Start

July 2010

KROMDRAAI PROJECT

Groundwater Risk Assessment of Gypsum Sludge Placement in the Yellow Buoy Section at Blaauwkraans

Submitted to:
Peter Gunther
Anglo Thermal Coal
P O Box 78
Klewer
1036

REPORT

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Executive Summary

At the request of Anglo Thermal Coal a groundwater risk assessment has been conducted of the placement of gypsum sludge from the Emalahleni Water Treatment Plant (WTP) on the Yellow Buoy Section of the Blaauwkraans Mine Residue Facility. The Water Use Licence for placement of the gypsum sludge at Blaauwkraans does not include gypsum placement in the Yellow Buoy Section, even though the Yellow Buoy Section was indicated as a standby placement location in the Licence Application. As of the writing of this report, Anglo Thermal Coal was placing gypsum in the Yellow Buoy Section and proposed to continue the placement until 2014.

The purpose of this assessment was to indicate whether a significant change in groundwater quality could be expected due to the placement of gypsum in the Yellow Buoy Section.

This assessment compared the chemical composition of the gypsum sludge, as determined by Golder at the time of the Licence Application in 2005, with recent chemical testing conducted by Infotox in 2010. It was found that the gypsum being deposited on the Yellow Buoy Section generally has lower elemental concentrations than the gypsum composition assumed in 2005 for the Water Use Licence Application. However, the concentration of As and five other elements is higher. Due to its potentially significant toxicity, the As may be of particular concern to groundwater quality if it is leachable from the gypsum.

Leachability was assessed from test results conducted in 2005 and 2010 on sludge samples. The liquid to solid ratios used in the leach testing differed from 2005 to 2010. The results suggest that the 2010 gypsum has lower leachable concentrations of salinity than indicated in the 2005 Licence Application. However, the trace element leachability results are not conclusive due to concentrations below laboratory detection limits and As was not included in the 2010 leachability testing.

The impact of the Yellow Buoy Section on groundwater quality depends on both the volume of seepage from the material in the section and the quality of the seepage. Provided the gypsum is dry deposited in the Yellow Buoy Section, the seepage volume is expected to be less than indicated in the 2005 Licence Application which assumed saturated conditions and higher seepage volume. The expected seepage quality from the gypsum is expected to be less saline than the seepage quality from the Yellow Buoy Section indicated in the Application. Deposition of WTP gypsum in the Yellow Buoy Section is therefore expected to result in a lower volume and improved quality of seepage which is in turn expected to have a groundwater quality impact no worse than indicated in the 2005 Water Use Licence Application.

Mass balance modelling results conducted by Keyplan (2010) were used to indicate future gypsum sludge quality as a result of WTP expansion and changes in feed water quality. Gypsum from the expansion will have significantly higher concentrations of Mg, Al and Fe compared to the 2005 and 2010 gypsum compositions. The only indication of leachable components from the expansion gypsum is provided by the modelled quality of the process water associated with the sludge. This was found to be comparable with the laboratory analyses of gypsum sludge leachate from 2005 and 2010. However, the leachability of certain trace elements remains uncertain, although expected to be low.

It is concluded that, provided saturated conditions are not developed in the Yellow Buoy Section, current gypsum deposition is not likely to worsen the groundwater quality around the Blaauwkraans facility. The indicative composition and leachate quality associated with the proposed plant expansion suggests that the quality of future seepage from the Yellow Buoy Section will generally remain unchanged.

It is recommended that the modelled estimates of sludge composition and process water quality be replaced by laboratory results on sludge samples from the WTP expansion when these become available. In particular, the leachability of trace elements, such as As, from the material placed in the Yellow Buoy Section should be assessed.

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1.0 INTRODUCTION

At the request of Anglo Thermal Coal, Golder has conducted an assessment of the geochemistry of by-product gypsum sludges from the Emalahleni Water Treatment Plant (WTP) and the groundwater impact of sludge disposal in the Yellow Buoy Section of the Blaauwkraans Mine Gypsum Facility (MRF). This report documents the results of the assessment.

1.1 Background

Gypsum sludge from the Emalahleni Water Treatment Plant is being disposed of in the Yellow Buoy Section of the Blaauwkrans MRF. A plan of the Blaauwkraans MRF is shown in Figure 1 and indicates the location of the Yellow Buoy Section and Module 1 and Module 2 for gypsum disposal.

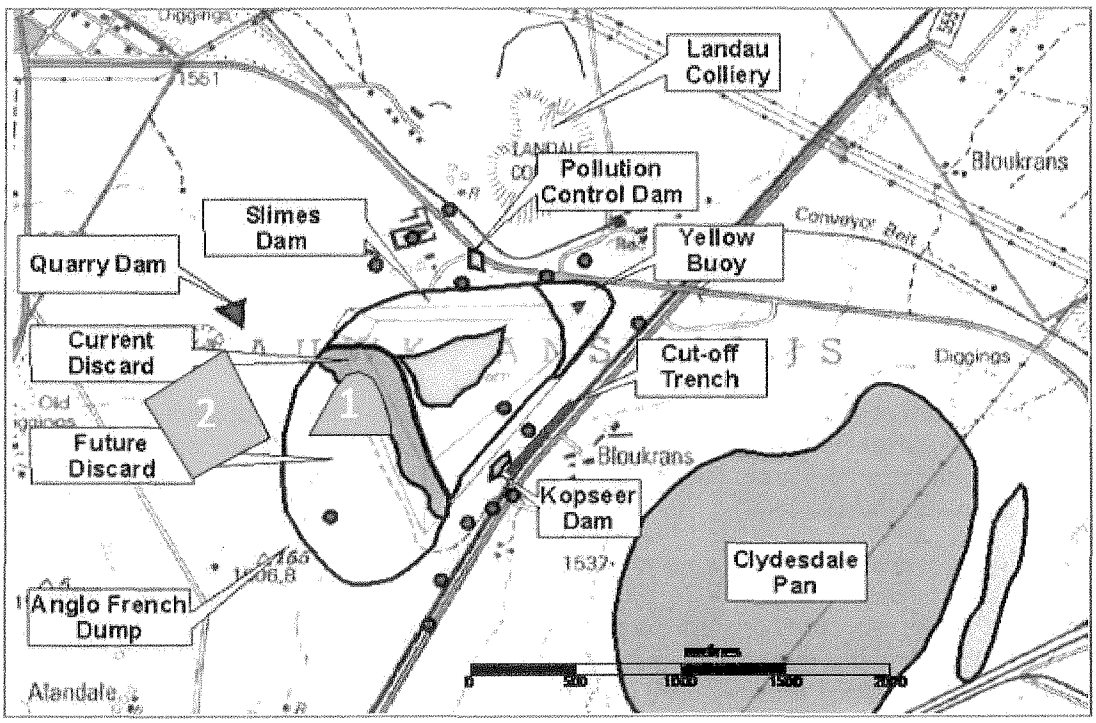

Figure 1: Layout of the Blaauwkraans MRF showing the location of the Yellow Buoy Section (in bright yellow) and the gypsum modules proposed for gypsum deposition (in green)

Supporting information for the Water Use Licence Application indicated that the Yellow Buoy Section would serve as a standby disposal site, should Module 1 and Module 2 be taken out of commission (Golder, 2005). However, gypsum sludge is now being disposed of on a permanent basis in the Yellow Buoy Section. In addition, the water use licence issued on 14 December 2007 does not mention disposal of sludge in the Yellow Buoy Section, even on a temporary basis, although this was motivated in the application.

It is understood that Anglo Thermal Coal prefers disposal of the sludge in the Yellow Buoy Section and that sufficient disposal space is available until 2014. Based on pilot plant gypsum samples, the Water Use Licence Application work indicated that the gypsum sludge would not have a detrimental impact on the receiving groundwater environment when disposed of in Modules 1 and 2 (Golder, 2005). However, such work was not conducted for the Yellow Buoy Section.

Furthermore, it is expected that the gypsum sludge composition will change when mine water from Kromdraai is processed at the WTP due to the higher iron content in the feed water. Anglo Thermal Coal therefore wants to verify that long term disposal of the gypsum sludge in the Yellow Buoy Section will not pose a significant impact on the receiving water environment.

2.0 OBJECTIVES

The objectives of this assessment are:

- To compare the composition of the sludge being deposited at the Yellow Buoy Section with the sludge composition presented in the Water Use Licence Application in 2005;
- To indicate whether a significant change in groundwater impact is expected from the sludge placement at the Blaauwkraans Yellow Buoy Section; and
- To assess the potential change in sludge composition with the introduction of Kromdraai feed water and whether placement of this sludge at the Yellow Buoy Section will change the groundwater impact.

3.0 SCOPE OF WORK

To achieve the objectives, the 2005 characterisation of seepage volume and quality from Module 1, Module 2 and the Yellow Buoy Section was reviewed. The sludge chemical characterisation made during the Phase 1 licensing was compared with the chemistry of sludge produced from the operational WTP. Based on the review, an assessment was made on the significance of the potential groundwater impact from the Yellow Buoy Section. Mass balance modelling results were reviewed and used to indicate the sludge composition from the plant modifications required to process Kromdraai water. The indicative seepage quality from the sludge was used to assess whether a significant change in groundwater impact could be expected. This work is described in detail in the following sections.

3.1 Sludge characterisation

The 2005 sludge characterisation conducted by Golder was based on samples from a pilot plant operated prior to construction of the Emalahleni WTP. Two by-products were sampled: "Metal Sludge" and "Gypsum Sludge". Based on the proposed plant process at the time, the Metal Sludge and Gypsum Sludge were to be mixed in the ratio 53:47 by mass (Golder, 2005).

More recently, chemical characterisation of gypsum sludge from the Emalahleni Plant was conducted for the purposes of a health risk assessment (Infotox, 2010). The sampling date was not indicated but, allowing 3 months prior to the report date for laboratory analysis, is assumed to be early 2010. The samples therefore include plant changes and modifications that may have been implemented since the characterisation of the pilot plant sludge in 2005. Three sludges were sampled in 2010 including:

- Primary Clarifier Sludge, which is assumed to correspond approximately with the Metal Sludge of 2005;
- R/O Filter Press Sludge, which is assumed to correspond approximately with the Gypsum Sludge of 2005; and
- Final R/O Gypsum, which is assumed to be the mixed Primary Clarifier Sludge and R/O Filter Press Sludge that is placed on the Yellow Buoy Section.

Both the Golder (2005) and Infotox (2010) sludge analyses included whole element determination and deionised water leach tests.

A whole element composition of the 53:47 mixture of Gypsum Sludge and Metal Sludge has been developed from the 2005 33-element analysis results. This is the assumed composition of the gypsum to be deposited on the Blaauwkraans Facility in the 2005 Water Use Licence Application. This assumed gypsum composition is compared to the Final R/O Gypsum composition, based on the 2009 sampling of the operating WTP in Table 1. Note that the elements Silicon and Sulphur were not analysed by Infotox (2010).

The composition of the gypsum, as determined from the 2005 results, is dominated by Ca, Mg and S which make up approximately 270 grammes out of every kilogramme of sludge. Other major components of the metal sludge include Fe, Mn and Al which make up a further 10 grammes. Much of the remaining mass of the sludge is water, which is not included in the elemental analysis.

Table 1: Comparison of the elemental compositions of gypsum sludge (in mg/kg) based on 2005 analyses of pilot plant sludges and 2010 analyses of WTP sludges

Determinant	53:47 mix of Gypsum Sludge and Metal Sludge (Golder, 2005)	Final R/O Gypsum (Infotox, 2010)	Percentage difference*
Aluminium (Al)	1 487	34	-98
Antimony (Sb)	0.03	<0.4	
Arsenic (As)	0.05	804	1 607 900
Barium (Ba)	6.5	<0.4	
Beryllium (Be)	0.81	<0.4	
Bismuth (Bi)	0.03	<0.4	
Boron (B)	0.01	<0.4	
Cadmium (Cd)	0.01	<0.4	
Calcium (Ca)	171 075	212 040	24
Chromium (Cr)	3.3	0.48	-85
Cobalt (Co)	33	1.12	-97
Copper (Cu)	3.9	0.76	-81
Iron (Fe)	7 033	167	-98
Lead (Pb)	0.03	<0.4	
Lithium (Li)	0.01	0.48	4 700
Magnesium (Mg)	32 626	5 200	-84
Manganese (Mn)	2 247	152	-93
Mercury (Hg)	0.02	<0.4	
Molybdenum (Mo)	0.01	<0.4	
Nickel (Ni)	37	1.92	-95
Phosphorous (P)	475	39	-92
Potassium (K)	154	48	-69
Selenium (Se)	0.05	<0.4	
Silicon (Si)	858		
Silver (Ag)	0.01	17	169 900
Sodium (Na)	518	160	-69
Strontium (Sr)	215	520	142
Sulphur (S)	64 786		
Tin (Sn)	0.03	<0.4	
Titanium (Ti)	9.2	256	2 680
Vanadium (V)	0.36	<0.4	
Zinc (Zn)	85	<0.4	
Zirconium (Zr)	7.8	0.64	-92

Note: ** No percentage difference is presented where the concentration is below the laboratory reporting limit*

Concentrations lower than the 2005 composition are indicated by negative percentages and green shading in Table 1. The Final R/O Gypsum Sludge generally has lower concentrations of all elements except As, Ca, Li, Ag, Sr and Ti. The As concentration in particular is significantly higher in the Final R/O Gypsum. Table 1 also indicates that the concentrations of Sb, Bi, B, Cd, Hg, Mo, Se and Sn are higher in the Final R/O Gypsum than in the 2005 gypsum. However, these elements were below the laboratory reporting limit and could conceivably be similar to, or less than, the 2005 gypsum concentrations. For the purposes of this comparison, they will be considered similar to the 2005 gypsum concentrations.

Based on the available compositions, the Final R/O Gypsum being deposited on the Yellow Buoy Section generally has lower elemental concentrations than the gypsum composition assumed in 2005 for the Water Use Licence Application. However, the concentration of As and five other elements is higher in the Final R/O Gypsum. Due to its potentially significant toxicity the As may be of particular concern to groundwater quality if it is leachable from the gypsum.

The leachability of elements from the 2005 and 2010 sludge samples is indicated by the results of leach testing (Table 2). Note that the Golder (2005) leach tests were conducted at a liquid to solid ratio of 1:4 while the Infotox (2010) tests were conducted at a liquid to solid ratio of 20 to 1. It is expected that the solubility of gypsum will control the concentration of Ca and SO_4 in the sludge leachates. However, metal oxyhydroxides are expected to influence the concentrations of trace elements such as Fe, Mn and As. Arsenic (As) was not included in the leach analysis of the 2010 samples and was below the laboratory detection limit in the leachates from the 2005 samples.

Table 2: Results of leach testing of sludges using deionised water

Determinant in mg/l (except pH)	Gypsum Sludge	Metal Sludge	Primary Clarifier Sludge	R/O Filter Press Sludge	Final R/O Gypsum	Yellow Buoy Pool
Source	Golder (2005)		Infotox (2010)			Golder (2005)
Total Alkalinity (as $CaCO_3$)	62	19	40	40	40	12
Total Dissolved Solids	3 350	2 974	–	–	–	4 402
pH	8.3	7.4	8.5	10.2	9.8	6.3
SO_4	1 980	1 809	1 320	1 406	1 333	2 770
Na	76	66	13	37	3	152
Ca	535	518	566	594	629	565
Mg	212	167	20	18	18	259
Fe	0.057	0.046	0.092	<0.025	<0.025	0.3
Mn	<0.025	0.041	0.037	0.051	<0.025	20

Except for Ca, the concentrations of major cations and anions in the Final R/O Gypsum leachate are lower than in the leachates from the Gypsum Sludge and Metal Sludge determined in 2005. This is also true for Fe and Mn.

Table 2 also indicates the composition of pool water in the Yellow Buoy Section measured in 2005. The sludge leachate concentrations from 2005 and 2010 are generally lower than the Yellow Buoy pool water, although Ca concentrations are similar.

An indication of the trace element leachability is presented in Table 3 which compares leachability under acidic conditions for Metal Sludge and Gypsum Sludge in 2005 to the leachability under alkaline conditions for the Final R/O Residue in 2010. The Yellow Buoy Pool water trace element concentrations are also included in Table 3.

Table 3: Comparison of trace element leachability

Determinant in mg/l	Metal sludge	Gypsum sludge	Final R/O Residue	Yellow Buoy Pool
Source	Golder (2005)		Infotox (2010)	Golder (2005)
Al	<0.01	<0.01	0.036	0.011
B	<0.01	<0.01	0.032	0.111
Ba	0.095	0.07	<0.025	-
K	1.1	1.2	<1	16.8
Li	<0.01	<0.01	<0.025	0.105
Mo	<0.01	<0.01	<0.025	0.001
Sr	0.03	0.75	2.25	2.4
V	<0.01	<0.01	0.038	0.001

The results in Table 3 suggest that trace element leachability is variable between the 2005 and 2010 samples. In general, trace elements appear to leach from the sludges in concentrations lower than measured in the Yellow Buoy Pool water in 2005.

Based on leachate testing, the salinity and metal content of leachate from the gypsum being placed on the Yellow Buoy Section are lower than the leachate concentrations indicated in the 2005 Water Use Licence Application. The sludge leachates are also less saline than the Yellow Buoy pool water measured in 2005. However, leachable concentrations of many trace elements, such as As, remains unknown.

3.2 Groundwater impact of the Yellow Buoy Section

The impact of the Yellow Buoy Section on groundwater quality depends on both the volume of seepage from the material in the section and the quality of the seepage.

For the Water Use Licence Application seepage volume for the Yellow Buoy Section was estimated by assuming that the pool of supernatant water would drive seepage and that the volume could be estimated from the Darcy equation (Golder, 2005). The pool area, based on field observations, was estimated to vary between 5 % and 20 % of the total area of the Yellow Buoy Section. The depth of the pool was estimated at 1 m and the saturated permeability of the material was estimated at 10^{-7} m/s. Post-closure seepage under unsaturated conditions was estimated as 1 % to 4 % of Mean Annual Precipitation (MAP) over the entire area of the Yellow Buoy Section. The result was an average seepage of 8 890 m^3/yr during operation reducing to 2 484 m^3/yr after closure. These seepage volume estimates did not consider deposition of gypsum sludge from the WTP in the Yellow Buoy Section.

In the supporting information for the Application, gypsum from the WTP was considered to be dry deposited in the proposed Module 1 and Module 2. Seepage would therefore occur under unsaturated flow conditions. The recharge and seepage volume through the gypsum was estimated at 6 % to 10 % of MAP during operation, reducing to 1 % to 4 % of MAP during post-closure (Golder, 2005). The estimated operational seepage volume from Module 1 was indicated to be 3 853 m^3/yr reducing to 1 107 m^3/yr after closure (Golder, 2005).

Assuming that the gypsum is dry deposited on the Yellow Buoy Section instead of Module 1 would yield an average seepage volume of 1 223 m^3/yr reducing to 382 m^3/yr after closure. The difference is due to the smaller area of the Yellow Buoy Section. Provided the pool of excess water and associated saturated material present in 2005 does not persist under the present dry deposition of gypsum, placement of gypsum in the Yellow Buoy Section is not expected to increase the volume of seepage to groundwater.

Seepage quality from the Yellow Buoy Section was assessed from the pool water quality (Golder, 2005). As indicated in Table 2, this is more saline than leachate from the gypsum, has a lower pH and higher concentrations of Na, Mg, Mn and SO_4.

The seepage volume associated with deposition of WTP gypsum sludge in the Yellow Buoy Section is considered to be lower than indicated in the Water Use Licence Application. This is due to the dry deposition of the gypsum and its low reported infiltration characteristics (Golder, 2005). The expected seepage quality from the gypsum is expected to be less saline than the seepage quality from the Yellow Buoy Section indicated in the Application. Deposition of WTP gypsum in the Yellow Buoy Section is therefore expected to result in a lower volume and improved quality of seepage which is in turn expected to have a groundwater quality impact no worse than indicated in the 2005 Water Use Licence Application.

3.3 Future sludge quality

Expansion of the Emalahleni Plant is under development. The expansion will allow Kromdraai mine water to be processed at the WTP which is expected to result in further changes to the composition of the gypsum sludge placed in the Yellow Buoy Section. Mass balance modelling of the expanded plant treatment process has been conducted by Keyplan (2010). An estimate of the sludge composition has been made from the modelling results and is presented, with the 2005 and 2010 sludge composition analyses in Table 4.

It should be noted that the mass balance modelling results are indicative and based on simplifying assumptions of the treatment process. The estimated sludge composition associated with the expansion should also be considered indicative.

Table 4: Estimated sludge composition associated with the Phase 2 and Phase 3 expansion of the Emalahleni WTP, based on mass balance modelling by Keyplan (2010)

Determinant	WTP Expansion Sludge	53:47 mix of Gypsum Sludge and Metal Sludge (Golder, 2005)	Final R/O Gypsum (Infotox, 2010)
Aluminium (Al)	6 091	1 487	34
Calcium (Ca)	79 655	171 075	212 040
Iron (Fe)	23 685	7 033	167
Magnesium (Mg)	99 567	32 626	5 200
Manganese (Mn)	1 880	2 247	152
Potassium (K)	69	154	48
Silicon (Si)	89	858	
Sodium (Na)	306	518	160
Sulphur (S)	61 836	64 786	

Based on Table 4 the sludge from the expansion will have significantly higher concentrations of Mg, Al and Fe compared to the 2005 and 2010 gypsum compositions. Sodium and Mn concentrations will be higher than the 2010 composition but lower than the 2005 composition.

As of the writing of this report, the only indication of leachable components from the expansion sludge is provided by the modelled quality of the process water associated with the sludge. This is presented and compared to the leach test results from the 2005 and 2010 sludge samples in Table 5.

Table 5: Comparison of modelled process water quality associated with the Expansion Sludge and leach test results from 2005 and 2010 sludge samples

Determinant in mg/l (except pH)	Gypsum Sludge	Metal Sludge	Primary Clarifier sludge	R/O Filter press sludge	Final R/O gypsum	Modelled process water
Source	Golder (2005)		Infotox (2010)			Keyplan (2010)
Liquid:solid	4:1	4:1	20:1	20:1	20:1	±1:1
Total Alkalinity (as $CaCO_3$)	62	19	40	40	40	87
Total Dissolved Solids	3 350	2 974	_	_	_	6 972
pH	8.3	7.4	8.5	10.2	9.8	10.5
SO_4	1 980	1 809	1 320	1 406	1 333	4 573
Na	76	66	13	37	3	966
Ca	535	518	566	594	629	476
Mg	212	167	20	18	18	368
Fe	0.057	0.046	0.092	<0.025	<0.025	0.1
Mn	<0.025	0.041	0.037	0.051	<0.025	0.1

As for the sludge composition, the modelled process water quality should be considered indicative since it is based on assumptions associated with the mass balance simulation of the water treatment process. The extent to which mineral precipitation and dilution reactions may influence the leachate quality from the Expansion Sludge can only be assessed from laboratory analysis of the sludge when it becomes available. The modelled process water quality presented should therefore be considered a conservative indication of the potential leachate quality from the Expansion Sludge.

Table 5 indicates that the modelled process water quality is more saline than the sludge leachates. However, the process water quality is for a liquid to solid ratio of approximately 1 to 1. Assuming that Ca and SO_4 concentrations are controlled by gypsum solubility, the concentrations of the other determinants in Table 5 are comparable if the respective dilutions are considered. The comparison of Fe, Mn and other trace element concentrations is limited by the concentrations falling below laboratory reporting limits. In general, the sludge leachate concentrations and modelled Fe and Mn process water concentrations are low and suggest that trace element concentrations in Yellow Buoy Section seepage are not likely to be a concern to groundwater quality. This is a preliminary assessment based on the mass balance modelling results and should be confirmed through laboratory testing and geochemical assessment when samples of the Expansion Sludge are available.

4.0 CONCLUSIONS

Module 1 for disposal of gypsum sludge from the Emalahleni WTP is located within the discard section of the Blaauwkraans facility. Results presented by Golder (2005) indicate that the seepage quality from the discard is significantly more saline and acidic than either gypsum sludge seepage or Yellow Buoy Section seepage. The impact of the gypsum on the soluble load from the discard was therefore found to be negligible (2 %). In relation to the impact from discard seepage, the additional low load from the gypsum was considered to have a low additional impact on groundwater quality (Golder, 2005).

Leachates from the 2005 and 2010 sludge testing are less saline than the Yellow Buoy Pool water reported by Golder (2005) and suggests that seepage quality from the sludge placed in the Yellow Buoy Section will be no worse than indicated in the Water Use Licence Application. The anticipated seepage volume from the dry deposited sludge is lower than the saturated conditions considered in the Water Use Licence Application. Therefore the soluble load from the sludge placed in the Yellow Buoy Section is likely to be lower than indicated in the Application. Provided saturated conditions are not developed in the Yellow Buoy Section,

current gypsum deposition is not considered likely to worsen the groundwater quality around the Blaauwkraans facility.

Indicative composition and leachate quality associated with the proposed plant expansion suggests that the quality of future seepage from the Yellow Buoy Section will generally remain unchanged.

5.0 RECOMMENDATIONS

It is recommended that the modelled estimates of sludge composition and process water quality be replaced by laboratory results on sludge samples from the WTP expansion when these become available. In particular, the leachability of trace elements, such as As, from the material placed in the Yellow Buoy Section should be assessed.

6.0 REFERENCES

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Terry Harck
Senior Geochemist-Hydrogeologist

Nico Bezuidenhout
Associate Geochemist

TH/NB/aj

Reg. No. 2002/007104/07

Directors: FR Sutherland, AM van Niekerk, SAP Brown, L Greyling, SM Manyaka

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Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Africa (Pty) Ltd.
Thandanani Park
Matuka Close
Midrand
South Africa
T: [+27] (11) 254 4800

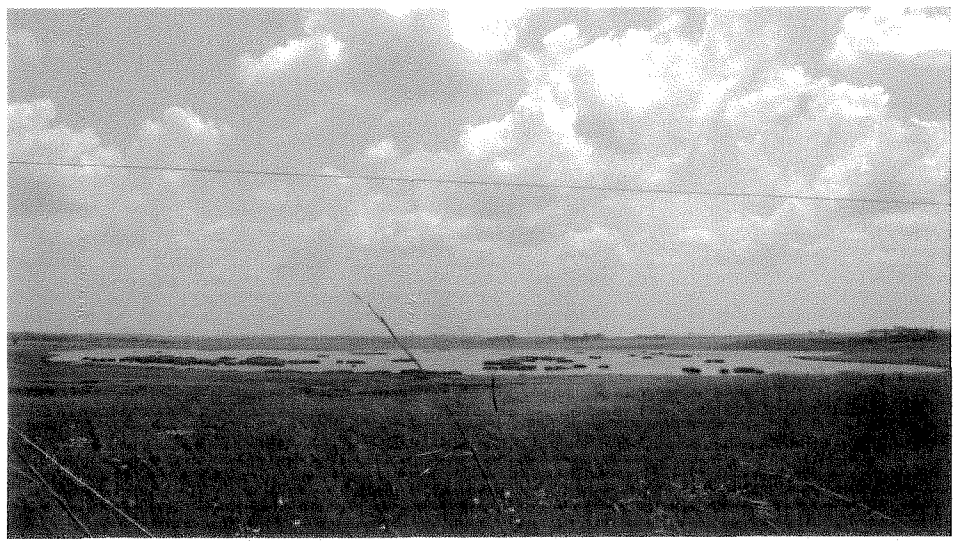
Golder Associates

APPENDIX I

Specialist Report: Terrestrial Ecology

October 2010

eMalahleni Mine Water Reclamation Project Terrestrial Ecology Report



Golder Report Number: 12485-9798-10

REPORT

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Executive Summary

Golder Associates Africa (Pty) Ltd Ecology Division was approached by Anglo American Thermal Coal (Anglo) to conduct an ecological survey on the terrestrial aspects of the proposed project. The project includes the expansion of the capacity on the existing Mine Water Reclamation Scheme in eMalahleni, Mpumalanga Province. It will involve expanding the capacity of the existing Water Reclamation Plant (WRP) at Greenside Colliery to treat approximately 50 Mℓ of mine water per day.

The study area is situated in the Grassland biome. The Grassland biome is characterised as land that is dominated by grass species rather than trees or large shrubs. A large percentage of exotic species were found and most areas were highly impacted already by mining activities or anthropogenic impacts. However, sensitive areas such as wetlands were also identified as well as protected species within the secondary grasslands or riparian zones. Based on physiognomy, moisture regime, rockiness, slope and soil properties, ten vegetation communities were recognised. Although these communities were recorded as such, there is some variation within these communities, due to external influences such as overgrazing, overutilisation and other anthropogenic impacts.

The sensitivity of an area was based on the vegetation communities. From here a low, moderate or high sensitivity was allocated to specific communities. High sensitivity areas include wetland or ridges on the pipeline route. Protected species that were found on site include *Brunsvigia radulosa* and *Gladiolus ecklonii.* The *Brunsvigia radulosa* was found in the grassland adjacent or within the riparian zone. This includes the third wetland region that Kromdraai collection pipeline runs through (approx. 25.8252S and 29.1398E) and the wetland site just before the Water Treatment Plant on the Middelburg route (approx.25.9347S and 29.1943E). The *Gladiolus ecklonii* can be found in numbers at route A11 in the rehabilitated mining area of the Kromdraai collection pipeline (approx 25.7600S and 29.0847E).

No Red Data fauna were encountered during the survey. Mammals found include hare, warthog, yellow mongoose and black backed jackal. The proposed project could include a rehabilitation process to improve the general veld conditions and create habitat for fauna.

The impact significance of the proposed project on terrestrial ecology ranges between high and moderate significance, depending on whether certain pipeline sections include sensitive areas. The significance can be reduced after mitigation is applied. Due to the fact that the pipeline will be buried, the impacts on burrowing mammals are high. If the small mammals have young, they will not move during construction and will be harmed.

It is recommended that the following ecological audits be undertaken during the Construction Phase:

- Vegetation audits need to be conducted prior to commencement of construction activities. These audits need to be conducted in the construction demarcated areas located in areas of a high and moderate sensitivity (including secondary grasslands) (see Figure 3). These areas may contain protected species, such as *Brunsvigia radulosa* and *Gladiolus ecklonii*; and
- Daily audits need to be conducted ahead of construction to identify if any fauna need to be relocated, especially burrowing mammals.

Furthermore, it is recommended that the pipeline be inserted before the rainy season to prevent potential flooding and decanting.

In all instances, contamination of the environment should be prevented by implementing management and maintenance measures, including monthly inspections of the proposed pipelines.

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APPENDICES

1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd Ecology Division was appointed by Anglo American Thermal Coal (Anglo) to conduct an ecological survey of the terrestrial aspects of the proposed project. The project includes the expansion of the capacity on the existing Mine Water Reclamation Scheme in eMalahleni, Mpumalanga Province. It will involve expanding the capacity of the existing Water Treatment Plant (WTP) at Greenside Colliery to treat approximately 50 Mℓ of mine water per day.

It is important to note that the initial assessment was conducted on the preliminary preferred pipeline routes. Additional studies were undertaken for three route refinements; the results of which are documented in this report.

The terrestrial impact assessment aimed to present baseline descriptions of floristic elements and fauna, occurring within the study area, and to highlight sensitive biological and environmental attributes that may potentially be impacted by the proposed project. Mitigation to reduce the identified impacts will also be suggested. This report should be read in collaboration with the wetland and aquatic ecology reports, and other relevant specialist reports.

2.0 OBJECTIVES

The objectives of the study, to achieve the above stated aim, are:

- Provide a description of the floristic elements of the study area and surrounding areas;
- Identify and describe the biodiversity patterns at community and ecosystem level (plant and animal communities in the vicinity and threatened/vulnerable species and ecosystems),species level (Red Data Book species, presence of alien species) and significant landscape features;
- Provide general comment on whether biodiversity processes would be affected (including comment on how these would be affected); and
- Identify potential impacts and recommend measures to prevent or mitigate these potential impacts.

3.0 LIMITATIONS

This assessment was based on information collected during a single site visit conducted during January 2010 and a survey for the route refinements in April 2010. No detailed soil, geological or geotechnical information was available at the time of the survey. In order to obtain a comprehensive understanding of the dynamics of communities and the status of endemic, rare or threatened species in any area, vegetation and faunal assessments should consider investigations at different time scales (across seasons/years) and through repetition. In such a scenario, the precautionary principle should be applied and all natural portions of grassland should be regarded as sensitive.

Furthermore, due to the vast expanse of the study area in relation to the time allotted for the completion of this study, most conclusions have been based on single sampling efforts for the both the original pipeline and route refinements. Limitations of this method of sampling include the following:

- Temporal changes in biodiversity are not taken into account during single sampling efforts;
- Variations in biodiversity due to temporal animal movements, such as migrations, are not taken into account; and
- Unusual environmental conditions (such as unusually high or unusually low rainfall) may cause unusual states of biodiversity during the period of study, which may not usually exist.

4.0 APPROACH

4.1 Red Data Floral Assessment

Baseline PRECIS data for the 2529CC and 2529CA grid squares were compared to the literature detailing Protected and Red Data plant species lists (Appendix A) in order to compile a list of Red Data plant species, that may potentially occur within the study area. Due to the sampling limitations, emphasis was placed on the identification of suitable habitats for Red Data plant species, by associating available habitat to known habitat requirements.

4.2 Floristic Sensitivity Analysis

Floristic sensitivity analysis was quantified by subjectively assessing two factors, namely ecological function and conservation importance. These were defined as follows:

Ecological Function:

- High ecological function: Sensitive ecosystems with either low inherent resistance or resilience towards disturbance factors or highly dynamic systems considered to be stable and important for the maintenance of ecosystems integrity (e.g. pristine grasslands, pristine wetlands and pristine ridges);
- Medium ecological function: Relatively important ecosystems at gradients of intermediate disturbances. An area may be considered of medium ecological function if it is directly adjacent to sensitive/pristine ecosystem; and
- Low ecological function: Degraded and highly disturbed systems with little or no ecological function.

Conservation Importance:

- High conservation importance: Ecosystems with high species richness which usually provide suitable habitat for a number of threatened species. Usually termed 'no-go' areas and unsuitable for development, and should be conserved;
- Medium conservation importance: Ecosystems with intermediate levels of species diversity without any threatened species. Low-density development may be accommodated, provided the current species diversity is conserved; and
- Low conservation importance: Areas with little or no conservation potential and usually species poor (most species are usually exotic).

All methods used were based on standard scientific investigative techniques, although these methodologies were modified in order to cover the vast expanse of the study area within the time allotted for the completion of this study. The precautionary principle is a moral and political principle which states that if an action or policy might cause severe or irreversible harm to the public or to the environment, in the absence of a scientific consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action (Raffensperger & Tickner, 1999). The principle implies that there is a responsibility to intervene and protect the public from exposure to harm where scientific investigation discovers a plausible risk in the course of having screened for other suspected causes. The protections that mitigate suspected risks can be relaxed only if further scientific findings emerge that more robustly support an alternative explanation. In some legal systems, as in the law of the European Union, the precautionary principle is also a general and compulsory principle of law (COMEST, 2005).

4.3 General Faunal Attributes

Recognised scientific methodologies were not used during the survey due to time limitations; however the following methods were used for the different fauna species.

4.3.1 Arthropoda

No active arthropod sampling was conducted. Arthropods that were encountered during the vegetation surveys were recorded. Identification of species was done to the lowest possible taxonomic level using Picker *et al* (2002).

4.3.2 Reptilia

No active reptile sampling was conducted. Only reptiles encountered during the vegetation survey were recorded. Snakes and other reptiles are identified visually and only captured if visual identification was hampered by swift-moving species or if they were obscured from view. Branch (1996) was used as an identification guide where necessary.

4.3.3 Amphibia

No active amphibian sampling was conducted. Only amphibians that were encountered during the vegetation surveys were recorded. Carruthers (2001) was used to confirm identification where necessary.

4.3.4 Avifauna

Birds observed during the vegetation surveys were recorded. Where possible, visual identification was used to confirm calls. Bird species were confirmed using Sinclair *et al*, 1998

4.3.5 Mammalia

Visual sightings and ecological indications were used to identify the small mammal inhabitants of the study area. Scats found were also collected and used for identification of nocturnal small mammals. Stuart and Stuart (1993) and Smithers (1992) were used for identification purposes.

4.4 Red Data Faunal Assessment

The following parameters were used to assess the Probability of Occurrence of each Red Data species:

- Habitat requirements (HR) – Most Red Data animals have very specific habitat requirements and the presence of these habitat characteristics in the study area was evaluated;
- Habitat status (HS) – The status or ecological condition of available habitat in the area is assessed. Often a high level of habitat degradation prevalent in a specific habitat will negate the potential presence of Red Data species (this is especially evident in wetland habitats); and
- Habitat linkage (HL) – Movement between areas for breeding and feeding forms an essential part of the existence of many species. Connectivity of the study area to surrounding habitat and the adequacy of these linkages are evaluated for the ecological functioning of Red Data species habitat within the study area.

Probability of occurrence is presented in four categories, namely:

- Low;
- Medium;

- High; or
- Recorded.

5.0 APPLICABLE LEGISLATIVE REQUIREMENTS

- The Constitution Act No. 108 of 1996 – Section 24;
- National Environmental Management Act No. 107 of 1998 and applicable regulations;
- Environmental Conservation Act No. 73 of 1989;
- National Environmental Management: Biodiversity Act No. 10 of 2004;
- Development Facilitation Act No. 67 of 1995;
- National Water Act No. 36 of 1998; and
- Mineral and Petroleum Resources Development Act No. 28 of 2002.

6.0 STUDY AREA

6.1 Locality of the study area

The study area is situated in Emalahleni, Mpumalanga (Figure 1). It stretches between and is inclusive of the Kromdraai Section of Landau Colliery and Middelburg Steam and Station Colliery regions.

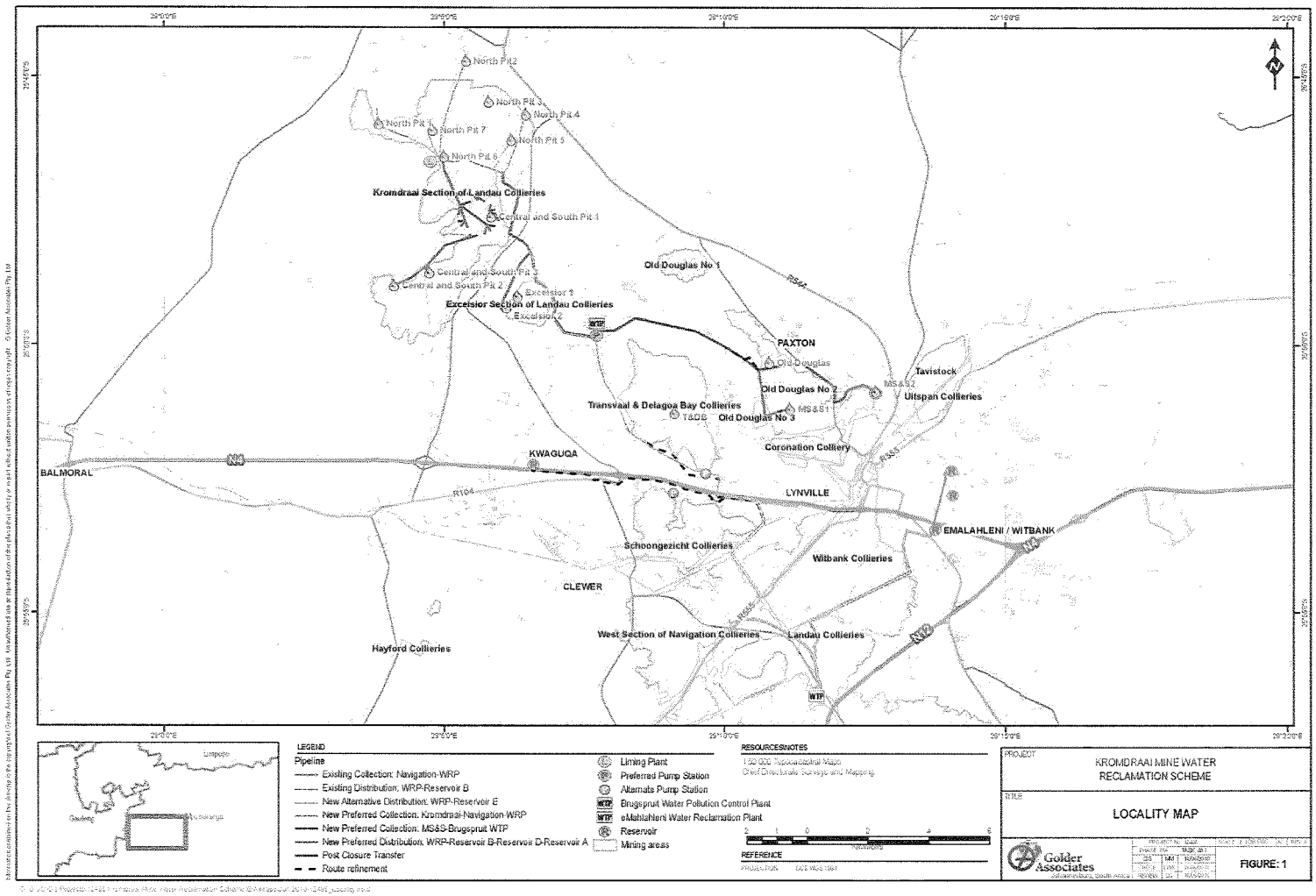

Figure 1: Locality of the propose project in Witbank, Mpumalanga.

6.2 The Biophysical Environment

The study area is situated in the Grassland biome. The Grassland biome is characterised as land that is dominated by grass species rather than trees or large shrubs. It receives less rain than the Savanna biome and the amount of precipitation determines the grass height; wetter regions have higher grasses. The amount of rainfall varies between 508 mm to 889 mm per annum and temperature ranges from 38°C in the summer to as low as -4°C in the winter (Webber, 2002).

Baseline PRECIS data for 2529CC and 2529CA grid squares were collected to determine the expected species list for this region according to SANBI (Appendix B). The vegetation type in which proposed site falls is Rocky Highveld Grassland (Mucina and Rutherford, 2006).

6.2.1 Rand Highveld Grassland

Rand Highveld Grassland is found in the highly variable landscape with extensive sloping plains and ridges in the Gauteng, North-West, Free State and Mpumalanga Provinces. The vegetation type is found in areas between rocky ridges from Pretoria to Witbank, extending onto ridges in the Stoffberg and Roossenekal regions as well as in the vicinity of Derby and Potchefstroom, extending southwards and north-eastwards from there. The vegetation is species rich, sour grassland alternating with low shrubland on rocky outcrops. The most common grasses on the plains belong to the genera *Themeda, Eragrostis, Heteropogon and Elionurus*. High numbers of herbs, especially *Asteraceae* are also found. In rocky areas shrubs and trees also prevail and are mostly *Protea caffra, Acacia caffra, Celtis africana and Searsia spp.*

This vegetation type is poorly conserved (approx 1 %) and has a target of 24 % of the vegetation type to be conserved. Due to the low conservation status this vegetation type is classified as endangered. Almost half of the vegetation type has been transformed by cultivation, plantations, urbanisation or dam-building.

Scattered aliens (most prominently *Acacia mearnsii*) are present in the unit (Mucina and Rutherford, 2006).

6.2.2 Eastern Highveld Grassland

The Eastern Highveld Grassland is found in the Mpumalanga and Gauteng Provinces on the plains between Belfast in the east and the eastern side of Johannesburg in the west and extending southwards to Bethal, Ermelo and west of Piet Retief. The landscape is dominated by undulating plains and low hills with short dense grassland dominating belong to the genera *Themeda, Aristida, Digitaria, Eragrostis, Tristachya etc.* Once again woody species are prevalent on the rocky outcrops. In terms of conservation and disturbance, 44 % of the vegetation type is already transformed by cultivation, plantations, mines, and urbanisation. No serious alien invasion, but *Acacia mearnsii* can dominate in certain areas (Mucina and Rutherford, 2006).

7.0 RESULTS

7.1 Fauna

7.1.1 Mammals

Mammals were identified through visual identification of the species, prints or faeces. Species identified during the survey can be seen in Table 1. Red Data mammals were also taken into account, but no Red Data species were encountered. The Red Data mammal known to occur in this area is *Felis (Leptailurus) serval* (Serval). The probability of occurrence for this species on the proposed project area is seen as moderate due to the high level of disturbance in certain areas and possible historical persecution of these cats due to them being seen as "problem animals"; however natural areas do occur in close vicinity that can present itself as habitat for the species.

Table 1: Mammals species identified during the survey

Species Name	Common Name
Canis mesomelas	Black-backed jackal
Phacochoerus aethiopicus	Warthog
Cynictis penicillata	Yellow mongoose
Lepus sp.	Hare

7.1.2 Avifauna

During the survey all birds species encountered or bird calls identified were listed (Table 2). Red Data species were also taken into account for this region, but no Red Data species were recorded during the surveys.

One of the Endangered species, the Whitewinged Flufftail (*Sarothrura ayresii*) is poorly known, secretive birds living in wetland habitat. Its populations have suffered decline due to habitat destruction and degradation. It is, however, believed to be unlikely to be found within the study area, due to the wetlands within the study area not presenting suitable habitat to any of these species (Barnes, 2000). The Wattled Crane (*Grus carunculatus*), which may occur in the study area is classified as Vulnerable both in terms of IUCN Red Listing and TOPS regulations. This is due to this bird's small population of an estimated 230 animals, vastly reduced range and the lowest reproductive potential of all crane species. Failure to address loss of wetland habitat on privately owned land will result in further decline and probably regional extinction (Barnes, 2000). The Vulnerable Blue Crane (*Anthropoides paradisea*) and Southern Crowned Crane (*Balearica regulorum*) have been recorded in this region previously and therefore have a high probability of occurrence on the site.

Table 2: Bird species identified during the field survey

Species Name	Common Name
Vanellus coronatus	Crowned plover
Lanius collaris	Common Fiscal Shrike
Riparia paludicola	Brown throated martin
Streptopelia capicola	Cape turtle dove
Acridotheres tristis	Indian myna
Euplectes orix	Red bishop
Serinus mozambicus	Yellow-eyed canary
Ploceus velatus	Masked weaver
Bostrychia hagedash	Hadeda
Bubulcus ibis	Cattle Egret
Passer melanurus	Cape Sparrow

7.1.3 Herpetofauna

During the field survey no Herpetofauna species were encountered. However trails of *Serpentes* species were found, but species level identification was not possible. It is suggested based on previous encounters and findings that snake species might include *Bitis arietans* (Puff adder); *Lamprophis capensis* (Brown house snake). Red Data species for the grid square of the proposed project area were taken into account; species included *Chamaesaura aenea* (Transvaal grass lizard). The probability of occurrence for this species is seen

as moderate due to the fact that the habitat type includes grasslands. The pipeline route crosses grassland vegetation communities, but the grasslands are disturbed.

