5. SENSITIVITY MAPPING

An overall sensitivity map was created with the use of the results from the aquatic, floral, faunal and wetland assessment of the subject property. The majority of the faunal species with a POC of 60% or more also inhabit the wetland areas. As a result, pan 1, 2, 3 and 6 were deemed to be of a highly sensitive nature. These areas were mapped and a sensitivity map was produced, which is presented in Section A of this report. A buffer zone was incorporated into the sensitivity map to protect the wetland features.

6. IMPACT ASSESSMENT

The tables below serve to summarise the significance of perceived impacts on the faunal biodiversity of the subject property. The tables present the impact assessment according to the method described above. The tables also indicate the required mitigatory measures needed to minimise the impact. The tables present an assessment of the significance of the impacts taking into consideration the available mitigatory measures assuming that they are fully implemented.

6.1 Impact Discussion

The impact tables below serve to summarise the significance of perceived impacts on the faunal biodiversity of the subject property. The tables present the impact assessment according to the method described in Section A and also indicate the mitigation measures required to minimise the impacts. In addition, an assessment of the significance of the perceived impacts is presented, taking into consideration the available mitigating measures assuming that they are fully implemented.

6.1.1 IMPACT 1: Impact on faunal habitat and ecological structure

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning and Closure
Poor planning leading to the placement of infrastructure within sensitive faunal habitat areas with special mention of wetland areas which have a higher biodiversity capacity	Site clearing and removal of vegetation and encroachment of alien floral species	On-going disturbance of faunal habitat within surrounding areas due to human activities associated with mining activities	Disturbance of faunal habitat as part of demolition and closure activities
Inadequate design of infrastructure leading to changes to faunal habitat and biodiversity	Construction of infrastructure leading to migratory corridor alterations which alter faunal behavioural patterns and over all biodiversity	Risk of introduction of alien plant species and further transformation of natural faunal habitat	Insufficient aftercare and maintenance leading to post closure impacts on faunal habitat due to poor management
Inadequate design of infrastructure leading to faunal food source pollution	Erosion as a result of infrastructure development and storm water runoff	Erosion as a result of storm water runoff	Ineffective monitoring of rehabilitation due to poor management
	Indiscriminate driving through surrounding open veld	Indiscriminate driving through of surrounding open veld	
	Construction of access roads within sensitive habitat areas	Risk of discharge, spillages and deliberate dumping of pollutants into the surrounding environment	
	Risk of discharge, spillages and deliberate dumping of pollutants into the surrounding environment		
	Fire hazards leads to loss of habitat due to increased personnel		

Aspects of faunal ecology affected

Pre-Construction	Construction	Operational	Decommissioning and Closure
Loss of important faunal habitat due to poor planning	Changes to faunal habitat through alien floral species proliferation leading to a loss of faunal habitat within the construction footprint	Changes to faunal habitat through alien floral species proliferation during operational activities	Direct impact on faunal habitat during decommissioning
	Changes to the faunal community due to habitat loss and transformation	Changes to the faunal community due to habitat loss and transformation	Changes to the faunal community due to habitat loss and transformation

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	5	3	3	3	5	8	11	88 (Medium-high

Essential mitigation measures:

- Development should be excluded from the riparian habitat, as indicated on the sensitivity map.
- No areas falling outside of the subject property may be cleared for construction purposes.
- Areas of increased ecological importance and sensitivity, such as the river and wetland habitat areas, should be considered during all phases of the proposed mine.
- The boundaries of the development footprint areas are to be clearly defined and it should be ensured that all activities remain within defined footprint areas.
- The proposed development footprint areas should remain as small as possible.
- All areas of increased ecological sensitivity should be marked as such and be off limits to all unauthorised construction and maintenance vehicles and personnel.
- Edge effects of all construction and operational activities, such as erosion and alien plant species proliferation, which may affect faunal habitat within surrounding areas, need to be strictly managed in all areas of increased ecological sensitivity.
- Ensure that construction and maintenance related waste or spillage and effluent do not affect the sensitive habitat and impact on the associated buffer zones.
- In the event of a breakdown, maintenance of vehicles must take place with care and the recollection of spillage should be practiced to prevent the ingress of hydrocarbons into the topsoil.
- No trapping or hunting of fauna is to take place. Access control must be implemented to ensure that no illegal trapping or poaching takes place.
- Alien and invasive vegetation control should take place throughout all phases of the development.

- All construction and operational mining related vehicles should be restricted to travelling only on designated roadways to limit the ecological footprint of the proposed mine development activities.
- Any natural areas beyond the development footprint, which have been affected by the construction activities, must be rehabilitated using indigenous grass species.
- Rehabilitate all faunal habitat areas to ensure that faunal ecology is re-instated.

Recommended mitigation measures:

- Fence construction footprint areas to contain all activities within designated areas.
- It is recommended that a speed limit of 40km/h is implemented on all maintenance and mining roads running through the subject property in order to minimise risk to RDL and other fauna from vehicles.
- Education and awareness campaigns on RDL faunal species and their habitat are recommended to help increase awareness, respect and responsibility towards the environment for all staff and contractors.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	5	3	2	2	5	8	9	72 (Medium-Low)

Probable latent impacts:

- Loss of faunal habitat may lead to altered faunal biodiversity.
- Decrease in faunal species diversity may occur throughout the subject property due to transformation of faunal habitat.

6.1.2 IMPACT 2: Impact on faunal diversity and ecological integrity

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning and Closure
Poor planning leading to the placement of infrastructure within sensitive faunal habitat areas with special mention of wetland areas which have a higher biodiversity capacity	Decline in faunal diversity due to disturbance in study area	Collision of operational vehicles with faunal species	Insufficient aftercare and maintenance leading to post closure impacts on faunal diversity due to poor management and rehabilitation of faunal habitat
Inadequate design of infrastructure leading to changes to faunal habitat and biodiversity	Collision of construction vehicles with faunal species	Poaching due to increased personnel	Ineffective monitoring of rehabilitation due to poor management
	Vehicles accessing site through sensitive faunal habitat areas		
	Poaching due to increased personnel		
	Fire hazards leads to loss of habitat due to increased personnel		

Aspects of faunal ecology affected

Pre-Construction	Construction	Operational	Decommissioning and Closure
	Loss of faunal biodiversity leading to changes on faunal behavioural patterns	Loss of faunal biodiversity leading to changes on faunal behavioural patterns	Loss of faunal biodiversity
	Changes to the faunal community assemblage	Changes to the faunal community assemblage	Changes to the faunal community assemblage

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	5	3	3	3	5	8	11	88 (Medium-high)

Essential mitigation measures:

- The proposed development footprint areas should remain as small as possible and where possible be confined to already disturbed areas.

- Sensitivity map needs to be taken into consideration during the construction phase.
- Ensure that migratory connectivity is maintained where appropriate, especially in the sensitive faunal habitat unit areas.
- Should any RDL or other common faunal species be found within the development footprint area, these species should be relocated to similar habitat within the vicinity of the subject property with the assistance of a suitably qualified specialist.
- No trapping or hunting of fauna is to take place.
- All informal fires in the vicinity of construction areas should be prohibited.
- Vehicles should be restricted to travelling only on designated roadways to limit the ecological footprint of the proposed development activities.

Recommended mitigation measures:

- Education on identification for any RDL faunal species that may be found within the subject property.
- It is recommended that a speed limit of 40km/h is implemented on all roads running through the subject property during the construction as well as operational phase in order to minimise risk to RDL and other fauna from vehicles.
- Speed humps should be constructed to help manage vehicle speed to mitigate collision with faunal species.
- Education and awareness campaigns on faunal species and their habitat are recommended to help increase awareness, respect and responsibility towards the environment for all staff and contractors.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	3	3	2	2	5	6	9	54 (Medium-low)

Probable latent impacts:

- A decrease in faunal species diversity may lead to loss of species richness over time.

6.1.3 IMPACT 3: Impact on faunal species of conservational concern

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning and Closure
Poor planning leading to the placement of infrastructure within sensitive faunal habitat areas for potential RDL faunal species	Vegetation and habitat clearing resulting in foraging habitat loss for potential RDL faunal species	Vegetation and habitat clearing resulting in foraging habitat loss for potential RDL faunal species	Ineffective rehabilitation and monitoring leading to latent impacts
	Collision of construction vehicles with potential species of conservational concern	Collision of construction vehicles with potential species of conservational concern	Ineffective monitoring of rehabilitation due to poor management
	Increased poaching risk of potential species of conservational concern and due to increased human activity on site	Increased poaching risk of potential species of conservational concern and due to increased human activity on site	Loss of faunal habitat and further potential RDL faunal biodiversity due to poor rehabilitation planning
	Increased risk of informal fires due to increased human activity on site	Increased risk of informal fires due to increased human activity on site	Ineffective rehabilitation and fire hazards due to decommissioning activities

Aspects of faunal ecology affected

Pre-Construction	Construction	Operational	Decommissioning and Closure
	Loss of species of conservational concern individuals	Loss of species of conservational concern individuals	Ineffective monitoring of rehabilitation due to poor management may lead to a loss of conservational concerned RDL species
	Changes of the species of conservational concern faunal community, within the greater region, due to habitat loss and transformation	Changes of the species of conservational concern faunal community, within the greater region, due to habitat loss and transformation	Changes to the potential RDL faunal community, within the greater region, due to ineffective monitoring of rehabilitation leading to habitat loss and transformation

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	3	3	3	3	5	6	11	66 (Medium-low)

Essential mitigation measures:

- All areas of increased ecological sensitivity should be marked as such and be off limits to all unauthorised construction and operational vehicles and personnel.
- No trapping or hunting of fauna is to take place.
- Edge effects of all construction and operational activities, such as erosion and alien plant species proliferation, which may affect faunal habitat, need to be strictly managed in these areas.
- Should any RDL species be noted within the subject property, these species should be relocated to similar habitat within or in the vicinity of the subject property with the assistance of a suitably qualified specialist.
- All informal fires in the vicinity of construction areas should be prohibited.
- Vehicles should be restricted to travelling only on designated roadways to limit the ecological footprint of the proposed development activities.

Recommended mitigation measures:

- Education on identification for any potential RDL faunal species that may be found within the subject property.
- Awareness campaigns are recommended to highlight the conservation of RDL faunal species, specifically for the avifaunal species highlighted in this report.
- It is recommended that a speed limit of 40km/h is implemented on all roads running through the subject property during the construction phase in order to minimise risk to RDL and other fauna from vehicles.
- Speed humps may be constructed to help slow vehicles and help mitigate collision with faunal species.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	2	3	1	2	5	5	8	40 (Low)

Probable latent impacts:

- Decrease in potential RDL faunal species diversity may lead to loss of species richness overtime throughout the greater region outside of the study area.
- Education and awareness campaigns are advised on potential RDL faunal species identification for all staff members and contractors.

6.2 Impact Assessment Conclusion

Based on the above assessment it is evident that there are three possible impacts on the faunal ecology within the subject property. Table 11 below summarizes the findings, indicating the significance of each impact before management takes place and the likely significance of the impacts if management and mitigation takes place. From the table it is evident that prior to management measures being put in place, two of the impacts are medium-high level impacts and one impact is a medium-low level impact. If effective management takes place, all impacts could be reduced to a lower level impact.

Table 11: A summary of the results obtained from the assessment of faunal ecological impacts.

Impact	Unmanaged	Managed
1: Impact on faunal habitat and ecological structure	Medium-high	Medium-low
2: Impact on faunal diversity and ecological integrity	Medium-high	Medium-low
3: Impact on potential RDL faunal species	Medium-low	Low

6.3 Cumulative impacts

At present due to extensive mining of minerals occurring in the Middelburg and the surrounding areas, along with extensive agriculture, the regional cumulative impacts a lack of and loss of suitable natural faunal habitat has result. The animal diversity is to be considered to be of a low abundance.

Cumulative impacts include:

- The loss of habitat through future mining activities and other activities associated to mining activities, may contribute towards lowering of the overall sensitivity of faunal communities within the region. The cumulative impact from habitat encroachment in the subject property may be considered to be high as the loss of habitat will contribute to an overall loss of faunal biodiversity.

No RDL faunal species were observed during the site survey. There are six (6) RDL species that have a Probability of Occurrence (POC) greater than 60%, namely; Sagittarius serpentarius (Secretarybird), Circus ranivorus (African Marsh Harrier), Falco peregrinus minor (Peregrine Falcon), Tyto capensis (African Grass Owl), the Geronticus calvus (Bald Ibis) and Pyxicephalus adspersus (Giant Bullfrog). Cumulative transformation and loss of habitat within the region may result in these species, as well as a number of common species known to occur within the Middelburg region, relocating and leading to the disappearance of these species in the region.

Effective rehabilitation and effective closure of the mining operation during the closure and decommissioning phase is essential in order to minimise cumulative impacts resulting from the mining activities on the faunal assemblage of this area.

7. RECOMMENDATIONS

After conclusion of this ecological assessment, it is the opinion of the ecologists that the proposed mixed development be considered favourably provided that the following essential mitigation measures as listed below are adhered to:

Mining footprint

- Subject property footprint should remain as small as possible and should not encroach on wetland areas and associated sensitive buffers. This can be achieved by fencing footprint areas to contain all activities within designated sensitive areas.
- Special care and thought when pre construction and designing of infrastructure should be taken into account to decrease the footprint left behind during all phases of construction right through till after decommissioning and closure.
- Demarcate all sensitive areas and ensure that these areas are off-limits to construction vehicles and personnel.
- No dumping of waste should take place within the study area. If any spills or waste deposits occur, they should be immediately cleaned up.

Faunal

- It is recommended that a speed limit of 40km/h is implemented on all roads running through the subject property area in order to minimise risk to RDL and other fauna from vehicles.
- Educate construction and personnel about the importance of the natural faunal species and biodiversity of the natural surroundings.
- Education and awareness campaign on identification for any RDL faunal species that may be found within the subject property.
- Signs must be erected along all roads on the property cautioning people driving through the property that fauna are present, thereby creating a heightened awareness regarding faunal conservation.

- All informal fires on the subject property should be prohibited. Where a burning regime is implemented, it should be overseen by a qualified and experienced professional.
- No trapping or hunting of fauna is to take place. Access control must be implemented to ensure that no illegal trapping or poaching takes place.
- Ensure that migratory connectivity is maintained where appropriate, especially in the wetland areas.

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http://www.iucnredlist.org/about/red-list-overview

FAUNAL APPENDICES

Appendix 1: RDL Mammalian species that occur in the Mpumalanga Province (MP SoER, 2003)

English Name	Species	Status
Cape mole rat	*Georychus capensis yatesi*	EN
Sclater's golden mole	*Chlorotalpa sclateri montana*	CR
Highveld golden mole	*Amblysomus septentrionalis*	VU
Rough-haired golden mole	*Chrysospalax villosus rufopallidus*	CR
Rough-haired golden mole	*Chrysospalax villosus rufus*	EN
Juliana's golden mole	*Neamblysomus julianae*	EN
Robust golden mole	*Amblysomus robustus*	VU
Meester's golden mole	*Amblysomus hottentotus meesteri*	VU
Laminate vlei rat	*Otomys laminatus*	VU
Peak-saddle horseshoe bat	*Rhinolophus blasii empusa*	EN
Lesser long-fingered bat	*Miniopterus fraterculus*	VU
Welwitsch's hairy bat	*Myotis welwitschii*	EN
Short-eared trident bat	*Cloeotis percivali australis*	EN
Antbear	*Orycteropus afer*	NE
Oribi	*Ourebia ourebi*	VU
African striped weasel	*Poecilogale albinucha*	NE
Wild dog	*Lycaon pictus*	EN
Pangolin	*Manis temminckii*	VU
Aardwolf	*Proteles cristatus*	NE
African Leopard	*Panthera pardus*	NE
Natal red rock rabbit	*Pronolagus crassicaudatus ruddi*	NE

Appendix 2: List threatened bird species which occur in Mpumalanga (MP SoER, 2003).

