra. Facultative wetland and facultative indicator category species such as Eragrostis plana and Setaria sphacelata respectively are co-dominant in many places providing evidence of temporary wetting.

5.10.3.2 Un-channelled Valley Bottom Wetlands

Unchannelled valley bottom wetlands make up less than 0.5 % of the wetland area on site. Within the study area these wetland systems do not differ significantly from the channelled valley bottom wetlands, but represent systems were the flow velocities and volumes are not sufficient to erode a channel through the length of the wetland.

5.10.3.3 Floodplains

Floodplains are the most extensive wetland systems on site and make up 60 % of the wetland area. Surface hydrological forces typically dominate the processes operating on floodplains. Typical floodplain features such as meandering channels and oxbows are associated with all the floodplains on site. This is as a result of the depositional history and the associated topography. As the name implies, floodplains receive water during periods of high rainfall, where the volume of water flowing down a watercourse exceeds the capacity of the channel, and spills out onto marginal areas. Once the black vertic clays are saturated, the floodwaters flow horizontally over the surface.

With sufficient flooding, oxbows and depressions fill up prior to draw down. The floodplain grasslands on site are all temporarily inundated meaning that they only remain inundated for short periods following flooding during high flow periods. Inundation does not occur every year. These floodplain grasslands dominate the wetland area on site with a total area of 1 877 ha (Table 5.10.2(a)). This area is made up of ten systems associated with each of the main river systems on site as shown in Figure 5.10.2(b). The impervious nature of the clays ensures that oxbows and depressions remain inundated for a period longer than the adjacent floodplain grasslands. These areas together with depressions, pools and areas within the active channels represent the only seasonally wet wetland habitats in these floodplain systems.

It is however also assumed that groundwater plays an important role in the functioning of the floodplain wetlands on site, with water (derived from upslope sources) moving along the interface between the soil and the underlying parent rock also contributing to saturating the soils within the floodplains and inundating the oxbows (the soils are assumed to fill up from the bottom).

Given the eroded, incised condition of many of the floodplain channels and the resultant reduced regularity of overtopping, the importance of this subsurface contribution is magnified.

Three different types of ox bows/cut-off meanders were identified on site, differentiated based on the duration of inundation. The duration of inundation is influenced by flooding of the river, the shape and size of the oxbow, as well as the substrate. In general, those areas that were inundated for longest (at least a few months during the summer rainfall season) by the time of the site visits had the highest habitat diversity while those that were inundated for shorter periods had the lowest, Oxbows are however naturally variable and in a reference type floodplain, a continuum of types is expected depending on the extent and duration of recent flooding.

Typical of all the types of oxbows on site, a tall emergent plant community zone dominates the lower elevations of the wetter oxbows. Plants in the tall emergent zone include obligate hydrophytic plants such as the sedge *Cyperus fastigiatus*. In the inundated ox bows, a floating leaved and submerged plant community comprising only obligate wetland indicator plants may also occur. The floating leaved and submerged pondweeds *Potamogeton thunbergii* and *Potamogeton pectinatus* respectively were the common species in this zone. Shorter mixed grass/sedge meadows occur immediately adjacent to the tall emergent zone and in the seasonally saturated zones of all the oxbows and the dominant plant species here include the grass *Leersia hexandra* and the sedges *Eleocharis dregeana*.

As is the case with the depressions and pools in the drainage lines, there is generally a rapid transition from the mixed grass/sedge zone of these more seasonally wet habitats to the more temporarily wet habitat associated with the adjacent marginally wet grasslands. These floodplain grasslands comprise a mixture of grasses, the dominant species being the upland grass *Themeda triandra*. Facultative wetland and facultative indicator category species such as *Eragrostis plana* and *Setaria sphacelata* respectively are co-dominant in many places providing evidence of temporary wetting.

5.10.3.4 Depressions (Pans)

Ten natural pans occur within the study area. One additional pan, Leeuwpan has been artificially enlarged by the construction of two weirs and is now by far the largest open water body in the area. It has a surface area of 578 ha. Leeuwpan also receives waste water inputs from Harmony Gold Mine. Given these modifications, Leeuwpan functions more as a dam than a pan in its current, modified condition.

The presence of Red Data listed bird species (Greater and Lesser Flamingo) does however reveal that the Leeuwpan is still important in terms of biodiversity support.

Table 5.10.3.4(a): Summary of water quality data Leeuwpan (Year 2000) and from 10 Highveld Pans sampled in September 2001

Determinant	Leeupan		10 Highveld pans	
	Mean	Range	Mean	Range
pH	8.24	8.8 – 4.48	8.05	8.96 – 6.73
Electrical Conductivity	623.56	788 – 360	819.09	3200 – 92.00
Chloride	1603.09	1800 – 168.5	156.36	729 – 7
Sulphate	715.60	1100 – 517	61.55	157 – 2
Sodium	1015.16	1279.96 – 875.5	172.62	656 – 10.8
Magnesium	54.63	72.9 – 48.6	9.12	15.3 – 3.44
Calcium	136.19	160 – 119.7	9.57	20.8 – 3.82
Potassium	67.09	94.4 – 52.7	20.99	89.4 – 3.37

The 2002 Report analysed numerous water samples taken from pans in the area and compared these to the quality of Leeuwpan (not sampled in the 2010 study). Water samples have been collected and analysed from Leeupan since 1993. A comparison of these early records with more recent ones, suggest that the concentrations of the major cations and anions sampled have not changed over time. In order to try and get an idea of the status of Leeuwpan, the water quality data was compared with that from 10 highveld pans not influenced by mining activities.

As can be seen from the results presented in Table 5.10.3.4(a), there was considerable inter pan variation in the concentrations of most of the determinants measured. Despite this between pan variability, none of the highest recorded concentrations of any of the determinants, (with the exception of electrical conductivity), approached even the average concentrations of the determinants measured in Leeuwpan. The most notable differences are the high concentrations of sodium, calcium, magnesium, and sulphate in Leeuwpan water when compared to the "natural range". This could reflect the consequences of mining activities. Mine waters associated with coal mining activities in the region are known to contribute these elements to surface waters, but they could conceivably reflect the underlying geology and natural weathering processes.

In addition to Leeuwpan, numerous smaller pans with a total surface area of 6.14 ha were also identified within the study area. The pans are not fed by groundwater or adjacent seepage wetlands as is the case with many pans in the region. Water loss is through evapotranspiration and seepage deeper into the soil. Changes in water chemistry as a result of the concentrating and precipitation of elements due to evaporative concentration would thus be expected to have a marked influence on the composition of the water quality in these systems as a whole, and probably also exerts an influence on the faunal and floristic components of these systems.

Typically, the pans are relatively floristically poor but some variation between the systems is evident based on the duration of inundation. Some of the pans hold water for shorter periods than others and thus lack the tall emergent, floating leaved and submerged hydrophytic communities associated with the open water in pans. These pans are therefore dominated more by mixed grass/sedge meadows of *Leersia hexandra/Setaria sphacelata* and *Eleocharis dregeana/Fimbristylis complanata* throughout.

The mixed grass/sedge meadows of *Leersia hexandra/Setaria sphacelata* and *Eleocharis dregeana/Fimbristylis complanata* also occur in more permanent pans, but these are restricted to the periphery where seasonal root zone wetting occurs. In contrast to the temporary pans, towards the centre of the more permanent pan, longer inundation produces longer-term saturation possibly extending over seasons.

As such, plants like the common bulrush, *Typha capensis*, that can survive in the conditions imposed by more semi-permanent root-zone saturation occur. Submerged hydrophytes like the fennel-leaved pondweed *Potamogeton pectinatus* and the broad-leaved pondweed *Potamogeton thunbergii* occur in the open water. The transitional zone (between the centre and edge of the pan) is characterised by seasonal inundation and extensive floating mats of the hydrophytic grass *Leersia hexandra* occur.

Indications are that the other pans are probably only inundated for short periods during the summer rainfall season following local rainfall events and then fairly rapidly draw down to empty. In the lowest lying areas, shallow water may stand for longer but for most of the year the pans do not contain surface water.

5.10.4 Fauna and Flora

5.10.4.1 Fauna

Small mammals such as mongoose, grey duiker and rodents naturally occur in the area. Yellow mongoose was seen on site and the presence of numerous Marsh owls (*Asio capensis*) in the wetlands suggest that rodents occur. Cape clawless otters (*Aonyx capensis*) and water mongoose (*Atilax paludinosus*) occur in the area and there was evidence of the presence of otters in the Wildebeestspruit and its tributaries in particular. They appeared to be targeting the large Potamonautes crabs that burrow into the *Eleocharis dregeana* and *Leersia hexandra* dominated oxbows and depressions that occur in these drainage lines and floodplains. For a more detailed assessment of the fauna occurring on site, refer to the terrestrial ecology report prepared for the Sasol Mining Middelbult (Block 8) Shondoni Project (Wetland Consulting Services, 2010).

The wetlands on site, especially the large floodplain wetlands with their numerous oxbows as well as the larger open water bodies on site (Leeupan and the farm dams) are expected to provide important habitat for waterfowl. The Red Data listed **African Grass Owl (*Tyto capensis*)**, listed as Vulnerable, was observed on site where it was flushed from its roost in a stand of *Imperata cylindrica* associated with the edge of the channel along a floodplain in the Springbokdraai Reserve area (-26.534313°S; 28.976503°E).

5.10.4.2 Flora

A total of 88 indigenous plant species were recorded in the wetlands of the study area. A total of 27 plant species were recorded in the riparian zones, 42 in the floodplain grasslands, 42 in the valley bottom wetlands, 29 in the floodplain and drainage line oxbows, pools and depressions, and 24 in the pans. A total of 18 exotic plant species were also recorded in the wetlands. All of the plant species recorded are common wetland and marginal wetland species.

The variability in species composition that was picked up within the floodplains and drainage lines is attributed to the differences in species composition between the marginally wet grasslands and the ox bows, pools and depressions. The presence of these features produces wetter habitats within the otherwise fairly dry, temporarily wet floodplain and drainage line grasslands that all had a similar plant species richness and composition throughout the study area. These grasslands for example, are dominated by more dryland species while the more seasonally wet habitats associated with the active channels, pools, depressions and oxbows are dominated by more facultative wetland (fw) and obligate wetland (ow) species.

There is also some variability between different oxbows, pools and depressions in terms of the abundance and composition of plant species. This is related to the extent and duration of wetting within and between these systems with those that are wettest for longest containing more of the obligate type species. Among these systems there is therefore a wet-dry continuum that further adds to the wetland diversity in the floodplain and drainage line systems. The plant species composition of the pans also appeared to reflect a response to a wet-dry continuum related to the variability and duration of inundation in the different pans.

When compared to the upper Olifants River catchment to the north of the study area however, the degree of variability in plant species composition and richness between the wetland types in the Middelbult area is low. This is probably attributable to the absence of seepage wetlands. This lack of seepage wetlands is in turn attributed to a general lack of sandy soils and groundwater influence in the study area.

A list of the plant species recorded in the main wetland types on site is given in Table 5.10.4.1(a).

Table 5.10.4.1(a): Wetland Plant Species Recorded

FAMILY	SPECIES	INDICATOR CATEGORY	RIPARIAN ZONE	FLOODPLAIN	OXBOWS/ DEPRESSIONS	DRAINAGE LINES	PANS
INDIGENOUS							
AMARYLLIDACEAE	*Crinum bulbispermum*	fw	1	1	1	1	1
ASCLEPIADACEAE	*Asclepias fruticosa*	fd		1			
	Asclepias gibba var. *gibba*	fw	1	1		1	
	Xysmalobium undulatum	fw	1	1			
ASTERACEAE	*Berkheya radula*	f		1		1	
	Berkheya spp.	fd	1	1	1	1	1
	Haplocarpha scaposa	fw		1	1		
	Helichrysum aureonitens	f	1				
	Helichrysum pilosellum	fw		1		1	
	Helichrysum rugulosum	f				1	
	Senecio erubescens	f	1				
	Senecio inornatus	f		1		1	
	Stoebe vulgaris	fd		1			
	Vernonia oligocephala	f		1			
COMMELINACEAE	Cyanotis spp.	f		1			
CRASSULACEAE	Crassula spp.	fd				1	
CYPERACEAE	Cyperus spp.	fw			1		
	Cyperus spp.	fw			1		
	Cyperus spp.	ow			1		
	Cyperus denudatus	ow				1	
	Cyperus fastigiatus	ow	1	1	1	1	
	Cyperus longus	fw		1	1		
	Eleocharis dregeana	ow		1	1	1	1
	Fimbristylis complanata	fw		1	1		1
	Fuirena pubescens	ow				1	1
	Isolepis costata	ow				1	
	Kyllinga erecta	fw		1		1	

FAMILY	SPECIES	INDICATOR CATEGORY	RIPARIAN ZONE	FLOODPLAIN	OXBOWS/ DEPRESSIONS	DRAINAGE LINES	PANS
	Bidens formosa	N/A	1			1	
	Cirsium vulgare	N/A	1	1	1	1	1
	Conyza bonariensis	N/A					
	Crepis hypochoeridea	N/A		1		1	
	Hypochaeris radicata	N/A				1	
	Pseudognaphalium luteo-album	N/A				1	
	Sonchus oleraceus	N/A	1	1			
	Tagetes minuta	N/A	1			1	
	Tragopogon dubius	N/A	1	1		1	
ONAGRACEAE	*Oenothera rosea*	N/A		1			
PLANTAGINACEAE	*Plantago lancelolata*	N/A	1				
POLYGONACAEA	*Persicaria lapathifolia*	N/A	1		1		1
	Rumex crispus	N/A		1	1	1	
SALICACEAE	*Salix babylonica*	N/A		1			
VERBENACEAE	*Verbena bonariensis*	N/A			1		
	Verbena braziliensis	N/A		1		1	
TOTALS			**7**	**10**	**4**	**9**	**3**

FAMILY	SPECIES	INDICATOR CATEGORY	RIPARIAN ZONE	FLOODPLAIN	OXBOWS/ DEPRESSIONS	DRAINAGE LINES	PANS
	Echinochloa colona	fw			1		
	Eragrostis curvula	fd	1	1	1	1	1
	Eragrostis gummiflua	fd				1	1
	Eragrostis heteromera	fw		1			
	Eragrostis plana	fw	1	1	1	1	1
	Eragrostis racemosa	f		1			
	Harpechloa falx	fd		1			
	Helicotrichon turgidulum	fw				1	1
	Hyparrhenia hirta	fd	1	1		1	1
	Ischaemum fasciculum	ow					1
	Leersia hexandra	ow			1	1	1
	Miscanthus junceus	fw	1				
	Panicum schinzii	fw				1	
	Paspalum dilatatum	fw	1	1	1	1	
	Pennisetum sphacelatum	fw				1	
	Phragmites australis	ow		1			
	Schizachyrium sanguineum	fw			1		1
	Setaria incrassata	fw			1		1
	Setaria sphacelata var. *sericea*	fw		1	1	1	1
	Setaria nigrirostris	fw				1	
	Themeda triandra	fd	1	1		1	
	Tragus spp.	UNKNOWN		1			
POLYGONACAEA	*Persicaria attenuata*	ow			1		
	Persicaria serrulata	ow	1		1	1	1
	Rumex lanceolatus	fw	1				
POTAMOGETONACEAE	*Potamogeton pectinatus*	ow			1		1
	Potamogeton thunbergii	ow			1		1
TYPHACEAE	*Typha capensis*	ow		1	1	1	1
TOTALS			**27**	**42**	**29**	**42**	**24**
EXOTICS							
APIACEAE	*Centella asiatica*	fw		1			
ASTERACEAE	*Bidens bipinnata*	N/A		1			1

FAMILY	SPECIES	INDICATOR CATEGORY	RIPARIAN ZONE	FLOODPLAIN	OXBOWS/ DEPRESSIONS	DRAINAGE LINES	PANS
	Mariscus congestus	ow			1	1	
	Schoenoplectus corymbosus	ow				1	
	Schoenoplectus spp.	ow			1		
EUPHORBIACEAE	*Euphorbia striata*	f	1				
FABACEAE	*Erythrina zeyheri*	fd	1				
	UNKNOWN SHRUB	fd	1				
GERANIACEAE	*Geranium* spp.	fd		1			
HYPOXIDACEAE	*Hypoxis acuminata*	f		1		1	
	Hypoxis hemerecocallidea	fd		1			
IRIDACEAE	*Gladiolus elliotii*	fw		1		1	
JUNCACEAE	*Juncus exsertus*	ow				1	
	Juncus oxycarpus	ow				1	
LEGUMINOSAE	*Crotalaria* spp.	UNKNOWN	1				
LENTIBULARIACEAE	*Utricularia stellaris*	ow			1		1
LILIACEAE	*Aloe* spp.	UNKNOWN					1
	Protoasparagus laricinus	fd	1				
OXALIDACEAE	*Oxalis obliquifolia*	fw			1	1	
PLANTAGINACEAE	*Plantago longissima*	fw	1				
POACEAE	*Agrostis eriantha* subsp. *eriantha*	f				1	
	Andropogon appendiculatus	fw			1		1
	Andropogon huillensis	fw	1				
	Aristida adscensionis	f	1	1			
	Aristida bipartita	f	1	1			
	Aristida congesta subsp. *barbicollis*	fd	1	1		1	
	Aristida congesta subsp. *congesta*	f		1		1	
	Aristida junciformis subsp. *junciformis*	fd	1	1		1	
	Arundinella nepalensis	fw	1				
	Cymbopogon plurinoides	fd		1			1
	Cymbopogon validus	f		1		1	
	Cynodon dactylon	f		1		1	
	Cynodon nlemfuensis	f		1			
	Dactylectinum aegyptium	fw			1		1
	Digitaria eriantha	f				1	

Plant Indicator Categories

There is a fairly even spread of plant indicator categories within the wetland habitats in the study area. Approximately 57% of the plants that were recorded within the wetlands (Figure 5.10.4.2(a)) can be regarded as wetland indicator species (in the ow and fw indicator classes).

The remaining 43% comprise plant species equally likely to occur in wetland and non-wetland areas and plant species more likely to occur in non wetland areas. This is a further indication of the relatively dry conditions common in the majority of the wetland habitats within the study area during the field surveys.

Within the riparian zones and floodplain grasslands there is a similar spread of plant indicator categories with very few (low percentage) of obligate wetland (ow) species and an even distribution of facultative wetland (fw) and more non wetland species (Figure 5.10.4.2(b)).

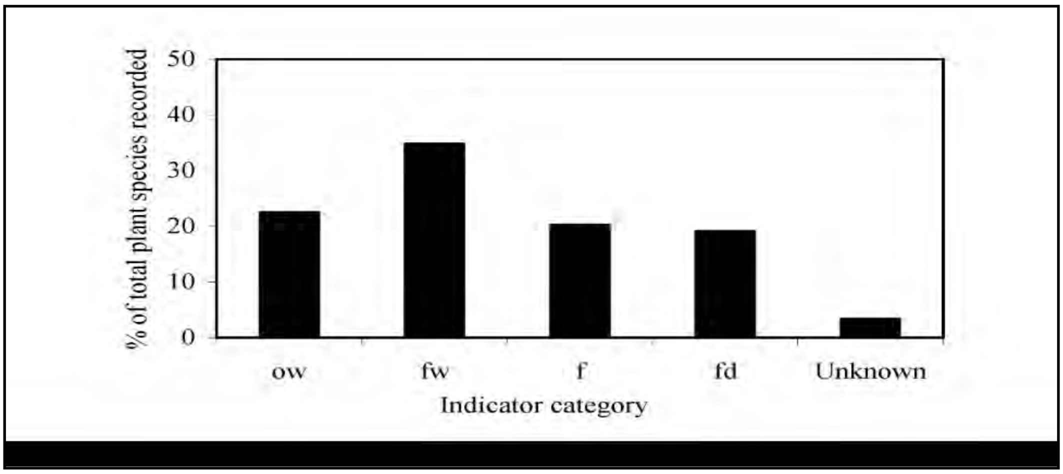

Figure 5.10.4.2(a): Percentage of plant species in the different indicator categories for all the wetlands in the study area at the time of the field surveys

Within the riparian zones and floodplain grasslands there is a similar spread of plant indicator categories with very few (low percentage) of obligate wetland (ow) species and an even distribution of facultative wetland (fw) and more non wetland species (Figure 5.10.4.2(b)).

In contrast, the valley bottom grasslands have a higher percentage of obligate wetland (ow) species compared to the former systems. This can probably be attributed to the existence of more seasonally wet habitats in some of the drainage lines, particularly where there is little channel erosion and there is a gradual transition from pools and depressions to the adjacent grasslands as is the case in the drainage lines of the Wildebeestspruit.

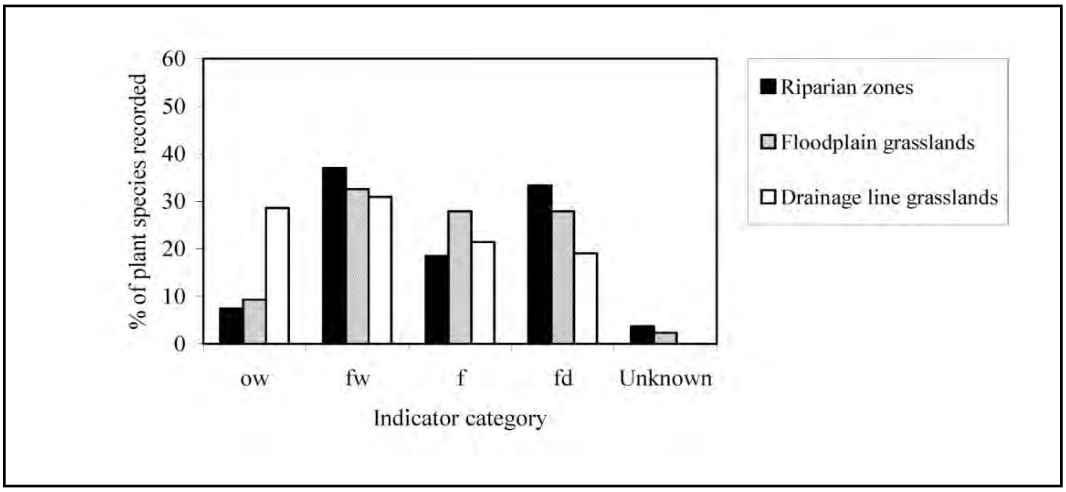

Figure 5.10.4.2(b): Percentage of plant species in the different indicator categories for the riparian zones, floodplain grasslands and drainage line grasslands at the time of the field surveys

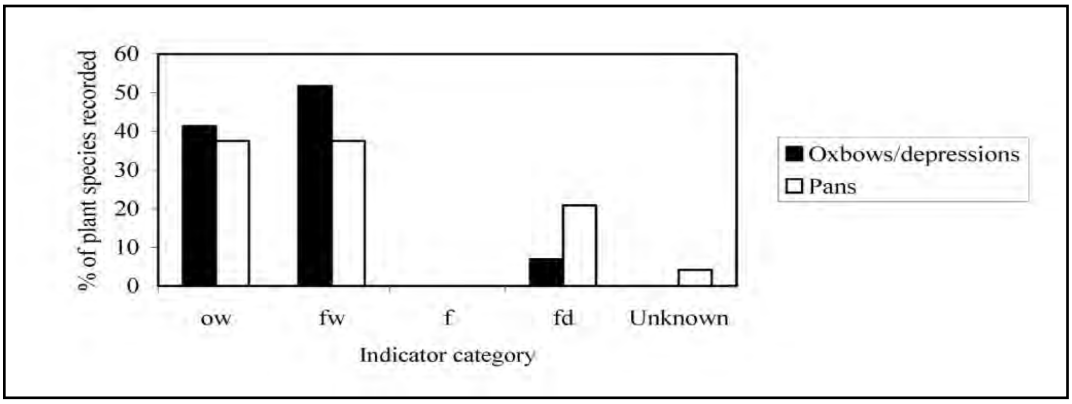

Figure 5.10.4.2(c): Percentage of plant species in the different indicator categories for the oxbows, pools and depressions and pans at the time of the field surveys

In contrast to these systems, plant species occurring in the oxbows, depressions and pans comprise predominantly obligate wetland (ow) and facultative wetland (fw) species (Figure 5.10.4.2(c). This means these systems comprise almost exclusively wetland indicator species with a few facultative dryland (fd) species on the edges. As expected these systems therefore represent the wetter group of wetland habitats in the study area and to a large extent these are quite different to the more extensive yet drier marginally wet habitats associated with the floodplain and drainage line grasslands.

5.10.5 Functional Assessment

Despite the widely held notions about wetland functionality, extensive literature searches reveal that very few practitioners have actually quantified these benefits (Batchelor, 2002). Moreover, it appears that these functions are highly variable depending on the characteristics of the wetlands and the landscape. In the present study, it was not possible to perform the types of investigations necessary for determining functionality such as nutrient balance studies or flood attenuation quantifications.

This was due both to the complexity of the task and the costs and time that would have been involved. It is therefore difficult to speculate on the functional values of the wetlands on site. Nevertheless, some general discussion is possible based on experience and other projects undertaken in the region. These are discussed for each of the main wetland types found within the study area.

5.10.5.1 Floodplains

Floodplains are commonly considered to be valuable in that they perform a number of beneficial functions to society. For example, due to the nature of the vegetation and the topography they occupy, they are considered important for flood attenuation. Their function in relation to enhancing water quality however is less clear. Since the dominant source of water on floodplains is the volume of water flowing over the surface of the floodplain area, the concentrations of nutrients are generally low due to dilution effects. This together with shorter retention times, reduces the chance of contact between the bulk of the water and the sediments and thus reduces the opportunity for the removal of certain nutrients.

One exception to this is suspended solids, the concentration of which may be high due to the ability of floodwaters to carry high suspended loads. Once flows overtop river banks, the velocity of the floodwaters reduces and permits the selective deposition of particles, with fine particles associated with slow flows and coarser sediments progressively higher flows. Some nutrient removal, for example phosphates and ammonia bound to clay minerals and soil particles, is likely to occur coincidentally with the deposition of sediments. Sedimentation will thus tend to reduce phosphate loads in the short term, which however are likely to be recycled through plant and animal uptake and possibly re released into the system. Re release may also occur if the sediments are submerged for periods long enough to result in the formation of anaerobic conditions, such as would occur in the depressions and oxbows.

During the drying out phase, similar processes to those documented in endorheic pans can be expected, with progressive concentrating of solutes until their solubility products are exceeded. The actual mass of these precipitates is however unlikely to represent a significant proportion of the mass of elements transported during the flood event. In addition to removal, flooding can also result in the release of salts and nutrients into the water column through mineral exchange. During the initial wetting phase for example, previously deposited salts and nutrients may be dissolved and leached from the sediments into the water column. Another effect that flooding has on sediments is a change in the redox potential. Typically the redox potential would decrease as a function of time after flooding. The change in redox increases the solubility of a number metals such as manganese and iron and can result in the release of these and previously bound phosphates. The converse also holds when the floodplain systems drain and the sediments become re aerated.

The ox bows within the floodplains retain water for longer (throughout the summer rainfall season in many cases) and therefore are major contributors to the biodiversity of the floodplains in that they create seasonally wet habitats within the temporarily wet floodplain grasslands in which they occur.

5.10.5.2 Valley Bottom Wetlands

The broad drainage lines within the study area are expected to perform similar functions to the floodplains, but at a smaller, and over different spatio-temporal scales. While retention times are expected to be shorter due to the steeper slopes in the drainage lines compared to the floodplains, there are some drainage lines where saturated conditions appear to persist for longer periods than in the floodplains due to local changes in slope and/or shallower channel incision. These areas act almost like seepage wetlands within the drainage lines and thus could be functioning in a similar manner to seepage wetlands. The longer retention times and anaerobic conditions in these systems is likely to facilitate the removal of excess nutrients and inorganic pollutants (Rogers, Rogers and Buzer, 1985; Gren, 1995; Ewel, 1997; Postel and Carpenter, 1997) that may be getting into the water courses associated with these drainage lines. In so doing they may be performing a purification service. The wetlands are not expected to be playing an important role in replenishing or recharging groundwater supplies, mainly because of their small size and fairly impervious clay base.

They may however be helping to retain water for longer in sections of the drainage lines and thus in the catchment and they probably contribute towards the biodiversity of the catchment by creating seasonally wet patches in a landscape that is dominated by dry grassland and temporarily wet wetlands.

5.10.5.3 Pans

Water quality in pans is influenced by the pedology, geology, and local climate (Batchelor, 2002). This in turn, is likely to have a marked influence of the response of these systems to nutrient inputs. In systems like those on site that dry out completely at some stage, some of the accumulated salts and nutrients such as organic nitrogen, various phosphate and sulphate salts might be transported out of system by wind and be deposited on the surrounding slopes. Where deposited materials are not transported out of the system they may re-dissolve when waters enter the system after rainfall events.

Of the phosphate load entering a pan, some may enter absorbed to particulates including the soil, and the other fraction as soluble reactive phosphate. It is likely that the there will be transfer between these forms. When on the one hand pans fill, anaerobic/anoxic conditions will develop, leading to the solubilisation of a fraction of the sediment bound phosphate component. When the pans dry out, conditions favouring the precipitation of Phosphate bound to iron and aluminium and/or as calcium phosphate will result followed by diagenesis.

Another possible sink for phosphates are plants that occur in the pans, either as terrestrial plants when the pan is empty or as aquatic plants when flooded. Some of the phosphates will be taken up by macrophytes present within the system, but unless these are removed, either by grazing and or harvesting, they will not in the long term contribute to phosphate removal, but will be part of an internal recycling system.

5.10.5.4 Hillslope Seepage Wetlands

Hillslope seepage wetlands are rare within the study area and are mostly found in the south west of the study area around Leeupan where the soils are sandier, allowing easier infiltration of rainwater into the soils and the lateral movement of water through the soils as interflow.

As is the case of the other wetland types, hillslope seepage wetlands support plants in particular, and associated insects, birds and small mammals adapted to the seasonal moisture regime. In addition hill slope seeps support conditions that facilitate both sulphate and nitrate reduction as interflow emerges through the organically rich wetland soil profile, and they can thus play an important role in maintaining water quality.

They typically represent low energy environments, and where soil moisture conditions remain high throughout the year can accumulate carbon. As hillslope seepage wetlands, for the most part, are dependent on the presence of an aquiclude, either a hard or soft plinthic horizon they are not generally regarded as significant sites for groundwater recharge (Parsons, 2004).

5.10.6 Present Ecological Status (PES) Assessment

While the 2002 Report did include an assessment of the present condition of the wetlands on site, the report did not contain a present ecological assessment as per the standard methodology proposed by "*Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems*" (DWAF, 1999).

For the purposes of this report a present ecological status assessment was carried out, with the results illustrated in the map below. The PES assessment for the area covered by the 2002 Report is based on the descriptions of the wetlands contained within the report, some limited field observation, as well as on changes in landuse within the wetlands catchment as visible from aerial imagery.

No pristine wetlands were found to occur within the study area, with all of the wetlands on site having undergone a degree of degradation due to changes in landuse and other anthropogenic activities.

All of the wetlands on site have been exposed to impacts associated with agricultural activities. Cultivation has had some direct impact on some of the smaller valley bottom wetlands and pans where cultivation has intruded into the wetlands. Further impacts from cultivation include an increase in sediment transported into the adjacent wetlands.

All of the wetlands on site have however been affected by livestock grazing, with overgrazing resulting in decreased diversity as well as decreased cover, increasing the risk of erosion, while cattle paths and trampling by cattle further create erosion nick points. Incorrect burning regimes and too frequent burning exacerbate the problems caused by cattle. Building of farm dams has in some areas also had a significant impact on the wetlands through changing the hydrological regime of the wetlands and leading to flow concentration, resulting in erosion.

The impact of such agricultural activities on the wetlands has however been fairly limited, as witnessed by the result of the PES assessment that classes the wetlands in the west of the study area, those that have only been affected by agricultural activities and have not been directly affected by mining, urbanisation and associated activities, as being in the best condition.

Mining and urbanisation have impacted on the wetlands on site through deterioration in water quality (e.g. through the release of treated wastewater, stormwater and/or mine water), in impacting on the hydrology (e.g. increased flows, including storing of mine water in Leeupan), and in direct modification of the wetlands (e.g. river diversions and the weirs to increase storage capacity in Leeupan. Road crossings have further resulted in concentration of flows, resulting in erosion and channel incision.

All of the above impacts have resulted in the current condition of the wetlands on site departing significantly from the reference or unimpacted condition of the wetland. This is reflected in the results of the PES assessment which indicates that most of the wetlands are in a moderately modified condition (PES C) due to the various impacts discussed above.

A significant percentage of the wetlands (16 %) is considered largely modified, mostly as a result of changes in hydrology and water quality due to urbanisation and infrastructure development, but also in some cases due to cultivation within the wetlands.

Table 5.10.6(a): Table showing the rating scale used for the PES assessment

Mean*	Category	Explanation
Within generally acceptable range		
>4	A	Unmodified, or approximates natural condition
>3 and <=4	B	Largely natural with few modifications, but with some loss of natural habitats
>2.5 and <=3	C	Moderately modified, but with some loss of natural habitats
<=2.5 and >1.5	D	Largely modified. A large loss of natural habitat and basic ecosystem function has occurred.
Outside generally acceptable range		
>0 and <=1.5	E	Seriously modified. The losses of natural habitat and ecosystem functions are extensive
0	F	Critically modified. Modification has reached a critical level and the system has been modified completely with almost complete loss of natural habitat.

Table 1.10.6(b): Results of the PES assessment

PES	Area (ha)	% of total wetlands
B	442.45	13.90%
C	1552.04	48.76%
D	508.97	15.99%
E	648.47	20.37%
F	31.40	0.99%
TOTAL	3185.89	100.00%

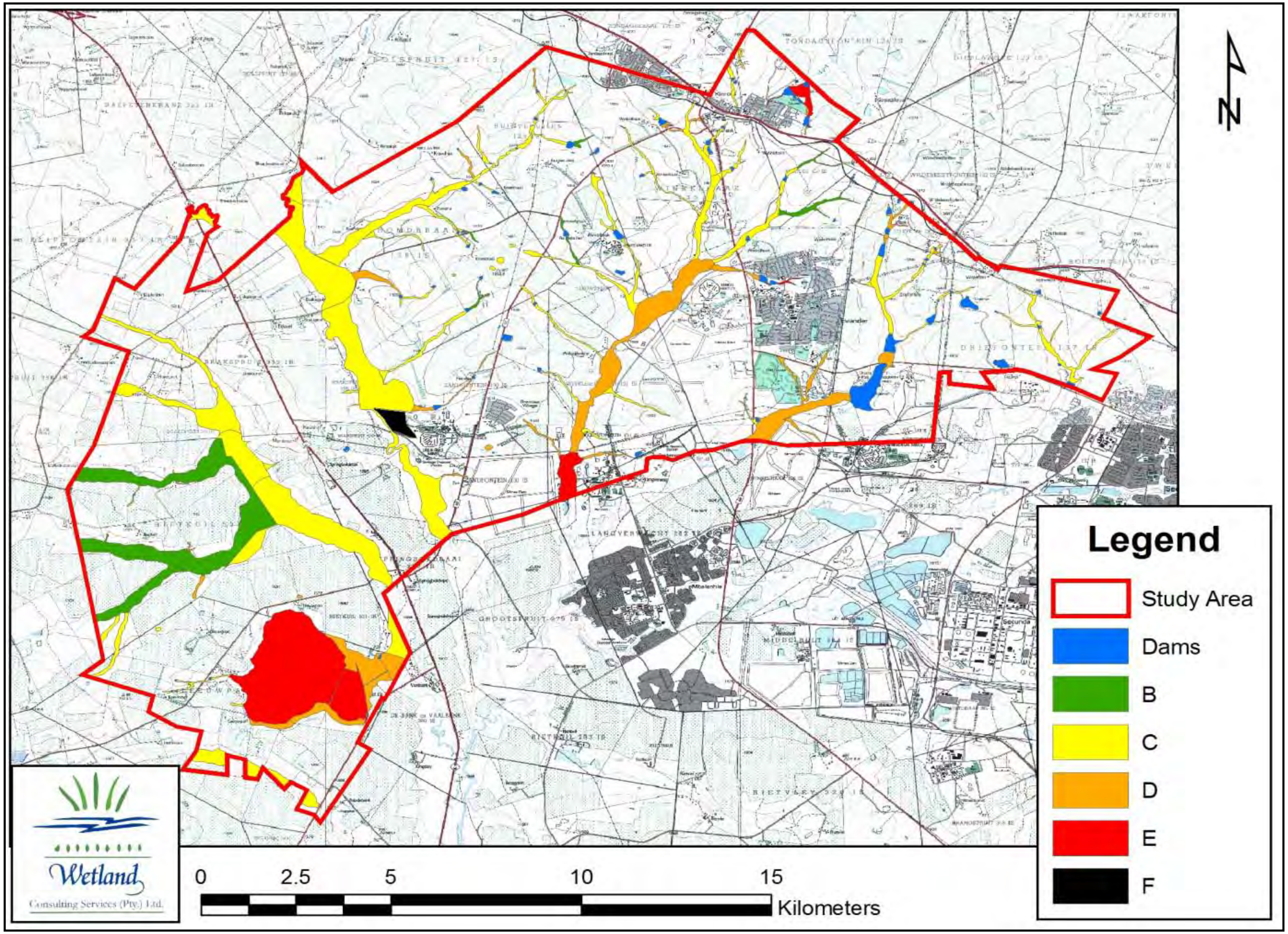

Figure 5.10.6(a): Map showing the results of the PES Assesssment

5.10.7 Ecological Importance and Sensitivity

The site has no formal conservation status. However, based on the current level of understanding and available knowledge of the wetlands of the region, the following discussion is given in the 2002 Report, with some modifications based on findings during the current survey.