7.1.4 Arthropoda

Arthropods identified during the site survey can be seen in Table 4. Unfortunately at this time no Red Data butterflies list exist for Mpumalanga and therefore the probability of occurrence for Red Data species could not be determined.

Table 3: Arthropods found during the site survey.

Common Name	Species Name
Meadow Katydid	*Conocephalus caudalis*
Two-spotted ground beetle	*Thermophilum homoplatum*
House fly	*Musca domestica*
Banded blowfly	*Chrysomya albiceps*
Cucurbit ladybird	*Henosepilachna bifasciata*
Yellow lucerne butterfly	*Colias electo*
Spider hunting wasp	*Tachypompilus ignitus*
Spider hunting wasp	*Hemipepis tamisieri*
Milkweed bug	*Oncopeltus famelicus*
Milkweed bug	*Spilostethus pandurus*

7.2 Flora

The vegetation species found during the site survey were identified and can be seen in Appendix C. A large percentage of exotic species were found and most areas were highly impacted already by mining activities or anthropogenic impacts. However, sensitive areas such as wetlands were also identified as well as protected species within the secondary grasslands or riparian zones. Based on physiognomy, moisture regime, rockiness, slope and soil properties, ten vegetation communities were recognised. Although these communities were recorded as such, there is some variation within these communities, due to external influences such as overgrazing, overutilization and other anthropogenic impacts. These communities (Figure 2) are described as:

- Rehabilitated mining area
- Mining area
- *Acacia mearnsii* woodland
- Secondary grassland
- Woodland
- Wetland region
- Disturbed area
- Eucalyptus woodland
- Farmland

Rehabilitated mining area: Previously mined areas that are part of a rehabilitation project. Rehabilitation species predominantly consist of grass species including *Pennisetum clandestinum* and *Eragrostis sp.*

Mining area: Areas that have been impacted by mining activities. These regions are of a low ecological integrity and very little to no species are found here due to the level of disturbance.

***Acacia mearnsii* woodland:** Areas that are dominated by trees, a woodland region that consists of a single species, *Acacia mearnsii.*

Secondary grassland: This study area has been disturbed by previous cultivation attempts, grazing or other developments. The primary vegetation is now lost and replaced by secondary growth. Species representing this community include grass species and invasive species: *Eragrostis curvula; Cenchrus ciliaris; Hyparrhenia hirta; Eragrostis rigidior; *Melinis repens; *Bidens pilosa; *Conyza albida; *Conyza bonariensis; *Schkuhhria pinnata; *Tagetes minuta; *Leonotis leonurus; *Argemone ochroleuca; *Asclepias fruticosa; *Datura stramonium; *Solanum sisymbrifolium* etc.

Woodland: Consists of exotic and indigenous trees. Natural vegetation that has been infiltrated by exotic species. However, indigenous species dominate this area. Species include: *Searsia lancea* and *Erythrina lysistemon.*

Wetland region: Sensitive area due to unique ecology of it. Area contains wetland indicator species and includes: *Bulbostylis capillaries; Cladium mariscus; Cyperus compressus; *Cyperus eragrostis; *Cyperus esculentus; Cyperus laevigatus; Phragmites australis; Typha capensis* etc.

Disturbed area: Highly disturbed area due to previous grazing or cultivation attempts followed by high level of anthropogenic impacts from surrounding informal settlements. Polluted areas dominated by exotic species: **Bidens pilosa; *Bidens bipinnata; *Bidens formosa; *Conyza albida; *Conyza bonariensis; *Gomphrena celosioides *Schkuhhria pinnata; *Tagetes minuta; *Leonotis leonurus; *Argemone mexicana *Argemone ochroleuca; *Asclepias fruticosa; *Datura stramonium; *Ricinus communis; *Solanum sisymbrifolium; *Solanum mauritianum; Phytolacca octandra etc.* Also a road reserve area that consists of cut grass, horticultural flowers or disturbed areas dominated by exotics.

Eucalyptus woodland: Areas that are dominated by trees, a woodland region that consists of a single genus, *Eucalyptus sp.*

Farmland: Cultivated areas of farm owners. No natural vegetation occur here. Cultivation species include *Zea mays* (Mielies).

Exotic species indicated by *

7.2.1 Red Data species

Red Data vegetation retrieved from SANBI for grid squares 2529CC and 2529CA were also taken into account (Table 6), but no identifiable Red Data species were found. However protected species were found on site including *Brunsvigia radulosa* and *Gladiolus ecklonii.* The *Brunsvigia radulosa* was found in the grassland adjacent or within the riparian zone. This includes the third wetland region that Kromdraai collection pipeline runs through (approx. 25.8252S and 29.1398E) and the wetland site just before the Water Treatment Plant on the Middelburg route (approx.25.9347S and 29.1943E). The Gladiolus ecklonii can be found in numbers at route A11 in the rehabilitated mining area of the Kromdraai collection pipeline (approx 25.7600S and 29.0847E).

Table 4: Red Data species for grid squares 2529CC and 2529CA that were taken into account.

Family	Species	Status
AQUIFOLIACEAE	*Ilex mitis*	Declining
ASTERACEAE	*Callilepis leptophylla*	Declining
FABACEAE	*Argyrolobium megarrhizum*	NT
MESEMBRYANTHEMACEAE	*Frithia humilis*	EN

Family	Species	Status
ZAMIACEAE	*Encephalartos lanatus*	VU

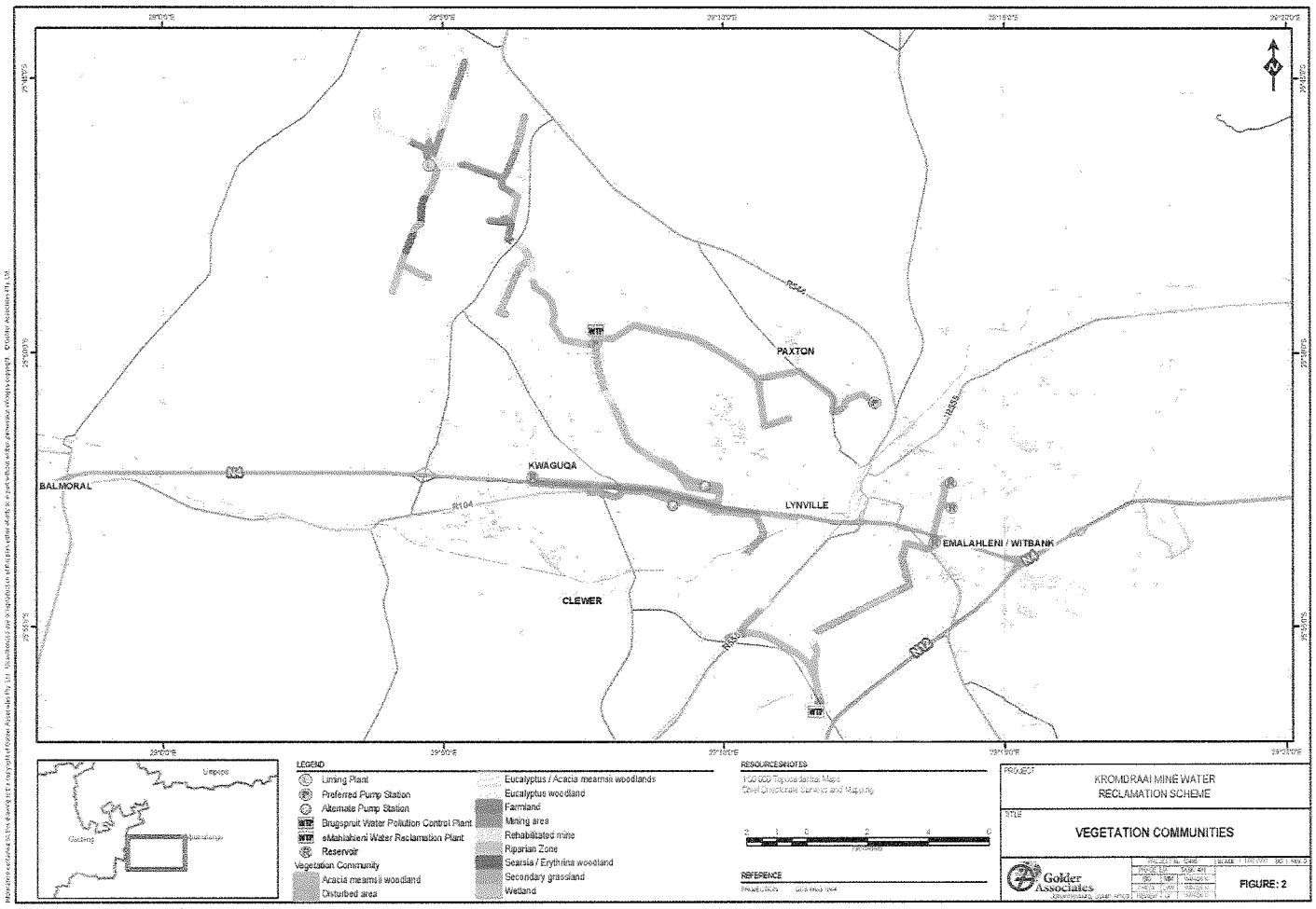

Figure 2: The identified vegetation communities for the project area.

7.3 Sensitive Habitat Assessment

Sensitive areas where defined by three statuses (Figure 3):

- Low sensitivity;
- Moderate sensitivity; and
- High sensitivity.

Low sensitivity areas on the project pipeline are of a low ecological integrity. The areas have been severely impacted by anthropogenic sources and are dominated by exotic species. The conservation importance and ecological function of this area are identified as low. Regions such as urban/rural development and industrial complexes fall into this category.

Moderate sensitivity includes areas such as secondary grassland. The ecological integrity is not as degraded. Habitat capabilities are high and the conservation importance moderate due to the possible presence of key stone, protected or endangered species.

High sensitivity areas include wetlands and ridges. The ecological functioning as well as the conservation importance of these sites are high. For this reasons sections of the pipeline that are identified as high sensitivity areas should be avoided as far as possible.

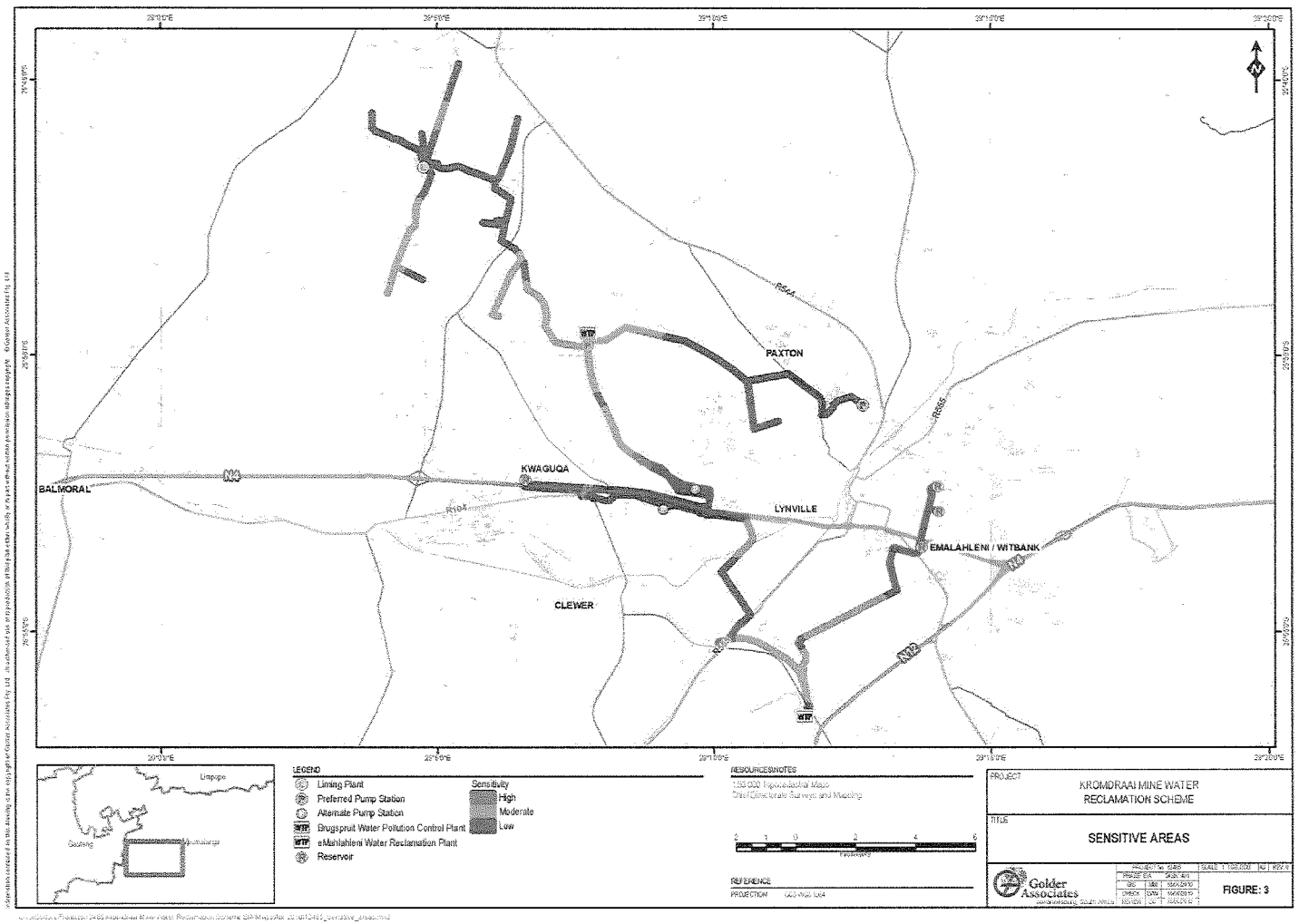

Figure 3: The sensitivity ratings based on the vegetation communities of the project area.

8.0 IMPACT ASSESSMENT

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Design-related impacts													
Loss or alteration to plant communities	10	5	1	4	64	H	Includes protected species that need to be avoided if possible or relocated. Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	8	3	1	3	36	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline. Avoid sensitive areas such as wetlands where possible.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Avoid sensitive areas such as wetlands where possible. Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	6	4	1	3	33	M

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Loss of Faunal species	8	5	1	3	42	M	Re-establish vegetation as to to ensure faunal habitat where possible, also small burrowing mammals will not move during construction specifically if they have young. Therefore an ecological audit is suggested during construction to assist in avoiding or relocating mammals.	6	5	1	3	36	M
Reduction in biodiversity on-site	8	4	1	5	65	H	Includes protected species that needs to remain protected and avoided by the development or relocated close to the original location. Re-establish indigenous species	6	4	1	4	44	M
Construction-related impacts													
Loss or alteration to plant communities	10	5	1	4	64	H	Includes protected species that need to be avoided if possible or relocated. Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	8	3	1	3	36	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment. Avoid sensitive areas such as wetlands where possible.	6	4	1	3	33	M

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Avoid sensitive areas such as wetlands where possible. Avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Re-establish vegetation as to ensure faunal habitat where possible. Small burrowing mammals will not move during construction specifically if they have young. Therefore an ecological audit is suggested during construction to assist in avoiding or relocating mammals.	6	5	1	3	36	M
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution.	8	3	2	3	39	M
Reduction in biodiversity on-site	8	4	1	5	65	H	Includes protected species that needs to remain protected and avoided by the development or relocated close to the original location. Re-establish indigenous species	6	4	1	4	44	M
Removal of current alien species	10	4	1	5	75	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	10	4	1	5	75	H
Operational-related impacts													
Loss or alteration to plant communities	10	5	1	4	64	H	Remove alien species and re-establish indigenous species, communities contain protected species therefore maintain and manage pipeline to ensure no contamination leaches into the	8	3	1	3	36	M

	Before mitigation							After mitigation						
Description of impact	Magnitude	Duration	Scale	Probability	Score	Significance rating	Mitigation measures	Magnitude	Duration	Scale	Probability	Score	Significance rating
							environment						
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and maintain indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Maintain vegetation as to ensure faunal habitat where possible. Prevent contamination into the environment through managing measures.	6	5	1	3	36	M
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M
Reduction in biodiversity on-site	8	4	1	5	65	H	Re-establish indigenous species, communities contain protected species therefore maintain and manage pipeline to ensure no contamination leaches into the environment	6	4	1	4	44	M

	Before mitigation							After mitigation					
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Removal of current alien species	10	4	1	5	75	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	10	4	1	5	75	H
Planned closure-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species, re-establish indigenous species and maintain protected species. Prevent contamination into the environment through management measures.	6	3	1	3	30	M
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities. Prevent contamination into the environment through management measures.	6	4	1	3	33	M
Unplanned closure-related impacts													
Contamination through pollution, leachate, runoff, flooding discharge	10	4	1	5	75	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M

9.0 ROUTE REFINEMENTS

9.1 Baseline information

This section includes the vegetation communities that exist on the suggested route refinements. From this the significance of the impacts on the communities can be established.

9.1.1 Route refinement 1

Route refinement consisted of two vegetation communities, wetland region and disturbed area.

Wetland region: Is a sensitive area due to the unique ecology of it. This area contains wetland indicator species and includes: *Bulbostylis capillaries; Cladium mariscus; Cyperus compressus; *Cyperus eragrostis; *Cyperus esculentus; Cyperus laevigatus; Phragmites australis; Typha capensis* etc.

Disturbed area: This is a highly disturbed area due to previous grazing or cultivation attempts followed by a high level of anthropogenic impacts from surrounding informal settlements. The polluted areas are dominated by exotic species: **Bidens pilosa; *Bidens bipinnata; *Bidens formosa; *Conyza albida; *Conyza bonariensis; *Gomphrena celosioides *Schkuhhria pinnata; *Tagetes minuta; *Leonotis leonurus; *Argemone mexicana *Argemone ochroleuca; *Asclepias fruticosa; *Datura stramonium; *Ricinus communis; *Solanum sisymbrifolium; *Solanum mauritianum; Phytolacca octandra etc.*

9.1.2 Route refinement 2

The second route refinement consists of a single vegetation community, disturbed area.

Disturbed area: The area consists of cut grass, horticultural flowers or disturbed areas. However, this region is dominated by a disturbed area that includes the dominance of exotic species and the presence of anthropogenic impacts.

9.1.3 Route refinement 3

The third route refinement has the same vegetation communities as the first. It includes a wetland region and disturbed areas.

Wetland region: A sensitive area due to the unique ecology. Area contains wetland indicator species and includes: *Bulbostylis capillaries; Cladium mariscus; Cyperus compressus; *Cyperus eragrostis; *Cyperus esculentus; Cyperus laevigatus; Phragmites australis; Typha capensis* etc.

Disturbed area: A highly disturbed area due to previous grazing or cultivation attempts followed by a high level of anthropogenic impacts from surrounding informal settlements. The polluted areas are dominated by exotic species: **Bidens pilosa; *Bidens bipinnata; *Bidens formosa; *Conyza albida; *Conyza bonariensis; *Gomphrena celosioides *Schkuhhria pinnata; *Tagetes minuta; *Leonotis leonurus; *Argemone mexicana *Argemone ochroleuca; *Asclepias fruticosa; *Datura stramonium; *Ricinus communis; *Solanum sisymbrifolium; *Solanum mauritianum; Phytolacca octandra etc.* Also a road reserve area that consists of cut grass, horticultural flowers or disturbed areas dominated by exotics.

9.2 Route refinements Impact Assessment

The impacts that every route refinement will have on the environment were calculated independently. From this comparisons can be made on the significance of the impacts and the preferred route. Generally the aspects of the route refinements that are significant are refinements with wetland regions on it. This is due to the fact that wetland regions are sensitive areas with a unique ecological system and a high habitat capability for fauna species. Route refinements without wetland regions on it have less significant impacts.

9.2.1 Route refinement 1

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Design-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	6	3	1	3	30	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline. Avoid sensitive areas such as wetlands where possible.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Avoid sensitive areas such as wetlands where possible. Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Re-establish vegetation as to ensure faunal habitat where possible, also small burrowing mammals will not move during construction specifically if they have young. Therefore an ecological audit is suggested during construction to assist in avoiding or relocating mammals.	6	5	1	3	36	M
Reduction in biodiversity on-site	6	4	1	5	55	M	Re-establish indigenous species	4	4	1	4	36	M

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Construction-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	6	3	1	3	30	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline. Avoid sensitive areas such as wetlands where possible.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Avoid sensitive areas such as wetlands where possible. Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Re-establish vegetation as to to ensure faunal habitat where possible, also small burrowing mammals will not move during construction specifically if they have young. Therefore an ecological audit is suggested during construction to assist in avoiding or relocating mammals.	6	5	1	3	36	M
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Reduction in biodiversity on-site	6	4	1	5	55	M	Re-establish indigenous species	4	4	1	4	36	M
Removal of current alien species	10	4	1	5	75	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	10	4	1	5	75	H
Operational-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species, maintain and manage pipeline to ensure no contamination leaches into the environment	6	3	1	3	30	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and maintain indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Maintain vegetation as to ensure faunal habitat where possible. Prevent contamination into the environment through managing measures.	6	5	1	3	36	M
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Reduction in biodiversity on-site	6	4	1	5	55	M	Re-establish indigenous species, maintain and manage pipeline to ensure no contamination leaches into the environment	4	4	1	4	36	M
Removal of current alien species	10	4	1	5	75	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	10	4	1	5	75	H
Planned closure-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species, maintain area. Prevent contamination into the environment through management measures.	6	3	1	3	30	M
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities. Prevent contamination into the environment through management measures.	6	4	1	3	33	M
Unplanned closure-related impacts													
Contamination through pollution, leachate, runoff, flooding discharge	10	4	1	5	75	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M

9.2.2 Route refinement 2

	Before mitigation							After mitigation					
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Design-related impacts													
Loss or alteration to plant communities	6	4	1	4	44	M	Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	4	3	1	3	24	L
Increased run-off and change in drainage patterns	4	2	2	3	24	L	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	6	4	2	4	48	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline.	4	4	1	3	27	L
Destruction of Faunal and Floral habitat	6	4	1	4	44	M	Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	4	4	1	3	27	L
Loss of Faunal species	6	3	1	3	30	M	Re-establish vegetation as to ensure faunal habitat where possible.	4	3	1	3	24	L
Reduction in biodiversity on-site	4	4	1	5	45	M	Re-establish indigenous species	2	4	1	4	28	L

	Before mitigation							After mitigation					
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Construction-related impacts													
Loss or alteration to plant communities	6	4	1	4	44	M	Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	4	3	1	3	24	L
Increased run-off and change in drainage patterns	4	2	2	3	24	L	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	6	4	2	4	48	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline.	4	4	1	3	27	L
Destruction of Faunal and Floral habitat	6	4	1	4	44	M	Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	4	4	1	3	27	L
Loss of Faunal species	6	5	1	3	36	M	Re-establish vegetation as to ensure faunal habitat where possible.	4	5	1	3	30	M
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M
Reduction in biodiversity on-site	4	4	1	5	45	M	Re-establish indigenous species	2	4	1	4	28	L
Removal of current alien species	10	4	1	5	75	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	10	4	1	5	75	H

	Before mitigation							After mitigation					
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Operational-related impacts													
Loss or alteration to plant communities	6	4	1	4	44	M	Remove alien species and re-establish indigenous species, maintain and manage pipeline to ensure no contamination leaches into the environment	4	3	1	3	24	L
Increased run-off and change in drainage patterns	4	2	2	3	24	L	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	6	4	2	4	48	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline.	4	4	1	3	27	L
Destruction of Faunal and Floral habitat	6	4	1	4	44	M	Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and maintain indigenous species where possible.	4	4	1	3	27	L
Loss of Faunal species	6	5	1	3	36	M	Maintain vegetation as to ensure faunal habitat where possible. Prevent contamination into the environment through managing measures.	4	5	1	3	30	M
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M
Reduction in biodiversity on-site	4	4	1	5	45	M	Re-establish indigenous species, maintain and manage pipeline to ensure no contamination leaches into the environment	2	4	1	4	28	L

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Removal of current alien species	10	4	1	5	75	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	10	4	1	5	75	H
Planned closure-related impacts													
Loss or alteration to plant communities	6	4	1	4	44	M	Remove alien species and re-establish indigenous species, maintain area. Prevent contamination into the environment through management measures.	4	3	1	3	24	L
Loss and changes in ecosystem functions	6	4	2	4	48	M	Re-establishment of indigenous plant communities. Prevent contamination into the environment through management measures.	4	4	1	3	27	L
Unplanned closure-related impacts													
Contamination through pollution, leachate, runoff, flooding discharge	10	4	1	5	75	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M

9.2.3 Route refinement 3

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Design-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	6	3	1	3	30	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline. Avoid sensitive areas such as wetlands where possible.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Avoid sensitive areas such as wetlands where possible. Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Re-establish vegetation as to ensure faunal habitat where possible, also small burrowing mammals will not move during construction specifically if they have young. Therefore an ecological audit is suggested during construction to assist in avoiding or relocating mammals.	6	5	1	3	36	M

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Reduction in biodiversity on-site	6	4	1	5	55	M	Re-establish indigenous species	4	4	1	4	36	M
Construction-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	6	3	1	3	30	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline. Avoid sensitive areas such as wetlands where possible.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Avoid sensitive areas such as wetlands where possible. Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Re-establish vegetation as to to ensure faunal habitat where possible, also small burrowing mammals will not move during construction specifically if they have young. Therefore an ecological audit is suggested during construction to assist in avoiding or relocating mammals.	6	5	1	3	36	M

	Before mitigation							After mitigation					
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M
Reduction in biodiversity on-site	6	4	1	5	55	M	Re-establish indigenous species	4	4	1	4	36	M
Removal of current alien species	10	4	1	5	75	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	10	4	1	5	75	H
Operational-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species, maintain and manage pipeline to ensure no contamination leaches into the environment	6	3	1	3	30	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and maintain indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Maintain vegetation as to ensure faunal habitat where possible. Prevent contamination into the environment through managing measures.	6	5	1	3	36	M
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Reduction in biodiversity on-site	6	4	1	5	55	M	Re-establish indigenous species, maintain and manage pipeline to ensure no contamination leaches into the environment	4	4	1	4	36	M
Removal of current alien species	10	4	1	5	75	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	10	4	1	5	75	H
Planned closure-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species, maintain area. Prevent contamination into the environment through management measures.	6	3	1	3	30	M
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities. Prevent contamination into the environment through management measures.	6	4	1	3	33	M
Unplanned closure-related impacts													
Contamination through pollution, leachate, runoff, flooding discharge	10	4	1	5	75	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M

10.0 ADDITIONAL DISTRIBUTION PIPELINE SECTION

10.1 Baseline information

Vegetation communities identified during the site survey for this project area included:

Secondary grassland: This study area has been disturbed by previous cultivation attempts, grazing or other developments. The primary vegetation is now lost and replaced by secondary growth. Species representing this community include grass species and invasive species: *Eragrostis curvula; Cenchrus ciliaris; Hyparrhenia hirta; Aristida congesta; Eragrostis rigidior; *Melinis repens; *Bidens pilosa; *Conyza albida; *Conyza bonariensis; *Schkuhhria pinnata; *Tagetes minuta; *Verbena bonariensis; *Asclepias fruticosa; *Seriphium plumosum; *Solanum sisymbrifolium* etc.

Disturbed area: This is a highly disturbed area due to previous grazing or cultivation attempts followed by a high level of anthropogenic impacts from surrounding informal settlements. The polluted areas are dominated by exotic species: **Bidens pilosa; *Bidens bipinnata; *Bidens formosa; *Conyza albida; *Conyza bonariensis; *Schkuhhria pinnata; *Tagetes minuta; *Leonotis leonurus; *Argemone mexicana *Argemone ochroleuca; *Asclepias fruticosa; *Datura stramonium; *Ricinus communis; *Solanum sisymbrifolium; *Solanum mauritianum; Phytolacca octandra; Cynodon dactylon etc.* Also a road reserve area that consists of cut grass, horticultural flowers or disturbed areas dominated by exotics.

Eucalyptus woodland: This includes areas that are dominated by trees, a woodland region that consists of a single genus, *Eucalyptus sp.*

Farmland: Includes cultivated areas of farm owners. No natural vegetation occur here. Cultivation species include *Zea mays* (Mielies).

Wetland region: This is a sensitive area due to unique ecology of it. The area contains wetland indicator species and includes: Imperata cylindrical; Cyperus longus; Eragrostis gummiflua; *Bulbostylis capillaries; Cladium mariscus; *Cyperus eragrostis; Phragmites australis; Typha capensis* etc

10.2 Impact Assessment

The distribution pipeline mostly occurs along existing roads, this reduces the impacts and the costs associated with the relocation of species, as it won't be necessary. However at one section the pipeline crosses a wetland, which will have a more significant impact specifically if leachate should escape from the pipeline into the environment. It is preferred that the pipeline remains to the south of the wetland where it has already been impacted to higher extent.

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Design-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	6	3	1	3	30	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Avoid sensitive areas such as wetlands where possible. Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Re-establish vegetation as to ensure faunal habitat where possible, also small burrowing mammals will not move during construction specifically if they have young. Therefore an ecological audit is suggested during construction to assist in avoiding or relocating mammals.	6	5	1	3	36	M
Reduction in biodiversity on-site	8	4	1	5	65	H	Re-establish indigenous species	6	4	1	4	44	M

	Before mitigation							After mitigation					
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Construction-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species during and after construction, maintain and manage pipeline to ensure no contamination leaches into the environment	6	3	1	3	30	M
Increased run-off and change in drainage patterns	4	4	2	3	30	M	Re-establishment of indigenous plant communities	2	2	2	3	18	L
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline. Avoid sensitive areas such as wetlands where possible.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Avoid sensitive areas such as wetlands where possible. Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and re-establish indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Re-establish vegetation as to ensure faunal habitat where possible, also small burrowing mammals will not move during construction specifically if they have young. Therefore an ecological audit is suggested during construction to assist in avoiding or relocating mammals.	6	5	1	3	36	M
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M

	Before mitigation							After mitigation					
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Reduction in biodiversity on-site	8	4	1	5	65	H	Re-establish indigenous species	6	4	1	4	44	M
Removal of current alien species	10	4	1	5	75	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	10	4	1	5	75	H
Operational-related impacts													
Loss or alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species, maintain and manage pipeline to ensure no contamination leaches into the environment	6	3	1	3	30	M
Loss and changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities and prevent contamination into the environment by managing and maintaining the pipeline.	6	4	1	3	33	M
Destruction of Faunal and Floral habitat	8	4	1	4	52	M	Manage and maintain pipeline to avoid contamination of the environment. Remove exotic species and maintain indigenous species where possible.	6	4	1	3	33	M
Loss of Faunal species	8	5	1	3	42	M	Maintain vegetation as to ensure faunal habitat where possible. Prevent contamination into the environment through managing measures.	6	5	1	3	36	M
Contamination through pollution, leachate, runoff, flooding discharge	10	4	2	4	64	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M
Reduction in biodiversity on-site	6	4	1	5	55	M	Re-establish indigenous species	4	4	1	4	36	M
Removal of current alien species	8	4	1	5	65	H	Positive impact that will remove all alien and invasive vegetation, no mitigation measures needed.	8	4	1	5	65	H

	Before mitigation							After mitigation						
Description of impact	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**	**Mitigation measures**	**Magnitude**	**Duration**	**Scale**	**Probability**	**Score**	**Significance rating**
Planned closure-related impacts													
Alteration to plant communities	8	4	1	4	52	M	Remove alien species and re-establish indigenous species, maintain and manage area. Prevent contamination into the environment through management measures.	6	3	1	3	30	M
Changes in ecosystem functions	8	4	2	4	56	M	Re-establishment of indigenous plant communities. Prevent contamination into the environment through management measures.	6	4	1	3	33	M
Unplanned closure-related impacts													
Contamination through pollution, leachate, runoff, flooding discharge	10	4	1	5	75	H	Take management measures and risk assessments to avoid accidental spillage, leachate or pollution	8	3	2	3	39	M

11.0 MITIGATION MEASURES

The proposed pipeline route predominantly runs through areas that have already been impacted by mining activities or anthropogenic influences, therefore large quantities of exotic species were found. The proposed project could include a rehabilitation process to improve the general veld conditions. The following will need to be implemented:

- All exotic and invasive species should be removed in the general area of the development.
- Thereafter, indigenous and currently occurring species should be planted and maintained. Species include grasses such as *Eragrostis* species.
- The maintenance and management of the pipeline to prevent leakage and contamination of the environment.

By restoring the biophysical environment, the habitat may be improved, which can, in turn, be adequate for ecological restoration if sources are sufficient for colonization of species. An ecosystem has characteristics that need to materialise in order for it to regain integrity.

- It needs to undergo natural development, where bare soil slowly releases nutrients through weathering; nutrients are in turn released to plants, which colonize the area.
- The initial vegetation releases more nutrients which allow the colonization of more species.
- The exotic species will have to be reduced, removed and managed (Cairns, 1995).
- Treatment of soil may be required to restore fertility and ensure healthy plant growth. The soil should allow all the natural nutrient cycles and therefore it will need "plant food" to provide the carbons, nitrogen and other important plant elements for growth. This should also be associated with the type of soil, organic material will assist in improving the drainage of the soil (Harris, 2000). However care must be taken to prevent the spread of pollutants and dangerous components.

Sensitive areas were identified according to the vegetation communities. Areas that are of a high sensitivity should be avoided and secondary grasslands with a moderate sensitivity might still contain protected species and for this reason cannot be regarded as an area with a low conservation value. Protected species *Brunsvigia radulosa* and *Gladiolus ecklonii* were found on the proposed pipeline route. It is suggested that areas with protected species are avoided; however, if avoidance is not possible relocation of the species will have to take place.

Due to the fact that the pipeline will be buried, the impacts on burrowing mammals are high. If the small mammals have young, they will not move during construction and will be harmed.

It is recommended that the following ecological audits be undertaken during the Construction Phase:

- Vegetation audits need to be conducted prior to commencement of construction activities. These audits need to be conducted in the construction demarcated areas located in areas of a high and moderate sensitivity (including secondary grasslands) (see Figure 3). These areas may contain protected species, such as *Brunsvigia radulosa* and *Gladiolus ecklonii*; and
- Daily audits need to be conducted ahead of construction to identify if any fauna need to be relocated, especially burrowing mammals.

Furthermore it is recommended that the pipeline be inserted before the rainy season to prevent potential flooding and decanting.

In all instances contamination of the environment is crucial and should be prevented by implementing managements and maintenance measures, including monthly inspection of the pipeline.

12.0 CONCLUSION

The site is situated in the Grassland biome. The Grassland biome is characterized as land that is dominated by grass species rather than trees or large shrubs. A large percentage of exotic species were found and most areas were highly impacted already by mining activities or anthropogenic impacts. However, sensitive areas such as wetlands were also identified as well as protected species within the secondary grasslands or riparian zones. Based on physiognomy, moisture regime, rockiness, slope and soil properties, ten vegetation communities were recognised. Although these communities were recorded as such, there is some variation within these communities, due to external influences such as overgrazing, overutilization and other anthropogenic impacts. The sensitivity of an area was based on the vegetation communities. From here a low, moderate or high sensitivity was allocated to specific communities. High sensitivity areas include wetland or ridges on the pipeline route. Protected species that were found on site include *Brunsvigia radulosa* and *Gladiolus ecklonii.* These regions are suggested to be avoided completely during the development of the pipeline, however if it cannot be avoided an ecological audit is obligatory during construction to avoid the species or to assist in the possible relocation of it.

No Red Data fauna were encountered during the survey. Mammals found include hare, warthog, yellow mongoose and black backed jackal. The proposed project could include a rehabilitation process to improve the general veld conditions and create habitat for fauna.

The impact significance ranges between high and moderate significance, depending on whether certain pipeline sections include sensitive areas. Due to the fact that the pipeline will be buried, the impacts on burrowing mammals are high. If the small mammals have young, they will not move during construction and will be harmed.

It is recommended that the following ecological audits be undertaken during the Construction Phase:

- Vegetation audits need to be conducted prior to commencement of construction activities. These audits need to be conducted in the construction demarcated areas located in areas of a high and moderate sensitivity (including secondary grasslands) (see Figure 3). These areas may contain protected species, such as *Brunsvigia radulosa* and *Gladiolus ecklonii*; and
- Daily audits need to be conducted ahead of construction to identify if any fauna need to be relocated, especially burrowing mammals.

Furthermore it is recommended that the pipeline be inserted before the rainy season to prevent potential flooding and decanting.

In all instances contamination of the environment is crucial and should be prevented by implementing managements and maintenance measures, including monthly inspection of the pipeline.

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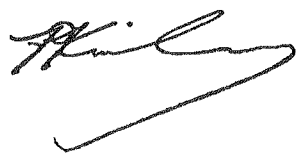

Louise van Wyk
Terrestrial Ecologist

Pieter Kimberg
Divisional Leader

LVW/PK/lvw

Reg. No. 2002/007104/07

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APPENDIX A

Protected species of Mpumalanga

Schedule 12: Specially Protected Plants
(Section 69(1)(b))

In this schedule "seedling" means a plant of which the diameter of the trunk or bulb, either above or below the ground, does not exceed 150mm.

Common Name	Scientific Name	Protection covers
Dolomiticus cycad	*Encephalartos dolomiticus*	Species, excluding seedlings
Dyer cycad	*E. dyerianus*	Species, excluding seedlings
Middelburg cycad	*E. middelburgensis*	Species, excluding seedlings
Eugene marias cycad	*E. Eugene maraissii*	Species, excluding seedlings
Heenen cycad	*E. heenanii*	Species, excluding seedlings
Inopinus cycad	*E. inopinus*	Species, excluding seedlings
Laevifolius cycad	*E. laevifolius*	Species, excluding seedlings
Lanatus cycad	*E. lanatus*	Species, excluding seedlings
Lebombo cycad	*E. lebomboensis*	Species, excluding seedlings
Ngoyanus cycad	*E. ngoyanus*	Species, excluding seedlings
Paucidentatus cycad	*E. paucidentatus*	Species, excluding seedlings
Modjadje cycad	*E. transvenosus*	Species, excluding seedlings
Villosus cycad	*E. villosus*	Species, excluding seedlings
Cupidus cycad	*E. cupidus*	Species
Humilis cycad	*E. humilus*	Species
Cycads in native habitat	All *Encephalartos*	Whole genus

Schedule 11: Protected Plants
(Section 69 (1)(a))

In this schedule:
a) the plants referred to shall not include plants which have been improved by selection or cross-breeding;
b) "seedling" means a plant of which the diameter of the trunk or bulb, either above or below the ground, does not exceed 150mm.

Common Name	Scientific Name	*Grouping*
Tree fern	*Cyathea capensis*	*Species*
	Cyathea dregei	*Species*
Cycads occurring in SouthAfrica and seedlings ofcycad sp. in schedule 12.		
Zamiaceae occurring in South Africa & Encephalartos seedling in schedule 12. Whole family		
Yellow wood	*Podicarpus*	*Whole genus*
Arum lilies	*Zantedeschia*	Whole genus
Volstruiskos	*Schizobasis intricata*	Species
Knolklimop	*Bowiea volubis*	Species
Red hot pokers	*Kniphofia*	Whole genus
All aloe sp. excluding: a) all sp. Not occurring in Mpumalanga	*Aloe*	Whole genus
Haworthias	*Haworthia*	Whole genus
Agapanthus	*Agapanthus*	Whole genus
Squill	*Scilla*	Whole genus

Pineapple flower	*Eucomis*	Whole genus
Dracaena	*Draceena*	Whole genus
Paint brush	*Haemanthus*	Whole genus
	Scadoxis	Whole genus
Cape poison bulb	*Boophane disticha*	Species
Clivia	*Clivia*	Whole genus
Brunsvigia	*Brunsvigia*	Whole genus
Crinum	*Crinum*	Whole genus
Ground lily	*Ammocharis coranica*	Species
	Cyrtanthus	Whole genus
Elephant's foot	*Dioscorea*	Whole genus
River lily	*Hesperantha coccinea*	Species
Gladioli	*Gladiolus*	Whole genus
Watsonia	*Watsonia*	Whole genus
Wild ginger	*Siphonochilus aethiopicus*	Species
Orchids	Orchidaceae	Whole family
Proteas	Proteaceae	Whole family
Black stinkwood	*Octea*	Whole genus
Kiaat	*Pterocarpus angolensis*	Species
Tamboti	*Spirostachys Africana*	Species
Euphorbia bernardii	*Euphorbia bernardii*	Species
Euphorbia grandialata	*Euphorbia grandialata*	Species
Common bersamia	*Bersamia tysoniana*	Species
Red ivory	*Berchemia zeyheri*	Species
Pepperbark tree	*Warbergia salutaris*	Species
Adenia	*Adenia*	Whole genus
Bastard onion weed	*Cassipourea gerrardii*	Species
Assegai tree	*Curtisia dentate*	Species
Olive trees	*Olea*	Whole genus
Impala lilies	*Adenium*	Whole genus
Kudu lily	*Pachypodium saundersii*	Species
Brachystelma	*Brachystelma*	Whole genus
Ceropegia	*Ceropegia*	Whole genus
Hueniopsis	*Hueniopsis*	Whole genus
Huernia	*Huernia*	Whole genus
Duvalia	*Duvalia*	Whole genus
Stapeliads	*Stapelia*	Whole genus
Orbeanthus	*Orbeanthus*	Whole genus
Orbeas	*Orbeas*	Whole genusrbeopsis genus

APPENDIX B

PRECIS expected species list

	2529CC	
Family	Species	Threat status
ACANTHACEAE	*Blepharis innocua*	LC
ACANTHACEAE	*Chaetacanthus costatus*	LC
ALLIACEAE	*Tulbaghia leucantha*	LC
AMARYLLIDACEAE	*Cyrtanthus breviflorus*	LC
AMARYLLIDACEAE	*Cyrtanthus tuckii var. transvaalensis*	LC
AMARYLLIDACEAE	*Nerine rehmannii*	LC
ANACARDIACEAE	*Ozoroa paniculosa*	LC
ANACARDIACEAE	*Searsia zeyheri*	LC
ANTHERICACEAE	*Chlorophytum calyptrocarpum*	LC
ANTHERICACEAE	*Chlorophytum fasciculatum*	LC
APIACEAE	*Afrosciadium magalismontanum*	LC
APIACEAE	*Alepidea setifera*	LC
APOCYNACEAE	*Asclepias albens*	LC
APOCYNACEAE	*Asclepias brevipes*	LC
APOCYNACEAE	*Asclepias eminens*	LC
APOCYNACEAE	*Asclepias fallax*	LC
APOCYNACEAE	*Aspidoglossum biflorum*	LC
APOCYNACEAE	*Aspidoglossum glabrescens*	LC
APOCYNACEAE	*Brachystelma rubellum*	LC
APOCYNACEAE	*Cordylogyne globosa*	LC
APOCYNACEAE	*Gomphocarpus glaucophyllus*	LC
APOCYNACEAE	*Huernia loeseneriana*	LC
APOCYNACEAE	*Pentarrhinum insipidum*	LC
APOCYNACEAE	*Periglossum angustifolium*	LC
APOCYNACEAE	*Raphionacme hirsuta*	LC
APOCYNACEAE	*Sisyranthus randii*	LC
APOCYNACEAE	*Xysmalobium asperum*	LC
ASPARAGACEAE	*Asparagus flavicaulis*	LC
ASPHODELACEAE	*Aloe ecklonis*	LC
ASPHODELACEAE	*Chortolirion angolense*	LC
ASPHODELACEAE	*Kniphofia ensifolia*	LC
ASPHODELACEAE	*Kniphofia porphyrantha*	LC
ASPHODELACEAE	*Trachyandra asperata*	LC
ASPHODELACEAE	*Trachyandra saltii*	LC
ASTERACEAE	*Aster harveyanus*	LC
ASTERACEAE	*Dimorphotheca caulescens*	LC
ASTERACEAE	*Dimorphotheca spectabilis*	LC
ASTERACEAE	*Euryops gilfillanii*	LC

	2529CC	
Family	Species	Threat status
ASTERACEAE	*Gazania krebsiana subsp. serrulata*	LC
ASTERACEAE	*Geigeria aspera*	LC
ASTERACEAE	*Helichrysum acutatum*	LC
ASTERACEAE	*Helichrysum aureonitens*	LC
ASTERACEAE	*Helichrysum cephaloideum*	LC
ASTERACEAE	*Helichrysum nudifolium*	LC
ASTERACEAE	*Helichrysum subglomeratum*	LC
ASTERACEAE	*Nidorella anomala*	LC
ASTERACEAE	*Nidorella hottentotica*	LC
ASTERACEAE	*Osteospermum striatum*	LC
ASTERACEAE	*Schistostephium heptalobum*	LC
ASTERACEAE	*Senecio coronatus*	LC
ASTERACEAE	*Senecio glanduloso-pilosus*	LC
ASTERACEAE	*Senecio gregatus*	LC
ASTERACEAE	*Senecio harveianus*	LC
ASTERACEAE	*Sonchus dregeanus*	LC
ASTERACEAE	*Ursinia nana subsp. leptophylla*	LC
ASTERACEAE	**Xanthium strumarium*	
AYTONIACEAE	*Asterella wilmsii*	
BRASSICACEAE	*Heliophila rigidiuscula*	LC
CARYOPHYLLACEAE	**Dianthus mooiensis*	
COLCHICACEAE	*Camptorrhiza strumosa*	LC
COMMELINACEAE	*Commelina africana*	LC
COMMELINACEAE	*Commelina modesta*	LC
COMMELINACEAE	*Cyanotis speciosa*	LC
CONVOLVULACEAE	*Convolvulus sagittatus*	LC
CONVOLVULACEAE	*Falkia oblonga*	LC
CONVOLVULACEAE	*Ipomoea bathycolpos*	LC
CONVOLVULACEAE	*Ipomoea crassipes*	LC
CONVOLVULACEAE	*Ipomoea ommanneyi*	LC
CONVOLVULACEAE	*Merremia verecunda*	LC
CYPERACEAE	*Bulbostylis contexta*	LC
CYPERACEAE	*Bulbostylis oritrephes*	LC
CYPERACEAE	*Bulbostylis schlechteri*	LC
CYPERACEAE	*Bulbostylis scleropus*	LC
CYPERACEAE	*Carex glomerabilis*	LC
CYPERACEAE	*Cyperus denudatus*	LC
CYPERACEAE	*Cyperus difformis*	LC
CYPERACEAE	*Cyperus indecorus var. decurvatus*	LC