English Name	Species	Status
Whitewinged Flufftail	*Sarothrura ayresi*	CR
Rudd's Lark	*Heteromirafra ruddi*	CR
Yellowbreasted Pipit	*Hemimacronyx chloris*	VU
Bald Ibis	*Geronticus calvus*	VU
Botha's Lark	*Spizocorys fringillaris*	EN
Wattled Crane	*Bugeranus carunculatus*	CR
Blue Crane	*Anthropoides paradiseus*	VU
Grey Crowned Crane	*Balearica reguloru,*	VU
Blue Swallow	*Hirundo atrocaerulea*	CR
Pinkthroated Twinspot	*Hypargos margaritatus*	NT
Chestnutbanded Plover	*Charadrius pallidus*	NT
Striped Flufftail	*Sarothrura affinis*	VU
Southern Ground Hornbill	*Bucorvus leadbeateri*	VU
Blackrumped Buttonquail	*Turnix hottentotta nana*	EN
Blue Korhaan	*Eupodotis caerulescens*	VU
Stanley's Bustard	*Neotis denhami*	VU
African Marsh Harrier	*Circus ranivorus*	VU
Grass Owl	*Tyto capensis*	VU
Whitebellied Korhaan	*Eupodotis cafra*	VU
Saddlebilled Stork	*Ephippiorhynchus senegalensis*	CR
Lappetfaced Vulture	*Torgos tracheliotos*	EN
Whiteheaded Vulture	*Trigonoceps occipitalis*	EN
Bateleur	*Terathopius ecaudatus*	VU
Cape Vulture	*Gyps coprotheres*	VU
Martial Eagle	*Polemaetus bellicosus*	VU
Peregrine Falcon	*Falco peregrinus minor*	VU
Taita Falcon	*Falco fasciinucha*	NT

Appendix 2a: Roberts Multimedia Birds of Southern Africa listing bird species expected to occur in the QDS 2529DA

R=Resident ;**E**=Endemic ; **BM**=Breeding Migrant ; **NBM**=Non breeding Migrant; **V**=Vagrant ; **A**=Abundant ; **VC**=Very Common ; **C**=Common ; **U**=Uncommon ; **R**=Rare ; **#**=Rare bird Record

SA Bird	English Common Name			Map Status	Scientific Name	
1	Ostrich			R-C	Struthio	camelus
6	Great	Crested		R-U/C	Podiceps	cristatus
8	Dabchick			R-VC	Tachybaptus	ruficollis
55	Whitebreasted	Cormorant		R-VC	Phalacrocorax	lucidus
58	Reed	Cormorant		R-VC	Phalacrocorax	africanus
60	Darter			R-C	Anhinga	rufa
62	Grey	Heron		R-C	Ardea	cinerea
63	Blackheaded	Heron		R-VC	Ardea	melanocephala
64	Goliath	Heron		R-U/C	Ardea	goliath
65	Purple	Heron		R-C	Ardea	purpurea
66	Great	White	Egret	R-C	Egretta	alba
67	Little	Egret		R-C	Egretta	garzetta
68	Yellowbilled	Egret		R-C	Egretta	intermedia
69	Black	Egret		R-C	Egretta	ardesiaca
71	Cattle	Egret		R-A	Bubulcus	ibis
72	Squacco	Heron		R-C	Ardeola	ralloides
74	Greenbacked	Heron		R-U	Butorides	striatus
76	Blackcrowned	Night	Heron	R-U	Nycticorax	nycticorax
78	Little	Bittern		R-U	Ixobrychus	minutus
80	Bittern			R-U	Botaurus	stellaris
81	Hamerkop			R-VC	Scopus	umbretta
83	White	Stork		NBM-C	Ciconia	ciconia
84	Black	Stork		R-U	Ciconia	nigra
85	Abdim's	Stork		NBM-U	Ciconia	abdimii
89	Marabou	Stork		R-U	Leptoptilos	crumeniferus
90	Yellowbilled	Stork		NBM-U	Mycteria	ibis
91	Sacred	Ibis		R-VC	Threskiornis	aethiopicus
92	Bald	Ibis		E-C	Geronticus	calvus
93	Glossy	Ibis		R-C	Plegadis	falcinellus
94	Hadeda	Ibis		R-A	Bostrychia	hagedash
95	African	Spoonbill		R-C	Platalea	alba
96	Greater	Flamingo		R-U/C	Phoenicopterus	ruber
97	Lesser	Flamingo		R-U/C	Phoenicopterus	minor
99	Whitefaced	Duck		R-VC	Dendrocygna	viduata
100	Fulvous	Duck		R-U	Dendrocygna	bicolor
101	Whitebacked	Duck		R-U	Thalassornis	leuconotus
102	Egyptian	Goose		R-VC	Alopochen	aegyptiacus
103	South	African	Shelduck	E-U	Tadorna	cana
104	Yellowbilled	Duck		R-U/VC	Anas	undulata
105	African	Black	Duck	R-C	Anas	sparsa
106	Cape	Teal		R-U	Anas	capensis

SA Bird	English Common Name			Map Status	Scientific Name	
107	Hottentot	Teal		R-U/C	Anas	hottentota
108	Redbilled	Teal		R-C	Anas	erythrorhyncha
112	Cape	Shoveller		E-U	Anas	smithii
113	Southern	Pochard		R-C	Netta	erythrophthalma
114	Pygmy	Goose		R-U	Nettapus	auritus
115	Knobbilled	Duck		R-U	Sarkidiornis	melanotos
116	Spurwinged	Goose		R-VC	Plectropterus	gambensis
117	Maccoa	Duck		R-U/VC	Oxyura	maccoa
118	Secretarybird			R-U/C	Sagittarius	serpentarius
122	Cape	Vulture		E-U	Gyps	coprotheres
126	Black	Kite		NBM-U	Milvus	migrans
126.1	Yellowbilled	Kite		BM-U	Milvus	aegyptius
127	Blackshouldered	Kite		R-VC	Elanus	caeruleus
128	Cuckoo	Hawk		R-U	Aviceda	cuculoides
130	Honey	Buzzard		NBM-U	Pernis	apivorus
131	Black	Eagle		R-C	Aquila	verreauxii
133	Steppe	Eagle		NBM-U	Aquila	nipalensis
135	Wahlberg's	Eagle		BM-U	Aquila	wahlbergi
136	Booted	Eagle		NBM-U	Hieraaetus	pennatus
137	African	Hawk	Eagle	R-C	Hieraaetus	spilogaster
138	Ayres'	Eagle		NBM-U	Hieraaetus	ayresii
140	Martial	Eagle		R-U	Polemaetus	bellicosus
141	Crowned	Eagle		R-C	Stephanoaetus	coronatus
142	Brown	Snake	Eagle	R-C	Circaetus	cinereus
143	Blackbreasted	Snake	Eagle	R-C	Circaetus	pectoralis
148	African	Fish	Eagle	R-U	Haliaeetus	vocifer
149	Steppe	Buzzard		NBM-C	Buteo	vulpinus
152	Jackal	Buzzard		E-U	Buteo	rufofuscus
154	Lizard	Buzzard		R-C	Kaupifalco	monogrammicus
156	Ovambo	Sparrowhawk		R-U	Accipiter	ovampensis
157	Little	Sparrowhawk		R-U	Accipiter	minullus
158	Black	Sparrowhawk		R-U	Accipiter	melanoleucus
159	Little	Banded	Goshawk	R-U	Accipiter	badius
160	African	Goshawk		R-C	Accipiter	tachiro
161	Gabar	Goshawk		R-U/C	Melierax	gabar
164	Eurasian	Marsh	Harrier	NBM-U	Circus	aeruginosus
165	African	Marsh	Harrier	R-U	Circus	ranivorus
166	Montagu's	Harrier		NBM-U	Circus	pygargus
167	Pallid	Harrier		NBM-U	Circus	macrourus
168	Black	Harrier		NBM-U	Circus	maurus
169	Gymnogene			R-C	Polyboroides	typus
170	Osprey			NBM-U	Pandion	haliaetus
171	Peregrine	Falcon		NBM-U	Falco	peregrinus
172	Lanner	Falcon		R-U	Falco	biarmicus
173	Northern	Hobby	Falcon	NBM-U	Falco	subbuteo

SA Bird	English Common Name			Map Status	Scientific Name	
179	Western	Redfooted	Kestrel	NBM-U	Falco	vespertinus
180	Eastern	Redfooted	Kestrel	NBM-C	Falco	amurensis
181	Rock	Kestrel		R-U	Falco	rupicolis
182	Greater	Kestrel		R-U	Falco	rupicoloides
183	Lesser	Kestrel		NBM-C	Falco	naumanni
188	Coqui	Francolin		R-C	Peliperdix	coqui
189	Crested	Francolin		R-U	Dendroperdix	sephaena
191	Shelley's	Francolin		R-C	Scleroptila	shelleyi
192	Redwing	Francolin		R-U	Scleroptila	levaillantii
196	Natal	Francolin		E-U	Pternistis	natalensis
199	Swainson's	Francolin		E-VC	Pternistis	swainsonii
200	Common	Quail		R-U	Coturnix	coturnix
201	Harlequin	Quail		BM-U	Coturnix	delegorguei
203	Helmeted	Guineafowl		R-VC	Numida	meleagris
205	Kurrichane	Buttonquail		R-U	Turnix	sylvatica
208	Blue	Crane		E-U	Anthropoides	paradisea
210	African	Rail		R-C	Rallus	caerulescens
211	Corncrake			NBM-U	Crex	crex
212	African	Crake		BM-U	Crecopsis	egregia
213	Black	Crake		R-C	Amaurornis	flavirostris
214	Spotted	Crake		Rare	Porzana	porzana
215	Baillon's	Crake		R-U	Porzana	pusilla
217	Redchested	Flufftail		R-U	Sarothrura	rufa
223	Purple	Gallinule		R-C	Porphyrio	madagascariensis
226	Common	Moorhen		R-C	Gallinula	chloropus
228	Redknobbed	Coot		R-VC	Fulica	cristata
229	African	Finfoot		R-U	Podica	senegalensis
231	Stanley's	Bustard		R-C	Neotis	denhami
233	Whitebellied	Korhaan		E-C	Eupodotis	barrowii
234	Blue	Korhaan		E-VC	Eupodotis	caerulescens
237	Redcrested	Korhaan		E-VC	Eupodotis	ruficrista
238	Blackbellied	Korhaan		R-C	Eupodotis	melanogaster
239.1	Whitewinged	Korhaan		E-VC	Eupodotis	afraoides
240	African	Jacana		R-U	Actophilornis	africanus
242	Old	World Painted	Snipe	R-U	Rostratula	benghalensis
245	Ringed	Plover		NBM-U	Charadrius	hiaticula
248	Kittlitz's	Plover		R-C	Charadrius	pecuarius
249	Threebanded	Plover		R-VC	Charadrius	tricollaris
252	Caspian	Plover		NBM-U	Charadrius	asiaticus
255	Crowned	Plover		R-VC	Vanellus	coronatus
257	Blackwinged	Plover		R-C	Vanellus	melanopterus
258	Blacksmith	Plover		R-VC/A	Vanellus	armatus
260	Wattled	Plover		R-VC	Vanellus	senegallus
262	Ruddy	Turnstone		NBM-U	Arenaria	interpres
264	Common	Sandpiper		NBM-C	Actitis	hypoleucos

SA Bird	English Common Name			Map Status	Scientific Name	
265	Green	Sandpiper		NBM-U	Tringa	ochropus
266	Wood	Sandpiper		NBM-C	Tringa	glareola
269	Marsh	Sandpiper		NBM-C	Tringa	stagnatilis
270	Greenshank			NBM-C	Tringa	nebularia
272	Curlew	Sandpiper		NBM-C	Calidris	ferruginea
274	Little	Stint		NBM-C	Calidris	minuta
281	Sanderling			NBM-U	Calidris	alba
284	Ruff			NBM-C	Philomachus	pugnax
286	Ethiopian	Snipe		R-C	Gallinago	nigripennis
289	Curlew			NBM-U	Numenius	arquata
290	Whimbrel			NBM-U	Numenius	phaeopus
294	Pied	Avocet		R-U	Recurvirostra	avosetta
295	Blackwinged	Stilt		R-C	Himantopus	himantopus
297	Spotted	Dikkop		R-C	Burhinus	capensis
298	Water	Dikkop		R-C	Burhinus	vermiculatus
300	Temminck's	Courser		R-U	Cursorius	temminckii
305	Blackwinged	Pratincole		NBM-C	Glareola	nordmanni
315	Greyheaded	Gull		R-U/C	Larus	cirrocephalus
322	Caspian	Tern		R-U	Sterna	caspia
338	Whiskered	Tern		BM-C	Chlidonias	hybridus
339	Whitewinged	Tern		NBM-U/C	Chlidonias	leucopterus
348	Feral	Pigeon		R-C	Columba	livia
349	Rock	Pigeon		R-VC	Columba	guinea
350	Rameron	Pigeon		R-C	Columba	arquatrix
352	Redeyed	Dove		R-VC	Streptopelia	semitorquata
354	Cape	Turtle	Dove	R-A	Streptopelia	capicola
355	Laughing	Dove		R-A	Streptopelia	senegalensis
356	Namaqua	Dove		R-C	Oena	capensis
358	Greenspotted	Dove		R-A	Turtur	chalcospilos
359	Tambourine	Dove		R-U	Turtur	tympanistria
361	African	Green	Pigeon	R-U	Treron	calva
373	Grey	Lourie		R-VC	Corythaixoides	concolor
374	Eurasian	Cuckoo		NBM-U	Cuculus	canorus
375	African	Cuckoo		BM-U	Cuculus	gularis
377	Redchested	Cuckoo		BM-C	Cuculus	solitarius
378	Black	Cuckoo		BM-U	Cuculus	clamosus
380	Great	Spotted	Cuckoo	BM-U	Clamator	glandarius
381	Striped	Cuckoo		BM-U	Clamator	levaillantii
382	Jacobin	Cuckoo		BM-U	Clamator	jacobinus
385	Klaas's	Cuckoo		BM-U	Chrysococcyx	klaas
386	Diederik	Cuckoo		BM-C	Chrysococcyx	caprius
391	Burchell's	Coucal		R-U	Centropus	burchellii
392	Barn	Owl		R-C	Tyto	alba
393	Grass	Owl		R-U	Tyto	capensis

SA Bird	English Common Name			Map Status	Scientific Name	
395	Marsh	Owl		R-C	Asio	capensis
396	African	Scops	Owl	R-C	Otus	senegalensis
397	Whitefaced	Owl		R-U/C	Ptilopsus	granti
398	Pearlspotted	Owl		R-C	Glaucidium	perlatum
400	Cape	Eagle	Owl	R-U	Bubo	capensis
401	Spotted	Eagle	Owl	R-C	Bubo	africanus
402	Giant	Eagle	Owl	R-U	Bubo	lacteus
404	Eurasian	Nightjar		NBM-U	Caprimulgus	europaeus
405	Fierynecked	Nightjar		R-C	Caprimulgus	pectoralis
408	Freckled	Nightjar		R-VC	Caprimulgus	tristigma
411	Eurasian	Swift		NBM-U	Apus	apus
412	Black	Swift		BM-U	Apus	barbatus
415	Whiterumped	Swift		BM-C	Apus	caffer
416	Horus	Swift		BM-U	Apus	horus
417	Little	Swift		R-VC	Apus	affinis
418	Alpine	Swift		BM-U/C	Tachymarptis	melba
421	Palm	Swift		R-C	Cypsiurus	parvus
424	Speckled	Mousebird		R-VC	Colius	striatus
426	Redfaced	Mousebird		R-VC	Urocolius	indicus
428	Pied	Kingfisher		R-C	Ceryle	rudis
429	Giant	Kingfisher		R-C	Megaceryle	maxima
430	Halfcollared	Kingfisher		R-U	Alcedo	semitorquata
431	Malachite	Kingfisher		R-U	Alcedo	cristata
432	Pygmy	Kingfisher		BM-C	Ispidina	picta
433	Woodland	Kingfisher		BM-U/C	Halcyon	senegalensis
435	Brownhooded	Kingfisher		R-C/VC	Halcyon	albiventris
437	Striped	Kingfisher		R-VC	Halcyon	chelicuti
438	Eurasian	Bee-eater		NBM-VC	Merops	apiaster
443	Whitefronted	Bee-eater		R-C	Merops	bullockoides
444	Little	Bee-eater		R-VC	Merops	pusillus
445	Swallowtailed	Bee-eater		R-U	Merops	hirundineus
446	Eurasian	Roller		NBM-U	Coracias	garrulus
447	Lilacbreasted	Roller		R-VC	Coracias	caudata
449	Purple	Roller		R-C	Coracias	naevia
451	African	Hoopoe		R-VC	Upupa	africana
452	Redbilled	Woodhoopoe		R-VC	Phoeniculus	purpureus
454	Scimitarbilled	Woodhoopoe		R-VC	Rhinopomastus	cyanomelas
457	Grey	Hornbill		R-C	Tockus	nasutus
458	Redbilled	Hornbill		R-U	Tockus	erythrorhynchus
459	Southern	Yellowbilled	Hornbill	E-VC	Tockus	leucomelas
464	Blackcollared	Barbet		R-VC	Lybius	torquatus
465	Pied	Barbet		E-U	Tricholaema	leucomelas
470	Yellowfronted	Tinker	Barbet	R-VC	Pogoniulus	chrysoconus
473	Crested	Barbet		R-U/VC	Trachyphonus	vaillantii
474	Greater	Honeyguide		R-C	Indicator	indicator

SA Bird	English Common Name			Map Status	Scientific Name	
476	Lesser	Honeyguide		R-U	Indicator	minor
478	Sharpbilled	Honeyguide		R-U	Prodotiscus	regulus
481	Bennett's	Woodpecker		R-U	Campethera	bennettii
483	Goldentailed	Woodpecker		R-U	Campethera	abingoni
486	Cardinal	Woodpecker		R-C	Dendropicos	fuscescens
487	Bearded	Woodpecker		R-U	Dendropicos	namaquus
489	Redthroated	Wryneck		R-C	Jynx	ruficollis
494	Rufousnaped	Lark		R-VC	Mirafra	africana
495.2	Eastern	Clapper	Lark	E-U	Mirafra	fasciolata
496	Flappet	Lark		R-U	Mirafra	rufocinnamomea
498	Sabota	Lark		E-U	Calendulauda	sabota
506	Spikeheeled	Lark		E-VC	Chersomanes	albofasciata
507	Redcapped	Lark		R-C	Calandrella	cinerea
508	Pinkbilled	Lark		E-C	Spizocorys	conirostris
518	Eurasian	Swallow		NBM-VC	Hirundo	rustica
520	Whitethroated	Swallow		BM-C	Hirundo	albigularis
523	Pearlbreasted	Swallow		R-U	Hirundo	dimidiata
524	Redbreasted	Swallow		BM-C	Hirundo	semirufa
526	Greater	Striped	Swallow	BM-VC	Hirundo	cucullata
527	Lesser	Striped	Swallow	BM-VC	Hirundo	abyssinica
528	South	African Cliff	Swallow	BM-C	Hirundo	spilodera
529	Rock	Martin		R-VC	Hirundo	fuligula
530	House	Martin		NBM-U	Delichon	urbica
532	Sand	Martin		NBM-U	Riparia	riparia
533	Brownthroated	Martin		R-C	Riparia	paludicola
534	Banded	Martin		BM-C	Riparia	cincta
536	Black	Sawwing	Swallow	BM-C	Psalidoprocne	holomelaena
538	Black	Cuckooshrike		R-C	Campephaga	flava
541	Forktailed	Drongo		R-VC	Dicrurus	adsimilis
545	Blackheaded	Oriole		R-VC	Oriolus	larvatus
547	Black	Crow		R-VC	Corvus	capensis
548	Pied	Crow		R-C	Corvus	albus
552	Ashy	Tit		E-C	Parus	cinerascens
554	Southern	Black	Tit	E-VC	Parus	niger
557	Cape	Penduline	Tit	E-U	Anthoscopus	minutus
558	Grey	Penduline	Tit	R-U	Anthoscopus	caroli
560	Arrowmarked	Babbler		R-VC	Turdoides	jardineii
568	Blackeyed	Bulbul		R-A	Pycnonotus	tricolor
576	Kurrichane	Thrush		R-U/VC	Turdus	libonyanus
577	Olive	Thrush		R-VC	Turdus	olivaceus
577.1	Karoo	Thrush		E-VC	Turdus	smithi
580	Groundscraper	Thrush		R-VC	Psophocichla	litsipsirupa
581	Cape	Rockthrush		E-C	Monticola	rupestris
582	Sentinel	Rockthrush		E-U	Monticola	explorator
586	Mountain	Chat		E-VC	Oenanthe	monticola