Considering the current degraded status of the floodplains within the study area, and the low diversity of plants associated with these, the presence of Red Data plant species in the floodplain grassland habitats is unlikely. It is more likely that if any Red Data plant species occur within the wetland habitats on site, these will be restricted to the few remaining intact riparian zones, either associated with the floodplains or the drainage lines.

Given the types of pans on site as well as the lack of seepage areas around the pans, it is unlikely that they contain any Red Data plant species. However, *Kniphofia typhoides* was recorded on site within on of the smaller valley bottom wetlands on site, and is considered likely to occur in several of the valley bottom wetlands and floodplains on site.

Very few unimpacted floodplains remain in the region, probably for similar reasons to those given above. Despite this type of floodplain (temporarily inundated channelled valley bottom floodplains without footslope seepage wetlands) being numerous in the region, it is the cumulative effect of these high levels of degradation that is of concern, particularly from a hydrological viewpoint. As a result, it is speculated that a large part of the functionality of these systems in the catchment has been lost. Those floodplains that are still in largely natural condition are thus of elevated importance.

Despite the large number of pans in the region, it is the cumulative impact relating to threats that is significant. It is unclear as to how many pans have been lost in the region. For pans in particular, loss is not simply a measure of the loss of surface area, but includes loss as a result of other factors such as their use as evaporation features for waste water from mines, for example.

Others include changes in wetting regimes and extent as a result of draining from undermining and water abstraction, while others occur as a result of changes of land-use or development of the basin or catchment area of the pan which is generally closely related to the footprint of the pan itself. For these reasons, it is difficult to speculate on this aspect other than to say that due to their limited distribution, pans in general in the region are under threat.

Based on the above discussion an ecological importance and sensitivity assessment was undertaken for the wetlands on site. Ecological Importance and Sensitivity is a concept introduced in the reserve methodology to evaluate a wetland in terms of:

- Ecological Importance;
- Hydrological Functions; and
- Direct Human Benefits

These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments (DWAF, 1999), and the work conducted by Kotze et al (2008) on the assessment of wetland ecological goods and services (the WET-EcoServices tool).

The results of the EIS assessment are illustrated in Figure 5.10.7(a).

Most of the wetlands on site are considered to be of moderate importance and sensitivity, with only those wetlands that have undergone extensive degradation being considered of low importance. It is however important to point out that all wetlands, irrespective of their state of degradation, are considered as sensitive landscapes and reflect the movement of water through the landscape.

Table 5.10.7(a): Results of the EIS Assessment

EIS	Area (ha)	% of total wetlands
B	865.58	27.19%
C	1917.43	60.23%
D	400.32	12.58%
TOTAL	3185.89	100.00%

Table 5.10.7(b): Table showing the EIS Assessment Scoring System

Ecological Importance and Sensitivity categories	Range of Median	Ecological Management Class
Very high	>3 and <=4	A
Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.		
High	>2 and <=3	B
Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.		
Moderate	>1 and <=2	C
Wetland that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.		
Low/marginal	>0 and <=1	D
Wetlands that is not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.		

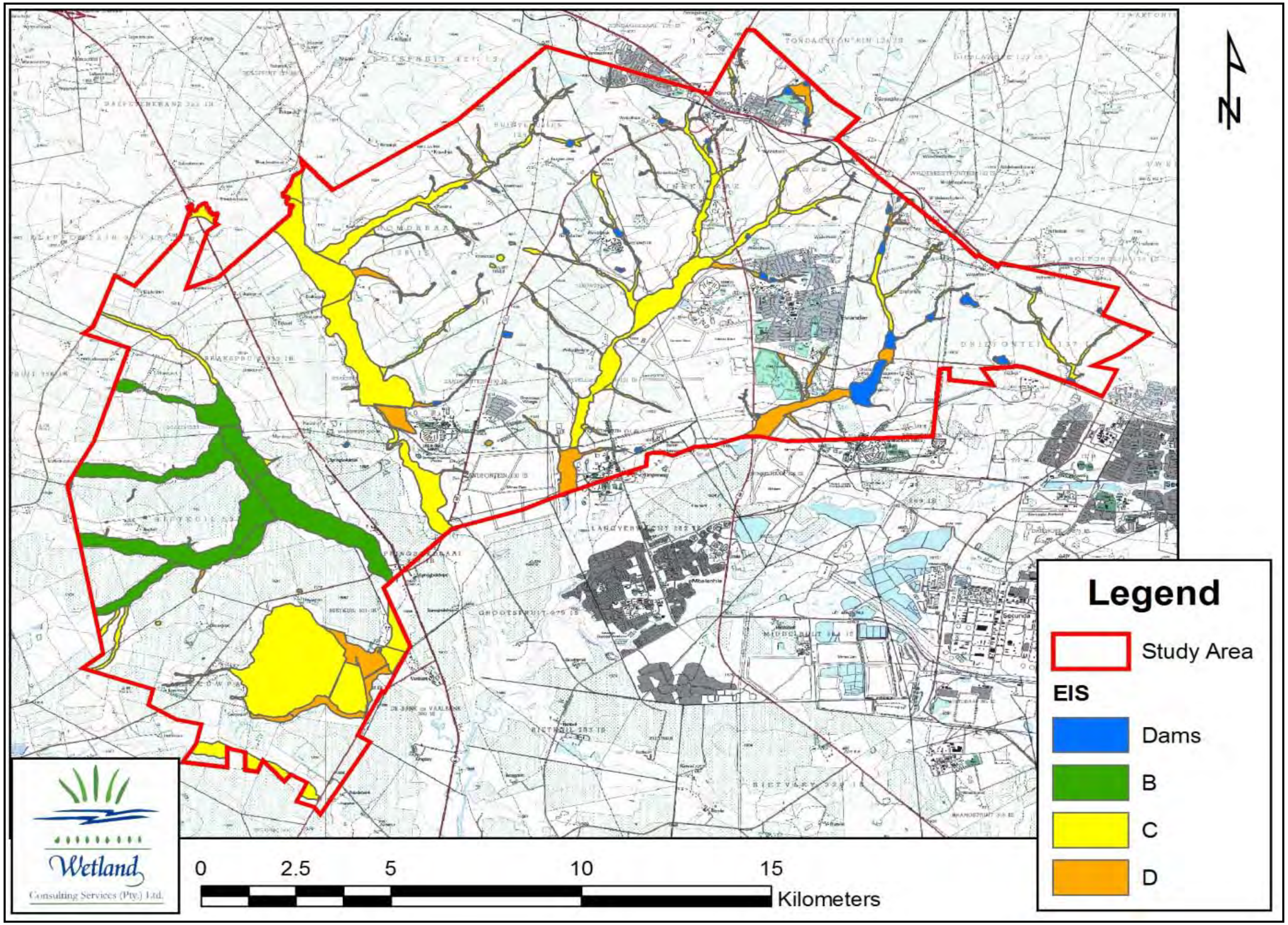

Figure 5.10.7(a): Map showing the results of the EIS Assessment

5.10.8 Conclusions

A detailed wetland assessment was undertaken for the Middelbult Block EMPR in 2002 by Wetland Consulting Services. The current study, the field work for which was undertaken in June 2010, was commissioned to extend the wetland information contained within the 2002 Report to an additional three areas (Block 8 Northern Reserves, Leeuwpan Reserves and Springbokdraai Reserves respectively), and to then combine this information with that contained within the 2002 Report and produce one single report for inclusion in the Sasol Mining Middelbult-Block 8 -Shondoni Project EIA and EMPR currently undertaken by JMA Consulting. As such, this report quotes extensively from the 2002 Report (attached in Appendix 2), but also adds some additional information.

Given the geology and soils characteristics of the study area which markedly influence that way that water moves through the landscape, the wetland area within the study site is limited in extent to approximately 3 185 ha, or 13.8 % of the study area. This is less than what is generally encountered in the Upper Olifants catchment of the Mpumalanga Highveld, but is due to the nature of the soils of the area (mostly vertic clay soils) that encourage run-off, with only limited infiltration and retention of water within the landscape. This is reflected within the vegetation of many of the wetlands on site where facultative dryland species, facultative species and facultative wetlands species are more common and cover far more extensive areas that obligate wetland species.

The study found that most of the wetlands on site have been moderately modified due to a range of impacts, including agricultural practices, infrastructure developments, urbanisation and mining related activities. This has resulted in no pristine wetlands being found on site and the majority of wetlands are considered to be of moderate importance and sensitivity.

Nonetheless, it is important to point out that all water resources, irrespective of their state of degradation are considered sensitive landscapes and that ***any activity which is contemplated and which will impact on the wetlands within the study area is subject to authorisation under Section 21 of the National Water Act (Act 36, 1998). As such, all proposed wetland crossings will require a Water Use License.***

5.11 AQUATIC ECOSYSTEMS (BIOMONITORING)

The JMA Consulting (Pty) Ltd team (Wetland Consulting Services) undertook an assessment of aquatic ecosystems within three additional areas associated with the Sasol Mining Middelbult - Block 8 - Shondoni Project west of Secunda, and incorporated the findings of this study into the existing aquatic ecosystem study available for the area (Palmer and Engelbrecht 2002).

The 2002 investigation formed part of the Middelbult - Block 8 EMPR Addendum for Sasol Coal. The study provided a baseline report on the aquatic ecosystems that fall within the extent of the proposed underground mining areas.

The purpose of this new report is to extend the baseline information contained within the original report to include the three additional areas, and then to compile one single report to cover the entire Sasol Mining Middelbult - Block 8 - Shondoni Project study area (referred to as the study area hereafter).

Field work during the current study was only undertaken for the additional areas; no additional field work was undertaken in the area covered by the 2002 Report. As such, this report draws extensively from the 2002 Report.

In order to extend the baseline information contained within the 2002 Report to include the three additional areas: Block 8 Northern Reserve, Springbokdraai Reserve and Leeupan Reserve, the following activities were undertaken:

- Initial desktop review of existing information;
- Bioassessment of aquatic macroinvertebrates (using SASS5);
- Present Ecological State of instream and riparian areas;
- Baseline Assessment Report, incorporating the findings of the 2002 study.

The following tools were used to assess the integrity of the aquatic ecosystems in surface water:

- Water quality: On-site assessment of conductivity, TDS, pH and temperature.

- The Present Ecological State was determined in consultation with the wetland specialists and is repeated in this report for the sake of completeness (Wetland Consulting Services 2009), thus providing an overall evaluation of aquatic ecosystem integrity.

- The scoring system as described in the document "Resource Directed Measures for Protection of Water Resources. Volumes 3 and 4. River and Wetland Ecosystems" (DWAF, 1999) was applied for the determination of the PES. The scoring system is outlined in Table 5.11(a).

Table 5.11(a): Rating scale used for the PES assessment (Based on DWAF 1999)

Class	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural, with few modifications.	80-90
C	Moderately modified.	60-79
D	Largely modified.	40-59
E	Extensively modified.	20-39
F	Critically modified.	<20

- Aquatic macroinvertebrates using SASS 5 (South African Scoring System). SASS5 is based on the presence or absence of sensitive aquatic macroinvertebrates collected and analysed according to the methods outlined in Dickens and Graham (2002). A high relative abundance and diversity of sensitive taxa present indicates a relatively healthy system with good water quality.

- Disturbance to water quality and habitat results in the loss of sensitive taxa. As this method was developed specifically for rivers, the methods of collection and analysis were modified for wetlands and pans. This meant sampling vegetation and substrate biotopes only, as no stone biotopes were available, and interpreting the results in terms of overall diversity and taxon composition in cases where no flowing water was present.

- In 2002, interpretation of SASS5 scores was based on a scatterplot of samples collected from the Olifants River catchment. In this report, data were interpreted according to updated guidelines provided in Dallas (2007) and illustrated below. This updated method introduced some interpretational changes to the 2002 results.

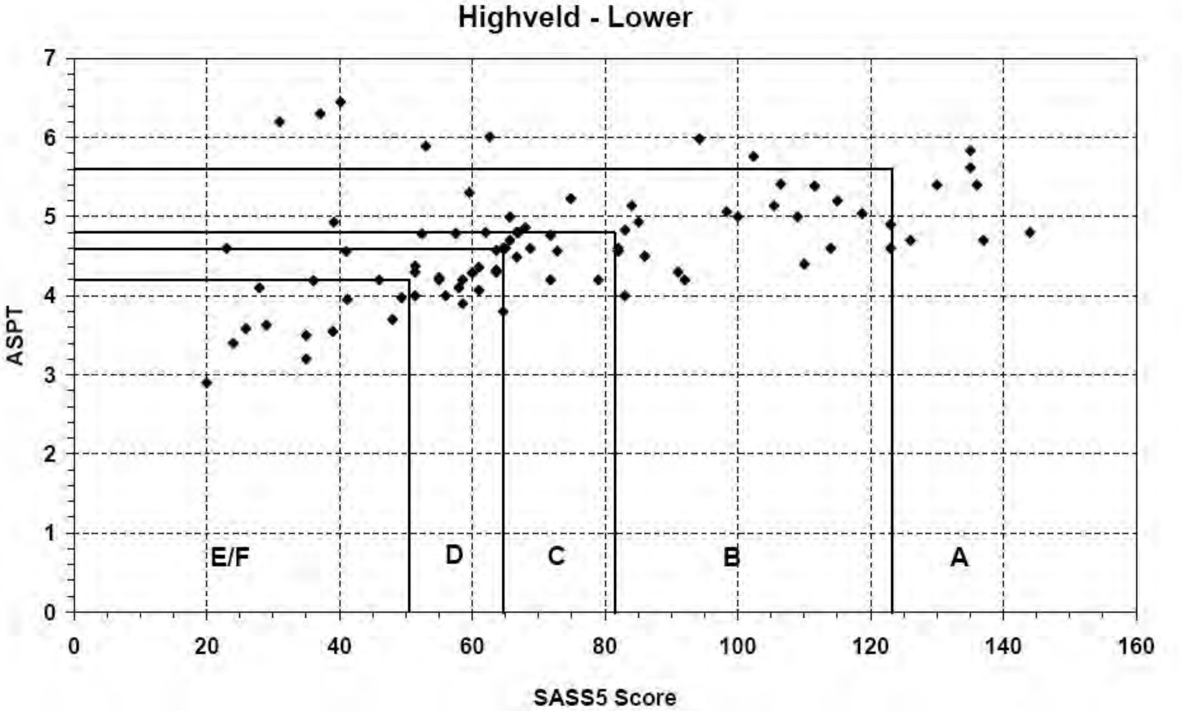

Figure 5.11(a): Biological Bands and Ecological Categories for the Highveld (Lower zone), calculated using percentiles (extracted from Dallas 2007)

Table 5.11(b): Summray of Biological Bands and Ecological Categories

Biological Band/ Ecological Category	Ecological Category Name	Description
A	Natural	Unmodified natural
B	Good	Largely natural with few modifications
C	Fair	Moderately modified
D	Poor	Largely modified
E	Seriously modified	Seriously modified
F	Critically modified	Critically or extremely modified

- Fish were only sampled in 2002 as follows: Historical data on fish was based on literature studies (Skelton 1993, Jubb 1967) and a few surveys conducted by the former Transvaal Directorate of Nature Conservation.

- Fish were sampled using mainly a 10mm-mesh seine net. Electro-narcosis was only used in riffle areas. All fish species were identified and anomalies and general age structure were recorded. Sampling effort was kept to about 15 minutes.

- A qualitative approach was used to estimate fish assemblage integrity. This method and scoring system takes into account the best available fish assemblage information, as well as the impact on physical habitat modifications and possible impacts of alien biota (Kleynhans and Engelbrecht 2001).

Table 5.11(c): Guidelines used for a qualitative assessment of fish [extracted from Palmer and Engelbrecht 2002]

FISH ASSEMBLAGE INDICATORS CONSIDERED FOR ESTIMATION	RIVER ZONE OR DEFINED RESOURCE UNIT (scoring/assessment criteria; provide comments for each score)
Native Species Richness	Number of species expected: number of species currently present (most recent). Score according to: None of expected present=0 Only few of expected present=1-2 Majority of expected species present=3-4 All/almost all of expected present=5
Presence of Native intolerant species	No intolerant species present=0 Few intolerant species =1-2 Majority of intolerant species present =3-4 All/almost all intolerant species present (OR no intolerants naturally present)=5
Abundance of native species	No fish=0 Only few individuals=1-2 Moderate abundance=3-4 Abundance as expected for natural conditions=5
Native species Frequency of Occurrence	Fish absent at all sites=0 Fish present at only very few sites=1-2 Fish present at most sites=3-4 Fish present at all sites=5
Health/condition; native & introduced species	All fish seriously affected/fish absent=0 Most fish affected=1-2 Most fish unaffected=3-4 Only single/few individuals affected=5
Presence of introduced fish species	Predaceous species and/or habitat modifying species with a critical impact on native species=0 Predaceous species and/or habitat modifying species with a serious impact on native species=1-2 Predaceous species and/or habitat modifying species with a moderate impact on native species=3-4 Predaceous species and/or habitat modifying species no impact on native species=5
Instream habitat modification	Water quality/Flow/Stream bed substrate, critically modified, no suitable conditions for expected species=0 Water quality/Flow/Stream bed substrate, seriously modified, little suitable conditions for expected species=1-2 Water quality/Flow/Stream bed substrate, moderately modified, moderately suitable conditions for expected species=3-4 Water quality/Flow/Stream bed substrate, little/no modification, abundant suitable conditions for expected species=5
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	TAKING INTO ACCOUNT THE ABOVE INFORMATION: RATE FISH ASSEMBLAGE INDEX CATEGORY A – F BASED ON GENERAL SCORING GUIDELINES: Category — % of total expected score A: 90 – 100 B: 80 – 90 C: 60 – 80 D: 40 – 60 E: 20 – 40 F: 0 – 20

Seventeen sites were sampled during the 2002 study. An additional eight sites were sampled in 2010. Combined sampling sites are illustrated in Figure 5.11(b) and summarised in Tables 5.11(d) and 5.11(e).

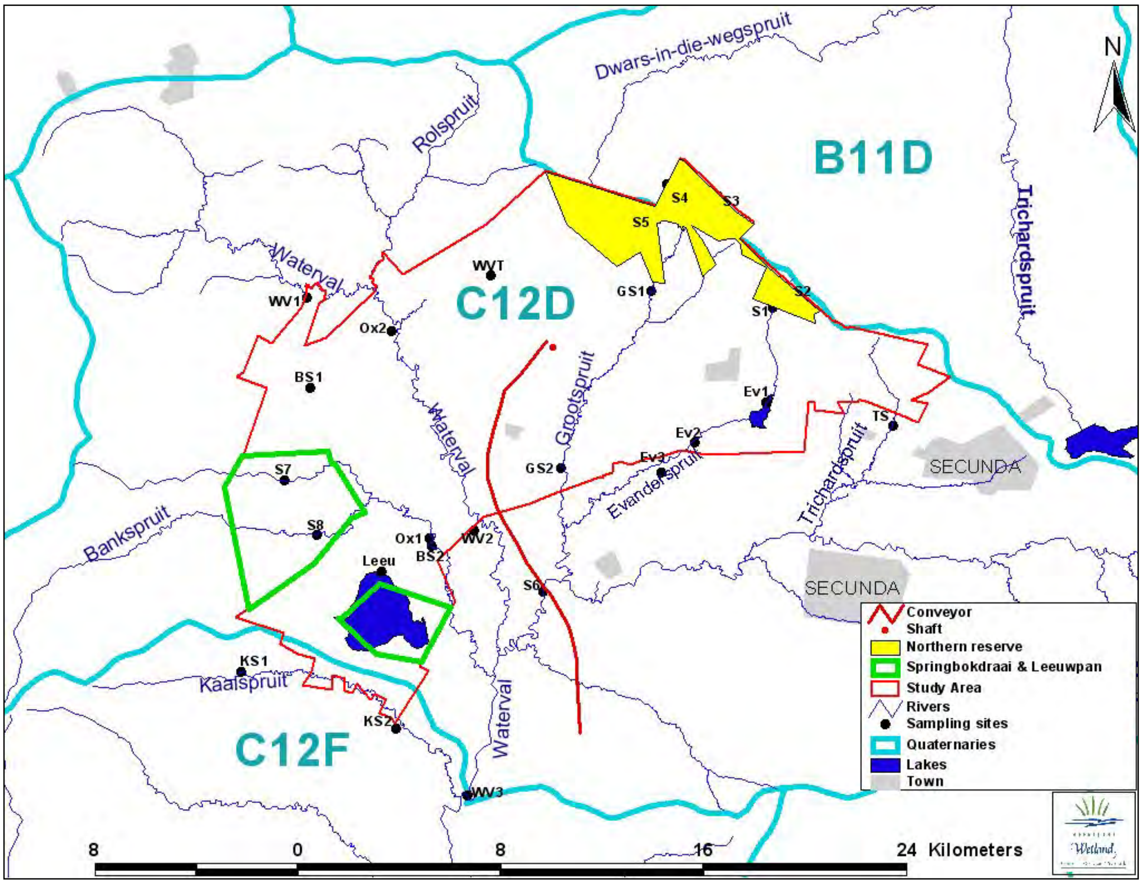

Figure 5.11(b): Aquatic ecosystems sampled during 2010 (S1-8) and 2002 relative to proposed conveyor routes and mining areas

Table 5.11(d): List of pans, streams and oxbow lakes sampled for aquatic macroinvertebrates and fish in March 2002, relative to Block 8 mining area (from Palmer and Engelbrecht 2002)

Site No	Code	River	Farm name	Position in relation to mining area	Altitude (m amsl)	Locality
Pans						
1	Leeu	N/A	Rietkuil 531IR	Downstream	1566	26° 32' 51.4"S; 28° 59' 37.3"E
Oxbow lakes						
13	OX1	Bankspruit	Springbokdraai 277 IS	Within	1564	26° 32' 08.3"S; 29° 00' 38.6"E
7a	OX2	Waterval	Kromdraai 128 IS	Within	1578	26° 27' 43.8"S; 28° 59' 50.2"E
Streams						
2	KS1	Kaalspruit	Kaalspruit 528 IR	Upstream	1582	26° 34' 59.0"S; 28° 56' 39.4"E
3	KS2	Kaalspruit	Roodebank 323 IS	Downstream	1558	26° 36' 12.6"S; 28° 59' 56.2"E
4a	BS1	Bankspruit	Brakspruit 359 IR	Upstream	1595	26° 28' 56.9"S; 28° 58' 06.9"E
4	BS2	Bankspruit	Springbokdraai 277 IS	Downstream	1562	26° 32' 18.3"S; 29° 00' 41.9"E
7c	WVT	Waterval trib.	Kromdraai 128 IS	Upstream	1601	26° 26' 33.9"S; 29° 01' 57.0"E
6	WV1	Waterval	Klipfontein 357 IS	Upstream	1590	26° 27' 02.1S; 28° 58' 02.6"E
5	WV2	Waterval	Springbokdraai 277 IS	Downstream	1562	26° 31' 59.2"S; 29° 01' 35.2"E
Roo	WV3	Waterval	Roodebank 323 IS	Downstream	1550	26° 37' 36.8"S; 29° 01' 26.7"E
9	GS1	Grootspruit	Winkelhaak 135 IS	Upstream	1596	26° 26' 53.0"S; 29° 05' 21.6"E
8	GS2	Grootspruit	Witkleifontein 131 IS	Downstream	1567	26° 30' 39.0"S; 29° 03' 26.3"E
12	EV1	Evanderspruit	Driefontein 137 IS	Within	1606	26° 29' 15.4"S; 29° 07' 48.3"E
10	EV2	Evanderspruit	Winkelhaak 135 IS	Within	1596	26° 30' 07.2"S; 29° 06' 17.6"E
11	EV3	Evanderspruit	Goedvervagting 287 IS	Downstream	1577	26° 30' 45.5"S; 29° 05' 35.0"E
14	TS	Trib. Trichardspruit	Driefontein 137 IS	Within	1590	26° 29' 45.7"S; 29° 10' 29.8"E

Table 2.11(e) List of sites sampled for aquatic macroinvertebrates in June 2010.

Site	River/Position	Affecting Mining Area	Classification	Locality
Quaternary Catchment B11D				
S3	Tributary of the Dwars-in-die-wegspruit	Northern Reserve	Channelled Valley Bottom Wetland	S26 24 52.6 E29 06 46.7
S4	Tributary of the Dwars-in-die-wegspruit	Northern Reserve	Channelled Valley Bottom Wetland	S26 24 36.9 E29 05 41.6
Quaternary Catchment C12D				
S1	Evanderspruit,	Northern Reserve	Channelled Valley Bottom Wetland	S26 27 14.1 E29 07 56.7
S2	Tributary of the Evanderspruit	Northern Reserve	Channelled Valley Bottom Wetland	S26 27 07.4 E29 08 37.0
S5	Tributary of the Grootspruit	Northern Reserve	Channelled Valley Bottom Wetland	S26 25 39.1 E29 05 11.0
S6	Grootspruit	Conveyor Route	Floodplain	S26 33 16.6 E29 03 04.1
S7	Tributary of the Bankspruit	Springbokdraai/ Leeupan	Floodplain	S26 30 54.8 E28 57 34.7
S8	Bankspruit	Springbokdraai/ Leeupan	Floodplain	S26 32 05.4 E28 58 15.4

5.11.1 Regional Description of Relevant Attributes

5.11.1.1 Location

The 2002 Report study area is approximately 19 300 ha in extent and is situated to the nor theast a nd east of S ecunda a nd s outh of K inross. It i ncludes the a rea surrounding Evander and the farms, or portions of the farms, Driefontein 137 IS, Kinross 133 IS, W inkelhaak 135 IS, W itkleifontein 131 IS, Leeuwspruit 134 IS, Zandfontein 130 IS, R uigtekuilen 129 IS, K romdraai 128 IS, B rakspruit 359 IR, Springbokdraai 377 IS, Rietkuil 531 IR, and Leeuwpan 532 IR (Figure 1).

The area lies between 26024’ and 26036S and 28056’ and 29011’E and is located on portions of the topographic map sheets 2628BD Leandra, 2628DB Willemsdal, 2629AC E vander a nd 2 629CA S ecunda (Published b y t he C hief D irectorate: Surveys and Land Information, Mowbray).

The t hree a reas a dded t o t he s tudy area dur ing the c urrent s urvey constitute a n additional approximately 4 000 ha, bringing the total size of the study area to 23 300 ha.

The locality and extent of the study area is shown in Figure 5.11.1.1(a).

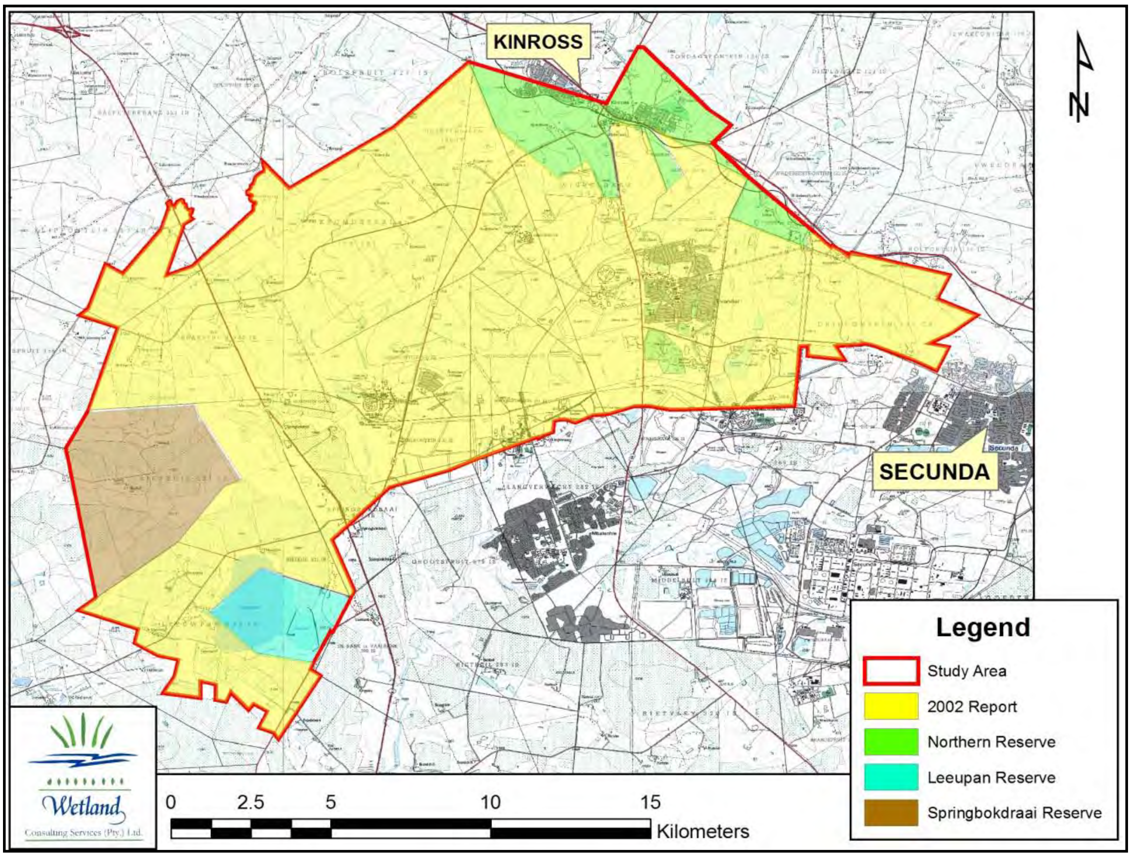

Figure 5.11.1.1(a): Map showing the extent and location of the study area. The area covered by the 2002 Report is shaded yellow, while the additional areas surveyed during the current study are shaded green, brown and blue respectively

5.11.1.2 Surface Water Catchments

The study area is located predominantly in primary catchment C, the Vaal River catchment, with the northern-most reaches of the site draining into primary catchment B, the Olifants River catchment. The affected quarternary catchments include catchments C12D, in which the majority of the study area falls, and C12F, both of which are drained by the Waterval River, as well as catchment B11D, which is drained by the Steenkoolspruit. More details on the affected catchments are provided in the Table below. There are a number of tributaries of the Waterval River that also traverse the study area. These are the Kaalspruit (C12F), Bankspruit, Grootspruit, Evanderspruit and Trichardspruit (all C12D). The Waterval River drains into the Vaal River upstream of the Vaal Dam.

Table 5.11.1.2(a): Table showing the mean annual precipitation, run-off and potential evaporation per quaternary catchment (Middleton, B.J., Midgley, D.C and Pitman, W.V., 1990)

Quaternary Catchment	Catchment Surface Area (ha)	Mean Annual Rainfall (MAP) in mm	Mean Annual Run-off (MAR) in mm	MAR as a % of MAP	Study area as % of catchment
C12D	**81 343**	**666.9**	**59.3**	**8.9 %**	**29 %**
C12F	**75 655**	**634.9**	**49.1**	**7.7 %**	**> 0.5 %**
B11D	**49 812**	**671.5**	**30.1**	**4.5 %**	**1 %**

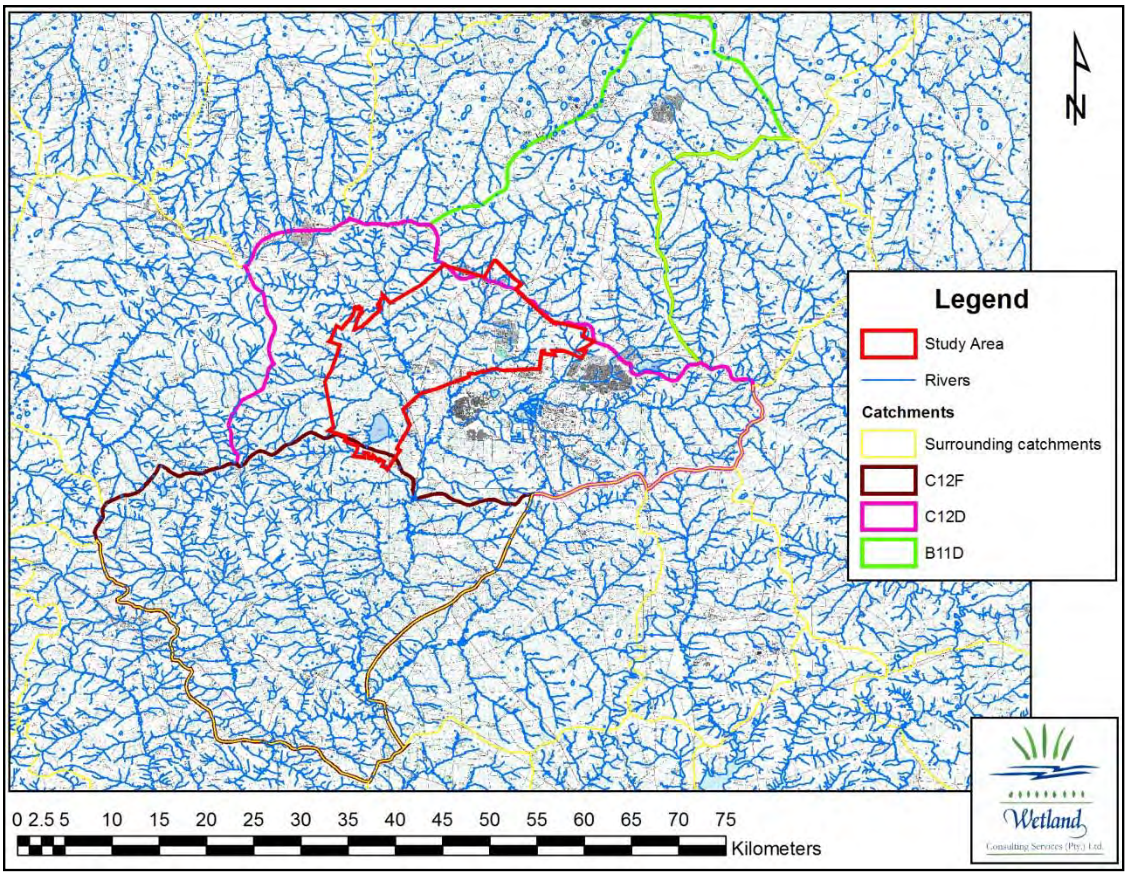

Figure 5.11.1.2(a): Map showing the Shondoni Project study area (red line) in relation to the quaternary catchments.

5.11.2 Current Status of Aquatic Ecosystems

5.11.2.1 Water Quality

On-site water quality data is given in the SASS5 Table 5.11.2.1(a). Water was generally clear, with pH ranging from neutral to alkaline at most sites. The oxbow lakes were slightly acidic. pH is affected by temperature, this partly explaining the difference between readings taken in March (temperatures greater than 16 degrees Celsius) and those taken in June (less than 10 degrees Celsius).

Leeupan is now a permanently inundated pan due to waste water inputs from Harmony Gold Mine. Two weirs have been constructed in order to increase its storage capacity and the water levels are now artificially maintained. Leeupan has a high level of TDS.

Water quality data for sites S 6 (Grootspruit below Embalenhle), the Watervalspruit and Bankspruit are shown in Table 5.11.2.1(b) and can be used as a baseline for future monitoring. Water quality within the Watervalspruit and Grootspruit are likely to be impacted by the conveyor route, while the Bankspruit will be impacted by potential mining within the Leeupan and Springbokdraai areas. The Grootspruit had high levels of salts, in particular, sulphates.