	2529CC	
Family	Species	Threat status
CYPERACEAE	*Cyperus margaritaceus*	LC
CYPERACEAE	*Cyperus marginatus*	LC
CYPERACEAE	*Cyperus obtusiflorus*	LC
CYPERACEAE	*Eleocharis dregeana*	LC
CYPERACEAE	*Eleocharis limosa*	LC
CYPERACEAE	*Fimbristylis complanata*	LC
CYPERACEAE	*Fuirena pubescens*	LC
CYPERACEAE	*Kyllinga alba*	LC
CYPERACEAE	*Kyllinga erecta*	LC
CYPERACEAE	*Pycreus macranthus*	LC
CYPERACEAE	*Schoenoplectus corymbosus*	LC
CYPERACEAE	*Schoenoplectus decipiens*	LC
CYPERACEAE	*Scirpoides dioecus*	LC
CYPERACEAE	*Scleria aterrima*	LC
DIOSCOREACEAE	*Dioscorea dregeana*	LC
DROSERACEAE	*Drosera madagascariensis*	LC
EBENACEAE	*Diospyros lycioides subsp. guerkei*	LC
ERICACEAE	*Erica drakensbergensis*	LC
ERIOSPERMACEAE	*Eriospermum porphyrovalve*	LC
EUPHORBIACEAE	*Jatropha lagarinthoides*	LC
FABACEAE	*Acacia caffra*	LC
FABACEAE	*Chamaecrista comosa var. capricornia*	LC
FABACEAE	*Elephantorrhiza elephantina*	LC
FABACEAE	*Eriosema burkei*	LC
FABACEAE	*Eriosema cordatum*	LC
FABACEAE	*Eriosema gunniae*	LC
FABACEAE	*Eriosema psoraleoides*	LC
FABACEAE	*Eriosema salignum*	LC
FABACEAE	*Indigofera atrata*	LC
FABACEAE	*Indigofera egens*	LC
FABACEAE	*Indigofera mollicoma*	LC
FABACEAE	*Indigofera oxalidea*	LC
FABACEAE	*Indigofera oxytropis*	LC
FABACEAE	*Lotononis foliosa*	LC
FABACEAE	*Lotononis solitudinis*	LC
FABACEAE	*Melolobium wilmsii*	LC
FABACEAE	*Pearsonia cajanifolia*	LC
FABACEAE	*Rhynchosia monophylla*	LC
FABACEAE	*Rhynchosia nervosa*	LC

	2529CC	
Family	Species	Threat status
FABACEAE	*Rhynchosia totta*	LC
FABACEAE	*Smithia erubescens*	LC
FABACEAE	*Tephrosia capensis*	LC
FABACEAE	*Tephrosia longipes*	LC
FABACEAE	*Vigna vexillata*	LC
FABACEAE	*Zornia linearis*	LC
FOSSOMBRONIACEAE	*Fossombronia crispa*	
FOSSOMBRONIACEAE	*Fossombronia gemmifera*	
GENTIANACEAE	*Chironia krebsii*	LC
GENTIANACEAE	*Chironia purpurascens subsp. humilis*	LC
GERANIACEAE	*Pelargonium luridum*	LC
GERANIACEAE	*Pelargonium pseudofumarioides*	LC
HYACINTHACEAE	*Albuca shawii*	LC
HYACINTHACEAE	*Dipcadi gracillimum*	LC
HYACINTHACEAE	*Dipcadi marlothii*	LC
HYACINTHACEAE	*Dipcadi rigidifolium*	LC
HYACINTHACEAE	*Dipcadi viride*	LC
HYACINTHACEAE	*Ledebouria cooperi*	LC
HYACINTHACEAE	*Ledebouria marginata*	LC
HYACINTHACEAE	*Ornithogalum tenuifolium*	LC
HYACINTHACEAE	*Schizocarphus nervosus*	LC
HYPERICACEAE	*Hypericum lalandii*	LC
HYPOXIDACEAE	*Hypoxis rigidula*	LC
IRIDACEAE	*Dierama mossii*	LC
IRIDACEAE	*Gladiolus elliotii*	LC
IRIDACEAE	*Gladiolus papilio*	LC
IRIDACEAE	*Gladiolus vinosomaculatus*	LC
IRIDACEAE	*Lapeirousia sandersonii*	LC
IRIDACEAE	*Watsonia bella*	LC
JUNCACEAE	*Juncus dregeanus*	LC
JUNCACEAE	*Juncus exsertus*	LC
JUNCACEAE	*Juncus lomatophyllus*	LC
JUNCACEAE	*Juncus oxycarpus*	LC
LAMIACEAE	*Acrotome hispida*	LC
LAMIACEAE	**Becium obovatum*	
LAMIACEAE	*Rotheca hirsuta*	LC
LAMIACEAE	*Syncolostemon pretoriae*	LC
LAMIACEAE	*Teucrium trifidum*	LC
LOBELIACEAE	*Lobelia angolensis*	LC

	2529CC	
Family	Species	Threat status
LOBELIACEAE	*Lobelia erinus*	LC
LYTHRACEAE	*Nesaea sagittifolia*	LC
LYTHRACEAE	*Nesaea schinzii*	LC
MALVACEAE	*Hermannia depressa*	LC
MALVACEAE	*Hermannia lancifolia*	LC
MALVACEAE	*Hermannia transvaalensis*	LC
MALVACEAE	*Hibiscus aethiopicus var. ovatus*	LC
MENYANTHACEAE	*Nymphoides thunbergiana*	LC
MESEMBRYANTHEMACEAE	*Mossia intervallaris*	LC
ORCHIDACEAE	*Disa rhodantha*	LC
ORCHIDACEAE	*Disa versicolor*	LC
ORCHIDACEAE	*Eulophia hians*	LC
ORCHIDACEAE	*Eulophia milnei*	LC
ORCHIDACEAE	*Eulophia ovalis*	LC
ORCHIDACEAE	*Satyrium hallackii subsp. ocellatum*	LC
ORCHIDACEAE	*Satyrium longicauda*	LC
ORCHIDACEAE	*Satyrium parviflorum*	LC
ORCHIDACEAE	*Satyrium trinerve*	LC
ORCHIDACEAE	*Schizochilus zeyheri*	LC
OROBANCHACEAE	*Alectra sessiliflora*	LC
OROBANCHACEAE	*Cycnium tubulosum*	LC
OROBANCHACEAE	*Sopubia cana*	LC
OROBANCHACEAE	*Striga bilabiata*	LC
OXALIDACEAE	*Oxalis obliquifolia*	LC
PALLAVICINIACEAE	*Symphyogyna brasiliensis*	
PILOTRICHACEAE	*Callicostella tristis*	
PILOTRICHACEAE	*Cyclodictyon vallis-gratiae*	
PITTOSPORACEAE	*Pittosporum viridiflorum*	LC
POACEAE	*Cenchrus ciliaris*	LC
POACEAE	*Chloris gayana*	LC
POACEAE	*Cynodon dactylon*	LC
POACEAE	*Eragrostis curvula*	LC
POACEAE	*Eragrostis plana*	LC
POACEAE	*Hyparrhenia hirta*	LC
POACEAE	*Ischaemum fasciculatum*	LC
POACEAE	*Koeleria capensis*	LC
POACEAE	*Leersia hexandra*	LC
POACEAE	*Leptochloa fusca*	LC
POACEAE	*Panicum repentellum*	LC

	2529CC	
Family	Species	Threat status
POACEAE	**Phalaris arundinacea*	
POACEAE	**Phalaris canariensis*	
POACEAE	*Sporobolus africanus*	LC
POACEAE	*Sporobolus albicans*	LC
POACEAE	*Stiburus conrathii*	LC
POLYGALACEAE	*Polygala houtboshiana*	LC
POLYGALACEAE	*Polygala producta*	LC
POLYGALACEAE	*Polygala spicata*	LC
POLYGALACEAE	*Polygala transvaalensis*	LC
POLYGONACEAE	*Oxygonum dregeanum subsp. canescens*	LC
POLYGONACEAE	**Persicaria lapathifolia*	
POTAMOGETONACEAE	*Potamogeton octandrus*	LC
POTAMOGETONACEAE	*Potamogeton pectinatus*	LC
POTAMOGETONACEAE	*Potamogeton trichoides*	LC
RHAMNACEAE	*Helinus integrifolius*	LC
RICCIACEAE	*Riccia atropurpurea*	
RICCIACEAE	*Riccia natalensis*	
RICCIACEAE	*Riccia volkii*	
RUBIACEAE	*Canthium inerme*	LC
RUBIACEAE	*Fadogia homblei*	LC
RUBIACEAE	*Kohautia amatymbica*	LC
RUBIACEAE	*Pachystigma pygmaeum*	LC
RUBIACEAE	*Pachystigma thamnus*	LC
RUBIACEAE	*Pentanisia angustifolia*	LC
RUBIACEAE	*Pentanisia prunelloides*	LC
RUBIACEAE	*Pygmaeothamnus zeyheri var. rogersii*	LC
RUTACEAE	*Zanthoxylum thorncroftii*	LC
SANTALACEAE	*Thesium procerum*	LC
SANTALACEAE	*Thesium spartioides*	LC
SAPOTACEAE	*Englerophytum magalismontanum*	LC
SCROPHULARIACEAE	*Jamesbrittenia aurantiaca*	LC
SCROPHULARIACEAE	*Manulea parviflora*	LC
SCROPHULARIACEAE	*Melanospermum*	LC
SCROPHULARIACEAE	*Zaluzianskya spathacea*	LC
SOLANACEAE	*Solanum giganteum*	LC
SOLANACEAE	**Solanum nigrum*	
SOLANACEAE	*Solanum retroflexum*	LC
SOLANACEAE	**Solanum sisymbriifolium*	
SOLANACEAE	*Withania somnifera*	LC

	2529CC	
Family	Species	Threat status
THELYPTERIDACEAE	*Thelypteris confluens*	LC
THYMELAEACEAE	*Gnidia capitata*	LC
THYMELAEACEAE	*Gnidia kraussiana*	LC
VELLOZIACEAE	*Xerophyta retinervis*	LC
VERBENACEAE	*Chascanum adenostachyum*	LC
VERBENACEAE	*Chascanum hederaceum*	LC
VERBENACEAE	**Verbena bonariensis*	
XYRIDACEAE	*Xyris gerrardii*	LC

	2529CA	
Family	Species	Threat status
ACANTHACEAE	*Blepharis subvolubilis*	LC
ACANTHACEAE	*Dicliptera clinopodia*	LC
ACANTHACEAE	*Isoglossa grantii*	LC
ACANTHACEAE	*Ruellia cordata*	LC
AMARYLLIDACEAE	*Haemanthus humilis subsp. hirsutus*	LC
ANACARDIACEAE	*Ozoroa paniculosa*	LC
ANACARDIACEAE	*Searsia dentata*	LC
ANACARDIACEAE	*Searsia gerrardii*	LC
ANACARDIACEAE	*Searsia gracillima var. glaberrima*	LC
ANACARDIACEAE	*Searsia zeyheri*	LC
APOCYNACEAE	*Ancylobotrys capensis*	LC
APOCYNACEAE	*Cryptolepis oblongifolia*	LC
APOCYNACEAE	**Gomphocarpus fruticosus*	
ARACEAE	*Stylochaeton natalensis*	LC
ARALIACEAE	*Cussonia transvaalensis*	LC
ASPARAGACEAE	*Asparagus angusticladus*	LC
ASPARAGACEAE	*Asparagus cooperi*	LC
ASPARAGACEAE	*Asparagus suaveolens*	LC
ASPARAGACEAE	*Asparagus transvaalensis*	LC
ASPARAGACEAE	*Asparagus virgatus*	LC
ASPHODELACEAE	*Kniphofia ensifolia*	LC
ASTERACEAE	*Brachylaena rotundata*	LC
ASTERACEAE	**Conyza chilensis*	
ASTERACEAE	*Conyza scabrida*	LC
ASTERACEAE	*Dicoma anomala*	LC
ASTERACEAE	*Euryops transvaalensis*	LC
ASTERACEAE	*Gerbera jamesonii*	LC
ASTERACEAE	*Helichrysum setosum*	LC

	2529CA	
Family	Species	Threat status
ASTERACEAE	*Pseudognaphalium oligandrum*	LC
ASTERACEAE	*Senecio venosus*	LC
ASTERACEAE	*Tarchonanthus camphoratus*	LC
BARTRAMIACEAE	*Philonotis africana*	
BARTRAMIACEAE	*Philonotis hastata*	
BUDDLEJACEAE	*Nuxia congesta*	LC
CELASTRACEAE	*Gymnosporia tenuispina*	LC
CELASTRACEAE	*Maytenus undata*	LC
CELASTRACEAE	*Pterocelastrus echinatus*	LC
COMBRETACEAE	*Combretum erythrophyllum*	LC
COMBRETACEAE	*Combretum molle*	LC
COMBRETACEAE	*Combretum zeyheri*	LC
COMMELINACEAE	*Commelina africana var. lancispatha*	LC
COMMELINACEAE	*Floscopa glomerata*	LC
CRASSULACEAE	**Crassula setulosa*	
CYATHEACEAE	*Cyathea dregei*	LC
CYPERACEAE	*Cyperus albostriatus*	LC
CYPERACEAE	*Lipocarpha nana*	LC
DENNSTAEDTIACEAE	*Pteridium aquilinum*	LC
DICHAPETALACEAE	*Dichapetalum cymosum*	LC
DICRANACEAE	*Campylopus robillardei*	
EBENACEAE	*Diospyros whyteana*	LC
ERIOSPERMACEAE	*Eriospermum porphyrovalve*	LC
EUPHORBIACEAE	*Clutia pulchella var. pulchella*	LC
EUPHORBIACEAE	*Croton gratissimus var. gratissimus*	LC
EUPHORBIACEAE	*Croton gratissimus var. subgratissimus*	LC
EUPHORBIACEAE	*Euphorbia striata*	LC
EXORMOTHECACEAE	*Exormotheca holstii*	
FABACEAE	*Acacia caffra*	LC
FABACEAE	*Aeschynomene rehmannii*	LC
FABACEAE	*Elephantorrhiza elephantina*	LC
FABACEAE	*Rhynchosia monophylla*	LC
FABACEAE	*Rhynchosia nitens*	LC
FABACEAE	*Smithia erubescens*	LC
FABACEAE	*Tephrosia elongata*	LC
GENTIANACEAE	*Chironia purpurascens subsp. humilis*	LC
GERANIACEAE	*Monsonia attenuata*	LC
GERANIACEAE	*Pelargonium multicaule*	LC
GLEICHENIACEAE	*Gleichenia polypodioides*	LC

	2529CA	
Family	Species	Threat status
HYACINTHACEAE	*Ledebouria revoluta*	LC
HYACINTHACEAE	*Schizocarphus nervosus*	LC
IRIDACEAE	*Hesperantha coccinea*	LC
LAMIACEAE	*Aeollanthus buchnerianus*	LC
LAMIACEAE	*Leonotis ocymifolia*	LC
LAMIACEAE	*Plectranthus hadiensis*	LC
LAMIACEAE	*Syncolostemon canescens*	LC
LYTHRACEAE	*Nesaea cordata*	LC
MALPIGHIACEAE	*Sphedamnocarpus pruriens*	LC
MALVACEAE	*Dombeya rotundifolia*	LC
MALVACEAE	*Grewia flavescens*	LC
MALVACEAE	*Hermannia lancifolia*	LC
MALVACEAE	*Hibiscus aethiopicus var. ovatus*	LC
MALVACEAE	*Hibiscus calyphyllus*	LC
MALVACEAE	*Triumfetta sonderi*	LC
MOLLUGINACEAE	*Psammotropha mucronata var. foliosa*	LC
MOLLUGINACEAE	*Psammotropha mucronata*	LC
MOLLUGINACEAE	*Psammotropha myriantha*	LC
MORACEAE	*Ficus abutilifolia*	LC
MORACEAE	*Ficus ingens*	LC
MORACEAE	*Ficus salicifolia*	LC
MORACEAE	*Ficus sur*	LC
MYRICACEAE	*Morella serrata*	LC
MYRSINACEAE	*Myrsine africana*	LC
OCHNACEAE	*Ochna natalitia*	LC
OCHNACEAE	*Ochna pretoriensis*	LC
OCHNACEAE	*Ochna pulchra*	LC
OPHIOGLOSSACEAE	*Ophioglossum costatum*	LC
ORCHIDACEAE	*Eulophia foliosa*	LC
ORCHIDACEAE	*Habenaria tridens*	LC
ORCHIDACEAE	*Satyrium hallackii subsp. ocellatum*	LC
PALLAVICINIACEAE	*Symphyogyna brasiliensis*	
PEDALIACEAE	*Ceratotheca triloba*	LC
PHYLLANTHACEAE	*Pseudolachnostylis maprouneifolia*	LC
PLANTAGINACEAE	*Plantago longissima*	LC
POACEAE	*Andropogon schirensis*	LC
POACEAE	*Digitaria eriantha*	LC
POACEAE	*Diheteropogon amplectens*	LC
POACEAE	*Elionurus muticus*	LC

	2529CA	
Family	Species	Threat status
POACEAE	*Eragrostis nindensis*	LC
POACEAE	*Loudetia simplex*	LC
POACEAE	*Miscanthus junceus*	LC
POACEAE	*Paspalum scrobiculatum*	LC
POACEAE	*Schizachyrium sanguineum*	LC
POACEAE	*Setaria lindenbergiana*	LC
POACEAE	*Sporobolus festivus*	LC
POLYGALACEAE	*Polygala africana*	LC
PTERIDACEAE	*Cheilanthes hirta*	LC
PTERIDACEAE	*Pellaea calomelanos*	LC
PTERIDACEAE	*Pteris catoptera*	LC
RHAMNACEAE	*Berchemia zeyheri*	LC
RICCIACEAE	*Riccia atropurpurea*	
RICCIACEAE	*Riccia lanceolata*	
RICCIACEAE	*Riccia mammifera*	
RICCIACEAE	*Riccia volkii*	
RUBIACEAE	*Afrocanthium gilfillanii*	LC
RUBIACEAE	*Fadogia homblei*	LC
RUBIACEAE	*Pavetta gardeniifolia var. subtomentosa*	LC
RUBIACEAE	*Pavetta lanceolata*	LC
RUBIACEAE	*Tricalysia lanceolata*	LC
RUTACEAE	*Vepris reflexa*	LC
SAPOTACEAE	*Mimusops zeyheri*	LC
SCROPHULARIACEAE	*Melanospermum transvaalense*	LC
SELAGINELLACEAE	*Selaginella dregei*	LC
SPHAGNACEAE	*Sphagnum truncatum*	
STRYCHNACEAE	*Strychnos cocculoides*	LC
THYMELAEACEAE	*Gnidia kraussiana*	LC
URTICACEAE	*Pouzolzia mixta*	LC
VISCACEAE	*Viscum combreticola*	LC
VISCACEAE	*Viscum rotundifolium*	LC

APPENDIX C

Vegetation species identified during the site survey

Family	Species Name	Common Name
Amaranthaceae	**Gomphrena celosioides*	Carrot weed
Amaryllidaceae	*Brunsvigia radulosa*	Candelabra flower
Anacardiaceae	*Searsia lancea*	Karee
Asclepiadaceae	**Asclepias fruticosa*	Shrubby milkweed
Asteraceae	**Bidens bipinnata*	Spanish blackjack
Asteraceae	**Bidens pilosa*	Common blackjack
Asteraceae	**Bidens formosa*	Cosmos
Asteraceae	**Campuloclinium macrocephalum*	Pom pom weed
Asteraceae	**Conyza albida*	Tall fleabane
Asteraceae	**Conyza bonariensis*	Horseweed
Asteraceae	*Felicia mossamedensis*	Yellow felicia
Asteraceae	*Helichrysum sp.*	
Asteraceae	**Pseudognaphalium luteo-album*	Jersey cudweed
Asteraceae	**Schkuhhria pinnata*	Dwarf marigold
Asteraceae	**Seriphium plumosum*	Bankrupt bush
Asteraceae	**Tagetes minuta*	Tall khaki weed
Asteraceae	**Taraxacum officinale*	Common dandelion
Asteraceae	*Vernonia poskeana*	
Asteraceae	**Xanthium strumarium*	Burweed
Bignoniaceae	**Jacaranda mimosifolia*	Jacaranda
Boraginaceae	**Echium vulgare*	Blue echium
Campanulaceae	*Wahlenbergia caledonica*	
Capparaceae	*Crassula lanceolata*	
Commelinaceae	*Commelina africana*	Yellow commelina
Crassulaceae	*Crassula pellucida*	
Cyperaceae	*Bulbostylis capillaris*	Densetuft hairsedge
Cyperaceae	*Cladium mariscus*	Sawgrass
Cyperaceae	*Cyperus compressus*	Poorland flatsedge
Cyperaceae	**Cyperus eragrostis*	Tall flatsedge
Cyperaceae	**Cyperus esculentus*	Yellow nutsedge
Cyperaceae	*Cyperus laevigatus*	Smooth flatsedge
Cyperaceae	*Cyperus marginatus*	
Cyperaceae	*Cyperus sp*	
Cyperaceae	*Rhychospora sp*	
Cyperaceae	*Schoenoplectus brachyceras*	Sedge
Dichapetalaceae	*Dichapetalum cymosum*	Poison leaf
Euphorbiaceae	**Euphorbia peplus*	Peety spurge
Euphorbiaceae	**Ricinus communis*	Castor-oil plant
Fabaceae	**Acacia mearnsii*	Black wattle
Fabaceae	*Chamaecrista comosa*	Trailing dwarf cassia

Family	Species Name	Common Name
Fabaceae	*Erythrina lysistemon*	Coral-tree
Fabaceae	*Indigofera sanguinea*	
Fabaceae	*Lotononis listii*	
Fabaceae	*Vigna vexillata*	Wild sweetpea
Hypoxidaceae	*Hypoxis sp.*	
Iridaceae	*Gladiolus ecklonii*	Sheathed gladiolus
Lamiaceae	**Leonotis leonurus*	Wild dagga
Meliaceae	**Melia azedarach*	Syringa
Myrtaceae	**Eucalyptus camadulensis*	River red gum
Myrtaceae	**Eucalyptus macrocarpa*	Mottlecah
Myrtaceae	**Eucalyptus sp.*	Blue gum
Papaveraceae	**Argemone mexicana*	Yellow-flowered mexican poppy
Papaveraceae	**Argemone ochroleuca*	White-flowered mexican poppy
Pedaliaceae	**Sesamum triphyllum*	Wild sesame
Phytolaccaceae	**Phytolacca octandra*	Inkberry
Pinaceae	**Pinus pinaster*	Patula pine
Poaceae	*Andropogon eucomus*	Snowflake grass
Poaceae	*Aristida congesta*	Tassel three-awn
Poaceae	*Cenchrus ciliaris*	Foxtail buffalo grass
Poaceae	*Cortaderia selloana*	Pampas grass
Poaceae	*Cymbopogon excavatus*	Broad-leaved turpentine grass
Poaceae	*Cynodon dactylon*	Couch grass
Poaceae	*Elionurus muticus*	Wire grass
Poaceae	*Eragrostis cilianensis*	Stink love grass
Poaceae	*Eragrostis curvula*	Weeping love grass
Poaceae	*Eragrostis gummiflua*	Gum grass
Poaceae	*Eragrostis lehmanniana*	Lehmann's love grass
Poaceae	*Eragrostis rigidior*	Curly leaf
Poaceae	*Eragrostis trichophora*	Hairy love grass
Poaceae	*Eustachys paspaloides*	Brown rhodes grass
Poaceae	*Hyparrhenia hirta*	Common thatching grass
Poaceae	*Hyparrhenia tamba*	Blue thatching grass
Poaceae	*Imperata cylindrica*	Cottonwool grass
Poaceae	**Melinis repens*	Natal red top
Poaceae	*Pennisetum clandestinum*	Kikuyu grass
Poaceae	*Phragmites australis*	Common reed
Poaceae	*Pogonarthria squarrosa*	Herringbone grass
Poaceae	*Schizachyrium sanguineum*	Red autumn grass
Poaceae	*Sporobolus africanus*	Ratstail dropseed
Poaceae	*Themeda triandra*	Red grass
Poaceae	*Urochloa mosambicensis*	Bushveld signal grass

Family	Species Name	Common Name
Rubiaceae	*Oldenlandia herbacea*	Oldenlandia
Rubiaceae	*Wahlenbergia grandiflora*	Gaint bell flower
Scrophulariaceae	**Striga asiatica*	Witchweed
Solanaceae	**Datura ferox*	Thorn apple
Solanaceae	**Datura stramonium*	Common thorn-apple
Solanaceae	**Solanum sisymbrifolium*	Dense-thorned bitter apple
Solanaceae	**Solanum mauritianum*	Bugweed
Typhaceae	*Typha capensis*	Bulrush
Verbenaceae	**Verbena bonariensis*	Purple top
Verbenaceae	**Verbena tenuisecta*	Fine-leaved verbena

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Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
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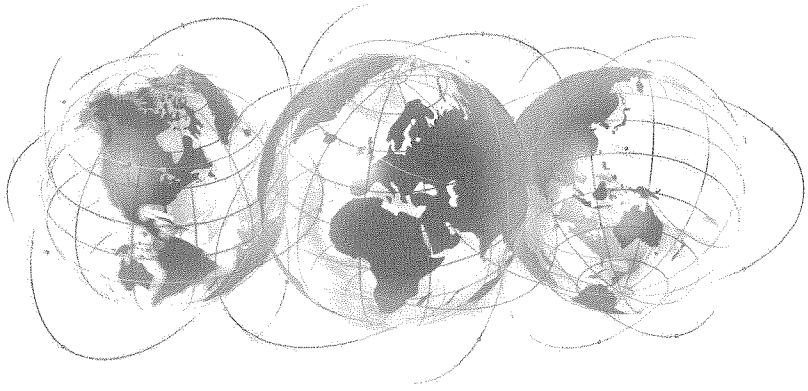
solutions@golder.com
www.golder.com



Golder Associates Africa (Pty) Ltd
25 Main Avenue
Florida
Roodepoort
South Africa
T: [+27] (11) 672 0666

Golder Associates

APPENDIX J

Specialist Report: Aquatic Ecology

October 2010

REPORT ON

Specialist Aquatic Study for the proposed eMalahleni Mine Water Reclamation Project

Golder Report Number: 12485-9455-4

REPORT

A world of capabilities delivered locally

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Executive Summary

The Ecology Division of Golder Associates Africa (Pty) Ltd. (Golder) was commissioned by Golder Environmental Services Division to conduct an aquatic assessment for input into the eMalahleni Mine Water Reclamation (MWR) expansion Environmental Impact Assessment (EIA). The project area is situated near eMmalahleni in the Mpumalanga Highveld. The project area falls within the Olifants Water Management Area (WMA) 4.

This document presents the results of the January 2010 survey of aquatic ecosystems associated with the aforementioned project. This survey included assessments of in situ water quality, habitat assessment, aquatic macroinvertebrates and ichthyofaunal diversity.

The project objectives were to:

- Characterise the biotic integrity of aquatic ecosystems in the project area;
- Evaluate the extent of site-related impacts in terms of selected ecological indicators;
- Identify potential impacts associated with the proposed project and recommend suitable mitigation measures;
- Identify listed aquatic biota based on the latest IUCN rankings, or other pertinent conservation ranking bodies;
- Identify sensitive or unique aquatic habitats which could suffer irreplaceable loss; and
- Identify the best route for the pipeline to follow based on the assessment of aquatic ecosystem.

The following results were obtained during the study:

- Based on *in situ* water quality analysis, the pH value at Site 1, Site 3, BS and KS were acidic. Dissolved oxygen concentrations were below guideline values at all the sites except site KS. Total dissolved solid concentrations were high at sites 3, BS and KS, contributing to the severely impaired biotic integrity recorded within the area;
- Based on the IHAS results, habitat availability was a limiting factor of aquatic macroinvertebrate diversity at all the sites. The absence of adequate Stones-In-Current habitat and increased channelization contributed to the poor habitat availability at these sites;
- Based on SASS5 results biotic integrity in the project area ranged from moderately impaired (PES Class C) to very seriously impaired (PES Class F);
- No fish species were recorded at any of the sites; and
- Based on the lack of fish from all of the sites the Fish Assemblage Integrity Index (FAII) was rated as critically modified (PES Class F).

Potential impacts on the aquatic ecosystems associated with the project include; impacts on water quality; aquatic habitat loss and alterations; and impacts on aquatic biota (aquatic macroinvertebrates, fish).

Potential mitigation measures include route refinements at sites 1, 3, 4 and 5; implementation of low impact construction techniques; prevention of large-scale disturbances to the wetland and aquatic ecosystems at the sites; containment and rehabilitation of any site related impacts to the aquatic ecosystems; and the implementation of a monitoring programme for water quality, habitat and biotic integrity;

The significance of the impacts was rated as low for most impacts with easily obtainable mitigations that reduced the impacts to the aquatic ecosystems. The positive impacts that would occur after completion of the pipeline would include improved water quality, which will lead to better habitat availability and more natural un-channelled systems.

Moderate impacts to macro-channel and in-stream habitats are expected. Implementation of mitigation measures reduced the significance of the impacts to low. Impacts were assessed for the additional infrastructure associated with the project including the WRP, pump stations, waste generation and scour valves. The significance of these impacts was rated as moderate. Prevention of water quality and erosion impacts to the aquatic ecosystem was mitigated.

Based on the results obtained during this study, it is clear that the water bodies associated with the proposed pipeline routes are already in an impacted state. As far as the assessment of the aquatic component of the associated sites goes, is there no reason why the construction of the pipeline should not go ahead. During the aquatic study no endangered or vulnerable taxa were found.

A monitoring programme for the aquatic ecosystem (including water quality, habitat and biotic integrity) is recommended for both the construction and operation phases. The monitoring program should consist of two aquatic biomonitoring surveys per year. One in the low flow season (May – September) and one in the high flow season (October – April). The monitoring programme should include the same indicators as used during the baseline survey.

Study Limitations

The following was assumed for the purposes of this aquatic ecosystem study:

- That the maps supplied were correct and that all the major aquatic and wetland pipeline crossings were identified and listed; and
- The information supplied by the client was correct at the time that fieldwork commenced.

The following limitations were placed on the aquatic and wetland ecosystem study of this project:

- A single wet season baseline assessment was conducted;
- Accuracy of the maps, aquatic and wetland pipeline crossings, routes and desktop assessments were made using the current 1:50 000 topographical map series of South Africa;
- Accuracy of Global Positioning System (GPS) coordinates were limited to 15 m accuracy in the field;
- Local security issues in and around many of the sites and locations reduced the length of time spent in field by specialists; and
- Many of the sites were impacted and degraded as a result of surrounding human activities. This limited the existing functioning and condition of the aquatic and wetland habitats.

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1.0 INTRODUCTION

The Ecology Division of Golder Associates Africa (Pty) Ltd. (Golder) was commissioned by Golder Environmental Services Division to conduct an aquatic assessment for input into the Anglo American Thermal Coal eMalahleni Mine Water Reclamation Expansion Environmental Impact Assessment (EIA). The proposed project is situated near to eMalahleni in the Mpumalanga Highveld, within quaternary drainage regions B11K, B20G and B11G, in the Olifants Water Management Area (WMA4). The study area falls within the Highveld (11) – Lower Level 1 Ecoregion and the Moist Sandy Highveld Grassland Biome (Low and Rebelo, 1996 and Dallas, 2007).

This document presents the results of the January 2010 survey of aquatic ecosystems associated with the aforementioned project. This survey is comprised of an assessment of the rivers, and includes in situ water quality, habitat, aquatic macroinvertebrates and ichthyofaunal assessments.

1.1 Objectives

The projects objectives included:

- Characterization of the biotic integrity of aquatic ecosystems at selected crossing sites associated with the proposed pipeline as per the scope of work;
- Evaluation of the extent of site-related impacts in terms of selected ecological indicators as per the scope of work;
- Identification of potential impacts associated with the proposed project and recommendation of suitable mitigation measures;
- Identification of listed aquatic biota based on the latest IUCN rankings, or other pertinent conservation ranking bodies;
- Identification of sensitive or unique aquatic habitats which could suffer irreplaceable loss;
- Identification of the best route for the pipeline to follow based on the assessment of aquatic ecosystem; and
- Provision of mitigation to any identified impacts.

2.0 APPROACH

In order to enable adequate description of the aquatic environment it is recommended that at least two, or preferably three, indicators be selected to represent each of the stressor, habitat and response components involved in the aquatic environment. Broad methodologies to characterise these components are described below. These proposed methodologies are generally applied and accepted and are as follows:

Stressor Indicators

- *In situ* water parameters.

Habitat Indicators

- General habitat assessment; and
- Invertebrate Habitat Assessment System (IHAS, *version 2*).

Response Indicators

- Aquatic macroinvertebrates (SASS, *version 5*); and
- Ichthyofauna (FAII).

Impact Assessment

- Identification of impacts;
- Development of mitigation measures; and
- Rating of impact significance.

3.0 STUDY AREA

Nine sites were selected at points where the proposed pipeline routes intersect drainage lines.

Co-ordinates of sampling sites were determined using a Garmin GPS 60CSx and are listed in Table 1 with descriptions of the sites. A map of the study area showing the location of aquatic sampling sites is presented in Figure 1. Photographs of sampling sites are presented in Appendix B.

Table 1: Location and description of aquatic sites.

Site	Latitude	Longitude	Description
Site 1	-25.8045763	29.1082959	Situated in the Klipspruit at the mine service road crossing point.
Site 2	-25.829503	29.1249206	Situated in the Brugspruit next to the waste water treatment works.
Site 3	-25.8249123	29.1402868	Situated in an unnamed tributary of the Brugspruit at the bridge on a small dirt road.
Site 4(RR3)	-25.8741338	29.1280413	Situated on the Brugspruit, between the R104 and the N4.
Site 5(RR1)	-25.8764814	29.1532537	Situated in an unnamed tributary of the Brugspruit.
Site 6a(RR2)	-25.8784195	29.1642723	Situated on the Brugspruit, between the R104 and the N4.
Site 7	-25.934759	29.1944207	Situated in an unnamed tributary on an existing tar road.
BS	-25.8481044	29.2121675	Situated in the Blesbokspruit, downstream of the Middelburg Steam Colliery.
KS	-25.7930451	29.0656874	Situated in the Kromdraaispruit on the Vosman Road.

4.0 METHODOLOGY

4.1 *In situ* water quality

During the survey, compact field instruments were used to measure the following parameters:

- pH (Eutech pH Tester);
- Electrical Conductivity (EC) (Eutech ECTester11 Dual Range);
- Dissolved Oxygen (DO) (Eutech CyberScan DO110); and
- Temperature (Eutech CyberScan DO110);

Water quality has a direct influence on aquatic life forms. Although these measurements only provide a "snapshot", they can provide valuable insight into the characteristics and interpretation of a specific sample site at the time of the survey.

4.2 Habitat Assessment

Habitat assessment can be defined as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour *et al.*, 1996). Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason habitat evaluation is conducted simultaneously with biological evaluations in order to facilitate the interpretation of results.

4.2.1 Invertebrate Habitat Assessment System (IHAS, *Version 2*)

The Invertebrate Habitat Assessment System (IHAS, *version 2*) was applied at each of the sampling sites in order to assess the availability of habitat biotopes for macroinvertebrates. The IHAS was developed specifically for use with the SASS5 index and rapid biological assessment protocols in South Africa (McMillan, 1998). It is presently thought that a total IHAS score of over 65% represents good habitat conditions, a score over 55% indicates adequate/fair habitat conditions (McMillan, 2002) (Table 2).

Table 2: Invertebrate Habitat Assessment System Scoring Guidelines (*version 2*)

IHAS Score	Description
> 65%	Good
55-65%	Adequate/Fair
< 55%	Poor

4.3 Aquatic macroinvertebrates

The monitoring of benthic macroinvertebrates forms an integral part of the monitoring of the health of an aquatic ecosystem as they are relatively sedentary and enable the detection of localised disturbances. Their relatively long life histories (±1 year) allow for the integration of pollution effects over time.

Field sampling is easy and since the communities are heterogeneous and several phyla are usually represented, response to environmental impacts is normally detectable in terms of the community as a whole (Hellawell, 1977).

Aquatic macroinvertebrates were sampled using the qualitative kick sampling method called SASS5 (South African Scoring System, *version 5*) (Dickens and Graham, 2001). The SASS5 protocol is a biotic index of the condition of a river or stream, based on the resident macroinvertebrate community, whereby each taxon is allocated a score according to its level of tolerance to river health degradation (Dallas, 1997). This method relies on churning up the substrate with your feet and sweeping a finely meshed SASS net (pore size of 1000 micron), over the churned up area. In the Stones-In-Current (SIC) biotope the net is rested on the

substrate and the area immediately upstream of the net disturbed by kicking the stones over and against each other to dislodge benthic invertebrates. The net is also swept under the edge of marginal and aquatic vegetation. Kick samples are collected from areas with gravel, sand and mud (GSM) substrates. Identification of the organisms is made to family level (Thirion *et al.*, 1995; Davies & Day, 1998; Dickens & Graham, 2001; Gerber & Gabriel, 2002).

The endpoint of any biological or ecosystem assessment is a value expressed either in the form of measurements (data collected) or in a more meaningful format by summarising these measurements into one or several index values (Cyrus *et al.*, 2000). The indices used for this study were, SASS5 Total Score and Average Score per Taxon (ASPT).

4.3.1 Biotic integrity based on SASS5 results

Reference conditions reflect the best conditions that can be expected in rivers and streams within a specific area and also reflect natural variation over time. These reference conditions are used as a benchmark against which field data can be compared. Modelled reference conditions for the Highveld Ecoregion were obtained from Dallas (2007) (Table 3).

Table 3: Modelled reference conditions for the Highveld Ecoregion (11) based on SASS5 and ASPT scores

SASS Score	ASPT	Class	Description
>124	>5.6	A	Unimpaired. High diversity of taxa with numerous sensitive taxa.
83-124	4.8-5.6	B	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.
60-82	4.6-4.8	C	Moderately impaired. Moderate diversity of taxa.
52-59	4.2-4.6	D	Considerably impaired. Mostly tolerant taxa present.
30-51	Variable <4.2	E	Severely impaired. Only tolerant taxa present.
<30	Variable	F	Critically impaired. A few tolerant taxa present.

4.4 Ichthyofaunal Assessment

Whereas invertebrate communities are good indicators of localised conditions in a river over the short-term, fish being relatively long-lived and mobile:

- Are good indicators of long-term influences;
- Are good indicators of general habitat conditions;
- Integrate effects of lower trophic levels; and
- Are consumed by humans (Uys *et al.*, 1996).

Fish samples were collected using a battery operated electro-fishing device (Smith-Root LR24). This method relies on an immersed anode and cathode to temporarily stun fish in the water column; the stunned fish can then be scooped out of the water with a net for identification. The responses of fish to electricity are determined largely by the type of electrical current and its wave form. These responses include avoidance,

electrotaxis (forced swimming), electrotetanus (muscle contraction), electronarcosis (muscle relaxation or stunning) and death (USGS, 2004). Electrofishing is regarded as the most effective single method for sampling fish communities in wadeable streams (Plafkin et al., 1989). All fish were identified in the field using the guide Freshwater Fishes of Southern Africa (Skelton, 2001) and released back into the river at the point of capture.

4.4.1 Presence of Red Data species

In order to assess the Red Data status of the expected fish species in the sample area, the IUCN Red List of Threatened Species was consulted (IUCN, 2009).

4.4.2 Biotic integrity based on the Fish Assemblage Integrity Index (FAII) results

Procedures used in the application of the FAII are described below:

Species Intolerance Ratings

Intolerance refers to the degree to which an indigenous species is unable to withstand changes in the environmental conditions at which it occurs (Kleynhans, 1999). Four components were considered in estimating the intolerance of fish species, i.e. habitat preferences and specialization (HS), food preferences and specialisation (TS), requirement for flowing water during different life stages (FW) and association with habitats with unmodified water quality (WQ). Each of these aspects was scored for a species according to low requirements/specialization (rating = 1), moderate requirement/specialization (rating = 3) and high requirement/specialization (rating = 5). The total intolerance (IT) of fish species is estimated as follows:

IT = (HS + TS + FW + WQ)/4

Frequency of Occurrence

For each species expected to be present in a fish habitat segment, the expected frequency of occurrence was estimated and the observed frequency of occurrence calculated:

- Occurrence at <34% of sites in a segment, score = 1 (infrequent occurrence)
- Occurrence at 34% to 67% of sites in a segment, score = 3 (frequent occurrence)
- Occurrence at >67% of sites in a segment, scores = 5 (widespread occurrence)

The same procedure was applied in the assessment of the expected frequency of occurrence of indigenous fish species at each of the sites sampled, taking into account habitat types actually present at a specific site and species' habitat preferences.

Fish Health Assessment

The assessment is conducted in such a way as to derive numeric values, which reflect the status of fish health. The percentage of fish with externally evident disease or other anomalies was used in the scoring of this metric (Kleynhans, 1999; Kilian *et al.*, 1997). The following procedures were followed to score the health of individual species at site:

- Frequency of affected fish >5%. Score = 1
- Frequency of affected fish 2 – 5%. Score = 3
- Frequency of affected fish < 2%. Score = 5

This approach is based in the principle that, even under unimpaired conditions, a small percentage of individuals can be expected to exhibit some anomalies (Kleynhans, 1999).

Calculation of FAII Score

The FAII is consists of the calculation of an expected value, which serve as the baseline or reference, the calculation of an observed value and the comparison of the expected and observed scores that provide a relative FAII score. The expected FAII rating for a fish habitat segment is calculated as follows (Kleynhans, 1999):

FAII value (Exp) = ∑IT x ((F + H)/2)

Where:

- Exp = expected for a fish segment
- IT = Intolerance rating for individual species expected to be present in a fish habitat segment and in habitats that were sampled
- H = Expected health rating for a species expected to be present.

The observed observation is calculated on a similar basis, but is based on information collected during the survey:

FAII value (Obs) = ∑IT x ((F + H)/2)

Where:

- Obs: = observed for a fish habitat segment

The relative FAII score is calculated by:

Relative FAII score = FAII value (Obs)/FAII value (exp) x 100

Interpretation of the FAII score

Interpretation of the relative FAII values is based on the habitat integrity classes of Kleynhans (1996) (Table 4).

Table 4: FAII Assessment Classes (Kleynhans, 1996; 1999).

FAII score (% of total)	PES Class	Description of generally expected conditions for integrity classes
90-100	A	Unmodified or approximate natural conditions closely.
80-89	B	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicate little modification
60-79	C	Moderately modified. A lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of this class
40-59	D	Largely modified. A clearly lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of this class
20-39	E	Seriously modified. A strikingly lower than expected species richness and general absence of intolerant and moderately intolerant species. Impairment of health may become evident.

FAII score (% of total)	PES Class	Description of generally expected conditions for integrity classes
0-19	F	Critically modified. Extremely lowered species richness and an absence of intolerant and moderately intolerant species. Only tolerant species may be present with a complete loss of species at the lower limit of the class. Impairment of health generally very evident.

5.0 ASSESSMENT OF POTENTIAL IMPACTS

In order to assess the impacts of the proposed project on the aquatic ecosystems, the following components were included:

- The identification of the main areas of impact associated with the proposed project, i.e. pipeline and aquatic and wetland crossings, and reduced/ceased pre-treated mine water discharges;
- The assessment of the impacts of the proposed project on the aquatic ecosystems;
- The recommendation of mitigation and management measures to deal with significant impacts;
- The provision of alternative routes and options for the pipelines, if necessary; and
- The identification of aspects which may require further study.

In order to successfully assess the impacts, it is necessary to evaluate the following:

- The current South African legislation;
- The development of mitigation measures; and
- The significance of the impacts.

5.1 The current South African legislation

As indicated at the outset of the report, this EIR is informed and influenced by the following key pieces of legislation:

- The National Water Act, 1998 (Act 36 of 1998);
- The National Environmental Management Act, 1998 (Act 107 of 1998); and
- The National Environmental Management Biodiversity Act, 2004 (Act 10 of 2004).

5.2 Environmental impact significance

The impacts of the proposed project were assessed in terms of impact significance and recommended mitigation measures. The determination of significant impacts relates to the degree of change in the environmental resource measured against some standard or threshold (DEAT, 2002). This requires a definition of the magnitude, prevalence, duration, frequency and likelihood of potential change (DEAT, 2002). The following criteria have been proposed by the Department of Environmental Affairs and Tourism for the description of the magnitude and significance of impacts (DEAT, 2002):

The consequence of impacts can be derived by considering the following criteria:

- Extent or spatial scale of the impact;

- Intensity or severity of the impact;
- Duration of the impact;
- Potential for Mitigation;
- Acceptability;
- Degree of certainty/Probability;
- Status of the impact; and
- Legal Requirements.

Describing the potential impact in terms of the above criteria provides a consistent and systematic basis for the comparison and application of judgments (DEAT, 2002).

The significance of the impact is calculated as:

Significance of Impact = Consequence (magnitude + duration + spatial scale) x Probability

Magnitude relates to how severe the impact is. Duration relates to how long the impact may be prevalent for and the spatial scale relates to the physical area that would be affected by the impact. Having ranked the severity, duration and spatial scale using the criteria outlined in Table 5, the overall consequence of impact can be determined by adding the individual scores assigned in the severity, duration and spatial scale. Overall probability of the impacts must then be determined. Probability refers to how likely it is that the impact may occur.

Table 5: Consequence and probability ranking of impacts.

Magnitude/Severity	Duration	Spatial Scale	Probability
10 - Very high/don't know	5 - Permanent	5 - International	5 - Definite/don't know
8 – High	4 - Long-term (impact ceases after operational life)	4 - National	4 - Highly probable
6 - Moderate	3 - Medium-term (5-15 years)	3 - Regional	3 - Medium probability
4 – Low	2 - Short-term (0-5 years)	2 - Local	2 - Low probability
2 – Minor	1 - Immediate	1- Site only	1 - Improbable
0 – None	0 - None	0 - None	0 - None

The maximum value, which can be obtained, is 100 significance points (SP). Environmental effects are rated as either of High, Moderate, Low or No Impact significance on the following basis:

- SP > 75 Indicates high environmental significance;
- SP 50 – 75 Indicates moderate environmental significance;
- SP < 50 Indicates low environmental significance; and
- SP = 0 Indicates no environmental significance.

The descriptors for the ratings are provided in (Table 6) (DEAT, 2002).

Table 6: Categories for the rating of impact magnitude and significance.

Category	Description
High	Of the highest order possible within the bounds of impacts that could occur, There is no possible mitigation that could offset the impact, or mitigation is difficult.
Moderate	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. Mitigation is both feasible and fairly easily possible.
Low	Impact is of a low order and therefore likely to have little real effect. Mitigation is either easily achieved or little mitigation is required, or both.
No Impact	Zero Impact

5.3 Development of mitigation measures

The quantitative accuracy and precision of impact predictions is particularly important for prescribing mitigation measures (DEAT, 2002). This is especially important for those impacts, pollutants or resources that require the setting of a site-specific discharge limit or need to be within legislated standards (DEAT, 2002). A common approach to describing mitigation measures for critical impacts is to specify a range of targets with predetermined acceptable range and an associated monitoring and evaluation plan (DEAT, 2002). To ensure successful implementation, mitigation measures should be unambiguous statements of actions and requirements that are practical to execute (DEAT, 2002). The following sections summarise the different approaches to prescribing and designing mitigation measures.