SA Bird	English Common Name			Map Status	Scientific Name	
587	Capped	Wheatear		R-U	Oenanthe	pileata
589	Familiar	Chat		R-C	Cercomela	familiaris
593	Mocking	Chat		R-C	Thamnolaea	cinnamomeiventris
595	Anteating	Chat		E-VC	Myrmecocichla	formicivora
596	Stonechat			R-VC	Saxicola	torquata
601	Cape	Robin		R-VC	Cossypha	caffra
602	Whitethroated	Robin		E-C	Cossypha	humeralis
613	Whitebrowed	Robin		R-U/VC	Cercotrichas	leucophrys
615	Kalahari	Robin		E-VC	Cercotrichas	paena
619	Garden	Warbler		NBM-U	Sylvia	borin
621	Titbabbler			E-C	Parisoma	subcaeruleum
625	Icterine	Warbler		NBM-U	Hippolais	icterina
628	Great	Reed	Warbler	NBM-U	Acrocephalus	arundinaceus
631	African	Marsh	Warbler	BM-C	Acrocephalus	baeticatus
633	Eurasian	Marsh	Warbler	NBM-U	Acrocephalus	palustris
634	Eurasian	Sedge	Warbler	NBM-U	Acrocephalus	schoenobaenus
635	Cape	Reed	Warbler	R-C	Acrocephalus	gracilirostris
637	Yellow	Warbler		R-U	Chloropeta	natalensis
638	African	Sedge	Warbler	R-C	Bradypterus	baboecala
643	Willow	Warbler		NBM-C	Phylloscopus	trochilus
645	Barthroated	Apalis		R-U	Apalis	thoracica
651	Longbilled	Crombec		R-VC	Sylvietta	rufescens
653	Yellowbellied	Eremomela		R-C	Eremomela	icteropygialis
657.1	Greybacked	BleatingWarbler		R-VC	Camaroptera	brevicaudata
661	Grassbird			E-C	Sphenoeacus	afer
664	Fantailed	Cisticola		R-C	Cisticola	juncidis
665	Desert	Cisticola		R-U/C	Cisticola	aridulus
666	Cloud	Cisticola		R-C	Cisticola	textrix
667	Ayres'	Cisticola		R-C	Cisticola	ayresii
668	Palecrowned	Cisticola		R-U	Cisticola	cinnamomeus
670	Wailing	Cisticola		R-C	Cisticola	lais
672	Rattling	Cisticola		R-C	Cisticola	chinianus
677	Levaillant's	Cisticola		R-VC	Cisticola	tinniens
679	Lazy	Cisticola		R-U	Cisticola	aberrans
681	Neddicky			R-C	Cisticola	fulvicapillus
683	Tawnyflanked	Prinia		R-VC	Prinia	subflava
685	Blackchested	Prinia		E-VC	Prinia	flavicans
686.1	Spotted	Prinia		E-C	Prinia	hypoxantha
689	Spotted	Flycatcher		NBM-U	Muscicapa	striata
693	Fantailed	Flycatcher		R-U	Myioparus	plumbeus
694	Black	Flycatcher		R-C	Melaenornis	pammelaina
695	Marico	Flycatcher		E-C/VC	Bradornis	mariquensis
696	Pallid	Flycatcher		R-C	Bradornis	pallidus
698	Fiscal	Flycatcher		E-VC	Sigelus	silens
700	Cape	Batis		R-VC	Batis	capensis

SA Bird	English Common Name			Map Status	Scientific Name	
701	Chinspot	Batis		R-C	Batis	molitor
706	Fairy	Flycatcher		NBM-C	Stenostira	scita
710	Paradise	Flycatcher		BM-VC	Terpsiphone	viridis
711	African	Pied	Wagtail	R-U	Motacilla	aguimp
713	Cape	Wagtail		R-VC	Motacilla	capensis
714	Yellow	Wagtail		NBM-C	Motacilla	flava
716	Grassveld	Pipit		R-VC	Anthus	cinnamomeus
717	Longbilled	Pipit		R-U	Anthus	similis
718	Plainbacked	Pipit		R-U	Anthus	leucophrys
719	Buffy	Pipit		R-U	Anthus	vaalensis
720	Striped	Pipit		R-U	Anthus	lineiventris
723	Bushveld	Pipit		R-U	Anthus	caffer
727	Orangethroated	Longclaw		E-VC	Macronyx	capensis
731	Lesser	Grey	Shrike	NBM-U	Lanius	minor
732	Fiscal	Shrike		R-A	Lanius	collaris
733	Redbacked	Shrike		NBM-VC	Lanius	collurio
735	Longtailed	Shrike		R-VC	Corvinella	melanoleuca
736	Southern	Boubou		E-VC	Laniarius	ferrugineus
739	Crimsonbreasted	Shrike		E-VC	Laniarius	atrococcineus
740	Puffback			R-A	Dryoscopus	cubla
741	Brubru			R-U	Nilaus	afer
743	Threestreaked	Tchagra		R-U	Tchagra	australis
744	Blackcrowned	Tchagra		R-VC	Tchagra	senegala
746	Bokmakierie			E-VC	Telophorus	zeylonus
748	Orangebreasted	Bush	Shrike	R-U	Telophorus	sulfureopectus
751	Greyheaded	Bush	Shrike	R-VC	Malaconotus	blanchoti
753	White	Helmetshrike		R-VC	Prionops	plumatus
758	Indian	Myna		R-VC	Acridotheres	tristis
759	Pied	Starling		E-C	Spreo	bicolor
760	Wattled	Starling		R-U	Creatophora	cinerea
761	Plumcoloured	Starling		BM-VC	Cinnyricinclus	leucogaster
764	Glossy	Starling		E-C/VC	Lamprotornis	nitens
769	Redwinged	Starling		R-VC	Onychognathus	morio
772	Redbilled	Oxpecker		R-U	Buphagus	erythrorhynchus
775	Malachite	Sunbird		R-U/VC	Nectarinia	famosa
779	Marico	Sunbird		R-VC	Cinnyris	mariquensis
785	Greater	Doublecollared	Sunbird	E-U	Cinnyris	afra
787	Whitebellied	Sunbird		R-U	Cinnyris	talatala
792	Black	Sunbird		R-VC	Chalcomitra	amethystina
796	Cape	White-eye		E-VC	Zosterops	virens
799	Whitebrowed	Sparrowweaver		R-U/VC	Plocepasser	mahali
801	House	Sparrow		R-VC	Passer	domesticus
803	Cape	Sparrow		E-A	Passer	melanurus
804	Southern	Greyheaded	Sparrow	E-VC	Passer	diffusus
805	Yellowthroated	Sparrow		R-C	Petronia	superciliaris

SA Bird	English Common Name			Map Status	Scientific Name	
806	Scalyfeathered	Finch		E-VC	Sporopipes	squamifrons
807	Thickbilled	Weaver		R-U	Amblyospiza	albifrons
810	Spectacled	Weaver		R-VC	Ploceus	ocularis
811	Spottedbacked	Weaver		R-U/VC	Ploceus	cucullatus
813	Cape	Weaver		E-VC	Ploceus	capensis
814	Masked	Weaver		R-VC	Ploceus	velatus
815	Lesser	Masked	Weaver	R-U	Ploceus	intermedius
819	Redheaded	Weaver		R-U	Anaplectes	rubriceps
820	Cuckoofinch			BM-U	Anomalospiza	imberbis
821	Redbilled	Quelea		R-VC	Quelea	quelea
824	Red	Bishop		R-VC	Euplectes	orix
826	Golden	Bishop		R-C	Euplectes	afer
827	Yellowrumped	Widow		R-U/C	Euplectes	capensis
828	Redshouldered	Widow		R-U/VC	Euplectes	axillaris
829	Whitewinged	Widow		R-C	Euplectes	albonotatus
831	Redcollared	Widow		R-VC	Euplectes	ardens
832	Longtailed	Widow		R-A	Euplectes	progne
834	Melba	Finch		R-U	Pytilia	melba
840	Bluebilled	Firefinch		R-C	Lagonosticta	rubricata
841	Jameson's	Firefinch		R-U	Lagonosticta	rhodopareia
842	Redbilled	Firefinch		R-U	Lagonosticta	senegala
844	Blue	Waxbill		R-VC	Uraeginthus	angolensis
845	Violeteared	Waxbill		E-U	Granatina	granatina
846	Common	Waxbill		R-VC	Estrilda	astrild
847	Blackcheeked	Waxbill		R-U	Estrilda	erythronotos
850	Swee	Waxbill		E-U	Estrilda	melanotis
852	Quail	Finch		R-C	Ortygospiza	atricollis
854	Orangebreasted	Waxbill		R-C	Amandava	subflava
855	Cutthroat	Finch		R-C	Amadina	fasciata
856	Redheaded	Finch		E-U/VC	Amadina	erythrocephala
857	Bronze	Mannikin		R-VC	Lonchura	cucullata
860	Pintailed	Whydah		R-VC	Vidua	macroura
861	Shafttailed	Whydah		E-U	Vidua	regia
862	Paradise	Whydah		R-U	Vidua	paradisaea
864	Black	Widowfinch		R-U/C	Vidua	funerea
867	Steelblue	Widowfinch		R-U	Vidua	chalybeata
869	Yelloweyed	Canary		R-U/VC	Serinus	mozambicus
870	Blackthroated	Canary		R-VC	Serinus	atrogularis
872	Cape	Canary		R-U/VC	Serinus	canicollis
881	Streakyheaded	Canary		R-C	Serinus	gularis
884	Goldenbreasted	Bunting		R-U/VC	Emberiza	flaviventris
885	Cape	Bunting		R-U	Emberiza	capensis
886	Rock	Bunting		R-VC	Emberiza	tahapisi
887	Larklike	Bunting		E-U	Emberiza	impetuani

Appendix 3: Threatened reptile species of Mpumalanga (MP SoER, 2003).

English Name	Species	Status
Haacke's flat gecko	*Afroedura haackei*	EN
Abel Erasmus Pass flat gecko	*Afroedura sp.*	EN
Mariepskop flat gecko	*Afroedura sp.*	EN
Rondavels flat gecko	*Afroedura sp.*	EN
Forest/Natal purpleglossed snake	*Amblyodipsas concolor*	VU
Lowveld shieldnosed snake	*Aspidelaps scutatus intermedius*	VU
Dwarf chameleon	*Bradypodion transvaalense complex*	VU
Sungazer/ Giant girdled lizard	*Cordylus giganteus*	VU
Barberton girdled lizard	*Cordylus warreni barbertonensis*	VU
Lebombo girdled lizard	*Cordylus warreni warreni*	VU
Swazi rock snake	*Lamprophis swazicus*	VU
Transvaal flat lizard	*Platysaurus orientalis orientalis*	NT
Wilhelm's flat lizard	*Platysaurus wilhelmi*	VU
Montane burrowing skink	*Scelotes mirus*	LC
Breyer's longtailed seps	*Tetradactylus breyeri*	VU

Appendix 4: Threatened amphibian species of Mpumalanga (MP SoER, 2003).

English Name	Species	Status
Karoo Toad	*Bufo gariepensis nubicolus*	VU
Natal Ghost Frog	*Heleophryne natalensis*	VU
Spotted Shovel-Nosed Frog	*Hemisus guttatus*	VU
Yellow Striped Reed Frog	*Hyperolius semidiscus*	VU
Plain Stream Frog	*Strongylopus wageri*	VU
Giant Bullfrog	*Pyxicephalus adspersus*	VU
Greater Leaf-Folding Frog	*Afrixalus fornasinii*	VU
Whistling Rain Frog	*Breviceps sp.*	VU

Appendix 5: Threatened invertebrate species of Mpumalanga (MP SoER, 2003).

English Name	Species	Status
Barbara’s Copper	*Aloeides barbarae*	EN
Cloud Copper	*Aloeides nubilis*	VU
Rossouw’s Copper	*Aloeides rossouwi*	EN
Stoffberg Widow	*Dingana fraterna*	EN
Irving’s Blue	*Lepidochrysops irvingi*	VU
Swanepoel’s Blue	*Lepidochrysops swanepoeli*	EN
Jeffery’s Blue	*Lepidochrysops jefferyi*	EN
Rossouw’s Blue	*Lepidochrysops rossouwi*	VU
Marsh Sylph*	*Metisella meninx*	VU

FAUNAL, FLORAL, WETLAND AND AQUATIC ASSESSMENT AS PART OF THE ENVIRONMENTAL ASSESSMENT AND AUTHORISATION PROCESS FOR THE PROPOSED RIETVLEI COLLIERY OUTSIDE MIDDELBURG, MPUMALANGA PROVINCE

Prepared for

WSP Group

April 2014

SECTION D – Wetland Assessment

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ACRONYMS

CSIR	Council of Scientific and Industrial Research
DEMC	Desired Ecological Management Class
DWA	Department of Water Affairs
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EAP	Environmental Assessment Practitioner
HGM	Hydrogeomorphic
NFEPA	National Freshwater Ecosystem Priority Areas
PEMC	Present Ecological management Class
PES	Present Ecological State
RHP	River Health Programme
SANBI	South African National Biodiversity Institute
SAS	Scientific Aquatic Services

1 INTRODUCTION

1.1 Background

Scientific Aquatic Services (SAS) was appointed to conduct a faunal, floral, wetland and aquatic assessment as part of the Environmental Assessment (EIA) and authorisation process for the proposed Rietvlei Colliery, hereafter referred to as the “subject property”. The subject property is situated south-east of the R555, outside Middelburg, Mpumalanga Province (25°40’18.59”S 29°39’16.47”E). The total area of the proposed opencast footprint extends over approximately 747.16ha.

The subject property is surrounded by properties on which agricultural activities dominate. The ecological assessment was done with special focus on areas earmarked for mining footprint as well as areas of considered of higher ecological importance and sensitivity. The surrounding area was however considered as part of the desktop assessment of the area. The land is currently used for forestry purposes with areas of edible crop lands also located on the subject property.

The purpose of the report is to present the delineation of the wetland resources associated with the development as well as to provide a summary of the wetland Present Ecological State (PES) and function prior to the proposed construction activities and to allow informed decision making by the authorities, proponent and Environmental Assessment Practitioner (EAP) consultants.

2 WETLAND ASSESSMENT METHODOLOGY

2.1 Desktop study

Prior to the commencement of the field assessment, a background study, including a literature review, was conducted in order to determine the ecoregion and ecostatus of the larger aquatic system within which the wetland feature present within the subject property, is located. Aspects considered as part of the literature review are discussed in the sections that follow.

2.1.1 Ecostatus

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments, the Ecological Importance and Sensitivity (EIS), Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC) were defined, and serve as a useful guideline in determining the importance and sensitivity of aquatic ecosystems prior to assessment, or as part of a desktop assessment.

Water resources are generally classified according to the degree of modification or level of impairment. The classes used by the South African River Health Programme (RHP) are presented in Table 1 below and will be used as the basis of classification of the systems in this field, and desktop study.

Table 1: Classification of River Health Assessment Classes in Line with the RHP.

Class	Description
A	Unmodified, natural
B	Largely natural, with few modifications
C	Moderately modified
D	Largely modified
E	Extensively modified
F	Critically modified

2.1.2 National Freshwater Ecosystem Priority Areas (NFEPA)

The NFEPA project is a multi-partner project between the Council of Scientific and Industrial Research (CSIR), Water Research Commission, South African National Biodiversity Institute (SANBI), Department of Water Affairs (DWA), South African Institute of Aquatic Biodiversity and South African National Parks. The project responds to the reported degradation of freshwater ecosystem condition and associated biodiversity, both globally and in South Africa. It uses systematic conservation planning to provide strategic spatial priorities of conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development.

The NFEPA project aims to identify a national network of freshwater conservation areas and to explore institutional mechanisms for their implementation. Freshwater ecosystems provide a valuable natural resource, with economic, aesthetic, spiritual, cultural and recreational value. The integrity of freshwater ecosystems in South Africa is however declining at an alarming rate, largely as a consequence of a variety of challenges that are practical (managing vast areas of land to maintain connectivity between freshwater ecosystems), socio-economic (competition between stakeholders for utilisation) and institutional (building appropriate governance and co-management mechanisms).

The NFEPA database was searched for information regarding the conservation status of rivers, wetland habitat and wetland features present within the subject property.

2.2 Classification System for Wetlands and other Aquatic Ecosystems in South Africa

All wetland features encountered within the subject property were assessed using the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland systems* (Ollis *et al*., 2013), hereafter referred to as the classification system.