Table 5.11.2.1(a): List of SASS5 data collected during March 2002 (by Palmer and Engelbrecht 2002) and June 2010

Quaternary		C12F		C12D																					B11D	
River System		Kaalspruit		Leeu pan	Banksruit					Waterval River					Grootspruit				Evandersprui					Trichardt spruit	Dwars-in-die-Wegspruit	
SITE		KS1	KS2	Leeu	BS1	S7	S8	BS2	Ox1	Ox2	WV1	WVT	WV2	WV3	S5	GS1	GS2	S6	S1	S2	Ev1	Ev2	Ev3	TS	S3	S4
Sampling Date		March 2002	March 2002	March 2002	March 2002	June 2010	June 2010	March 2002	March 2002	March 2002	March 2002	March 2002	March 2002	March 2002	June 2010	March 2002	March 2002	June 2010	June 2010	June 2010	March 2002	March 2002	March 2002	March 2002	June 2010	June 2010
Temp (°C):		17	22	22	17	7.8	7.57	24		22	20	28		24	8.6	25	24	10.6	8.5	7.7	22		23		9.3	8.93
pH:		7.1	7.4	7.4	7.5	10.02	9.41	7.6	6.8	6.6	7.5	8.6	7.5	7.6	8.8	8	7.1	8.8	8.8	9.36	7.9	8.1	8.1	8.2	8.4	8.7
Cond (mS/m):		48.5	54.7	1560	46.9	58.6	55.3	56.3	26.6	15.6	75	49.4	92.2	69.9	97	108	105	66.4	111	70.5	90.7	82.8	105	113	66.6	131.9
Biotopes Sampled (Rated 1-5)	Stones	0	1	0	0	1	1	2	0	0	4	2	4	4	0	0	4	0	0	0	0	3	2	0	0	0
	Marginal vege	4	3	4	5	3	3	3	5	5	4	3	3	4	4	3	3	3	3	3	3	4	4	3	3	3
	Sediment	2	2	2	3	2	2	1	3		3	3	4	3	1	2	3	2	2	1	3	1	2	3	1	2
TOTAL No. SASS TAXA (+non-SASS taxa)		17	19	9 (+1)	21	13	20	15	8 (+5)	12 (+2)	19	23	14	13	12	18	14	8	9	13	20	7	11	14	5 (+1)	12
SASS Score		89	88	N/A	103	61	100	70	N/A	N/A	86	108	67	55	61	82	58	28	39	59	90	20	44	69	n/a	n/a
Average Score per Taxon		5.2	4.6	N/A	4.9	4.7	5.0	4.7	N/A	N/A	4.5	4.7	4.8	4.2	5.1	4.6	4.1	3.5	4.3	4.5	4.5	2.9	4.0	4.9	n/a	n/a
PES (aquatic macroinvertebrates)		B	C	E	B	C	B	C	B	C	C/D	B	C	E	B	C	E	F	E	D	C/D	F	E	C	C	C
SASS5 Taxon	SASS5 Sensitivity Score*																									
Porifera	5												A													
Turbellaria	3					1			A		A															
ANNELIDA																										
Oligochaeta (Earthworms)	1				A	A	A		C		B	B	A				B	B			A	B	A	A		
Hirudinea (Leeches)	3								1					1				1				1				
CRUSTACEA																										
Potamonautidae* (Crabs)	3	A									B	A	A			A	A				1	A		1		
Atyidae (Freshwater Shrimps)	8	B	B	1	C		A	B			C	1	C	C			B				B		1	B		
HYDRACARINA (Mites)	8	1	A		B					A		A				A				1	A			C	1	
EPHEMEROPTERA (Mayflies)																										
Baetidae 1sp	4			A										1	A				A	A					A	A
Baetidae 2 sp	6	B	A				A	A						B		C	A	B			B		A	B		
Baetidae > 2 sp	12				B	B			C	C	B	B	B													
Caenidae (Squaregills/Cainfles)	6					A	A	A			1	B	A				A		A							A
Leptophlebiidae (Prongills)	9																									
ODONATA (Dragonflies & Damselflies)																										
Coenagrionidae (Sprites and blues)	4	B	A	B	B	A	A	A		A	B	A	A	C	A	B	B	A	A	A	B		A	A		A
Lestidae (Emerald Damselflies/Spreadwings)	8	B	1		B							1												A		
Aeshnidae (Hawkers & Emperors)	8	A	A	A	1		1								A	A				A						
Gomphidae (Clubtails)	6																									
Libellulidae (Darters/Skimmers)	4		1				1			1		1				A	1				1					
HEMIPTERA (Bugs)																										
Belostomatidae* (Giant water bugs)	3	A	1	A	A		A			A	1		A	A		B	A			A	C	B	A	1		A
Corixidae* (Water boatmen)	3	1	A	A	A	B	B			A	A	A				A			A	A	D		1			A
Gerridae* (Pond skaters/Water striders)	5	A	A		A		A	A	A	A		A			A	A			A	A	A					A
Hydrometridae* (Water measurers)	6															A					1					
Naucoridae* (Creeping water bugs)	7																									
Nepidae* (Water scorpions)	3		A					1						A			A				A	1				
Notonectidae* (Backswimmers)	3	A	A	C	B	A	A	A	B		A	A	A			B	A	A	A	A	A			A		A
Pleidae* (Pygmy backswimmers)	4	1		A	A							B			A	B			A		B		A	1	A	
Veliidae/M...veliidae* (Ripple bugs)	5	A									A			A		A								A		A

Quaternary		C12F		C12D																					B11D	
River System		Kaalspruit		Leeu pan	Bankspruit					Waterval River					Grootspruit				Evanderspruit					Trichardt spruit	Dwars-in-die-Wegspruit	
SITE		KS1	KS2	Leeu	BS1	S7	S8	BS2	Ox1	Ox2	WV1	WVT	WV2	WV3	S5	GS1	GS2	S6	S1	S2	Ev1	Ev2	Ev3	TS	S3	S4
Sampling Date		March 2002	March 2002	March 2002	March 2002	June 2010	June 2010	March 2002	March 2002	March 2002	March 2002	March 2002	March 2002	March 2002	June 2010	March 2002	March 2002	June 2010	June 2010	June 2010	March 2002	March 2002	March 2002	March 2002	June 2010	June 2010
Temp (°C):		17	22	22	17	7.8	7.57	24		22	20	28		24	8.6	25	24	10.6	8.5	7.7	22		23		9.3	8.93
pH:		7.1	7.4	7.4	7.5	10.02	9.41	7.6	6.8	6.6	7.5	8.6	7.5	7.6	8.8	8	7.1	8.8	8.8	9.36	7.9	8.1	8.1	8.2	8.4	8.7
Cond (mS/m):		48.5	54.7	1560	46.9	58.6	55.3	56.3	26.6	15.6	75	49.4	92.2	69.9	97	108	105	66.4	111	70.5	90.7	82.8	105	113	66.6	131.9
Biotopes Sampled (Rated 1-5)	Stones	0	1	0	0	1	1	2	0	0	4	2	4	4	0	0	4	0	0	0	0	3	2	0	0	0
	Marginal vege	4	3	4	5	3	3	3	5	5	4	3	3	4	4	3	3	3	3	3	3	4	4	3	3	3
	Sediment	2	2	2	3	2	2	1	3		3	3	4	3	1	2	3	2	2	1	3	1	2	3	1	2
TOTAL No. SASS TAXA (+non-SASS taxa)		17	19	9 (+1)	21	13	20	15	8 (+5)	12 (+2)	19	23	14	13	12	18	14	8	9	13	20	7	11	14	5 (+1)	12
SASS Score		89	88	N/A	103	21	38	70	N/A	N/A	86	108	67	55	26	82	58	15	24	34	90	20	44	69	n/a	n/a
Average Score per Taxon		5.2	4.6	N/A	4.9	1.6	1.9	4.7	N/A	N/A	4.5	4.7	4.8	4.2	2.2	4.6	4.1	1.875	2.7	4.5	4.5	2.9	4.0	4.9	n/a	n/a
PES (aquatic macroinvertebrates)		B	C	E	B	C	B	C	B	C	C/D	B	C	E	B	C	E	F	E	D	C/D	F	E	C	C	C
TRICHOPTERA (Caddisflies)																										
Hydropsychidae 1 sp	4				1	1	1	A			B	A	A	B			A	A								
Cased caddis:																										
Hydroptilidae	6																									
Leptoceridae	6																									
COLEOPTERA (Beetles)																										
Dytiscidae* (Diving beetles)	5	A	A		A	A	A	1	B	B	A	B	A		A	B				A			A		A	A
Noteridae*	5																									
Gyrinidae* (Whirligig beetles)	5	B	A		1						A		A			A	A				A					
Haliplidae* (Crawling water beetles)	5																									
Helodidae (Marsh beetles)	12																									
Hydraenidae* (Minute moss beetles)	8					1	1					A			1											
Hydrophilidae* (Water scavenger beetles)	5				A	1		1				A			A	A			1	A	A		A			A
Limnichidae (Marsh-Loving Beetles)	10																									
DIPTERA (Flies)																										
Ceratopogonidae (Biting midges)	5				1		1				1	1							1					1		
Chironomidae (Midges)	2		B	A	B	A	A	A	A	A	B	A	A	B	A	A	A	A			B	C	A	C	A	A
Culicidae* (Mosquitoes)	1		1		1							A														
Dixidae* (Dixid midge)	10	B					B								B											
Empididae (Dance flies)	6																									
Ephydridae (Shore flies)	3																									
Muscidae (House flies, Stable flies)	1											1														
Psychodidae (Moth flies)	1																									
Simuliidae (Blackflies)	5		C			A		A			C	B		C				A		A	A	A	A			
Syrphidae* (Rat tailed maggots)	1																									
Tabanidae (Horse flies)	5																									
Tipulidae (Crane flies)	5																									
GASTROPODA (Snails)																										
Ancylidae (Limpets)	6		A		C		A	A			1		A	A			1									
Sphaeridae	3									A	A													B		
Unionidae (mussels)	6						1 shell																			
Lymnaeidae* (Pond snails)	3						A							1												
Physidae* (Pouch snails)	3				C			1		A		1		1	A	A				A	A					A
Planorbinae* (Orb snails)	3									A					A					A	A					
Thiaridae* (=Melanidae)	3																									
NON-SASS5 Taxa	**N/A**																									
Cladocera	N/A	Present	Present			C	C		Present	Present					B	Present									C	B
Copepoda	N/A	Present		B		B	B		Present											B				Present		
Ostracoda	N/A						B		Present	Abundant									B							
Conchostraca	N/A								Present																	
Anostraca	N/A								Present																	

Table 5.11.2.1(b): Water quality results for samples taken in watercourses potentially impacted by the conveor route and possible mining in the Springbokdraai area

Water Quality Variable	S6 Grootspruit	WV2 Waterval River	BS2 Bankspruit
pH	7.28	8.52	8.35
Electrical Conductivity (mS/m)	66	55	50
Cations/Anions (mg/l)			
Fluoride (1.5)	0.7	0.41	0.25
Nitrite (4.0)	1.21	0	0
Nitrate (44.0)	16.39	1.12	0.82
Chloride (250)	32.19	17.05	11.12
Sulphate (500)	136.39	42.25	35.15
Phosphate	4.65	0	0
Carbonate (20.0)	0	9	4.5
Bicarbonate	173.85	350.75	338.55
Subtotal	365.4	420.58	390.39
Sodium Carbonate	0	15.9	7.95
Sodium Bicarbonate	0	37.24	20.03
Alkalinity	142.50	302.5	285
Temp. Hardness	142.50	265.3	265.58
Perm. Hardness	86.01	0	0
Sodium (400)	74.32	53.93	38.9
Potassium (400)	8.78	4.32	4.38
Calcium (200)	50.19	48.17	48.56
Magnesium (100)	24.35	35.14	35.03
Boron (1.5)	0.21	0.03	0.01
Subtotal	157.85	141.59	126.88
Total dissolved Solids	436.08	386.63	347.73

5.11.2.2 Habitat Integrity

Results of the Habitat Integrity assessments of 2002 and 2010 are summarised in Table 5.11.2.2(a). These results are site specific for the reaches sampled and do not reflect conditions upstream or downstream within the catchment. A more catchment-level approach to present state is outlined in the wetlands report.

In general, sites along the Bankspruit were considered near-pristine, with agricultural impacts being the only disturbance. Trampling by cattle, weirs and farm roads have caused erosion and channel incision. The upper reaches (BS1) were considered close to pristine, with negligible incision and no alien fish.

The Kaalspruit was also considered near-pristine, the only impacts being from farm dams in the upper reaches which may have aggravated seasonal cessation of flows.

The Waterval River and Grootspruit had highly incised main channels, with associated bank collapse in places. This is probably due to road crossings or dams which have lowered the water table, negatively affecting the growth of riparian vegetation. Carp are expected to occur throughout the Waterval River although they were only recorded from the lower reaches.

Table 5.11.2.2(a): PES of aquatic sampling sites based on the Index of Habitat Integrity (DWAF 1999)

	C12F		C12D																					B11D	
	Kaalspruit		Leeu pan	Bankspruit					Waterval River					Grootspruit				Evanderspruit					Trichardt spruit	Dwars-in die-	
	KS1	KS2	Leeu	BS1	S7	S8	BS2	Ox1	Ox2	WV1	WVT	WV2	WV3	S5	GS1	GS2	S6	S1	S2	Ev1	Ev2	Ev3	TS	S3	S4
Instream																									
Water Abstraction	3	3		1	2	2	2			3	1	5	5	0	0	2	10	8	0	5	3	2	0	8	0
Flow Modification	8	2		1	2	2	1			2	1	3	3	5	5	5	14	14	11	15	20	20	10	16	10
Bed Modification	2	4		0	4	3	3			11	10	3	6	2	4	8	6	6	7	20	2	7	3	7	4
Channel Modification	4	2		0	7	5	7			8	6	10	2	8	2	12	5	5	13	20	2	6	4	15	11
Water Quality	2	4		3	3	3	3			7	4	5	13	5	10	8	20	5	2	8	25	20	12	2	4
Inundation	0	0		0	1	1	1			0	2	0	10	0	0	0	0	0	0	12	2	3	2	8	0
Exotic Macrophytes	0	0		0	0	0	0			0	0	0	0	0	0	0	1	0	0	0	8	0	0	1	1
Exotic Fauna	0	0		0	0	0	0			0	0	5	5	0	0	0	0	0	0	5	0	0	0	0	0
Solid Waste	0	0		0	1	0	1			0	3	12	8	2	5	5	7	0	0	2	0	0	10	0	0
TOTAL (Instream)	**A**	**A**		**A**	**A**	**A**	**A**			**B**	**B**	**B**	**C**	**B**	**B**	**B**	**D**	**C**	**C**	**D**	**D**	**D**	**B**	**C**	**B**
Riparian																									
Indigenous vegetation removal	0	0		0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Exotic Vegetation encroachment	2	2		1	1	1	1			4	1	3	5	4	1	4	5	3	2	0	0	0	0	2	2
Bank erosion	3	6		1	5	5	5			15	5	8	3	4	3	10	4	4	2	0	5	12	3	2	5
Channel modification	3	2		0	5	5	5			15	5	8	0	3	2	14	8	8	10	15	2	3	3	16	10
water abstraction	3	0		0	0	0	0			3	0	0	0	0	0	0	5	10	0	3	0	3	0	8	8
Inundation	0	0		0	0	0	0			0	0	0	4	0	0	0	0	0	0	5	3	3	0	8	0
Flow modification	2	0		0	0	0	0			0	0	0	3	10	0	2	10	10	7	12	15	8	3	11	10
Water quality	0	0		2	0	0	0			3	0	3	5	0	3	4	4	4	2	10	15	8	8	2	5
TOTAL (Riparian)	**A**	**A**		**A**	**A**	**A**	**A**			**C**	**A**	**B**	**B**	**B**	**A**	**B**	**B**	**B**	**B**	**C**	**B**	**B**	**A**	**D**	**B**
TOTAL PES (Habitat Integrity)	**A**	**A**	**n/a**	**A**	**A**	**A**	**A**	**n/a**	**n/a**	**B/C**	**A/B**	**B**	**B/C**	**B**	**A/B**	**B**	**C/D**	**C**	**C**	**C/D**	**C/D**	**C**	**A/B**	**C/D**	**B**

Site S6 lies on the Grootspruit immediately downstream of Embalenhle and is likely to have been impacted by stormwater and effluent inputs containing high levels of organic matter, salts, nutrients and sewage, in addition to mining-derived contaminants from further up in the catchment.

The upper Evanderspruit has been highly modified by grazing cattle (trampling and eutrophication) and farm dams. In 2002, sewage effluent and associated water quality impacts were evident at EV2 and EV3.

The main impacts within the two Dwars-in-die-wegspruit tributaries were dams, which cause channel incision and erosion in downstream reaches. In addition, grazing and trampling by cattle had compacted the substrate and affected water quality (by nutrient enrichment).

Leeupan was not assessed for habitat integrity in 2002 but was considered in the wetland Assessment report to be Category E (Seriously Modified) on account if its altered hydrology. Neverthless, the presence of flamingos within the pan suggests it may have some importance as a habitat for water birds.

5.11.2.3 Aquatic Macroinvertebrates

SASS5 aquatic macroinvertebrate results are displayed in Table 5.11.2.1 (a) and summarised in Table 5.11.2.3(a). PES categories assigned according to invertebrates may have changed since the 2002 study due to updated interpretation guidelines, as described in section 5.1.

Oxbow Lakes and Leeupan could not be analysed according to SASS5 criteria, which apply specifically to running water. These wetlands were not sampled during 2010 and the relevant excerpts from Palmer and Engelbrecht (2002) are duplicated below.

<u>Oxbow Lakes</u>

Aquatic vegetation in both oxbow lakes that were sampled provided excellent habitat conditions for aquatic invertebrates (Score=5). The diversity of crustacean species in the oxbow lakes was high, but this would not be detected by the SASS method. The fauna was characterised by a wide variety of taxa typically associated with temporary ponds, including Anostraca, Conchostraca, Copepoda, Ostrocoda and Cladocera. Crabs were notably absent from these lakes. Baetid mayflies were abundant and comprised more than two species.

Fish were absent from both ponds, and this may partly explain the high numbers of invertebrates. It is likely that fish are naturally absent from these systems. Shrimps were also absent, as would be expected. Overall, the invertebrate fauna at these sites comprises an interesting group of taxa that justifies special conservation measures to protect these habitats. This is particularly so for the oxbow lake adjacent to the Bankspruit (OX1), which based on professional judgement, was considered to be in an excellent Present Ecological State in terms of invertebrates (Category B).

Table 5.11.2.3(a): Summarised SASS5 results for aquatic sites sampled in 2002 and 2010

Quaternary	C12F		C12D																					B11D	
River System	Kaalspruit		Leeu pan	Bankspruit					Waterval River					Grootspruit				Evanderspruit					Trichardt spruit	Dwars-in-die-Wegspruit	
SITE	KS1	KS2	Leeu	BS1	S7	S8	BS2	Ox1	Ox2	WV1	WVT	WV2	WV3	S5	GS1	GS2	S6	S1	S2	Ev1	Ev2	Ev3	TS	S3	S4
Sampling Date	March 2002	March 2002	March 2002	March 2002	June 2010	June 2010	March 2002	March 2002	March 2002	March 2002	March 2002	March 2002	March 2002	June 2010	March 2002	March 2002	June 2010	June 2010	June 2010	March 2002	March 2002	March 2002	March 2002	June 2010	June 2010
Temp (°C):	17	22	22	17	7.8	7.57	24		22	20	28		24	8.6	25	24	10.6	8.5	7.7	22		23		9.3	8.93
pH:	7.1	7.4	7.4	7.5	10.02	9.41	7.6	6.8	6.6	7.5	8.6	7.5	7.6	8.8	8	7.1	8.8	8.8	9.36	7.9	8.1	8.1	8.2	8.4	8.7
Cond (mS/m):	48.5	54.7	1560	46.9	58.6	55.3	56.3	26.6	15.6	75	49.4	92.2	69.9	97	108	105	66.4	111	70.5	90.7	82.8	105	113	66.6	131.9
Biotopes Sampled (Rated 1-5): Stones	0	1	0	0	1	1	2	0	0	4	2	4	4	0	0	4	0	0	0	0	3	2	0	0	0
Marginal vege	4	3	4	5	3	3	3	5	5	4	3	3	4	4	3	3	3	3	3	3	4	4	3	3	3
Sediment	2	2	2	3	2	2	1	3		3	3	4	3	1	2	3	2	2	1	3	1	2	3	1	2
TOTAL No. SASS TAXA (+non-SASS taxa)	17	19	9 (+1)	21	13	20	15	8 (+5)	12 (+2)	19	23	14	13	12	18	14	8	9	13	20	7	11	14	5 (+1)	12
SASS Score	89	88	N/A	103	61	100	70	N/A	N/A	86	108	67	55	61	82	58	28	39	59	90	20	44	69	n/a	n/a
Average Score per Taxon	5.2	4.6	N/A	4.9	4.7	5.0	4.7	N/A	N/A	4.5	4.7	4.8	4.2	5.1	4.6	4.1	3.5	4.3	4.5	4.5	2.9	4.0	4.9	n/a	n/a
PES (aquatic macroinvertebrates)	B	C	E	B	C	B	C	B	C	C/D	B	C	E	B	C	E	F	E	D	C/D	F	E	C	C	C

Leeupan

During this study, the invertebrate fauna at Leeupan was characterised by a low numbers and low numbers of species, dominated mainly by bugs (hemiptera), particularly Notonectidae (Appendix A). One species of mayfly was recorded, and a single freshwater shrimp (Caridina africana) was collected. The water column contained low populations of zooplankton (copepoda). The taxa present were hardy and highly tolerant of polluted conditions. The low numbers of invertebrates may reflect severe predation by fish, as refuges from predation in the pan by way of habitat diversity, are limited. Overall, and based on professional judgement, the present condition of the invertebrate assemblage at this site is considered poor (Category E).

Streams

The highest overall diversity of aquatic macroinvertebrates was recorded within the Bankspruit system (S7 and S8), the tributary of the Watervalrivier (WVT) and the upper reaches of the Evanderspruit (Ev1).

Category B: Largely Natural

SASS5 scores were also highest within the Bankspruit and its tributaries (BS1 and S8), as well as the Watervalrivier tributary (WVT). These sites indicated a higher prevalence of sensitive taxa and were considered Largely Natural (Category B) for invertebrates (ASPT = 4.9 and 5.0). The Bankspruit system was characterised by high numbers of atyid shrimps, limpets (Ancylids), bulinid snails, lestid damselflies and water mites (Hydracarina) (at BS1). In addition, a mussle (Unionidae) shell was found at S8, together with an abundance of dixid midges which are highly sensitive to changes in water quality. Otter scats were observed along the Bankspruit tributary at S7.

A number of Oxbow lakes are associated with the Bankspruit (e.g. adjacent to S8 and BS2). These lakes are inhabited by highly specialised invertebrates that are adapted to seasonal drying, including pan-adapted taxa such as Conchostraca and Anostraca, recorded at Ox1. As such, they contribute significantly to the overall biodiversity of the area. In addition, they provide abundant food resources for waterfowl, further increasing the local biodiversity.

The Watervalrivier tributary (WVT) was characterised by sensitive lestid damselflies, more than two species of baetid mayfly and caenid mayflies.

The upper reaches of the Kaalspruit was also characterised by a number of sensitive taxa (ASPT = 5.2), including lestid damselflies and dixid midges.

Category B-C: Largely Natural to Moderately Modified

Sites along the Watervalrivier showed a decline in water quality from upstream to downstream reaches. The river was characterised by high numbers of baetid mayflies and freshwater shrimps, and the notable absence of Gerridae, Hydracarina and Pleidae.

Freshwater sponges (Porifera) were recorded in the middle reaches of the Waterval River (WV2), and nowhere else in the study area. Downstream of the confluence with the Grootspruit, the water quality declines markedly and at WV3 water quality issues can be considered serious.

The same trend is evident in the Grootspruit, with sensitive taxa being present within the upper reaches (S5 and GS1), including dixid midges, aeshnid dragonflies, hydraenid beetles and water mites. At site GS2, downstream of Evander and associated mining activities, atyid shrimps were still present but at site S6, downstream of Embalenhle and the confluence with the Evanderspruit, no sensitive taxa remain and the river was considered Critically Modified for invertebrates.

Category D-F: Largely to Critically Modified

Very low SASS5 scores were recorded from the Evanderspruit, with sensitive taxa only being recorded at S2 and Ev1 (aeshnid dragonflies and water mites respectively). However, S1 and S2 had very limited biotope availability, this contributing to the low scores.

Sites S3 and S4, both tributaries of the Dwars-in-die-wegspruit, recorded low diversities and SASS5 scores. However, this is unlikely to be due to water quality impacts and is more likely to be associated with low habitat diversity, as well as very low flows at the time of sampling. These two sites were essentially wetland areas and should ideally not be analysed according to the SASS5 methodology. A subjective assessment of these sites was therefore mad, classifying them as Category C (Moderately Modified) for invertebrates.

5.11.2.4 Fish

Fish were not assessed in 2010 and results from Palmer and Engelbrecht (2002) are summarised below.

The most important sites for fish were:

- the Bankspruit (Category A, Unimpacted – Category B, Largely Natural). The fish in the Bankspruit recorded high observed species richness, abundance, sensitivity and health compared with those expected. Exotic fish were absent and habitat suitability was high.
- the upper reaches of the Kaalspruit (Category B, Largely Natural)

There is a possibility that the rare Rock Catlet (*Austroglanis sclateri*) could occur in at least the lower reaches of the Watervalrivier.

Table 5.11.2.4(a): Qualitative assessment of the fish assemblage integrity at the sampling sites in Middelbult Block 8 mining area. Sites are arranged in order of decreasing Present Ecological State with respect to fish. (Extracted from Palmer and Engelbrecht 2002).

	SAMPLING SITE																
INDICATORS	BS1	KS1	BS2	GS2	TS	WV1	KS2	WV2	VW3	EV1	GS1	WVT	EV3	Lee	EV2	OX1	OX2
Native Species Richness	5	3	5	4	4	4	3	4	3	4	3	3	3	2	0	N/A	N/A
Presence of Native intolerant species	5	3	5	5	4	3	3	4	4	3	3	3	3	2	0	N/A	N/A
Abundance of native species	4	4	3	3	3	4	3	3	3	3	2	2	2	2	0	N/A	N/A
Native species Frequency of Occurrence	4	4	3	3	3	4	3	3	3	3	2	2	2	2	0	N/A	N/A
Health/condition; native & introduced species	5	5	5	5	5	5	3	5	5	5	5	5	4	5	0	N/A	N/A
Presence of introduced fish species	5	5	5	5	5	4	5	4	4	4	5	5	5	3	5	N/A	N/A
Instream habitat modification	4	5	3	5	3	3	5	2	3	2	3	2	1	2	2	N/A	N/A
	32	29	29	2	27	27	25	25	25	24	23	21	20	18	7	N/A	N/A
SCORE	**91**	**83**	**83**	**77**	**77**	**77**	**71**	**71**	**71**	**69**	**66**	**60**	**57**	**51**	**20**	**N/A**	**N/A**
CLASS	A	B	B	C	C	C	C	C	C	C	C	C	D	D	E	N/A	N/A

5.11.3 Overall PES and Ecological Importance and Sensitivity

The overall PES is given in Table 5.11.3(a).

Table 5.11.3(a): Overall PES for aquatic sampling sites, derived from assessments of invertebrates, habitat integrity and fish

			Habitat Integity PES	Invertebrates PES	Fish PES	OVERALL PES
C12F	Kaalspruit	KS1	A	B	B	B
		KS2	A	C	C	C
C12D	Leeupan	Leeu	n/a	E	D	E
	Bankspruit	BS1	A	B	A	A
		S7	A	C		B
		S8	A	B		A/B
		BS2	A	C	B	B
		Ox1	n/a	B	n/a	B
	Waterval River	Ox2	n/a	C	n/a	C
		WV1	B/C	C/D	C/D	C
		WVT	A/B	B	C	C
		WV2	B	C	C	C
		WV3	B/C	E	C	D
	Grootspruit	S5	B	B		B
		GS1	A/B	C	C	C
		GS2	B	E	C	D
		S6	C/D	F		E
	Evanderspruit	S1	C	E		C
		S2	C	D		C
		Ev1	C/D	C/D	C/D	C
		Ev2	C/D	F	E	E
		Ev3	C	E	D	E
	Trichardtspruit	TS	A/B	C	C	C
B11D	Dwars-in-die-Wegspruit	S3	C/D	C		C
		S4	B	C		B/C

PES A/B: HIGH Ecological Importance and Sensitivity

The Bankspruit should receive priority status in terms of sensitivity and conservation importance. BS1 and S8 were considered to be close to pristine in terms of habitat integrity and fish. All species of indigenous fish that were expected within the Bankspruit were recorded (BS1 and BS2). No exotic fish were present and at BS1 there was negligible incision of the main channel. Sites S7 and S8 were not sampled for fish but are expected to yield the same results. In addition, the ox bow lakes present along the Bankspruit should be considered ecologically important as they support unique and highly adapted crustaceans that increase the overall biodiversity value of the area, as well as supporting a diversity of waterfowl. The pan-adapted crustaceans that were recorded within Ox1 are highly sensitive to changes in water quality and seasonal hydrology.

The Upper reaches of the Kaalspruit was considered to be Largely Natural (Category B), with a number of sensitive invertebrates having being recorded, together with a high habitat integrity and healthy fish population (with no alien fish species).

PES C: Moderate Importance and Sensitivity

The Watervalrivier was, for the most part, considered to be Moderately Modified (Category C), although there was a gradual deterioration downstream with the Roodewaal site (WV3) considered Largely Modified (Category D), particularly with respect to invertebrates and water quality.

The upper Grootspruit, upper Evanderspruit, Dwars-in-die-wegspruit, Trichardtspruit and the lower reaches of the Kaalspruit were considered Moderately Modified, although conditions along the Grootspruit and Evanderspruit deteriorated significantly in their lower reaches.

The most significant feature of these streams is severe incision of the main channel, and associated bank slumping. This appears to have been caused by stream crossings, which have constricted flows and increased erosion downstream. The deepening of the main channel has reduced the level of the riparian water table, and in doing so, the survival of remaining riparian wetlands is at stake. Carp are expected to occur throughout most of the Waterval River, although they were recorded in the lower reaches only, at Roodebank.

PES D/E: Low Importance and Sensitivity

Flow within the middle and lower Evanderspruit, at the time of sampling in 2002, consisted entirely of treated sewage effluent and was classified as seriously modified (Category E). No fish were recorded immediately downstream of the sewage outlet (EV2), while two out of the three species expected were recorded further downstream (EV3) but only in aerated riffle areas, suggesting low levels of dissolved oxygen at this site. The invertebrate fauna in this stream comprised fauna typically associated with highly polluted conditions.

The Grootspruit below Embalenhle and above the confluence with the Watervalriver was also Seriously Modified with a complete absence of sensitive invertebrates and a low diversity of taxa. Water quality impacts are likely to be from mining and sewage within urban stormwater effluent.

It should be noted that impacts on the Evanderspruit and Grootspruit are likely to be carried further downstream into the Watervalspruit.

Leeupan was also classified as seriously modified (Category E), on account of the unnaturally high and stable water levels, the high concentration of Total Dissolved Solids, and the depauperate fish and invertebrate fauna. However, it may have some importance in providing habitat for water birds.

5.11.4 Conclusions

The Bankspruit was found to be highly sensitive and important, with near-pristine conditions present. As such, it should be given priority conservation status, with little risk allowed. Mining in the Springbokdraai area is likely to have highly significant impacts on this river system.

In addition, the temporary oxbow lakes associated with the Bankspruit, as well as the Waterval River, should be regarded as important and sensitive ecosystems for their role in supporting and enhancing biodiversity. It is suggested that rehabilitation of incised reaches of the Bankspruit and Watervalrivier will assist in maintaining the hydrology that supports these oxbow lakes.

The upper reaches of the Kaalspruit should also be maintained in a Largely Natural (Category B) condition. Rehabilitation within the lower reaches will offset some of the impacts of farm dams in the upper reaches.

The Waterval River was considered, for the most part, to be Moderately Modified (Category C) with channel incision and erosion being the main impact. Water quality appears to be relatively good upstream of its confluence with the Grootspruit.

Most of the Evanderspruit has been polluted by sewage effluent, mining contaminants and urban stormwater. The lower reaches were considered to be Seriously Modified (Category E) and these impacts are transferred downstream into the lower reaches of the Grootspruit, also considered Seriously Modified.

Leeupan was also considered to be Seriously Modified for fish and invertebrates, although it does support a diversity of water birds, including flamingos and, as such, should be regarded as ecologically important and sensitive for birds.

Finally, it is important to point out that any activity which is contemplated and which will impact on the wetlands within the study area is subject to authorisation under Section 21 of the National Water Act (Act 36, 1998). As such, all proposed wetland crossings will require a Water Use License.

5.12 AIR QUALITY

Background air quality for the study area was obtained from a publication by Tyson et al (1998).

5.12.1 Current Status

Annual mean sulphur dioxide concentrations on the Mpumalanga highveld are between 8.8 – 41.3 $\mu g/m^3$ which compares with typical concentrations for semi-urban and urban areas even though it could be classed as a rural area.

The background dust fallout level for the study area is below 0.25 g/m^2 which is the "slight" impact category of the Department of Environmental Affairs & Tourism. The most significant air pollution source in the area is the Sasol Synfuels Complex to the southeast. In winter particulates from burning of coal in townships is a major local pollution source.

5.13 NOISE

JMA Consulting (Pty) Ltd appointed ACUSOLV Acoustical Engineers on behalf of Sasol Mining to conduct a base line noise survey in the area of the proposed new Shondoni Shaft and surface coal conveyor within the Middelbult – Block 8 – Shondoni Mine Lease Area. The base line study also represents an upgraded ambient noise study relevant to the bigger Middelbult – Block 8 – Shondoni Reserve Area.

5.13.1 Terms of Reference and Scope of Work

The acoustic specialist's brief was to investigate the noise impact of the proposed development on the surrounding area and, where applicable, to consider the requirements and options for mitigation. Figure 5.13.1(a) shows the project area with the location of the shaft and the conveyor route to which the findings of this noise study apply.

For the pruposes of this discussion the scope of the word was to carry out a physical scoping and a measurement survey to assess the nature of the existing noise environment and to determine typical existing, i.e. predevelopment outdoor ambient sound levels in the area. This would represent the base line noise levels from which to quantify the expected impact of the development by means of computer modeling of the emission and atmospheric propagation of noise expected to be generated by mining-related surface operations at and around the shaft.

5.13.2 Approach and Methodology

The Shondoni Project noise study is carried out in accordance with SANS 10328, a South African Standard presenting guidelines on procedures to conduct noise assessments.

5.13.2.1 Baseline Field Survey

Selection of Noise Monitoring Locations

Criteria and practical considerations which influence the selection of suitable locations for noise monitoring, include the following:

- **Community concerns:** In selecting locations for noise monitoring, concerns raised by interested and affected parties should be taken into account.
- **Worst-case impact:** Focus on areas where maximum noise impact is expected.
- **Suitability for future surveys:** As far possible, select locations likely to be accessible in future surveys.
- **Avoid interference:** As far as practically possible, stay clear of and avoid **interference** by localised noise sources which may distort the data. Examples are power distribution boxes, barking dogs, speech interference by curious visitors and insects.