5.3.1 Avoidance

Mitigation by not carrying out the proposed action on the specific site, but rather on a more suitable site.

5.3.2 Minimisation

Mitigation by scaling down the magnitude of a development, reorienting the layout of the project or employing technology to limit the undesirable environmental impact.

5.3.3 Rectification

Mitigation through the restoration of environments affected by the action.

5.3.4 Reduction

Mitigation by taking maintenance steps during the course of the action.

5.3.5 Compensation

Mitigation through the creation, enhancement or acquisition of similar environments to those affected by the action.

6.0 RESULTS AND DISCUSSION

6.1 *In situ* water quality

In situ water quality measurements were recorded during the field surveys using portable field instruments. This information assists in the interpretation of biological results because of the direct influence water quality has on aquatic life forms. Sites 5 and 7 were identified as a drainage line at a desktop level, but were dry at the time of the survey.

Table 7: Water Quality collected during the January 2010 survey.

Site	January 2010				
	pH	DO (mg/l)	EC (^{m}S/m)	TDS (mg/l)	Temp (˚C)
Site 1	3.7	2.90	20	130.00	24.00

Site	January 2010				
	pH	DO (mg/l)	EC (^{m}S/m)	TDS (mg/l)	Temp (˚C)
Site 2	6.7	2.70	100	650.00	24.00
Site 3	3.7	4.88	230	1495.00	22.30
Site 4(RR3)	7.7	4.26	55	357.50	26.20
Site 5(RR1)	Dry				
Site 6a(RR2)	6.7	4.88	89	578.50	23.10
Site 7	Dry				
BS	2.7	4.88	250	1625.00	29.80
KS	4.8	5.50	330	2145.00	23.00

DO *Dissolved Oxygen*

EC *Electrical Conductivity*

TDS *Total Dissolved Salts*

6.1.1 pH

Most fresh waters are usually relatively well buffered and more or less neutral, with a pH range from 6.5 to 8.5, and most are slightly alkaline due to the presence of bicarbonates of the alkali and alkaline earth metals (Bath, 1989). The pH of natural waters is determined by geological influences and biotic activities. The pH target for fish health is presented as ranging between 6.5 and 9.0, as most species will tolerate and reproduce successfully within this pH range (Alabaster & Lloyd, 1982).

During the January 2010 survey, pH values were generally acidic < 7 and ranged from 7.7 at Site 4 to 2.7 at site BS (Figure 2). Human-induced acidification is the result of effluents, such as those from industries, and water draining from mines (Davies and Day, 1998). Based on the January 2010 results pH at Site 1, Site 3, BS and KS may have a limiting affect on aquatic biota, while at the remainder of the sites pH was not considered to have a limiting effect.

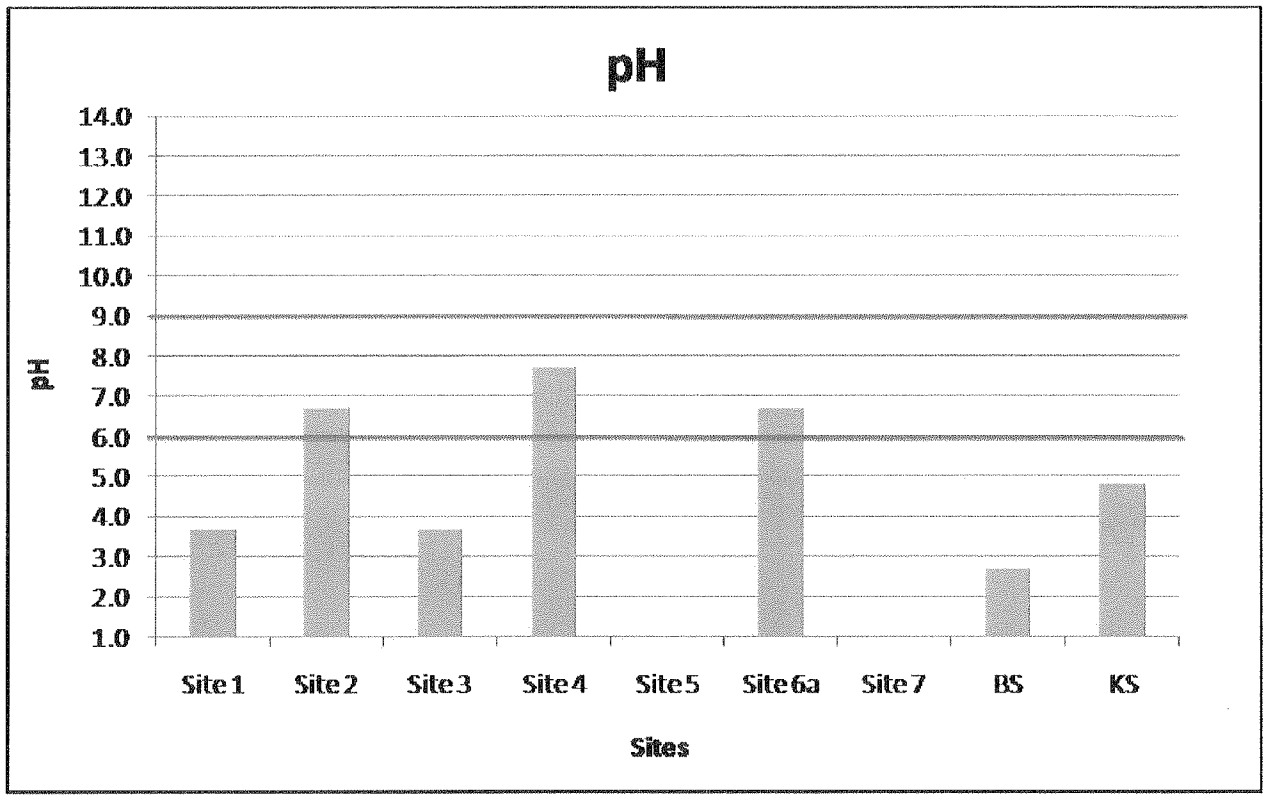

Figure 2: pH values recorded during the January 2010 survey (red lines indicate guideline values).

6.1.2 Electrical Conductivity (EC) / Total Dissolved Salts (TDS)

Electrical conductivity (EC) is a measure of the ability of water to conduct an electrical current (DWAF, 1996). This ability is a result of the presence in water of ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium, all of which carry an electrical charge (DWAF, 1996). Many organic compounds dissolved in water do not dissociate into ions (ionise), and consequently they do not affect the EC (DWAF, 1996). Electrical conductivity (EC) is a rapid and useful surrogate measure of the Total Dissolved Solids (TDS) concentration of waters with a low organic content (DWAF, 1996). For the purpose of interpretation of the biological results collected during the June 2008 survey the TDS concentrations were calculated by means of the EC using the following **generic** equation, used throughout South Africa (DWAF, 1996):

TDS (mg/l) = EC (mS/m at 25 °C) x 6.5

If more accurate estimates of the TDS concentration from EC measurements are required then the conversion factor should be experimentally determined for each specific site and for specific runoff events (DWAF, 1996). According to Davies & Day (1998), freshwater organisms usually occur at TDS values less than 3000 mg/l. According to the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996) the rate of change of the TDS concentration, and the duration of the change is more important than absolute changes in the TDS concentration. Most of the macroinvertebrate taxa that occur in streams and rivers are sensitive to salinity, with toxic effects likely to occur in sensitive species at salinities > 1000mg/ℓ (DWAF, 1996). According to the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996; Volume 7) TDS concentrations in South African inland waters should not be changed by > 15%.

During the January 2010 survey Total Dissolved Solid (TDS) concentrations ranged from 130 mg/l at Site 1 to 2145 mg/l at site KS (Figure 3). The TDS concentrations at Site 3, BS and KS may have a limiting affect on aquatic biota as they were observed to be above 1000 mg/l.

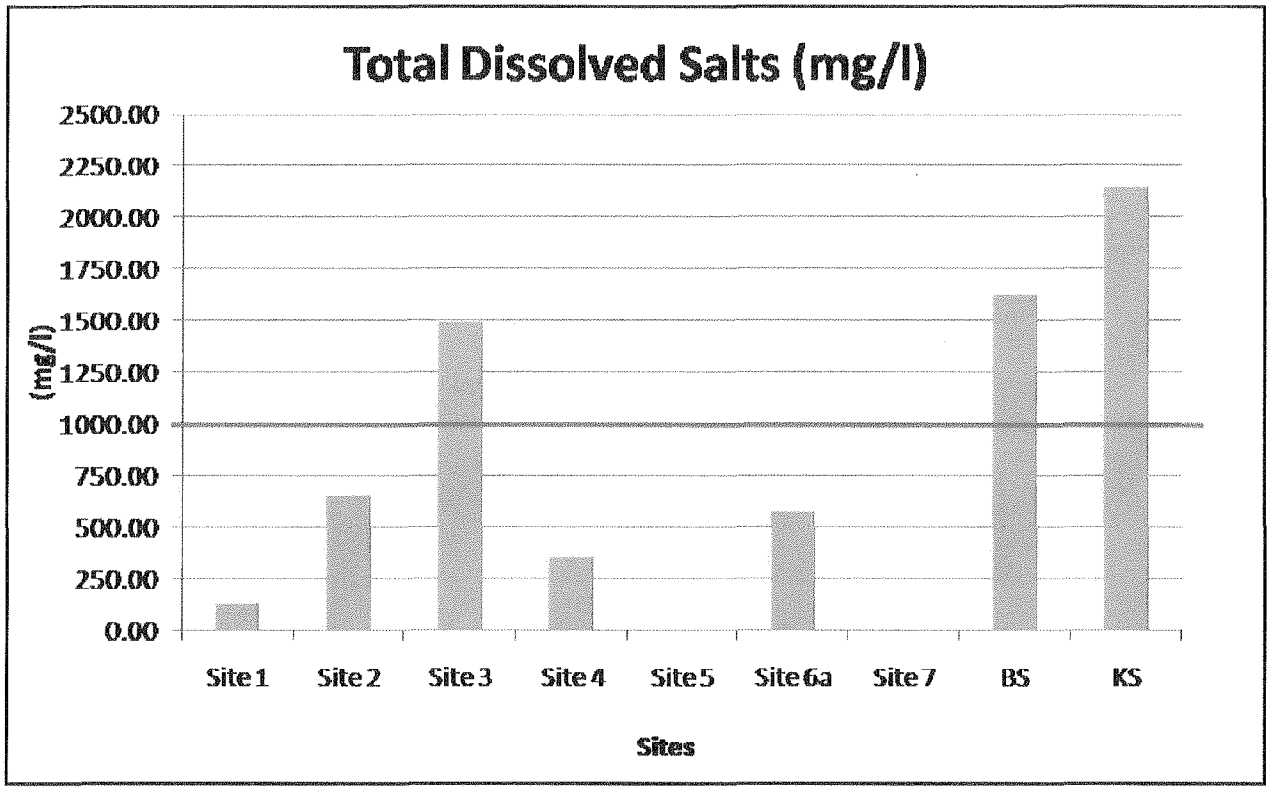

Figure 3: TDS recorded during the January 2010 survey (red line indicates guideline value).

6.1.3 Dissolved Oxygen (DO)

The maintenance of adequate Dissolved Oxygen (DO) concentrations is critical for the survival and functioning of the aquatic biota as it is required for the respiration of all aerobic organisms (DWAF, 1996). Therefore, DO concentration provides a useful measure of the health of an ecosystem (DWAF, 1996). The median guideline for DO for the protection of aquatic biota is > 5 mg/ℓ (Kempster *et al.*, 1980).

During the January 2010 survey DO levels were considered inadequate (> 5 mg/l) with only site KS (5.50 mg/l) being above the median guideline. Low oxygen concentrations at the remainder of the sites are is likely to have a limiting affect on aquatic biota (Figure 4).

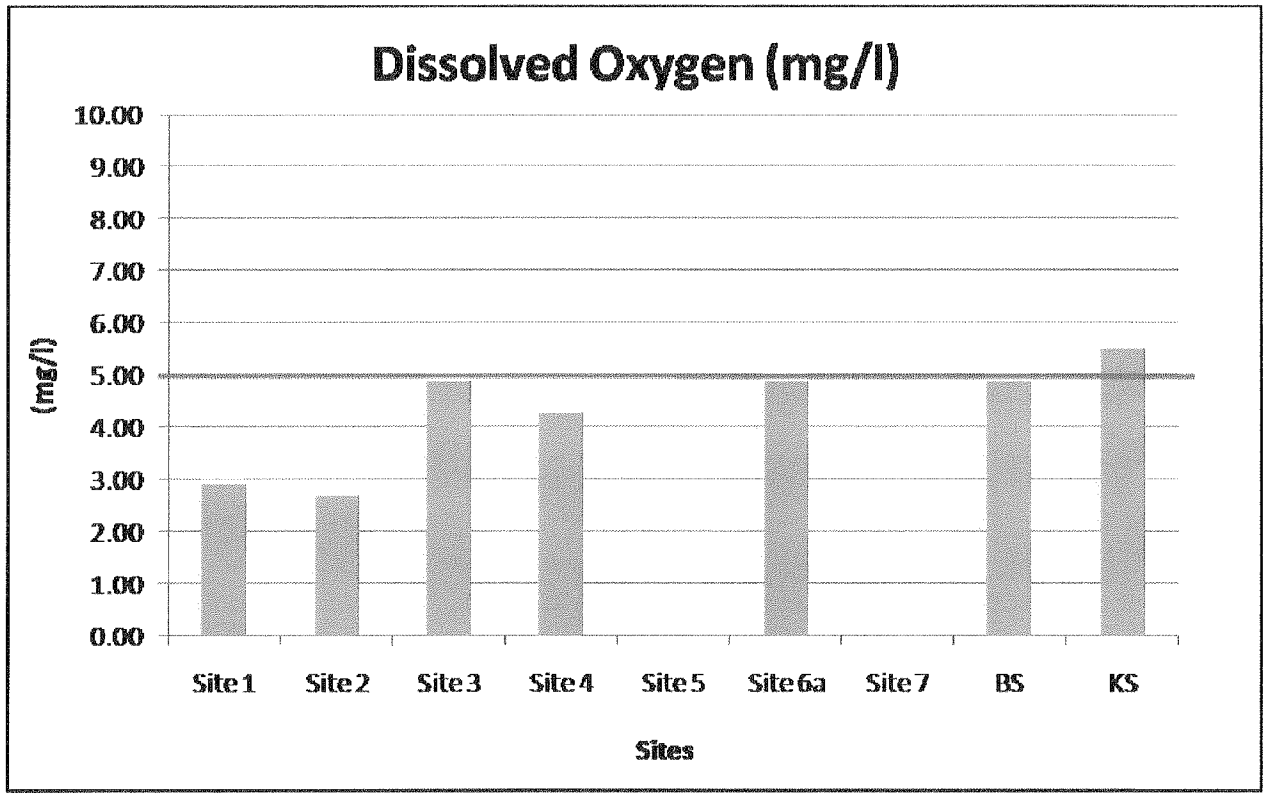

Figure 4: DO concentrations recorded during the January 2010 survey (red line indicates guideline value).

6.1.4 Temperature (˚C)

Water temperature plays an important role in aquatic ecosystems by affecting the rates of chemical reactions and therefore also the metabolic rates of organisms (DWAF, 1996). Temperature affects the rate of development, reproductive periods and emergence time of organisms (DWAF, 2005). Temperature varies with season and the life cycles of many aquatic macroinvertebrates are cued to temperature (DWAF, 2005). The temperatures of inland waters generally range from 5 to 30 degrees Celsius (˚C) (DWAF, 1996).

During the January 2010 survey water temperatures ranged from 23.0˚C at site KS to 29.8 ˚C at site BS (Figure 5). The water temperatures recorded were considered to be normal for these freshwater aquatic systems at that time of the year and would not have a limiting effect on aquatic biota.

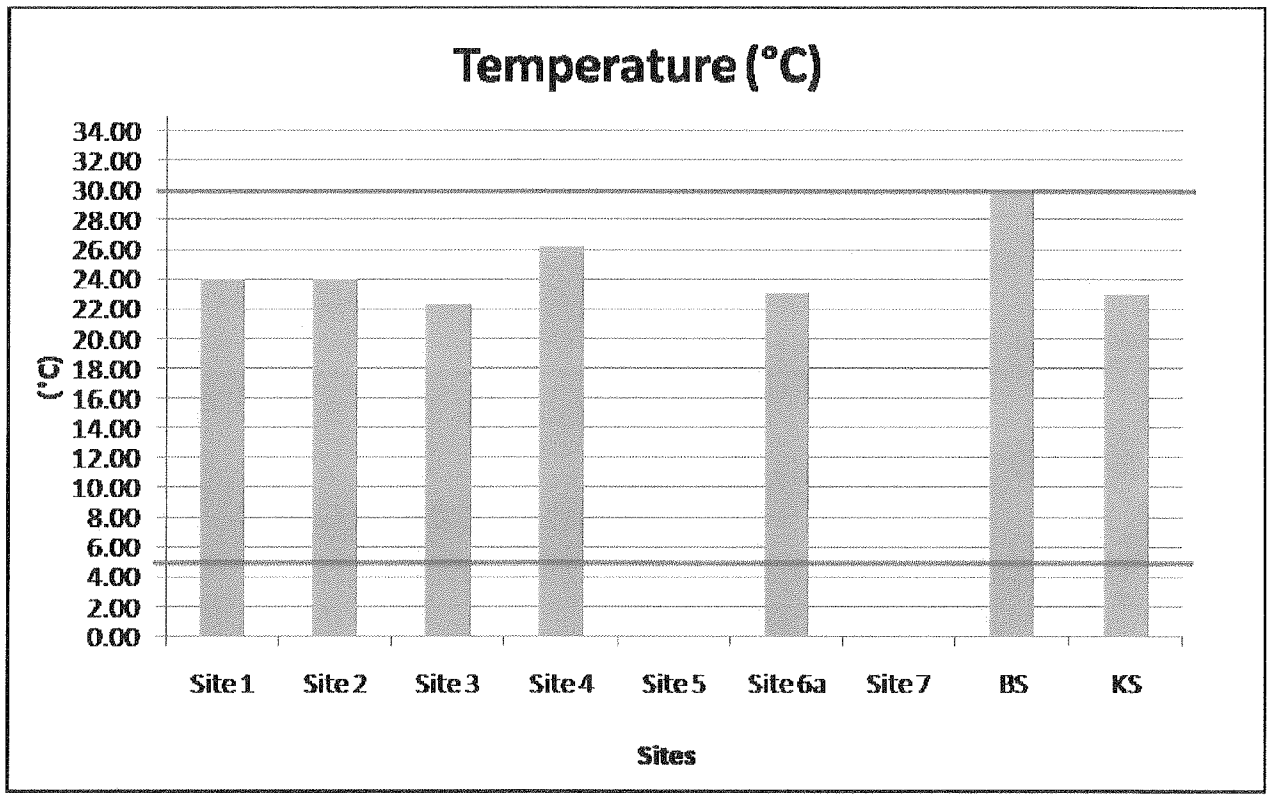

Figure 5: Temperature recorded during the January 2010 survey (red lines indicate guideline values).

6.2 Habitat Assessment

6.2.1 Invertebrate Habitat Assessment System (IHAS, *version 2*)

The Invertebrate Habitat Assessment System (IHAS, *version2*) was developed specifically for use with rapid biological assessment protocols in South Africa (McMillan, 1998) and focuses on the evaluation of the habitat suitability for aquatic macroinvertebrates. The IHAS scores recorded during the January 2010 survey are presented in Table 8.

Table 8: Invertebrate Habitat Assessment System (IHAS, *version 2*) scores recorded during the January 2010 survey.

Site	January 2010	
	IHAS Score	Description
Site 1	32	Inadequate / poor
Site 2	34	Inadequate / poor
Site 3	52	Inadequate / poor
Site 4(RR3)	47	Inadequate / poor
Site 5(RR1)	Dry	
Site 6a(RR2)	42	Inadequate / poor
Site 7	Dry	
BS	N/A	
KS	49	Inadequate / poor

Based on the IHAS results habitat availability was inadequate for diverse aquatic macroinvertebrate communities due to the homogenous habitat structure and absence of stones-in-current biotope. Site BS was an artificial channel that was not suitable for SASS5 sampling, for this reason the IHAS could not be applied.

6.3 Aquatic Macroinvertebrates

Aquatic macroinvertebrates were collected using the standard SASS5 protocol described in section 4.3. A list of the aquatic macroinvertebrates collected during the January 2010 survey is provided in Appendix C and a summary is provided in Table 9.

Table 9: Aquatic macroinvertebrate data collected during January 2010 survey

Site	January 2010		
	Number of taxa	SASS5 Score	ASPT
Site 1	10	50	5.00
Site 2	4	12	3.00
Site 3	2	7	3.50
Site 4(RR3)	7	30	4.29
Site 5(RR1)	Dry		
Site 6a(RR2)	4	10	2.50
Site 7	Dry		
BS	N/A		
KS	1	5	5.00

ASPT *Average Score Per Taxon*

A total of 18 aquatic macroinvertebrate taxa were recorded in the sample area during the January 2010 survey (1 to 10 taxa per site) (Table 9). The SASS5 scores ranged from 5 at site KS to 50 at Site 1 (Table 9). The Average Score per Taxa (ASPT) values, an indication of the average tolerance / intolerance of the taxa to river health degradation, ranged from 2.5 at Site 6a to 5.0 at site KS and Site 1 (Table 9). Although the ASPT score observed at KS is high, it should be noted that this was based on one taxa only and will therefore be interpreted appropriately under section 6.3.1.

6.3.1 Biotic integrity based on SASS5 results

The Present Ecological State (PES) classes and descriptions of each of the classes are presented in Table 10.

Table 10: Present Ecological State (PES) classes based on SASS5 results obtained in January 2010

Site	January 2010	
	PES Class	Description
Site 1	C	Moderately Impaired
Site 2	F	Very Severely Impaired
Site 3	F	Very Severely Impaired
Site 4(RR3)	E	Severely Impaired
Site 5(RR1)	Dry	
Site 6a(RR2)	F	Very Severely Impaired
Site 7	Dry	
BS	N/A	

Site	January 2010	
	PES Class	Description
KS	F	Very Severely Impaired

Based on the SASS5 results, biotic integrity in the project area ranged from moderately impaired to very seriously impaired (Table 10). Biotic integrity at site 1, which showed the highest diversity of taxa ranked as moderately impaired. Biotic integrity at site 4 was considered severely impaired with only tolerant taxa present, whilst the remainder of the sites displayed both low diversity and only tolerant taxa.

6.4 Ichthyofaunal Assessment

6.4.1 Expected species list

An expected fish species list for the generalised sampling area was compiled based on the following sources: Skelton (2001), SAIAB (2009) and Kleynhans *et al.* (2007). Based on this assessment twelve indigenous fish species are expected to occur in the sample area. The expected fish species list is provided in Table 11. Due to the location and close proximity of sites to informal settlements and mining activities, the likelihood of observing many of these species is reduced.

Table 11: Expected fish species list and current IUCN status.

Species	Common Name	IUCN Status
Barbus anoplus	Chubbyhead Barb	Least Concern
Barbus neefi	Sidespot Barb	Unlisted
Barbus paludinosus	Straightfin Barb	Unlisted
Barbus trimaculatus	Threespot Barb	Unlisted
Chiloglanis pretoriae	Shortspine Suckermouth	Least Concern
Clarias gariepinus	Sharptooth Catfish	Unlisted
Cyprinus carpio	Carp	Data Deficient*
Gambusia affinis	Mosquitofish	Unlisted*
Labeo cylindricus	Redeye Labeo	Unlisted
Labeo umbratus	Moggel	Least Concern
Labeobarbus marequensis	Lowveld Largescale Yellow	Least Concern
Labeobarbus polylepis	Smallscale Yellowfish	Least Concern
Micropterus salmoides	Largemouth Bass	Unlisted*
Pseudocrenilabrus philander	Southern Mouthbrooder	Unlisted
Tilapia sparrmanii	Banded Tilapia	Unlisted

* *Exotic Species*

6.4.2 Observed species list

No fish species were recorded during the fish sampling that was conducted in the sample area during the January 2010 survey. An electro-fishing device (Smith – Root LR24) was used to conduct the fish survey. Electro-fishing was performed for 40 minutes at each site or until the entire available habitat in a 100m stretch of river has been sampled.

Sites 1 and 2 were found to be wetland habitats once on site. Due to the habitat availability in wetlands and lack of certain biotopes, such as stones, species such as *Chiloglanis pretoriae, Labeo cylindricus, Labeo*

umbratus, Labeobarbus marequensis and Labeobarbus polylepis would not be expected to occur at these sites.

Site 5 and 7 were dry at the time of sampling and could therefore not be sampled.

6.4.3 Presence of Red Data species

Of the twelve expected fish species:

- Nine are currently unlisted on the IUCN Red List;
- Four are currently listed as Least Concern (LC). Species in this category are widespread and abundant (IUCN, 2009) (Table 11); and
- One species (*Cyprinus carpio*) is currently listed as Data Deficient. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking (IUCN, 2009). This species is exotic in South Africa, introduced in the 1700's (Skelton, 2001).

Based on this assessment no rare or endangered fish species were expected to occur or were recorded in the sample area.

6.4.4 Biotic integrity based on fish results

The interpretation of the FAII scores follows a descriptive procedure into which the FAII score is allocated into a particular class known as the Present Ecological Status (PES) Class (Table 12).

Table 12: FAII Results and PES Classes recorded during the January 2010 survey.

Site	FAII Score	PES Class	Description
Site 1	0	F	Critically modified
Site 2	0	F	Critically modified
Site 3	0	F	Critically modified
Site 4(RR3)	0	F	Critically modified
Site 5(RR1)	Dry		
Site 6a(RR2)	0	F	Critically modified
Site 7	Dry		
BS	0	F	Critically modified
KS	0	F	Critically modified

According to the FAII results, all the sites in the study area were in a critically modified state (Ecological Class F). Homogeneous habitat and poor water quality resulted in the lack of Ichthyofaunal diversity.

7.0 ASSESSMENT OF POTENTIAL IMPACTS AND MITIGATION MEASURES

Any development in a natural system will impact on the environment, usually with adverse effects. From a technical, conceptual or philosophical perspective the focus of impact assessment ultimately narrows down to a judgment on whether the predicted impacts are significant or not (DEAT, 2002). Alterations of the natural variation of flow by river regulation through decreasing or increasing the flows can have a profound influence upon almost every aspect of river ecological functioning (Davies and Day, 1998).

Current South African legislation, as indicated at the outset of this report, requires that the necessary study be conducted and mitigation measures assessed so as to reduce or prevent the degradation of aquatic and

wetland habitats and biotic populations due to barriers in the river that may impact on migration and ecosystem functioning.

7.1 Potential impacts of proposed collection and distribution pipelines on the aquatic ecosystems

The assessment of potential impacts of the proposed collection and distribution pipelines on the aquatic ecosystems are discussed according to the following:

- Impacts on water quality;
- Aquatic habitat loss and alteration impacts; and
- Aquatic biotic impacts (aquatic macroinvertebrates, fish).

7.1.1 Water quality

Water quality at the pipeline / watercourse crossing sites will be impacted on as a result of in-stream impacts and bank disturbances during the construction and operational phases. Impacts on water quality are likely to result from the following activities:

- Riparian vegetation removal and bank disturbances, leading to increased erosion and runoff;
- Building of access roads to the site and servitudes along the pipeline routes, resulting in large quantities of topsoil removal and the potential for increased erosion;
- Trenching of site to lay pipeline, resulting in large sediment and soil loads entering the streams or wetland areas;
- Oil from generators and vehicles may enter the river systems;
- General structure disturbances, resulting in increased sediment input from erosion;
- River diversion, which will have direct impacts on the water quality due to the invasive nature of the activity; and
- Spills into the aquatic ecosystem occurring from leaking or burst pipelines.

Fluctuations in water quality (pH, Electrical Conductivity (EC), TDS, DO, and temperature) will in turn have impacts on the biotic communities and vegetation. During construction, these impacts are considered to be of minimal (moderate impact) significance, temporary and localised.

Once construction has been completed, the fluctuations in water quality are likely to stabilise and reach a new equilibrium.

During the operation of the pipeline, provided that the pipeline / watercourse crossings are constructed below the groundwater flow of the stream (in the case of buried crossings, i.e. pipe jack), water quality changes to the downstream aquatic ecosystems will be minimal (low impact) and localised. This should minimise upstream inundation as a result of a damming effect on groundwater or surface water flow and ensure the natural flow regime and flood events are maintained.

Impacts on the water quality of watercourses may occur during the operational phase as a result of accidental scour valve discharges, leaking pipelines and accidental spillages.

7.1.2 Habitat changes

Macro-channel habitat and riparian vegetation loss or alteration

The most significant impact on the macro-channel and riparian vegetation is expected to occur during the construction phase. The following proposed activities will impact on the macro-channel and riparian vegetation during this phase:

- Riparian vegetation removal;
- Building of access roads to the site and servitudes along the pipeline routes, resulting in large quantities of topsoil removal and possible increased erosion potential;
- Trenching of site to lay pipeline, resulting in large sediment and soil loads entering the streams or wetland areas;
- Bank disturbances; and
- River diversion.

These activities may result in possible bank destabilisation, increased erosion potential and exotic vegetation encroachment. The construction phase activities should be conducted during the dry season so as to minimise the construction effort in wet and muddy conditions as well as limit the impact. Once construction has been completed, rehabilitation of the site is essential to minimise the impact. The impact is rated as moderate and localised (Table 13).

During the operational phase, in-stream channel modifications or bank vulnerabilities may result in increased bank erosion and undercutting, as well as the deposition of sand bars or levies downstream of the crossing site. These impacts are expected to be minimal (low impact) (Table 13) depending on the design trenches and the degree to which surface and ground water flow is impeded.

In-stream channel habitat loss or alteration

Due to the temporary impacts and disturbances to the riparian and marginal vegetation as well as the in-stream habitats during the construction phase, the impact will only be minimal (moderate impact) and on a localised scale. Once in the operational phase, these impacts should be minimal (low impact) and the habitats should recover with suitable rehabilitation methods.

Minimal bed armouring and degradation downstream of the crossings are likely to occur. Silt load increases (sediment supply increase) downstream of the crossings are also likely to occur. These impacts are considered to be minimal (low impact) and localised.

These impacts will have direct implication on the type and distribution of in-stream habitats, in particular, rocky habitats, within the downstream river channel. Siltation of cobble and gravel beds may occur as a result. This will, however, flush out with the first high flow event.

Aquatic macroinvertebrate habitat availability

Due to the minimal and localised in-stream habitat alterations, it is expected that impact on the current habitat availability will only be minimal (low impact). Increased siltation may reduce the amount of stones in current (SIC) habitat, but this will be minimal and should recover during high flow events.

Ichthyofaunal habitat availability

Due to the minimal and localised in-stream habitat alterations a slight decrease in marginal vegetation cover types will occur. This is considered to be minimal (low impact) and localised.

7.1.3 Biotic changes

Aquatic macroinvertebrate diversity and abundance

During the construction phase, large disturbance to the habitats within the localised area will impact on the aquatic macroinvertebrate communities. This is especially so at sites where the pipeline will be constructed via excavation trenches. These impacts will, however, be localised and temporary, and thus the aquatic macroinvertebrate communities should recover quickly as the habitats are rehabilitated and re-colonisation takes place.

Ichthyofaunal diversity and abundance

During the construction phase, any fish species that occurs at or near the sites will move away. It is likely that this will continue for the duration of the construction phase. During the operational phase, re-colonisation of the aquatic macroinvertebrate communities will result in fish moving back into the area. This scenario depends on whether refuge areas still exist in close proximity to the site. Any fish population existing in highly modified areas may already represent refuge areas as a result of previous disturbances or loss of habitats in the area. As long as flow is not impeded, migration and stream connectivity will allow for the free movement of fish species to, from and within the sites.

7.2 Mitigation measures

The mitigation measures are discussed collectively in the sections that follow. However, specific mitigation measures for specific sites have also been provided, and indicated as such.

7.2.1 Avoidance

In order to avoid significant (high) impacts to the aquatic ecosystems, certain sections of the pipeline routes could be re-aligned so as to follow different routes that would have less of an impact on the aquatic and wetland ecosystems or none at all. In particular, the following routes should be re-aligned / refined:

Kromdraai Collection Pipeline Route

- At the watercourse crossing: Site 1, the pipeline should be re-routed to follow the upstream road servitude to the northeast. This will minimise the impact to the wetland and aquatic ecosystems at this site. This can be done by increasing the size of the culvert on the road crossing and constructing the pipeline along this route.

Middelburg Steam and Station Collection Pipeline Route

- At the watercourse crossing: Site 3, the pipeline should be re-routed to cross the stream at the upstream road servitude 100 m to the east. This will minimise the impact to the wetland and aquatic ecosystems at this site. This can be done by increasing the size of the culvert on the road crossing and constructing the pipeline along this route.

Distribution Pipeline Route

- At the watercourse crossing: Site 4, along the Brugspruit, the pipeline should be re-routed to follow the upstream road servitude (R104) to the south. This will minimise the impact to the wetland and aquatic ecosystems at this site. This can be done by increasing the size of the culvert on the road crossing and constructing the pipeline along this route; and

- At the watercourse crossing: Site 5, the pipeline should be re-routed to follow the upstream road servitude (R104) to the south. This will minimise the impact to the wetland and aquatic ecosystems at this site. This can be done by increasing the size of the culvert on the road crossing and constructing the pipeline along this route.

7.2.2 Minimisation

In order to minimise the impacts of the proposed pipeline / watercourse crossings on the aquatic ecosystems, it is necessary to minimise the impacts on the flow, sediment input, habitat availability, and migration paths of aquatic biota. This can be accomplished by the following:

- Place the relevant sections of the pipeline below the groundwater flow component of the streams and wetlands so as to not impede the flow and impact the sites once construction is completed;
- At sites 1, 3, 4 and 5, construct the pipeline as close to the existing upstream road servitudes as possible;
- Construct pipeline / watercourse crossings during the dry season so as to limit impacts to the sites, particularly in terms of flow diversion;
- Construct pipeline / watercourse crossings in stages so as to limit the impact to the sites. As one stage is complete, rehabilitate the habitat before starting the next construction section;
- Implement low impact construction techniques so as to minimise the impact on the river system, especially during the diverting of any water during construction;
- Where possible, keep construction activities out of the wetland buffer zone;
- Limit movement of construction vehicles within wetlands;
- Restrict vehicles to service roads;
- Put construction practices in place to avoid dumping on or damage to the wetlands; and
- Monitor the water quality, habitat and biological responses both upstream and downstream of the pipeline / watercourse crossing sites during construction on a quarterly basis, and on a bi-annual basis during the operational phase of the project. Information from this monitoring can be used to quickly implement management actions should a significant decrease in ecological integrity upstream or downstream of the crossings occur.

7.2.3 Reduction

- Clean up and rehabilitate any accidental spillages or impacts to the aquatic and wetland ecosystems;
- Devise and implement a relocation plan if rare and sensitive species are identified during construction;
- Monitor the pipeline for leaks and spills on a regular basis during the operational phase;
- Repair damaged pipes immediately to avoid excessive spills;
- Contain spills to avoid degrading water quality downstream;
- Implement dust suppression on dirt roads during construction to avoid excessive dust formation;
- Maintain service roads to avoid erosion and excessive dust formation; and
- Design and implement suitable long-term water and habitat monitoring programmes as well as an ecological biomonitoring programme, for both the construction and operational phases of the project.

7.2.4 Rectification

- Implement suitable vegetation and habitat rehabilitation where construction site impacts occur. This should be done in consultation with the aquatic and wetland ecologist;

- Prevent pipeline spillages and, should any occur, clean up and rehabilitate immediately;
- Where wetland soils have been compacted, labourers on foot should loosen soils with light weight tools; and
- Implement corrective mitigation measures should any significant decrease in ecological integrity occur (both aquatic and wetland) within any biomonitoring period as a result of impacts associated with the pipeline / watercourse crossings.

7.2.5 Compensation

Compensation for the impacts associated with the pipeline is not foreseeable. The purpose of this study was to ensure that the impacts to the aquatic and wetland ecosystems are minimal and that the project does remove or degrade the systems to a large degree.

7.3 Impact significance

The significance of the impacts of the pipeline / watercourse crossings on the aquatic ecosystems are discussed separately (Table 13) to (Table 15) for the following impacts:

- Removal of mine water from the project area;
- Pipeline construction; and
- Pipeline layout and operation.

8.0 CONCLUSIONS

Based on the results of the January 2010 survey the following conclusions were reached:

- Based on *in situ* water quality analysis, the pH value at Site 1, Site 3, BS and KS were acidic. Dissolved oxygen was below guideline values at all sites except site KS. Total dissolved solid concentrations were high at sites 3, BS and KS contributing to the severely impaired biotic integrity recorded within the area.
- Based on the IHAS results, habitat availability was a limiting factor of aquatic macroinvertebrate diversity at all sites. The absence of adequate Stones-In-Current habitat and increased channelization contributed to the poor habitat availability at these sites;
- Based on SASS5 results biotic integrity in the project area ranged from moderately impaired (PES Class C) to very seriously impaired (PES Class F);
- No fish species were recorded at any of the sites;
- Based on the lack of fish from all the sites the Fish Assemblage Integrity Index (FAII) was rated as critically modified (PES Class F);
- Impacts associated with the project on the aquatic ecosystems include; impacts on water quality; aquatic habitat loss and alteration; and impacts on aquatic biota (aquatic macroinvertebrates, fish);
- Mitigations included route refinements at sites 1, 3, 4 and 5; implementation of low impact construction techniques; prevention of large-scale disturbances to the wetland and aquatic ecosystems at the sites; containment and rehabilitation of any site related impacts to the aquatic ecosystems; and the implementation of a monitoring programme for water quality, habitat and biotic integrity;
- The significance of the impacts were rated according to the impact from the removal of mine water from the project area; pipeline construction; and pipeline layout and operation;
- The significance of the impacts were rated as low for most impacts with easily obtainable mitigations that reduced the impacts to the aquatic ecosystems;
- Moderate impacts to macro-channel and in-stream habitats were identified and mitigations indicated that the impact would be low if implemented;
- Impacts from the other proposed infrastructure for the project were identified for the WRP, pump stations, waste generation and scour valves. Prevention of water quality and erosion impacts to the aquatic ecosystem was mitigated.
- Based on the results obtained during this study, it is clear that the water bodies associated with the proposed pipeline are already in an impacted state.
- As far as the assessment of the aquatic component of the associated sites goes, is there no reason why the construction of the pipeline cannot go ahead. During the aquatic study no endangered or vulnerable taxa was found.

9.0 RECOMENDATIONS

It is recommended that:

- All mitigation options are implemented so as to prevent large-scale impacts to the aquatic ecosystems;
- A monitoring programme for the aquatic ecosystem is implemented for both the construction and operation phases, including water quality, habitat and biotic integrity. The monitoring program must consist of two aquatic biomonitoring surveys per year. One in the low flow season (May – September)

and one in the high flow season (October – April). The monitoring programme must include the same indicators as used during the baseline survey.

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GOLDER ASSOCIATES AFRICA (PTY) LTD

Alvar Koning
Aquatic Biologist

Peter Kimberg
Divisional Leader - Ecology Division

AK/WA/CVB/PK/ak

Reg. No. 2002/007104/07

Directors: FR Sutherland, AM van Niekerk, SAP Brown, L Greyling, SM Manyaka

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APPENDIX A
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APPENDIX B
SITE PHOTOGRAPHS

Site 1 – Downstream

(Taken by: A .Koning. 01/2010)

Site 2 – Downstream

(Taken by: A .Koning. 01/2010)

Site 3 – Downstream

(Taken by: A .Koning. 01/2010)

Site 3 – Upstream

(Taken by: A .Koning. 01/2010)

Site 4 – Downstream

(Taken by: A .Koning. 01/2010)

Site 5 – Downstream

(Taken by: A .Koning. 01/2010)

Site 6a – Downstream

(Taken by: A .Koning. 01/2010)

BS – Downstream

(Taken by: A .Koning. 01/2010)

KS – Downstream

(Taken by: A .Koning. 01/2010)

APPENDIX C

AQUATIC MACROINVERTEBRATE DATA

	January 2010					
Aquatic macroinvertebrate	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 6a**	**KS**
ANNELIDA						
Oligochaeta (Earthworms)		A				
Hirudinea (Leeches)				A		
CRUSTACEA						
Potamonautidae* (Crabs)				A		
EPHEMEROPTERA (Mayflies)						
Baetidae 1sp					A	
Baetidae 2 sp				A		
ODONATA (Dragonflies & Damselflies)						
Coenagrionidae (Sprites and blues)	B					
Aeshnidae (Hawkers & Emperors)	B			A		
HEMIPTERA (Bugs)						
Corixidae* (Water boatmen)					1	
Gerridae* (Pond skaters/Water striders)	A					
Hydrometridae* (Water measurers)	A					
Pleidae* (Pygmy backswimmers)	A					
Veliidae/M...veliidae* (Ripple bugs)	B	A				
TRICHOPTERA (Caddisflies)						
Cased caddis:						
Leptoceridae	A					
COLEOPTERA (Beetles)						
Dytiscidae/Noteridae* (Diving beetles)	B					
Gyrinidae* (Whirligig beetles)	A		OBS	A		A
DIPTERA (Flies)						
Chironomidae (Midges)	B		B	A	C	
Culicidae* (Mosquitoes)					B	
GASTROPODA (Snails)						
Physidae* (Pouch snails)		A				
Planorbinae* (Orb snails)		A		A		
Total number of taxa	**10**	**4**	**2**	**7**	**4**	**1**
SASS Score	**50**	**12**	**7**	**30**	**10**	**5**
ASPT	**5.00**	**3.00**	**3.50**	**4.29**	**2.50**	**5.00**

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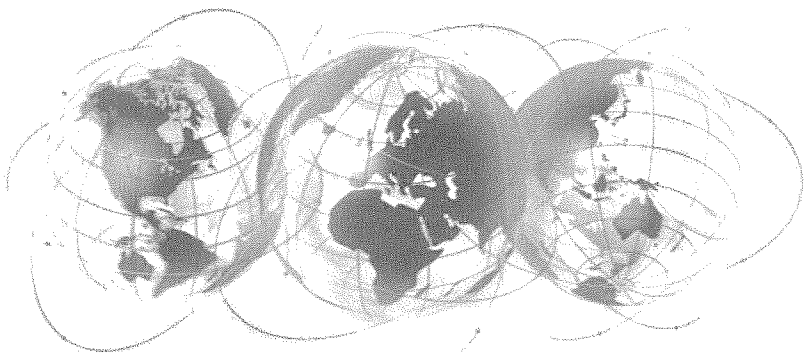

Golder Associates Africa (Pty) Ltd
25 Main Avenue
Florida
Roodepoort
South Africa
T: [+27] (11) 672 0666

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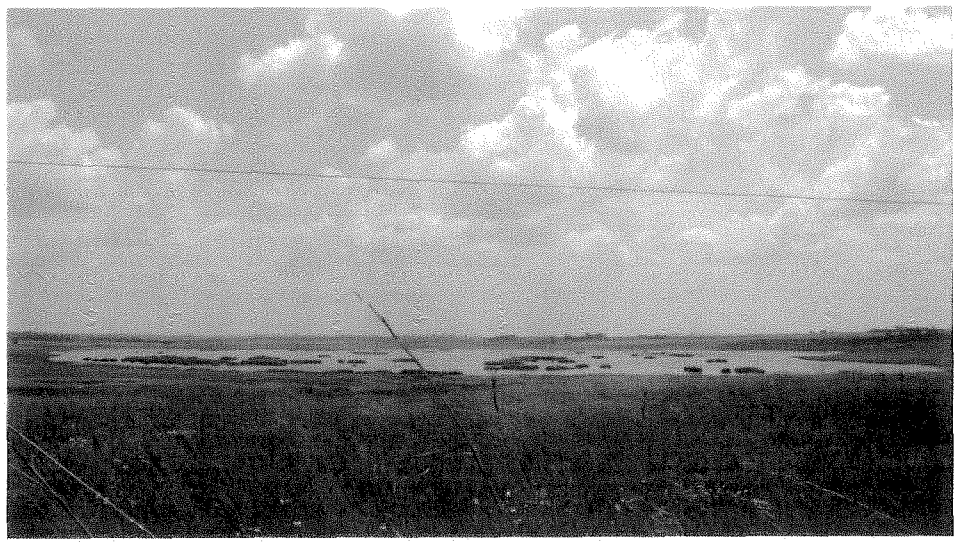
APPENDIX K

Specialist Report: Wetland Ecology

October 2010

REPORT ON

SPECIALIST WETLAND STUDY FOR THE PROPOSED eMALAHLENI MINE WATER RECLAMATION PROJECT



Golder Report Number: 12485-9819-11

REPORT

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Executive Summary

The Ecology Division of Golder Associates Africa (Pty) Ltd. (GAA) was commissioned to conduct a wetland assessment for input into the Anglo American Thermal Coal eMalahleni Mine Water Reclamation Environmental Impact Assessment (EIA).

The main objectives of the wetland study were to delineate and classify the wetlands, assess the integrity and importance of the wetlands, and propose suitable mitigation measures.

Wetlands were delineated using the procedure for wetland delineation as stipulated by DWAF, using terrain, soil wetness indicator and vegetation. SANBI's "Further development of a proposed National Classification System for South Africa" was used to classify the wetlands within the study area. The wetlands were classified up to level five. The wetlands found on site were classified as channelled valley-bottom wetlands, non-channelled valley-bottom wetlands, a hill slope seep and depressions.

The Present Ecological Status (PES) Method was used to establish the integrity of the wetland in the study area. During the assessment of the wetlands it was found that most of the wetland's integrity was moderate. Five wetlands had a very low integrity and two had a high ecological integrity. Using the Wetland Index for Habitat Integrity (Wetland-IHI) the habitat integrity of the wetlands was found to be moderately to largely modified with a loss of natural habitat, biota and basic ecosystem functions.

The ecological importance and sensitivity assessment was conducted according to the guidelines as discussed by DWAF and it was found that the wetlands were mostly considered ecologically important and sensitive on a provincial or local scale. Four of the sites weren't considered ecologically important.

The natural services as calculated by the Wet-EcoServ technique were scored for the wetlands on the project site and it was found that the wetlands mostly scored moderately, with two wetlands having high natural services and one with low natural services. The human services ranged from very low to moderate.