A summary of Levels 1 to 4 of the proposed classification system for Inland Systems are presented in Table 2 and 3, below.

Table 2: Proposed classification structure for Inland Systems, up to Level 3.

WETLAND / AQUATIC ECOSYSTEM CONTEXT		
LEVEL 1: SYSTEM	LEVEL 2: REGIONAL SETTING	LEVEL 3: LANDSCAPE UNIT
Inland Systems	DWA Level 1 Ecoregions OR NFEPA WetVeg Groups OR Other special framework	Valley Floor
		Slope
		Plain
		Bench (Hilltop / Saddle / Shelf)

Table 3: Hydrogeomorphic (HGM) Units for the Inland System, showing the primary HGM Types at Level 4A and the subcategories at Level 4B to 4C.

FUNCTIONAL UNIT		
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT		
HGM type	Longitudinal zonation/ Landform / Outflow drainage	Landform / Inflow drainage
A	**B**	**C**
River	Mountain headwater stream	Active channel
		Riparian zone
	Mountain stream	Active channel
		Riparian zone
	Transitional	Active channel
		Riparian zone
	Upper foothills	Active channel

FUNCTIONAL UNIT		
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT		
HGM type	Longitudinal zonation/ Landform / Outflow drainage	Landform / Inflow drainage
A	**B**	**C**
		Riparian zone
	Lower foothills	Active channel
		Riparian zone
	Lowland river	Active channel
		Riparian zone
	Rejuvenated bedrock fall	Active channel
		Riparian zone
	Rejuvenated foothills	Active channel
		Riparian zone
	Upland floodplain	Active channel
		Riparian zone
Channelled valley-bottom wetland	(not applicable)	(not applicable)
Unchannelled valley-bottom wetland	(not applicable)	(not applicable)
Floodplain wetland	Floodplain depression	(not applicable)
	Floodplain flat	(not applicable)
Depression	Exorheic	With channelled inflow
		Without channelled inflow
	Endorheic	With channelled inflow
		Without channelled inflow
	Dammed	With channelled inflow
		Without channelled inflow
Seep	With channelled outflow	(not applicable)
	Without channelled outflow	(not applicable)
Wetland flat	(not applicable)	(not applicable)

2.2.1 Level 1: Inland systems

For the proposed Classification System, Inland Systems are defined as ***an aquatic ecosystem that have no existing connection to the ocean***[1] (i.e. characterised by the complete absence of marine exchange and/or tidal influence) but ***which are inundated or saturated with water, either permanently or periodically.*** It is important to bear in mind, however, that certain Inland Systems may have had an historical connection to the ocean, which in some cases may have been relatively recent.

[1] Most rivers are indirectly connected to the ocean via an estuary at the downstream end, but where marine exchange (i.e. the presence of seawater) or tidal fluctuations are detectable in a river channel that is permanently or periodically connected to the ocean, it is defined as part of the estuary.

2.2.2 Level 2: Ecoregions

For Inland Systems, the regional spatial framework that has been included at Level 2 of the proposed Classification System is that of DWA's Level 1 Ecoregions for aquatic ecosystems (Kleynhans *et al.,* 2005). There are a total of 31 Ecoregions across South Africa, including Lesotho and Swaziland (figure below). DWA Ecoregions have most commonly been used to categorise the regional setting for national and regional water resource management applications, especially in relation to rivers.

2.2.3 Level 2: NFEPA Wet Veg Groups

The Vegetation Map of South Africa, Swaziland and Lesotho (Mucina & Rutherford, 2006) group's vegetation types across the country according to Biomes, which are then divided into Bioregions. To categorise the regional setting for the wetland component of the NFEPA project, wetland vegetation groups (referred to as WetVeg Groups) were derived by further splitting Bioregions into smaller groups through expert input (Nel *et al*., 2011). There are currently 133 NFEPA WetVeg Groups. It is envisaged that these groups could be used as a special framework for the classification of wetlands in national- and regional-scale conservation planning and wetland management initiatives.

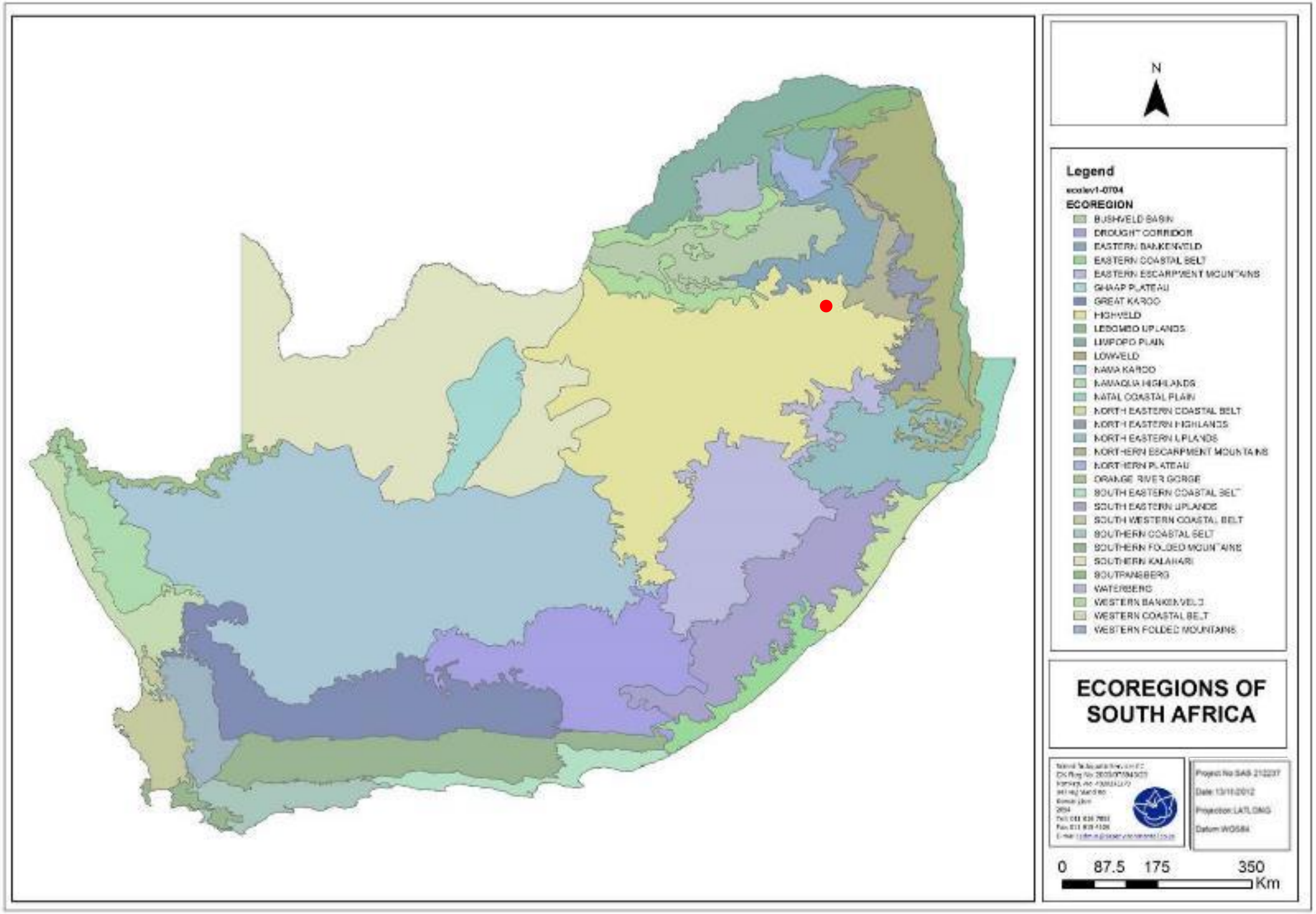

Figure 1: Map of Level 1 Ecoregions of South Africa, with the approximate position of the subject property indicated in red.

2.2.4 Level 3: Landscape Setting

At Level 3 of the proposed classification System, for Inland Systems, a distinction is made between four Landscape Units (Table 2) on the basis of the landscape setting (i.e. topographical position) within which an HGM Unit is situated, as follows (Ollis *et al.,* 2013):

- ***Slope*****:** an included stretch of ground that is not part of a valley floor, which is typically located on the side of a mountain, hill or valley.
- ***Valley floor:*** The base of a valley, situated between two distinct valley side-slopes.
- ***Plain:*** an extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land.
- ***Bench (hilltop/saddle/shelf):*** an area of mostly level or nearly level high ground (relative to the broad surroundings). This including hilltops/crests (areas at the top of a mountain or hill flanked by down-slopes in all directions), saddles (relatively high-lying areas flanked by down-slopes on two sides in one direction and up-slopes on two sides in an approximately permendicular direction), and shelves/terraces/ledges (relatively high-lying, localised flat areas along a slope, representing a break in slope with an up-slope one side and a down-slope on the other side in the same direction).

2.2.5 Level 4: Hydrogeomorphic Units

Eight primary HGM Types are recognised for Inland Systems at Level 4A of the proposed classification system (Table 3), on the basis of hydrology and geomorphology (Ollis *et al*., 2013), namely:

- ***River:*** a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water.
- ***Channelled valley-bottom wetland:*** a valley-bottom wetland with a river channel running through it.
- ***Unchannelled valley-bottom wetland:*** a valley-bottom wetland without a river channel running through it.
- ***Floodplain wetland:*** the mostly flat or gently sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, which is subject to periodic inundation by over-topping of the channel bank.
- ***Depression:*** a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates.

- ***Wetland Flat:*** a level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat
- ***Seep:*** a wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend into a valley floor.

The above terms have been used for the primary HGM Units in the Classification System to try and ensure consistency with the wetland classification terms currently in common usage in South Africa. Similar terminology (but excluding categories for "channel", "flat" and "valleyhead seep") is used, for example, in the recently developed tools produced as part of the Wetland Management Series including WET-Health (Macfarlane *et al.,* 2008) and WET-EcoServices (Kotze *et al.,* 2009).

2.3 WET-Health

Healthy wetlands are known to provide important habitats for wildlife and to deliver a range of important goods and services to society. Management of these systems is therefore essential if these attributes are to be retained within an ever-changing landscape. The primary purpose of this assessment is to evaluate the eco-physical health of wetlands, and in so doing promote their conservation and wise management.

2.3.1 Level f Evaluation

Two levels of assessment are provided by WET-Health:

- Level 1: Desktop evaluation, with limited field verification. This is generally applicable to situations where a large number of wetlands need to be assessed at a very low resolution;
- Level 2: On-site evaluation. This involves structured sampling and data collection in a single wetland and its surrounding catchment; and
- Due to security risks on site and the limited time spent on site this study was undertaken as a level 1 assessment

2.3.2 Framework for the Assessment

A set of three modules has been synthesised from the set of processes, interactions and interventions that take place in wetland systems and their catchments: hydrology (water inputs, distribution and retention, and outputs), geomorphology (sediment inputs, retention and outputs) and vegetation (transformation and presence of introduced alien species).

2.3.3 Units of Assessment

Central to WET-Health is the characterisation of hydrogeomorphic (HGM) units, which have been defined based on geomorphic setting (e.g. hillslope or valley-bottom; whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated) and pattern of water flow through the wetland unit (diffusely or channelled) as described under the *Classification System for Wetlands and other Aquatic Ecosystems* in Section 2.2.

2.3.4 Quantification of Present State of a wetland

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. This takes the form of assessing the spatial *extent* of impact of individual activities and then separately assessing the *intensity* of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall *magnitude* of impact. The impact scores and Present State categories are provided in Table 4.

Table 4: Impact scores and categories of present State used by WET-Health for describing the integrity of wetlands.

Impact category	Description	Impact score range	Present State category
None	Unmodified, natural	0-0.9	A
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4-5.9	D
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E

Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

2.3.5 Assessing the Anticipated Trajectory of Change

As is the case with the Present State, future threats to the state of the wetland may arise from activities in the catchment upstream of the unit or from within the wetland itself or from processes downstream of the wetland. In each of the individual sections for hydrology, geomorphology and vegetation, five potential situations exist depending upon the direction and likely extent of change (Table 5).

Table 5: Trajectory of Change classes and scores used to evaluate likely future changes to the present state of the wetland.

Change Class	Description	HGM change score	Symbol
Substantial improvement	State is likely to improve substantially over the next 5 years	2	↑↑
Slight improvement	State is likely to improve slightly over the next 5 years	1	↑
Remain stable	State is likely to remain stable over the next 5 years	0	→
Slight deterioration	State is likely to deteriorate slightly over the next 5 years	-1	↓
Substantial deterioration	State is expected to deteriorate substantially over the next 5 years	-2	↓↓

2.3.6 Overall health of the wetland

Once all HGM units have been assessed, a summary of health for the wetland as a whole needs to be calculated. This is achieved by calculating a combined score for each component by area weighting the scores calculated for each HGM unit. Recording the health assessments for the hydrology, geomorphology and vegetation components provides a summary of impacts, Present State, Trajectory of Change and Health for individual HGM units and for the entire wetland.

2.4 Wetland function assessment

"The importance of a water resource, in ecological social or economic terms, acts as a modifying or motivating determinant in the selection of the management class".[2] The assessment of the ecosystem services supplied by the identified wetlands was conducted

[2] Department of Water Affairs and Forestry, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999*

according to the guidelines as described by Kotze *et* al (2009). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the service is provided:

- Flood attenuation
- Stream flow regulation
- Sediment trapping
- Phosphate trapping
- Nitrate removal
- Toxicant removal
- Erosion control
- Carbon storage
- Maintenance of biodiversity
- Water supply for human use
- Natural resources
- Cultivated foods
- Cultural significance
- Tourism and recreation
- Education and research

The characteristics were used to quantitatively determine the value, and by extension sensitivity, of the wetlands. Each characteristic was scored to give the likelihood that the service is being provided. The scores for each service were then averaged to give an overall score to the wetland.

Table 6: Classes for determining the likely extent to which a benefit is being supplied.

Score	Rating of the likely extent to which the benefit is being supplied
<0.5	Low
0.6-1.2	Moderately low
1.3-2	Intermediate
2.1-3	Moderately high
>3	High

2.5 Environmental Importance and Sensitivity (EIS) Method of assessment

The method used for the EIS determination was adapted from the method as provided by DWA (1999) for floodplains. The method takes into consideration PES scores obtained for WET-Health as well as function and service provision to enable the assessor to determine the most representative EIS category for the wetland feature or group being assessed.

A series of determinants for EIS are assessed on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. The median of the determinants is used to assign the EIS category as listed in Table 7 and 8 below.

Table 7: Score sheet for determining the EIS.

Determinant	Score	Confidence
PRIMARY DETERMINANTS		
1. Rare & Endangered Species		
2. Populations of Unique Species		
3. Species/taxon Richness		
4. Diversity of Habitat Types or Features		
1. Migration route/breeding and feeding site for wetland species		
6. PES as determined by WET-Health assessment		
7. Importance in terms of function and service provision		
MODIFYING DETERMINANTS		
8. Protected Status according to NFEPA Wetveg		
9. Ecological Integrity		
TOTAL		
MEDIAN		
OVERALL EIS		

Table 8: EIS Category definitions.

EIS Category	Range of Median	Recommended Ecological Management Class[3]
Very high Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains 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.	>3 and <=4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate Wetlands that are considered to be 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.	>1 and <=2	C

[3] Ed's note: Author to confirm exact wording for version 1.1

Low/marginal Wetlands that is not ecologically important and sensitive at any scale. The biodiversity of these floodplains 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.	>0 and <=1	D

2.6 Recommended Ecological Category (REC)

"A high management class relates to the flow that will ensure a high degree of sustainability and a low risk of ecosystem failure. A low management class will ensure marginal maintenance of sustainability, but carries a higher risk of ecosystem failure." [4]

The REC (Table 9) was determined based on the results obtained from the PES, reference conditions and EIS of the resource (sections above). Followed by realistic recommendations, mitigation, and rehabilitation measures to achieve the desired REC.

A wetland may receive the same class for the PES as the REC if the wetland is deemed in good condition, and therefore must stay in good condition. Otherwise, an appropriate REC should be assigned in order to prevent any further degradation as well as enhance the PES of the wetland feature.

Table 9: Description of REC classes.

Category	Description
A	Unmodified, natural
B	Largely natural with few modifications
C	Moderately modified
D	Largely modified

2.7 Wetland delineation

For the purposes of this investigation, a wetland habitat is defined in the National Water Act (1998) as including the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas.

The wetland zone delineation took place according to the method presented in the final draft of "A practical field procedure for identification and delineation of wetlands and riparian areas" published by the DWA in February 2005. The foundation of the method is based on the fact that wetlands and riparian zones have several distinguishing factors including the following:

[4] Department of Water Affairs and Forestry, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources 1999*

- The presence of water at or near the ground surface;
- Distinctive hydromorphic soils;
- Vegetation adapted to saturated soils and
- The presence of alluvial soils in stream systems.

By observing the evidence of these features, in the form of indicators, wetlands and riparian zones can be delineated and identified. If the use of these indicators and the interpretation of the findings are applied correctly, then the resulting delineation can be considered accurate (DWA, 2005).

Riparian and wetland zones can be divided into three zones (DWA, 2005). The permanent zone of wetness is nearly always saturated. The seasonal zone is saturated for a significant part of the rainy season and the temporary zone surrounds the seasonal zone and is only saturated for a short period of the year, but is saturated for a sufficient period, under normal circumstances, to allow for the formation of hydromorphic soils and the growth of wetland vegetation. The object of this study was to identify the outer boundary of the temporary zone and then to identify a suitable buffer zone around the wetland area.