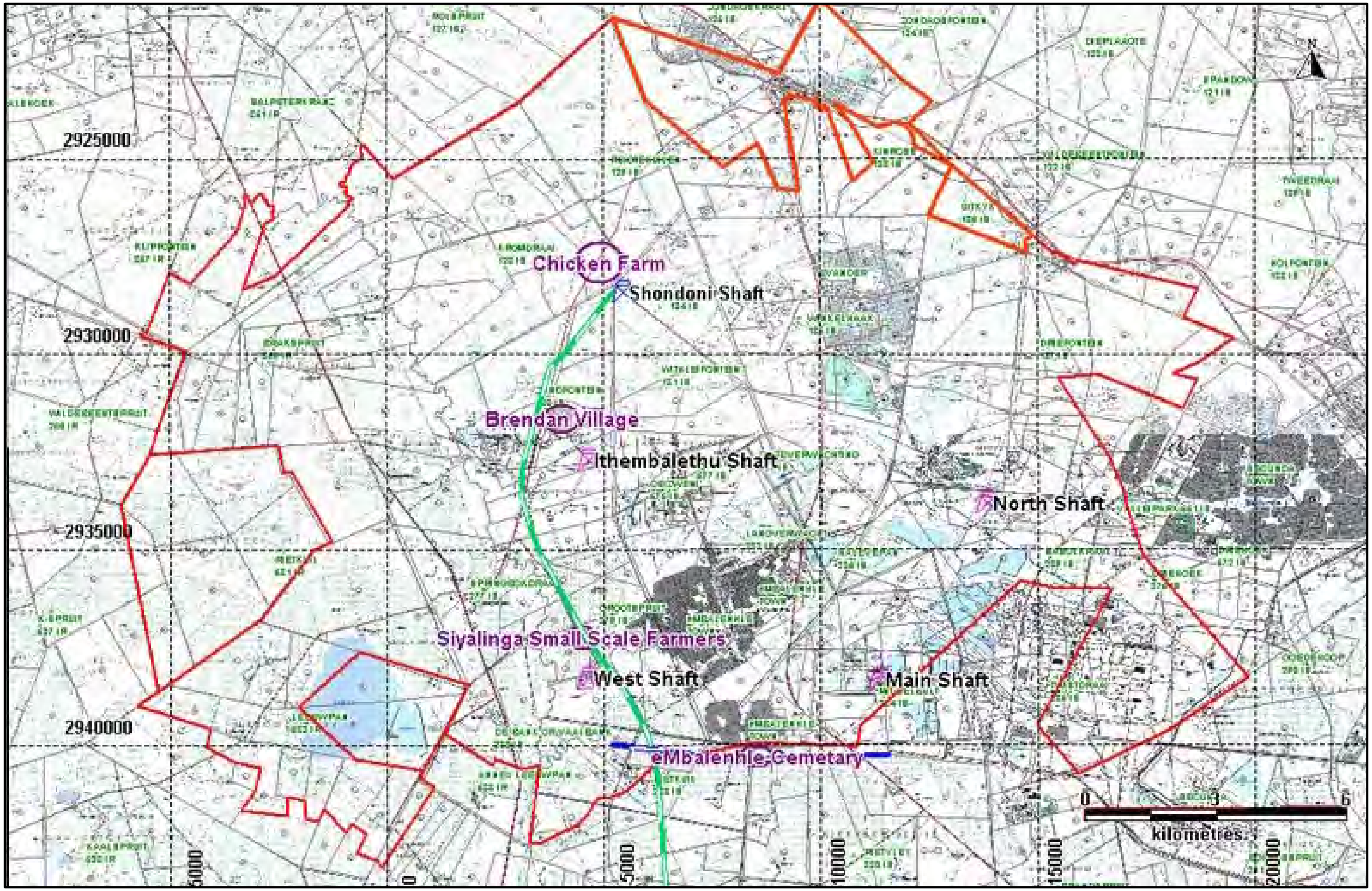

Figure 5.13.1(a): Shondoni Noise Study Area and Location of the Shaft and Conveyor Route

- **Equipment safety:** Measurement procedure, integration periods and sample size depend on the availability of facilities for safeguarding equipment. Long duration samples are only possible at locations where facilities are available to lock away recording equipment connected via a cable to a microphone positioned out doors at a point clear of vertical reflecting surfaces and protected from the elements.

Meteorological Considerations

Outdoor noise measurement is not permitted under certain weather conditions. Rain, drizzle or fog affects the conductivity of measurement microphones, resulting in faulty readings. It may also damage the microphone and measuring equipment. Secondly, although measurement often has to be performed in the presence of wind, care should be taken to verify that wind turbulence noise on the microphone capsule is negligible compared to the sound level being measured. There is no fixed upper limit for permissible wind speed, it all depends on the level being measured. Another weather phenomenon which may cause interference and spoil measurement data, is thunder.

Meteorological conditions also affect the acoustic environment and the actual sound levels without causing interference or measurement error. Normal fluctuations in atmospheric conditions may cause large variations in noise level which cannot and should not be avoided in the planning and execution of noise monitoring surveys. These variations constitute the natural variance in both background and intrusive noise levels. Noise levels at a distance from large sources are highly dependent on meteorological conditions. In fact, the difference in characteristic day and night meteorological patterns is one reason why 24-hour mining or industrial operations always have a much greater noise impacts at night[1].

It should be noted that, for the reasons explained above, the monitoring of meteorological conditions, such as temperature, wind and humidity on the ground can at best only serve to avoid errors and distortion of measurement data. Knowledge of cloud cover, temperature, humidity and wind which prevailed during the course of a noise survey has little if any value in the post-processing and interpretation of data.

Sampling Considerations

To be of any use as an environmental management tool, noise monitoring has to produce accurate and relevant data. As a minimum requirement, the right equipment should be used and measurements performed with the necessary precision and accuracy, as laid down in SANS 10103. Just as important, no matter how accurate the measurements, the data is only as good as the sample.

What complicates noise sampling, is that ambient noise is all but constant. As a rule, it is the net result of contributions from various constant, cyclic and randomly fluctuating sources.

1 *The other main reason is the increased community sensitivity at night due to a natural decline in road traffic and human activity noise.*

To account for the intrinsic 24-hour cyclic variation, measurements should be taken within the relevant period of interest, e.g. daytime, night-time or a 24-hour cycle. Noise regulations require that the noise investigated must be measured (averaged) over a period of at least 10 minutes; i.e. 10 minutes or longer.

Occasionally, in the investigation of noise complaints, a 10 minute sample may be sufficient to obtain the data needed to make a finding. For purposes of predictive noise studies and monitoring surveys, however, much longer averaging periods are required to determine baseline or operational noise levels. Noise levels have to be averaged over periods long enough to ensure that the sample is representative of the true average.

Where this is possible, in addition to measuring the average over the day or night-time period of interest, equipment may be programmed to simultaneously determine averages in a contiguous series of short sub-intervals of say 10-minute, 30-minute, or 1 hour duration, covering the main survey period.

In this way, a picture can be obtained of the noise pattern over that period. For practical reasons, it is often not possible to attend measurements for the full duration of such long recordings.

<u>Base Line Noise Survey Conducted in the Shondoni Study</u>

Monitoring Localities

In a baseline investigation carried out during the period 02-Jul-2010 to 07-Jul-2010, ambient noise surveys were conducted at locations shown in Figure 5.13.2.1(a), as follows:

M1 Chicken farm

M2 Brendan Village

M3 Near Siyalinga small scale farmers

At M1 and M2, noise recording equipment was programmed to measure averages in sequences of 10-minute intervals for a total duration of 24 or longer. At M3 where facilities suitable for long-duration unattended recordings were not available, shorter duration samples of 20 minutes were taken.

In all recordings, A-weighted, equivalent continuous sound pressure levels LAeq (dBA) were measured, using an integrating sound analyser. For purposes of identifying sources of noise, third-octave spectra were examined during attended sessions, as well as in post-processing of data. This made it possible to distinguish between background ambient and mining-related noise.

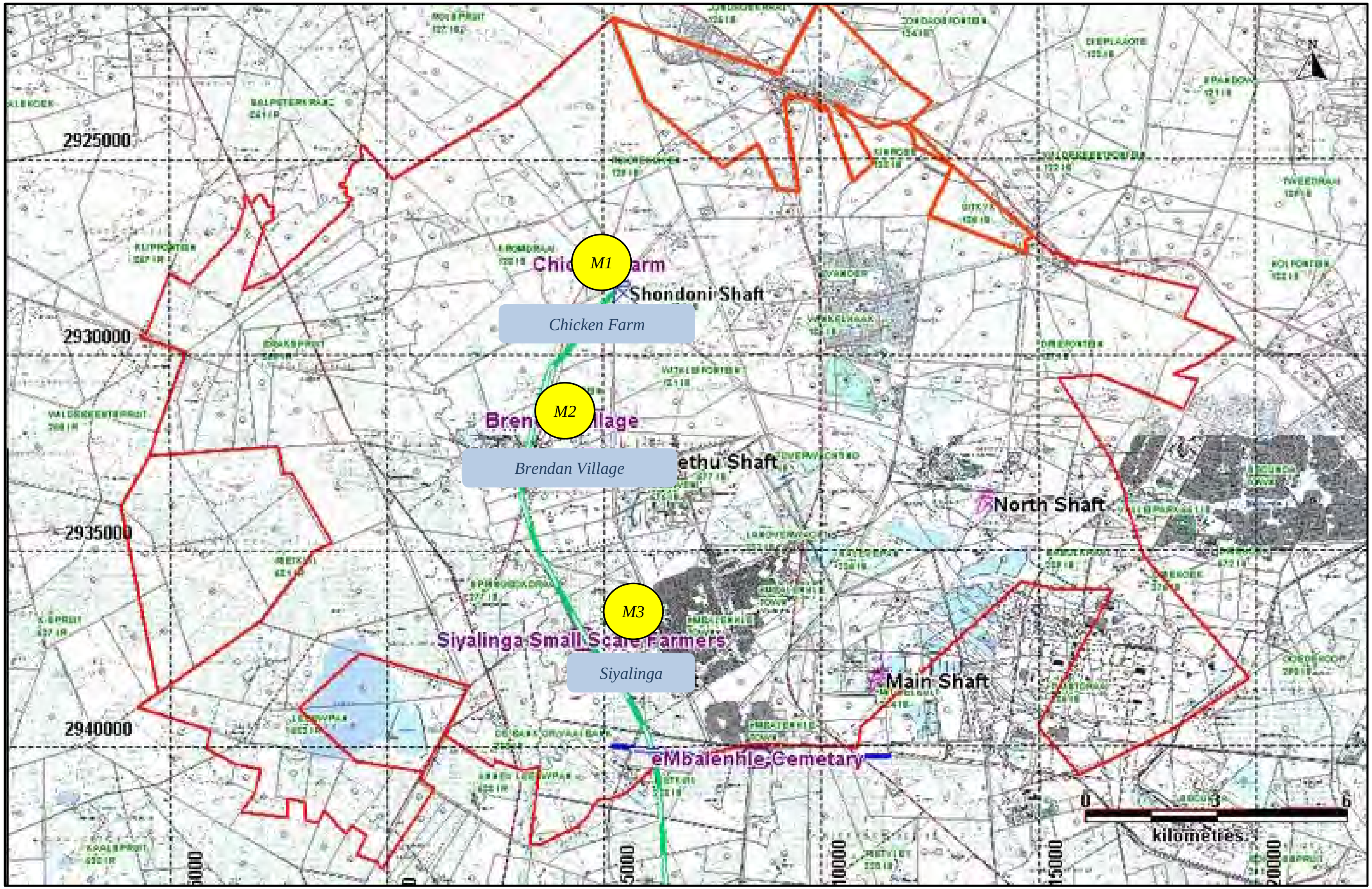

Figure 5.13.2.1(a): Noise Monitoring Locations M1, M2 and M3

Test Equipment

Noise measurements were carried out using the following equipment:

(a) Brüel & Kjaer Type 2260 Modular Precision Sound Analyser (Ser no. 1875497)

(b) Brüel & Kjaer Type 4189 Measurement Microphone (Ser no. 1858498)

(c) Brüel & Kjaer Type 4231 Sound Calibrator (Ser no. 2606011)

Equipment conformed to IEC 61672-1 Electro-Acoustics – Sound Level Meters – Part 1: Specifications.

Calibration: De Beer Calibration Services Certificates No's 2009-336 & 2009-337

5.13.2.2 Noise Regulations and Assessment Criteria

South African Noise Regulations

In 1994, with the devolution of regulatory power from governmental to provincial level, the authority to promulgate noise regulations was ceded to provinces. Each province could henceforth decide whether to develop their own regulations, or to adopt and adapt existing regulations. As yet, however, only three provinces (Gauteng, Free State and Western Cape) have promulgated such regulations. Elsewhere, including Limpopo Province, no provincial noise regulations have been put in place.

Consequently, in noise studies undertaken in provinces lacking official noise regulations, specialists usually consider the old national noise regulations to apply by default. For further guidance, it is noted that noise criteria in all previous national and current provincial regulations, as well as current metropolitan noise policies, are all derived from SANS 10103. SANS 10103 defines the relevant acoustic parameters that should be measured, gives guidelines with respect to acceptable levels and assessment criteria and specifies test methods and equipment requirements.

In this noise monitoring survey, the provisions of the old national noise regulations are taken into account, but noise assessment is based by and large on the principles, guidelines and criteria of SANS 10103.

Prohibitions

Prohibition of Disturbing Noise

In accordance with international and South African standard practice, noise impact assessments are made with respect to outdoor noise levels. Noise regulations prohibit any changes to existing facilities, or uses of land, or buildings or the erection of new buildings, if it will house activities that will cause a disturbing noise, unless precautionary measures to prevent disturbing noises have been taken to the satisfaction of the local authority. Noise is deemed to be disturbing, if it exceeds certain limits. Depending on what data is available, SANS 10103 allows for different formulations of the excess.

- **If the actual residual ambient level is known:** The excess is taken to be the difference between the noise under investigation and the residual noise measured in the absence of the specific noise under investigation. This definition, based on the *noise emergence criterion,* finds application in both predictive and noise monitoring assessments, if baseline noise data is available.

- **If the actual residual ambient level is unknown:** Alternatively, the excess may also be defined as the difference between the ambient noise under investigation and the acceptable ambient rating for the type of district under consideration in accordance with SANS 10103. This definition, based on the *acceptable level criterion,* is employed in predictive noise studies and in noise monitoring assessments, if there is no baseline data available or if an existing source of intrusive noise cannot be switched off for purposes of measuring the residual background level.

In terms of the old national noise regulations, a disturbing noise means a noise that causes the ambient sound level to increase by 7 dB or more above the designated zone level, or if no zone level has been designated, the ambient sound level measured at the same point. Noise regulations also require that the measurement and assessment of ambient noise comply with the guidelines of SANS 10103.

It should be cautioned, however, that the legal limit of 7 dB should not be construed as the upper limit of acceptability. SANS 10103 (See Table 5.13.2.2(b) in this report) warns that an increase of 5 dB is already significant and that an increase of 7 dB can be expected to evoke widespread complaints from the community. Hence, although the applicant would be within legal limits if the noise impact is prevented from exceeding 7 dB, that would not prevent a community from being disturbed and to complain about the noise.

In the EIA phase, i.e. in the design and planning stage of a new development, it is advised the target be set much lower at 3 dB. The 4 dB margin is required as a matter of good planning and to maintain good relations with neighbors. It also brings the assessment in line with World Bank guidelines. Once in operation, an appropriate limit in EMP noise monitoring of the actual levels would be an excess of 5 dB, which is still 2 dB below the legal limit.

Prohibition of a Noise Nuisance

Noise regulations also prohibit the creation of a noise nuisance, defined as any sound which disturbs, or impairs the convenience or piece of any person. The intent of this clause is to make provision for the control of types of noise not satisfactorily covered by measurement and assessment criteria applicable to disturbing noises.

These are noises which are either difficult to capture[2], or noises for which the readings registered on sound level meters do not correlate satisfactorily with the annoyance it causes, when assessed against standard criteria. Noise regulations list specific activities which are prohibited if exercised in a manner to cause a noise nuisance, such as[3]:

- The playing of musical instruments and amplified music;
- Allowing an animal to cause a noise nuisance.
- Discharging fireworks;
- Discharge of explosive devices, firearms or similar devices which emit impulsive sound, except with the prior consent in writing of the local authority concerned and subject to conditions as the local authority may deem necessary;
- Load, unload, open, shut or in any other way handle a crate, box, container, building material, rubbish container or any other article, or allow it to be loaded, unloaded, opened, shut or handled, (if this may cause a noise nuisance).
- Drive a vehicle on a public road in such a manner that it may cause a noise nuisance.
- Use any power tool or power equipment used for construction work, drilling or demolition work in or near a residential area, (if this may cause a noise nuisance).

and:

- Except in an emergency, emit a sound, or allow a sound to be emitted, by means of a bell, carillon, siren, hooter, static alarm, whistle, loudspeaker or similar device (if it may cause a noise nuisance).

One or more of these activities may occur on industrial sites and in project activities. A common cause of noise nuisance are reverse hooters, the last item listed above.

The essential difference between a disturbing noise and a noise nuisance is as follows:

Noise disturbance – Is quantifiable and its assessment is based on estimated or measured sound levels, expressed in decibel (dBA). Investigation and assessment of existing noise disturbance problems involve the measurement of ambient levels in the presence of a specific source under investigation and comparison of this level with either the level measured in the absence of the source, or a table value deemed to be an acceptable level for the type of district under consideration.

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2 *For example, barking dogs. Not only is the occurrence of the noise unpredictable and erratic, but the presence of a person investigating the problem with a noise meter is likely to attract attention and trigger incessant barking.*

3 *See Noise Regulations for the full list of prohibited activities.*

Noise nuisance – Is difficult to quantify and is not confirmed or assessed by measurement. Judging whether a noise qualifies as a nuisance is based purely on its character and audibility, in conjunction with subjective considerations such as the perceived intent of the noise maker and connotations attributable to the source of noise. Where measurement is possible, measured data may serve as supplementary information.

SANS 10103

As mentioned before, noise regulations require that the measurement and assessment of noise comply with the guidelines of in SANS 10103. The concept of noise nuisance, however, only features in the regulations. SANS 10103 only deals with quantifiable noise (noise disturbance), without any guidelines for, or reference to noise nuisance whatsoever.

It is normally expected of an EIA noise study to make findings based on noise modelling and quantitative assessment of predicted noise levels, i.e. based on noise disturbance considerations. The same applies to noise monitoring conducted in terms of an EMP, where the report is expected to make findings based on measured data, assessed in terms of noise disturbance criteria as well.

But once an industrial site or mine starts operating, predictable as well as unexpected sources of noise nuisance may emerge. If present, they often constitute a major cause of complaints. It is therefore imperative that, in addition to quantitative predictions and measurements, noise studies as well as monitoring surveys also identify potential and actual sources of noise nuisance.

SANS 10103 - Acceptable Ambient Levels

Noise regulations require that the rating level of the ambient noise be compared with the rating level of the residual noise (where this can be measured), or alternatively (where the noise source cannot be switched off or interrupted), with the appropriate rating level given in Table 2 of SANS 10103. Neither the noise regulations, nor SANS 10103 defines or refers to the term noise impact. It is however generally understood and defined for purposes of this study, as the amount in dB by which the total noise level exceeds the nominal or the measured ambient level rating, whichever is applicable, for the area under consideration.

Table 5.13.2.2(a) in this report summarises SANS 10103 criteria for acceptable ambient levels in various districts. Note that ratings increase in steps of 5 dB from one to the next higher category and that, in general, regardless of the type of district, ambient noise levels tend to decline by typically 10 dB from daytime to night-time. It follows that, for the same level of intrusive noise, the noise impact would typically increase by 10 dB from daytime to night-time.

Table 5.13.2.2(a): Typical outdoor ambient noise levels in various districts (SANS 10103)

Type of district	Noise level Equivalent continuous level L_{Aeq} (dBA)		
	Day-Night L_{dn}	Day-time L_d	Night-time L_n
(a) Rural	45	45	35
(b) Suburban – With little road traffic	50	50	40
(c) Urban	55	55	45
(d) Urban - With some workshops, business premises & main roads	60	60	50
(e) Central business districts	65	65	55
(f) Industrial districts	70	70	60

A 24 hour cycle is divided into the following periods:

Day-time (06:00 – 22:00)
Night-time (22:00 – 06:00)
Day-Night (24-hour day-night period)

The day-night level L_{dn} represents a 24-hour average of the ambient noise level, with a weighting of + 10 dB applied to night-time levels, yielding numerically equal values for daytime and day-night levels.

SANS 10103 also gives guidelines in relation to expected community response to different levels of noise impact (increase in noise level), as summarized in Table 5.3.2.2(b).

Table 5.13.2.2(b): Expected community response to an increase in ambient noise level (SANS 10103)

Increase in ambient level [dB]	Expected community reaction
0 - 10	Sporadic complaints
5 - 15	Widespread complaints
10 - 20	Threats of community action
More than 15	Vigorous community action

5.13.2.3 Practical considerations

By defining the actual predevelopment ambient sound level as the reference, noise regulations applicable in Mpumalanga effectively apply what is known as *noise emergence criteria*. An alternative approach (as employed in the Gauteng Noise Regulations), is to use nominal table values recommended in SANS 10103. This is known as *acceptable level criteria.* Both methods have advantages and disadvantages.

Caution should be exercised in applying noise criteria, bearing in mind that no single principle or criterion will perfectly fit and be adequate or fair in all applications. The sensibility and fairness of any given criterion depend on the nature and origin of the existing ambient noise. In situations where existing ambient levels are on the high side, it is of crucial importance in the assessment of noise impact of a new development, to establish whether the existing ambient sound is primarily a result of interior or domestic activity (self-noise), or whether it is primarily caused by external sources of noise (intrusive noise).

Where the predevelopment ambient sound is dominated by noise emanating from external sources, such as industrial plants, mining activity and road traffic on external main roads, special precaution needs to be exercised not to aggravate conditions. If the existing ambient level is already higher than what is regarded as typical or recommended, specific noise from a proposed new development should not be allowed to exceed the nominal value regarded as acceptable for the type of district under consideration. It would be more fitting in such instances, to apply acceptable level criteria; e.g. setting the daytime limit for specific noise from the development at the lower nominal limit.

Noise criteria should never be applied without due consideration of the practical consequences. Finally, whatever guidelines are followed, it should always be investigated if there is a specific period (daytime or night-time) during a 24-hour cycle during which the noise impact will be at its worst. For constant 24-hour operations, this would normally occur at night-time.

5.13.2.4 Note on Animal Response to Noise

The author is not qualified to comment or speculate on animal behaviour in response to noise. Moreover, it should be cautioned that any assessment or statement made with regard to the possible impact of project activity noise on animals in the surrounding area should take cognizance of the following:

Assessment in any scientific noise study of the impact of noise on humans, is based on well defined scientific criteria. Based on decades of statistic data, international and national standards provide consistent guidelines with respect to noise disturbance and community reaction. If the measured or predicted elevation caused by an intrusive noise exceeds certain reference levels, the response of humans to such noise can be quantified.

As for animals, however, not only are human criteria not applicable at all, but there simply are no national or international standards pertaining to animal response to noise - not in terms of audibility or disturbance, let alone the effect of noise on their well-being, health or re-production.

It should be pointed out that not even in the case of humans, can the effect of noise on human health be quantified (except for hearing damage) and no standards or criteria exist in that regard.

It is completely understandable that farmers would be concerned about the effect of intrusive noise on their livestock. But in the lack of standards or criteria, any statements made in the findings and recommendation of a noise study in that regard, would be speculative, unscientific and irresponsible. Hence in this report, we refrain to make any such unfounded statements either confirming or rejecting popular views on the matter.

5.13.3 Findings - Current Background Ambient Noise Levels

5.13.3.1 General

The Middelbult – Block 8 - Shondoni study area is located in a district where the initial rural ambient noise character has been affected over time by an increase in ambient levels as a result of scattered mining activity and increased traffic on the main roads. On the whole, considering the level of industrial activity and road traffic, the area in its current state cannot be considered a pure rural environment any more.

5.13.3.2 Noise at M1 (Chicken Farm)

Ambient noise at the Chicken Farm at M1 is determined primarily by farming activity, such as manual work activities, tractor movements, motor vehicles and speech communication. Another significant source of ambient noise, especially after working hours, is domestic activity in and around residences located on the premises. As the survey was carried out just after harvesting, there were no chickens in the buildings. It stands to reason that the presence of chickens is likely to elevate rather than decrease the ambient level; although the effect may be small.

With the premises located in close proximity to the R547 main road, traffic noise is also a source contributing to the ambient level. However, because of low traffic volumes on this road, the contribution to the average ambient level at the Chicken Farm is relatively small compared to work and domestic activity noise.

Depending on atmospheric conditions, mining noise is occasionally audible in the distance, but with no measureable effect on the readings. There are no mining activities in close proximity of the premises and general mining activities in the district are barely audible, if at all.

Average daytime and night-time ambient levels recorded in a 24-hour survey during the course of this investigation, were 48 dBA (day) and 46 dBA (night), respectively. These levels are approximately 10 dB higher than typical Rural District levels in accordance with SANS 10103, but perfectly acceptable, considering that it is self-noise generated by in-house working and living activities, rather than intrusive noise originating from outside the property boundaries.

5.13.3.3 Noise at M2 (Brendan Village)

Local traffic, maintenance work and domestic activity are the primary sources of ambient noise in Brendan Village. As in the case of the Chicken Farm, it also borders on the R547 main road on the western side. The contribution of traffic noise from the main road is relatively small.

The nearest source of mining noise is Sasol iThemba Lethu Shaft approximately 750 m south of the village. Visually and acoustically, the village is partially screened off from the shaft by the topography and as far as could be established, noise from the shaft is not audible in the village. Noise from other mining activity in the district could not be heard and did not affect readings obtained in the course of this investigation.

For practical reasons, position M2 where a long-duration (4 x 24-hours) survey was conducted, was located at the reception building approximately 200 m from the R547 main road. Night-time average levels recorded during four nights varied between 36 and 38 dBA. Closer to the main road, levels at houses nearest to the road and also nearest to the proposed conveyor route, are 2 to 3 dB higher with a typical night-time level of 40 dBA.

5.13.3.4 Noise at M3 (Siyalinga and Surroundings)

In addition to domestic activity, wind, birds and insect sounds, ambient noise in and around the Siyalinga small farmers settlement is to a minor extent affected by noise from Sasol Middelbult West Shaft. Depending on atmospheric conditions and wind direction, the audibility of shaft noise varies.

Based on short duration samples taken near the boundary of the settlement, typical day and night-time ambient levels in the area are 44 and 40 dBA, respectively.

5.13.3.5 Summary

The results of the survey are summarised on the map in Figure 5.13.3.5(a). Daytime and night-time intervals are as defined in SANS 10103. Detailed results of the recordings made in 10-minute intervals at M1 and M2 are presented in Figure 5.13.3.5(b) and Figure 5.13.3.5(c).

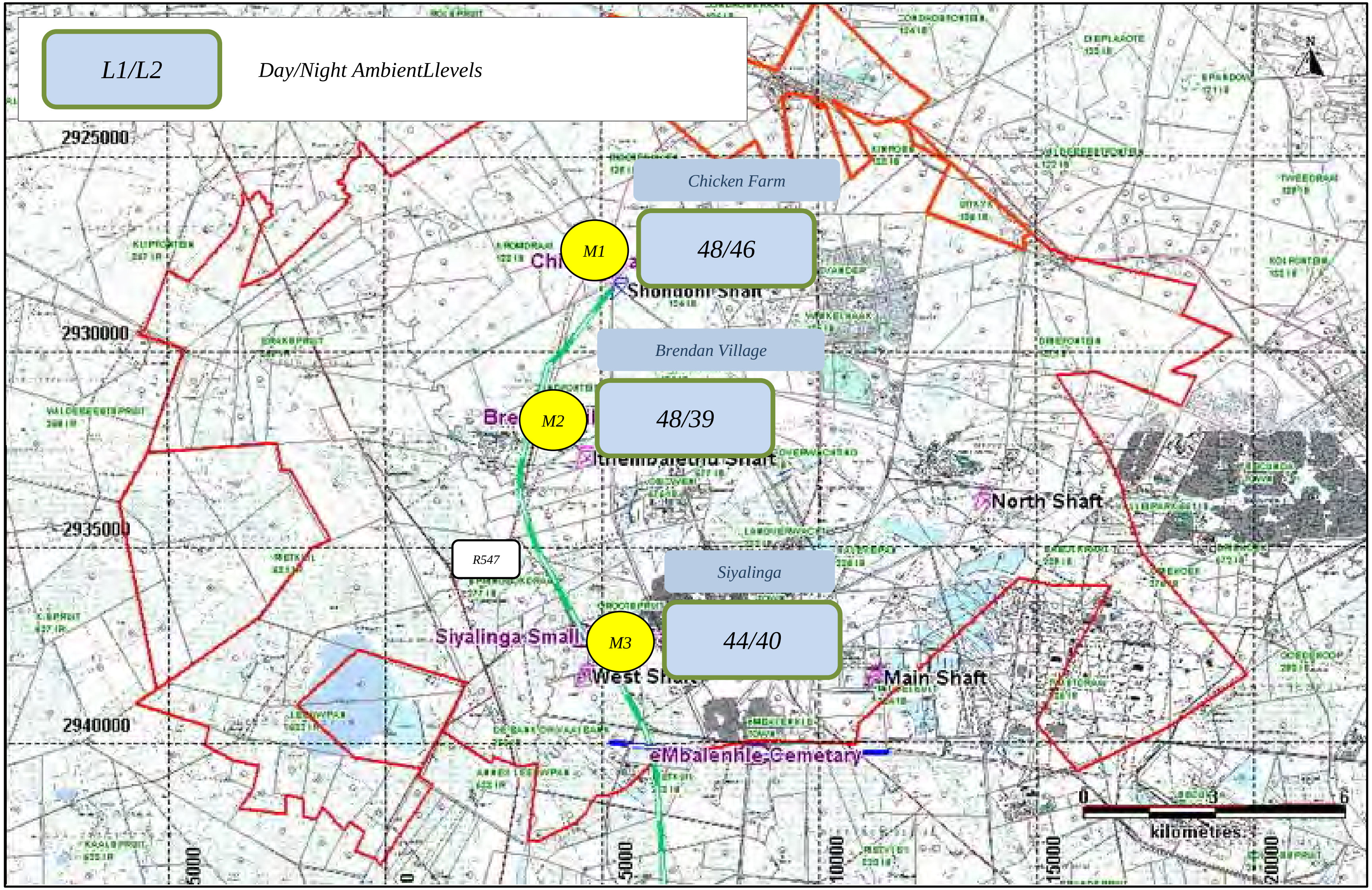

Figure 5.13.3.5(a): Results of Baseline Survey: Average Daytime (06:00 to 22:00) and Night-Time (22:00 to 06:00) Ambient Levels

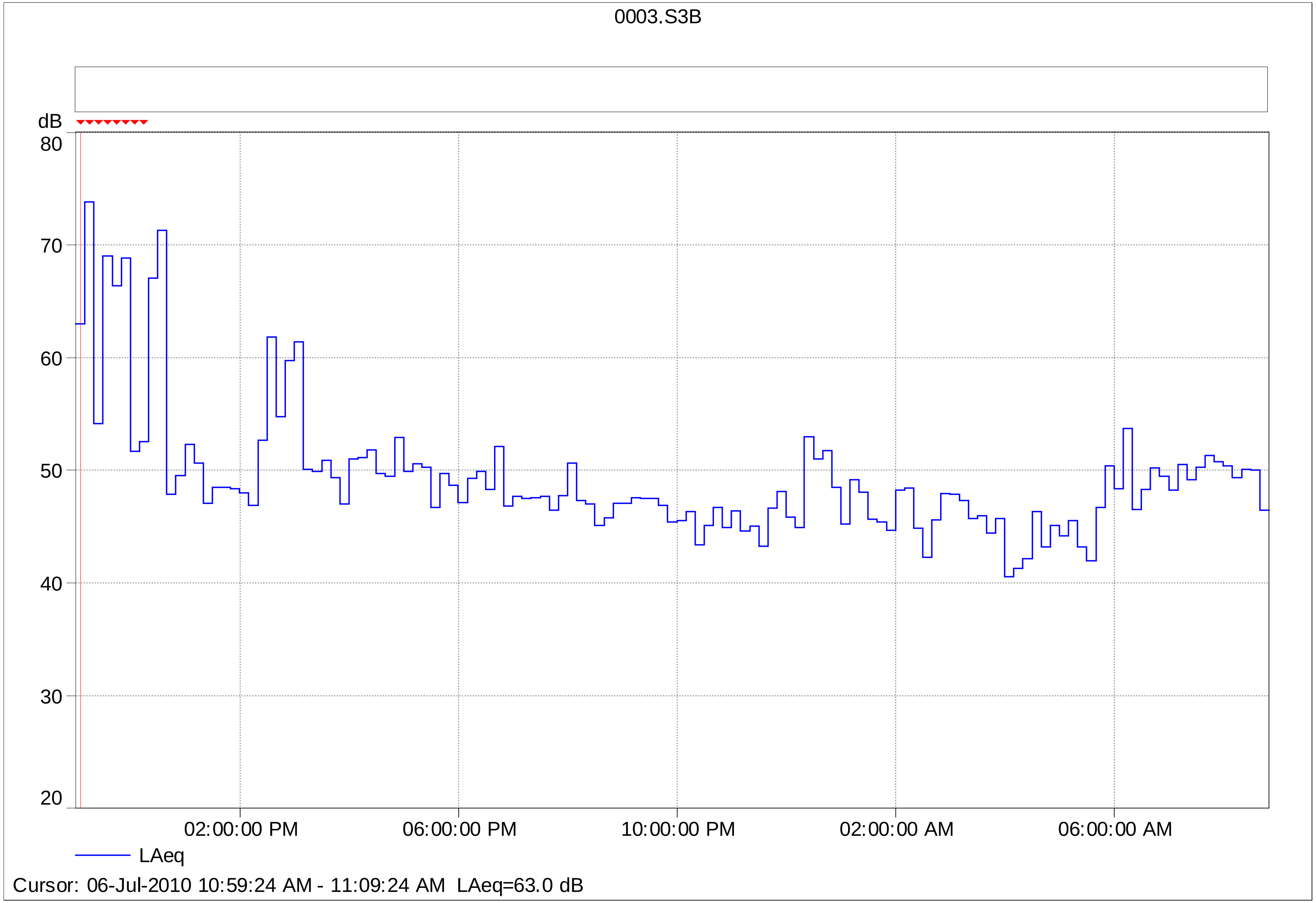

Figure 5.13.3.5(b): Noise Monitroring Results at Monitoring Point M1 (Chicken Farm) for Period 06 to 07 July 2010

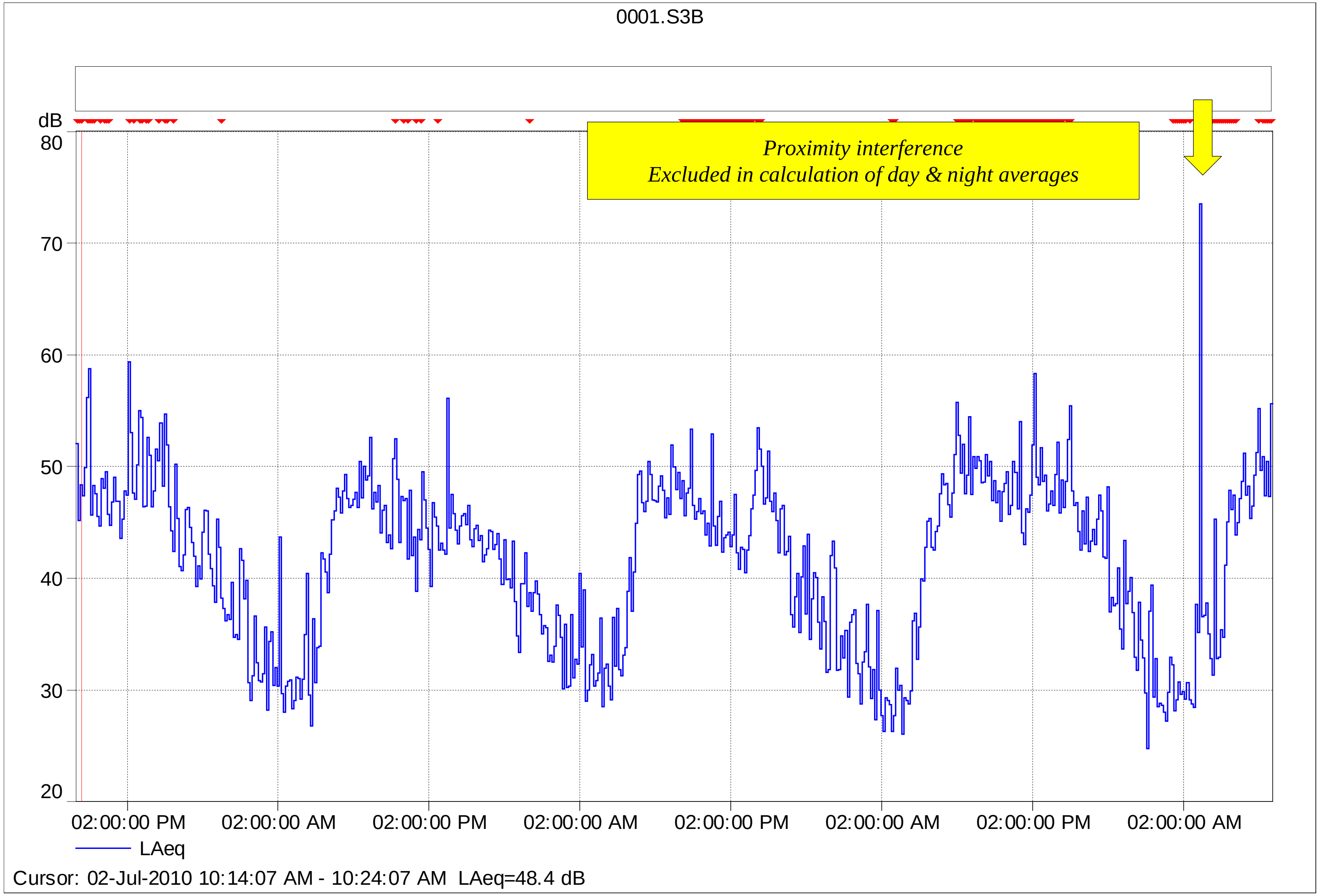

Figure 5.13.3.5(c): Noise Monitroring Results at Monitoring Point M1 (Chicken Farm) for Period 06 to 07 July 2010

5.13.4 Baseline Ratings

In allocating baseline ambient noise ratings, it should be borne in mind that the levels obtained in any particular survey do not represent absolute values, but samples only of what is a variable parameter. Ambient noise is not fixed and even relatively long-duration averages of day and night levels at any location will vary over time. This is in response to variances in noise source emission levels, as well as unpredictable day, night and seasonal fluctuations in atmospheric conditions.