During the assessment of the possible impacts that the pipeline and associated infrastructure could have on the wetland the following was of concern:

- Construction phase
  - Bed disturbance, vegetation removal and habitat degradation
  - Inundation due to narrowing of the channel during construction
  - Dust and sediment settling on the wetland
  - Compacting of wetland soils
- Operation phase
  - Inundation due to pipeline not buried deep enough below the wetland water table
  - Eroding of wetland substrates due to water released from scour valves
  - Degradation of habitat due to untreated mine water released/spilled into the system

It is recommended that when constructing pipeline they be buried below the water flow table, to avoid restriction of water upstream of the wetland. It was suggested that the pipeline at sites WC 1, WC3, WC4, WC5, WC6 and WC8 were built above ground to follow road, or railroad servitudes, or existing pipe-bridges where applicable and feasible.

Construction should be managed in order to apply good construction practices. Weak spots on pipelines should be reinforced if detected to avoid spillage. Where a spill does occur, it should be contained and cleaned as quickly as possible.

It was also suggested that the ecological status of the wetland (through Wetland-IHI and PES method), floral species composition (through community analysis) and water quality at pipelines, abstraction points and downstream points along the Blesbokspruit and Kromdraaispruit be monitored. The pipelines should be monitored bi-annually during construction and bi-annually for a year thereafter. At abstraction points the monitoring should be conducted bi-annually after initiation of abstraction. Monitoring should be conducted by a wetland ecologist. Findings from the monitoring cycle will indicate further management action if required.

Rehabilitation of the sites post-construction was recommended.

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FIGURES

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1.0 INTRODUCTION

The Ecology Division of Golder Associates Africa (Pty) Ltd. (GAA) was commissioned to conduct a wetland assessment for input into the Anglo Kromdraai Pipeline Baseline and Environmental Impact Assessment (EIA). The proposed pipeline is situated near to eMalahleni in the Mpumalanga Highveld, within the quaternary drainage regions B11K, B20G and B11G, in the Olifants Water Management Area (WMA4). The study area falls within the Highveld (11) – Lower Level 1 Ecoregion and the Moist Sandy Highveld Grassland Biome (Low and Rebelo, 1996).

This document presents the results of the January 2010 survey of wetland ecosystems associated with the aforementioned project.

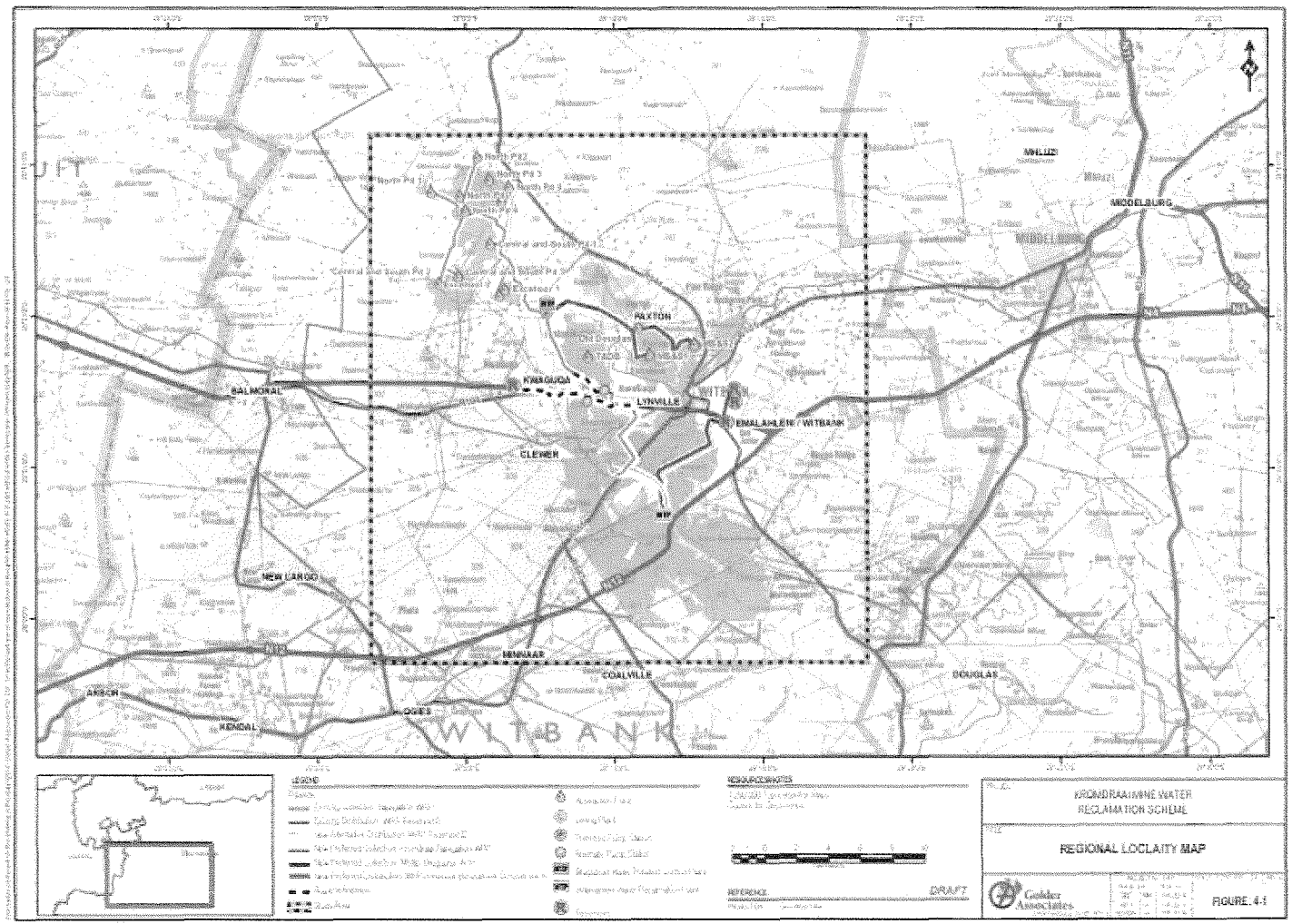

Figure 1: Regional location of study area.

2.0 STUDY AREA

Ten sites were selected in accordance with the proposed pipeline crossings and impacts related to reduction of water input into the wetlands.

Co-ordinates of sampling sites were determined using a Garmin GPS 60CSx and are listed in Table 1. A map of the study area showing the location of wetland survey sites is presented in Figure 2.

Table 1: Location of wetland sites

Site	Latitude	Longitude
WC 1	-25.8045763	29.1082959
WC 2	-25.829503	29.1249206
WC 3	-25.8249123	29.1402868
WC 4	-25.8741338	29.1280413
WC 5	-25.8764814	29.1532537
WC 6 (original)	-25.8784195	29.1642723
WC 6 (route refinement)	-25.8754000	29.1582000
WC 7	-25.934759	29.1944207
WC 8	-25.917819°	29.172401°
WC 9	-25.9150000	29.1754000
BS	-25.8481044	29.2121675
KS	-25.7930451	29.0656874
WC 10 (existing and additional distribution pipeline section)	-25.925243°	29.193668°
WC 11(existing and additional distribution pipeline section)	-25.921179°	29.192759°
WC12 (existing and additional distribution pipeline section)	-25.909429°	29.211777°

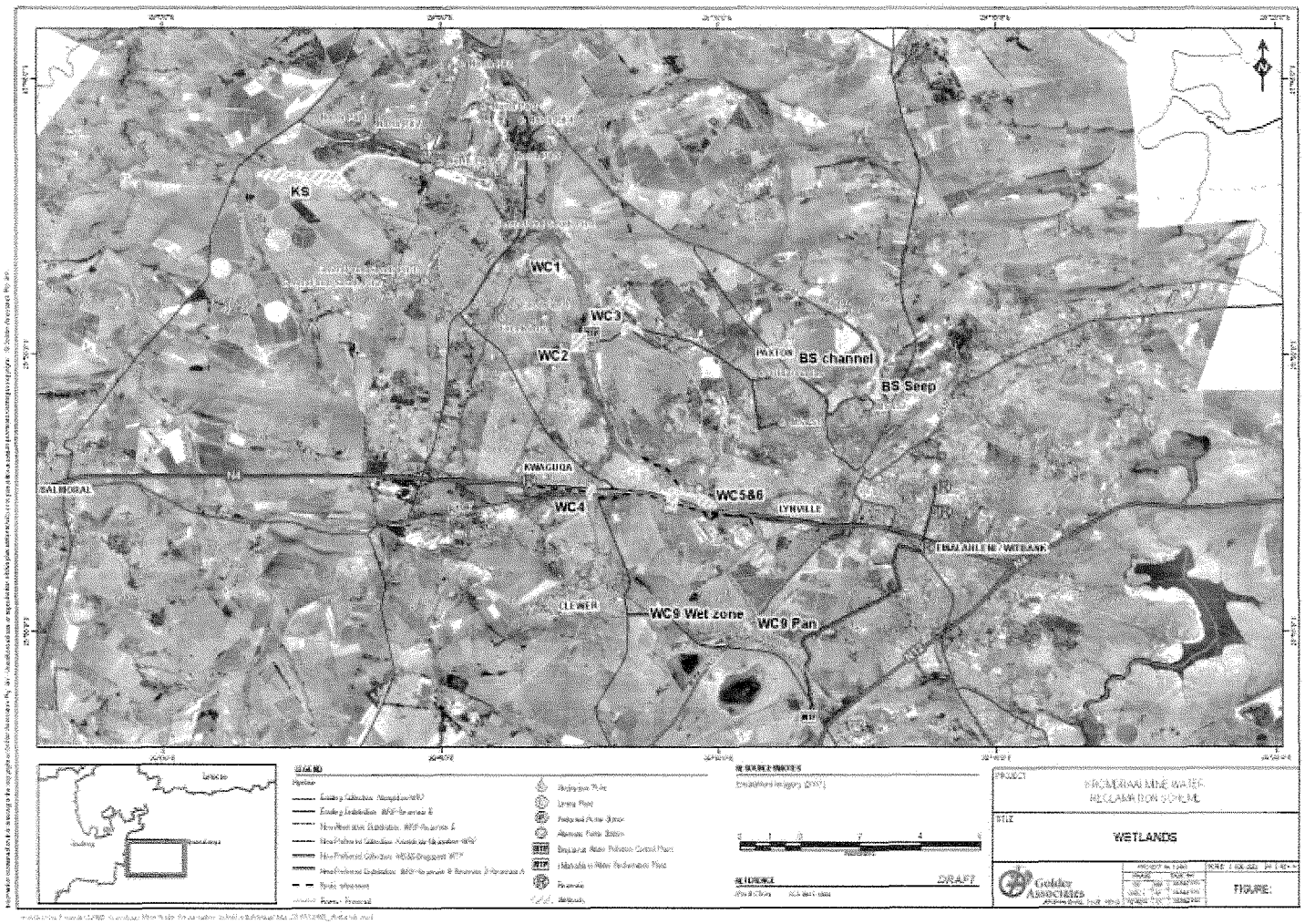

Figure 2: Study area.

3.0 OBJECTIVES

The main objectives of the wetland study were to:

- Delineate and classify the wetland associated with the pipeline;
- To assess the integrity and importance of the wetland; and
- To assess the significance of the potential impacts and propose mitigation measures.

4.0 METHODOLOGY

4.1 Wetland delineation

The procedure for the wetland delineation was conducted according to the Guidelines for delineating the boundaries of a wetland set out by the Department of Water Affairs and Forestry (DWAF, 2005). Due to the transitional nature of wetland boundaries, these are often not clearly apparent and the delineations should therefore be regarded as a human construct. The delineations are based on scientifically defensible criteria and are aimed at providing a tool to facilitate the decision making process regarding the assessment of the significance of impacts that may be associated with the proposed developments.

The wetlands were delineated by considering the following wetland indicators (DWAF, 2005):

- Terrain unit indicator helps identifying those parts of the landscape where wetlands are most likely to occur. Wetlands occupy characteristic positions in the landscape and can occur on the following terrain units: crest, midslope, footslope, and valley bottom;
- Soil wetness indicator identifies the morphological signatures developed in the soil profile as a result of prolonged and frequent saturation;
- The vegetation indicator identifies hydrophytic vegetation associated with frequently saturated soils; and
- Soil form was also used where necessary to verify seasonal boundaries.
-

The following procedure was followed during the delineation of the wetland boundaries and zones:

- Desktop delineations were undertaken using satellite imagery of the study sites;
- Areas for verification were identified; and

Areas were then assessed in the field with boundaries being recorded using a GPS.

4.2 Wetland classification

SANBI's "Further development of a proposed National Classification System for South Africa" was used to classify the wetlands within the study area **(SANBI, 2009)**. The wetlands were classified up to level five, which includes the system, regional setting, landscape unit, hydrogeomorphic unit, hydroperiod and depth of inundation (**Table 2** and **Table 3**).

Table 2: Wetland classification level 1-4.

Level 1: System	Level 2: Regional setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit			
Connectivity to open ocean	Ecoregion	Landscape setting	HGM type	Longitudinal zonation / landform	Drainage - outflow	Drainage - inflow
			A	B	C	D
INLAND	DWAF Level 1	SLOPE	Channel (river)	Mountain headwater stream	Not applicable	Not applicable

Level 1: System	Level 2: Regional setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit			
	Ecoregions			Mountain stream	Not applicable	Not applicable
				Transitional river	Not applicable	Not applicable
				Rejuvenated bedrock fall	Not applicable	Not applicable
			Hillslope seep	Not applicable	With channel inflow	Not applicable
					Without channel inflow	Not applicable
			Depression	Not applicable	Exorheic	With channel inflow
						Without channel inflow
					Endorheic	With channel inflow
						Without channel inflow
					dammed	With channel inflow
						Without channel inflow
		VALLEY FLOOR	Channel (river)	Mountain stream	Not applicable	Not aplicable
				Transitional river	Not applicable	Not aplicable
				Rejuvenated bedrock fall	Not applicable	Not aplicable
				Upper foothill river	Not applicable	Not aplicable
				Lower foothill river	Not applicable	Not aplicable
				Lowland river	Not applicable	Not aplicable
				Rejuvenated foothill river	Not applicable	Not aplicable
				Upland floodplain river	Not applicable	Not aplicable
			Channelled valley-bottom wetland	Valley-bottom depression	Not applicable	Not aplicable
				Valley-bottom flat	Not applicable	Not aplicable
			Unchannelled valley-bottom wetland	Valley-bottom depression	Not applicable	Not aplicable
				Valley-bottom flat	Not applicable	Not aplicable
			Floodplain wetland	Floodplain depression	Not applicable	Not aplicable
				Floodplain flat	Not applicable	Not aplicable
			Depression	Not applicable	Exorheic	With channel inflow
						Without channel inflow
					Endorheic	With channel inflow
						Without channel inflow
					dammed	With channel inflow
						Without channel inflow
			Valleyhead seep	Not applicable	Not applicable	Not applicable
		PLAIN	Channel (river)	Lowland river	Not applicable	Not applicable
				Upland floodplain river	Not applicable	Not applicable
			Floodplain wetland	Floodplain depression	Not applicable	Not applicable
				Floodplain flat	Not applicable	Not applicable
			Unchannelled valley-bottom wetland	Valley-bottom depression	Not applicable	Not applicable
				Valley-bottom flat	Not applicable	Not applicable
			Depression	Not applicable	Exorheic	With channel inflow
						Without channel inflow
					Endorheic	With channel inflow
						Without channel inflow
			Flat	Not applicable	Not applicable	Not applicable
		BENCH (Hilltop/saddle/shelf)	Depression	Not applicable	Exorheic	With channel inflow
						Without channel inflow
					Endorheic	With channel inflow
						Without channel inflow
			Flat	Not applicable	Not applicable	Not applicable

Table 3: Wetland classification level 5.

LEVEL 5: HYDROPERIOND AND DEPTH OF INUNDATION		
A	B	C
INUNDATION PERIODICITY	SATURATION PERIODICITY (within 0.5m of soil surface)	INUNDATION DEPTH CLASS
Permanently inundated	Not applicable	Limnetic

LEVEL 5: HYDROPERIOND AND DEPTH OF INUNDATION		
A	B	C
INUNDATION PERIODICITY	SATURATION PERIODICITY (within 0.5m of soil surface)	INUNDATION DEPTH CLASS
		Littoral
Seasonally inundated	Permanently saturated	Not applicable
	Seasonally saturated	Not applicable
	Unknown	Not applicable
Intermittently inundated	Permanently saturated	Not applicable
	Seasonally saturated	Not applicable
	Intermittently saturated	Not applicable
	Unknown	Not applicable
Never inundated	Permanently saturated	Not applicable
	Seasonally saturated	Not applicable
	Intermittently saturated	Not applicable
	Unknown	Not applicable
Unknown	Permanently saturated	Not applicable
	Seasonally saturated	Not applicable
	Intermittently saturated	Not applicable

DWAF's "permanent zone"
DWAF's "seasonal zone"
DWAF's "temporary zone"

4.3 Wetland fauna and flora

The area was traversed on foot and all species of fauna and flora seen or deduced as being present were recorded. Background literature surveys were also conducted to assess what species have previously been recorded in the area as well as their conservation status.

4.4 Wetland integrity

4.4.1 Present Ecological Status (PES)

The Present Ecological Status (PES) Method (DWAF, 2005) was used to establish the integrity of the wetlands in the study area and is based on the modified Habitat Integrity approach developed by Kleynhans (1996, 1999 In DWAF 2005). Table 4 shows the criteria for assessing the habitat integrity of wetlands along with

Table 5 describing the allocation of scores to attributes and the rating of confidence levels associated with each score. These criteria were selected based on the assumption that anthropogenic modification of the criteria and attributes listed under each selected criterion can generally be regarded as the primary drivers in the ecological integrity of a wetland.

Table 4: Habitat integrity assessment criteria for wetland ecosystems (DWAF 1999).

Criteria and Attributes	Relevance
Hydrologic	
Flow Modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.
Water Quality	
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.
Sediment Load Modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.
Hydraulic/Geomorphic	
Canalization	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or changes wetland habitat directly in inundation patterns.
Biota	
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.
Indigenous Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.
Invasive Plant Encroachment	Affects habitat characteristics through changes in

Criteria and Attributes	Relevance
	community structure and water quality changes (oxygen reduction and shading).
Alien Fauna	Presence of alien fauna affecting faunal community structure.
Over utilization of Biota	Overgrazing, over fishing, etc.

Table 5: The allocation of scores to attributes and the rating of confidence levels associated with each score (DWAF, 1999).

Scoring Guidelines per Attribute:	
Natural/Unmodified	5
Largely Natural	4
Moderately Modified	3
Largely Modified	2
Seriously Modified	1
Critically Modified	0
Relative Confidence of Scores:	
Very High Confidence	4
High Confidence	3
Moderate Confidence	2
Marginal/Low Confidence	1

Once the wetland units have been assessed the Present Ecological Status Class (PESC) is then assigned (Table 6) based on the mean score determined for Table 4. This approach is based on the assumption that extensive degradation of any of the wetland attributes may determine the PESC (DWAF, 2005).

Table 6: Guidelines for the determination of the Present Ecological Status Class (PESC) of a wetland (DWAF, 1999).

Class Boundary	**Class**	**Class Description**
Within generally acceptable range		
>4	**Very High**	Unmodified or approximated natural condition.
>3 and <=4	**High**	Largely natural with few modifications, but with some loss of natural habitats.
>2 and <=3	**Moderate**	Moderately modified, but with some loss of natural habitats.
2	**Low**	Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
Outside generally acceptable range		
>0 and <2	**Very Low**	Seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.
0	**Non Existent**	Critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

4.4.2 Wetland Index for Habitat Integrity (Wetland-IHI)

The Wetland Habitat Integrity (Wetland-IHI) (DWAF, 2007) was designed for the rapid assessment of floodplain and channelled valley bottom wetlands. The purpose of this assessment is to determine the habitat integrity of the two wetlands found on site. From this rating the Present Ecological Status (PES) of wetlands can be derived in the form of Ecological Category (EC).

Prior to field assessment a set of 1:50 000 topographical maps of the area, recent aerial photographs and land-cover were obtained. From this data sites for verification during the field assessment were identified.

Site information was recorded according to the following components:

Wetland type classification

The wetland types were classified according to Wetland-IHI. The reference state was determined by considering what the site would have looked like if no impacts occurred.

Vegetation alteration assessment

The extent of the surrounding land use activities and rating of the impacts thereof on the wetland were recorded. The following land use activities were assessed:

- Mining or excavation;
- Infilling or backfilling;
- Vegetation clearing, loss or alteration; and
- Invasive species.

Hydrological assessment

At the catchment scale the following criteria were evaluated:

- Changes in flood peaks and frequencies;
- Changes in base flows;
- Changes in seasonality; and
- Changes in occurrence or duration of zero flow periods.

The within wetland factors that were evaluated were:

- Connectivity – altered channel size or competency;
- Increased water retention on the floodplain; and
- Decreased water retention on the floodplain.

Reference state patterns were also recorded by considering the site without any impacts.

Geomorphic assessment

At the catchment scale the following criteria were evaluated:

- Changes in sediment budget; and
- Sediment transport capacity.

The within wetland factors that were evaluated were:

- Erosional processes; and
- Depositional processes.

Present Ecological Status (PES) assessment

The field data was transferred to the Wetland-IHI spreadsheet from where the PES obtained and the final Ecological Category (EC) calculated. The percentages and descriptions of the EC are given in Table 7 below.

Table 7: Ecological categories (Kleynhans, 2007).

Ecological Category	%	Description of Ecological Category
A	90-100	Unmodified/Natural
B	80-89	Largely natural with few modification. A small change in natural habitat and biota may have taken place, but the ecosystem function is essentially unchanged.
C	60-79	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	40-59	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred.
E	20-39	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions are extensive.
F	0-19	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. The basic ecosystem functions have been destroyed and the changes are irreversible.

4.5 Wetland ecological importance and sensitivity (EIS)

The ecological importance and sensitivity assessment was conducted according to the guidelines as discussed by DWAF (1999). Here DWAF defines "ecological importance" of a water resource as an expression of its importance to the maintenance of ecological diversity and function on local and wider scales. "Ecological sensitivity", according to DWAF (1999), refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and Sensitivity (EIS) provide a guideline for the determination of the Ecological Management Class (EMC).

In the method outline by DWAF a series of determinants for EIS are assessed for the wetlands on a scale of 0 to 4 (Table 8), where 0 indicates no importance and 4 indicates very high importance. The median of the determinants is used to determine the EIS and EMC of the wetland unit (Table 9).

Table 8: Score sheet for the determination of ecological importance and sensitivity (DWAF, 1999).

Determinant	Score	Confidence
Primary determinants		
Rare and endangered species		
Species/taxon richness		
Diversity of Habitat types or features		
Migration route/breeding and feeding site for wetland species		
Sensitivity to changes in the natural hydrological regime		
Sensitivity to water quality changes		
Flood storage, energy dissipation and particulate/element removal		
Modifying determinants		

Determinant	Score	Confidence
Protected status		
Ecological integrity		

Score guideline: 4 = Very High; 3 = High; 2 = Moderate; 1 = Marginal/Low; 0 = None. Confidence rating: 4 = Very High Confidence; 3 = High Confidence; 2 = Moderate Confidence; 1 = Marginal/Low Confidence.

Table 9: Ecological Importance and Sensitivity (EIS) categories and the interpretation of median scores for biotic and habitat determinants (DWAF, 1999).

Range of Median	EIS Category	Category Description	Recommended Ecological Management Class
>3 and <=4	Very High	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.	A
>2 and <=3	High	Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water in major rivers.	B
>1 and <=2	Moderate	Wetlands that are to be considered ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains 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.	C
>0 and <=1	Low/ Marginal	Wetlands that are 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.	D

4.6 Ecosystem services supplied by wetlands (Wet-EcoServe)

The assessment of the ecosystem services supplied by the identified wetland units was conducted according to the guidelines as described by Kotze, et al. (2005). A Level 2 assessment was undertaken which examines and rates Natural and Human services.

Natural Services

The following natural services were assessed:

- Flood attenuation;
- Stream flow regulation;

- Sediment trapping;
- Phosphate trapping;
- Nitrate removal;
- Toxicant removal;
- Erosion control;
- Carbon storage; and
- Maintenance of biodiversity.

Scores for each of the above natural service assessments were allocated a class based on those shown in Table 10. These scores were then added to determine the overall level of natural services for the wetland unit using the classes shown in Table 11.

Table 10: Classes for service scores.

Class Boundary	Class Score
0 - 0.99	1
1 - 1.99	2
2 - 2.99	3
3 - 4	4

Table 11: Classes for the overall level of natural services provided by a wetland unit.

Natural Services and Functions		
Class Boundaries	**Class**	**Class Description**
Within acceptable range		
30 - 36	Very High	Unmodified or approximated natural condition.
24 - 29.9	High	Largely natural with few modifications, but with some loss of natural habitats.
18 - 23.9	Moderate	Moderately modified, but with some loss of natural habitats.
12 - 17.9	Low	Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
Outside acceptable range		
6 - 11.9	Very Low	Seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.
0 - 5.9	Non Existent	Critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

Human Services

The following human services were assessed:

- Water supply for human use;

- Natural resources;
- Cultivated foods;
- Cultural significance;
- Tourism and recreation; and
- Education and research.

Scores for each of the above human service assessments were allocated a class based on those shown in Table 10. These scores were then added to determine the overall level of human services for the wetland unit using the classes shown in Table 12.

Table 12: Classes for the overall level of human services provided by a wetland unit.

Human Services and Functions		
Class Boundaries	**Class**	**Class Description**
Within acceptable range		
20 - 24	Very High	Local people are extremely dependent on the wetland and benefit from it greatly.
16 - 19.9	High	Local people have a high level of dependence on the wetland and benefit from it considerably.
12 - 15.9	Moderate	Local people are moderately dependent on the wetland and benefit from it from occasionally.
8 - 11.9	Low	Local people have a low dependency on the wetland and seldom benefit from it.
Outside acceptable range		
4 - 7.9	Very Low	Local people rarely rely on the wetland and almost never benefit from it.
0 - 3.9	Non Existent	Local people have no interaction with the wetland and never receive any benefits from it.

5.0 ASSESSMENT OF POTENTIAL IMPACTS

In order to assess the impacts of the proposed project on the aquatic ecosystems, the following components were included:

- The identification of the main areas of impact associated with the proposed project, i.e. pipeline and aquatic and wetland crossings, and reduced/ceased pre-treated mine water discharges;
- The assessment of the impacts of the proposed project on the aquatic ecosystems;
- The recommendation of mitigation and management measures to deal with significant impacts;
- The provision of alternative routes and options for the pipelines, if necessary; and
- The identification of aspects which may require further study.

In order to successfully assess the impacts, it is necessary to evaluate the following:

- The current South African legislation;
- The development of mitigation measures; and

- The significance of the impacts.

5.1 Current South African legislation

As indicated at the outset of the report, this EIR is informed and influenced by the following key pieces of legislation:

- The National Water Act, 1998 (Act 36 of 1998);
- The National Environmental Management Act, 1998 (Act 107 of 1998); and
- The National Environmental Management Biodiversity Act, 2004 (Act 10 of 2004).

5.2 Environmental impact significance

The impacts of the proposed project were assessed in terms of impact significance and recommended mitigation measures. The determination of significant impacts relates to the degree of change in the environmental resource measured against some standard or threshold (DEAT, 2002). This requires a definition of the magnitude, prevalence, duration, frequency and likelihood of potential change (DEAT, 2002). The following criteria have been proposed by the Department of Environmental Affairs and Tourism for the description of the magnitude and significance of impacts (DEAT, 2002):

The consequence of impacts can be derived by considering the following criteria:

- Extent or spatial scale of the impact;
- Intensity or severity of the impact;
- Duration of the impact;
- Potential for Mitigation;
- Acceptability;
- Degree of certainty/Probability;
- Status of the impact; and
- Legal Requirements.

Describing the potential impact in terms of the above criteria provides a consistent and systematic basis for the comparison and application of judgments (DEAT, 2002).

The significance of the impact is calculated as:

$$\text{Significance of Impact} = \text{Consequence (magnitude + duration + spatial scale)} \times \text{Probability}$$

Magnitude relates to how severe the impact is. Duration relates to how long the impact may be prevalent for and the spatial scale relates to the physical area that would be affected by the impact. Having ranked the severity, duration and spatial scale using the criteria outlined in Table 13, the overall consequence of impact can be determined by adding the individual scores assigned in the severity, duration and spatial scale. Overall probability of the impacts must then be determined. Probability refers to how likely it is that the impact may occur.

Table 13: Consequence and probability ranking of impacts.

Magnitude/Severity	Duration	Spatial Scale	Probability
10 - Very high/don't know	5 - Permanent	5 - International	5 - Definite/don't know
8 – High	4 - Long-term (impact ceases	4 - National	4 - Highly probable

Magnitude/Severity	Duration	Spatial Scale	Probability
	after operational life)		
6 - Moderate	3 - Medium-term (5-15 years)	3 - Regional	3 - Medium probability
4 – Low	2 - Short-term (0-5 years)	2 - Local	2 - Low probability
2 – Minor	1 - Immediate	1- Site only	1 - Improbable
0 – None	0 - None	0 - None	0 - None

The maximum value, which can be obtained, is 100 significance points (SP). Environmental effects are rated as either of High, Moderate, Low or No Impact significance on the following basis:

- SP > 75 Indicates high environmental significance;
- SP 50 – 75 Indicates moderate environmental significance;
- SP < 50 Indicates low environmental significance; and
- SP = 0 Indicates no environmental significance.

The descriptors for the ratings are provided in (Table 14) (DEAT, 2002).

Table 14: Categories for the rating of impact magnitude and significance.

Category	Description
High	Of the highest order possible within the bounds of impacts that could occur, There is no possible mitigation that could offset the impact, or mitigation is difficult.
Moderate	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. Mitigation is both feasible and fairly easily possible.
Low	Impact is of a low order and therefore likely to have little real effect. Mitigation is either easily achieved or little mitigation is required, or both.
No Impact	Zero Impact

5.3 Development of mitigation measures

The quantitative accuracy and precision of impact predictions is particularly important for prescribing mitigation measures (DEAT, 2002). This is especially important for those impacts, pollutants or resources that require the setting of a site-specific discharge limit or need to be within legislated standards (DEAT, 2002). A common approach to describing mitigation measures for critical impacts is to specify a range of targets with predetermined acceptable range and an associated monitoring and evaluation plan (DEAT, 2002). To ensure successful implementation, mitigation measures should be unambiguous statements of actions and requirements that are practical to execute (DEAT, 2002). The following sections summarise the different approaches to prescribing and designing mitigation measures.

5.3.1 Avoidance

Mitigation by not carrying out the proposed action on the specific site, but rather on a more suitable site.

5.3.2 Minimization

Mitigation by scaling down the magnitude of a development, reorienting the layout of the project or employing technology to limit the undesirable environmental impact.

5.3.3 Rectification

Mitigation through the restoration of environments affected by the action.

5.3.4 Reduction

Mitigation by taking maintenance steps during the course of the action.

5.3.5 Compensation

Mitigation through the creation, enhancement or acquisition of similar environments to those affected by the action.

6.0 RESULTS

The results for the survey are discussed for each water crossing and affected area.

6.1 Site KS

This wetland forms part of the Kromdraaispruit and falls within the Highveld Level 1 Ecoregion. The wetland is situated on a valley floor and was classified as a Channelled Valley Bottom wetland. The wetland was permanently inundated with a littoral depth class.

Acacia trees were located on the edge of the wetland in most areas. The channel had been excavated at certain sections and there were road crossings at several locations through the channel. Sand and Gravel mounds were also present on the sides of the wetland. The permanent inundation in the wetland was due to the constant release of water from the Kromdraai mine.

Figure 3: Site photo of KS.

APPENDIX A lists the floral species recorded at this site. Exotic species found on site included *Cyperus eragrostis, Circium vulgare, Acacia mearnsii* and *Paspalum notatum*. The presence of *Stoebe vulgaris* and *Eragrostis gummiflua* are signs of the impacted nature of the site. No faunal species were recorded at this site during the survey.

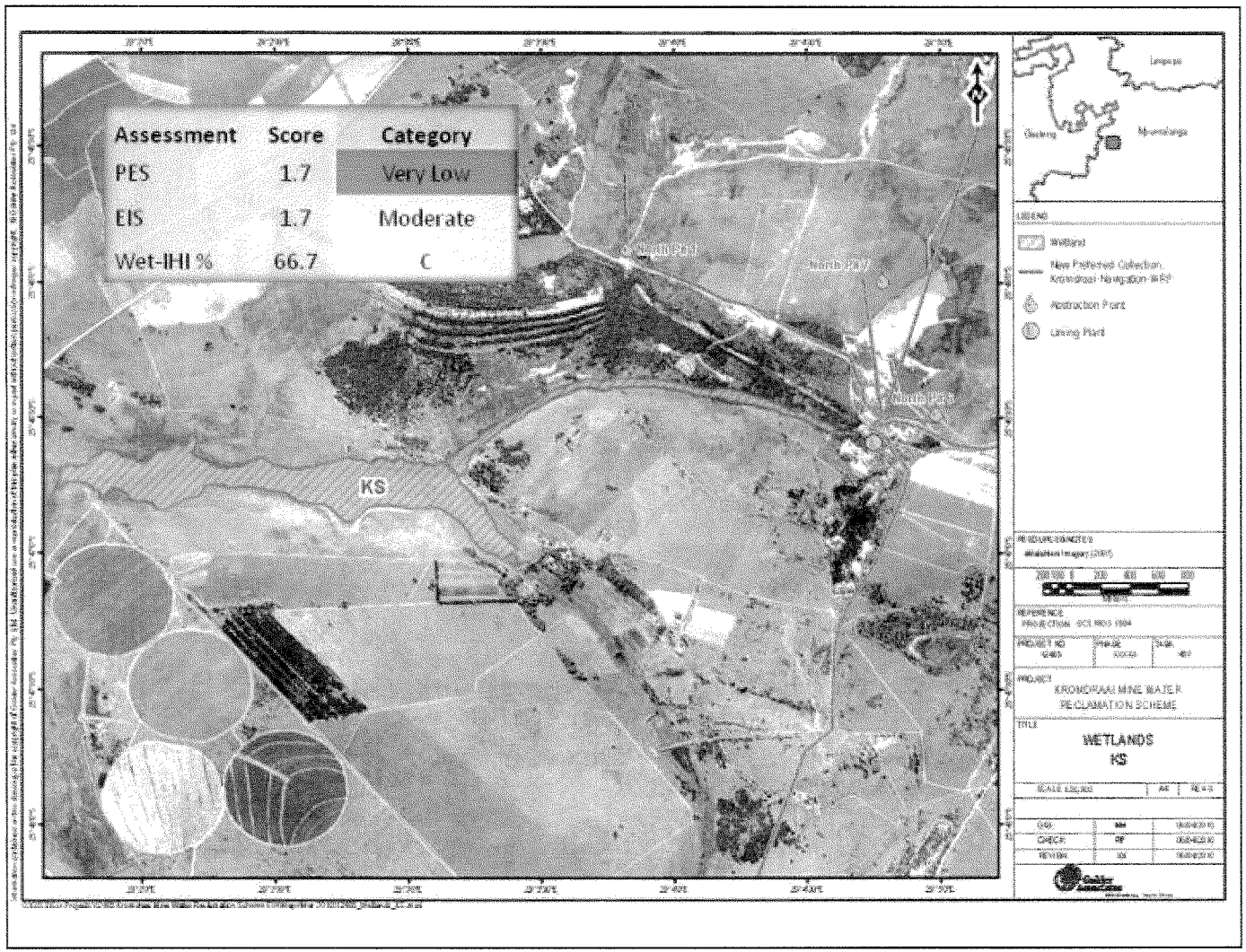

Figure 4: KS delineation and scores.

Present Ecological Status Assessment

A present ecological score of "Very Low" was assigned to this wetland. This score is outside of the generally excepted range and suggests that this wetland is seriously modified with extensive loss of natural habitat (as described in Table 6) (APPENDIX D) details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Moderate" score for Ecological Importance and Sensitivity. This wetland is thus important on a provincial or local scale with the present biodiversity not being sensitive to flow and habitat modifications. Wetlands in this category play a small role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

Wetland-IHI

The habitat integrity of this wetland was calculated and a C class was assigned to it. A loss and change of natural habitat has occurred (As described in Table 7). The detailed scores for habitat integrity are shown in APPENDIX C.

Wet-Ecoservices

Site KS scored "Moderate" for natural services and "Low" for human services. The natural services score was due to the loss of natural habitat and subsequent loss of some of the natural functions provided by the wetland. The "Low" human services score can be ascribed to the locality of the wetland. There are not many people in the vicinity of the wetland that are reliant on this particular wetland. Figure 5 shows the ratings for the different services provided by this wetland. This wetland is mostly effective in phosphate- and nutrient trapping, erosion control and toxicant removal.

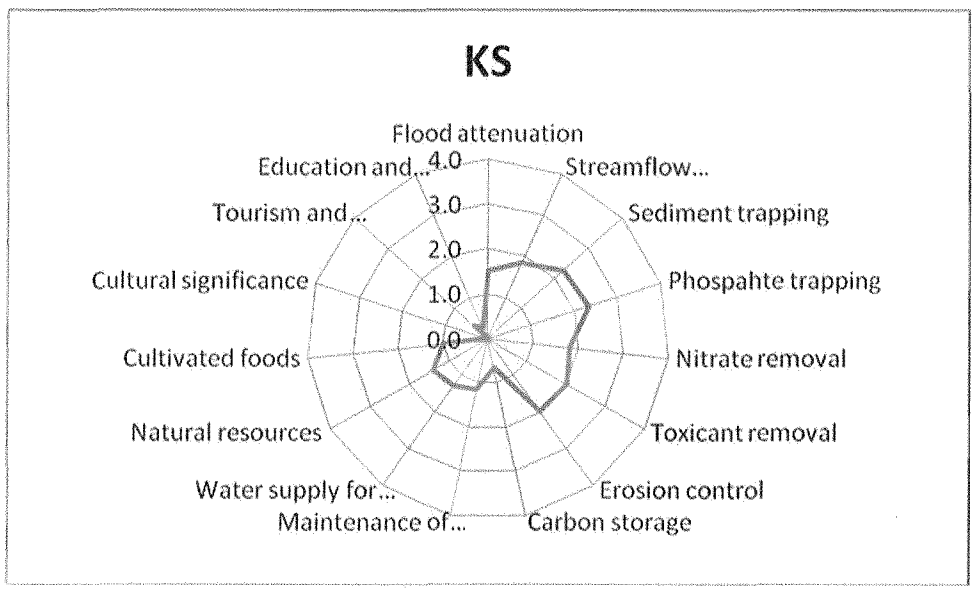

Figure 5: Ecological services scores for site KS.

6.2 Site WC1

This wetland forms part of the Klipspruit and falls within the Highveld Level 1 Ecoregion. The wetland is situated on a valley floor and was classified as a Channelled Valley Bottom wetland. The wetland is seasonally inundated and permanently saturated.

A service road for the mine runs across the wetland at the point of the proposed pipeline crossing site. There is a small channel running through the wetland with a large permanent zone. Acacia trees are encroaching onto the wetland's temporary zone and growing next to the road bridge.

Figure 6: Photo of site WC1.

APPENDIX A lists the floral species recorded at this site. Some exotic species found on site were *Paspalum urvillei* and *Acacia mearnsii*. The presence of *Stoebe vulgaris* and *Verbena bonariensis* are signs of the degraded nature of the site. One faunal species was recorded at this site during the survey, the Golden Bishop *(Euplectes afer)*. This species is usually associated with wetlands where it breeds within the grass and reed stands.

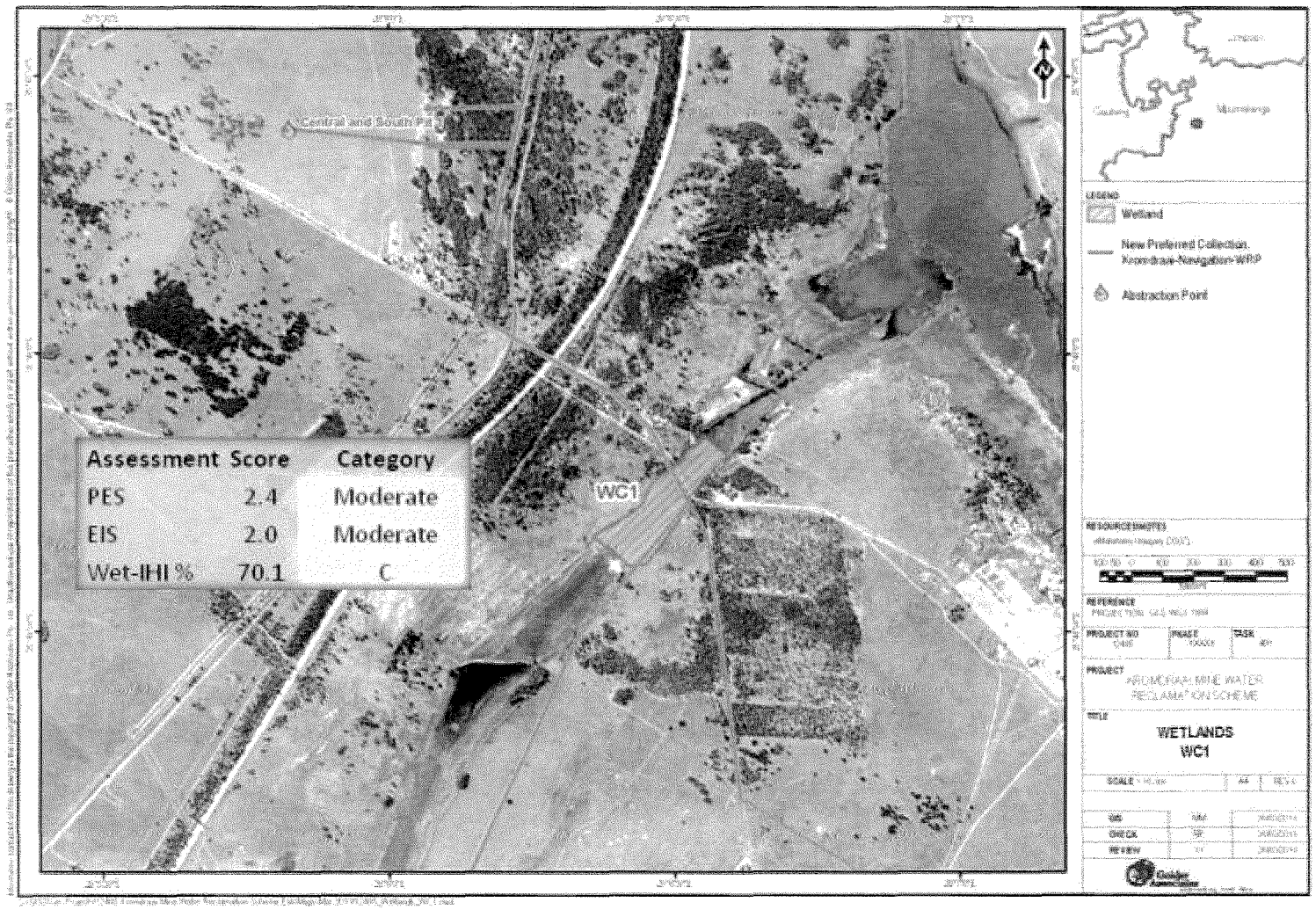

Figure 7: Site WC 1 delineation and scores.

Present Ecological Status Assessment

A present ecological score of "Moderate" was assigned to this wetland. This score suggests that this wetland is moderately modified with some loss of natural habitat (as described in Table 6) (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Moderate" score for Ecological Importance and Sensitivity. This wetland is thus important on a provincial or local scale with the present biodiversity not being sensitive to flow and habitat modifications. Wetlands in this category play a small role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

Wetland-IHI

The habitat integrity of this wetland was calculated and a "C" class was assigned to it. A loss and change of natural habitat has occurred in this wetland (as described in Table 7). The detailed scores for habitat integrity are shown in APPENDIX C.

Wet-Ecoservices

Site WC1 scored "Moderate" for natural and human services. The moderate natural services score can be attributed to the loss of diversity of natural habitat and site degradation due to anthropogenic impacts which contributed to the loss of some of the natural functions provided by the wetland. The "Moderate" human services score can be ascribed to the locality of the wetland. Upstream of the site plots and high density housing developments are located on either sides of the wetland. There are thus people in the vicinity that make use of the wetland. Figure 5 shows the ratings for the different services provided by this wetland. As can be seen, this wetland was mostly effective in flood attenuation, streamflow regulation, phosphate- and nitrate trapping, erosion control and toxicant removal. It is also a source of natural resources and is used for cultivation.

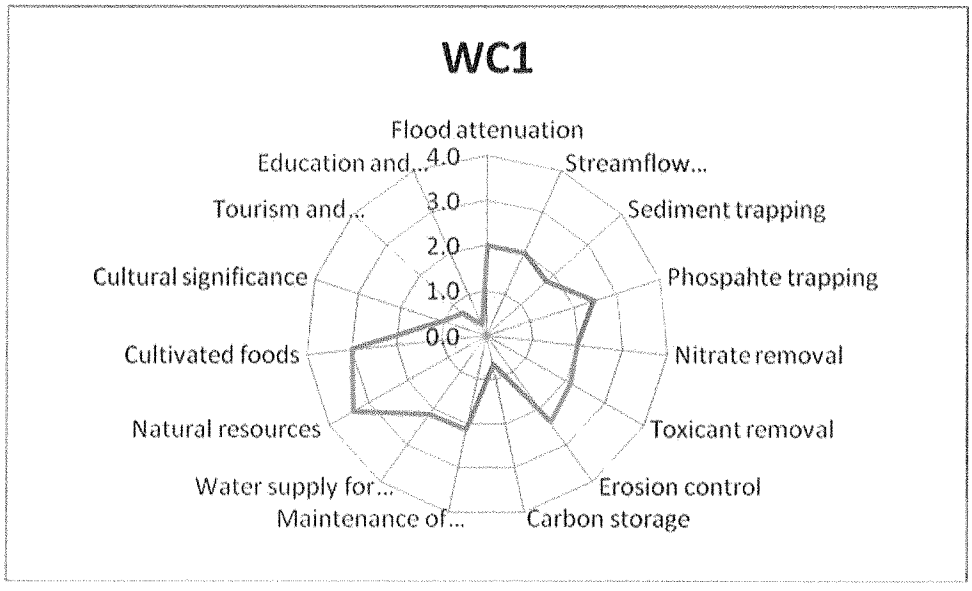

Figure 8: Ecological services scores for site WC1.

6.3 Site WC2

This wetland forms part of the Brugspruit and falls within the Highveld Level 1 Ecoregion. The wetland is situated on a valley floor and was classified as a Channelled Valley Bottom wetland. The wetland is seasonally inundated and permanently saturated.

The site is situated next to a wastewater treatment works and a formal settlement is located upstream. Mining activities are taking place to the west of the wetland.