3 RESULTS

3.1 Wetland System Characterisation

Several wetland and pan features were identified within the subject property. The wetland and pan features identified during the assessment of the subject property were categorised according to the method provided by Ollis *et al*., (2013) outlined in Section 2.2. The results of the classification, which show that the features were classified as an Inland system falling within the Highveld Ecoregion, are presented in Table 10 below and conceptually presented in Figure 2:

Table 10: Classification system for the wetland features within the subject property.

Wetland feature location	Level 1: System	Level 2: Regional Setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit HGM Type
Rietvlei Colliery	**Inland:** An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	**Highveld Ecoregion:** The subject property falls within the Highveld Ecoregion **WetVeg Group:** Mesic Highveld Grassland Group 4	**Plain:** An extensive area of low relief. These areas are characterised by relatively level, gently undulating or uniformly sloping land with a very gently gradient that is not located in a valley	***Depression:*** a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates
			Valley floor: The base of a valley, situated between two distinct valley side-slopes	***Channelled valley-bottom wetland:*** a valley-bottom wetland with a river channel running through it
			Bench (hilltop/saddle/shelf): an area of mostly level or nearly level high ground (relative to the broad surroundings)	**Wetland flat:** A level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench

Both the DWA Ecoregions and the NFEPA WetVeg groups were applied as the default special frameworks at Level 2. The relevant DWA 1 Ecoregion is the Highveld ecoregion (Ecoregion 11, Kleynhans *et al*., 2005), while the relevant NFEPA WetVeg Group is the Mesic Highveld Grassland (Nel *et al*., 2011). At Level 3 (Landscape Unit), the landscape setting of the wetland features is a “plain; valley floor and bench”. At Level 4 (HGM Unit), the wetland features can be classified as depressions, channelled valley bottoms and wetland flats.

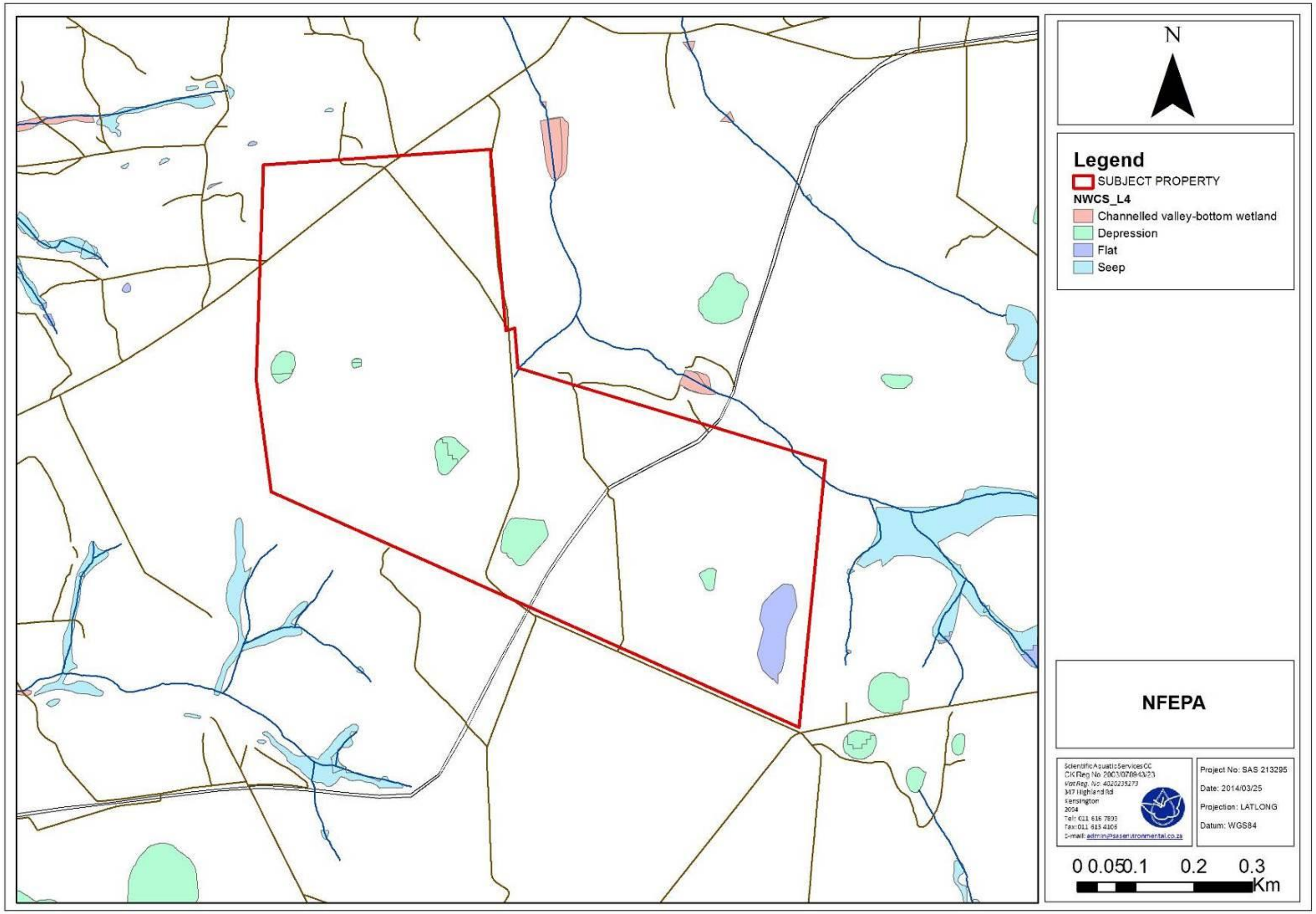

Figure 2: Locality map of the type of wetland features within the subject property.

Several wetland and pan features were identified within the subject property. The pan features were characterised as endorheic depression systems and the wetland features as a flat seepage according to the National Freshwater Ecosystem Priority Areas (NFEPA) water management database. Further to this the wetland features within the subject property was divided into two broad categories namely wetland features with permanent zones of saturation and wetland features with no permanent zones of saturation (Figure 3).

The table below identifies the two broad wetland feature types, based on the levels of inundation observed in the systems.

Table 11: The two broad wetland feature types identified within the subject property.

Wetland features with a permanent zone of saturation (Permanent wetland)	Wetland features with no permanent zone of saturation (Seasonal Wetland)
Pan 1	Pan 4
Pan 2	Pan 5
Pan 3	Wetland 1
Pan 6	Wetland 2
Selons River	Wetland 3
	Wetland 4
	Wetland 5
	Wetland 6
	Wetland 7

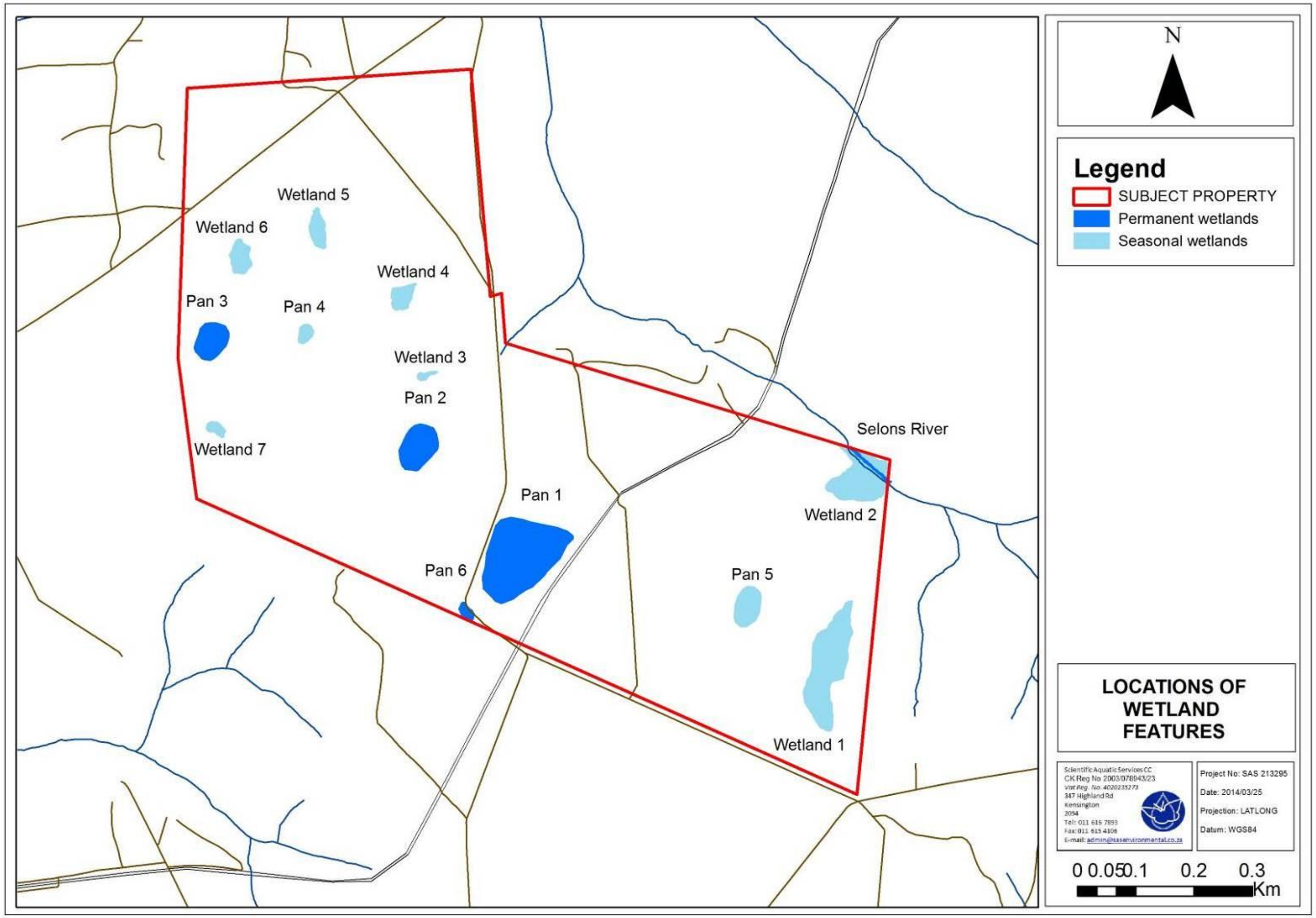

Figure 3: Location of the permanent and seasonal wetland features within the subject property.

Pan features 1 to 3 and 6 have mostly natural vegetation occurring, with very little alien encroachment except close to the main road and cultivated lands. These pan features could provide very good habitat for avifaunal species.

The Selons River was located on the northeastern corner of the subject property. This river system is classified as a NFEPA river, providing suitable habitat for avifaunal and aquatic species. Some transformation has occurred within the river system due to grazing of livestock and vegetation clearance resulting in erosion of the riverbanks.

Exotic and invader vegetation species occurred within the seasonal wetland features (Pan 4-5; Wetland 1-7). Although some alien encroachment occurred due to the adjacent plantation and agricultural activities, pockets of well-vegetated habitat still occur within these features and will allow flora and fauna species to occur.

Upon the assessment of the subject property, the various wetland vegetation components were assessed. Dominant species were characterised as either wetland or terrestrial species. The wetland species were then further categorised as temporary, seasonal and permanent zone species. This characterisation is presented in the tables below, including the terrestrial species identified on the subject property.

Table 12: Main floral species identified during the wetland delineation in the permanent wetland features (Pan 1-3, 6 and the Selons River) within the subject property.

Terrestrial species	Temporary species	Seasonal species	Permanent species
Acacia mearnsii	*Brachiaria serrata*	*Andropogon eucomus*	*Cyperus esculentis*
Eragrostis chloromelas	*Cyperus esculentis*	*Brachiaria serrata*	*Cyperus rotundus*
Eragrostis rigida	*Cyperus longus*	*Eragrostis heteromera*	*Imperata cylindrica*
Eragrostis gummiflua	*Cyperus marginatus*	*Eragrostis gummiflua*	*Kylinga alba*
Eucalyptus grandis	*Cyperus rupestris*	*Helichrysum pilosellum*	*Mariscus congesta*
Denekia capensis	*Eragrostis curvula*	*Homeria pallida*	*Miscanthus junceus*
Gazania krebsiana	*Eragrostis rigida*	*Hypoxis rigida*	*Phragmites australis*
Hyparrhenia hirta	*Kylinga alba*	*Monopsis decipiens*	*Typha capensis*
Ipoemoea purpurea	*Mariscus congesta*	*Kylinga alba*	*Verbena bonariensis*
Lopholaena coriifolia	*Senecio gregatus*	*Pelargonium luridum*	
Seriphium plumosum	*Taraxicum officinalis*	*Paspalum dilatatum*	
Taraxicum officinalis	*Verbena bonariensis*	*Senecio inaequidens*	
		Sporobulus pyramidalis	
		Wahlenbergia caledonica	

Table 13: Main floral species identified during the wetland delineation in the seasonal wetland features (Pan 4-5, Wetland 1-7) within the subject property.

Terrestrial species	Temporary species	Seasonal species
**Acacia mearnsii*	*Cyperus esculentis*	*Andropogon eucomus*
Eragrostis chloromelas	*Cyperus longus*	*Cyperus marginatus*
Eragrostis rigida	*Cyperus marginatus*	*Cyperus rupestris*
Eragrostis curvula	*Cyperus rupestris*	*Eragrostis heteromera*
Eragrostis gummiflua	*Eragrostis rigida*	*Helichrysum pilosellum*
**Eucalyptus grandis*	*Imperata cylindrica*	*Homeria pallida*
Denekia capensis	*Kylinga alba*	*Hypoxis rigida*
Gazania krebsiana	*Mariscus congesta*	*Monopsis decipiens*
Hyparrhenia hirta	*Senecio gregatus*	*Paspalum dilatatum*
**Ipomoea purpurea*	**Verbena bonariensis*	*Pelargonium luridum*
Lopholaena coriifolia		*Senecio inaequidens*
**Seriphium plumosum*		*Sporobulus pyramidalis*
Themeda triandra		*Wahlenbergia caledonica*

3.2 Wetland Function Assessment

The wetland function and service provision were assessed according to the method defined in section 2.4 of this report, taking into consideration the desktop and field assessment results. The average scores for the wetland feature are presented in the table below as well as the radar plot in the figure that follows. The findings of the assessment are then discussed highlighting wetland features of increased significance from an ecoservice point of view and emphasising ecoservices provided by the various wetlands that are of increased significance

Table 14: Wetland functions and service provision for the permanent wetland features.

Ecosystem service	Wetland features with a permanent zone of saturation				
	Pan 1	Pan 2	Pan 3	Pan 6	Selons River
Flood attenuation	0.8	0.9	0.8	0.7	1.2
Streamflow regulation	0	0	0	0	2.4
Sediment trapping	1	0.6	1.6	0.6	1
Phosphate assimilation	1.9	1.6	1.6	1.6	1.6
Nitrate assimilation	2.1	1.9	1.9	2	2.1
Toxicant assimilation	2	1.9	1.8	1.8	1.9
Erosion control	1.6	1.9	1.5	1.3	1.4
Carbon Storage	2.7	2.6	2.7	2.3	2
Biodiversity maintenance	2.1	1.3	1.5	1.7	1.6
Water Supply	1.5	1.2	1.3	1.3	1.5
Harvestable resources	1.2	0.6	0.6	0.8	0.6
Cultural value	0	0	0	0	0
Cultivated foods	1	0.6	0.6	0.8	0.6
Tourism and recreation	0.75	0.5	0.5	0.4	0.5
Education and research	1	0.8	0.5	0.8	0.8
SUM	**19.7**	**16.4**	**16.9**	**16.1**	**19.2**
Average score	**1.3**	**1.1**	**1.1**	**1.1**	**1.3**

Table 15: Wetland functions and service provision for the seasonal wetland features

Ecosystem service	Wetland features with no permanent zone of saturation		
	Pan 4-5	Wetland 2	Wetland 1,3-7
Flood attenuation	0.9	0.9	0.8
Streamflow regulation	0	1.8	0
Sediment trapping	0.75	0.5	0.5
Phosphate assimilation	1.7	1.6	1.3
Nitrate assimilation	2	2.2	1.4
Toxicant assimilation	1.8	1.8	1.3
Erosion control	1.6	1.4	1.1
Carbon Storage	1.7	1.7	1.3
Biodiversity maintenance	0.9	1.3	0.9
Water Supply	1.2	1.2	0.3
Harvestable resources	0.2	0.8	0
Cultural value	0	0	0
Cultivated foods	0.2	0.8	0
Tourism and recreation	0.1	0.1	0.1
Education and research	0.5	0	0.5
SUM	**13.6**	**16.1**	**9.5**
Average score	**0.9**	**1.1**	**0.6**

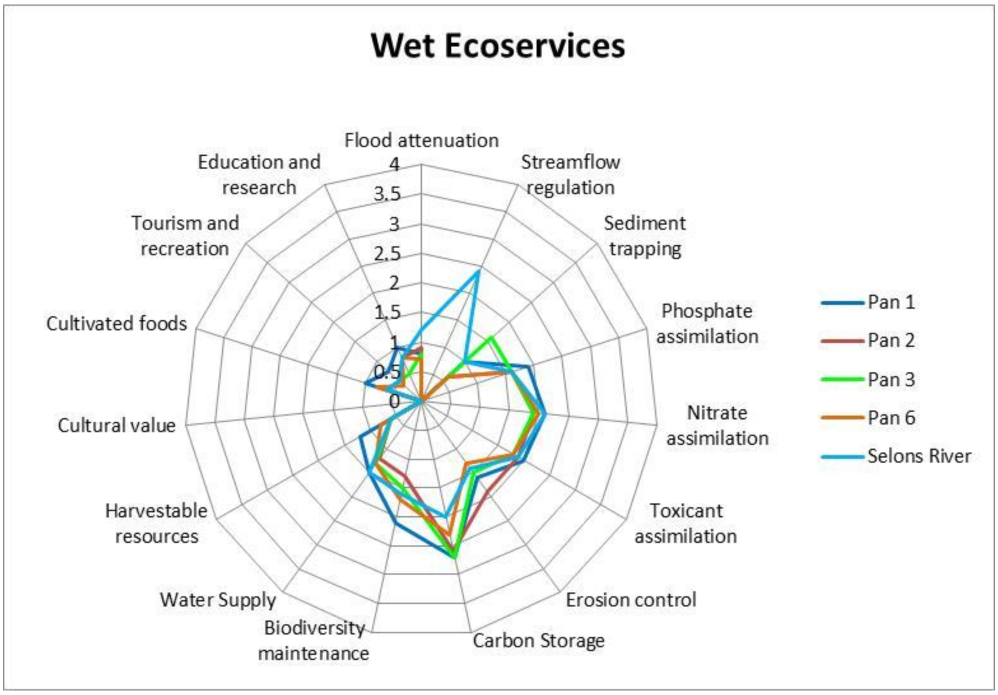

Figure 4: Radar plot of wetland services provided by the wetland features with a permanent zone.