It should also be noted that for purposes of noise impact assessment, noise contours are calculated at nominal intervals best suited for evaluation of specific locations of concern, as well as for the global study area.

With these considerations in mind, the ratings allocated in the study area were determined by rounding the levels obtained in the survey to the nearest 5 dB day or night interval of typical levels for district categories in accordance with SANS 10103 guidelines (See Table 5.13.2.2(a)). The result is presented in Table 5.13.4(a). These are realistic best estimates of baseline ambient noise ratings for the area that will be used to define limits in the noise impact assessment to be carried out in terms of the EIA.

Table 5.13.4(a): Middelbult Shondoni Shaft Project - Baseline Outdoor Ambient noise levels derived from field surveys rounded to the nearest day and night ratings for districts according to SANS 10103 guidelines

Area		Baseline Ambient Noise Level L_{Aeq} (dBA)	
		Day-time L_d	**Night-time** L_n
Specific locations	Chicken farm	50	45
	Brendan Village	50	40
	Siyalinga small farmers	45	40
Remainder of study area		50	40

5.14 VISUAL ASPECTS

JMA Consulting was appointed by Sasol Mining (Pty) Ltd - Secunda to complete a Visual Impact Assessment (VIA) specialist study in support of the overall EMP / EIA process for the proposed Shondoni Shaft and conveyor route.

The proposed Shondoni Shaft and associated conveyor route will be located approximately 5 km west of Evander. The landscape of the region is that of slightly undulating grassland. The region is known for its mining activities with five other shafts within a 5 km radius of the proposed shaft area.

Due to the nature of the proposed Shaft and its associated conveyor route, a degree of visual impact will occur, affecting observers in the vicinity of the site. It is therefore the aim of this assessment to determine the extent and significance of the visual impact and if necessary the mitigatory methods available.

5.14.1 Approach and Methodology

The point of departure for the Visual Aspects Specialist Study Report was Hans Martens, the 19th century German architect's, principle that the total aesthetic impression is related to the range and distance that a normal human eye can encompass (Higuchi, 1988).

His ideas with respect to distance and angle of elevation have become standard in the field of visual analysis and will also be considered for this report. Higuchi (Higuchi, 1988) proposes eight criteria or indices for determining the visual structure of landscape:

- **Visibility or invisibility.** This concerns the fundamental question of what can be seen and what cannot be seen from a given viewpoint.
- **Distance.** This has to do with the changes that take place in the appearance of an object as the distance between the observer and the object varies.
- **Angle of incidence.** When a landscape is conceived of as a group of surfaces, the angle at which the line of vision strikes each surface determines to a large degree what can be seen of it. This index evaluates the comparative visibility of the various surfaces in a given landscape.
- **Depth of visibility.** This gauges the degree of visibility in terms of the depth of the unseen section with respect to the line of vision.
- **Angle of depression.** This clarifies the viewer's sense of position as he/she looks at a scene from above.
- **Angle of elevation.** This indicates the nature of upward view and the limits of the visible space.
- **Depth.** This clarifies the degree of three-dimensionality of the landscape as it unfolds before the viewer.
- **Light.** The appearance of a landscape changes drastically in accordance with the manner in which the light strikes it. This index has to do with the transformation that take place as the position of the source of light moves from front to side to back.

Thus, the visual character of a landscape is measured in many different ways; each employed for a specific evaluation.

Whichever methods are used, the importance of being able to assess the long-term aesthetic effects of proposed landscape alteration is critical prior to a proposed area being constructed or activity undertaken. Keeping Martens' and Higuchi's principles in mind, specific methods have been taken from these and additional sources to ensure that appropriate answers to the standard requirements of the VIA Process are generated.

5.14.1.1 Actions Performed

A synoptic discussion of the actions performed in order to conduct this visual assessment of the proposed Shondoni Project will now be given.

Contextual Analysis

A contextual analysis was performed in order to establish the visual character "base line" for the site. The analysis was based on published information for the area available from public sources such as the internet. The information used is considered to be biased slightly towards a "marketing" perspective for the Mpumalanga province, which is good as it provides a conservative base line for the contextual analyses.

View Shed Analyses

A view shed analysis was performed prior to the site specific photographic analyses in order to determine the visibility of the site from priority access points/routes such as public roads and residential areas.

The analysis was performed with both SURFER and ARCVIEW, creating 3-dimensional shaded relief, 3-dimensional topographical contour and preliminary view shed maps, using the 1:50 000 published DTM information obtained from the Surveyor General.

The resulting maps provided a sound basis from which to assess potential vantage points to the site and on which to base planning for the photographic assessment. The 3-dimensional topographical relief and contour maps for the Shondoni Shaft site and its surroundings are shown in Figure 5.14.1.1 (a) and Figure 5.14.1.1(b).

The points eventually selected for the photographic survey are also indicated.

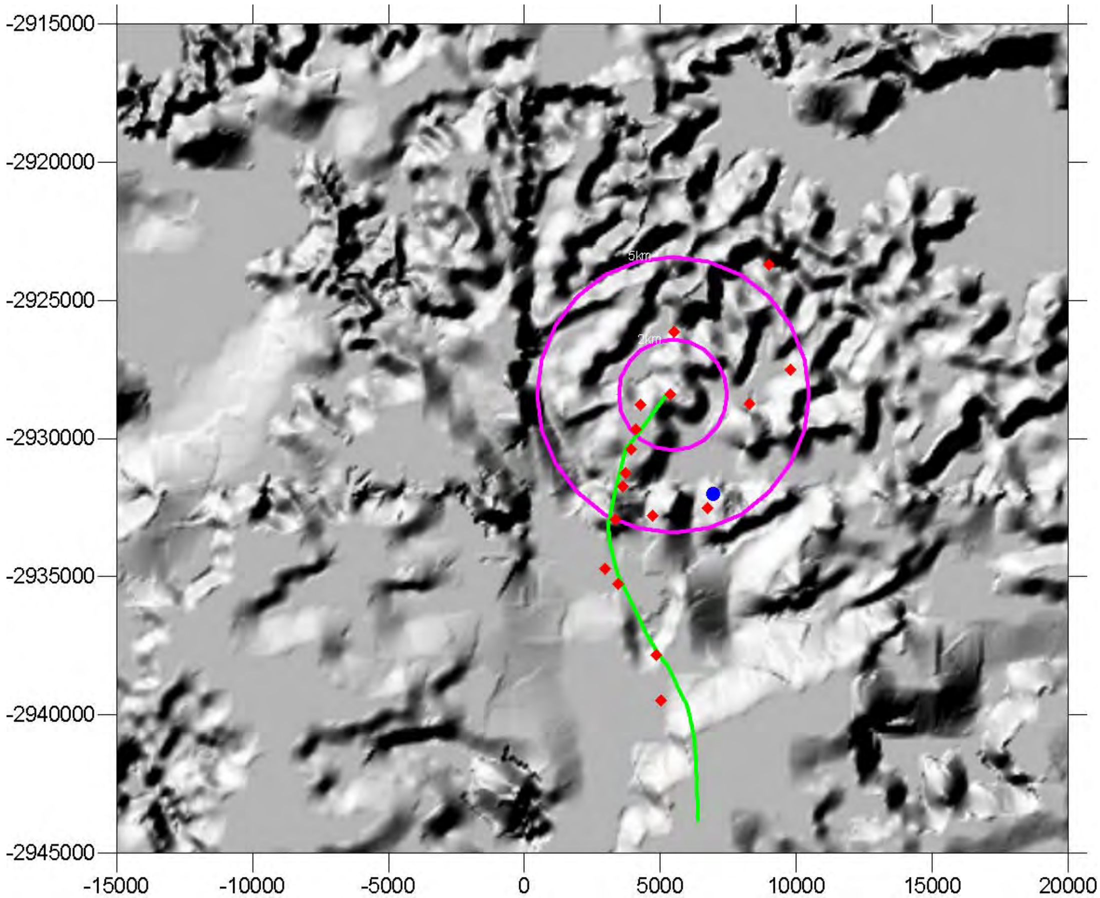

Figure 5.14.1.1(a): Topographical Relief (Shaded Relief) Map for Shondoni Shaft and Conveyor Belt with a 2 km and 5 km buffer zone indicated around the Shaft

The photographical survey points were selected along public roads around the site.

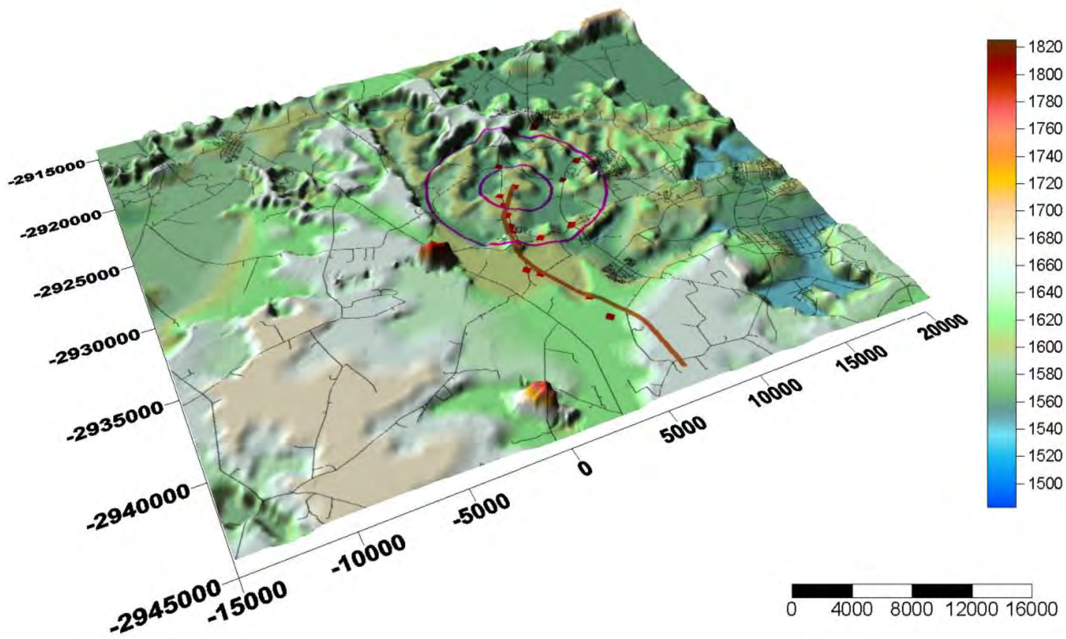

Figure 5.14.1.1(b): Topographical Relief (View Shed) Map for Shondoni Shaft area

The view shed done only considered the topography and not other visual barriers such as manmade structures and high vegetation. Because the view shed was done using only 20 m contour data it is a rough estimate of what could be expected in the field. The resulting view shed maps of the Shaft Area and Conveyor Route are shown in Figure 5.14.1.1(c) and Figure 5.14.1.1(d) respectively.

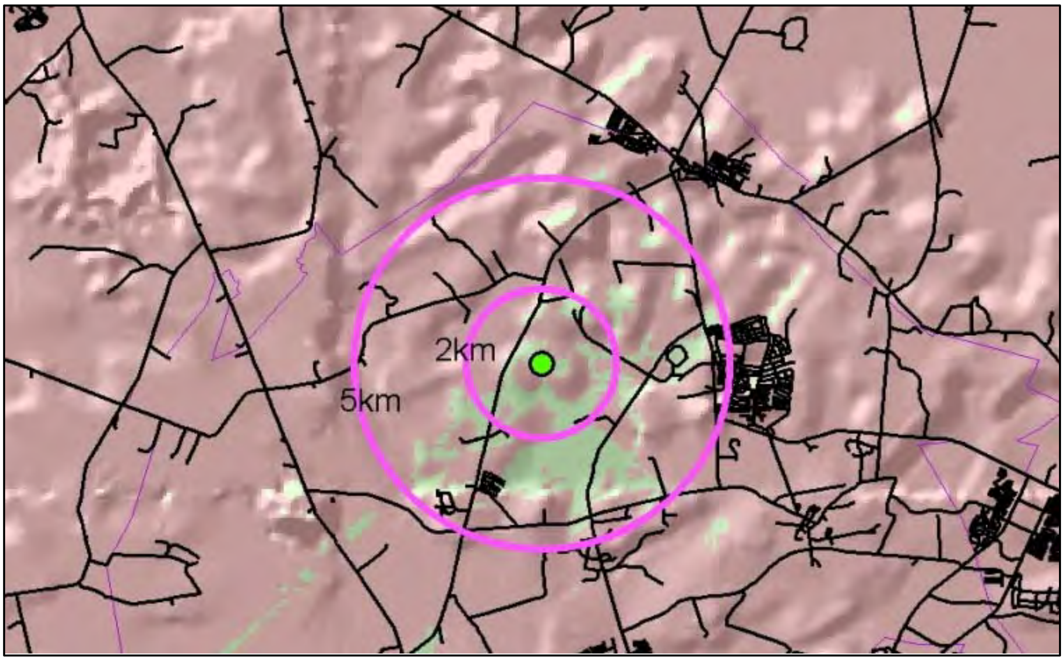

Figure 5.14.1.1(c): View Shed Analysis Map done with ArcView for Shondoni Shaft Area

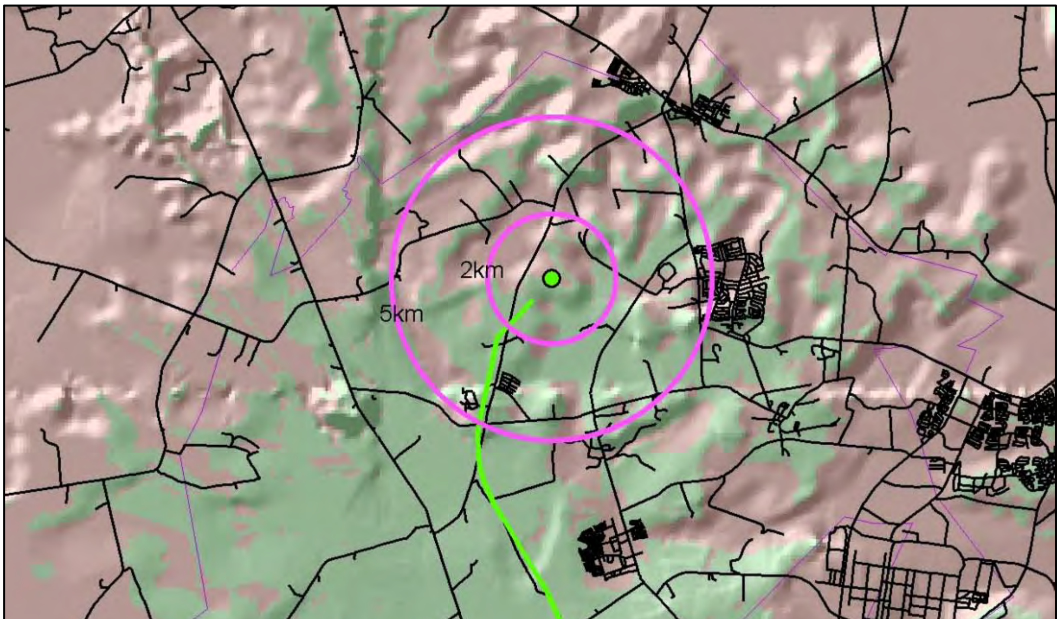

Figure 5.14.1.1(d): View Shed Analysis Map done with ArcView for Shondoni Conveyor Route

The green areas on the maps indicate vantage areas from which the relevant infrastructure will be visible from a vantage point on ground surface.

Photographic Survey

A detailed photographic survey was also done of the study site and adjacent areas, from numerous surrounding vantage points. The photographic compilations are produced in 2D by taking a series of panoramic photographs of a 3D environment. These are then superimposed onto one another to complete a view of the study area. This is done to give a clearer indication of the visual nature of the areas that will visually be affected by the activities, which will in turn aid in the design and installation of visual mitigation measures. The points elected for the photographic survey were chosen along public roads surrounding the infrastructure for the Shondoni Shaft and Conveyor Route. The points are shown on the map in Figure 5.14.1.1(e).

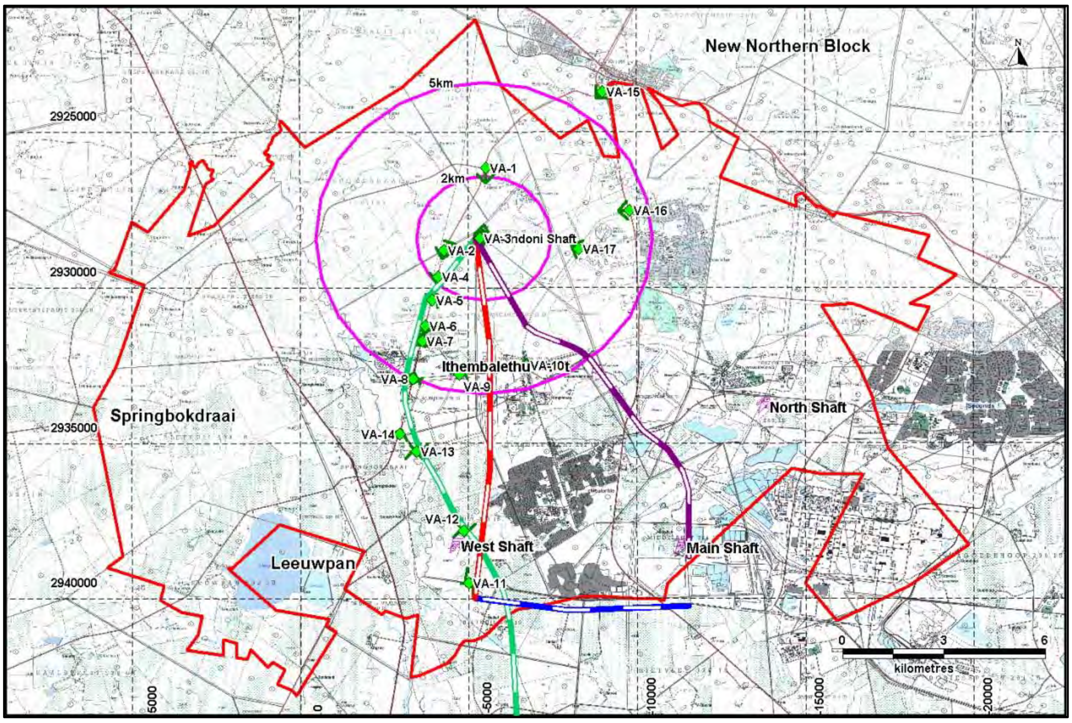

Figure 5.14.1.1(e): Vantage Points from which Photographs were taken

The assessment distinguishes between long-range and short-range, as well as highly-, slightly-, and not-visible views. Showing, (**in magenta**), on the map a 2 km and 5 km radius around the Shondoni Shaft site, an understanding of scale is also established. When discussing the assessment, the character of the area, a mining belt, will be noted. This is the specific character of the site and surrounding regions and should be the point of departure/terms of reference for the Shondoni Project visual assessment.To avoid clustering of data and information, the photographic assessment will be discussed at the hand of 4 photographic compilations (Figure 5.14.1.1(f) through to Figure 5.14.1.1(i)), each representing views from different vantage points. The active vantage points are shown as **brown** dots (**green** dots are non-active vantage points). Note the view angles for each vantage point shown as highlighted arcs on the locality map portion of the compilation.

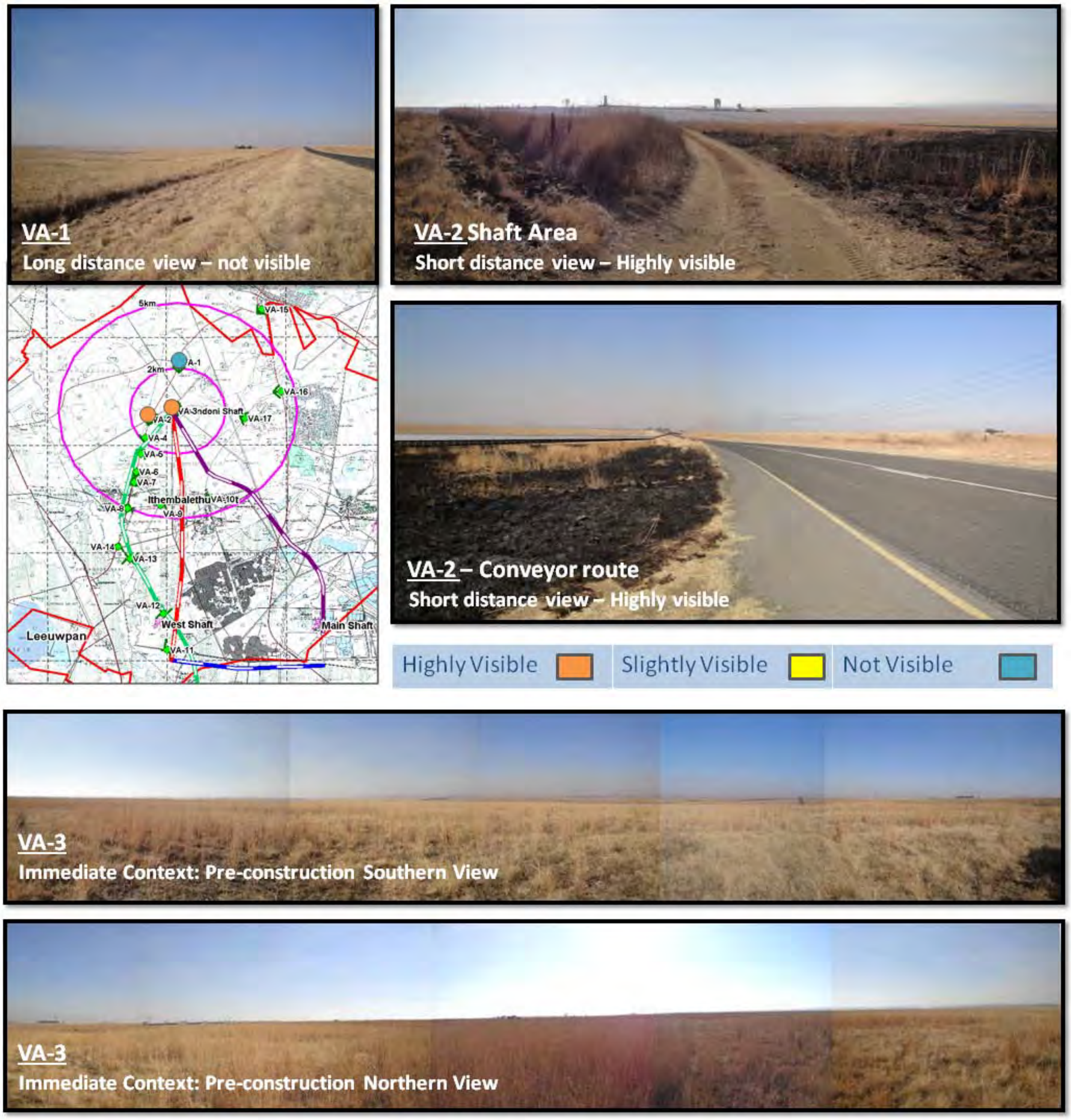

Figure 5.14.1.1(f): Shondoni Visuals VA-1 through VA-3

Shondoni Visual VA-1 is a long range view in a southerly direction. The viewing locality is approximately 3kms from the Shondoni shaft area. The shaft is not visible from this locality.

Shondoni Visual VA-2 is a short range view from the entrance to the shaft area. The shaft and its associated infrastructure are highly visible.

Shondoni Visual VA-3 South and VA-3 North shows the character of the immediate context.

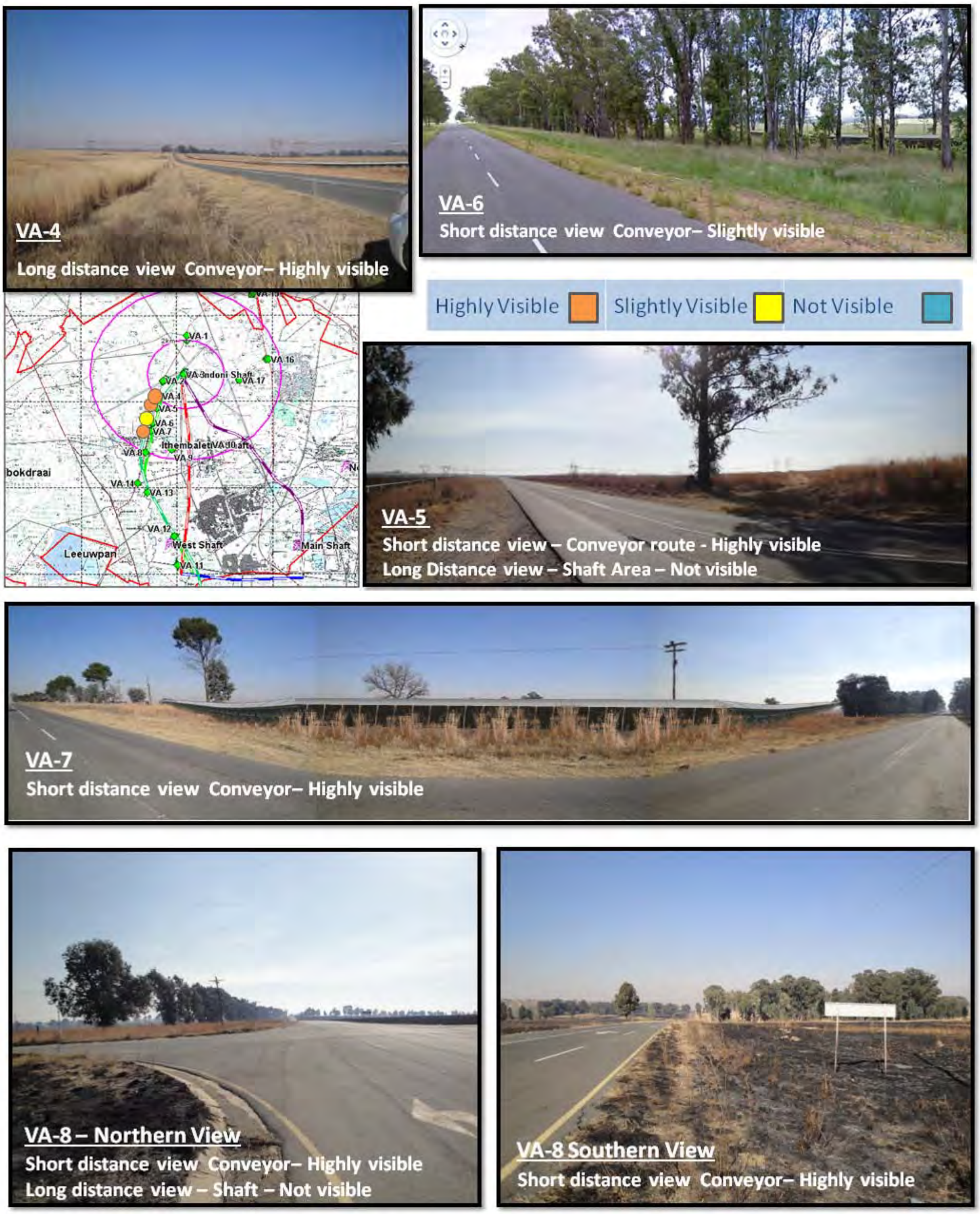

Figure 5.14.1.1(g): Shondoni Visuals VA-4 through VA-8

Shondoni Visual VA-4 is a long range view of the conveyor route which is highly visible.

Shondoni Visuals VA-5, VA-7, VA-8 are short range views and the conveyor route is highly visible. The visual impact though is low despite the high visibility, because the conveyor does not provide the viewers with a negatively perceived landmark. VA-8 is an important viewing locality because the conveyor crosses the road here.

Shondoni Visual VA-6 is a short distance view of the conveyor route which is slightly visible. This is a perfect example of how local screening by shrubs and trees provide visual screening as objects close to the road

Shondoni Visual VA-8 Northern View is also a long range view of the Shaft which is not visible from this locality.

Figure 5.14.1.1(h): Shondoni Visuals VA-11 through VA-14

Shondoni Visual VA-11 is a long range view. The conveyor route is highly visible because of the topography and the fact that it crosses the road a short distance east of the viewing locality.

Shondoni Visual VA-12 is a short distance view of the conveyor route which, when constructed will be situated about 50 m east of the farm boundary on the left of the photo.

Shondoni Visual VA-13 is a short range view. The conveyor route is highly visible because of the topography. The viewing locality is however not on the main road, but a dirt road leading to the farm house at VA-12.

Shondoni Visual VA-14 is a short range view. The conveyor route is highly visible because of the topography and the fact that it crosses the road a short distance east of the viewing locality.

Figure 5.14.1.1(i): Shondoni Visuals VA-9, VA-10, VA-15, VA-16, VA-17

Shondoni Visual VA-9 is a long range view from the iThemba Lethu Shaft crossing and the Shondoni shaft is not visible.

Shondoni Visual VA-10 and VA-16 are long range views and the shaft is only slightly visible due to the distance as well as local screening.

Shondoni Visual VA-15 is a long range view from the crossing south of Kinross. The Shondoni shaft is not visible.

Shondoni Visual VA-17 is a long range view and the shaft is highly visible due to the topography.

Current Status Description

A current status description was performed to record the visual impact base line conditions for both long range views, as well as for medium to short range views. It is important to establish the current visual character of the area in order to determine whether the proposed new facilities blend into the visual environment and general visual character of the area. Locally it must also be established how the proposed construction of the Shondoni Shaft and Conveyor will alter the visual impact and if they will blend with existing environment.

5.14.2 Shondoni Project Visual Attributes

The Middelbult (Block 8) Shondoni Project comprises the development of a new Shaft Complex in the Block 8 Reserves, the construction and commissioning of a Conveyer Belt system to transport the coal to Middelbult Main Shaft and then to Sasol Coal Supply (SCS, the central coal stockpiles) and the associated development of underground bord and pillar and high extraction mining on the No. C4L and No. C2 Coal Seams.

5.14.2.1 Proposed Project Infrastructure

The Shondoni Shaft Complex will be located within a fenced secondary security area. The Shaft Complex will be accessed along a newly constructed tar road with a T-junction from the provincial secondary road R547. The Shaft Complex itself will contain the following infrastructure:

- Offices
- Workshops
- Wash bays
- Stores
- Change houses
- Internal Roads and Parking Areas
- Electrical Substations
- Fuels Storage
- Soils/Overburden Stockpiles
- People and Material Shafts
- Ventilation Shafts
- Surface Bunker/ROM Emergency Stockpile
- Raw/Potable Water Supply and Storage
- Process Water Supply and Storage
- Storm Water Management System (bunds/berms/canals/outlets)
- Pollution Control Dams
- Sewage Treatment Plant
- Domestic Waste Disposal Facilities
- Industrial/Hazardous Waste Disposal Facilities
- Salvage Yard

A tarred access road of approximately 600 m will be constructed from the R 547 to the Shondoni Shaft Complex.

The underground operation will comprise of nine mechanised sections and two stone work sections, for which support facilities will be located on surface.

Internal roads and parking areas will be fully paved. Other open areas will be grassed with kikuyu lawns. The photograph depicted in Figure 5.14.2.1(a) and Figure 5.14.2.1(b) shows a typical infrastructure at a Shaft Complex.

The Shondoni shaft will be supplied with ESKOM power. A sub-station of sufficient capacity will be located on surface at the Shondoni Shaft. Fuel storage on surface at Shondoni will be restricted to one or two surface diesel tanks to be located on concrete a floor and within a bunded area.

Figure 5.14.2.1(a): Typical Shaft Complex Infrastructure

Figure 5.14.2.1(b): People and Material Shaft as well as Ventilation Shaft

Coal will be brought out of the mine to surface via the incline shaft on a conveyor belt. On surface at the Shaft Complex, the ROM coal will be stored in a surface bunker. This storage is an intermediate step in the coal conveyance as it merely represents a buffer and a transfer station in order to feed the overland coal conveyer which will transport the coal to the central coal stockpile area. The surface bunker is an enclosed concrete structure but also has an emergency coal throw out area adjacent to it.

The throw out area is an emergency stockpile area and is not allowed to exist as a matter of routine operation. A typical surface coal bunker and its associated surface throw out area is depicted in Figure 5.14.2.1(c).

Figure 5.14.2.1(c): Surface ROM Coal Bunker & Emergency Throw-out

The ROM coal from the Shondoni operations will be transported along a surface coal conveyer from the Shaft Complex to the central coal stockpile area. The new overland conveyor will be some 17 km in distance. The conveyor system will be covered and critical sections will be fitted with special low noise rollers to minimize noise. Access across and underneath the servitude will be provided to land owners. The access crossings are specifically designed according to the individual requirements of the relevant property owner.

The photograph depicted in Figure 5.14.2.1(d) depicts a typical overland coal conveyor with its associated infrastructure and servitude.

Figure 5.14.2.1(d): A Typical Overland Coal Conveyor

Sasol Mining performs water management on a mine by mine basis as far as practically possible. Each shaft therefore provides for its own water management infrastructure on surface, whilst underground mine water management is designed on a reserve and mine lease boundary scale.

Shondoni Shaft will use Rand Water for potable and general domestic purposes. The Rand Water take off pipe line supplying the mine, will most probably run within the surface coal conveyor servitude. An elevated header tank and a surface buffer storage facility, similar to the ones shown in Figure 5.14.2.1(e) will be constructed at Shondoni.

Figure 5.14.2.1(e): Potable Water Storage at Shaft Complex

Mine water accumulating into the underground workings is recycled and used for mining purposes underground. The water is extracted from underground via a borehole and pumped into service water dams located on surface at the shaft complex. This will be done to generate a sufficient pressure head before the water is reticulated back into the mine workings under gravitation.

The service water dams on surface are specifically constructed facilities as they contain affected (dirty) water and are authorized in terms of a NWA section 21(g) water use. A typical service water dam system is shown in Figure 5.14.2.1(f).

Figure 5.14.2.1(f): Service/Process Water Storage at Shaft Complex

Storm water management at the shaft complex will be done in accordance with the requirements as specified in regulation GN 704 of the NWA, which deals specifically with mine water management at mines. This will involve the separation of clean and dirty water at the shaft with a series of berms, cut-off canals and bunds around dirty areas. Clean water will be diverted around and off the site whilst dirty water will be captured and contained in a Storm Water Pollution Control Dam with an oil trap. Similar to the service water dams, PCD's are also specifically constructed facilities as they contain affected (dirty) water and are also authorized in terms of a NWA section 21(g) water use. A typical PCD layout is shown in Figure 5.14.2.1(g).

Figure 5.14.2.1(g): Storm Water PCD at Shaft Complex

A modular Prentec type sewage plant will be provided at the Shondoni Shaft Complex. These plants are self-contained systems, the maturation water discharge from which are managed to acceptable standards for either discharge into the environment, or else for storage into the Storm Water PCD. A typical sewage plant layout is shown in Figure 5.14.2.1(h).