Figure 9: Site photo of WC2.

APPENDIX A lists the floral species recorded at this site. One exotic species, *Paspalum urvillei* was recorded on site. The channel was overgrown with *Typha capensis*, possibly indicating high nutrient levels that lead to the dominance of hardy species. Two faunal species were recorded at this site during the survey, the Golden Bishop *(Euplectes afer)* and the Longtailed widow (*Euplectes progne)*. The Golden bishop is usually associated with wetlands where it breeds within the grass and reed stands. The Longtailed widow is occasionally associated with wet areas.

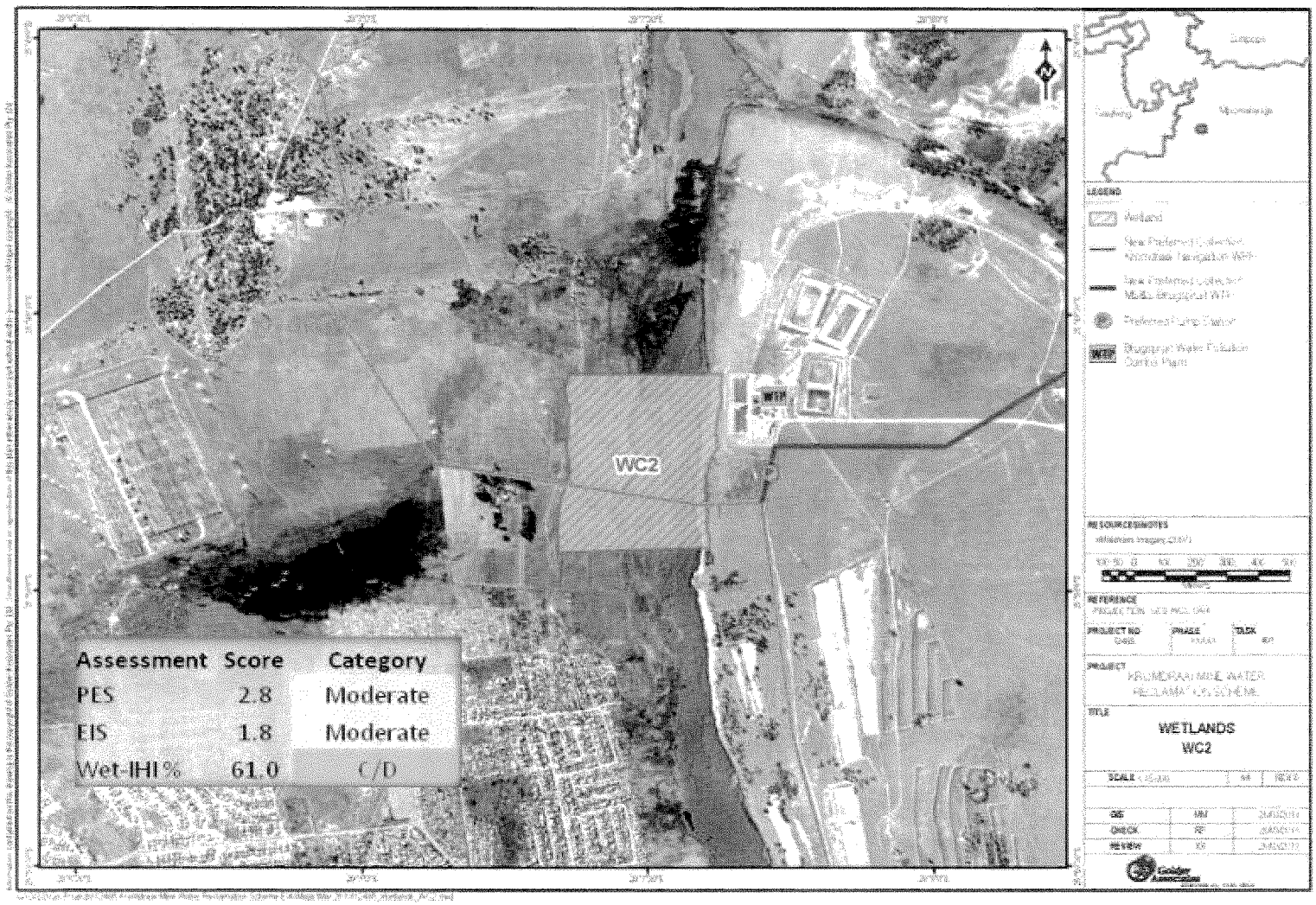

Figure 10: Site WC 2 delineation and scores.

Present Ecological Status Assessment

A present ecological score of "Moderate" was assigned to this wetland. This score suggests that this wetland is moderately modified with some loss of natural habitat (as described in Table 6) (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Moderate" score for Ecological Importance and Sensitivity. This wetland is thus important on a provincial or local scale with the present biodiversity not being sensitive to flow and habitat modifications. Wetlands in this category play a small role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

Wetland-IHI

The habitat integrity of this wetland was calculated and a "C/D" class was assigned to it. A moderate to large loss and change of natural habitat has occurred in this wetland (as described in Table 7). This can clearly be illustrated by the dominance of *Typha* and the lack of biodiversity within the wetland. The detailed scores for habitat integrity are shown in APPENDIX C.

Wet-Ecoservices

Site WC2 scored "High" for natural services and "Moderate" for human services. The natural services score was due to the large amount of vegetation within the channel that can effectively sequester nutrients and toxins and attenuate floods. The "Moderate" human services score can be ascribed to the locality of the wetland. Plots and formal settlements are located upstream of the site. There are therefore people in the vicinity of the site that make use of the wetland. Figure 5 shows the ratings for the different services provided by this wetland. As can be seen, this wetland was mostly effective in phosphate- and nitrate trapping, erosion control and toxicant removal. It was also a source of natural resources and is used for cultivation.

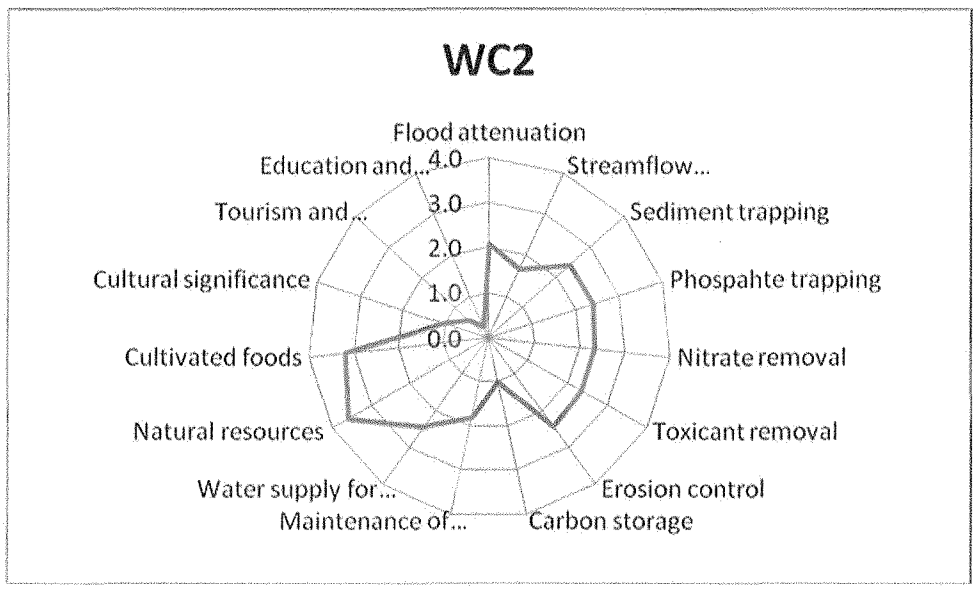

Figure 11: Ecological services scores for site WC2.

6.4 Site WC3

This wetland is a tributary of the Brugspruit and falls within the Highveld Level 1 Ecoregion. The wetland is situated on a valley floor and was classified as a Channelled Valley Bottom wetland. The wetland is permanently inundated with a littoral depth class.

The wetland is permanently inundated due to the release of water from the upstream mine. The channel was incised due to bank erosion, becoming more deeply channelled further downstream. A small dirt road crosses the channel with culverts beneath it. Downstream of the site exotic trees line the banks.

Figure 12: Site photo of WC3.

APPENDIX A lists the floral species recorded at the site. Some exotic species found on site were *Paspalum urvillei, Solanum sisymbriifolium* and *Acacia mearnsii*. The presence of *Eragrostis gummiflua* and *Botriochoa insculpta* are signs of the degraded nature of the site. No faunal species were recorded at this site during the survey.

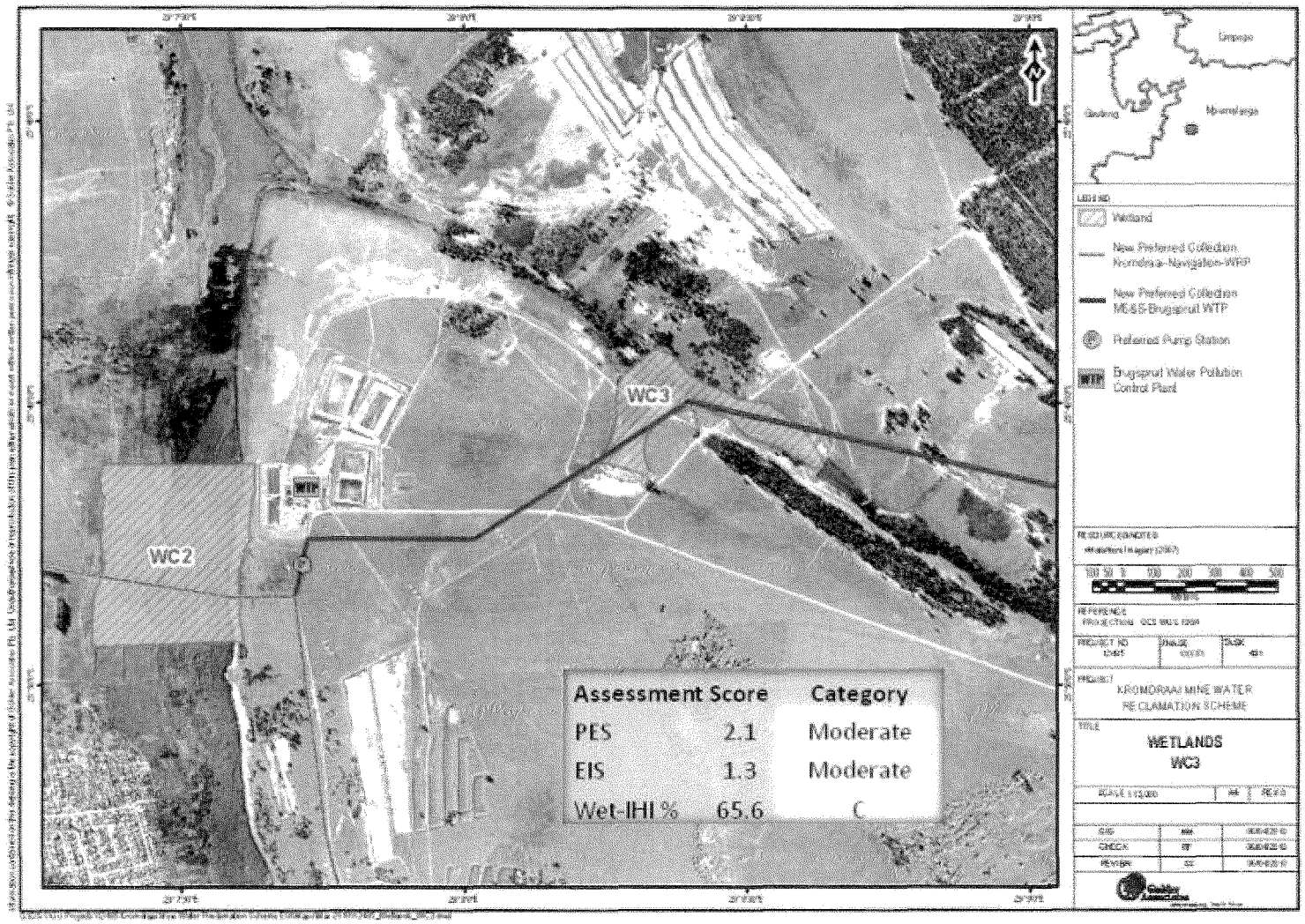

Figure 13: Site WC 3 delineation and scores.

Present Ecological Status Assessment

A present ecological score of "Moderate" was assigned to this wetland. This score suggests that this wetland is moderately modified with some loss of natural habitat (as described in Table 6) (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Moderate" score for Ecological Importance and Sensitivity. The wetland is thus important on a provincial or local scale with the present biodiversity not being sensitive to flow and habitat modifications. Wetlands in this category play a small role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

Wetland-IHI

The habitat integrity of this wetland was calculated and a "C" class was assigned to it. A loss and change of natural habitat has occurred in this wetland (as described in Table 7). This can be ascribed to the encroachment of exotic plant species and trees. The detailed scores for habitat integrity are shown in APPENDIX C.

Wet-Ecoservices

Site WC3 scored "Moderate" for natural services and "Very low" for human services. The moderate natural services score was due to the loss of natural vegetation diversity, bank sloping and channelization, and site degradation that has resulted in loss of natural functions. The "Very low" human services score can be ascribed to the low number of people living in the vicinity of the wetland and utilizing the wetland. Figure 5 shows the ratings for the different ecological services provided by this wetland.

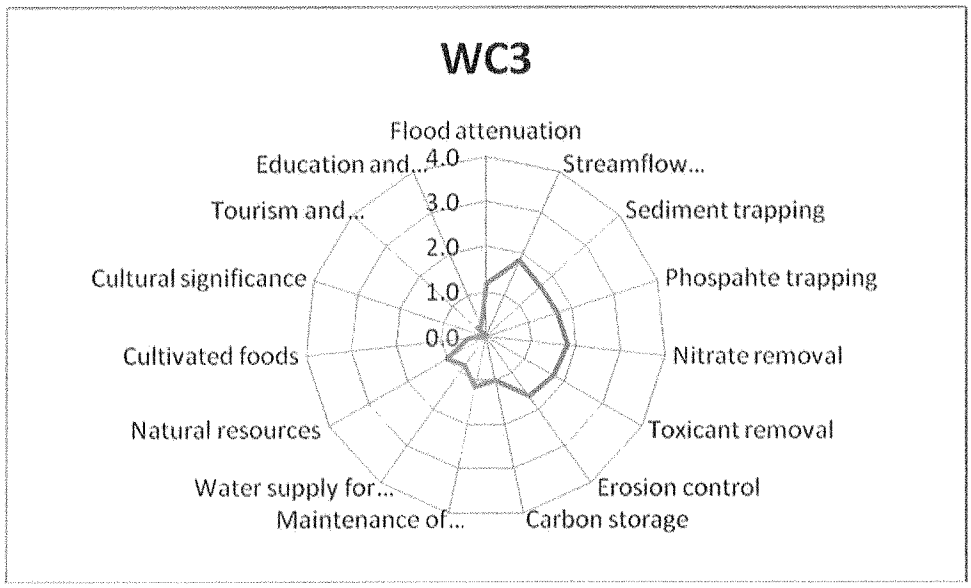

Figure 14: Ecological services scores for site WC3.

6.5 Site WC4 (and RR3)

This wetland forms part of the Brugspruit and falls within the Highveld Level 1 Ecoregion. The wetland is situated on a valley floor and was classified as a Channelled Valley Bottom wetland. The wetland is permanently inundated with a littoral depth class.

This wetland is situated between the R104 and the N4. The wetland is artificially inundated due to the two roads crossing it. There is a house that is informally utilized by people situated in the temporary zone on the eastern side of the wetland.

Figure 15: Site photo of WC4

APPENDIX A lists the floral species recorded at this site. Exotic species found on site included *Salix babylonica* and *Datura stramonium*. The presence of *Hyparrhenia hirta, Uruchloa mosambicensis* and *Setaria sphacelata* are signs of the disturbed nature of the site. Two faunal species were recorded at this site during the survey, the Golden Bishop *(Euplectes afer)* and the Southern Red Bishop *(Euplectes oryx)*. These species are usually associated with wetland habitats where they breed within the grass and reed stands.

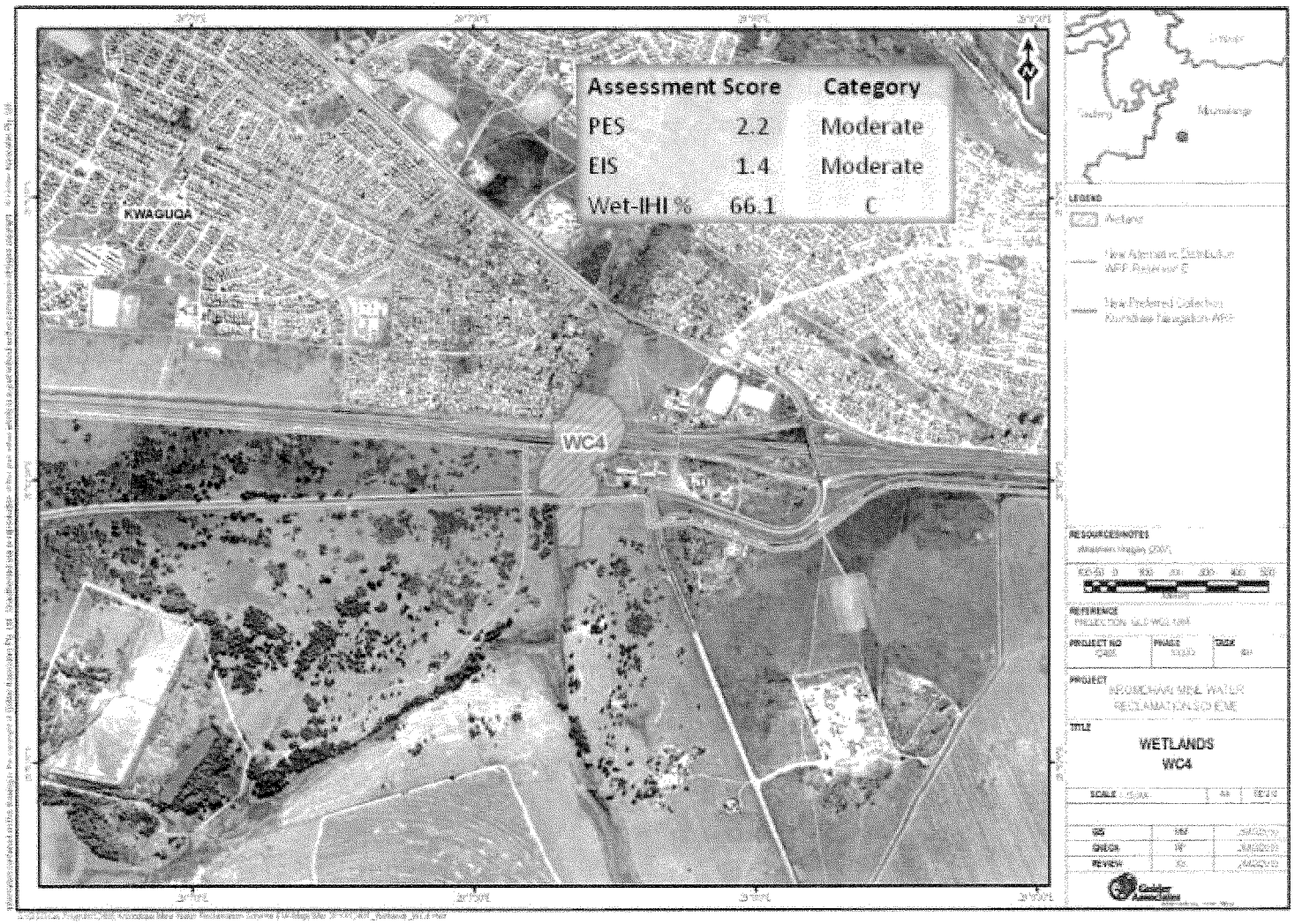

Figure 16: Site WC 4 delineation and scores.

Present Ecological Status Assessment

A present ecological score of "Moderate" was assigned to this wetland. This score suggests that this wetland is moderately modified with some loss of natural habitat (as described in Table 6) (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Moderate" score for Ecological Importance and Sensitivity. This wetland is thus important on a provincial or local scale with the present biodiversity not being sensitive to flow and habitat modifications. Wetlands in this category play a small role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

Wetland-IHI

The habitat integrity of this wetland was calculated and a "C" class was assigned to it. A loss and change of natural habitat has occurred in this wetland (as described in Table 7). The score can be ascribed to the dominance of *Typha capensis* and the low overall vegetation diversity. The detailed scores for habitat integrity are shown in APPENDIX C.

Wet-Ecoservices

Site WC4 scored "Moderate" in terms of natural and human services. The moderate natural services score can be attributed to the loss of natural habitat diversity and site degradation due to anthropogenic impacts which has resulted in the loss of some of the natural functions provided by the wetland. The "Moderate" human services score can be ascribed to the locality of the wetland. The downstream part of the wetland is surrounded by plots and high density housing. There are therefore people in the vicinity that make use of the wetland. Figure 5 shows the ratings for the different services provided by this wetland. As can be seen, this wetland was mostly effective in sediment trapping, phosphate- and nitrate trapping, erosion control and toxicant removal. It was also a source for natural resources, used for cultivation and as a water supply.

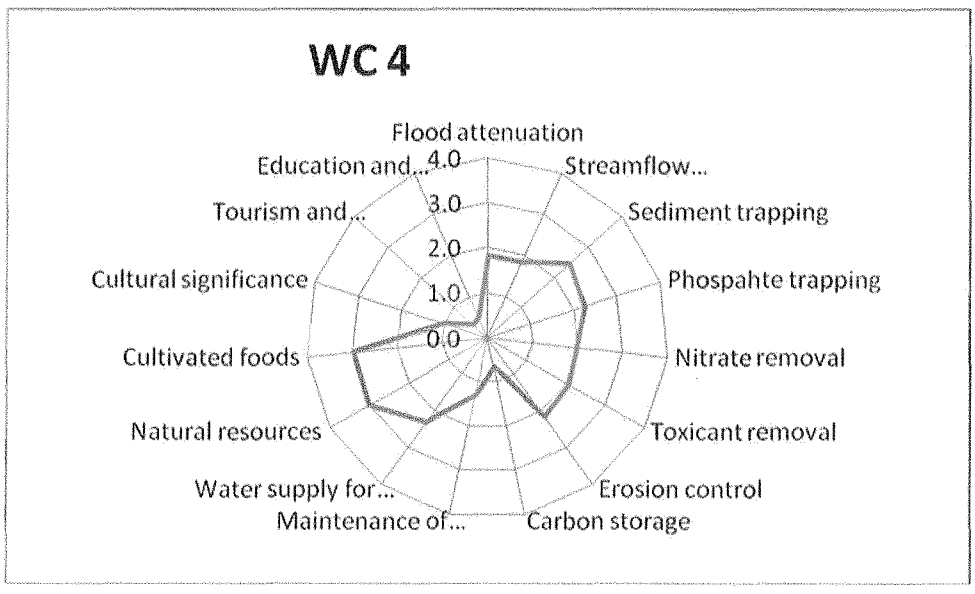

Figure 17: Ecological services scores for site WC4.

6.6 WC5 and 6 (and RR1 and RR3)

This wetland is a tributary of the Brugspruit and falls within the Highveld Level 1 Ecoregion. The wetland is situated on a valley floor and was classified as a Channelled Valley Bottom wetland. The wetland is permanently inundated with a littoral depth class.

At site WC5 the wetland is situated between the R104 and the N4. The wetland is artificially inundated largely due to the two roads crossing it (Figure 18).

At site WC6 building material and rubble has been dumped on the channel edge where the road crosses the wetland. An artificial channel has been constructed next to the wetland to collect storm flows. The downstream channel is narrow and incised with exotic vegetation species on the slopes (Figure 19).

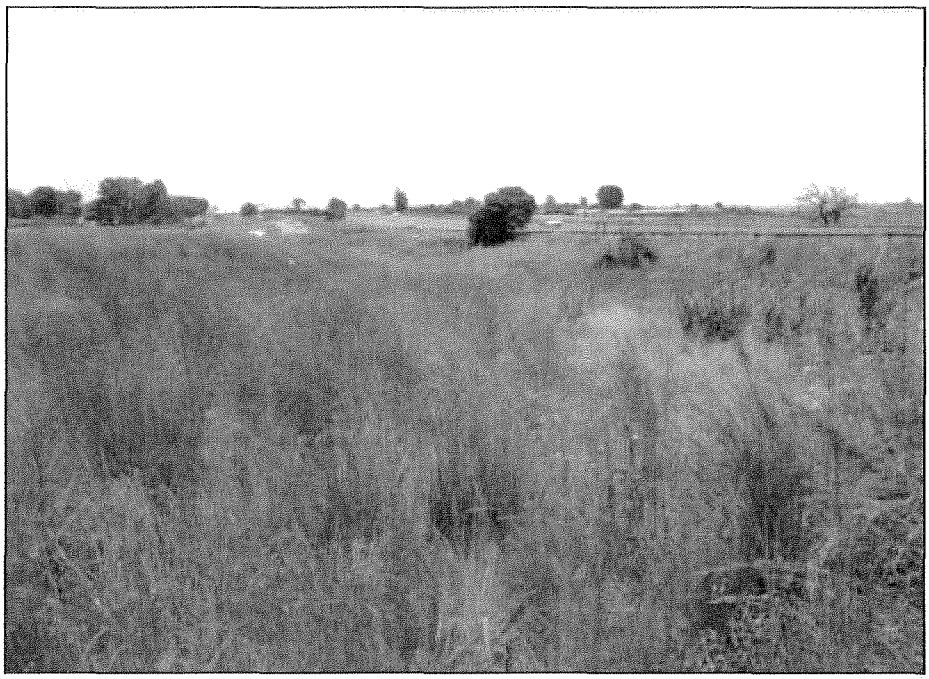

Figure 18: Site photo of WC5.

Figure 19: Site photo of WC6.

APPENDIX A lists the floral species recorded at this site. Exotic species recorded on site included *Datura stramonium, Cynodon dactylon* and *Pennisetum clandestinum*. The presence of *Hyparrhenia hirta, Eragrostis gummiflua* and *Botriochoa insculpta* are signs of the impacted nature of the site. No faunal species were recorded at this site during the survey.

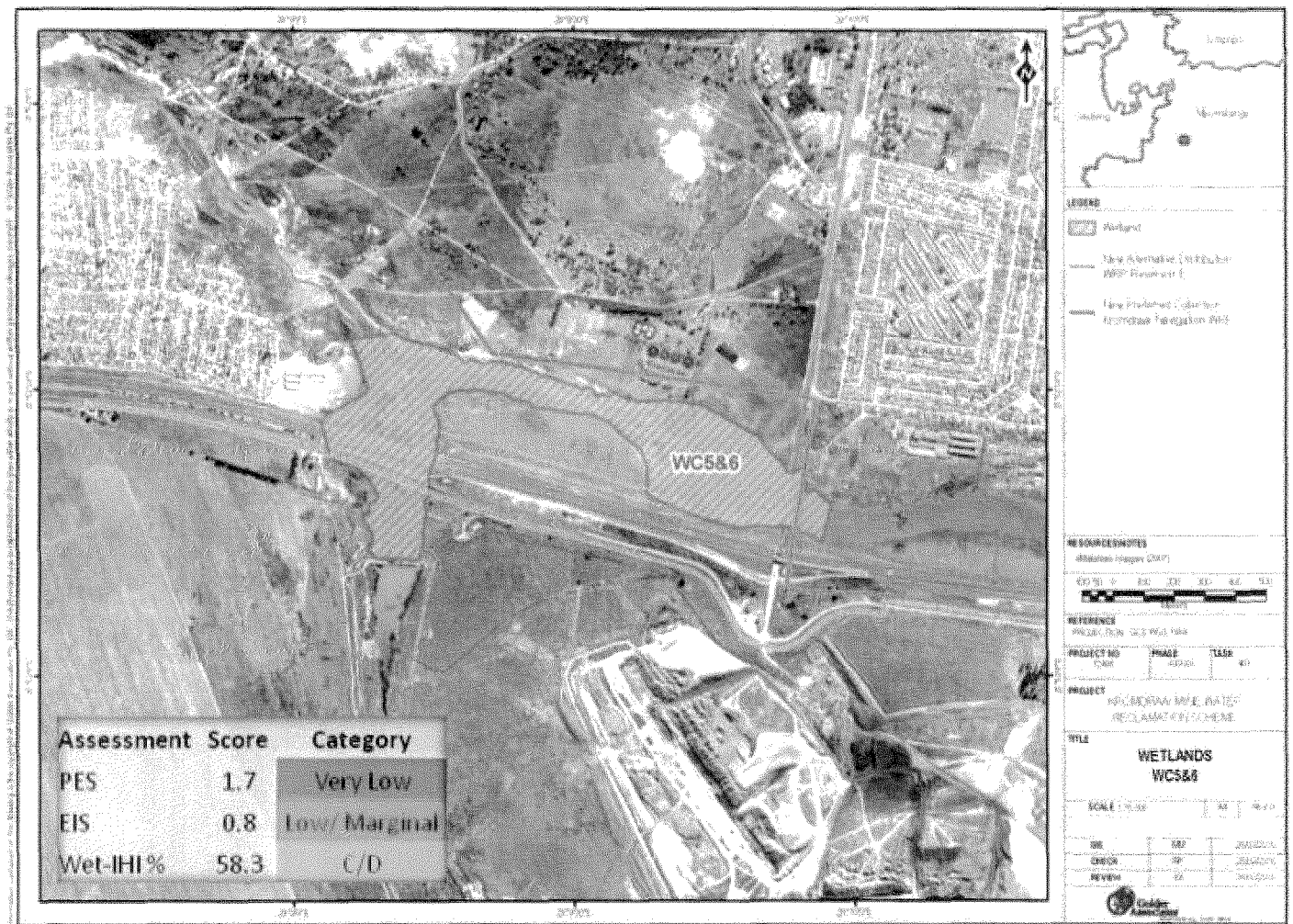

Figure 20: Sites WC 5 & 6 delineation and scores.

Present Ecological Status Assessment

A present ecological score of "Very Low" was assigned to this wetland. This score is outside of the generally excepted range and suggests that this wetland is seriously modified with extensive loss of natural habitat (as described in Table 6). The impacted state of the site can be attributed to overgrazing and anthropogenic impacts (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Low" score for Ecological Importance and Sensitivity. The wetland is thus not ecologically sensitive at any scale and the biodiversity is not sensitive to habitat modifications. Wetlands in this category play an insignificant role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

Wetland-IHI

The habitat integrity of this wetland was calculated and a "C/D" class was assigned to it. A moderate to large loss and change of natural habitat has occurred in this wetland (as described in Table 7). This can clearly be illustrated by the dominance of *Phragmites* and *Pennisetum* and the lack of biodiversity within the wetland. The detailed scores for habitat integrity are shown in APPENDIX C.

Wet-Ecoservices

Sites WC5 & 6 scored "Moderate" for natural and human services. The moderate natural services score can be attributed to the loss of natural habitat diversity and site degradation due to anthropogenic impacts which have contributed to loss of some of the natural functions provided by the wetland. The "Moderate" human services score can be attributed to the locality of the wetland. Upstream high density housing surrounds the wetland. There are thus people in the vicinity that can make use of the wetland. Figure 5 shows the ratings for the different services provided by this wetland. As can be seen, this wetland is mostly effective in sediment trapping, phosphate trapping and toxicant removal. It was also a source for natural resources, is used for cultivation and as a water supply.

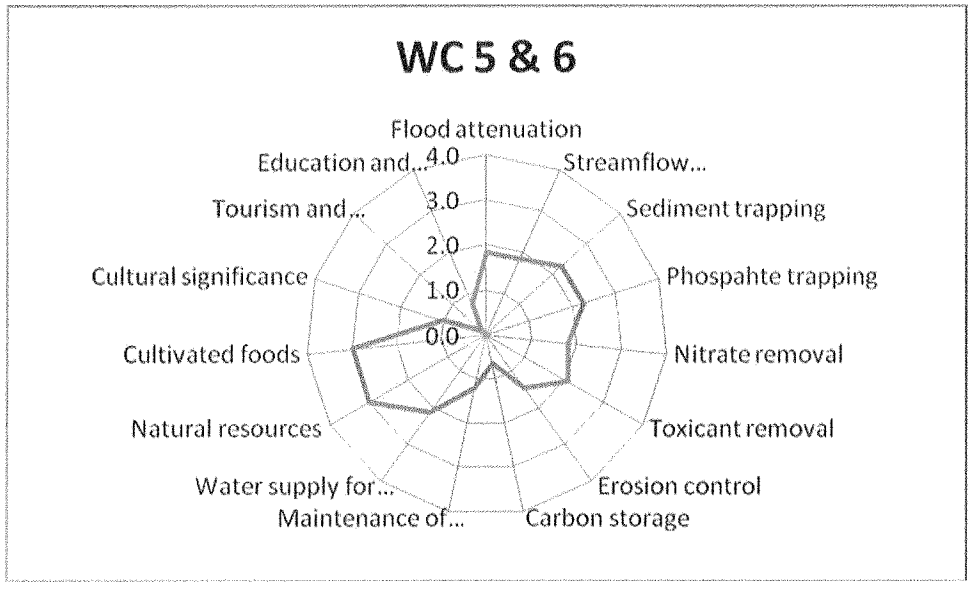

Figure 21: Ecological services scores for site WC 5 & 6.

6.7 Site WC7

No assessments were conducted at this site as there was no functioning wetland present. There might have previously been a wetland as the soils suggest temporary zones, but no other evidence of an existing wetland was found during the survey.

6.8 Site WC8

This wetland forms part of the Klipspruit and falls within the Highveld Level 1 Ecoregion. The wetland is situated on a valley floor and was classified as a valley-head seep. The wetland is seasonally inundated and permanently saturated.

This very broad wetland is situated in between Landau colliery, cultivation, roads and roadwork, and a conveyor belt. The wetland has been disturbed by anthropogenic activities resulting in the surface being uneven with mounds throughout the wetland. The vegetation at this site was abundant but not diverse.

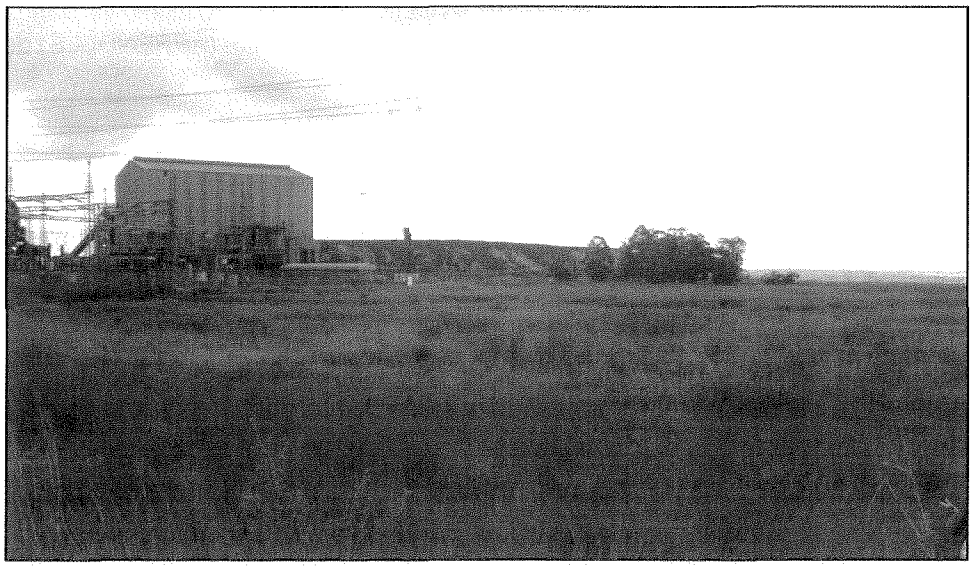

Figure 22: Site photo of BS seep.

APPENDIX A lists the floral species recorded at the site. The dominant species in the wetland was *Paspalum urvillei, Cyperus* sp, different *Helichrysum* sp and *Verbena bonariensis*. One faunal species was recorded at this site during the survey namely the Longtailed widow (*Euplectes progne)*. The Longtailed widow is occasionally associated with wet areas.

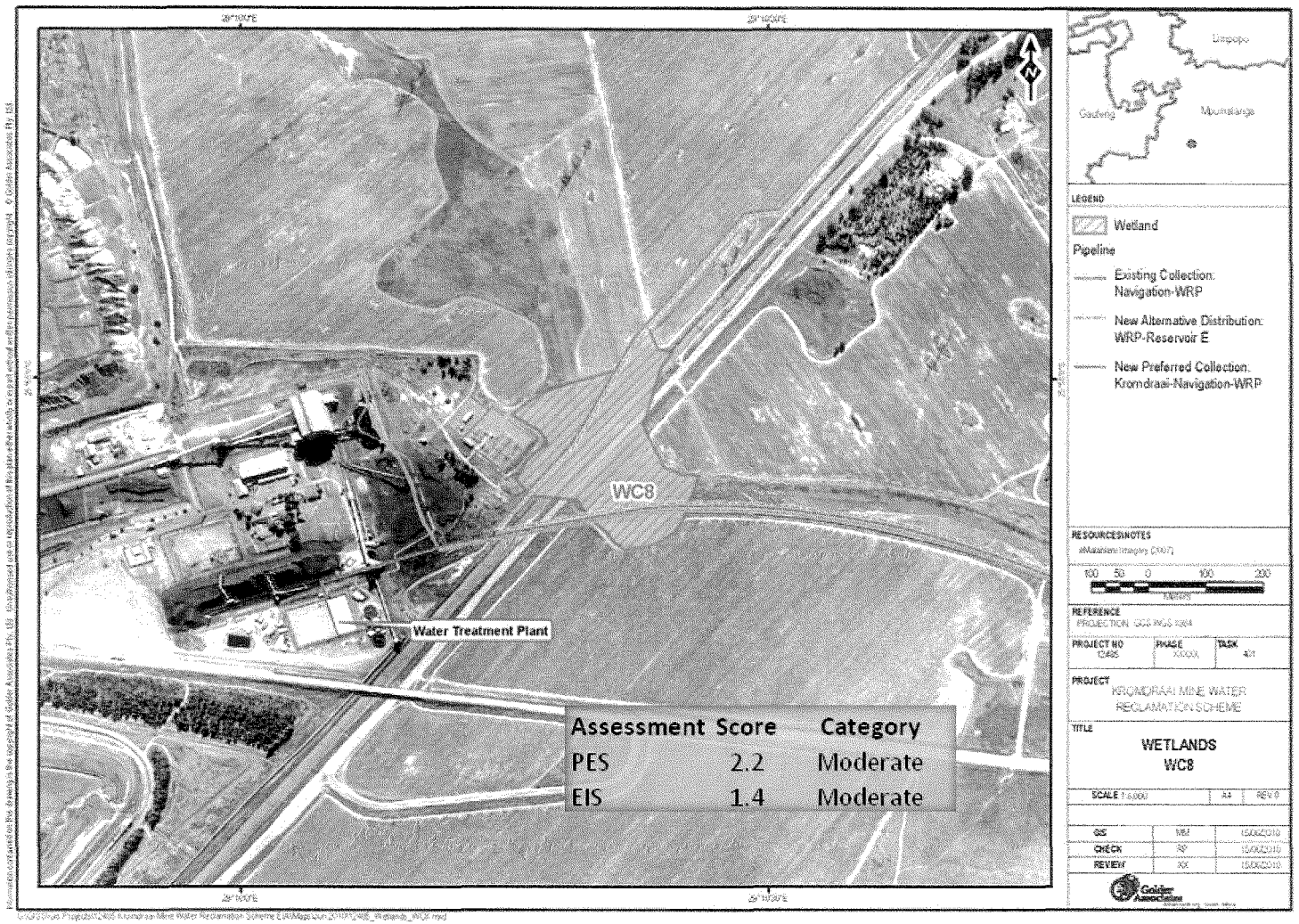

Figure 23: Site WC8 delineation and scores.

Present Ecological Status Assessment

A present ecological score of "moderate" was assigned to this wetland. This score suggests that the wetland is moderately modified with some loss of natural habitat (Table 6) (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Moderate" score in terms of Ecological Importance and Sensitivity. This wetland is therefore important on a provincial or local scale with the present biodiversity not being sensitive to flow and habitat modifications. Wetlands in this category play a small role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

These categories can be attributed mostly to the wetland being impacted on by the coal from the adjacent colliery, road construction and anthropogenic surface disturbance.

Wet-Ecoservices

Site WC8 scored "Moderate" for natural services and "Low" for human services. The natural services score was due to the past and current anthropogenic impacts and subsequent loss of some of the natural functions provided by the wetland. The "Low" human services score can be ascribed to the locality and type of the wetland. There are not many people in the vicinity of the wetland that are reliant on this particular wetland. Figure 33 shows the ratings for the different services provided by this wetland. This wetland is mostly effective in sediment and nutrient trapping, streamflow regulation and toxicant removal.

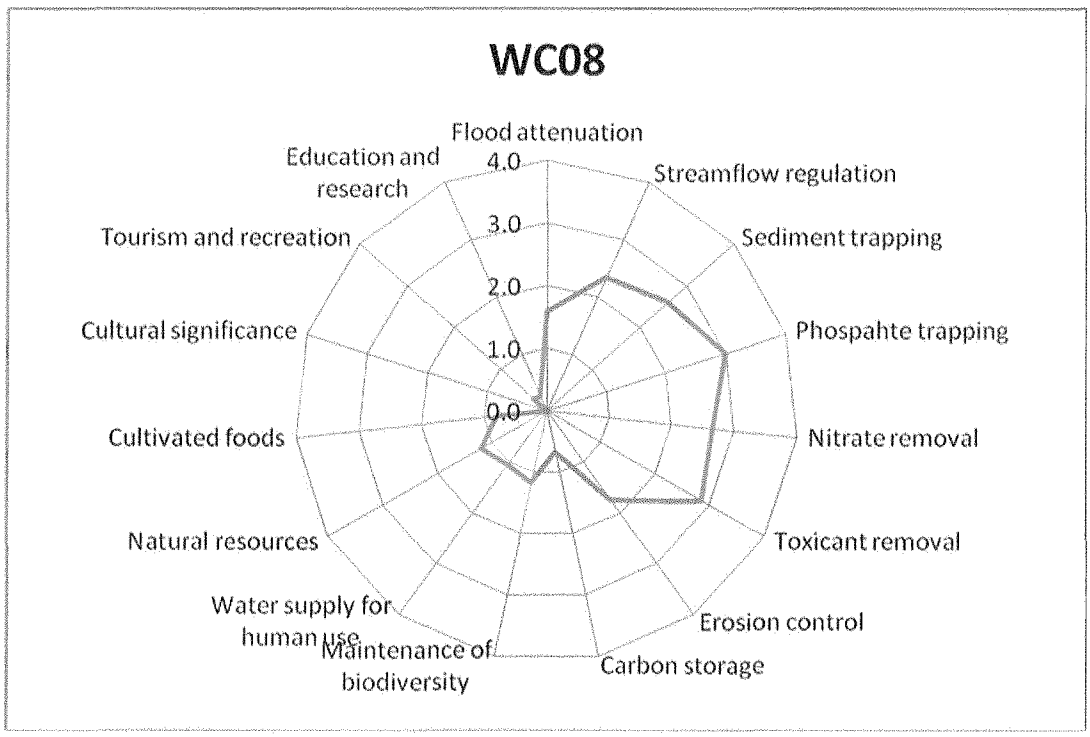

Figure 24: Ecological services scores for site WC8.

6.9 Site WC9

This wetland falls within the Highveld Level 1 Ecoregion. The wetland is situated on a bench (Hilltop) and was classified as an endorheic depression without channelled inflow. The depression is permanently inundated with a littoral depth class.

The existing road was possibly built through the seasonal zone of this depression as there was a wet area on the western side of the road. This wet area has been degraded by crop cultivation. The upgrading of the road is further impacting on the wetland. Further degradation of the depression is caused by surrounding cultivation and the encroachment of exotic trees.

Figure 25: Site photo of WC9.

APPENDIX A lists the floral species recorded at this site. Exotic species recorded on site included *Cyperus esculentus, Paspalum urvillei, Tagetes minuta* and *Acacia mearnsii*. The dominant species within the wetland was *Imperata cylidrica*. Two faunal species were recorded at this site during the survey namely the Golden Bishop *(Euplectes afer)* and the Southern Red Bishop *(Euplectes oryx)*. These species are usually associated with wetland areas where they breed within the grass and reed stands.

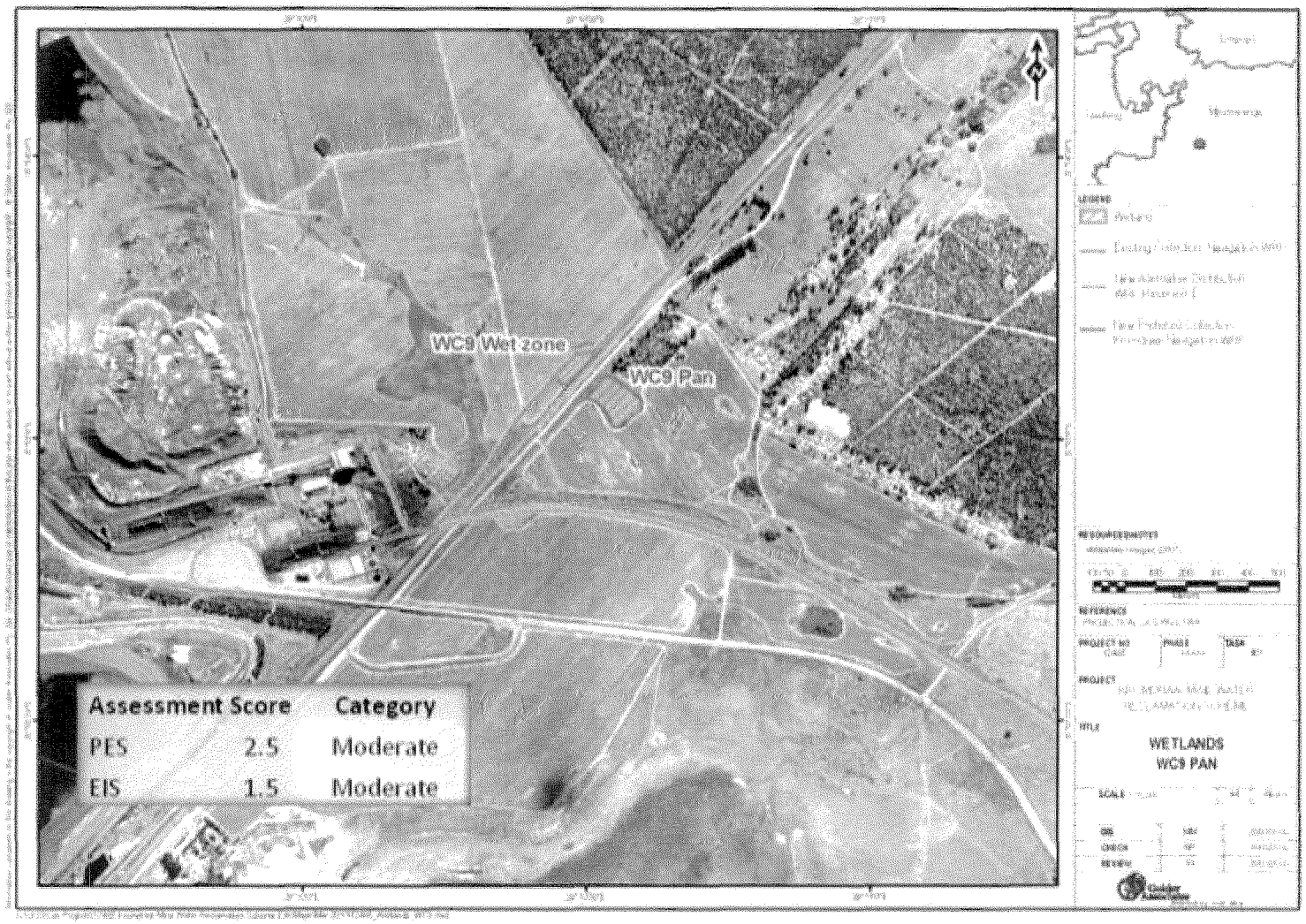

Figure 26: Site WC 9 delineation and scores.