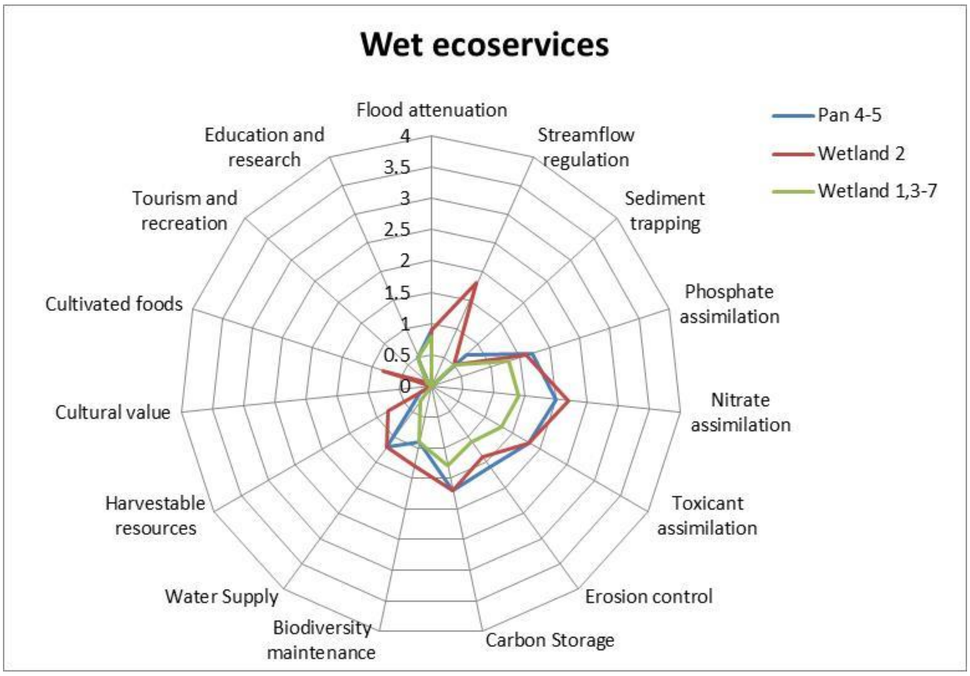

Figure 5: Radar plot of wetland services provided by the wetland features with no permanent zones.

Wetland features with permanent zone of saturation

From the results of the assessment of the permanent features, it is evident that Pan 1 and the Selons River have an intermediate level of ecological function and service provision and Pan 2, 3 and 6 has a moderately low level of ecological function and service provision.

The Pan features 1-3 and 6 are the most important in terms of carbon storage. These results obtained were mainly due to the fact that these pan features have higher peat content and little soil disturbances, thus increasing the wetlands contribution to trapping carbon. The Selons River was most important in terms of streamflow regulation and nutrient assimilation.

Thus from the overall scores obtained from the wetland ecoservices calculation it was found that Pan feature 1 and the Selons River was the most important in terms of services and function, therefore obtaining a higher service value than the Pans 2, 3 and 6.

Wetland features with no permanent zone of saturation

From the results of the assessment, it is evident that all of the seasonal wetland features on the subject property have a moderately low level of ecological function and service provision. These wetland features and pans are the most important in terms of nitrate assimilation. The results obtained were mainly due to the fact that all of the wetland features with no permanent zone of saturation display diffuse flow characteristics causing a seepage area to occur. Agricultural practises surround some parts of these wetlands, causing water and possibly some fertilisers to wash off into the wetland sections. This increases the nutrient levels within the wetlands, thus lowering the water quality.

3.3 Wet-Health

Wetlands protect and regulate water resources, performing vital functions such as flood attenuation, recharging of ground water, nutrient assimilation, filtering of pollutants and prevention of soil erosion. Wetland ecosystems comprise the abiotic characteristics of an area, including climate, geology and soil, water, nutrient supply and radiant energy, together with a biotic community suited to the prevailing environmental conditions and natural disturbance regimes.

A system in which natural inputs of resources or toxins has not been modified by recent human intervention, and which experiences levels of disturbance that are regarded as natural, is considered to be in a 'natural reference condition'. Here, it is worth recognising that humans have long influenced disturbance regimes in Southern Africa through practices such as veld burning. These low-impact disturbances should be regarded as part of the natural disturbance regime. Given this context, wetland health is defined as a measure of the similarity of a wetland to a natural or reference condition. In thinking about wetland health, it is appropriate to consider 'deviation' from the natural or reference condition. For the purposes of the WET-Health assessment, the state of a wetland is a measure of the extent to which human impacts have caused the wetland to differ from the natural reference condition (Macfarlane *et. al.* 2008).

A Level 1 WET-Health assessment was applied to the features within the subject property. The table below summarises the scores received for the three modules assessed; namely hydrology, geomorphology and vegetation.

Table 16: Summarised results of the WET-Health results for the wetland features.

Wetland feature	Hydrology		Geomorphology		Vegetation		Overall score
	Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score	
Pan 1	C	↓↓	A	↓↓	C	↓	**C**
Pan 2	D	→	A	→	D	↓	**C**
Pan 3	C	→	A	→	C	↓↓	**B**
Pan 6	C	→	A	↓	D	↓↓	**C**
Selons River and Wetland 2	B	→	A	→	C	↓	**B**
Pan 4	C	→	B	↓	E	↓	**C**
Pan 5	D	→	B	↓	E	↓↓	**D**
Wetland 1, 3-7	D	→	B	↓	E	↓↓	**D**

The present hydrological state of the wetland features calculated a score falling between Category B (A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place) and Category D (A large change in ecosystem processes and loss of natural habitat and biota and has occurred). The present geomorphological state of the features calculated a score falling between a Category A (A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place) and a Category B (A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place). The current vegetation status within the wetland features was calculated with a score falling between Category C (A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact) and Category E (Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota).

The above results indicate that moderate to high levels of modifications of hydrology, geomorphology and vegetation have occurred. Modifying factors include historic and current agricultural activities such as vegetation clearing for crop cultivation, plantation and grazing activities contributing to increased erosion and sediment input. Considering the current rate of transformation of the landscape and proximity and expansion of plantation and agricultural activities in the vicinity, deviation from a Category B-D is expected in all of the systems, unless mitagatory measures are implemented to prevent further deterioration.

The overall score for the wetland systems that aggregates the scores for the three modules, namely hydrology, geomorphology and vegetation, was calculated using the formula[5] as provided by the Wet-Health methodology. The overall score calculated for each wetland feature was determined (Table 16). Due to the forestry and agricultural activities, deterioration from this categories are expected. It can be concluded from the WET-Health assessment that Pan feature 1, 3; the Selons River and Wetland feature 2 have a higher function in terms of the three modules as mentioned above.

3.3.1 Wetland EIS Assessment

The results of the wetland function assessment and WET-Health assessment were used to obtain the EIS assessment, for which the results are presented in the tables below.

Wetland features with a permanent zone of saturation

The scores of 2.0 to 2.89 calculated during the assessment indicate that the permanent wetland features falls into the “high” EIS category (category ‘B’). It should be noted that the high EIS score was obtained primarily as a result of habitat diversity and ecological function and status of the wetland features.

Wetland features with no permanent zones of saturation

The scores of 1.33 to 1.56 calculated during the assessment indicate that the seasonal wetland features falls into the “moderate” EIS category (category ‘C’). It should be noted that the lower EIS score was obtained primarily as a result of historical agricultural practices such as crop cultivation and grazing may have contributed to the present condition of these pans through water attenuation, increased siltation and clearing of natural vegetation.

[5] [(Hydrology score) x 3 + (geomorphology score) x2 + (vegetation score) x 2)]/ 7 = PES

Table 17: Wetland EIS Score for the wetland features with permanent zones located within the subject property.

Determinant	Permanent Wetland feature									
	Pan 1		Pan 2		Pan 3		Pan 6		Selons River	
	Score	Confidence	Score	Confidence	Score	Confidence	Score	Confidence	Score	Confidence
PRIMARY DETERMINANTS										
1. Rare & Endangered Species	2	4	2	4	2	4	1	4	2	3
2. Populations of Unique Species	1	4	1	4	1	4	1	4	2	3
3. Species/taxon Richness	2	4	1	4	1	4	1	3	2	4
4. Diversity of Habitat Types or Features	2	3	1	4	2	3	1	3	2	3
5. Migration route/breeding and feeding site for wetland faunal and avifaunal species	3	3	2	3	2	3	1	3	2	3
6. PES as determined by WET Health assessment	3	4	3	4	4	4	3	4	4	4
7. Importance in terms of function and service provision	3	4	2	4	2	4	2	3	3	4
MODIFYING DETERMINANTS										
8. Protected Status according to NFEPA WetVeg	4	4	4	4	4	4	4	4	4	4
9. Ecological Integrity	3	3	2	3	2	3	4	3	3	3
TOTAL	**26**		**18**		**20**		**18**		**24**	
MEAN	**2.89**		**2.0**		**2.22**		**2.0**		**2.67**	
OVERALL EIS	**B**		**B**		**B**		**B**		**B**	

Table 18: Wetland EIS Score for the wetland features with only temporary and seasonal zones located within the subject property.

Determinant	Permanent Wetland feature							
	Pan 4		Pan 5		Wetland 2		Wetland 1, 3-7	
	Score	Confidence	Score	Confidence	Score	Confidence	Score	Confidence
PRIMARY DETERMINANTS								
1. Rare & Endangered Species	0	3	0	3	0	3	0	4
2. Populations of Unique Species	1	4	1	3	1	3	0	4
3. Species/taxon Richness	1	4	1	3	1	2	1	4
4. Diversity of Habitat Types or Features	1	4	1	3	1	3	1	3
5. Migration route/breeding and feeding site for wetland faunal and avifaunal species	1	3	0	4	1	3	1	3
6. PES as determined by WET Health assessment	3	4	3	4	4	4	3	4
7. Importance in terms of function and service provision	1	3	1	3	1	3	1	4
MODIFYING DETERMINANTS								
8. Protected Status according to NFEPA WetVeg	4	4	4	4	4	4	4	4
9. Ecological Integrity	1	3	1	3	1	4	1	4
TOTAL	**13**		**12**		**14**		**12**	
MEAN	**1.44**		**1.33**		**1.56**		**1.33**	
OVERALL EIS	**C**		**C**		**C**		**C**	

3.3.2 Recommended Ecological Category (REC)

The results of the wetland function assessment and WET-Health assessment, together with the results of the EIS assessment, were used to form the REC. It is thus recommended that the REC for the wetland and pan features not to be mined is improved where possible and no further degradation occurs as a result of the mining activities. Strict mitigation measures needs to be implemented to ensure that the wetland function is restored. This could ensure that the impact on the wetland features and pans that may result in a decrease of the PES can be mitigated as far as possible.

3.4 Wetland Delineation and Sensitivity mapping

During the assessment, the following temporary zone indicators were used:

- Terrain units were used to determine in which parts of the landscape the wetland feature is most likely to occur.
- The soil form indicator was used to determine the presence of soils that are associated with prolonged and frequent saturation, as well as variation in the depth of the saturated soil zone within 50cm of the soil surface. This indicator was used to identify gleyed soils where the soil is a greyish/greenish/bluish colour due to the leaching out of iron. Whilst mottling was not extensive, it was present in the temporary zone. These factors were utilised to aid in determining the location of the wetland zones and their boundaries.
- The vegetation indicator was used in the identification of the wetland boundary through the identification of the distribution of both facultative and obligate wetland vegetation associated with soils that are frequently saturated. Changes in vegetation density and levels of greening were also considered during the delineation process.
- Surface water was absent during the field assessment, but saturated soils were noted within some of the wetland areas.

Despite the fact that the wetland feature shows severe transformation due to alien encroachment and soil alterations, these features could provide habitat for avifaunal and wetland floral species. The following guidelines for buffers around the wetlands are suggested by the Department of Water Affairs (2000):

No person in control of a mine or activity may:

(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding

boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become water-logged, undermined, unstable or cracked;

The 1:100 year flood-line restriction is the internationally accepted norm for the placement of anything that may be in danger of failing or have a potential safety hazard. This norm is also reflected in section 144 of the National Water Act in respect of the locality of townships. Although certain of the regulations refer to the 1:50 year flood-line requirement (see sub regulations 4(b) below), the aspects referred to in this sub regulation is considered to potentially have a big impact on the water resources, therefore the more conservative minimum requirement is set.

This sub regulation should be interpreted similarly to sub regulation 4(b) below, which stipulates *whichever is the greatest*. This implies that the mine or activity should comply with both requirements stipulated in this sub regulation, namely the 1:100 year flood-line and the horizontal distance of 100m.

The 1:100 year flood-line should be determined by a suitably qualified person, e.g. hydrologist, civil engineer, agricultural engineer, etc., who can professionally be held liable for his/her calculations in the case of a disaster (loss of human life, extreme water pollution, etc.).

(b) except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, whichever is the greatest.

The figure below illustrates the sensitivity of the subject property. High and medium sensitivity areas included pan feature 1 and 3 and 6 and the Selons River with associated 100m buffers. Low sensitivity was allocated to the seasonal wetland sections. The remainder of the site is considered very low due to the complete vegetation transformation of agricultural and plantation activities. The mining activities and structures must also ensure no de-watering of the sensitive wetland areas occur during the mining process as a result of open pit mining methods.

It can be concluded that the mining footprint and activities will have a significant effect on the permanent wetland features (Pan 1-3, 6 and the Selons River) specifically referring to the highly sensitive features should mitigation measures not be implemented. Thus planning of the mining footprint should consider higher sensitivity areas as “no-go” areas. Based on the observations of the study, mining infrastructure should, as far as possible, be limited to the previously disturbed areas, such as the crop fields and plantation areas. Should mining activity occur within any of the wetland features, relevant authorisation should be deemed according to the National Environmental Management Act (NEMA) 107 of 1998 and Sections 21 c and i of the National Water Act 36 of 1998.

Clean and dirty water systems need to be clearly separated in line with the requirements of Regulation GN704 of the National Water Act (Act 36 of 1998) in order to minimise the impact on the wetland resources on the subject property and on adjacent farms. Specific attention must be paid to preventing decant during both the operational phase of the mine and beyond closure. Specific attention must be given to preventing runoff from dirty water areas or discharge of effluent from reaching the pan features to be retained as well as the Selons River.

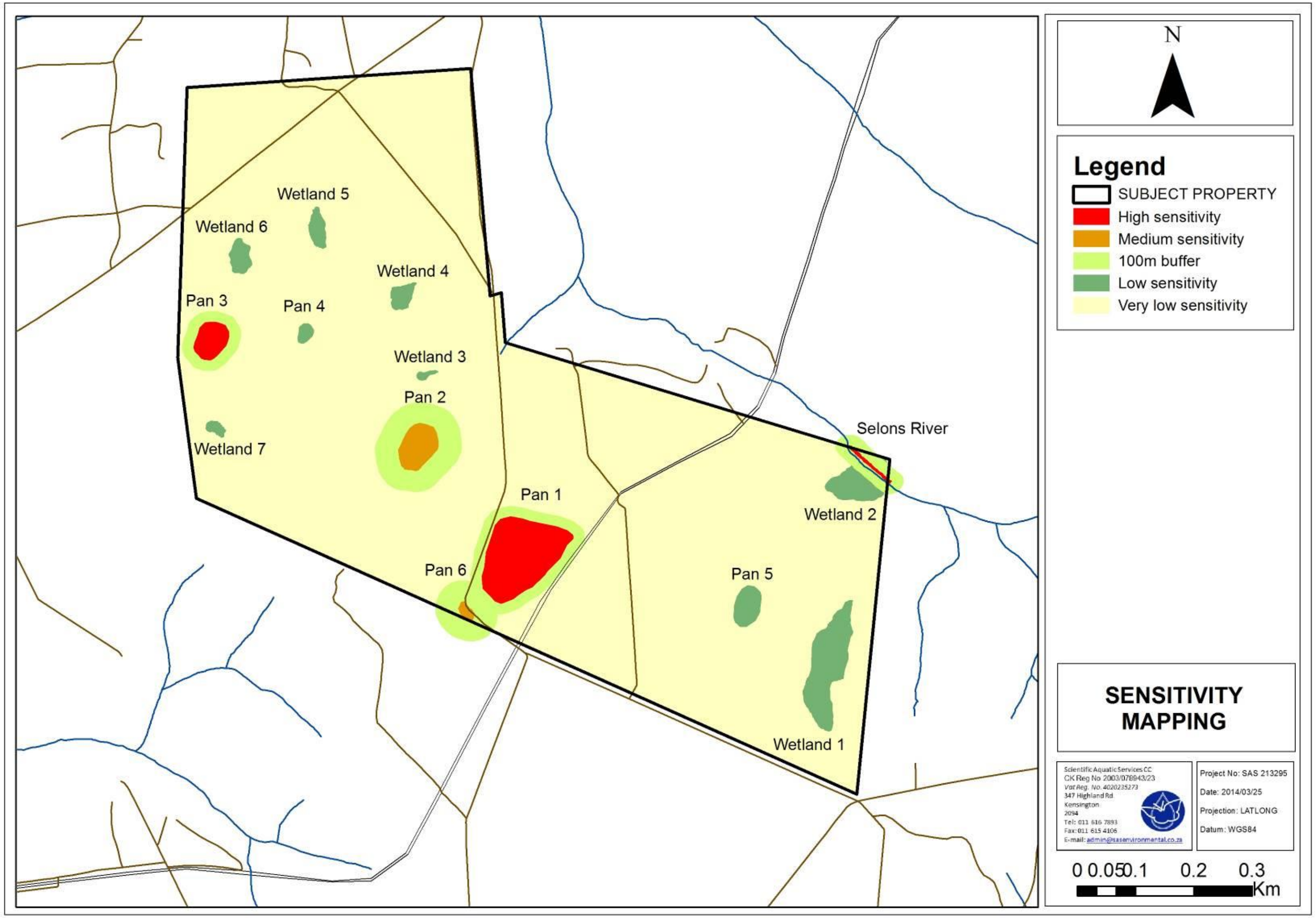

Figure 6: Sensitivity mapping with the associated wetland buffer zone.