Figure 5.14.2.1(h): Typical Sewage Plant at Shaft Complex

No mining wastes such as discard or coal fines slurry will be generated at Shondoni. The coal will be cut from the coal seams underground and then conveyed as ROM coal along the conveyor belt to the central coal stockpile area. The overburden material excavated from the shaft during the shaft construction will be used in small amounts for berm walls and embankments at the shaft complex and will be covered with clay and topsoil before these structures are re-vegetated. The placement of these materials is dealt with in terms of a NWA section 21(g) water use authorisation.

All household (general or domestic) and small volumes industrial wastes are separated and disposed of in bins within dedicated concrete lined and bunded structures for removal off-site by outside licensed waste management contractors.

Figure 5.14.2.1(i): Domestic/Industrial Waste Disposal Facilities

5.14.3 Project Life Cycle Activities

5.14.3.1 Construction Phase Activities

Construction activities will be restricted to the Shaft Complex and its access route from the R 547, as well as along the coal conveyor servitude. The construction phase will run for approximately three years and is scheduled to commence in 2011 with completion in 2013. The mine needs to be in production by 2014.

Construction will commence with site clearance and will primarily comprise civil and building construction works of the access road, the shaft complex buildings, water pollution control measures, service water dams, as well as the vertical people and materials shaft, the incline coal conveyance shaft and the vertical ventilation shaft.

Activities will be restricted to within the different servitude areas for the access road, the shaft complex, and the conveyor route.

As indicated earlier blasting will occur during the vertical and incline shaft construction. The excavated materials from the shaft will be used to construct berms and embankments around and within the shaft complex.

All construction sites will be fenced to regulate access during the construction period.

Of particular importance during the construction phase, are the potential for stream crossings by the coal conveyor system and possibility of one stream diversion that may be required. Depending on the selected conveyor route, a number of stream crossings may be required. At the incline shaft for the proposed shaft locality, a stream diversion may be required depending on the final design. Stream crossings and river diversions are authorized as NWA section 21 (c) and (i) water uses or General Authorisations.

5.14.3.2 Operational Phase Activities

The mine will go into production in 2014 and will have an expected life of approximately 27 years. The mine will operate on a 24 hour per day basis.

During the operational phase most activities will occur underground. The two coal seams will be mined with continuous miners and therefore no routine mining related blasting will occur. However, when dolerite structures need to be penetrated to access the coal seams, limited underground blasting will occur from time to time.

The coal is cut at the mining faces, loaded automatically onto the shuttle cars from which it is loaded onto the conveyor system which takes the coal along the incline shaft to surface.

On surface the coal goes directly into the surface bunker from where it is transferred onto the overland conveyor which transports the ROM coal to Middelbult Main shaft and Sasol Coal Supply.

The surface coal bunker also has an emergency surface throw our area in the event that the conveyor system cannot handle the volume of coal as a result of maintenance.

Surface activities at the shaft relate to general administration and management. Underground personnel access the mine through the vertical people and material shaft after preparing for shifts in the change houses, where they also wash and refresh at the end of shifts. The shaft complex also handles all materials that need to go underground and has stores and workshops to cater for repairs that cannot be done underground.

The ventilation shaft is also operated at the shaft complex and comprises the operation of extraction fans to drive the up cast ventilation system. Apart from the operational activities, general water management and waste management is also done on surface at the shaft complex. Potable water, service water and storm water management infrastructure are located at the shaft and operated on an ongoing basis. Waste generated on surface is disposed in bins located in dedicated areas and removed by waste management contractors.

Water make in the underground mining sections is largely managed underground. Only that portion which is required for service water purposes is pumped to surface and stored in specially constructed service water dams, and then gravitated back underground for use for mining and dust suppression.

5.14.3.3 Decommissioning and Closure Phase

During decommissioning and closure equipment will be removed and sold for re-use or disposed of as scrap. The buildings will be renovated for alternative use or be demolished. Access roads, if not used, will be scarified and re-vegetated. All plant will be sold to appropriate dealers and removed from the mine property. Electrical and water supplies in the plant area, if not used, will be terminated and made safe.

The shaft entrance will be sealed according to the requirements of the MPRDA. Overburden removed from the shaft originally will be returned to the hole and compacted. Usable soil will then be replaced and contoured to be free draining. Topsoil will be replaced over this material. Final soil remediation and re-vegetation of the site will be undertaken.

Figure 5.14.3.3(a): Typical Closed and Rehabilitated Vertical Shaft

During decommissioning any cracks that resulted from surface subsidence in the mining area will be filled and subsided areas made free draining.

Water levels in the workings will start to recover once mining ceases. However, the relatively low percentage of pillar extraction planned (25% of the mining area) and the isolation of these areas from the rest of the mining is likely to result in favourable conditions for decant (i.e. decant of a good water quality) over most of the area. Of the predicted decant, some 60% is predicted to be from the areas of pillar extraction, with the balance from the areas of bord-and-pillar mining.

The high extraction compartments are expected to fill nearly three times faster than the bord-and-pillar compartments, and these areas may require water to be actively extracted and managed within 30 years of mine closure. Should the compartments remain separate as intended, this will delay the onset of decant from the areas mined by bord-and-pillar methods.

Various options remain to manage the pillar extraction compartments, including placing this water into the base of bord-and-pillar compartments (if this can be done without affecting stratification of these compartments) and/or management as part of the Synfuels Complex water balance. Options of moving water between compartments will be evaluated and submitted to the authorities if and when applicable. A commitment will be given to actively manage water from the high extraction compartments if required, as well as to monitor, reuse and treat (if necessary, but considered unlikely) the water in the bord-and-pillar areas.

5.14.3.4 Post Closure Phase

It is envisaged that during the Post Closure Phase the surface infrastructure which has not been demolished will be used for alternative purposes. In the remainder of the mining area it is expected that the current pre-mining land uses will be able to continue.

The only significant post closure residual impact that could occur, relates to possible decant of contaminated water from the underground mine if proper management is not followed. Various options to manage this residual impact exist. The selected methodology and technology will be formalized during application for Closure.

5.14.4 Contextual Analyses

It is important to provide a contextual description of the study area as it provides the main emphasis for the required visual character of the site and its activities.

5.14.4.1 Macro Context

The site of this project is located in the Mpumalanga Province of South Africa.

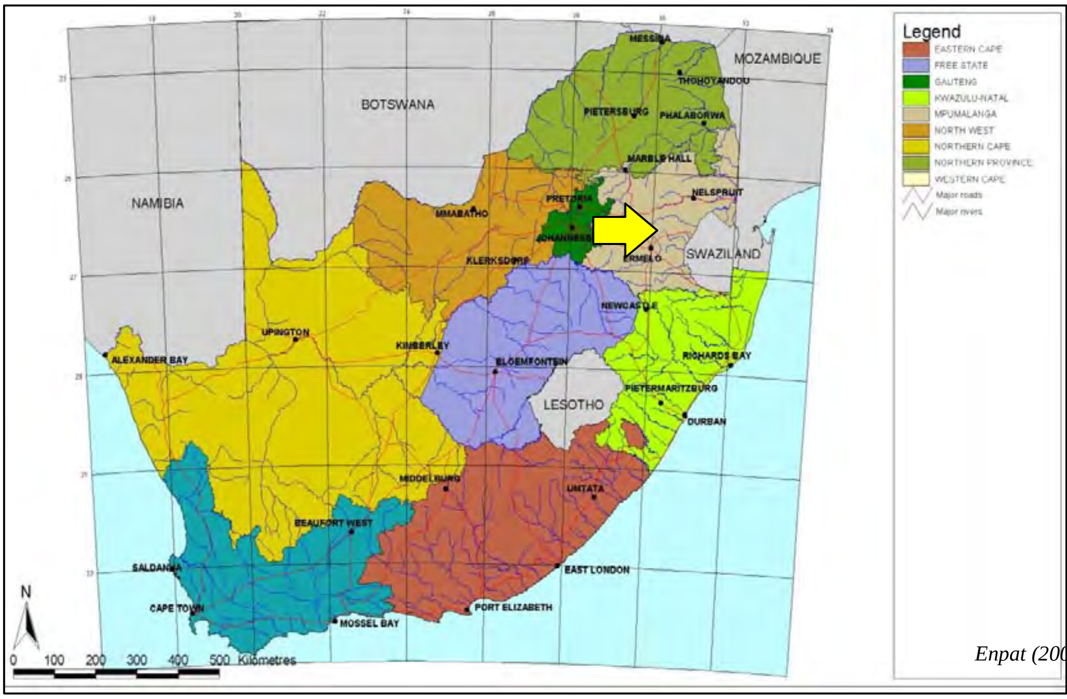

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Figure 5.14.4.1(a): Setting of the Site in South Africa (macro context)

The Mpumalanga Province is bounded in the north by the Limpopo Province of SA, in the west by the Gauteng Province of SA, in the east by the Swaziland and Mozambique and in the south by the Free State and Kwa-Zulu Natal Provinces of SA.

5.14.4.2 Micro Context

A di scussion on t he m icro c ontext pr ovides t he m otivation t o ke ep t he a rea visually acceptable.

Mpumalanga Province Profile

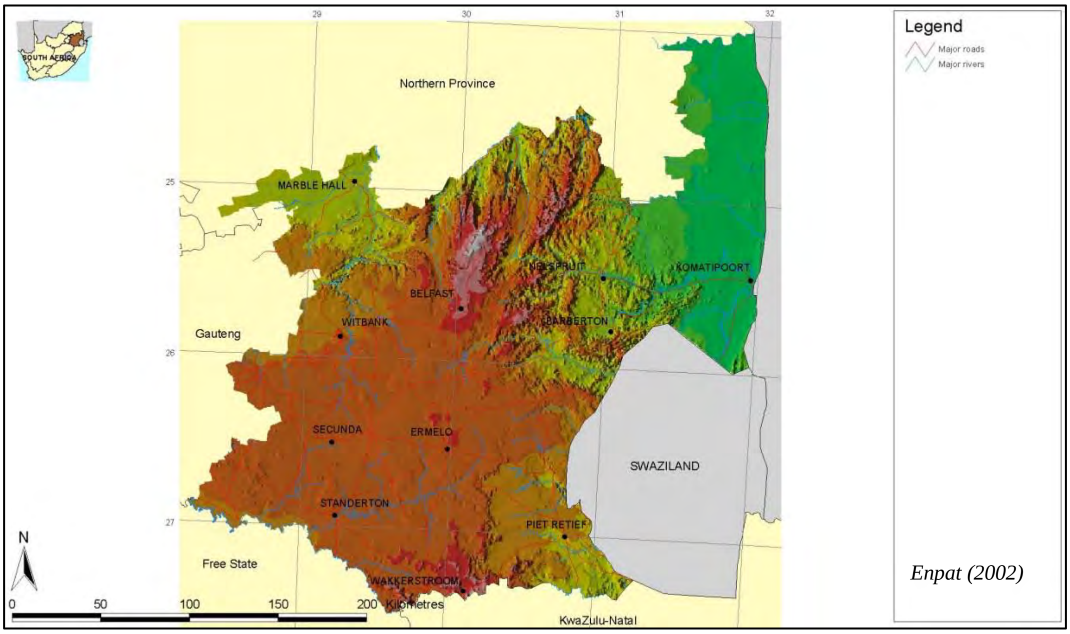

Figure 5.14.4.2(a): Regional Setting of the Site

Mpumalanga means "Place Where the Sun Rises". Due to the province's spectacular scenic beauty and abundance of wildlife, it is one of South Africa's major tourist destinations. With a surface area of only 79 490 km^2, the second-smallest province after Gauteng, it has the fourth-largest economy in South Africa.

Bordered by Mozambique and Swaziland in the east, and Gauteng in the west, it is situated mainly on the high plateau grasslands of the Middleveld, which roll eastwards for hundreds of kilometres. In the north-east, it rises towards mountain peaks and terminates in an immense escarpment. In some places, this escarpment plunges hundreds of metres down to the low-lying area known as the Lowveld.

The area has a network of excellent roads and railway connections, making it highly accessible. Because of its popularity as a tourist destination, Mpumalanga is also served by a number of small airports, such as the Kruger Mpumalanga International Airport.

The best-performing sectors in the province include mining, manufacturing and services. Tourism and agro-processing are potential growth sectors in the province.

Mining is an important sector in Mpumalanga providing jobs and contributing to over one fifth of Mpumalanga's GGP (Gross Geographic Product). Extensive coal resources are situated in the western and south-western part of the Province and sustain several large coal-fired power stations situated on the Highveld between Witbank, Standerton, Piet Retief and Carolina, as well as and the petrochemical plants in the area. The Witbank coalfield lies between Bethal and Springs in Gauteng Province, while the southern Highveld coalfield lies between Secunda and Standerton and the eastern Highveld coalfield lies between Ermelo and Volksrust.

Mpumalanga falls mainly within the grassland biome. The escarpment and the Lowveld form a transitional zone between this grassland area and the savannah biome.

Long stretches of undulating grasslands change abruptly into thickly forested ravines and thundering waterfalls of the escarpment, only to change again into the subtropical wildlife splendour of the Lowveld.

Basic Information

LAND AREA:	79 490 km²
POPULATION:	3.508 million
CAPITAL CITY:	Nelspruit
LANGUAGES:	SiSwati, IsiZulu, English
CLIMATE:	Extremely varied climate across province.
AIRPORTS:	Nelspruit
ROADS:	Good to fair, suitable for all vehicles
RAIL AND BUS SERVICES:	Available throughout the Mpumalanga Province.
DISTRICTS:	The province consists of 3 districts: Ehlanzeni, Gert Sibande, Nkangala Districts (www.mpumalanga.gov.za)

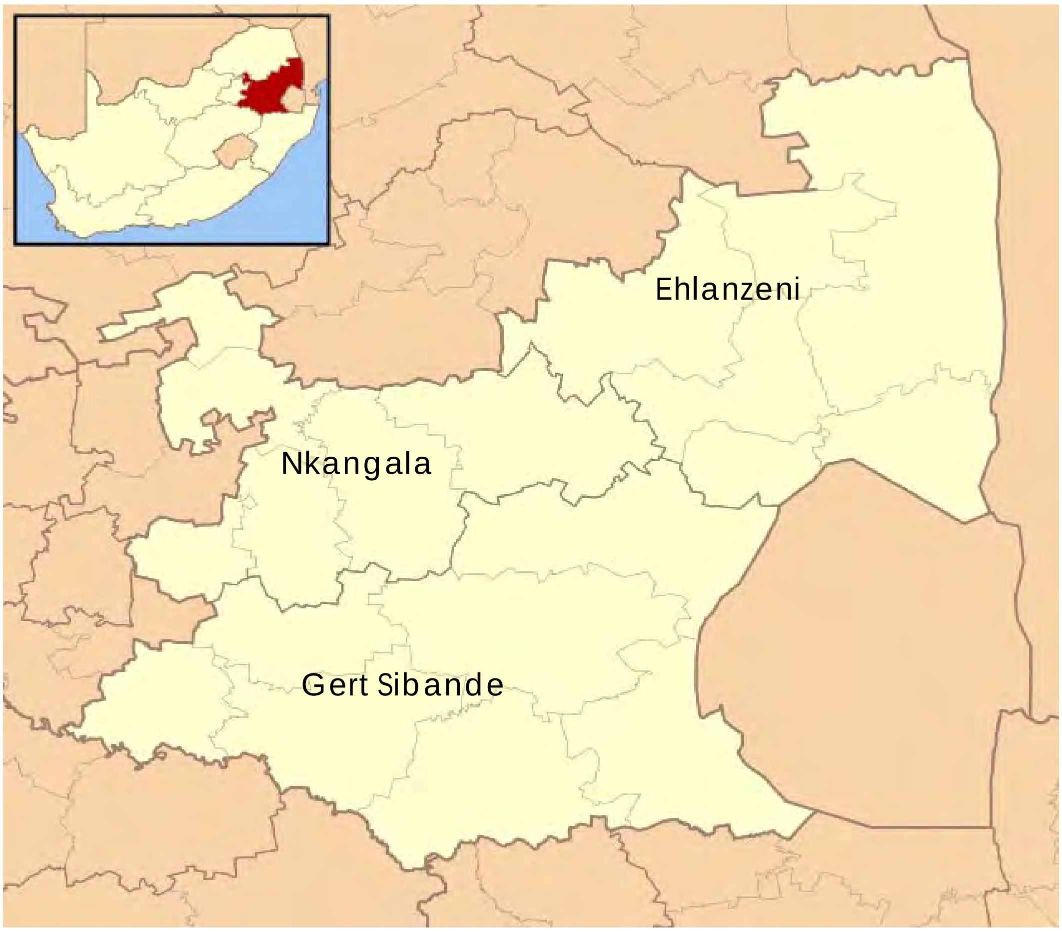

Figure 5.14.4.2(b): District Location of Site (Gert Sibande)

Describing the Mpumalanga Province

Boundaries

The Mpumalanga Province is bounded in the north by the Limpopo Province of SA, in the west by the Gauteng Province of SA, in the east by the Swaziland and Mozambique and in the south by the Freestate and Kwa-Zulu Natal Provinces of SA.

Major Natural Features

Mpumalanga falls mainly within the grassland biome. The escarpment and the Lowveld form a transitional zone between this grassland area and the savanna biome. Long sweeps of undulating grasslands change abruptly into thickly forested ravines and thundering waterfalls of the escarpment, only to change again into the subtropical wildlife splendour of the Lowveld.

Climate

The Lowveld is subtropical, due to its proximity to the warm Indian Ocean and latitude. The Highveld is comparatively much cooler, due to its altitude of 2300m to 1700m above sea level. The Drakensberg Escarpment receives the most precipitation, with all other areas being moderately well-watered by mostly summer thunderstorms. The Highveld often experiences severe frost, whilst the Lowveld is mostly frost-free. Winter rainfall is rare, except for some drizzle on the escarpment. The differences in climate are demonstrated below by the capital, Nelspruit, which is in the Lowveld, located just an hour from Belfast on the Highveld.

Belfast averages: January maximum: 23°C (min: 12°C), June maximum: 15°C (min: 1°C), annual precipitation: 878 mm

Population

- Total Population 3,643,435
- Rank: 6th in South Africa
- Density: 45.8/km2 (118.7/sq mi)
- Density rank: 3rd in South Africa [Community Survey 2007: Basic results". Statistics South Africa. p. 2.]

Literacy Rate

The Mpumalanga Department of Social Services, Population and Development reported that 29% of the population in the province aged 20 years and older received no schooling or formal education at all, constituting almost a third of the population in this age group (DSSPD, 2001). In addition, it is estimated that only 5% of the population in the province has post-school qualifications. Furthermore, it was reported that only 47% of Grade 12 learners in the province obtained their matriculation in 1996 and that Mpumalanga has a high percentage of ever-age learners (HSRC, 1998).

Major Cities and Towns

Nelspruit, Witbank, Standerton, Barberton, Ermelo, Secunda, Middelburg

Sites of Importance

Nelspruit is the capital, and the administrative and business hub of the Lowveld.

Witbank is the centre of the local coal-mining industry; Standerton, in the south, is known for its large dairy industry; and Piet Retief in the southeast is a production area for tropical fruit and sugar.

A large sugar industry is also found at Malelane in the east; Ermelo is the district in South Africa that produces the most wool; Barberton is one of the oldest gold-mining towns in South Africa; and Sabie is situated in the forestry heartland of the country.

The Maputo Development Corridor, which links the province with Gauteng and the Port of Maputo in Mozambique, heralds a new era of economic development and growth for the region. As the first international toll road in Africa, the corridor is set to attract investment and release the local economic potential of the landlocked parts of the country.

Economy

- Agriculture

  More than 68% of Mpumalanga is utilised by agriculture. Crops include maize, wheat, sorghum, barley, sunflower seed, soybeans, groundnuts, sugar cane, vegetables, coffee, tea, cotton, tobacco, citrus, subtropical and deciduous fruit.

  Natural grazing covers approximately 14% of Mpumalanga. The main products are beef, mutton, wool, poultry and dairy.

- Mining

  Extensive mining is done and the minerals found include: Gold, Platinum group metals, Silica, Chromite, Vanadiferous Magnetite, Argentiferous Zinc, Antimony, Cobalt, Copper, Iron, Manganese, Tin, Coal, Andalusite, Chrysotile Asbestos, Kieselguhr, Limestone, Magnesite, Talc and Shale.

  Mpumalanga accounts for 83% of South Africa's coal production. 90% of South Africa's coal consumption is used for electricity generation and the synthetic fuel industry. Coal power stations are in proximity to the coal deposits. A coal liquefaction plant in Secunda (Secunda CTL) is the one of the country's two petroleum-from-coal extraction plants, which is operated by the synthetic fuel company Sasol.

- Tourism

  Mpumalanga is also a popular tourism destination. Kruger National Park, established in 1898 for the protection of Lowveld wildlife, covering 20,000 square kilometres (7,800 square miles), is a popular destination. The other major tourist attractions include the Sudwala Caves and the Blyde River Canyon.

  Many activities including The big jump, mountain and quad biking, horse trails, river rafting and big game viewing are endemic to the region. This is Big 5 territory.

  In 2008 a Haute Cuisine route was formed, trickling from Mbombela down to Hazyview, the Lowveld Gourmet Route covers the four top fine dining restaurants the area has to offer. The restaurants include Summerfields Kitchen, Oliver's Restaurant, Orange and Salt.

Biological Diversity

Mpumalanga province boasts a high level of biological diversity, with three recognised centres of endemism in the province (Barberton, Sekhukhuneland and Wolkberg) and one proposed centre of endemism (Lydenburg). The level of protection of these centres is, however, very low and conservation efforts should be focused on these areas. Despite this though, many areas of the province are still in pristine condition.

The Gert Sibande District

Gert Sibande District Municipality lies in the Highveld grass-lands of Mpumalanga. It is bounded by Gauteng Province to the west, Swaziland and Ehlanzeni District Municipality to the east, Free State and KwaZulu-Natal in the south and Nkangala District Municipality in the north.

The district is the largest municipality in the province, covering 40% of the area and has seven local municipalities under its jurisdiction. The head office is located in Secunda, which is 100 km away from Johannesburg (South Africa's economic hub). The district is home to 985 632 people who constitute 25% of the Mpumalanga Province's total population, with an average population density of 30.12 per km².

Gert Sibande District Municipality has a strong economy within the region which is predominantly mining. The coal belt starts from Govan Mbeki, running through Msukaligwa and Pixley Ka Seme. The district's forestry sector stretches from Mkhondo, Pixley Ka Seme and to Albert Luthuli.

Farming includes cattle, sheep breeding and maize production. The district host one of the largest petro-chemical industries in the country (Sasol) and a number of Eskom coal powered stations. The district also boasts attractive leisure and conservation areas.

To date the district still has a huge backlog in terms of addressing the basic needs of i ts c ommunity. M uch f inancial r esources ha ve b een i nvested towards accelerating the provisions of free basic services and more people are enjoying the benefits of de mocracy and access t o basic s ervices. (http://www.mputopbusiness.co.za /site/gert-sibande-district-municipality/).

Figure 5.14.4.2(c): The Gert Sibande District

5.14.5 Current Visual And Landscape Character

5.14.5.1 Regional Visual Character – Long Range Views

Regionally the visual character is three-fold:

The first: is that of the coalfields of Mpumalanga. The area around Secunda is largely occupied by mining facilities. Here the perceived degree of human intrusion is moderate to high, and the vegetation not uniquely grassland anymore. Therefore if the shaft infrastructure is viewed from close up, against the surrounding environment as backdrop, the visual impact will be relatively low, as the nature of these elements will not contrast greatly with their surrounding visual context.

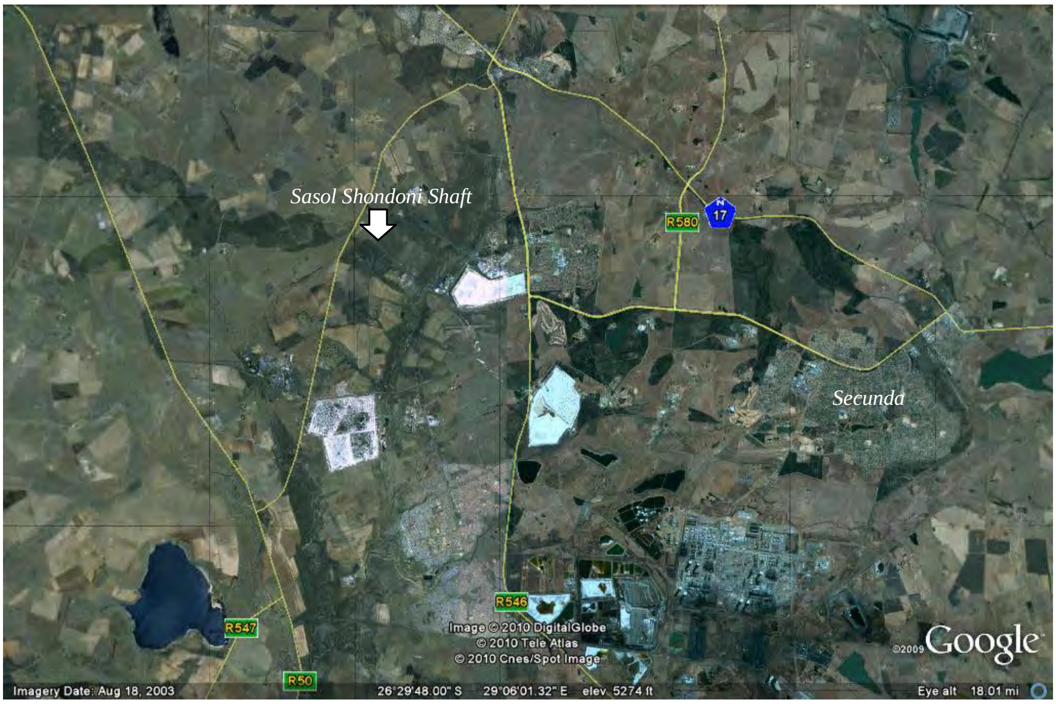

Figure 5.14.5.1(a): Aerial Photograph indicating Site within the Secunda Area

If the proposed Shondoni site is analysed in this context, it cannot be described as the highest or biggest structure in the Secunda area and thus does not present a problem considering visual intrusion from long range views.

Figure 5.14.5.1 (b): Shondoni Shaft viewed from the West

The second: is that of the grassland in which the shaft is located. The perceived degree of human intrusion in this area is low with natural grasslands surrounding the proposed shaft area. The veld adjacent to this area is acceptable for natural camouflage of lower structures.
The visual impact of the Shondoni shaft and conveyor route in this area is moderate, as only a few high structures can also be found here.

The third: visual character area is that of human settlement. Because the proposed shaft will be situated within an open veld area, it will be seen by some of the western suburban residential parts of Evander. Even though the shaft is visible, it blends in with the other mining activities in the area.

The area is characterised by extensive human intrusion and alteration, and is visually very complex.

To the south of the proposed Shondoni shaft, lies a small residential area called Brendan Village, the shaft is not visible from the edge of the village. The conveyor route however will run past the village on the opposite side of the R547. For the most part the existing trees will successfully screen the conveyor route. Because it is a low lying structure, the impact will also be softened by the grasses growing naturally in the area.

Figure 7.1 (c): Trees Screening the Proposed Conveyor Belt next to Brendan Village

To the south, the conveyor route runs across an open veld area on the Grootspruit farm. Here the conveyor route will be highly visible. The population density in this area is very low, with only a few farmers and local workers using the dirt road running alongside the conveyor route.

The Sasol Shondoni Shaft and associated conveyer route visual impact on the town of Secunda and regional areas is that of a minimum, as it is not a unique feature in the area's landscape as many other similar activities can be identified. The visual impact of the shaft on the passersby in near vicinity of the site is negative, but little or no measures can be taken to improve this.

In terms of visual character, the proposed facility does not intrude radically with the surrounding regional visual character.

5.14.5.2 Local Visual Character – Short/Medium Range Views

When buildings, vegetation or landforms obscure a view, the range of the view is shortened, resulting in a short-range view. In this report, short-range views are those views that are closer than 300 meters to a feature.

In instances where physical objects do not dominate short-range views or obscure objects that are further off in the distance, the eye is automatically drawn to any prominent vertical feature, even if these are some distance away. In this proposed context, this phenomenon is illustrated by the proposed Shondoni Shaft and conveyor route in the landscape. Where views are not obstructed by nearby objects, the proposed shaft and conveyor route will draw the observer's attention

In this instance, from the western side of the site, views across to the site and its surroundings are generally not restricted and long-range views become dominant. Although vegetation growing close to or along the road, blocks long-range views in many instances, the shaft and conveyor route are still visible from several sections along the roads and from other significant vantage points. Furthermore the vegetation found along the road is constantly changing, and as such the visibility of the site and surroundings subtly changes as time passes.

From the eastern, southern and northern sides the dominance of short range views are definite because of the landscape and structures closer to the road which can be observed, restricting views to the shaft area.

The proposed conveyor route has five public road crossings as well as a number of private road crossings. The visual impact of the conveyor belt at these road crossings can be minimised by routing the conveyor belt underneath the road instead of over it. This is illustrated in Figure 5.14.5.2(a) below.

Figure 5.14.5.2(a): Examples of Conveyor Belts crossing over the Road versus under the Road

For the conveyor route the southern, northern and western sides are dominated by long range views, where as the eastern side is dominated by short range views. Regarding the long range view; although the conveyor belt can be seen, the visual impact is generally low.

Another factor that may influence short-range views is the backdrop against which an element is viewed. When viewed from close up, landscape elements are usually seen against the sky and are therefore more visible. When the same elements are viewed against a backdrop of similar colour, they tend to be "hidden" more.

5.14.5.3 Current Landscape Character

In this document, Landscape Character is a discussion of the nature and occurrence of the physical environment:

Morphology and Topography

The Shondoni Shaft area and associated conveyor route will be located in an open veld area that lies among other mining sites, near Secunda. The site is therefore, from a morphological and topographical point of view, partially modified from its pristine condition.

The topography of the shaft site itself is relatively flat and generally slopes at a small gradient towards the south and south-west. The site is surrounded by open grasslands. A chicken farm is situated approximately 500 m to the west of the proposed Shondoni site. Towards the south a buffer zone of some 3.2 km exists between the proposed Shondoni Shaft and Brendan Village residential area, whilst open grassland area occurs towards the north. A Kinross mines shaft is situated 1.7 km to the north-east to the site, while another shaft is situated 3.2 km to the east of the site.

The site and its surrounds therefore occur in an area where the local topography and morphology have been altered due to mining and residential activities. The area therefore by no means represents a green fields morphological and/ or topographical environment.

Hydrology

The Shondoni Block 8, Block 8 Northern Reserves, Springbokdraai and Leeuwpan reserves are located on the southern side of the watershed (1580 - 1600 mamsl) between the Waterval River, which drains to the Vaal River and a number of tributaries (Blesbokspruit, Rietspruit and Vaalbankspruit) draining to the Olifants River. The proposed Shondoni Shaft and associated conveyor belt lies within the quaternary catchment C12D.

The Waterval River drains to the south across the western side of the reserves at an elevation of 1580 mamsl in the north, to 1560 mamsl in the south. The surface of the reserve area is gently undulating between the tributaries of the Waterval River that drain in a south-westerly direction from the watershed on which the N17 national road runs from Trichardt to Leandra.

To the south-west of the site, a non-perennial stream runs from north-west to south-east. The conveyor belt will cross this stream at approximately 600 m from the shaft area. Several stream crossings by the coal conveyor system and possibility of one stream diversion that may be required. Depending on the selected conveyor route, a number of stream crossings may be required.

At the incline shaft for the proposed shaft locality, a stream diversion may be required depending on the final design. Stream crossings and river diversions are authorized as NWA section 21 (c) and (i) water uses or General Authorisations. Despite these issues, it can be stated that the hydrological attributes of the site in general, make no significant contribution to the visual appeal of the region.

Surface Vegetative Cover

The study area is located within the grassland biome of South Africa. The grassland biome is one of the most threatened biomes in South Africa, due to agricultural and mining activities. According to Low and Rebelo (1996), the mining area falls within the Moist Clay Highveld Grassland (10 265 km² total area; ± 79% transformed; 0% conserved).

Visually this vegetation community is quite permeable, allowing for long-range views, especially where the viewer is in an elevated position and looks onto lower-lying areas. Small clumps of larger trees may however obscure long-range views locally.

Current On-Site and Adjacent Land Use

Land use within the Block 8 study area is predominantly agriculture, consisting of maize cropping and grazing. Underground gold mining activities also occur in the area and surface infrastructure consists of shaft complexes and gold slimes dams. Human settlements in the south and east of the study area are largely urbanised with scattered farmsteads and farm worker houses in the north-western area. Mixed commercial and residential land use activities are concentrated in the towns of Evander located in the east while the residential area of Brendan village occurs in the west.

The Shondoni Shaft Complex will be located within a fenced secondary security area. The Shaft Complex will be accessed along a newly constructed tar road with a T-junction from the provincial secondary road R547. The Shaft Complex itself will contain the following infrastructure:

- Offices
- Workshops
- Wash bays
- Stores
- Change houses
- Internal Roads and Parking Areas
- Electrical Substations
- Fuels Storage
- Soils/Overburden Stockpiles
- People and Material Shafts
- Ventilation Shafts
- Surface Bunker/ROM Emergency Stockpile
- Raw/Potable Water Supply and Storage
- Process Water Supply and Storage
- Storm Water Management System (bunds/berms/canals/outlets)
- Pollution Control Dams
- Sewage Treatment Plant

- Domestic Waste Disposal Facilities
- Industrial/Hazardous Waste Disposal Facilities
- Salvage Yard

The towns and residential areas of Secunda, eMbalenhle and Kinross are located adjacent to the south-eastern, southern and northern boundaries of the study area, respectively. The adjacent land use consists of agricultural activities in the north and west, mixed commercial and residential activities to the south and east, coal and gold mining activities occur in the region with concentrations to the south, and industrial activities (Sasol Synfuels) in the southeast.

Structure plans for the Govan Mbeki Municipality indicate future expansion of Secunda, Kinross, Evander and eMbalenhle towards each other along axes between the towns. This plan will soon be revised in terms of new legislation.

The current land use attributes undoubtedly represents the dominant component of the landscape character.

5.14.5.4 Existing Visual Character

The site lies in an active residential and mining area. Long range views of the site occur from lower vantage points located east and west of the site. From the north and south the undulating topographical definition restricts long range views to a few vantage points only, and then even if visible, the infrastructure is visually absorbed by the background and surrounding landscape.

The existing visual character of the site and greater region is therefore not undisturbed and is in fact characterised by manmade elements. The proposed facilities will not be uniquely visible and therefore will not visually dominate the area, and will only contrast visually with the area's character context to a small extent.

<u>**Landscape Visual Quality Assessment**</u>

In this document, Landscape Quality is a measurement of the union of ecological integrity and aesthetic appeal. Ecological integrity refers to the condition or overall health of the landscape measured in terms of the quality of the physical environment – morphology, topography, vegetation and hydrology.

Note that air quality and dust pollution is not investigated in this study. It should however be noted that dust from truck traffic and smoke pollution can be the most visible features of mining and industrial activities, when viewed from some distance away. Emissions from mines and other industrial activities are visible from great distances away, more so than the structures or activities themselves that causes it.

Aesthetic appeal refers not only to the visual quality of elements of an environment but also to the way in which combinations of elements in an environment appeal to our senses. Studies of perceptual psychology have shown human preferences for landscapes with a higher visual complexity, rather than homogeneous ones.

On the basis of contemporary research by Crawford (Crawford, 1994), landscape quality increases when:

- Topographic ruggedness and relative relief increase.
- Where water forms are present.
- Where natural landscapes increase and human-made landscapes decrease.
- Where land use compatibility increases and land use edge diversity decreases.

Using these criteria to analyse the landscape quality of the existing site and its immediate surroundings, the following conclusions were subjectively (but in a professional opinion) made. Where the natural/expected condition of the site and immediate surroundings is unaltered, a rating of 1 is given, and where the expected existing condition is not present or has been changed, a rating of 0 is given.

Table 5.14.5.4(a) - Local Landscape Quality

Ecological integrity	
Morphology	0
Topography	0
Vegetation	0
Hydrology	0
Aesthetic appeal	
Topographical ruggedness	0
Presence of water	1
Natural versus human landscape	0
Land use compatibility	1

As can be seen from the Table above, the ecological integrity of the site and immediate surroundings has been largely altered. With the exception of the localised alteration of the horizon from some vantage points, no significant topographical alterations will occur at Sasol Shondoni – no excavations.