Present Ecological Status Assessment

A present ecological score of "Moderate" was assigned to this wetland. This score suggests that the wetland is moderately modified with some loss of natural habitat (Table 6) (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Moderate" score in terms of Ecological Importance and Sensitivity. This wetland is therefore important on a provincial or local scale with the present biodiversity not being sensitive to flow and habitat modifications. Wetlands in this category play a small role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

These categories can be attributed mostly to the wetland being an endorheic depression and thus not contributing to a stream network.

Wet-Ecoservices

Site WC9 scored "Moderate" in terms of natural services and "Very low" in terms of human services. The moderate natural services score can be attributed to the loss of natural vegetation diversity and the site being a depression. The "Very low" human services score can be attributed to the low degree of human utilization of the wetland. Figure 5 shows the ratings for the different services provided by this wetland. The wetland is mostly functioning as a sediment and phosphate trap.

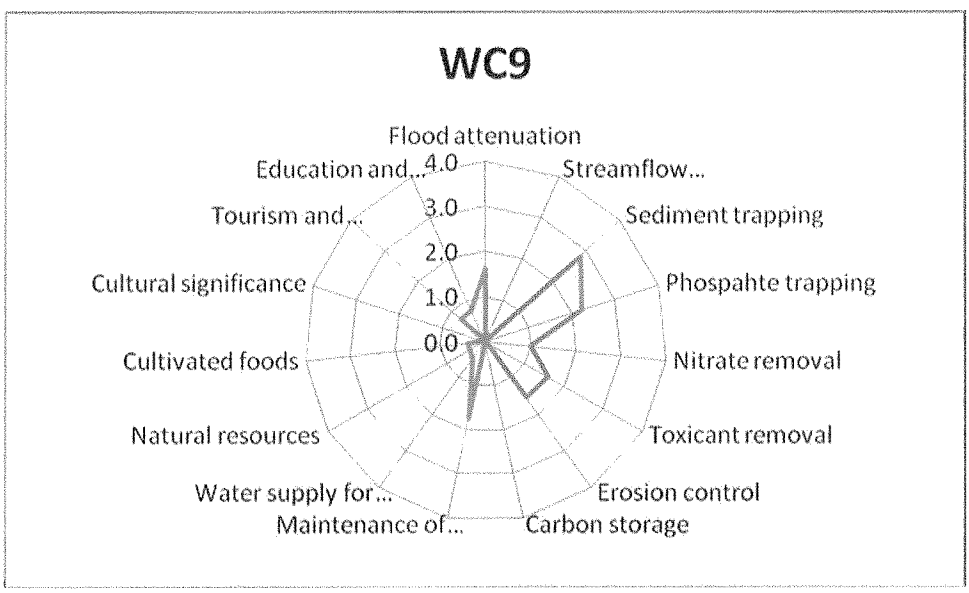

Figure 27: Ecological services scores for site WC3.

6.10 Site BS

This wetland forms part of the Blesbokspruit and falls within the Highveld Level 1 Ecoregion. The wetland is situated on a valley floor and was classified as a Channelled Valley Bottom wetland. The wetland is permanently inundated with a littoral depth class.

The reason for the permanent inundation is due to decant of water from the Middelburg Steam and Station Colliery. The channel is small and slightly incised, with water flowing on the slopes as well. The valley bottom is overgrown with *Eucalyptus,* indigenous vegetation is largely absent.

Figure 28: Site photo of WC5.

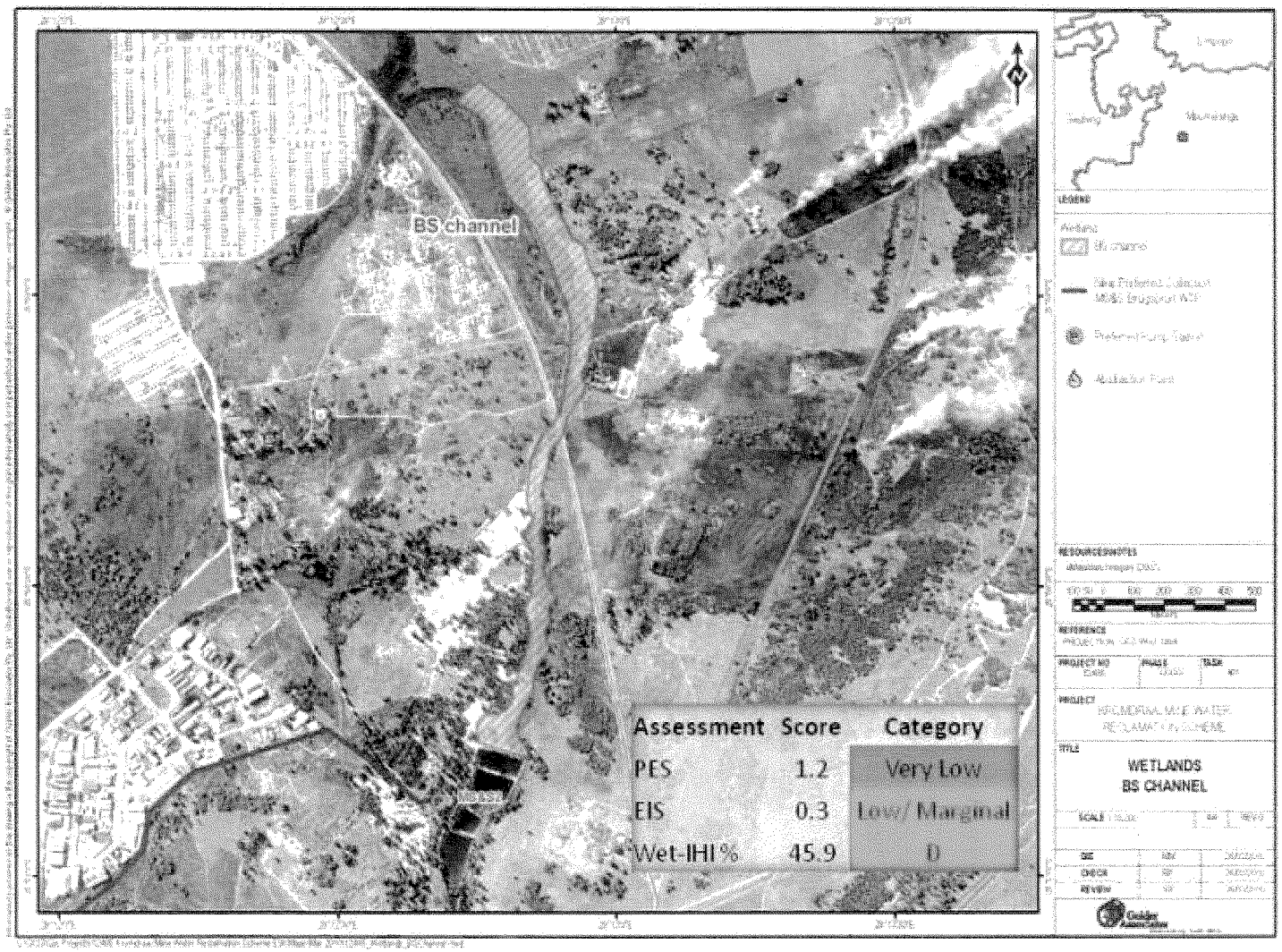

Figure 29: Site BS delineation and scores.

Present Ecological Status Assessment

A present ecological score of "Very Low" was assigned to this wetland. This score is outside of the generally excepted range and suggests that the wetland is seriously modified with extensive loss of natural habitat (as described in Table 6), The impaired state of the wetland can be attributed primarily to the decanting of acidic water, encroachment of exotic trees and other anthropogenic impacts (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Low" score for Ecological Importance and Sensitivity. The wetland is not ecologically sensitive at any scale and the biodiversity is not sensitive to habitat modifications. Wetlands in this category play an insignificant role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

Wetland-IHI

The habitat integrity of this wetland was calculated and a "C/D" class was assigned to it. A moderate to large loss and change of natural habitat has occurred in this wetland (as described in Table 7). This can clearly be illustrated by the bare areas lacking vegetation and the encroachment of exotic trees into the wetland. The detailed scores for habitat integrity are shown in APPENDIX C.

Wet-Ecoservices

Site BS scored "Low" for natural services and "Moderate" for human services. The low natural services score is due to anthropogenic impacts that have resulted in the loss of the natural functions provided by the wetland. The "Moderate" human services score can be attributed to the location of the wetland. Downstream high density housing surrounds the wetland. There are thus people in the vicinity that could make use of the wetland. Figure 5 shows the ratings for the different services provided by this wetland. As can be seen, this wetland is mainly contributing natural resources and is used for cultivation further downstream.

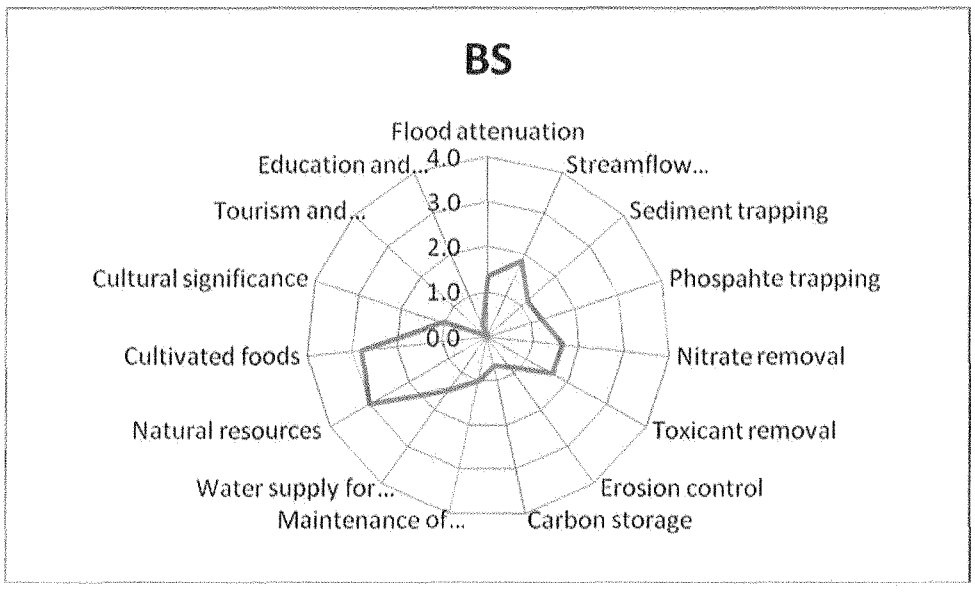

Figure 30: Ecological services scores for site BS.

6.11 Site BS seep

This wetland forms part of the Blesbokspruit and falls within the Highveld Level 1 Ecoregion. The wetland is situated on a slope and was classified as a Hillslope seep wetland without channelled outflow. The wetland is seasonally inundated and permanently saturated.

The site is situated adjacent to the channelled valley bottom wetland and is not affected by the decanting water as the water is seeping from higher up on the slope. The vegetation at this site was abundant but not diverse.

Figure 31: Site photo of BS seep.

APPENDIX A lists the floral species recorded at the site. The dominant species in the wetland was *Imperata cylindrica* and *Andropogon huillensis*. Two faunal species were recorded at this site during the survey namely the Golden Bishop *(Euplectes afer)* and the Glossy Ibis (*Plegadis falcinllus)*. The Golden bishop is usually associated with wetland areas where it breeds within the grass and reed stands. The Glossy ibis is always associated with wetlands as it feeds there.

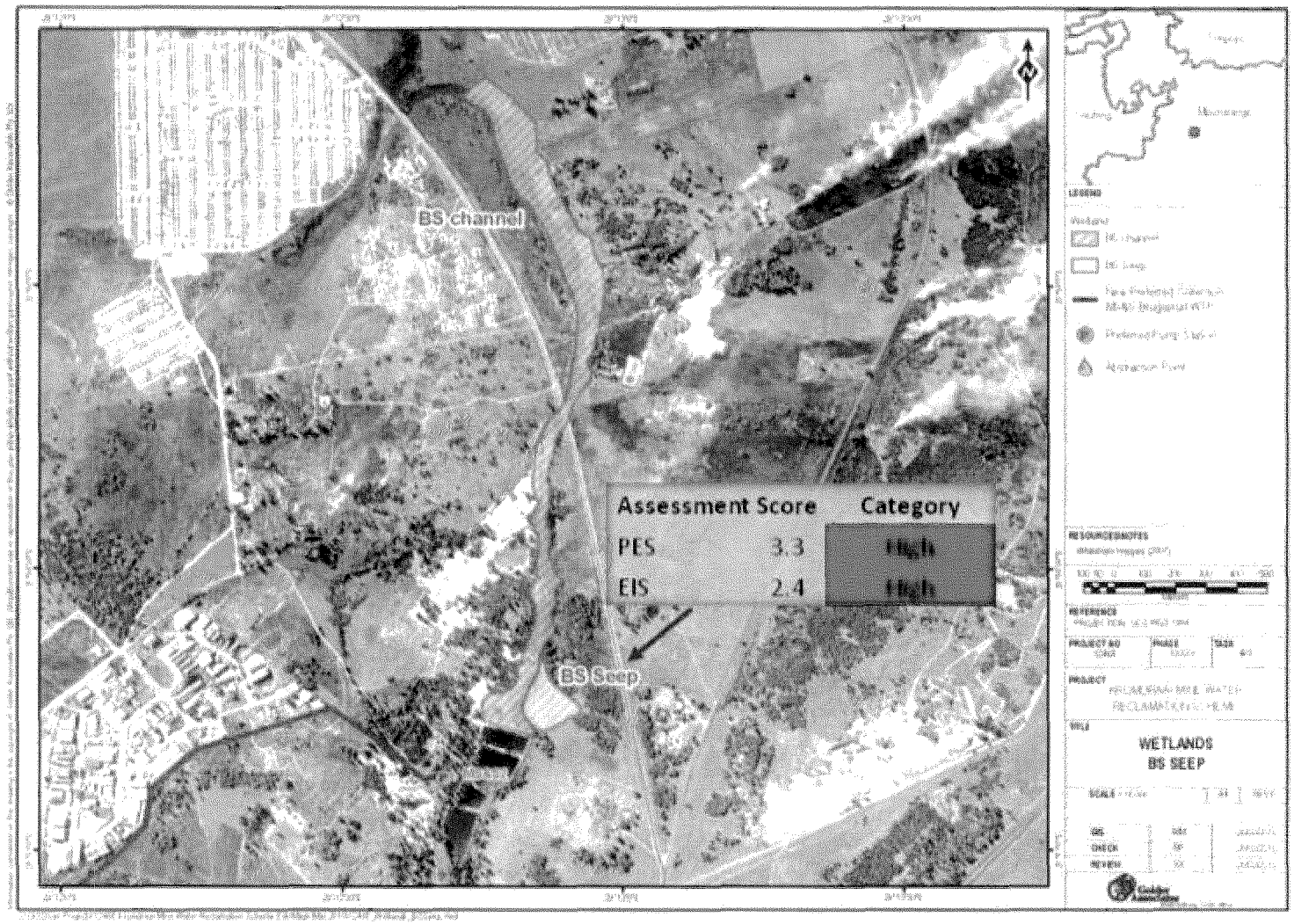

Figure 32: Site BS seep delineation and scores.

Present Ecological Status Assessment

A present ecological score of "High" was assigned to this wetland. This score suggests that this wetland is largely natural with some loss of natural habitat (as described in Table 6) (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "High" score for Ecological Importance and Sensitivity. The wetland is therefore important and sensitive on any scale with the present biodiversity being very sensitive to flow and habitat modifications. Wetlands in this category play a role in the quality of waters flowing into rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment). This is due to the dense natural vegetation occurring on the seep.

Wet-Ecoservices

Site WC2 scored "High" for natural services and "Moderate" for human services. The high natural services score can be attributed to the large amount of vegetation within the channel that can effectively sequester nutrients and toxins and attenuate floods. The "Moderate" human services score can be attributed to the location of the wetland. Some settlements are located in the vicinity of the site. There are thus people in the vicinity that make use of the wetland. Figure 5 shows the ratings for the different services provided by this wetland. As can be seen, this wetland is mostly effective in streamflow regulation, nutrient trapping, erosion control, carbon storage, maintenance of biodiversity and toxicant removal. It is also a source of natural resources.

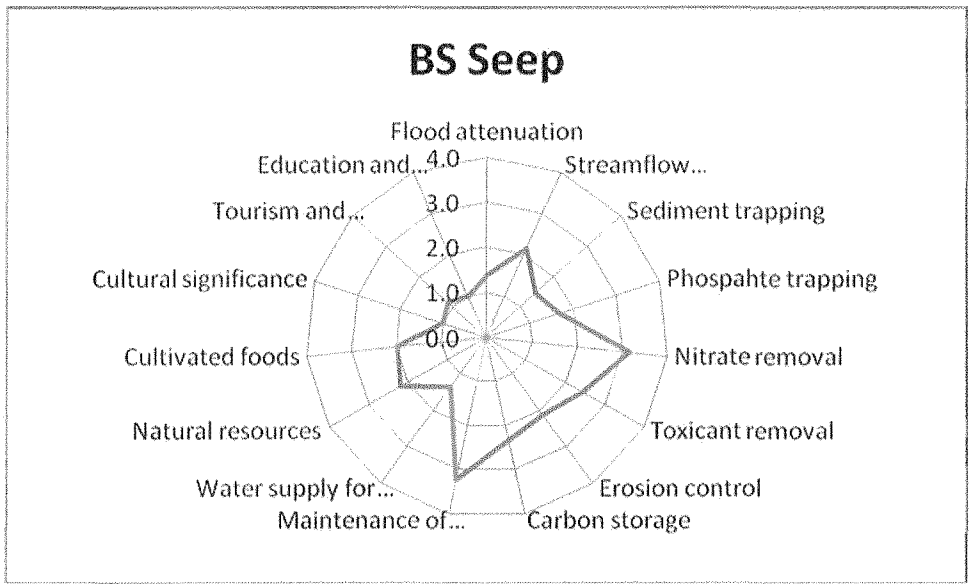

Figure 33: Ecological services scores for site BS seep.

6.12 Site WC10

This wetland falls within the Highveld Level 1 Ecoregion. The wetland is situated on a bench (Hilltop) and was classified as an endorheic depression without channelled inflow. The two depressions are permanently inundated with a littoral depth class. The depressions were further classified as artificial, being an off-channel dam.

The area was heavily impacted upon by grazing and anthropogenic disturbance. It is also situated in very close proximity to subsidence due to underground coal mining activities. These dams were possibly created as a water source for cattle.

Figure 34: Site photo of WC10

APPENDIX A lists the floral species recorded at this site. Dominant species recorded on site included *Cymbopogon excavatus, Seriphium plumosum* and *Verbena bonariensis*. No faunal species associated with wetlands were recorded at this site during the survey.

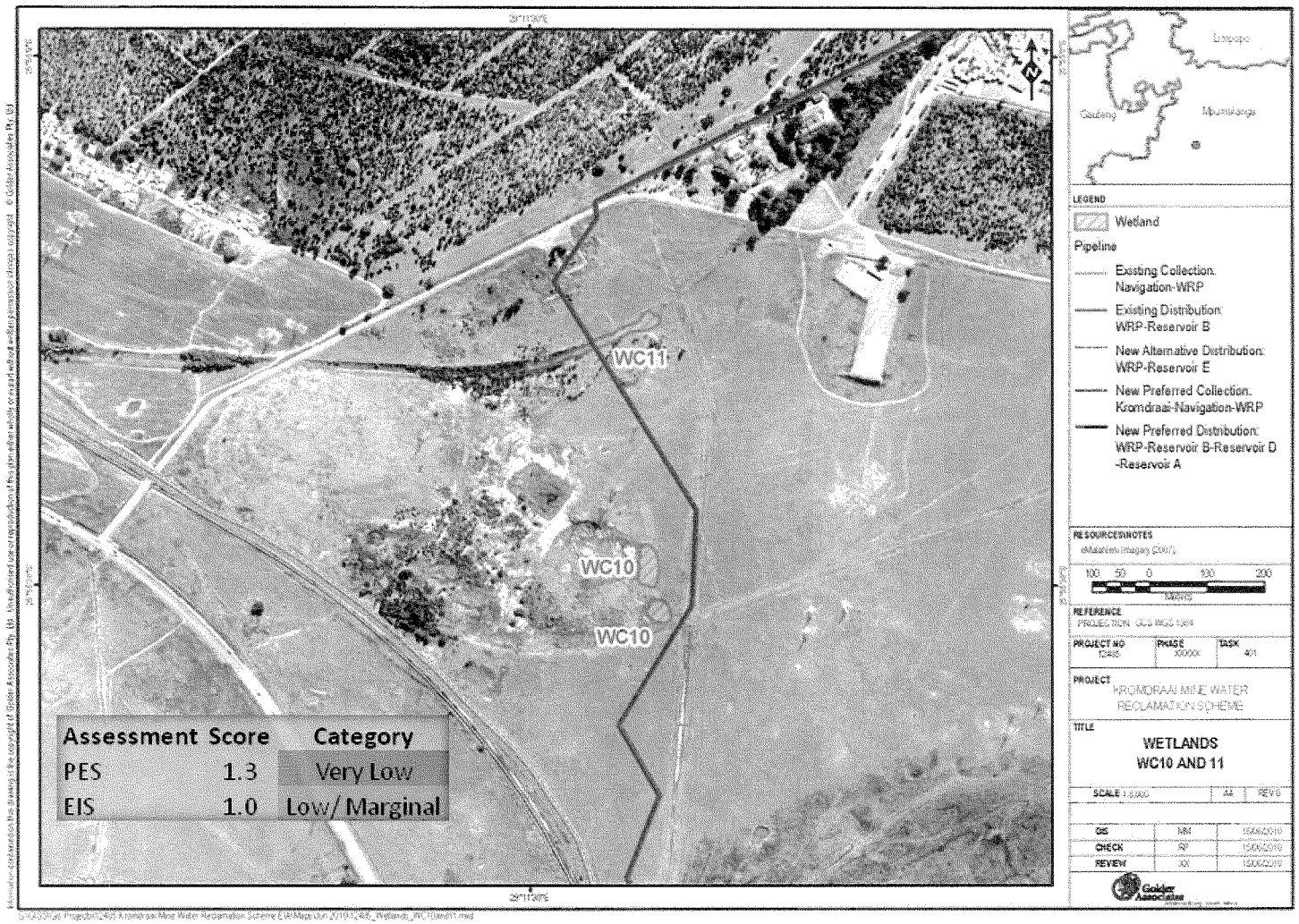

Figure 35: Sites WC 10 and 11 delineations and scores.

Present Ecological Status Assessment

A present ecological score of "Very Low" was assigned to these dams. This score is outside of the generally excepted range and suggests that the wetland is seriously modified with extensive loss of natural habitat (as described in Table 6), The impaired state of the wetland can be attributed to the overgrazed veldt and other anthropogenic impacts (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The wetland attained a "Low" score for Ecological Importance and Sensitivity. The wetland is not ecologically sensitive at any scale and the biodiversity is not sensitive to habitat modifications. Wetlands in this category thus play an insignificant role in the quality of waters flowing into major rivers (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

Wet-Ecoservices

Site WC10 scored "Moderate" for natural services and "Low" for human services. The natural services score was due to the artificial and degraded nature of the dams. The "Low" human services score can be ascribed to the locality of the wetland. The dams were possibly designed only as a water source for cattle. Figure 5 shows the ratings for the different services provided by this wetland. This wetland is mostly effective in phosphate- and sediment trapping.

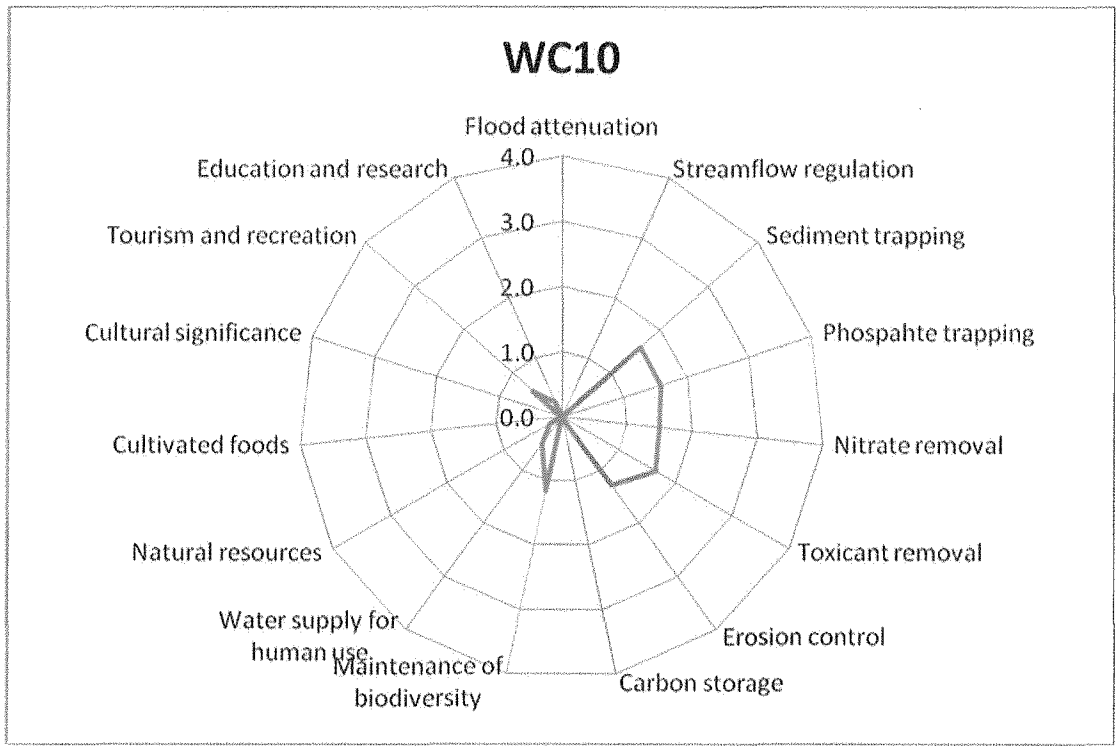

Figure 36: Ecological services scores for site WC10.

6.13 Site WC11

During the survey this site was found to be heavily impacted upon. The soils didn't show any sign of wetland soils, and instead consisted of fine coal up to a depth of 50 cm, with a layer of red soil on top. No running surface water was found to indicate a functioning wetland and the channel was overgrown with *Eucalyptus camaldulensis.* The channel is possibly an artificial furrow that was constructed to drain water into the wetland situated further downstream.

Figure 37: Soils at WC11.

Figure 38:Site WC11 site photo.

6.14 Site WC12

For the purpose of this assessment the pan was divided into two sections due to the difference in integrity. A pipeline runs through the middle of the pan with the northern section having a high integrity and the southern section having a lower integrity.

The northern section is surrounded by *Acacia mearnsii* on the outer edges and grass dominated in the pan itself. There are roads in the pan, but it doesn't seem to have significant impacts on the pan itself. The only noticeable erosion was seen on the road that enters the pan at a steep gradient. There were also two small manmade structures that were built in the wetland, but these also didn't seem to have a significant effect. This is possibly due to the large size of the pan. Within the pan there were open areas with water that boasted a few species of water fowl.

APPENDIX A lists the floral species recorded at this site. Dominant species recorded on site included *Cymbopogon excavatus, Seriphium plumosum* and *Verbena bonariensis*.

Figure 39: Site WC12 North looking South.

Due to limited access the southern section of the pan could not be surveyed in field and the ratings and integrity was thus based on desktop studies and what was found in the surrounding areas.

It was found that the subsidence from the mining in the area has also affected the southern section of the pan. The geohydrology and topography has been compromised, thus changing the pans functioning and biodiversity. One of the effects of subsidence is cracks caused by the uneven topography which could then drain the water in certain areas (Singh & Yadav, 1995). This then leads to the change in species composition and possible terrestrial encroachment.

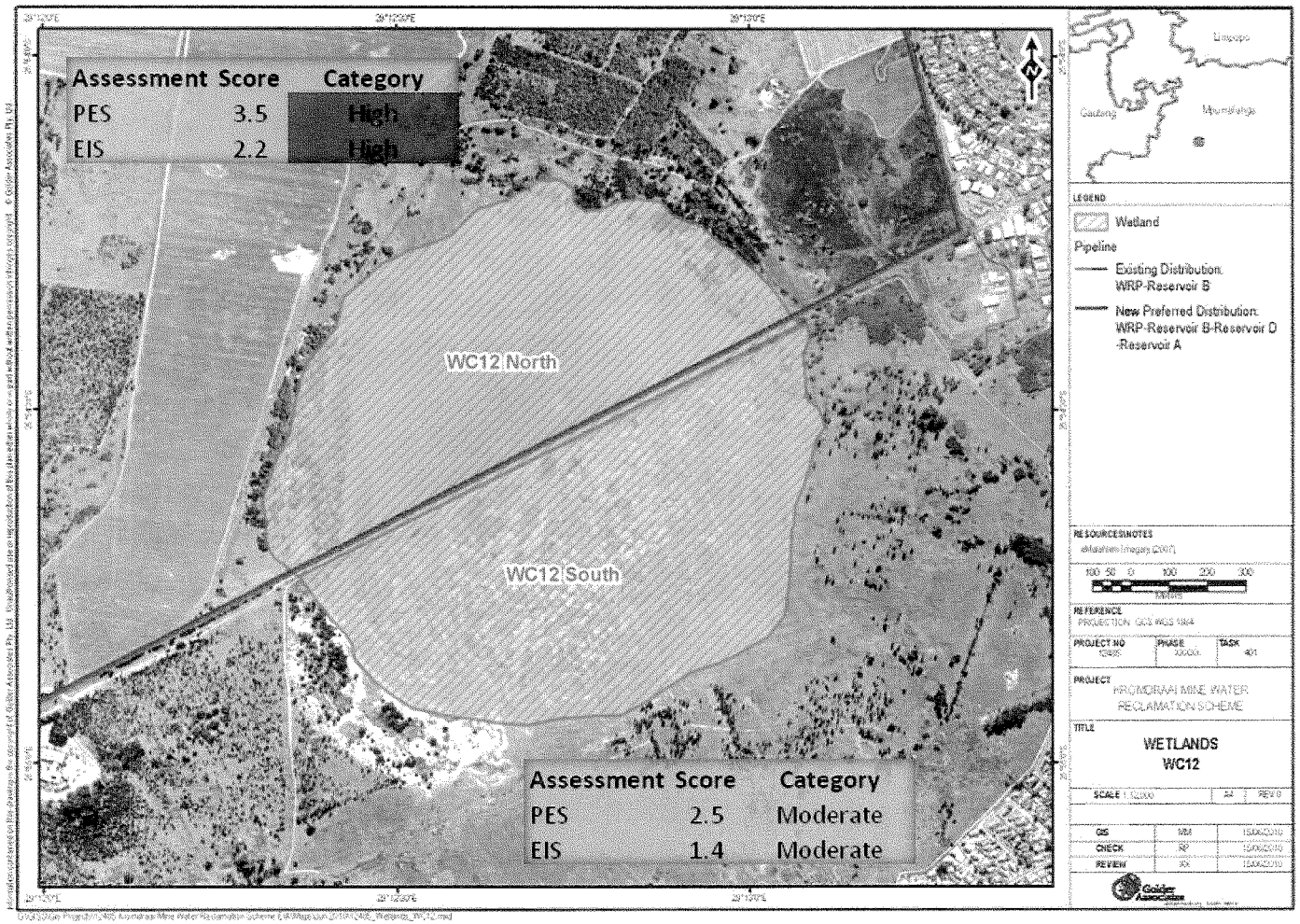

Figure 40: Site WC 12 delineation and scores.

Present Ecological Status Assessment

A present ecological score of "High" was assigned to the northern section of the pan. This score suggests that this wetland is largely natural with some loss of natural habitat (as described in Table 6).

The southern section of the pan was assigned an ecological score of "Moderate". This score suggests that the wetland is moderately modified with some loss of natural habitat (Table 6) (APPENDIX D details the results of the Ecological Status assessment).

Ecological Importance and Sensitivity

The northern section attained a "High" score for Ecological Importance and Sensitivity. The wetland is therefore important and sensitive on any scale with the present biodiversity being very sensitive to flow and habitat modifications. This is due to the dense natural vegetation occurring in the section of the pan.

The southern section of the pan attained a "Moderate" score in terms of Ecological Importance and Sensitivity. This wetland is therefore important on a provincial or local scale with the present biodiversity not being sensitive to flow and habitat modifications (APPENDIX E) details the results of the Ecological Importance and Sensitivity assessment).

Wet-Ecoservices

The northern section of the pan scored "Moderate" for natural and human services. The moderate natural services score can be attributed to the slight loss of natural habitat diversity and site degradation due to anthropogenic impacts which have contributed to loss of some of the natural functions provided by the wetland. The "Moderate" human services score can be attributed to the locality of the wetland. Some informal settlements are located around the pan, so there are people in the vicinity that can make use of the wetland. Figure 5 shows the ratings for the different services provided by this wetland. As can be seen, this wetland is mostly effective in nutrient trapping, erosion control, toxicant removal and maintenance of biodiversity. It was also a source of natural resources.

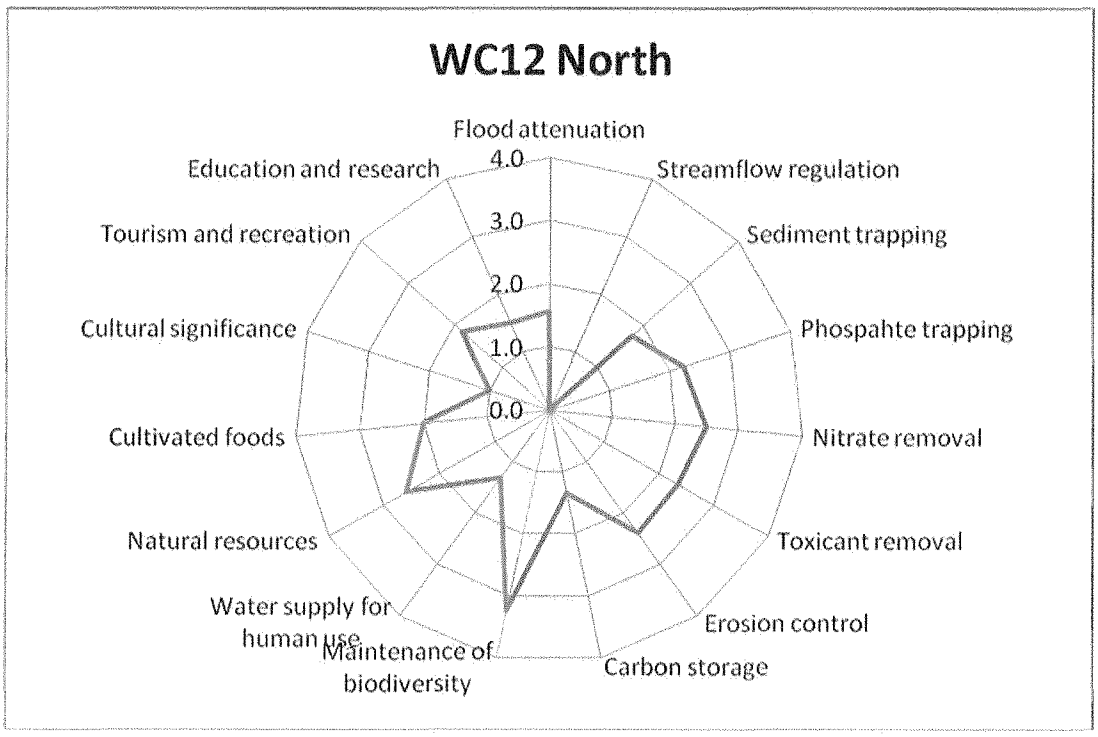

Figure 41: Ecological services scores for site WC 12 North.

The southern section of the pan scored "Moderate" for natural services and "Low" for human services. The natural services score was mostly due to the topographic alteration as a result of the subsidence, and

subsequent loss of some of the natural functions provided by the wetland. The "Low" human services score can be ascribed to the dangerous and impacted nature of the wetland. Figure 33 shows the ratings for the different services provided by this wetland. This wetland is not very effective in trapping, regulation or toxicant removal.

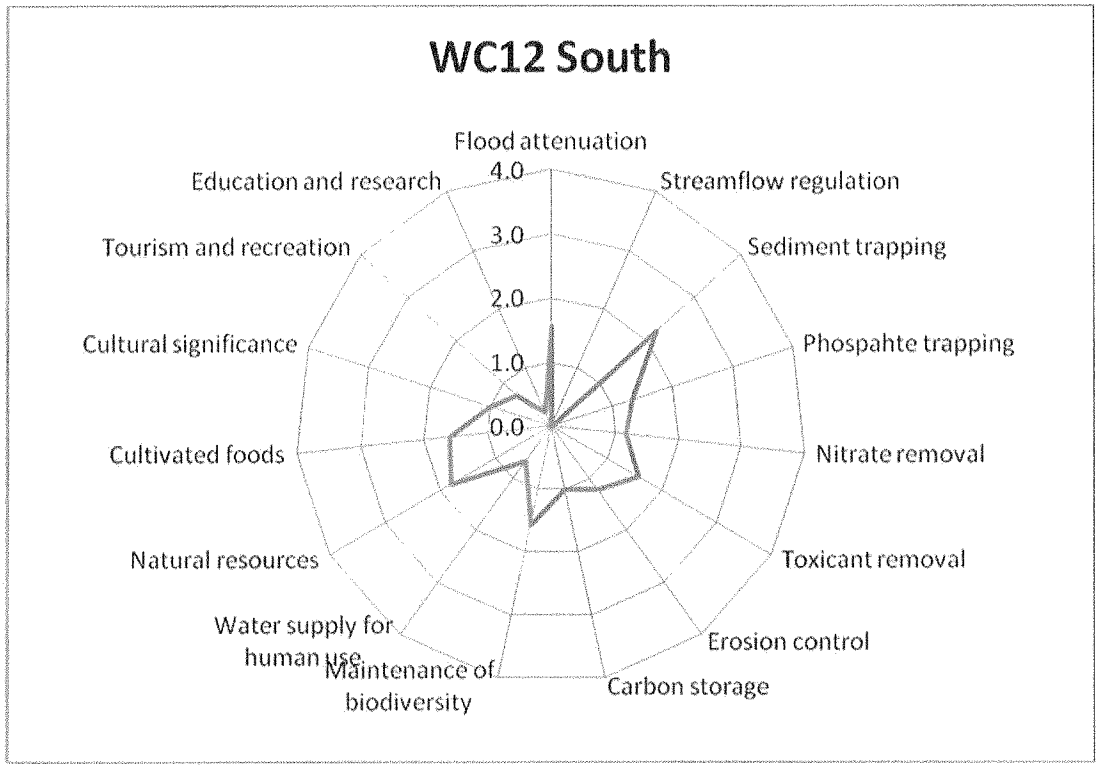

Figure 42: Ecological services scores for site WC12 South.

7.0 IMPACT ASSESSMENT

During the assessment of the possible impacts the following phases were taken into consideration:

- Construction phase
  - Bed disturbance, vegetation removal and habitat degradation;
  - Inundation due to narrowing of the channel during construction;
  - Dust and sediment settling on the wetland; and
  - Compacting of wetland soils.
- Operation phase
  - Inundation due to pipeline not buried deep enough below the wetland water table;
  - Eroding of wetland substrates due to water released from scour valves; and
  - Degradation of habitat due to untreated mine water released/spilled into the system.

7.1 Impact assessment significance

The impact significance was rated based on the above mentioned impacts and the results are presented below. Impact assessments were not conducted for the following sites:

- **WC 7** – No active wetland was found at the pipeline crossing site. It is suggested that the pipeline be constructed as close to the conveyer belt as possible and that rehabilitation of the site be done after construction;
- **WC 9** – The proposed pipeline will be located on the western side of the road and railway. This area has been extensively degraded through cultivation and thus no functional wetland is present. The pan is situated on the other side of the road and won't be impacted upon;
- **BS seep** – This seep zone is not affected by the reduction in water to the valley bottom channel; and
- **WC 11** – This artificial furrow is already heavily impacted upon, and the channel is very narrow. Thus a pipeline would not have a significant impact on this artificial system.

7.1.1 Best practice guidelines

The following mitigation measures were considered "best practise guidelines" for the building of the pipeline, and are applicable for all of the sites:

- Pipeline construction mitigation:
  - Construct pipeline / watercourse crossings during the dry season;
  - Construct pipeline / watercourse crossings in sections so as to limit the impact to the sites and the amount of water being inundated;
  - Where possible, keep construction activities out of the wetland;
  - Limit movement of construction vehicles within wetlands and restrict vehicles to service roads;
  - Avoid dumping on or damage to the wetlands;
  - Monitor the ecological status of the wetland (through Wetland-IHI and PES method), floral species composition (through community analysis) and water quality both upstream and downstream of the pipeline / watercourse crossing sites. The monitoring should be conducted bi-annually during construction by a wetland ecologist, and bi-annually for a year after completion of construction;
  - After the final years monitoring results should not be lower than what was found during the baseline study.
  - Contain and clean up any accidental spillages or impacts to the aquatic and wetland ecosystems during construction;
  - Appoint an Environmental officer to oversee construction and make workers aware of rare and sensitive species. Devise and implement a relocation plan if rare and sensitive species are encountered during construction;
- Dust and sediment control
  - Contain loose soils to avoid degrading wetland habitats downstream;
  - Implement dust suppression on dirt roads during construction to avoid excessive dust formation;
  - Maintain service roads to avoid erosion and dust formation.
- Soil impact mitigation

- Where wetland soils have been compacted, labourers on foot should loosen soils with light weight tools.

- Pipeline operation mitigation
  - Monitor the pipeline for leaks and spills on a regular basis during the operational phase. This should be conducted by mine personnel;
  - Repair damaged pipes immediately to avoid excessive spills;
  - Prevent pipeline spillages and, should any occur, contain, clean up and rehabilitate immediately;
  - Ensure that any release or spills from scour valves are contained and not released into the environment.
- General mitigation
  - Implement rehabilitation where construction site impacts occur;
  - Revegetate bare areas and remove exotic vegetation.

Table 15: Impacts significance table for site KS.

Removal of mine water								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Impacts on water quality	**SBM**						Removal of mine water is considered to be a positive impact on the water quality of the entire project area, as the water currently flowing down the Kromdraaispruit is currently very acidic.	No mitigation is required as the wetland will be returning to a more natural state. The water will also be of a better quality. Due to the impacted nature of the site the proposed project will have a positive impact in the long run.
	2	4	2	4	**32**	Low		
	SAM							
	No applicable mitigation measures							
Impacts on habitat: Seasonal zone	**SBM**						Removal of the discharged mine water from the wetland will revert the seasonal wetland zones size to a more natural state. Although the seasonal wetland area will then be smaller than usual the overall impact will be positive.	**Minimization:** • Monitor the ecological status of the wetland (through Wetland-IHI and PES method), floral species composition (through community analysis) and water quality at abstraction points and downstream points along the Kromdraaispruit. The monitoring should be conducted bi-annually after initiation of abstraction by a wetland ecologist. Findings from the monitoring cycle will indicate further management action if required. **Rectification:** • Implement rehabilitation where negative habitat impacts have occurred and are likely to occur in the future; i.e. revegetate bare areas; • Remove exotic vegetation. • Prevent encroachment of exotic vegetation at both sites.
	6	4	2	4	**48**	Low		
	SAM							
	4	4	2	4	**40**	Low		
Impacts on habitat: Permanent zone	**SBM**						Removal of the discharged mine water from the wetland will change the permanently inundated zones to seasonally inundated zones, which is a more natural state. The overall impact will be positive.	**Minimization:** • Monitor the ecological status of the wetland (through Wetland-IHI and PES method), floral species composition (through community analysis) and water quality at abstraction points and downstream points along the Kromdraaispruit. The monitoring should be conducted bi-annually
	4	4	2	4	**40**	Low		
	SAM							

	2	3	2	4	**28**	Low		after initiation of abstraction by a wetland ecologist. Findings from the monitoring cycle will indicate further management action if required. **Rectification:** • Implement rehabilitation where negative habitat impacts have occurred and are likely to occur; i.e. revegetate bare areas; • Remove exotic vegetation from the Kromdraaispruit wetland area to prevent loss off water in the wetland. • Prevent encroachment of exotic vegetation at both sites.