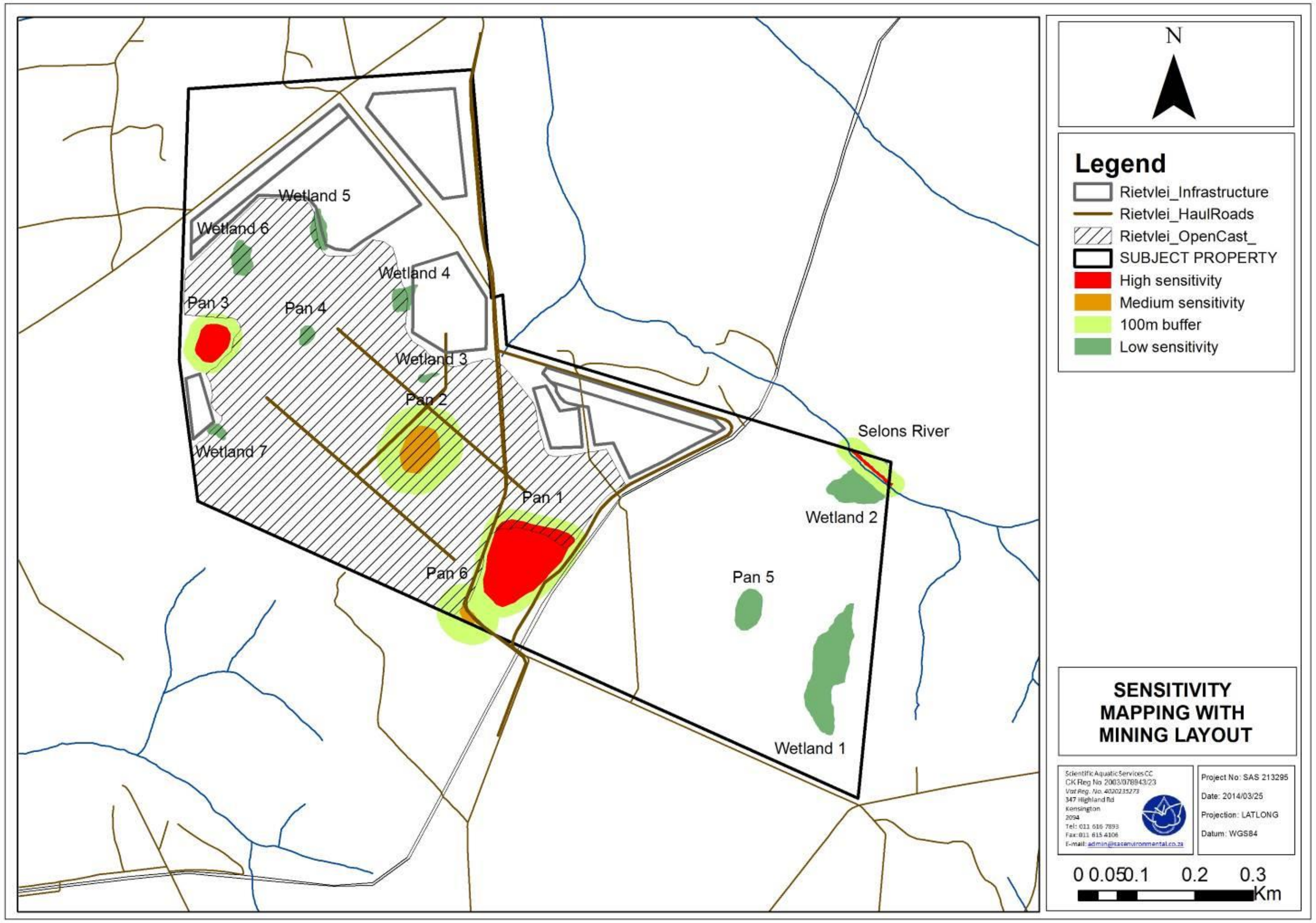

Figure 7: Sensitivity Map with the proposed mining layout for the subject property.

4 IMPACT ASSESSMENT

The tables below serve to summarise the significance of potential impacts on the wetland communities occurring on or directly adjacent to the subject property. A summary of all potential pre-construction, construction, operational and decommissioning and closure phase impacts is provided. The sections below present the impact assessment according to the method described in Section A. In addition, it also indicates the required mitigatory and management measures needed to minimise potential ecological impacts and presents an assessment of the significance of the impacts taking into consideration the available mitigatory measures, assuming that they are fully implemented.

4.1 Impact Discussion

All proposed development activities that may result in an impact on the wetland communities of the subject property are discussed below.

4.1.1 IMPACT 1: Loss of wetland habitat and ecological structure

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Planning of infrastructure within sensitive wetland areas	Site clearing and the removal of vegetation	Ongoing disturbance of soils with general operational activities	Disturbance of soils as part of demolition activities
Inadequate design of infrastructure leading to risks of pollution	Site clearing and the disturbance of soils	Spillages and seepage of hazardous waste material into the groundwater	Ongoing seepage and runoff from mining infrastructure to the groundwater regime
Inadequate design of infrastructure leading to changes to system hydrology	Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns	Risk of discharge from the mining infrastructure	Ongoing risk of discharge from mining infrastructure beyond closure
	Topsoil stockpiling adjacent to wetlands and runoff from stockpiles	Potential contamination from mining infrastructure, general dirty water areas as well as spillages of hydrocarbons, has the potential to contaminate the groundwater environment which in turn can affect water quality in surface water sources in the area	Potential contamination from the decommissioning of mining infrastructure

	Waste material spills and waste refuse deposits into the wetland features	Runoff, seepage and potential discharge from mining infrastructure such as pipelines	Vehicles may impact upon sensitive riparian and wetland areas resulting in a loss of habitat
	Movement of construction vehicles within wetlands	Dumping of hazardous and non-hazardous waste into the wetland areas	Decommissioning activities may lead to wetland habitat transformation and alien plant species proliferation
	Dumping of hazardous and non-hazardous waste into the wetland areas may result in a loss of wetland habitat and ecological structure	Erosion and sedimentation of wetlands	Ineffective rehabilitation may lead to habitat transformation and alien vegetation encroachment
		Inadequate separation of clean and dirty water areas	Ongoing erosion and sedimentation of wetlands
		Loss of instream flow due to abstraction for water for production and the formation of a cone of dewatering from open pits	
		Topsoil stockpiling adjacent to wetlands and runoff from stockpiles may contaminate wetland features	

Aspects of wetland ecology affected

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Direct impact on wetland habitat due to erosion, sedimentation and increased runoff	Direct impact on wetland habitat due to erosion, sedimentation and increased runoff	Direct impact on wetland habitat during decommissioning
	Loss of wetland biodiversity due to vegetation clearance	Loss of wetland biodiversity due to alien floral encroachment	Loss of wetland biodiversity due to alien floral encroachment and mismanagement of wetland rehabilitation
	Contamination of wetland soils and surface water impacting foraging and breeding habitat for wetland/riverine species	Contamination of wetland soils	Ongoing contamination of wetland soils
	Contamination of water within wetlands	Contamination of water within wetlands	Ongoing contamination of water within wetlands
	Compaction and loss of wetland soils	Compaction and loss of wetland soils	Compaction and loss of wetland soils during decommissioning

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Sedimentation and incision leading to altered habitats	Sedimentation and incision leading to altered habitats	Sedimentation and incision leading to altered habitats
	Changes to the wetland community due to alien invasion vegetation leading to altered habitat conditions	Changes to the wetland community due to alien invasion vegetation leading to altered habitat conditions	Changes to the wetland community due to alien invasion vegetation leading to altered habitat conditions
		Dewatering of wetlands and loss of habitat	Continued dewatering of wetlands and loss of habitat

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	4	3	3	3	5	7	11	77 (Medium-High)

Essential mitigation measures:

- A sensitivity map has been developed for the subject property, indicating the various wetland features, which are considered to be of increased ecological importance. It is recommended that this sensitivity map be considered during the planning/ pre-construction and construction phases of the proposed development activities to aid in the conservation of ecology within the subject property.
- It must be ensured that planning of mining infrastructure includes consideration of adjacent wetland / pan areas to ensure that these areas are avoided as far as possible.
- Development / mining impacts on the affected wetland features should be managed to minimise impacts on adjacent wetland features.
- Edge effects of activities including erosion and alien / weed control need to be strictly managed in these areas.
- Access into adjacent wetland / pan areas, particularly by vehicles, is to be strictly controlled.
- All vehicles should remain on designated roads with no indiscriminate driving through adjacent wetland / pan areas.
- Ensure that all stockpiles are well managed and have measures such as berms and hessian curtains implemented to prevent erosion and sedimentation.
- Run-off from dirty water areas entering wetland habitats must be prevented and clear separation of clean and dirty water in the vicinity of the proposed infrastructure must take place. Oil must be prevented from entering the clean water system.
- Pollution control dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge.

- Ensure that seepage from dirty water systems is prevented as far as possible.
- It must be ensured that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage. All vehicles must be regularly inspected for leaks. Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into topsoil.
- All spills should be immediately cleaned up and treated accordingly.
- Appropriate sanitary facilities must be provided for the life of the mine and all waste removed to an appropriate waste facility.
- Effective waste management must be implemented in order to prevent construction related waste from entering the wetland environment.
- All adjacent wetland systems must be monitored for erosion and incision.
- Erosion berms may be installed in any areas where soil disturbances within the vicinity of the wetland features have occurred to prevent gully formation and siltation of the aquatic resources. The following points should serve to guide the placement of erosion berms:
  - Where the track has slope of less than 2%, berms every 50m should be installed.
  - Where the track slopes between 2% and 10%, berms every 25m should be installed.
  - Where the track slopes between 10% and 15%, berms every 20m should be installed.
  - Where the track has slope greater than 15%, berms every 10m should be installed

Recommended mitigation measures

- Restrict construction to the drier winter months if possible to avoid sedimentation of wetland features in the vicinity of the proposed mine development areas.
- Desilt all adjacent wetland areas affected by mining and runoff from dirty water areas.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	3	3	3	4	4	6	11	66 (Medium-Low)

Probable latent impacts:

- Sedimentation of the systems may lead to altered wetland habitats.
- Wetland and riparian habitat within the study area may be permanently altered or lost if mining activities are undertaken within the features and inadequate rehabilitation takes place.
- Erosion and incision of the adjacent wetland areas may occur

4.1.2 IMPACT 2: Changes to wetland ecological and sociocultural service provision

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Poor planning leading to the placement of infrastructure within wetland areas	Site clearing and the removal of vegetation	Operational activities within wetland and riparian features presently considered important in terms of biodiversity, tourism and recreation	Closure related activities within wetland and riparian features presently considered important in terms of biodiversity, tourism and recreation
Inadequate design of infrastructure leading to changes to instream habitat that would reduce assimilation capability	Site clearing and the removal of vegetation leading to loss in ecological and sociocultural services dependent on abundance of vegetation present and surface roughness	Ongoing disturbance leading to loss in ecological and sociocultural services dependent on abundance of vegetation present and surface roughness	Site clearing and the removal of vegetation leading to loss in ecological and sociocultural services dependent on abundance of vegetation present and surface roughness
Poor planning leading to the placement of infrastructure within wetland and riparian features leading to loss in ecological and sociocultural services dependent on abundance of vegetation present and surface roughness	Construction of infrastructure leading to changes to instream habitat that would reduce assimilation capability	Loss of water volumes for abstraction by farmers due to abstraction for water for production and the loss of base flow in the riverine resources in the area	Seepage from any latent discard dumps and dirty water areas leading to a loss in ecological and sociocultural services
	Construction related activities resulting in changes to riparian and instream characteristics that are important in terms of flood attenuation, streamflow regulation and sediment trapping	Operation related activities resulting in changes to riparian and instream characteristics that are important in terms of flood attenuation, streamflow regulation and sediment trapping	Decommissioning and closure related activities resulting in changes to riparian and instream characteristics that are important in terms of flood attenuation, streamflow regulation and sediment trapping

Aspects of floral ecology affected

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Loss of phosphate, nitrate and toxicant removal abilities	Loss of phosphate, nitrate and toxicant removal abilities	Loss of phosphate, nitrate and toxicant removal abilities
	Loss of carbon storage capabilities	Loss of carbon storage capabilities	Loss of carbon storage capabilities

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Inability to support biodiversity	Inability to support biodiversity	Inability to support biodiversity
	Loss of water supply to the local community	Loss of water supply to the local community	Loss of water supply to the local community

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	4	3	4	3	5	7	12	84 (Medium-High)

Essential mitigation measures:

- A sensitivity map has been developed for the subject property, indicating the various wetland features, which are considered to be of increased ecological importance. It is recommended that this sensitivity map be considered during the planning/ pre-construction and construction phases of the proposed development activities to aid in the conservation of ecology within the subject property.
- It must be ensured that planning of mining infrastructure includes consideration of adjacent wetland areas to ensure that these areas are avoided as far as possible.
- All demarcated sensitive zones outside of the construction area must be kept off limits during any development and closure phases of the mine.
- The development footprint area must be limited to what is absolutely essential in order to minimise environmental damage.
- Run-off from dirty water areas entering adjacent wetland habitats must be prevented and clear separation of clean and dirty water in the vicinity of the proposed shaft must take place. Oil must be prevented from entering the clean water system.
- It must be ensured that seepage from dirty water systems is prevented as far as possible.
- It must be ensured that the mine process water system is managed in such a way as to prevent discharge to the receiving environment.
- Edge effects of activities including erosion and alien / weed control need to be strictly managed in wetland areas.
- As much vegetation growth as possible should be promoted within the proposed mine development area in order to protect soils. In this regard, special mention is made of the need to use indigenous vegetation species where hydroseeding, wetland and rehabilitation planting (where applicable) are to be implemented.
- Implement effective waste management in order to prevent construction related waste from entering the wetland environment.
- All wetland areas must be rehabilitated upon decommissioning to ensure that wetland functions are

re-instated during decommissioning and all disturbed wetland areas adjacent to the mining development must be re-vegetated with indigenous wetland species

Recommended mitigation measures

- Desilt all wetland areas affected by mining and runoff from dirty water areas.
- Restrict activities to winter months in order to limit impact on wetland species utilising wetlands as foraging and breeding habitat
- Re-vegetate all disturbed areas with indigenous wetland species.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	3	3	3	3	3	6	9	54 (Medium-Low)

Probable latent impacts

- Ability for features to provide ecological and sociocultural services may be permanently lost or reduced if mining activities are undertaken within 100 meter of the features and inadequate rehabilitation takes place.

4.1.3 IMPACT 3: Impact on wetland hydrological function

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Placement of infrastructure within wetland areas	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils with general operational activities	Disturbance of soils as part of demolition activities
Inadequate design of infrastructure leading to changes in hydrological function and sediment control capacity	Site clearing and the disturbance of soils leading to increased erosion	Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns	Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns
	Earthworks in the vicinity of wetland areas leading to increased runoff and erosion and altered runoff patterns	Topsoil stockpiling adjacent to wetlands and runoff form stockpiles leading to sedimentation of the system	Movement of construction vehicles within wetlands
	Construction of stream crossings altering stream and base flow patterns and water velocities	Movement of construction vehicles within wetlands	Altered hydrology due to in channel stormwater dams

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Topsoil stockpiling adjacent to wetlands and runoff form stockpiles leading to sedimentation of the system	Altered hydrology due to stormwater channels and dams	Movement of construction vehicles within wetlands
	Movement of construction vehicles within wetlands	Increased runoff volumes due to increased paved and other impervious surfaces	
	Increased runoff volumes due to increased paved and other impervious surfaces	Dewatering of wetlands and loss of habitat	

Aspects of floral ecology affected

Pre-Construction	Construction	Operational	Decommissioning & Closure
	Change in flood peak flows	Change in flood peak flows	Incision of wetland areas and erosion of wetland habitat
	Concentration and canalisation of flow	Concentration and canalisation of flow	Sediment deposition
	Incision of wetland areas and erosion of wetland habitat	Incision of wetland areas and erosion of wetland habitat	
	Sediment deposition	Sediment deposition	

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	3	2	3	3	5	5	11	55 (Medium Low)

Essential mitigation measures:

- A sensitivity map has been developed for the subject property, indicating the various wetland features, which are considered to be of increased ecological importance. It is recommended that this sensitivity map be considered during the planning/ pre-construction and construction phases of the proposed development activities to aid in the conservation of ecology within the subject property.
- It must be ensured that planning of mining infrastructure includes consideration of adjacent wetland areas to ensure that these areas are avoided as far as possible.
- Keep all demarcated sensitive zones outside of the construction area off limits during development phases.
- Prevent run-off from dirty water areas entering wetland habitats.