The vegetation on the Sasol Shondoni shaft area will be altered with the establishment of the site. The alteration of vegetation will be restricted to the site, its associated infrastructure (including its access road) and the conveyor belt and its immediate surroundings.

The aesthetic appeal of the local setting is moderate, the greatest negative impact being the extensive presence of manmade elements (specifically extensive mining and residential activities).

The land use compatibility of the proposed activity is high. The shaft area and conveyor belt will have only a low to moderate effect on the visual character of the local vicinity of the site. The proposed Shondoni shaft facilities will not greatly contrast with the regional character, as there are many similar structures present locally and regionally. Thus the degree of visual intrusion of these structures in their regional setting is low.

From the above it can be argued that the landscape quality is relatively low, but acceptable, considering that mining in this area is a major economic booster for the region and the country and the area character is already damaged and typically mining. Substantial human intervention has already occurred locally and the visual intrusion of a new intervention will be relatively low.

<u>Visual Character (Sense of Place) Assessment</u>

According to Lynch (Lynch, 1992) sense of place is "the extent to which a person can recognise or recall a place as being distinct from other places, as having a vivid or unique, or at least particular character of its own". Thus sense of place means that a site has a uniqueness or distinctiveness, which distinguishes it from other places. The primary informant of these qualities is the spatial form and character of the natural landscape together with the cultural transformation associated with historic use and habitation. In this analysis the cultural transformation can be seen as the site and regional character, which has been described above. A landscape can be said to have a strong sense of place, regardless of whether it is considered to be scenically beautiful or not. Where high landscape quality and strong sense of place coincides, the visual resource is considered to be high.

Using these criteria to analyse the sense of place of the Sasol Shondoni site, the following subjective conclusions are made:

- The region discussed in the mining district of Secunda has a very specific character, which is a mining, agricultural and residential/rural combination. The area itself has a relatively moderate - low visual quality, but fits into the character of place. This area is not visually unique, as it is a monotonous, typical mining/industrial area, but the natural landscape, the grasslands of Mpumalanga does give the region a unique feeling when viewed from other vantage points.
- The proposed Shondoni shaft development is similar in character to those of the current mining facilities and it can therefore not be considered to have a unique genus loci or sense of place.
- The presence of the proposed Shondoni facilities will not detract from the aesthetic appeal of the area, as the entire area consist of similar activities, which will to some extent lessen the visual impact of the proposed facilities. The nature of the visual impact will however be undesirable and visual mitigation should be considered.

5.15 HERITAGE ASPECTS (CULTURAL & ARCHAEOLOGICAL)

JMA Consulting (Pty) Ltd commissioned Julius Pistorius Heritage Consultant to undertake a Phase I HIA study for the Middelbult - Block 8 - Shondoni Mine lease area, but with special focus on the activities related to the Shondoni shaft and associated surface infrastructure and underground mining.

The Phase I Heritage Impact Assessment (HIA) study for the Sasol Project is specialist report which considers the level of significance for the various types and ranges of heritage resources in the Sasol Project Area as well as the mitigation of heritage resources which may be affected by the Sasol Project. This section, however, only deals with the current base line situation.

The aims with the Phase I HIA were the following:

- To establish whether any of the types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999) (see Box 5.15(a) do occur within the perimeters of the Sasol Project Area.

Focused archaeological research has been conducted in the Mpumalanga Province for more than four decades. This research consists of surveys and of excavations of Stone Age and Iron Age sites as well as the recording of rock art and historical sites.

The Mpumalanga Province has a rich heritage comprised of remains dating from the pre-historical and from the historical (or colonial) periods of South Africa. Pre-historical and historical remains in the Mpumalanga Province of South Africa therefore form a record of the heritage of most groups living in South Africa today.

Previous heritage surveys conducted for Sasol Mining indicated that the most common types and ranges of heritage resources on the Eastern Highveld in the Mpumalanga Province include historical farmstead complexes associated with formal and informal graveyards.

Stone walled settlements dating from the Late Iron Age and Historical Period also occur but are limited to areas where low, dolerite kopjes and randjes exist. These topographical features are generally scarce in the mining areas where Sasol is operational.

However, various types and ranges of heritage resources that qualify as part of South Africa's 'national estate' as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999) do occur across the Mpumalanga Province (see Box 5.15(a), next page).

Box 5.15(a): Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999)

The National Heritage Resources Act (Act No 25 of 1999, Section 3) outlines the following types and ranges of heritage resources that qualify as part of the national estate, namely:

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

(h) sites of significance relating to the history of slavery in South Africa;
(i) moveable objects, including -
- *(i) objects recovered from the soil or waters of South Africa, including archaeological and paleontological objects and material, meteorites and rare geological specimens;*
- *(ii) objects to which oral traditions are attached or which are associated with living heritage;*
- *(iii) ethnographic art and objects;*
- *(iv) military objects;*
- *(v) objects of decorative or fine art;*
- *(vi) objects of scientific or technological interest; and*
- *(vii) books, records, documents, photographs, positives and negatives, graphic, film or video material or sound recordings, excluding those that are public records as defined in section 1(xiv) of the National Archives of South Africa Act, 1996 (Act No 43 of 1996).*

The National Heritage Resources Act (Act No 25 of 1999, Art 3) also distinguishes nine criteria for places and objects to qualify as 'part of the national estate if they have cultural significance or other special value …'. These criteria are the following:

(a) its importance in the community, or pattern of South Africa's history;
(b) its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;
(c) its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;
(d) its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects
(e) ;its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
(f) its importance in demonstrating a high degree of creative or technical achievement at a particular period;
(g) its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;
(h) its strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa;
(i) sites of significance relating to the history of slavery in South Africa

This Phase I HIA study was conducted by means of the following:

- Surveying the Middelbult – Block 8 – Shondoni Area with a vehicle and selected spots on foot.
- Briefly surveying literature relating to the pre-historical and historical context of the Middelbult – Block 8 – Shondoni Area.
- Consulting maps of the Middelbult – Block 8 – Shondoni Area.
- Consulting archaeological (heritage) data bases.
- Consulting spokespersons regarding the possible presence of graves and graveyards in the project area.
- Synthesising all information obtained from the data bases, fieldwork, maps and literature survey.

Databases kept and maintained at institutions such as the Provincial Heritage Resources Agency (PHRA) and the Archaeological Data Recording Centre at the National Flagship Institute (Museum Africa) in Pretoria were consulted to determine whether any heritage resources of significance has been identified during earlier heritage surveys in or near the Middelbult – Block 8 – Shondoni Area.

Literature relating to the pre-historical and the historical unfolding of the Eastern Highveld where the Middelbult – Block 8 – Shondoni Area is located was reviewed (see section 5.15.2, 'Contextualising the Middelbult – Block 8 – Shondoni Area').

It is important to contextualise the pre-historical and historical background of the Study Area in order to comprehend the identity and meaning of heritage sites in and near the project area.

In addition, the Study Area was studied by means of 1:50 000 topographical maps and the 1:250 000 map on which it appears.

Spokespersons living in the Middelbult – Block 8 – Shondoni Area were consulted regarding the possible presence of solitary graves and graveyards. Many graveyards on the Eastern Highveld have been abandoned or occur in desolated areas or in maize fields where they remains undetected if not pointed out by persons, such as farmers and workers, who are well acquainted with the Study Area. The following persons were consulted during the study:

- Solly Ndlof, farm labourer on Kromdraai 128IS
- Mike Combrick, farm owner of several farms in the Middelbult Mining Area
- Willie Oosthuizen, tenant of farmstead complex on Winkelhaak 139IS
- Robbie Bekker, farm owner on Brakspruit 359IH
- Francois Bekker, farm owner on Brakspruit 359IH
- Steve Shabangu, resident on Witkleifontein 138IS
- Hennie Pretorius, farm owner on Springbokdraai 277IS
- Boet Conradie, Environmental Manager, Harmony Gold.
- Wynne Song, farm owner on Brakspruit 359JR.
- Frans Els, farm owner on Wildebeesspruit 356JR
- Alfred Kudeka, farm worker onWildebeesspruit 356JR

It is possible that this baseline heritage survey may have missed heritage resources in the Middelbult – Block 8 – Shondoni Area considering the size of the area and the fact that heritage sites may occur in thick clumps of vegetation while others may lie below the surface of the earth and may only be exposed once development commences. If any heritage resources of significance is exposed during the Shondoni Project or during any future exploration, mining or other development activities, the South African Heritage Resources Authority (SAHRA) should be notified immediately, all development activities must be stopped and an archaeologist accredited with the Association for Southern African Professional Archaeologist (ASAPA) should be notify in order to determine appropriate mitigation measures for the discovered finds. This may include obtaining the necessary authorisation (permits) from SAHRA to conduct the mitigation measures.

Terms that may be used in this report are briefly outlined in Box 5.15(b).

Box 5.15(b): Terminologies that may be used in this report

The Heritage Impact Assessment (HIA) referred to in the title of this report includes a survey of heritage resources as outlined in the National Heritage Resources Act, 1999 (Act No 25 of 1999) (See Box 1).
Heritage resources (cultural resources) include all human-made phenomena and intangible products that are the result of the human mind. Natural, technological or industrial features may also be part of heritage resources, as places that have made an outstanding contribution to the cultures, traditions and lifestyles of the people or groups of people of South Africa.
The term 'pre-historical' refers to the time before any historical documents were written or any written language developed in a particular area or region of the world. The historical period and historical remains refer, for the Sasol Project Area, to the first appearance or use of 'modern' Western writing brought to the Eastern Highveld by the first Colonists who settled in this area during the 1830's.
The term 'relatively recent past' refers to the 20th century. Remains from this period are not necessarily older than sixty years and therefore may not qualify as archaeological or historical remains. Some of these remains, however, may be close to sixty years of age and may, in the near future, qualify as heritage resources.
It is not always possible, based on observations alone, to distinguish clearly between archaeological remains and historical remains, or between historical remains and remains from the relatively recent past. Although certain criteria may help to make this distinction possible, these criteria are not always present, or, when they are present, they are not always clear enough to interpret with great accuracy. Criteria such as square floor plans (a historical feature) may serve as a guideline. However, circular and square floors may occur together on the same site.
The term 'sensitive remains' is sometimes used to distinguish graves and cemeteries as well as ideologically significant features such as holy mountains, initiation sites or other sacred places. Graves in particular are not necessarily heritage resources if they date from the recent past and do not have head stones that are older than sixty years. The distinction between 'formal' and 'informal' graves in most instances also refers to graveyards that were used by colonists and by indigenous people. This distinction may be important as different cultural groups may uphold different traditions and values with regard to their ancestors. These values have to be recognised and honoured whenever graveyards are exhumed and relocated.
The term 'Stone Age' refers to the prehistoric past, although Late Stone Age peoples lived in South Africa well into the historical period. The Stone Age is divided into an Earlier Stone Age (3 million years to 150 000 thousand years ago) the Middle Stone Age (150 000 years to 40 000 years ago) and the Late Stone Age (40 000 years to 200 years ago).
The term 'Iron Age' refers to the last two millennia and 'Early Iron Age' to the first thousand years AD. 'Late Iron Age' refers to the period between the 16th century and the 19th century and can therefore include the historical period.
Mining heritage sites refer to old, abandoned mining activities, underground or on the surface, which may date from the pre-historical, historical or the relatively recent past.
The term 'study area', or 'Sasol Project Area' refers to the area where the developer wants to focus its development activities (refer to plan).
Phase I studies refer to surveys using various sources of data in order to establish the presence of all possible types of heritage resources in any given area.
Phase II studies include in-depth cultural heritage studies such as archaeological mapping, excavating and sometimes laboratory work. Phase II work may include the documenting of rock art, engraving or historical sites and dwellings; the sampling of archaeological sites or shipwrecks; extended excavations of archaeological sites; the exhumation of bodies and the relocation of graveyards, etc. Phase II work may require the input of specialists and requires the co-operation and approval of SAHRA.

5.15.1 Relevant Regional Attributes

5.15.1.1 Location

Sasol Mining's mine lease area incorporates a vast track of land on the Eastern Highveld in the Mpumalanga Province of South Africa. The mine lease area is demarcated in various mining areas.

These include the Middelbult, Brandspruit, Twistdraai and Bosjesspruit Mining Areas which are located to the south of Leandra and Kinross and which stretches towards Balfour and Belfast in the south; the Block A (North) and Block B (South) Mining Areas which are located further to the west incorporating the village of VAL and which stretches towards Greylingstad further to the south as well as Sasol's Block 8 Mining Area which incorporates the Springbokdraai Reserves, Leeuwpan Reserves and the Northern Reserves.

This report focuses on the Middelbult – Block 8 - Shondoni Area which falls within in the Middelbult Mining Area and on Sasol's Block 8, which will now also incorporate the Springbokdraai Reserves, Leeuwpan Reserves and the Block 8 Northern Reserves (Figure 5.15.1.1(a)) (2628BD Leandra; 1: 50 000 topographical map & 2628 East Rand; 1:250 000 map).

The Study Area stretches across an undulating piece of veldt which incorporates agricultural fields as well as stretches with pristine grass veldt. The area has been transformed in the north where the towns of Leandra and Kinross are located as a result of town and mine development.

Towards the south, untransformed grass veldt and relatively pristine heritage resources such as colonial farmsteads and graveyards are common.

Few trees occur in the Sasol Project Area. Those that do occur are exotics such as Blue Gum lots, poplar-groves on the banks of streams and Oak trees which are usually located near historical farm homesteads. Most of these trees are anthropogenic as they have been introduced by human activities in the area in the past.

The Study Area is known for the production of agricultural crops such as maize wheat, sorghum, dairy, potatoes and other vegetables. Cattle and sheep ranching also make a significant contribution to the local economy. Coal, gold and silica mines also occur in the area.

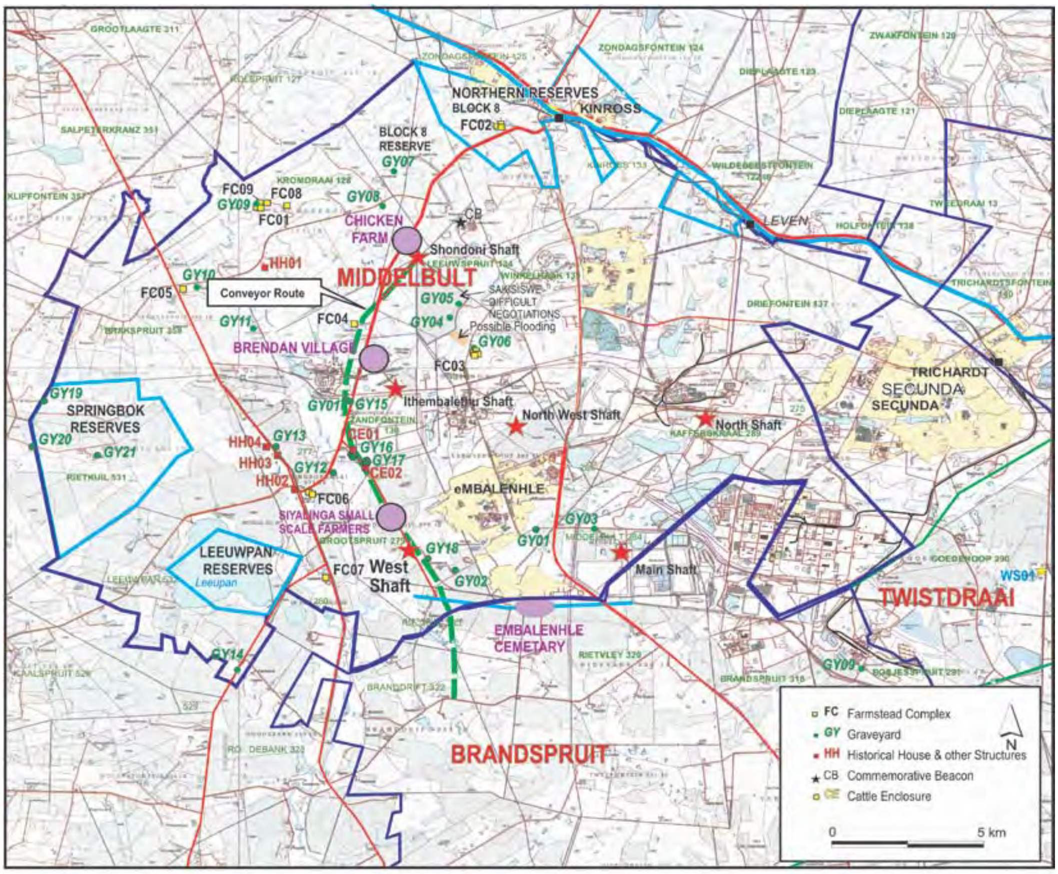

Figure 5.15.1.1(a): The Middelnult – Block 8 – Shondoni Area consisting of the Middelbult Mining Area as well as Block 8 which now includes the Springbokdraai, Leeuwpan and Northern Reserves. Note the presence of historical farmsteads complexes, historical houses and structures, graveyards and a commemorative beacon in the Study Area.

Figure 5.15.1.1.(b): The Middelnult – Block 8 – Shondoni Area on the Eastern Highveld of the Mpumalanga Province is an undulating piece of land which is characterised by outstretched grass veldt interspersed with agricultural fields. This tract of land is dotted with farmstead complexes which are usually associated with Blue Gum avenues or with smaller plantations of these trees.

5.15.2 The Shondoni Project

The proposed new developments at Middelbult Mine for which new enviroemental authroizations are sought, include the following components:

- The proposed Shondoni Project which involves the development of a new shaft, associated infrastructure around the shaft area and an overland conveyor belt running southwards from the shaft to one of Sasol's existing conveyor belts further to the south. This development component is primarily located in the Middelbult Mining Area.
- Extension of Sasol's Block 8, which includes the Springbokdraai Reserves, Leeuwpan Reserves and the Northern Reserves. These three mining areas involves parts of the following farms, namely Rietkuil 531IR, Leeuwpan 532IR and Zondagsfontein 124IS.

5.15.3 Within a Cultural Landscape

The Study Area is located in the midst of a cultural landscape that is marked by heritage remains dating from the pre-historical into the historical (colonial) period. Stone Age sites, Iron Age sites and colonial remains therefore do occur in the Eastern Highveld.

The archaeological and historical significance of this cultural landscape therefore must be described and explained in more detail before the results of the Phase I HIA study is discussed.

5.15.4 Contextualising the Middelbult – Block 8 – Shondoni Study Area

The following brief overview of pre-historical, historical, cultural and economic evidence will help to contextualise the Study Area.

5.15.4.1 Stone Age and Rock Art Sites

Stone Age sites are marked by stone artefacts that are found scattered on the surface of the earth or as parts of deposits in caves and rock shelters. The Stone Age is divided into the Early Stone Age (ESA) (covers the period from 2.5 million years ago to 250 000 years ago), the Middle Stone Age (MSA) (refers to the period from 250 000 years ago to 22 000 years ago) and the Late Stone Age (LSA) (the period from 22 000 years ago to 200 years ago).

Dongas and eroded areas at Maleoskop near Groblersdal is one of only a few places in Mpumalanga where ESA Olduwan and Acheulian artefacts have been recorded.

Evidence for the MSA has been excavated at the Bushman Rock Shelter near Ohrigstad. This cave was repeatedly visited over a prolonged period. The oldest layers date back to 40 000 years BP and the youngest to 27 000BP.

LSA occupation of the Mpumalanga Province also has been researched at Bushman Rock Shelter where it dates back 12 000BP to 9 000BP and at Höningnestkrans near Badfontein where a LSA site dates back to 4 870BP to 200BP.

The LSA is also associated with rock paintings and engravings which were done by San hunter-gatherers, Khoi Khoi herders and EIA farmers. Approximately 400 rock art sites are distributed throughout Mpumalanga, note-ably in the northern and eastern regions at places such as Emalahleni (Witbank) (4), Lydenburg (2), White River and the southern Kruger National Park (76), Nelspruit and the Nsikazi District (250). The Ermelo area holds eight rock paintings.

The rock art of the Mpumalanga Province can be divided into San rock art which is the most wide spread, herder or Khoe Khoe paintings (thin scattering from the Limpopo Valley) through the Lydenburg district into the Nelspruit area) and localised late white farmer paintings. Farmer paintings can be divided into Sotho-Tswana finger paintings and Nguni engravings (Only 20 engravings occur at Boomplaats, north-west of Lydenburg). Farmer paintings are more localised than San or herder paintings and were mainly used by the painters for instructional purposes.

During the LSA and Historical Period, San people called the Batwa lived in sandstones caves and rock shelters near Lake Chrissie in the Ermelo area. The Batwa are descendants of the San, the majority of which intermarried with Bantu-Negroid people such as the Nhlapo from Swazi-descend and Sotho-Tswana clans such as the Pai and Pulana. Significant intermarriages and cultural ex changes occurred between these groups. The Batwa were hunter-gatherers who lived from food which they collected from the veldt as well as from the pans and swamps in the area. During times of unrest, such as the *difaqane* in the early nineteenth century, the San would converge on Lake Chrissie for food and sanctuary. The caves, lakes, water pans and swamps provided relatively security and camouflage. Here, some of the San lived on the surfaces of the water bodies by establishing platforms with reeds. With the arrival of the first colonists in the nineteenth century many of the local Batwa family groups were employed as farm labourers. Descendants of the Batwa people still live in the larger Project Area.

5.15.4.2 Iron Age Remains

The Iron Age is associated with the first agro-pastoralists or farming communities who lived in semi-permanent villages and who practised metal working during the last two millennia. The Iron Age is usually divided into the Early Iron Age (EIA) (covers the 1st millennium AD) and the Later Iron Age (LIA) (covers the first 880 years of the 2nd millennium AD).

Evidence for the first farming communities in the Mpumalanga Province is derived from a few EIA pot sherds which occur in association with the LSA occupation of the Höningnest Shelter near Badfontein. The co-existence of EIA potsherds and LSA stone tools suggest some form of 'symbiotic relationship' between the Stone Age hunter-gatherers who lived in the cave and EIA farmers in the area (also note Batwa and Swazi/Sotho Tswana relationship).

The Welgelegen Shelter on the banks of the Vaal River near Ermelo also reflects some relationship between EIA farmers who lived in this shelter and hunter-gatherers who manufactured stone tools and who occupied a less favourable overhang nearby during AD1200.

EIA sites were also investigated at Sterkspruit near Lydenburg (AD720) and in Nelspruit where the provincial governmental offices were constructed. The most infamous EIA site in South Africa is the Lydenburg head site which provided two occupation dates, namely during AD600 and from AD900 to AD1100. At this site the Lydenburg terracotta heads were brought to light. Doornkop, located south of Lydenburg, dates from AD740 and AD810.

The Late Iron Age is well represented in Mpumalanga and stretches from AD1500 well into the nineteenth century and the Historical Period. Several spheres of influence, mostly associated with stone walled sites, can be distinguished in the region. Some of the historically well known spheres of influence include the following:

- Early arrivals in the Mpumalanga Province such as Bakone clans who lived between Lydenburg and Machadodorp and Eastern Sotho clans such as the Pai, Pulana and Kutswe who established themselves in the eastern parts of the province.
- Swazi expansion into the Highveld and Lowveld of the Mpumalanga Province occurred during the reign of Sobhuza (AD1815 to 1836/39) and Mswati (AD1845 to 1868) while Shangaan clans entered the province across the Lembombo Mountains in the east during the second half of the nineteenth century.
- The Bakgatla (Pedi) chiefdom in the Steelpoort Valley rose to prominence under Thulare during the early 1800's and was later ruled by Sekwati and Sekhukune from the village of Tsjate in the Leolo Mountains. The Pedi maintained an extended sphere of influence across the Limpopo and Mpumalanga Provinces during the nineteenth century.
- The Ndzundza-Ndebele established settlements at the foot of the Bothasberge (Kwa Maza and Esikhunjini) in the 1700's and lived at Erholweni from AD1839 to AD1883 where the Ndzundza-Ndebele's sphere of influence became known as KoNomthjarhelo which stretched across the Steenkampsberge.
- The Bakopa lived at Maleoskop (1840 to 1864) where they were massacred by the Swazi while the Bantwane live in the greater Groblersdal and Marble Hall areas.
- Corbelled stone huts which are associated with ancestors of the Sotho on Tafelkop near Davel which date from the AD1700's into the nineteenth century.
- Stone walled settlements spread out along the eastern edge of the Groot Dwarsriver Valley served as the early abode for smaller clans such as the Choma and Phetla communities which date from the nineteenth century.

5.15.4.3 The Historical Period

Historical towns closest to the Sasol Project Area include Leandra, Kinross, Evander and Secunda. The town of Leandra's name is derived from two townships, Leslie and Eendrag, which are incorporated in this mining village.

Kinross, about 20 km east of Leandra, is the railhead for the township of Leandra and four gold mines in the region, namely Winkelhaak, Leslie, Bracken and Kinross who all opened in the 1950's. The village was proclaimed in the 1915 and named for Kinross in Scotland by the engineers who constructed the railway line between Springs and Breyton. Kinross is near the watershed that separates the rivers flowing towards the Indian Ocean in the east and the rivers flowing towards the Atlantic Ocean in the west.

Secunda developed around Sasol 1 and Sasol 2 in the 1970's. Sasol was born during the oil crisis of 1973 when OPEC virtually quadrupled the price of crude oil overnight. Construction started in 1976 and the first oil was delivered on 1 March 1980. Following the overthrow of the Shah of Iran in 1979, South Africa's major source of crude oil at the time, the government announced the construction of a second plant at Secunda to double output. Sasol 3 delivered its first oil from coal in May 1982. The total costs of the two plants came to R 5,8 billion, mostly financed by levies on motorists.

Sasol 2 and Sasol 3 use about 35 million tons of coal a year to produce mostly liquid fuels. The coal is produced by four mines collectively known as Secunda Colliers which is the world's largest underground mining complex and by a new open-cast mine at Syferfontein.

Evander, south of Kinross, was established in 1955 by the Union Corporation as a residential township for the employees of the Winkelhaak. Leslie and Bracken mines. The name Evander is a composite of Evelyn and Anderson, the names of the widow of the managing director of the company when prospecting began in the area.

Several large coal mines which feed the Sasol plants at Secunda and Eskom's giant power stations on the Eastern Highveld are located near the project area. The Sasol Project Area is one of the most productive agricultural areas in the country. The principal crops which are produced in the region include maize, wheat, sorghum, dairy, potatoes and other vegetables.

5.15.4.4 A Coal Mining Heritage

Coal mining on the Eastern Highveld is now older than one century and has become the most important coal mining region in South Africa. Whilst millions of tons of high-grade coal are annually exported overseas more than 80 % of the country's electricity is generated on low-grade coal in Eskom's power stations such as Duvha, Matla and Arnot situated near coalmines on the Eastern Highveld.

The earliest use of coal (charcoal) in South Africa was during the Iron Age (300-1880AD) when metal workers used charcoal, iron and copper ores and fluxes (quartzite stone and bone) to smelt iron and copper in clay furnaces.

Colonists are said to have discovered coal in the French Hoek Valley near Stellenbosch in the Cape Province in 1699. The first reported discovery of coal in the interior of South Africa was in the mid-1830 when coal was mined in Kwa Zulu/Natal. The first exploitation for coal was probably in Kwa Zulu/Natal as documentary evidence refers to a wagon load of coal brought to Pietermaritzburg to be sold in 1842. In 1860 the coal trade started in Dundee when a certain Pieter Smith charged ten shillings for a load of coal dug by the buyer from a coal outcrop in a stream. In 1864 a coal mine was opened in Molteno. The explorer, Thomas Baines mentioned that farmers worked coal deposits in the neighbourhood of Bethal (Transvaal) in 1868. Until the discovery of diamonds in 1867 and gold on the Witwatersrand in 1886, coal mining only satisfied a very small domestic demand.

With the discovery of gold in the Southern Transvaal and the development of the gold mining industry around Johannesburg came the exploitation of the Boksburg-Spring coal fields, which is now largely worked out. By 1899, at least four collieries were operating in the Middelburg-Witbank district, also supplying the gold mining industry. At this time coal mining also has started in Vereeniging. The Natal Collieries importance was boosted by the need to find an alternative for imported Welsh anthracite used by the Natal Government Railways. By 1920 the output of all operating colliers in South Africa attained an annual figure of 9.5 million tonnes. Total in-situ reserves were estimated to be 23 billion tonnes in Witbank-Springs, Natal and Vereeniging. The total in situ reserves today are calculated to be 121 billion tonnes. The largest consumers of coal are Sasol, Iscor and Eskom.

5.15.4.5 A Vernacular Stone Architectural Heritage

A unique stone architectural heritage was established in the Eastern Highveld from the second half of the 19th century well into the early 20th century. During this time period stone was used to build farmsteads and dwellings, both in urban and in rural areas. Although a contemporary stone architecture also existed in the Karoo and in the Eastern Free State Province of South Africa a wider variety of stone types were used in the Eastern Highveld. These included sandstone, ferricrete (‘ouklip’), dolerite (‘blouklip’), granite, shale and slate.

The origins of a vernacular stone architecture in the Eastern Highveld may be ascribed to various reasons of which the ecological characteristics of the region may be the most important. Whilst this region is generally devoid of any natural trees which could be used as timber in the construction of farmsteads, outbuildings, cattle enclosures and other structures, the scarcity of fire wood also prevented the manufacture of baked clay bricks. Consequently stone served as the most important building material in the Eastern Highveld.

LIA Sotho, Pedi, Ndebele and Swazi communities contributed to the Eastern Highveld’s stone walled architecture. The tradition set by these groups influenced settlers from Natal and the Cape Colony to utilize the same resources to construct dwellings and shelters. Farmers from Scottish, Irish, Dutch, German and Scandinavian descend settled and farmed in the Eastern Highveld. They brought the knowledge of stone masonry from Europe. This compensated for the lack of fire wood on the eastern Highveld which was necessary to bake clay bricks.

5.15.5 The Base Line Heritage Survey

The baseline heritage impact assessment for the Study Area revealed the following types and ranges of heritage resources in and near the Middelbult – Block 8 – Shondoni Area as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999), namely:

- Farmstead complexes associated with historical houses, outbuildings and cattle enclosures.
- Informal and formal graveyards.

These heritage resources were geo-referenced and mapped (Figure 5.15.5(a) and Table 5.15.5(a) - Farmsteads and Table 5.15.5(b) - Graveyards.

Remains from the recent past also occur in the Sasol Project Area but have no historical significance and therefore were not geo-referenced or mapped and are not discussed in this report.

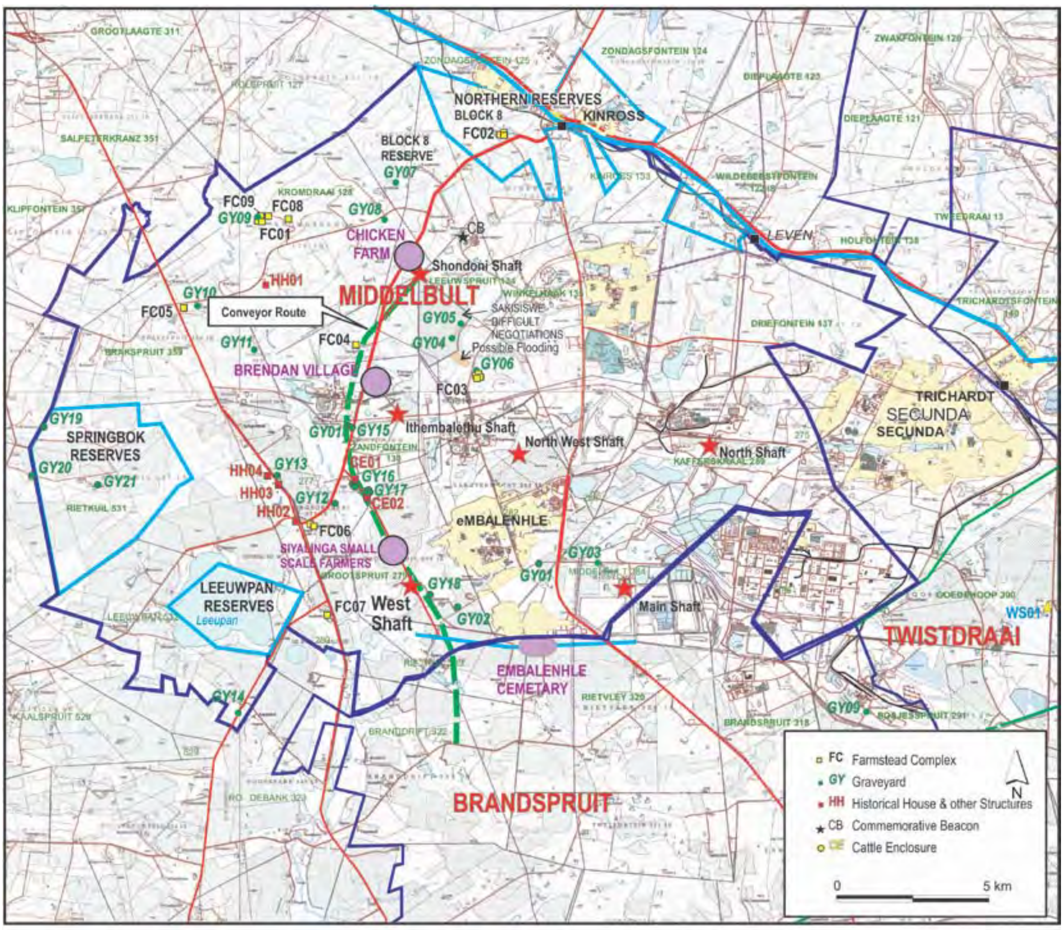

Figure 5.15.5(a): The Sasol Study Area consisting of the Middelbult – Block 8 – Shondoni Mining Area, which now also includes the Springbokdraai, Leeuwpan and Block 8 Northern Reserves. Note the presence of historical farmsteads complexes, historical houses and structures, graveyards and a commemorative beacon in the Study Area

5.15.5.1 Farmsteads

Farmstead Complex 01

FC01 on Kromdraai 128IS is associated with some of the oldest graves that were observed in the area. The complex comprises of the following individual buildings:

- A wagon shed which was constructed with sandstone bricks and dolerite stone.
- A rondavel which was constructed with dolerite.
- An extended residence which was built with sandstone and dolerite stone.
- A cattle enclosure with exceptionally high walls which was probably used as an enclosure for cattle but which may also has served as a wagon shed.

Figure 5.15.5.1(a): A historical wagon shed on Kromdraai 128IS which is part of FC01 (above)

Figure 5.15.5.1(b): The main residence in FC01 on Kromdraai 128IS consists of a residence which was built with sandstone bricks and dolerite stone (above)

Farmstead Complex 02

This farmstead complex on Winkelhaak 139 IS is occupied by Mr. Frikkie Oosthuizen and his wife and comprises of the following individual structures:

- An excellently well preserved main residence in an Edwardian style which was constructed with sandstone and with 'stoeps' (verandas) on at least two sides. It is fitted with a pitched iron corrugated roof.
- A wagon shed which was constructed with sandstone and which is fitted with a pitched corrugated iron roof.
- A possible 'bywonershouse' which was constructed with sandstone and which is fitted with a pitched corrugated iron roof.

Figure 5.15.5.1(c): The main sandstone residence on Winkelhaak 139IS with Edwardian features

Figure 5.15.5.1(d): The "bywonershuis" on Winkelhaak 139IS, also constructed with sandstone

Farmstead Complex 03

This farmstead complex on Witkleifontein 181IS is associated with the Pieterse family whose remains occur in a graveyard (GY06) some distance from the farmstead complex. This complex holds the following individual structures:

- A wagon shed which was constructed with sandstone bricks and dolerite stone.
- A small square structure which was constructed with dolerite stone, possibly a ‘bywonershuis’ or cool room (‘koelkamer’).
- A main residence which was constructed with sandstone bricks and with dolerite stones.
- An elongated cattle enclosure which was built with rocks.

Figure 5.15.5.1(e): A possible ‘bywonershuis’ or a cool room (‘koelkamer’) on Witkleifontein 181IS which was constructed with dolerite stone in FC03

Figure 5.15.5.1(f): A cattle enclosure on Witkleifontein 181IS which is part of FC03 which was constructed with stones

Farmstead Complex 04

This farmstead complex on Zandfontein 190IS is currently occupied by the Brits family and involves a number of individual buildings, namely:

- A residence constructed with sandstone.
- A wagon shed constructed with sandstone.

This farmstead complex was not accessible at the time when the fieldwork was done.