Table 16: Impacts significance table for site WC1

Construction of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Bed disturbance vegetation removal and habitat degradation	**SBM**						Due to the proposed pipeline being buried at this site the vegetation will be cleared and a trench will be excavated. This may constitute a considerable impact if not kept to a minimum and if spoils are not kept out of the wetland. It is expected that this process will destroy a moderate amount of habitat.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude that lies to the north of the current proposed pipeline. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
	10	2	1	5	**65**	**Moderate**		
	SAM							
	4	2	1	4	**28**	Low		
Inundation	**SBM**						Due to diversion and smaller channels being available during construction and excavation of trenches, an area upstream of the construction site might be inundated. This could result in habitat loss.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude that lies to the north of the current proposed pipeline. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. • Allow for ample flow through of water.
	8	2	2	4	**48**	Low		
	SAM							

Construction of the pipeline

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
	2	2	1	4	20	Low		See Best Practice Guidelines (7.1.1)
Dust and sediment settling on the wetland	SBM						During construction, vehicles will move in the vicinity of the wetland. This is likely to contribute to dust and sediment entering the wetland. This is a negative impact that could cause vegetation degradation.	See Best Practice Guidelines (7.1.1)
	8	2	2	5	60	Moderate		
	SAM							
	6	2	2	4	40	Low		
Compacting of soils	SBM						The movement of construction vehicles could result in compacting of soils in the wetland area. This is a negative impact that could cause vegetation degradation and the path of flow of water in the wetland to change.	See Best Practice Guidelines (7.1.1)
	8	3	2	5	65	Moderate		
	SAM							
	4	2	1	3	21	Low		

Operation of the pipeline

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Inundation and flow obstruction due to pipeline location and spills	SBM						If the pipeline is not buried deep enough belowground water flow will be impeded and inundation could occur. This will further result in habitat loss in the wetland and possible decrease in water downstream of the pipeline.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude that lies to the north of the current proposed pipeline. If it cannot be constructed above ground it should be buried deep enough to not impede groundwater flow. • Allow for ample flow through of water. See Best Practice Guidelines (7.1.1)
	8	5	1	4	56	Moderate		
	SAM							
	2	2	1	4	20	Low		
Eroding of wetland channel due to release from scour valves	SBM						If the release from the scour valves is not contained it could cause erosion in the wetland channel and subsequent habitat degradation and loss.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude that lies to the North of the current proposed pipeline. If it cannot be constructed above ground it should be buried deep
	8	3	2	5	65	Moderate		
	SAM							

Construction of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
	4	2	1	4	**28**	**Low**		enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
Degradation of wetland integrity due to spill of untreated water at scour valves	**SBM**						If the spill from the damaged scour valves or pipelines is not addressed immediately it could cause erosion in the wetland channel and subsequent habitat degradation and loss due to decreased water quality.	See Best Practice Guidelines (7.1.1)
	10	3	3	5	**80**	**High**		
	SAM							
	6	1	2	4	**36**	**Low**		

Table 17: Impacts significance table for site WC2.

Construction of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Bed disturbance, vegetation removal and habitat degradation	**SBM**						Due to the pipeline being buried at this site the vegetation will be cleared and a trench will be excavated. This may result in a considerable impact especially if spoils are not kept out of the wetland. This process may contribute to moderate degree of habitat modification.	See Best Practice Guidelines (7.1.1)
	10	2	1	5	**65**	**Moderate**		
	SAM							
	8	1	1	5	**50**	**Moderate**		
Inundation	**SBM**						During construction flow in the wetland will need to be diverted in order to prevent inundation of the construction activities. This may lead to increased inundation upstream of the construction activities. The duration of this impact will be limited to the construction phase.	**Minimization:** • Allow for enough flow through of water to avoid upstream inundation. See Best Practice Guidelines (7.1.1)
	8	2	2	4	**48**	**Low**		
	SAM							
	4	2	1	4	**28**	**Low**		
Dust and sediment settling on the wetland	**SBM**						Construction activities are likely to result in increased dust and sediment entering the wetland. This is a negative impact that could cause vegetation degradation and direct impacts of sensitive aquatic biota	See Best Practice Guidelines (7.1.1)
	8	2	2	5	**60**	**Moderate**		
	SAM							
	6	2	2	4	**40**	**Low**		

Construction of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Compacting of soils	**SBM**						The movement of heavy construction vehicles may result in compacting of soils in the wetlands. This is a negative impact that could cause vegetation degradation and the change of flow patterns within the wetlands.	See Best Practice Guidelines (7.1.1)
	8	3	2	5	**65**	**Moderate**		
	SAM							
	6	2	1	4	**36**	**Low**		

Operation of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Inundation and flow obstruction due to pipeline location and spills	**SBM**						If the pipeline is not buried below the level of the water table the water flow will be impeded and inundation could occur. This will further result in habitat loss in the wetland and possible decrease in water downstream of the pipeline.	**Avoidance:** • Insure that the pipeline is buried below the wetland groundwater table. See Best Practice Guidelines (7.1.1)
	8	5	1	4	**56**	**Moderate**		
	SAM							
	4	0	1	5	**25**	**Low**		
Eroding of wetland channel due to release from scour valves	**SBM**						If releases from the scour valves are not contained it could cause erosion in the wetland channel and subsequent habitat degradation and loss.	See Best Practice Guidelines (7.1.1)
	8	2	2	4	**48**	**Low**		
	SAM							
	4	2	1	4	**28**	**Low**		
Degradation of wetland integrity due to spill of untreated water at scour valves	**SBM**						If the spills from the damaged scour valves or pipelines are not addressed immediately it could cause erosion in the wetland channel and subsequent habitat degradation and loss due to poor water quality.	See Best Practice Guidelines (7.1.1)
	10	3	3	5	**80**	**High**		
	SAM							
	8	1	2	4	**44**	**Low**		

Table 18: Impacts significance table for site WC3.

Construction of the pipeline

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Bed disturbance, vegetation removal and habitat degradation	**SBM**						Burying of the pipeline will require removal of the wetland vegetation and the excavation of a trench resulting in the destruction of wetland habitat. This may result in a substantial impact if not carefully controlled and if spoils are dumped on the remaining wetland. Two wetlands areas will be crossed.	**Minimization:** • It is suggested that the pipeline be constructed above ground and follow the road servitude that crosses the channel. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
	8	2	1	5	**55**	**Moderate**		
	SAM							
	2	2	1	4	**20**	**Low**		
Inundation	**SBM**						Due to diversion and smaller channels being available during construction and excavation of trenches, an area upstream of the construction site might become more inundated than usual. This could also result in habitat loss.	**Minimization:** • It is suggested that the pipeline be constructed above ground and follow the road servitude that crosses the channel. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. • If extra culverts need to be added, allow for ample flow through of water. See Best Practice Guidelines (7.1.1)
	6	2	2	4	**40**	**Low**		
	SAM							
	2	2	1	4	**20**	**Low**		
Dust and sediment settling on the wetland	**SBM**						During construction, vehicles will move in the vicinity of the wetland. This is likely to contribute to dust and sediment entering the wetland. This is a negative impact that could cause vegetation degradation	See Best Practice Guidelines (7.1.1)
	8	2	2	5	**60**	**Moderate**		
	SAM							
	6	2	2	4	**40**	**Low**		
Compacting of soils	**SBM**						The movement of construction vehicles could cause compacting of soils in the wetland area. This is a negative impact that could cause vegetation degradation and the flow of water in the wetland to change.	See Best Practice Guidelines (7.1.1)
	6	2	2	5	**50**	**Moderate**		
	SAM							
	4	2	1	3	**21**	**Low**		

Operation of the pipeline

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		

Construction of the pipeline									
Inundation and flow obstruction due to pipeline location and spills	SBM						If the pipeline is not buried deep enough ground water flow will be impeded and this could result in increased inundation upstream of the pipeline. This will further result in habitat loss in the wetland and possible decreased flow downstream of the pipeline.	**Minimization:** • It is suggested that the pipeline be constructed above ground and follow the road servitude that crosses the channel. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
	6	5	1	4	**48**	Low		
	SAM							
	2	2	1	4	**20**	Low		
Eroding of wetland channel due to release from scour valves	SBM						If the releases from the scour valves are not contained it could contribute to erosion of the wetland channel and subsequent habitat degradation and loss. In a channel already subject to erosion this could significantly worsen the rate of erosion.	See Best Practice Guidelines (7.1.1)
	10	3	3	5	**80**	High		
	SAM							
	6	2	2	4	**40**	Low		
Degradation of wetland integrity due to spill of untreated water at scour valves	SBM						If the spills from the damaged scour valves or pipelines are not addressed immediately it could cause erosion in the wetland channel and subsequent habitat degradation and loss due to poor water quality.	See Best Practice Guidelines (7.1.1)
	8	3	3	5	**70**	Moderate		
	SAM							
	6	1	2	4	**36**	Low		

Table 19: Impacts significance table for site WC4 (and RR3).

Construction of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Bed disturbance, vegetation removal and habitat degradation	8	2	1	5	**55**	Moderate	Burying of the pipeline will require removal of the wetland vegetation and the excavation of a trench resulting in the destruction of wetland habitat. This may result in a substantial impact if not carefully controlled and if spoils are dumped on the	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude. If it cannot be constructed above ground it should be buried deep enough so as to not impede groundwater flow. • If culverts need to be extended, allow enough culvert space for ample flow through of water.
	SAM							
	4	2	1	4	**28**	Low		

							remaining wetland.	See Best Practice Guidelines (7.1.1)
Inundation	**SBM**						During construction flow in the wetland will need to be diverted in order to prevent inundation of the construction activities. This may lead to increased inundation upstream of the construction activities. The duration of this impact will be limited to the construction phase.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. • If culverts need to be extended, allow enough culvert space for ample flow through of water. See Best Practice Guidelines (7.1.1)
	8	2	2	5	**60**	**Moderate**		
	SAM							
	2	2	1	4	**20**	**Low**		
Dust and sediment settling on the wetland	**SBM**						During construction, vehicles will move around the wetland. This will cause excessive dust and sediment to enter and settle on the wetland. This is a negative impact that could cause vegetation degradation	See Best Practice Guidelines (7.1.1)
	8	2	2	5	**60**	**Moderate**		
	SAM							
	6	2	2	4	**40**	**Low**		
Compacting of soils	**SBM**						The movement of construction vehicles could cause compacting of soils in the wetland area. This is a negative impact that could cause vegetation degradation and the flow of water in the wetland to change.	See Best Practice Guidelines (7.1.1)
	6	3	2	5	**55**	**Moderate**		
	SAM							
	2	2	1	3	**15**	**Low**		

Operation of the pipeline

Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Inundation and flow obstruction due to pipeline location and spills	**SBM**						If the pipeline is not buried deep enough ground water flow may be impeded resulting in increased inundation upstream of the pipeline site. This will further result in habitat loss in the wetland and possible decrease in flow downstream of	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. • If culverts need to be extended, allow enough culvert space for ample flow through of water.
	10	5	1	5	**80**	**High**		
	SAM							
	2	2	1	4	**20**	**Low**		

							the pipeline.	See Best Practice Guidelines (7.1.1)
Eroding of wetland channel due to release from scour valves	**SBM**						If the releases from the scour valves are not contained it could contribute to erosion in the wetland channel resulting in habitat degradation and loss.	See Best Practice Guidelines (7.1.1)
	6	3	2	5	**55**	**Moderate**		
	SAM							
	4	2	1	4	**28**	**Low**		

Table 20: Impacts significance table for site WC5 (and RR3).

Construction of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Bed disturbance, vegetation removal and habitat degradation	**SBM**						Burying of the pipeline will require removal of the wetland vegetation and the excavation of a trench resulting in the destruction of wetland habitat. This may result in a substantial impact if not carefully controlled and if spoils are dumped on the remaining wetland.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. • If extra culverts are needed, allow for ample flow through of water. See Best Practice Guidelines (7.1.1)
	8	2	1	5	**55**	**Moderate**		
	SAM							
	6	2	1	5	**45**	**Low**		
Inundation	**SBM**						During construction flow in the wetland will	**Minimization:**

Construction of the pipeline								
	10	2	2	5	**70**	**Moderate**	need to be diverted in order to prevent inundation of the construction activities. This may lead to increased inundation upstream of the construction activities. The duration of this impact will be limited to the construction phase.	• It is suggested that the pipeline be constructed above ground on the road servitude. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. • Where extra culverts need to be added, allow for ample flow through of water See Best Practice Guidelines (7.1.1)
	SAM							
	2	2	1	4	**20**	**Low**		
Dust and sediment settling on the wetland	**SBM**						During construction, vehicles will move around in the vicinity of the wetland. This may contribute to dust and sediment entering the wetland. This is a negative impact that could cause vegetation degradation	See Best Practice Guidelines (7.1.1)
	6	2	2	5	**50**	**Moderate**		
	SAM							
	4	2	2	4	**32**	**Low**		
Compacting of soils	**SBM**						The movement of construction vehicles could cause compacting of soils in the wetland area. This is a negative impact that could cause vegetation degradation and the flow of water in the wetland to change.	See Best Practice Guidelines (7.1.1)
	10	3	2	5	**75**	**High**		
	SAM							
	8	2	1	4	**44**	**Low**		
Operation of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Inundation and flow obstruction due to pipeline location and spills	**SBM**						If the pipeline is not buried enough ground water flow will be impeded resulting in increased inundation upstream of the pipeline crossing site. This will further result in habitat loss in the wetland and possible decrease in water downstream of the pipeline.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. • Where extra culverts need to be added, allow for ample flow through of water See Best Practice Guidelines (7.1.1)
	8	5	1	5	**70**	**Moderate**		
	SAM							
	4	2	1	4	**28**	**Low**		

Construction of the pipeline									
Eroding of wetland channel due to release from scour valves	SBM						If releases from the scour valves are not contained it could result in erosion of the wetland channel and subsequent habitat degradation and loss.	See Best Practice Guidelines (7.1.1)
	6	3	2	5	55	Moderate		
	SAM							
	4	2	1	4	28	Low		

Table 21: Impacts significance table for site WC6 (original)

Construction of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Bed disturbance, vegetation removal and habitat degradation	SBM						Burying of the pipeline will require removal of the wetland vegetation and the excavation of a trench resulting in the destruction of wetland habitat. Even though the site is degraded there will be an impact especially if spoils are not kept out of the wetland.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude that lies to the East of the current proposed pipeline. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
	6	2	1	5	45	Low		
	SAM							
	2	2	1	4	20	Low		
Inundation	SBM						During construction flow in the wetland will need to be diverted in order to prevent inundation of the construction activities. This may lead to increased inundation upstream of the construction activities. This could also result in habitat loss. The duration of this impact will be limited to the construction phase.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude that lies to the East of the current proposed pipeline. See Best Practice Guidelines (7.1.1)
	6	2	2	4	40	Low		
	SAM							
	2	2	1	4	20	Low		
Dust and	SBM						During construction, vehicles will move	See Best Practice Guidelines (7.1.1)

sediment settling on the wetland	6	2	2	5	**50**	**Moderate**	around in the vicinity of the wetland. This is likely to contribute to dust and sediment entering the wetland. This is a negative impact that could cause further vegetation degradation	
	SAM							
	4	2	2	4	**32**	Low		
Compacting of soils	**SBM**						The movement of construction vehicles could cause compacting of soils in the wetland area. This is a negative impact that could cause vegetation degradation and the flow of water in the wetland to change. Due to the already degraded nature of this site the impact is not that significant.	See Best Practice Guidelines (7.1.1)
	6	3	2	5	**55**	**Moderate**		
	SAM							
	4	2	1	3	**21**	Low		

Operation of the pipeline

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Inundation and flow obstruction due to pipeline location and spills	**SBM**						If the pipeline is not buried deep enough ground water flow will be impeded resulting in increased inundation upstream of the crossing site. This will further result in habitat loss in the wetland and possible decrease in flow downstream of the pipeline.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude that lies to the East of the current proposed pipeline. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
	8	5	1	4	**56**	**Moderate**		
	SAM							
	2	2	1	4	**20**	Low		
Eroding of wetland channel due to releases from scour valves	**SBM**						If releases from the scour valves are not contained it could result in erosion of the wetland channel and habitat degradation and loss.	**Minimization:** • It is suggested that the pipeline be constructed above ground on the road servitude that lies to the East of the current proposed pipeline. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
	6	3	2	5	**55**	**Moderate**		
	SAM							
	4	2	1	4	**28**	Low		

Degradation of wetland integrity due to spill of untreated water at scour valves	SBM						If the spills from the damaged scour valves or pipelines are not addressed immediately it could result in erosion of the wetland channel and subsequent habitat degradation and loss due to decreased water quality.	See Best Practice Guidelines (7.1.1)
	8	3	3	5	70	Moderate		
	SAM							
	4	1	2	4	28	Low		

Table 22: Impacts significance table for site WC6 (RR1).

Construction of the pipeline

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Bed disturbance vegetation removal and habitat degradation	SBM						Due to this pipeline not running through the wetland the possible impacts were rated as low. Care still needs to be taken to avoid entering the wetland zone.	**Minimization:** • This route should be taken if a road is to be built on the route in the near future See Best Practice Guidelines (7.1.1)
	6	2	1	5	45	Low		
	SAM							
	2	1	1	2	8	Low		
Dust and sediment settling on the wetland	SBM						During construction, vehicles will move around in the vicinity of the wetland and the ground will be excavated. This is likely to contribute to dust and sediment entering the wetland. This is a negative impact that could cause further vegetation degradation	See Best Practice Guidelines (7.1.1)
	6	2	2	5	50	Moderate		
	SAM							
	4	2	2	4	32	Low		
Compacting of soils	SBM						The movement of heavy construction vehicles could cause compacting of soils in the wetland area. This is a negative impact that could cause vegetation degradation and the flow of water in the wetland to change.	**Minimization:** • This route should be taken if a road is to be built on the route in the near future See Best Practice Guidelines (7.1.1)
	8	3	2	5	65	Moderate		
	SAM							
	2	2	1	4	20	Low		

Operation of the pipeline

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Eroding of wetland	SBM						If releases from the scour valves are not	See Best Practice Guidelines (7.1.1)

due to releases from scour valves	8	2	2	4	**48**	Low	contained it could cause erosion in the wetland and subsequent habitat degradation and loss.	
	SAM							
	4	2	1	4	**28**	Low		
Degradation of wetland integrity due to spill of untreated water at scour valves	**SBM**						If spills from damaged scour valves or pipelines are not addressed immediately it could result in erosion of the wetland and subsequent habitat degradation and loss due to decreased water quality.	**Minimization:** • This route should be taken if a road is to be built on the route in the near future See Best Practice Guidelines (7.1.1)
	10	3	3	5	**80**	High		
	SAM							
	8	1	2	4	**44**	Low		

Table 23: Impacts significance table for site WC8.

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Construction of the pipeline								
Bed disturbance vegetation removal and habitat degradation	**SBM**						In order to bury the pipeline vegetation will be cleared and a trench will be excavated. This is will have an impact especially if not kept to a minimum and if spoils are not kept out of the wetland. Due to the already compromised nature of this site, the impact was rated as moderate before implementation of mitigation.	**Minimization**: • It is suggested that the pipeline be moved and located in between the road and the railway line, or as close to the railway line as possible. It is also suggested that the pipeline be constructed above ground at this site. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
	8	2	1	5	**55**	**Moderate**		
	SAM							
	2	2	1	4	**20**	**Low**		
Inundation	**SBM**						If the pipeline is not buried deep enough ground water flow will be impeded resulting in increased inundation upstream of the crossing site. This could also result in habitat loss or change.	**Minimization:** • It is suggested that the pipeline be moved and located in between the road and the railway line, or as close to the railway line as possible. It is also suggested that the pipeline be constructed above ground at this site. See Best Practice Guidelines (7.1.1)
	6	2	1	4	**36**	**Moderate**		
	SAM							
	2	1	1	2	**8**	**Low**		
Dust and sediment settling on the wetland	**SBM**						During construction, vehicles will move around the wetland. This may contribute to increased dust and sediment settling on the wetland. This will have a negative impact that could cause vegetation degradation. Due to the already compromised nature of this site, the impact was rated as moderate.	**Minimization:** • It is suggested that the pipeline be moved and located in between the road and the railway line, or as close to the railway line as possible. See Best Practice Guidelines (7.1.1)
	6	2	2	4	**40**	**Moderate**		
	SAM							
	4	2	1	3	**21**	**Low**		
Compacting of soils	**SBM**						The movement of construction vehicles could cause compacting of soils in the wetland area. This will have a negative impact that could cause vegetation degradation and the flow of water in the wetland to change.	**Minimization**: • It is suggested that the pipeline be moved and located in between the road and the railway line, or as close to the railway line as possible. See Best Practice Guidelines (7.1.1)
	6	2	1	5	**45**	**Moderate**		
	SAM							
	2	2	1	2	**10**	**Low**		
Operation of the pipeline								

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Inundation and flow obstruction due to pipeline location and spills	**SBM**						If the pipeline is buried and not far enough below the water table the water flow will be obstructed and inundation could occur. This will further result in habitat loss in the wetland.	**Minimization**: • It is suggested that the pipeline be moved and located in between the road and the railway line, or as close to the railway line as possible. It is also suggested that the pipeline be constructed above ground at this site. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
	8	5	2	4	**60**	**Moderate**		
	SAM							
	4	3	1	3	**24**	Low		
Eroding of wetland channel due to release from scour valves	**SBM**						If the release from the scour valves are not contained it could cause erosion in the wetland channel and subsequent habitat degradation and loss. Due to the already compromised nature of this site, the impact will not be that great.	**Minimization**: • It is suggested that the pipeline be moved and located in between the road and the railway line, or as close to the railway line as possible. If it cannot be constructed above ground it should be buried deep enough to not restrict the groundwater flow. See Best Practice Guidelines (7.1.1)
	6	2	2	4	**40**	**Moderate**		
	SAM							
	4	2	1	3	**21**	Low		
Degradation of wetland integrity due to spill of untreated water at scour valves	**SBM**						If the spills from the damaged scour valves or pipelines are not addressed immediately as it happens it could cause erosion in the wetland channel and further habitat degradation and loss due to poor water quality.	See Best Practice Guidelines (7.1.1)
	6	2	2	4	**40**	**Moderate**		
	SAM							
	6	2	1	3	**27**	Low		

Table 24: Impacts significance table for site BS.

	Removal of mine water							
Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		

Removal of mine water											
Impacts on water quality	**SBM**						Removal of mine water discharge will have a positive impact on the water quality of the entire project area. Current discharge into the Blesbokspruit is very acidic.	No mitigation is required as the wetland will be returning to a more natural state. The water will also be of a better quality. Due to the impacted nature of the site the proposed project will have a positive impact in the long run.			
	2	4	2	4	**32**	Low					
	SAM										
	No applicable mitigation measures										
Impacts on habitat: Seasonal zone	**SBM**						Removal of the mine water discharge will return the seasonal wetland zones to a more natural state. Although the seasonal wetland area will be smaller than usual the overall impact will be positive.	**Minimization:** • Monitor the ecological status of the wetland (through Wetland-IHI and PES method), floral species composition (through community analysis) and water quality at abstraction points and downstream points along the Blesbokspruit. The monitoring should be conducted bi-annually after initiation of abstraction by a wetland ecologist. Findings from the monitoring cycle will indicate further management action if required. **Rectification:** • Implement rehabilitation where negative habitat impacts have occurred and are likely to occur in the future; i.e. revegetate bare areas; remove exotic vegetation from the Blesbokspruit wetland area and prevent encroachment at both sites.			
	4	4	2	4	**40**	Low					
	SAM										
	2	4	2	4	**32**	Low					
Impacts on habitat: Permanent zone	**SBM**						Removal of the mine water discharge from the wetland will change the permanently inundated zones to seasonally inundated zones, thereby returning the wetland to a more natural state. Vegetation diversity will increase as the quality of the water now entering the system from adjacent seeps will improve. The overall impact will be positive. Due to the seep feeding into the Blesbokspruit, the valley bottom will be replenished.	**Minimization:** • Monitor the ecological status of the wetland (through Wetland-IHI and PES method), floral species composition (through community analysis) and water quality at abstraction points and downstream points along the Blesbokspruit. The monitoring should be conducted bi-annually after initiation of abstraction by a wetland ecologist. Findings from the monitoring cycle will indicate further management action if required. **Rectification:** • Implement rehabilitation where negative habitat			
	2	4	2	3	**24**	Low					
	SAM										
	0	3	2	2	**10**	Low					

Removal of mine water								
								impacts have occurred and are likely to occur; i.e. revegetate bare areas; remove exotic vegetation from the Blesbokspruit wetland areas to prevent loss off water in the wetland. Prevent exotic encroachment at both sites.

The following impact assessments were conducted for the case where a new pipeline needs to be constructed. At the time of reporting it was not yet clear on whether the existing pipeline will be used or whether a new pipeline will be constructed.

Table 25: Impacts significance table for site WC10.

Construction of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Vegetation removal and habitat degradation	**SBM**						In order to bury the proposed pipelinevegetation will need to be cleared and a trench excavated. Burying of the pipeline will have an impact on the biodiversity and habitat of the northern section of the wetland.	See Best Practice Guidelines (7.1.1)
	6	2	1	4	**36**	**Moderate**		
	SAM							
	6	2	1	3	**27**	**Low**		
Dust and sediment settling on the wetland	**SBM**						During construction, vehicles will move around the wetland. This may contribute to increased dust and sediment entering the dams. This will have a negative impact that could cause vegetation degradation and degrade water quality, especially if constructed on in the northern section of the pan.	See Best Practice Guidelines (7.1.1)
	4	2	1	4	**28**	**Low**		
	SAM							
	2	2	1	3	**15**	**Low**		
Operation of the pipeline - no impacts are foreseen								

Table 26: Impacts significance table for site WC12.

Construction of the pipeline								
Impacts	**Significance Score**						**Discussion**	**Possible mitigation measures**
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Bed disturbance, vegetation removal and habitat degradation	**SBM**						In order to bury the proposed pipeline vegetation will need to be cleared and a trench excavated. This could have a significant impact especially if not kept to a minimum and if spoils are not kept out of the wetland. During this process a fair amount of habitat will be degraded.	**Avoidance:** • It is suggested that if a new pipeline is constructed, that it should be constructed around the southern side of the pan. **Minimization:** • If the pipeline cannot be moved to the southern side of the pan, it should be constructed in the pipeline servitude in the southern section of the pan, thus avoiding the less impacted northern section. See Best Practice Guidelines (7.1.1)
	8	2	2	5	**60**	**Moderate**		
	SAM							
	6	2	1	4	**36**	**Moderate**		
Dust and sediment settling on the wetland	**SBM**						During construction, vehicles will move around the wetland. This may contribute to increased dust and sediment entering and settling on the wetland. This will have a negative impact vegetation in the wetland	**Avoidance:** • It is suggested that if a new pipeline is constructed, that it should be constructed around the southern side of the pan. **Minimization:** • If the pipeline cannot be moved to the southern side of the pan, it should be constructed in the pipeline servitude in the southern section of the pan, thus avoiding the less impacted northern section. See Best Practice Guidelines (7.1.1)
	8	2	2	5	**60**	**Moderate**		
	SAM							
	4	2	1	4	**28**	Low		
Compacting	**SBM**						The movement of	**Avoidance:**

of soils	8	2	1	5	**55**	**Moderate**	construction vehicles could cause compacting of soils in the wetland area. This is a negative impact that could cause vegetation degradation and the flow of water in the wetland to change.	• It is suggested that if a new pipeline is constructed, that it should be constructed around the southern side of the pan. **Minimization:** • If the pipeline cannot be moved to the southern side of the pan, it should be constructed in the pipeline servitude in the southern section of the pan, thus avoiding the less impacted northern section. See Best Practice Guidelines (7.1.1)
	SAM							
	4	2	1	3	**21**	**Low**		

Operation of the pipeline

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	**D**	**SS**	**P**	**Total**	**Significance**		
Inundation and flow obstruction due to pipeline location and spills	**SBM**						Trenches and berms could cause irregular inundation thus changing the wetland community composition and patterns.	**Avoidance:** • It is suggested that if a new pipeline is constructed, that it should be constructed around the southern side of the pan. **Minimization:** • If the pipeline cannot be moved to the southern side of the pan, it should be constructed in the pipeline servitude in the southern section of the pan, thus avoiding the less impacted northern section. See Best Practice Guidelines (7.1.1)
	8	4	1	4	**52**	**Moderate**		
	SAM							
	4	2	1	3	**21**	**Low**		
Eroding of wetland due to releases from scour valves	**SBM**						If releases from the scour valves are not contained it could cause erosion in the wetland and subsequent habitat degradation and loss.	**Avoidance:** • It is suggested that if a new pipeline is constructed, that it should be constructed around the southern side of the pan. **Minimization:** • If the pipeline cannot be moved to the southern side of the pan, it should be constructed in the pipeline servitude in the southern section of the pan, thus avoiding the less impacted northern section. See Best Practice Guidelines (7.1.1)

7.2 Recommendation of Mitigation/Management Measures

7.2.1 Avoidance

- Insure that the pipeline is buried below the wetland groundwater level; and
- Move pipeline to southern side of pan at WC12

7.2.2 Minimization

- It is suggested that the pipeline be constructed above ground on the existing road and railroad servitude, and existing pipe bridges at sites WC 1, WC3, WC4, WC5, WC6 and WC8;
- If a road is to be built at below the WWTW at WC6 (RR1) in the near future, then the pipeline can be constructed along the road servitudes;
- Construct pipeline / watercourse crossings in stages so as to limit the impact to the sites and during the dry season;
- Keep construction activities and heavy vehicles out of the wetland buffer zone where possible;
- Allow for ample flow through of water where culverts are constructed;
- Limit movement of construction vehicles within wetlands;
- Restrict vehicles to service roads;
- Put construction practices in place to avoid dumping of construction materials and spoils on to the wetlands; and
- If pipeline cannot be moved to the southern side of the pan at site WC12, it is suggested that it should be constructed on the southern side of the existing pipeline running through the pan as this area has already been heavily impacted upon.

7.2.3 Rectification

- Implement rehabilitation where negative habitat impacts have occurred and is likely to occur in the future;
- Revegetate bare areas and remove exotic vegetation;
- Where wetland soils have been compacted, labourers on foot should loosen soils with light weight tools; and
- Prevent pipeline and scour valve spillages and, should any occur, clean up and rehabilitate immediately.

7.2.4 Reduction

- Monitor the ecological status of the wetland (through Wetland-IHI and PES method), floral species composition (through community analysis) and water quality both upstream and downstream of the pipeline / watercourse crossing sites. The monitoring should be conducted bi-annually during construction by a wetland ecologist, and bi-annually for a year after completion of construction;
- Monitor the ecological status of the wetland (through Wetland-IHI and PES method), floral species composition (through community analysis) and water quality at abstraction points and downstream points along the Kromdraaispruit and Blesbokspruit. The monitoring should be conducted bi-annually after initiation of abstraction by a wetland ecologist. Findings from the monitoring cycle will indicate further management action if required.

- After the final years monitoring results should not be lower than what was found during the baseline study;
- Clean up and rehabilitate any accidental spillages or impacts to the aquatic and wetland ecosystems;
- Devise and implement a relocation plan if rare and sensitive species are identified during construction;
- Contain lose soils to avoid degrading in-stream habitats downstream of construction sites;
- Implement dust suppression on dirt roads during construction to avoid excessive dust formation;
- Maintain service roads to avoid erosion and excessive dust formation;
- Monitor the pipeline for leaks and spills on a regular basis during the operational phase;
- Repair damaged scour valves and pipes immediately to avoid excessive spills; and
- Contain and prevent spills to avoid degrading downstream water quality.

7.2.5 Compensation

- N/A

8.0 CONCLUSION

It was concluded that:

- Most of the floral species found on site were indicative of disturbed habitats.
- Sites KS, WC 5, 6, 10 and 11 had Present Ecological Statuses below the acceptable range. These wetlands were seriously modified with extensive loss of natural habitat. The hillslope seep at site BS was mostly unmodified with natural conditions remaining. The remaining wetlands were all moderately modified;
- Sites WC 5, 6, 10 and 11, and the valley bottom at site BS were not considered be ecologically important or sensitive. The hillslope seep at site BS was considered as an ecologically important and sensitive wetland with biodiversity being very sensitive to habitat changes. The remaining wetlands were ecologically important and sensitive only at a provincial or local scale. The biodiversity is usually not sensitive to habitat changes.
- The habitat integrity of all the channelled wetlands was moderately to largely modified. A loss of natural habitat and biota had occurred at the wetlands associated with the project;
- Sites WC2 and the hillslope seep at site BS scored "very high" for natural services with unmodified natural conditions. The valleybottom wetland at site BS had a large loss of basic ecosystem functions. The remaining wetlands had a moderate loss of natural services and functions;
- The human services at sites WC3 and WC9 were outside of the acceptable range with people rarely relying on or benefitting from these wetlands. Sites KS, WC8, WC10 and WC12 (South) scored "low" with people having low dependency on this wetland. The remaining wetlands occasionally benefitted local people;
- The impact of the reduction in release of water was considered to be positive due to the increase in habitat integrity along with the improvement in water quality;

- The construction impacts were rated as low to moderate before mitigation, and mostly low if mitigation measures were implemented;
- The operational impacts were rated as high before mitigation, and decreased to low if mitigation measures were implemented;
- It was suggested that at sites WC 1, WC3, WC4, WC5, WC6 and WC8 the pipeline be constructed above ground in order to follow road, or railroad servitudes or existing pipe bridges where applicable and feasible.

GOLDER ASSOCIATES AFRICA (PTY) LTD

Riana Panaino
Wetland Specialist

Pieter Kimberg
Ecology Reviewer

LVW/PK/lvw

Reg. No. 2002/007104/07

Directors: FR Sutherland, AM van Niekerk, SAP Brown, L Greyling, SM Manyaka

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APPENDIX A

Flora recorded during the survey

Family	Species	Protected status	Wetland species	Indication of disturbed areas	KS	WC 1	WC 2	WC 3	WC 4	WC 5	WC 6	WC 7	WC 8	WC 9	BS seep	WC 10	WC 12
Amaryllidaceae	*Crinum* sp	p						x									
Amaryllidaceae	*Brunsvigia* sp	p								x							
Amaryllidaceae	*Brunsvigia radulosa*	p															
Asteraceae	*Bidens pilosa**			Disturbed areas													x
Asteraceae	*Bidens formosa**			Disturbed areas									x				x
Asteraceae	*Circium vulgare**			Disturbed areas	x												
Asteraceae	*Helichrysum alloides*				x		x										
Asteraceae	*Helichrysum aureonitens*		w				x					x	x	x	x		x
Asteraceae	*Helichrysum ruderale*			Disturbed areas									x			x	
Asteraceae	*Stoebe* sp			Disturbed areas			x										
Asteraceae	*Stoebe vulgaris*			Disturbed areas				x								x	
Asteraceae	*Berkheya speciosa*			Disturbed areas				x									
Asteraceae	*Tagetes minuta**											x	x	x			
Asteraceae	*Conyza bonariensis**																x
Asteraceae	*Conyza podocephala**																x
Asteraceae	*Nidorella anomala*		w										x				
Asteraceae	*Helichrysum decorum*											x					
Campanulaceae	*Wahlenbergia caledonica*																x
Cyperarceae	*Cladium mariscus*		w										x		x		
Cyperarceae	*Cyperus eragrostis**		w		x												
Cyperarceae	*Cyperus compressus*		w			x		x									
Cyperarceae	*Schoenoplectus brachyceras*		w		x	x								x			
Cyperarceae	*Cyperus laevigatus*		w				x										
Cyperarceae	*Cyperus* sp		w					x					X				
Cyperarceae	*Cyperus esculentus**		w						x		x			x			
Cyperarceae	*Rhychospora* sp		w												x		
Cyperarceae	*Cyperus marginatus*		w												x		
Cyperarceae	*Cyperus longus*		w														x
Cyperarceae	*Kylinga sp*		w										x				
Euphorbiaceae	*Euphorbia inaequilatera*										x						

Family	Species	Protected status	Wetland species	Indication of disturbed areas	KS	WC 1	WC 2	WC 3	WC 4	WC 5	WC 6	WC 7	WC 8	WC 9	BS seep	WC 10	WC 12
Hyacinthaceae	*Ledebouria ovatifolia*							x									
Hypoxidaceae	*Hypoxis rigidula*		w					x									
Iridaceae	*Gladiolus* sp		w					x									
Juncaceae	*Juncus lomatophyllus*		w										x				
Myrtaceae	*Eucalyptus sp**							x									
Fabaceae	*Acacia mearnsii**							x						x			
Orchidaceaea	*Habenaria epipactidea*				x												
Poaceae	*Paspalum dilatatum**		w		x												
Poaceae	*Eragrostis inamoena*		w		x	x	x	x							x		
Poaceae	*Sporobolus centrifigus*				x				x								
Poaceae	*Heteropogon contortus*		occasionally		x		x			x							
Poaceae	*Andropogon eucomis*		w		x		x										
Poaceae	*Andropogon huillensis*		w		x	x		x							x		
Poaceae	*Eragrostis gummiflua*		w	Disturbed areas	x			x		x		x	x				x
Poaceae	*Paspalum notatum**		occasionally	Disturbed areas	x												
Poaceae	*Paspalum urvillei**		w			x	x	x		x			x	x			
Poaceae	*Hyparrhenia tamba*		occasionally	Disturbed areas									x				
Poaceae	*Hyparrhenia hirta*		occasionally	Disturbed areas		x			x	x	x						
Poaceae	*Digitaria eriantha*		occasionally			x	x										
Poaceae	*Bothriochloa insculpta*		occasionally	Disturbed areas		x		x		x					x		
Poaceae	*Melinis nerviglumis*						x										
Poaceae	*Perotis patens*			Disturbed areas				x									
Poaceae	*Elionurus muticus*			Disturbed areas				x									
Poaceae	*Harpochloa falx*							x									
Poaceae	*Sporobolus africanus*		w	Disturbed areas				x		x							
Poaceae	*Tristachya leucothrix*		w					x									
Poaceae	*Dactyloctenium sp*			Disturbed areas				x									
Poaceae	*Leersia hexandra*		w					x					x				
Poaceae	*Melinis repens*			Disturbed areas				x									
Poaceae	*Urochloa mosambicensis*			Disturbed areas					x								
Poaceae	*Setaria sphacelata* var *sericea*		w	Disturbed areas					x								

Family	Species	Protected status	Wetland species	Indication of disturbed areas	KS	WC 1	WC 2	WC 3	WC 4	WC 5	WC 6	WC 7	WC 8	WC 9	BS seep	WC 10	WC 12
Poaceae	*Tricholaena monachne*			Disturbed areas					x								
Poaceae	*Themeda triandra*		ocasionally							x		x					
Poaceae	*Pennisetum clandestinum**		w	Disturbed areas							x						
Poaceae	*Pogonarthria Squarrosa*			Disturbed areas								x					
Poaceae	*Cymbopogon excavatus*			Disturbed areas												x	
Poaceae	*Cynodon dactylon*			Disturbed areas					x		x		x				
Poaceae	*Phragmites australis*		w	Disturbed areas													
Poaceae	*Imperata cylindrica*		w			x							x	x	x		x
Polygonaceae	*Persicaria decipiens*		w										x				
Salicaceae	*Salix babylonica*		w						x								
Solanaceae	*Solanum sisymbriifolium**			Disturbed areas				x									
Solanaceae	*Datura stramonium**								x								
Typhaceae	*Typha capensis*		w		x	x			x				x				
Verbenaceae	*Verbena bonariensis**			Disturbed areas		x			x	x			x	x		x	x
Zygophyllaceae	*Tribulus terrestris*			Disturbed areas							x						

Mpumalanga Protected Plants

Mpumalanga Nature Conservation Act
Act No. 10 (1998)

Schedule 12: Specially Protected Plants

(Section 69(1)(b))

In this schedule "seedling" means a plant of which the diameter of the trunk or bulb, either above or below the ground, does not exceed 150mm.

Common Name	Scientific Name	Protection covers
Dolomiticus cycad	*Encephalartos dolomiticus*	Species, excluding seedlings
Dyer cycad	*E. dyerianus*	Species, excluding seedlings
Middelburg cycad	*E. middelburgensis*	Species, excluding seedlings
Eugene marias cycad	*E. Eugene maraissii*	Species, excluding seedlings
Heenen cycad	*E. heenanii*	Species, excluding seedlings
Inopinus cycad	*E. inopinus*	Species, excluding seedlings
Laevifolius cycad	*E. laevifolius*	Species, excluding seedlings
Lanatus cycad	*E. lanatus*	Species, excluding seedlings
Lebombo cycad	*E. lebomboensis*	Species, excluding seedlings
Ngoyanus cycad	*E. ngoyanus*	Species, excluding seedlings
Paucidentatus cycad	*E. paucidentatus*	Species, excluding seedlings
Modjadje cycad	*E. transvenosus*	Species, excluding seedlings
Villosus cycad	*E. villosus*	Species, excluding seedlings
Cupidus cycad	*E. cupidus*	Species
Humilis cycad	*E. humilus*	Species
Cycads in their native habitat	All *Encephalartos* species in their native habitat	Whole genus

Schedule 11: Protected Plants

(Section 69 (1)(a))

In this schedule:

a) the plants referred to shall not include plants which have been improved by selection or cross-breeding;

b) "seedling" means a plant of which the diameter of the trunk or bulb, either above or below the ground, does not exceed 150mm.

Common Name	Scientific Name	Grouping
Tree fern	*Cyathea capensis*	Species
	Cyathea dregei	Species
Cycads occurring in South Africa and seedlings of cycad sp. in schedule 12.	Zamiaceae occurring in South Africa and the Encephalartos seedling in schedule 12.	Whole family
Yellow wood	*Podicarpus*	Whole genus
Arum lilies	*Zantedeschia*	Whole genus
Volstruiskos	*Schizobasis intricata*	Species
Knolklimop	*Bowiea volubis*	Species
Red hot pokers	*Kniphofia*	Whole genus
All aloe sp. excluding: a) all sp. not occurring in Mpumalanga	*Aloe*	Whole genus
Haworthias	*Haworthia*	Whole genus
Agapanthus	*Agapanthus*	Whole genus
Squill	*Scilla*	Whole genus
Pineapple flower	*Eucomis*	Whole genus
Dracaena	*Draceena*	Whole genus
Paint brush	*Haemanthus*	Whole genus
	Scadoxis	Whole genus
Cape poison bulb	*Boophane disticha*	Species
Clivia	*Clivia*	Whole genus
Brunsvigia	*Brunsvigia*	Whole genus
Crinum	*Crinum*	Whole genus
Ground lily	*Ammocharis coranica*	Species
Fire lily	*Cyrtanthus*	Whole genus
Elephant's foot	*Dioscorea*	Whole genus
River lily	*Hesperantha coccinea*	Species
Gladioli	*Gladiolus*	Whole genus
Watsonia	*Watsonia*	Whole genus
Wild ginger	*Siphonochilus aethiopicus*	Species
Orchids	Orchidaceae	Whole family
Proteas	Proteaceae	Whole family
Black stinkwood	*Octea*	Whole genus
Kiaat	*Pterocarpus angolensis*	Species
Tamboti	*Spirostachys Africana*	Species
Euphorbia bernardii	*Euphorbia bernardii*	Species
Euphorbia grandialata	*Euphorbia grandialata*	Species
Common bersamia	*Bersamia tysoniana*	Species
Red ivory	*Berchemia zeyheri*	Species
Pepperbark tree	*Warbergia salutaris*	Species

Adenia	*Adenia*	Whole genus
Bastard onion weed	*Cassipourea gerrardii*	Species
Assegai tree	*Curtisia dentate*	Species
Olive trees	*Olea*	Whole genus
Impala lilies	*Adenium*	Whole genus
Kudu lily	*Pachypodium saundersii*	Species
Brachystelma	*Brachystelma*	Whole genus
Ceropegia	*Ceropegia*	Whole genus
Hueniopsis	*Hueniopsis*	Whole genus
Huernia	*Huernia*	Whole genus
Duvalia	*Duvalia*	Whole genus
Stapeliads	*Stapelia*	Whole genus
Orbeanthus	*Orbeanthus*	Whole genus
Orbeas	*Orbeas*	Whole genus
Orbeopsis	*Orbeopsis*	Whole genus

APPENDIX C

Wetland IHI

KS

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**1.9**	*Rating*	
Hydrology	1	100	1.9	*4.0*	**C**
Geomorphology	2	80	1.8	*4.0*	**C**
Water Quality	3	30	2.0	*4.0*	**C/D**
WETLAND LANDUSE ACTIVITIES:		**80**	**1.4**	***4.7***	
Vegetation Alteration Score	1	100	1.4	*4.7*	**C**
Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)*					

OVERALL SCORE:		**1.7**	*Confidence Rating*
	PES %	**66.7**	
	PES Category	**C**	***2.1***

WC1

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**2.1**	*Rating*	
Hydrology	1	100	2.3	*4.6*	**D**
Geomorphology	2	80	2.2	*4.5*	**D**
Water Quality	3	30	1.5	*4.0*	**C**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.7**	***4.9***	
Vegetation Alteration Score	1	100	0.7	*4.9*	**B**
Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)*					

OVERALL SCORE:		**1.5**	*Confidence Rating*
	PES %	**70.1**	
	PES Category	**C**	***2.2***

WC2

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**2.4**	*Rating*	
Hydrology	1	100	2.5	*4.9*	**D**
Geomorphology	2	80	2.3	*4.7*	**D**
Water Quality	3	30	2.1	*4.0*	**D**
WETLAND LANDUSE ACTIVITIES:		**80**	**1.4**	***4.7***	
Vegetation Alteration Score	1	100	1.4	*4.7*	**C**
Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)*					

OVERALL SCORE:		**1.9**	*Confidence Rating*
	PES %	**61.0**	
	PES Category	**C/D**	***2.1***

WC3

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**2.7**	*Rating*	
Hydrology	1	100	2.7	*5.0*	**D**
Geomorphology	2	80	3.3	*4.7*	**E**
Water Quality	3	30	1.2	*4.0*	**C**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.5**	***4.0***	
Vegetation Alteration Score	1	100	0.5	*4.0*	**A/B**
Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)*					

OVERALL SCORE:		**1.7**	*Confidence Rating*
	PES %	**65.6**	
	PES Category	**C**	***1.8***

WC4

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**1.8**		
Hydrology	1	100	1.7	*5.0*	**C**
Geomorphology	2	80	2.0	*4.5*	**C/D**
Water Quality	3	30	1.3	*4.0*	**C**
WETLAND LANDUSE ACTIVITIES:		**80**	**1.6**	***4.0***	
Vegetation Alteration Score	1	100	1.6	*4.0*	**C**
Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)*					

OVERALL SCORE:		**1.7**	*Confidence Rating*
	PES %	**66.1**	
	PES Category	**C**	***1.8***

WC5 & 6

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**2.3**		
Hydrology	1	100	2.7	*4.3*	**D**
Geomorphology	2	80	2.4	*4.7*	**D**
Water Quality	3	30	1.0	*4.0*	**B/C**
WETLAND LANDUSE ACTIVITIES:		**80**	**1.8**	***4.0***	
Vegetation Alteration Score	1	100	1.8	*4.0*	**C**
Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)*					

OVERALL SCORE:		**2.1**	*Confidence Rating*
	PES %	**58.3**	
	PES Category	**C/D**	***1.8***

BS

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**3.3**		
Hydrology	1	100	3.9	*5.0*	**E**
Geomorphology	2	80	3.0	*4.5*	**D/E**
Water Quality	3	30	2.4	*4.0*	**D**
WETLAND LANDUSE ACTIVITIES:		**80**	**1.9**	***4.0***	
Vegetation Alteration Score	1	100	1.9	*4.0*	**C/D**

Weighting needs to consider the sensitivity of the type of wetland
(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)

OVERALL SCORE:		**2.7**	*Confidence Rating*
	PES %	**45.9**	
	PES Category	**D**	*1.8*