Farmstead Complex 05

This farmstead complex on Brakspruit 359IH belongs to the Bekker family and consists of the following individual buildings, namely:

- Three wagon sheds next to each other which were constructed with clay bricks and whose walls are plastered. The sheds are fitted with pitched corrugated iron roofs.
- A main residence which was constructed with clay bricks and whose walls are plastered. The house is fitted with a pitched corrugated iron roof. This residence dated from the 1930/40's.

Farmstead Complex 06

This farmstead complex on Springbokdraai 277IS is located near the T-junction between the Kinross road with the Leandra-Balfour road on Springbkdraai 277IS and incorporates the following two structures:

- A wagon shed constructed with corrugated zinc
- A dilapidated sandstone house.

These two structures are standing on a slight rise overlooking part of the Eastern Highveld.

Farmstead Complex 07

This farmstead complex is located on Vaalbank on Roodebank 325IS to the south-east of Leeuwpan and consists of the following buildings and structures, namely:

- A house constructed with sandstone and fitted with a pitched corrugated iron roof.
- Large shed constructed with sandstone fitted with a pitched corrugated iron roof and a stand for a water tank.
- Diary constructed with sandstone and fitted with a pitched corrugated iron roof.

5.15.5.2 Historical Houses

Historical House 01

This farm residence on Brakspruit 359IH is fitted with a pitched corrugated iron roof. It was constructed with clay bricks and its walls are plastered. This residence probably dates from the 1920's. It is associated with an out building which probably served as a garage for a vehicle.

Figure 5.15.5.2(a): The historical house on Brakspruit 359IH which probably dates from the 1910/20's

Historical House 02

This sandstone house on Rietkuil 531IR near the T-junction between the Kinross road with the Leandra-Balfour road is partly constructed with sandstone and possibly with clay bricks as well. It is fitted with a pitched corrugated iron roof and is painted green.

Historical House 03

This house on Rietkuil 531IR next to the Leandra-Balfour road was constructed during the 1930/40's and was built with clay bricks and cement. The walls of the house were plastered with cement and it is fitted with a pitched corrugated iron roof. It belongs to the De la Rey family.

Historical House 04

This house on Rietkuil 531IR next to the Leandra-Balfour road was constructed during the 1930/40's and was built with clay bricks and cement.

The front part of HH04 is fitted with a gable. The walls of the house were plastered with cement and it is fitted with a pitched corrugated iron roof. This residence belongs to the De la Rey family.

5.15.5.3 Other Historical Structures

Wagon Shed

This wagon shed on Rietkuil 531 IR was constructed with sandstone and fitted with a pitched corrugated iron roof.

Figure 5.15.5.3(a): A wagon shed constructed with sandstone on Rietkuil 531IR next to the Leandra-Balfour road

Cattle Enclosures

Two cattle enclosures are located on the high ridge where the proposed overland conveyor belt will be constructed. Both enclosures were constructed with dolerite stone and are rectangular in ground plan.

The two enclosures (CE01, CE02) are respectively associated with GY16 and GY17.

It is highly likely that the two enclosures were associated with farm dwellings as well as with the graveyards but that the original farm dwellings have been demolished a long time ago.

Figure 5.15.5.3(b): One of two cattle enclosures built with dolerite stone

Table 5.15.5(a): Coordinates and significance rating for historical structures in the Study Area

Historical Structures	Coordinates	Significance
Farmstead complex (FC01) This f armstead complex on K romdraai 128I S consists of the following structures: Main residence (FC01a) Wagon shed (FC01b) Rondavel (FC01c) Cattle kraal (FC01d)	 26° 27.026' 29° 00.328' 26° 27.001' 29° 00.855' 26° 27.021' 29° 00.331' 26° 27.022' 29° 00.364'	**HIGH**
Farmstead complex (FC02) This farmstead c omplex on W inkelhaak 139I S consists of the following structures: Main residence (FC01a) Wagon shed (FC02b) 'Bywonershuis' (FC02c)	 26° 25.507' 29° 04.590' 26° 25.500' 29° 04.624' 26° 25.499' 29° 04.645'	**HIGH**
Farmstead complex (FC03) This farmstead complex on W itkleifontein 181IS is associated with the Pieterse family and consists of the following structures: Main residence (FC03a) Wagon shed (FC03b) 'Bywonershuis' (Cool room) (FC03c) Elongated cattle enclosure (FC03d)	 26° 29.761' 29° 04.209' 26° 29.723' 29° 04.204' 26° 29.756' 29° 04.216' 26° 29.747' 29° 04.166'	**HIGH**
Farmstead complex (FC04) This farmstead complex on Z andfontein 190IS is occupied consists of the following structures: Main residence Wagon shed 'Bywonershuis'	26° 29.209' 29° 02.037'	**HIGH**
Farmstead complex (FC05) This f armstead c omplex on B rakspruit 35 9IH holds the following structures: Main residence (1930/40's) (FC05a))Three Wagon shed (FC05b)	26° 30.616' 29° 59.995'	**HIGH**
Farmstead complex (FC06) This farmstead complex on Springbokdraai 277IS holds the following structures: A wagon shed constructed with corrugated iron (FC06a) A dilapidated sandstone house (FC06b)	26° 32.400' 29° 01.283' 26° 32.376' 29° 01.256'	**HIGH**
Farmstead complex (FC07) This farmstead complex on Springbokdraai 277IS holds the following structures: A wagon shed constructed with sandstone A residence constructed with sandstone A diary constructed with sandstone A stand for a water tank	26° 33.971' 29° 01.538'	**HIGH**
Historical House 01 Farm house on Brakspruit 359IH	26° 28.156' 29° 00.453'	**HIGH**
Historical House 02 Farm house on Springbokdraai 277IS	26° 32.290' 29° 01.043'	**HIGH**
Historical House 03 Farm hous e on R ietkuil 531 IR ne xt t o the Leandra-Balfour road (De la Rey)	26° 31.666' 29° 00.720'	**HIGH**
Historical House 04 Second farm house on Rietkuil 531IR next to the Leandra-Balfour road (De la Rey)	26° 27.825' 29° 58.364'	**HIGH**
Wagon shed (WS) Wagon shed on Rietkuil 531IR constructed with sandstone next to the Leandra-Balfour road	26° 28.119' 29° 58.687'	**HIGH**
Cattle enclosure (CE01)	26° 31.636' 29° 02.027'	**HIGH**
Cattle enclosure (CE02)	26° 31.962' 29° 02.257'	**HIGH**

5.15.5.4 Graveyards

The following graveyards were observed in the Middelbult – Block 8 - Shondoni Mining Area:

Graveyard 01

This large informal cemetery is located at a crossing between several rural villages and squatter camps on Langverwacht 282 IS and holds hundreds of graves. It seems as if the graveyard is divided into two sections.

Graveyard 02

This graveyard is located on the southern perimeter of a rural village on Grootspruit 479 IS near Eskom's existing power lines and holds as many as forty graves. Most of the graves are fitted with cement headstones and a few with granite headstones.

Inscriptions on a few of the headstones read as follow:

- 'Jonas Ramokhampe Oompie Mooketsi O hlahle ka 24-10-1937 A hlokahahla KA 16-01-1962'
- 'Andries Mfungeni 18-4-1963 20-12-1963'
- 'Alfred Mawela Mofokeng 1905 1975-09-28'

Figure 5.15.5.4(a): GY02 is a historical graveyard located in close proximity of Eskom's existing power lines

Graveyard 03

This graveyard is located on the northern shoulder of the road on Middelbult 289IS that runs to Sasol's main gate. It contains approximately twelve graves. A few of the graves are demarcated with red clay bricks and fitted with cement head stones. No inscriptions are visible on any of the headstones of the graves.

Figure 5.15.5.4(b): GY03 is located on the northern shoulder of the road running to one of Sasol's entrance gates

Graveyard 04

This historical graveyard is located near the abandoned farmstead complex of J.C. Kruger on Witkleifontein 138IS and holds the remains of six visible graves two of which are covered with piles of stone; three are fitted cement head and tombstones and one is decorated with a granite tombstone and headstone.

Figure 5.15.5.4(c): The historical graveyard on Witkleifontein 138IS dates from the 20th century and even possibly from the 19th century

The inscription on the headstone reads as follow:

- 'Hier rus ons moeder Jaenetta Jacoba Nel Gebore Gouws 18-3-1895 Oorlede 21-12-1939'

Graveyard 05

This informal graveyard on Witkleifontein 138IS is located in the midst of a squatter camp. It holds the remains of approximately twenty individuals. Most of the graves are covered with piles of stone. A few cement headstone occur.

Figure 5.15.5.4(d): An informal graveyard on Witkleifontein 138IS which is barely visible in the midst of a squatter camp

Graveyard 06

This historical graveyard on Witkleifontein 138IS is associated with Farmstead Complex 03 and holds the remains of approximately twelve individuals, mostly from the Pieterse family.

GY06 is located in open veldt some distance from the farmstead complex. Most of the graves are covered with cement tombstones. A few granite headstones occur as well as a marble headstone. The inscriptions on these headstones read as follow:

- 'Hier rus my dierbare eggenoot ons vader en grootvader Gielaum Jacobus Pieterse Gebore 28-10-1892 Oorlede 28-?-1954 Jes 40:7 Die gras verdor die blom verwelk'
- 'Hier rus ons moeder en grootmoeder Elizabetha Magrietha Pieterse Gebore van den Berg 7-12-1895 Oorlede 17-3-1958 Uit liefde vir al u sorg en trou'

- ‘Hier rus my geliefde eggenoot Barend Paul Pieterse Gebore 19 Julie 1835 Oorlede 23 November 1916 Gesang 62 Heilig Jesus Heilig my’

Figure 5.15.5.4(e): Historical Graveyard 06 of the Pieterse family near farmstead complex (FC03) in open veldt. Some of the graves have been vandalised

Graveyard 07

This informal graveyard on Kromdraai 128 IS is located within a patch with cosmos flowers. The graveyard is overgrown but holds the remains of at least ten individuals.

Inscriptions on some of the granite headstones read as follow:

- ‘Dlamini Finose *22-09-1942 †19-04-1992 Lala Ngokuthula Siyakuthanda’
- ‘Mashiyane Jabulane Born 25-08-1943 Died 16-01-1990 lala ngo xolo’
- ‘In memory of our mother Merriam Moldieni Mashiane *01-03-1937 28-02-1948’

Figure 5.15.5.4(f): An informal graveyard with at least ten graves in a field with cosmos flowers on Kromdraai 128IS

<u>Graveyard 08</u>

This informal graveyard Kromdraai 128IS is located next to a border fence and contains approximately ten graves. Only two of the graves are fitted with cement headstones with no inscriptions.

<u>Graveyard 09</u>

This historical graveyard on Kromdraai 128 IS is currently overgrown with popular trees. It may hold as many as ten or more graves, most of which comprises of heaps of dolerite stone.

One of the graves is fitted with a cement head stone which bears the following inscription:

- 'Hier rust Sameul Pieter Marthinus Mulder BG 16 Januarie 1882 Gesneuveld 12 Mei 1901 Gs 22 Rus my siel u God is koning wees tevrede met u lot'

A second gave contains a weathered sandstone headstone with the following inscription:

- 'Jan Simon Venter Voortrekker'

Graveyard 10

This informal graveyard on Brakspruit 359IH contains as many as fifty graves. Most of the graves are covered with piles of stone. Some are fitted with cement headstones.

Graveyard 11

GY11 is a historical graveyard on Brakspruit 359IH and is located near Eskom's 400kV power line. This small demarcated graveyard is overgrown but may hold as many as six graves.

Inscriptions on some of the headstones read as follow:

- 'J.J. Oberholster 1880-1945 Hier rus Josea Jacobus Oberholster Gebore 19 Februarie 1892 Oorlede 22-?-1895 Ges 29 V3'
- 'Hier rus ons moeder Magdalena Dreyer Gebore Jun1895 Overlede 5 Julie 1933 Ges V1'

Figure 5.15.5.4(g): A historical graveyard on Brakspruit 359IH in open veldt near Eskom's power lines

Graveyard 12

This graveyard on Zandfontein 230IS is located near the Kinross road which is linked with the road running between Leandra and Balfour. It is also situated near Eskom's 400kV power line. GY12 holds approximately seven graves consisting of three heaps of stone, two with granite headstones and two with cement headstones and cement edges.

Inscriptions on two of the granite headstones read as follow:

- 'Mathebesi M ahlangu washona 1969 -05-22 Lala n goxolo s obona na kwelizayo yimi u sesi stand 3556 x10 Leskie'
- 'Miss Sara Mndawesi Born 1918 Died Nov 1962'

Graveyard 13

This graveyard is located on Springbokdraai 277IS in a soya field next to the road running to Leandra. It holds an unknown number of graves. The following can be distinguished: f our graves w ith c ement he ad s tones; t wo g raves w ith g ranite headstones and at least two stone piles.

Inscriptions on the granite headstones read as follow:

- 'Lizz Mathakwende 20-10-1977'
- 'Oubaas James Mathakwende 1948'

Graveyard 14

This is a large historical graveyard on R oodebank 329IS which is located on t he eastern shoulder of the R547.

Most of the graves are decorated and are fitted with sandstone, marble and granite headstones and other decorations.

At t he t ime of t he s urvey t he graveyard could not be a ccessed t o obt ain inscriptions on the headstones due to heavy downpours.

Figure 5.15.5.4(h): GY14 is a large historical graveyard on Roodebank 329IS on the eastern shoulder of the R547

Graveyard 15

GY15 is located in a Blue Gum plantation near the western shoulder of the road running to Kinross further to the north. It holds the remains of at least eleven individuals. All the graves are covered with piles of stone. Only one is fitted with a granite headstone with the following inscription:

- 'Maria Mahlangu 31-12-1974'

Graveyard 16

This historical graveyard is situated on the higher ridge where the proposed conveyor belt will be constructed. GY16 holds at least seven graves of which four are lined with cement strips and fitted with headstones. Inscriptions on the headstones are indecipherable. Three graves are covered with piles of stone.GY02 is demarcated with a low wall which was constructed with dolerite.

Graveyard 17

GY17 is demarcated with a solidly constructed dolerite wall and is also located on the high ridge where the proposed conveyor belt will be constructed.

This graveyard holds at least five or six graves which all have been vandalised. Only one cement headstone is still standing. It has the following inscription:

- 'Hier rus Jan Hendrik Adriaan Roets Geb 24 Mei 1859 Oorl 28 Sept 1940 Ges 182:1'

Figure 5.15.5.4(i): GY17 is one of two historical graveyards located on a ridge in close proximity of Sasol's proposed new conveyor belt

Graveyard 18

GY18 is located on the northern shoulder of the tar road running to the Middelbult West Shaft. It contains as many as thirteen graves mostly covered with piles of stone. A few of the graves are fitted with cement headstones which have the following inscriptions:

- 'Dorema Bhava wala Ngoaku Lusa lalango xolo'
- 'Musafa Macuva washona 14-2-1971'

Figure 5.15.5.4(j): GY18 holding approximately thirteen graves next to the road running to the Middelbult West Shaft

Graveyard 19

This graveyard contains approximately fifty graves which are located on both sides (west and east) of the border fence for the Springbokdraai Reserves. Several of the graves are covered with stones while another number are fitted with granite and concrete headstones and edged with the same material.

Inscriptions on a few of the headstones read as follow:

- 'Mokgathle Raborifi 12-12-62 – 39-03-63 Robala Kakootso'
- 'Robala ka k gotso N tate w a R ona J MK, bor n 17 -12-901 D ied 18 -5-1979 Segopotso sa Raborifi'
- '* 1949-11-30 † 1950-02-02 Mamojakgomo robala kakgotso phuti Robala ka khotso Masipati R Nyakale Born 20-2-1872 Died 2-12-1949'

Figure 5.15.5.4(k): GY19 on both sides of a fence holds at least fifty graves, some of which seems to have been vandalised in the more recent past

Graveyard 20

This historical graveyard is demarcated with a low wall which was constructed with dolerite stone of which the outer surface was chiselled and chipped in order to obtain a roughened surface which was darkened with some substance. The top of the wall was constructed with sandstone.

Figure 5.15.5.4(l): The wall that demarcates GY20 is constructed with dolerite stone and capped with sandstone trimmings

GY20 contains the graves of three children of the Bezuidenhout family. The headstones of the graves were manufactured from sandstone and bear the following inscriptions:

- 'Hier light begraven ons geliefd zoontje Geboren 22 November 1891 Overleden 19 April 1892 Zoon van EJ Bezuidenhout en WCJ Bezuidenhout'
- 'Hier light begraven on steer geliefd dochtertjie Jacomina Hendrina Johanna Bezuidenhout Geboren 27 Februyarie 1885 Overleden 19 Februarie 1886'
- Hier rust onze geliefde dochter Anna Magdalena Bezuidenhout Geboren 7 Augustus 1882 Overleden 22 Julie 1892'

Graveyard 21

Graveyard 21 is a historical graveyard which holds the remains of the Du Plooy and Booysen families. Six graves can be identified. They are all fitted with marble (one), sandstone (three) and cement headstones (three). These headstones bear the following inscriptions, namely:

- 'Hier rus ons geliefde eggenote en vader Frederik Carel Booysen Geb 30 Mei 1885 Oorl 28 Junie 1944 Openb 14 V13 Salig is van nouaf die dode wat in die Here sterwe MCB'
- 'Hier rus Francois N Booysen Geb 8-2-1930 Oorl 30-11-1939'
- 'Cornelle Johannes Du Plooy Geb 14 Junie 1927 Ovl 7 April 1929 Veilig in Jesus Armen Rus in Vrede'
- 'Petrus Nuclaas Johannes Du Plooy Geb 6 April 1922 Ovl 3 April 1928 Gez 181 Vers 4'
- 'Hier rus Frederik J Botha Geb 5-8-1871 Ovl 30-8-1938'

Table 5.15.5(b): Coordinates and significance rating for graveyards in the Middelbult – Block 8 – Shondoni Mining Area

Graveyards	Coordinates	Significance
GY01. Large graveyard on Langverwacht 282IS between villages	26° 33.081' 29˚ 05.181'	**HIGH**
GY02. Graveyard on Rietkuil 333IS close to Eskom's power lines on outskirts of village		**HIGH**
GY03. Graveyard on Middelbult close to one of Eskom's entrance gates	26° 33.021' 29º 06.294	**HIGH**
GY04. J.C. Kruger's abandoned farmstead complex on Witkleifontein 181IS with six graves	26° 29.095' 29˚ 03.740'	**HIGH**
GY05. Graveyard on Witkleifontein 181IS in squatter camp.	26° 28.845' 29˚ 03.902'	**HIGH**
GY06. Pieterse graveyard on Witkleifontein 181IS in open veldt near historical farmstead complex	26° 29.656' 29˚ 04.158'	**HIGH**
GY07. Graveyard on Kromdraai 128IS in patch with cosmos flowers	26° 26.288' 29˚ 02.421'	**HIGH**
GY08. Graveyard on Kromdraai 128IS next to a border fence	26° 26.940' 29˚ 00.491'	**HIGH**
GY09. Voortrekker graves on Kromdraai 128IS	26° 26.965' 29˚ 00.371	**HIGH**
GY10. Informal graveyard on Brakspruit IH	26° 28.573' 29˚ 59.750'	**HIGH**
GY11. Voortrekker graves on Brakspruit IH near Eskom's power lines	26° 29.284' 29˚ 00.225'	**HIGH**
GY12. On Zandfontein 230IS next to Kinross road and Eskom's 400kV power line.	26° 31.999' 29˚ 01.658'	**HIGH**
GY13. Next to road running between Leandra and Balfour on Springbokdraai 277IS.	26° 31.509' 29˚ 00.658'	**HIGH**
GY14. Graveyard on the eastern shoulder of the R547	26º 35.689' 28º 59.972′	**HIGH**
GY15. Approximately 11 graves in a Blue Gum plantation next to tar road.	26º 30.679' 29º 01.969'	**HIGH**
GY16.Historical graveyard on ridge. (Four corner posts, use one coordinate)	26º 31.682' 29º 02.036' 26º 31.684' 29º 02.029' 26º 31.680' 29º 02.031' 26º 31.691' 29º 02.036'	**HIGH**
GY17. Second historical graveyard on ridge. (Four corner posts, use one coordinate)	26º 31.842' 29º 02.281' 26º 31.844' 29º 02.256' 26º 31.835' 29º 02.259' 26º 31.835' 29º 02.254'	**HIGH**
GY18. Approximately 13 graves next to tar road running to the Middelbult West Shaft	26º 33.675' 29º 03.375'	**HIGH**
GY19. Approximately 50 graves located on both sides of the western border of the Springbokdraai Reserves	26º 30.650' 29º 56.515'	**HIGH**
GY20. Holds the remains of three children of the Bezuidenhout family	26º 31.548' 28º 56.282'	**HIGH**
GY21. Holds the remains of the Du Plooy and Booysen families	26º 31.701' 28º 57.450'	**HIGH**

5.15.5.5 Commemorative Beacon

A commemorative beacon for mine workers who died in a mine accident on 16 September 1986 is erected within the confines of Harmony's No 8 Shaft complex. This granite tombstone bears the following inscription:

- 'In memory of the employees who died in the disaster 16 September 1986. Erected 16 September 1995'

A Karee tree (*Rhus Lancea*) was planted next to the commemorative beacon to commemorate this event on 16 September 1994.

Figure 5.15.5.5(a): A commemorative beacon in honour of mine workers who died during a mine disaster on 16 September 1986 in the No 8 Shaft of Harmony Gold Mine

Table 5.15.5(c): Coordinates and significance rating for Commemorative Beacon and Karee Tree in the No 8 Harmony Gold Shaft in the Middelbult – Block 8 – Shondoni Mining Area

Heritage Resource	Coordinates	Significance
Commemorative beacon	26° 27.312' 29° 03.924'	**HIGH**
Karee tree	26° 27.312' 29° 03.924'	**HIGH**

5.16 SOCIO-ECONOMIC ENVIRONMENT

Baseline information was obtained through the collation of desktop information, and several site visits. The type and level of information collected was guided by the need for decision-making and issues and concerns raised by Interested and Affected Parties (I&APs) during scoping for the Middelbult Block 8 Expansion Project.

Data sources included:

- Statistics South Africa (SSA)
- The Municipal Demarcation Board (MDB)
- Various studies already conducted in the area
- 1: 10 000 ortho-photographs, and
- 1: 50 000 topographic maps.

5.16.1 Current Status

The Middelbult - Block 8 - Shondoni area is located within the Govan Mbeki Municipality in the Mpumalanga Province. The neighbouring municipalities are Lesedi, Middleburg, Emalahleni, Msakaligwa, Lekwa, Dipaleseng, and Delmas. The Govan Mbeki Municipality covers an area of 295 900 ha and has a total perimeter of ±352 km^2. The district comprises several towns and rural areas, namely: Bethal, Secunda, Kinross, eMbalenhle, Evander, Leandra, Lebohang, Highveld Ridge (Rural), Charl Cillies, and Emzinoni.

<u>Population Density and Distribution</u>

Population statistics for the Govan Mbeki Municipality were obtained from the MDB (2000), which used aggregate data from the 1996 census. To derive present-day population figures, data were extrapolated based on the 2001 population growth statistics provided by SSA. In 1996 the total population of the Govan Mbeki Municipality was estimated at ±209 659 people. Using the inferred growth rate published by SSA (2000) this population will now number ±232 712. The population growth for Africans, Coloureds, Asians and Whites is shown in Table 5.16.1 (a) for this time period.

Table 5.16.1(a): Population growth for Africans, Coloured, Asians, Whites and others in the Govan Mbeki Municipality

RACE	Growth Rate	1996	1997	1998	1999	2000	2001
African	0,024	164491	168439	172481	176621	180860	185200
Coloured	0,019	2390	2435	2482	2528	2577	2626
Indian	0,016	2402	2440	2480	2519	2560	2600
White	0,009	38488	38834	39184	39536	39892	40251
Other	0,015	1888	1916	1945	1972	2004	2034
Total	0,022	209659	214065	218571	223180	227892	232712

The average population density over the area is between 0 – 200 people. Several clusters of high density are located at eMbalenhle, Secunda, Trichardt, Emzinoni, Bethal and Lebohang. The area with highest population density is situated in eMbalenhle and is located ±3.5 km away, at it nearest point.

Population statistics for the Middelbult - Block 8 - Shondoni mining boundary were obtained through proportional division of the ward districts in a GIS, and extrapolated based on inferred growth rates published by SSA (1999). Within the Middelbult - Block 8 –Shondoni reserve boundary the total population is ±8 823, based on the inferred growth rate of Mpumalanga for males and females. The population density over 70% of the area is expressed as 24 people per km^2. The combined population density for the other 30 % is less than 70 people per kilometre. Higher population density (more than 100 people per kilometre over an area of ±29-km^2) is experienced in the eastern part of the Block 8 reserves around Evander, and toward Secunda, and Kinross.

Age Structure

The age distribution, of people living in the Govan Mbeki municipality is shown in Figure 5.16.1(a).

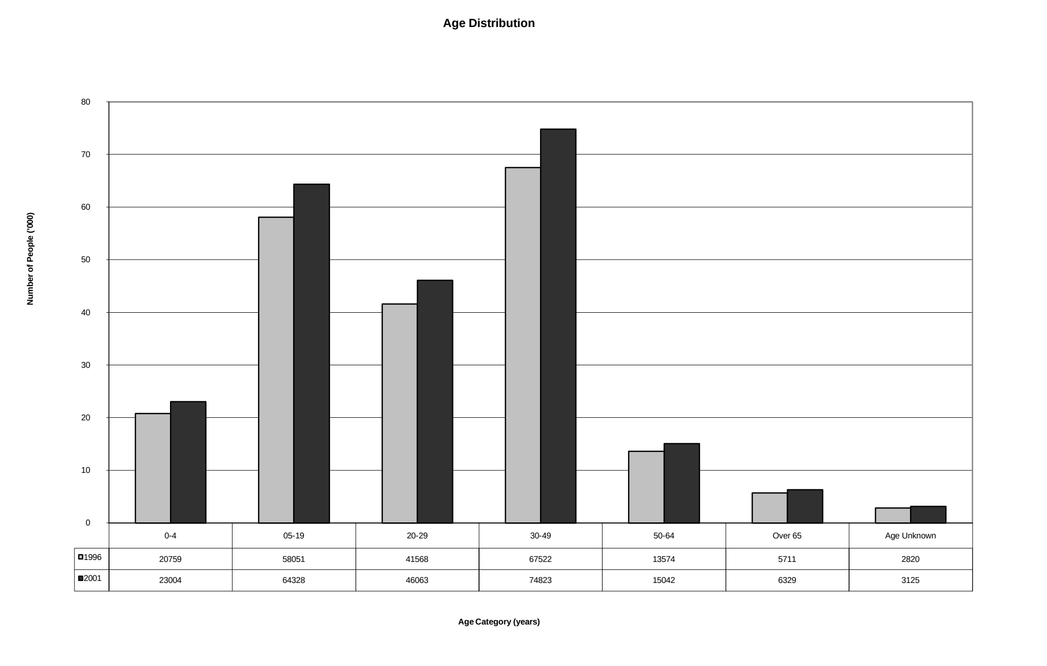

Figure 5.16.1(a): Age Distribution of People living in the Govan Mbeki Municipality

It is evident that the largest age group are those between the ages of 30 - 49 years, contributing 32,15% to the general population; followed by those aged between 6 – 19 years, which contribute 27,64% to the general population in the district.

According to Development Planning and Research (DPR), who conducted a similar study in the area in 1999, a significant trend of the age structure in the district is the low number of people aged over 65.

DPR (2000) state that this is representative of a migrant population, in which older people retire to homes and families elsewhere. According to DPR, this age structure will change in response to post apartheid trends.

The number of people aged 20 – 49 years (51,94%) indicates a large workforce. Furthermore, the number of people aged between 6 – 19 years (27,64%), who will mature into the next generation of workers within the next 1 - 20 years, represents a large potential workforce.

Gender Structure

In 1996 the total percentage of men in the Govan Mbeki Municipality was 52,9% (or 110 903 men) and percentage of women was 47,1% (or 98 718 women). According to SSA (1999) the inferred mid-year provincial growth rate for men and women in Mpumalanga was 2,6812% and 2,3906% respectively. Based on this growth rate men in the Govan Mbeki Municipality today account for 53,26% (or ±126 590 men) and women 46,74% (or ±111 096 women).

Services

Services in the Govan Mbeki Municipality are described in terms of percentage of people with access to electricity, sanitation and water supply. The source is aggregated 1996 census data per household as reflected by the MDB (2000). Population figures, where quoted, have been extrapolated to present day figures based on data provided by SSA (2000). Data for the Block 8 district was obtained through spatial analysis and proportional division of the ward districts, with the use of a GIS.

Energy

The details of energy use in the Block 8 area are given in Table 5.16.1(b). More than 50% of the households in the Govan Mbeki Municipality are connected to grid electricity through their local energy supplier. A large component, more than 40%, use candles, paraffin, gas and other sources.

According to the analysis the largest portion of the population make use of energy supplied by the local authority (81,62%), followed by candles (14,18%). By comparison to the Govan Mbeki Municipality at large, people living within the Block 8 reserve boundary have better access to electricity (more than 20%) and are less dependent on other sources of energy.

Table 5.16.1(b): Energy use within the Middel - Block 8 – Shondoni Reserve Area according to 1996 Census Data

Energy Source	Number of Households	Number of People	Percentage (%)
Electricity from local energy supplier	1 742	6 765	81,62
Electricity other source	3	13	0,11
Candles	262	1 620	14,18
Gas	1	6	0,05
Paraffin	37	228	2,45
Unspecified	48	190	1,60
Total	**2 093**	**8 823**	**100**

Sanitation

The majority of households (more than 70%) have access to flush toilets and safe sanitation, more than 18% of people are still reliant on pit and bucket latrines, and sanitation facilities in more than 9% of the households in the districts are unknown.

The details of sanitation supply within the Block 8 reserve boundary was obtained through a proportional sample of the ward districts. The details are given in Table 5.16.1(c). The largest proportion of people makes use of flush toilets (83,84%), followed by pit latrines (8,58%). These trends follow those of the Govan Mbeki Municipality, with slightly higher percentage (±10%) of people having access to flush toilets than the average for the district. The use of bucket latrines and those with none/unspecified sanitation is lower by ±10% than the average in the Govan Mbeki Municipality.

Table 5.16.1 (c): Sanitation Practices within the Middelbult - Block 8 – Shondoni Mining Area according to the 1996 Census Data

Sanitation	Number of Households	Number of People	Percentage (%)
Flush Toilet	1 781	6 953	83,84
Pit Latrine	137	845	8,58
Bucket Latrine	84	520	3,80
None	61	380	2,77
Unspecified	30	125	1,01
Total	**2 093**	**8 823**	**100**

Water Supply

The largest number of the households in the districts makes use of taps within the dwelling (51,09%), followed by on site (23,46%) and public taps (20,65%). Only 1,2% had unspecified water supply and more than 3% make use of other water sources.

Access to water supply was determined for the area within the Block 8 reserve boundary with the aid of a GIS. The details are given in Table 5.16.1(d).

It was found that the largest portion of the population within the Block 8 area obtains water from a source inside their dwellings (81,45%). In comparison to the Govan Mbeki Municipality average, this indicates that over 30% of people in the Block 8 area have a water source inside their house.

The remainder of houses in the Block 8 area obtain water from onsite water sources (6,67%) and public taps (7,09%). Combined water from tankers, boreholes, natural resources and other sources account for less than 5% of water supply, this is in line with the district average.

Table 5.16.1(d): Water Sources within the Block 8 Mining Area according to the 1996 Census Data

Water Source	Number of Households	Number of People	Percentage (%)
Water in dwelling	1 749	6 737	81,45
Water onsite	116	680	6,67
Public tap	156	969	7,09
Water from tanker	4	25	0,18
Water from borehole	53	323	3,97
Water from natural resource	9	53	0,39
Other water source	6	35	0,25
Total	**2 093**	**8 823**	**100**

Language

The most preferred first language in the Govan Mbeki Municipality is Zulu used by 35 % of the people, followed closely by Afrikaans (24%). Other primary languages used in the district are Xhosa, North and South Sotho and English. A number of other languages are also used, namely: Shangaan; Tswana; Ndebele, Swazi, Portugese and German (Development Planning and Research, 2000).

Individual and Household Income

The distribution of individual and household incomes for the Govan Mbeki Municipality is given in Table 5.16.1(e). The majority of the people in the area (43,67%) earn no income.

Those individuals earning between R6 001 and R12 000 a year (between R500,00 and R1 000,00 a month) account for 7,54% of the people in the Govan Mbeki Municipality. A large percentage of the population (21,40%) did not specify an income.

There are a total of 49 665 houses in the Govan Mbeki Municipality, with a total household income amounting to ±R1 158 039 600, this amounts to approximately R23 317 per household.

Distribution of household earnings in Table 5.16.1(e) shows that the most what their earnings were significant number household (11,84 %) have no annual earnings, followed by income in the range of R6 001 and R12 000 a month, which accounts for 10,14 %. A large proportion of houses 25,70 % did not specify.

Table 5.16.1(e): Income Distribution of Individuals and Households in the Govan Mbeki Municipality

PART 1: Category	Individual Earnings		Household Income	
	Number of People	Percentage (%)	Number of Households	Percentage (%)
None	91533	43,67	5882	11,84
R 1 – 2 400	5432	2,59	1851	3,73
R 2 401 – 6 000	13700	6,54	4957	9,98
R 6 001 – 12 000	15800	7,54	5036	10,14
R 12 001 – 18 000	12347	5,89	4619	9,30
R 18 001 – 30 000	8272	3,95	4009	8,07
R 30 001 – 42 000	4490	2,14	2207	4,44
R 42 001 – 54 000	3171	1,51	1757	3,54
R 54 001 – 72 000	3375	1,61	2038	4,10
R 72 001 – 96 000	1876	0,89	1330	2,68
R 96 001 – 132 000	1260	0,60	1439	2,90
R 132 001 – 192 000	689	0,33	937	1,89
R 192 001 – 360 000	328	0,16	562	1,13
Over R 360 000	116	0,06	137	0,28
Unspecified	44854	21,40	12765	25,70
N/A	2378	1,13	139	0,28

Employment Status

According to MDB (2000), in 1996 the number of people employed in the Govan Mbeki Municipality amounts to ±67 172 people (or 32% of the total population), the number of people under the age of 15 was 60 123 (28,63%), and the number of people unemployed in 1996 was estimated at 28 172 people (13,41%).

Not reflected in these figures is the amount of informal employment within the district. In a study conducted by DPR (2000), the number of people involved in the informal employment sector in the Highveld Ridge District was ±7 000. This estimate was however incomplete, and represented only 5% of the economically active population. DPR (2000) state that in a complete survey, the informal sector usually accounts for 12 - 15% of local employment statistics, should this be the case people involved in the informal sector in the Govan Mbeki Municipality will be between ±8 000 and 10 100 people.

The occupational distribution of individuals in the Govan Mbeki Municipality is shown in Table 5.16.1(f). According to this table more than 48% of people are under the age 15 and not considered employable. The largest occupational categories are Craft and Trade (9,58%), Elementry (15,11%) and Plant Machine (8,33%).

Table 5.16.1(f): Occupational Distribution according to 1996 Census Data

Occupation	Number of People	Percentage (%)
Unknown	577	0,46
Under 15	60123	48,29
N/A	2372	1,91
Senior Management	2731	2,19
Professional	4550	3,65
Technical	2557	2,05
Clerks	4089	3,28
Service Related	4677	3,76
Skilled	1712	1,38
Craft and Trade	11926	9,58
Plant Machine	10371	8,33
Elementary	18809	15,11
Total	**124 494**	**100**

Shown in Table 5.16.1(g) are the various sectors of the economy and the number of people employed in these sectors. Mining accounts for the highest number of employees at 9,54% (20 018 people) followed by manufacturing at 4,35% (9 130 people).

Table 5.16.1(g): Sectoral Employment Distribution according to 1996 Census Statistics

Industrial Sector	Number of People	Percentage (%)
Farming	3414	1,63
Mining	20018	9,54
Manufacturing	9130	4,35
Utilities	1048	0,50
Construction	2889	1,38
Trade	6078	2,90
Transport	2343	1,12
Business	1755	0,84
Social Services	6062	2,89
Private Household	7119	3,39
Ex Territorial	8	0,00
Diplomatic	14	0,01
National Executive Council	7471	3,56
Not Applicable	140085	66,77
Institution	2372	1,13
Total	**209 806**	**100**