- Ensure that seepage from dirty water systems is prevented as far as possible.
- Ensure that the mine process water system is managed in such a way as to prevent discharge to the receiving environment.
- Implement effective waste management in order to prevent construction related waste from entering the wetland environment.
- All wetland areas must be rehabilitated upon decommissioning to ensure that wetland functions are re-instated during decommissioning and all disturbed wetland areas adjacent to the mining development must be re-vegetated with indigenous wetland species.
- It must be ensured that all activities potentially impacting on geohydrological resources are managed according to the relevant DWA Licensing regulations and groundwater monitoring requirements.
- Post closure groundwater management will need to be very carefully managed to ensure that no impact on the wetland areas takes place after mine closure has taken place.
- Future mine planning should ensure that mining activities does not lead to a reduction of stream flow or dewatering of any wetland areas.

Recommended mitigation measures

- Desilt all adjacent wetland areas affected by mining and runoff from dirty water areas.
- Re-vegetate all disturbed areas with indigenous wetland species upon closure

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
	2	2	2	2	4	4	8	32 (Low)

Probable latent impacts

- Impacts on water quality may affect service provision of wetland features to both the local community and the environment beyond closure.
- Sedimentation of the systems may lead to altered wetland habitats.
- Erosion and incision of the wetland areas may occur

4.2 Impact Assessment Conclusion

Based on the above assessment it is evident that there are three possible impacts on the wetland ecology within the subject property. The table below summarises the findings indicating the significance of the impact before management takes place and the likely impact if management and mitigation takes place. In the consideration of mitigation it is assumed that a high level of mitigation takes place but which does not lead to prohibitive costs.

From the table it is evident that prior to management measures being put in place, all of the impacts are medium-high to medium-low level impacts. If effective management takes place, all impacts could be reduced to a lower level impact with impacts on the loss of wetland habitat and loss of wetland ecoservices being moderately low and impacts on impacted hydrology of the systems being regarded as a low level impact.

Table 19: A summary of the results obtained from the assessment of the wetland ecological impacts.

Impact	Unmanaged	Managed
1: Loss of wetland habitat and ecological structure	Medium-High	Medium-Low
2: Change to wetland ecological and sociocultural service provision	Medium-High	Medium-Low
3: Impact on wetland hydrological function	Medium-Low	Low

4.3 Cumulative impacts

Due to extensive mining and beneficiation in the Middelburg and surrounding areas, along with extensive agriculture, the regional cumulative impacts as a result of loss of wetlands is considered to be highly significant. It is also critically important to consider the general impact from mining activities in the greater Olifants catchment, which includes coal mining as well as platinum group metals and the severe impact from the urban areas of Mpumalanga. In particular, specific mention is made of the impact of urban runoff and the release of treated and raw sewage effluent into the riverine systems in the area. Seepage from mining facilities such as waste dumps, TSF and general dirty water areas, agricultural activities, as well as spillages of hydrocarbons, has the potential to contaminate the groundwater environment which in turn can affect water quality in surface water sources in the area.

Within the Olifants catchment there has been significant impact on wetlands due to erosion, incision, and sedimentation into the wetlands. These impacts have led to the loss of wetlands and the loss of the wetland's ability to function naturally.

Cumulative impacts associated with the mine include:

- The loss of wetland habitat, functioning and ecoservice provision as a result of mining activities within the Middelburg region, which may in turn impact on water resources and vegetation structure.
- Loss of wetland connectivity and dewatering of wetlands due to mining activities will have a detrimental impact on faunal species utilising riparian zones as migratory corridors and the overall biodiversity in the area.

The impact on the wetland resources in the vicinity of the Middelburg operations could lead to an overall reduction of the assimilative capacity of wetlands in the Olifants catchment and lead to a general loss of ecological and socio-cultural services within this important water resource.

5 RECOMMENDATIONS

After conclusion of this ecological assessment, it is the opinion of the ecologists that the proposed activity be considered favourably provided that the following essential mitigation measures as listed below are adhered to:

Mining footprint

- A sensitivity map has been developed for the subject property, indicating the various wetland features, which are considered to be of increased ecological importance. It is recommended that this sensitivity map be considered during the planning/ pre-construction and construction phases of the proposed development activities to aid in the conservation of ecology within the subject property.
- All demarcated sensitive zones outside of the construction area must be kept off limits during any development and closure phases of the mine.
- It must be ensured that planning of mining infrastructure includes consideration of adjacent wetland areas to ensure that these areas are avoided as far as possible.
- Edge effects of activities including erosion and alien / weed control need to be strictly managed in these areas.
- Ensure that seepage from dirty water systems is prevented as far as possible.
- It must be ensured that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage. All vehicles must be regularly inspected for leaks. Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into topsoil.
- All spills should be immediately cleaned up and treated accordingly.
- Appropriate sanitary facilities must be provided for the life of the mine and all waste removed to an appropriate waste facility.
- Effective waste management must be implemented in order to prevent construction related waste from entering the wetland environment.
- Restrict construction to the drier winter months if possible to avoid sedimentation of wetland features in the vicinity of the proposed mine development areas.

Wetland features

- Development / mining impacts on the affected wetland features should be managed to minimise impacts on adjacent wetland features.

- Run-off from dirty water areas entering wetland habitats must be prevented and clear separation of clean and dirty water in the vicinity of the proposed infrastructure must take place. Oil must be prevented from entering the clean water system.
- Pollution control dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge.
- All adjacent wetland systems must be monitored for erosion and incision.
- Desilt all adjacent wetland areas affected by mining and runoff from dirty water areas
- It must be ensured that all activities potentially impacting on geohydrological resources are managed according to the relevant DWA Licensing regulations and groundwater monitoring requirements.
- Post closure groundwater management will need to be very carefully managed to ensure that no impact on the wetland areas takes place after mine closure has taken place.
- Future mine planning should ensure that mining activities does not lead to a reduction of stream flow or dewatering of any wetland areas.

Vehicle access

- Access into adjacent wetland / pan areas, particularly by vehicles, is to be strictly controlled.
- All vehicles should remain on designated roads with no indiscriminate driving through adjacent wetland / pan areas.

Soils

- Ensure that all stockpiles are well managed and have measures such as berms and hessian curtains implemented to prevent erosion and sedimentation.
- Erosion berms may be installed in any areas where soil disturbances within the vicinity of the wetland features have occurred to prevent gully formation and siltation of the aquatic resources. The following points should serve to guide the placement of erosion berms:
    - Where the track has slope of less than 2%, berms every 50m should be installed.

- Where the track slopes between 2% and 10%, berms every 25m should be installed.
- Where the track slopes between 10% and 15%, berms every 20m should be installed.
- Where the track has slope greater than 15%, berms every 10m should be installed

Rehabilitation

- As much vegetation growth as possible should be promoted within the proposed mine development area in order to protect soils. In this regard, special mention is made of the need to use indigenous vegetation species where hydroseeding, wetland and rehabilitation planting (where applicable) are to be implemented.
- All wetland areas must be rehabilitated upon decommissioning to ensure that wetland functions are re-instated during decommissioning and all disturbed wetland areas adjacent to the mining development must be re-vegetated with indigenous wetland species.

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FAUNAL, FLORAL, WETLAND AND AQUATIC ASSESSMENT AS PART OF THE ENVIRONMENTAL ASSESSMENT AND AUTHORISATION PROCESS FOR THE PROPOSED RIETVLEI COLLIERY, MIDDELBURG

Prepared for

WSP

April 2014

SECTION E - Aquatic Ecological Assessment

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1 PROJECT OBJECTIVES AND SCOPE

Scientific Aquatic Services (SAS) was appointed to conduct a floral, faunal, wetland and aquatic ecological assessment as part of the Environmental Assessment (EIA) and authorisation process for the proposed Rietvlei Colliery (Figure 1 and 2), hereafter referred to as the "subject property". The subject property is situated south-east of the R555, outside Middelburg, Mpumalanga Province (25°40'18.59"S and 29°39'16.47"E). The total area of the proposed opencast footprint subject property extends over approximately 747,16ha. It includes a survey of general aquatic habitat integrity, habitat conditions for aquatic macro-invertebrates, aquatic macro-invertebrate community integrity and fish community integrity. This document presents the results obtained during the ecological survey of aquatic ecosystems during October 2011 and January 2014.

The purpose of this report is to define areas of increased aquatic Ecological Importance and Sensitivity (EIS) and the Present Ecological State (PES) of the aquatic resources in the vicinity of the proposed colliery development. In addition a wetland delineation exercise was undertaken and can be found in Section D of the report. It is the objective of this study to provide detailed information to guide the activities associated with the proposed mining operation in the vicinity of the riverine areas to ensure that the ongoing functioning of the wetlands and rivers are facilitated with specific mention of the following:

- Ensure that connectivity of the river areas are maintained between the areas upstream and downstream of the portions of proposed mining operation;
- Ensure ongoing functioning of the river areas in the vicinity of proposed mining operation;
- Ensure that no incision and canalisation of the river systems takes place as a result of the proposed mining operation;
- Ensure that no significant persistent impact on water quality will take place and
- Minimise impacts on the aquatic ecology of the resources within and adjacent to the proposed mining operations.

The study then also aimed to identify and quantify any impacts on the aquatic resources in the area and to develop a list of mitigatory measures which could be employed to minimise impacts on the receiving aquatic environment.

1.1 Background to the study site

For general subject property background please refer to Section A. The main aquatic drainage features in the vicinity of the subject property are the Selons River System which lies in the north eastern area of the study area and predominantly outside the subject property (see Figure 1). The Selons River flows into the Middle Olifants River region downstream of Loskop Dam along the segments *39 – 57 (OREWRA, 2001).* The subject property falls within the Olifants North water Management area of which quaternary catchments B12C, B12D, B12E and B32B which is of most importance to operations related to the proposed Rietvlei Colliery. NFEPA (2011), database was consulted to define the aquatic ecology of the river systems close to or within the subject property that may be of ecological importance. For additional background information refer to Section A.

1.2 Aquatic Ecological Description

1.2.1 Ecostatus

Water resources are generally classified according to the degree of modification or level of impairment. The classes used by the South African River Health Program (RHP) are presented in Section A and will be used as the basis of classification of the systems in this field and desktop study as well as future field studies (refer to Table 1).

Table 1: Classification of river health assessment classes in line with the RHP

Class	Description
A	Unmodified, natural.
B	Largely natural, with few modifications.
C	Moderately modified.
D	Largely modified.
E	Extensively modified.
F	Critically modified.

In addition the ecological category (EC) classification will be employed using the eco-status A to F continuum approach (Kleynhans et al, 2007). This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 1.

Figure 1: Ecological categories (EC) eco-status A to F continuum approach employed

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments the Ecological Importance and Sensitivity (EIS), Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC) were defined and serve as a useful guideline in determining the importance and sensitivity of aquatic ecosystems prior to assessment or as part of a desktop assessment.

This database was searched for the quaternary catchments of concern (B32B, B12C, B12D and B12E, refer to Figure 2) in order to define the EIS, PEMC and DEMC. The findings are based on a study undertaken by Kleynhans (1999) as part of "A procedure for the determination of the ecological reserve for the purpose of the national water balance model for South African rivers". The results of the assessment are summarised in Section A.

1.2.2 State of the Rivers Report. Crocodile, Sabie-Sand and Olifants River Systems (DWAF and RHP, 2014)

Olifants River system catchment overview

The Olifants Catchment covers about 54 570 km2 and is subdivided into 9 secondary catchments. The total mean annual runoff is approximately 2400 million cubic meters per year. The Olifants River and some of its tributaries, notably the Klein Olifants River, Elands River, Wilge River and Bronkhorstspruit, rise in the Highveld grasslands.

The upper reaches of the Olifants River Catchment are characterised mainly by mining, agricultural and conservation activities. Over-grazing and highly erodable soils result in such severe erosion, in parts of the middle section that after heavy rains the Olifants River has a red-brown colour from all the suspended sediments.

Thirty large dams in the Olifants River Catchment include the Witbank Dam, Renosterkop Dam, Rust de Winter Dam, Blyderivierspoort Dam, Loskop Dam, Middelburg Dam, Ohrigstad Dam, Arabie Dam and the Phalaborwa Barrage. In addition, many smaller dams in this catchment, have a considerable combined capacity.

The Olifants River meanders past the foot of the Strydpoort Mountains and through the Drakensberg, descending over the escarpment. The Steelpoort and Blyde tributaries, and others, join the Olifants River before it enters the Kruger National Park and neighboring private game reserves. Crossing the Mozambique border, the Olifants River flows into the Massingire Dam

Refer to the reference link provided below for any additional information on this catchment http://www.dwa.gov.za/iwqs/rhp/state_of_rivers/state_of_crocsabieolif_01/olif_eco.html

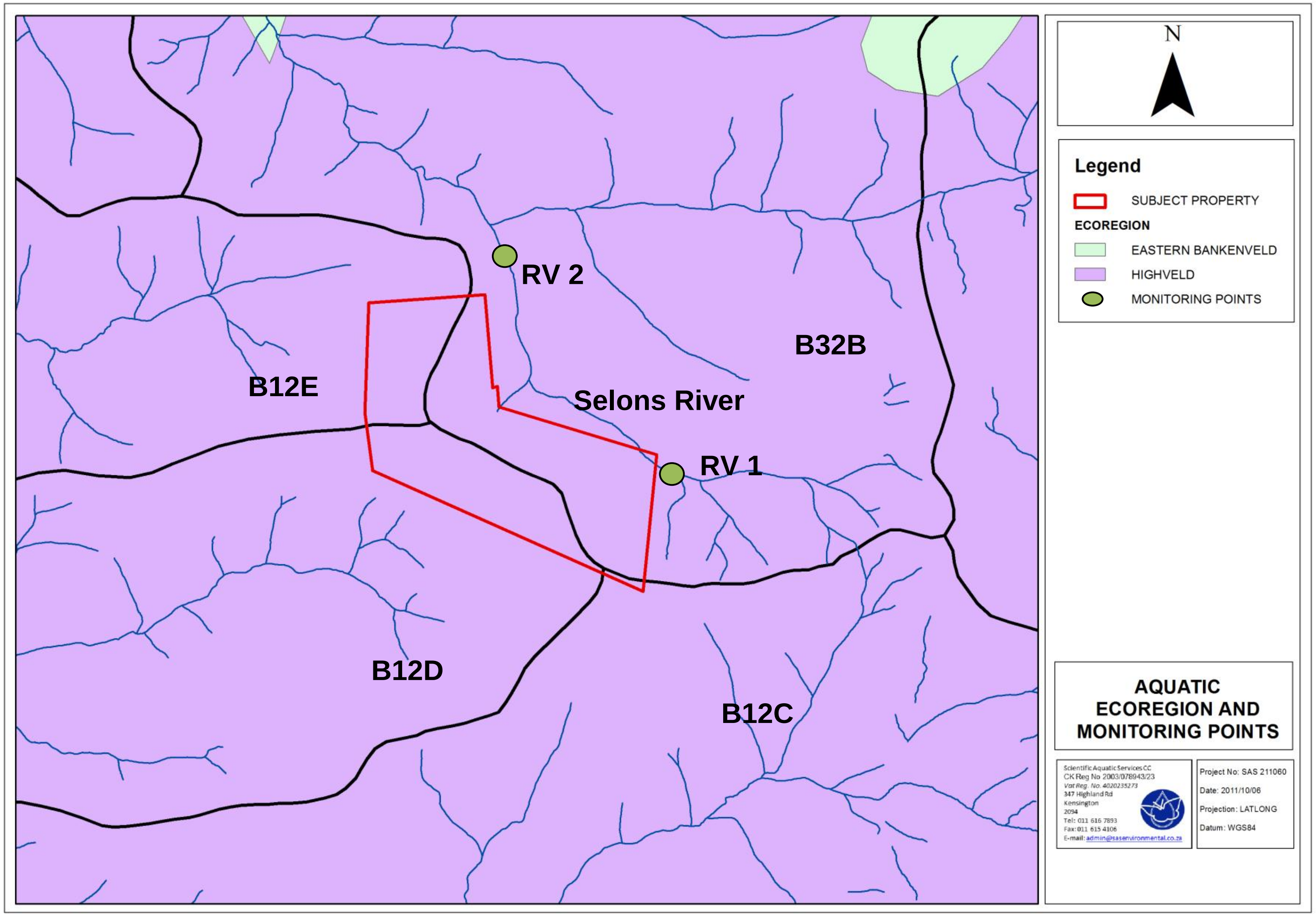

Figure 2: Aquatic ecological Ecoregions, biomonitoring points on the Selons River system and quaternary catchments indicated within the proposed Rietvlei subject property.

The following aspects were considered in the selection of suitable sites for assessing the level of aquatic ecological integrity in the area of the proposed development. See Table 1 in conjunction with Figure 2.

- Site location in relation to the existing infrastructure and activities in the area.
- Consideration was given to the area and position for an assessment point on the various riverine resources in the area to indicate the aquatic ecological conditions to provide reference in order to assist in defining the Present Ecological State and any impacts in this area.
- Accessibility with a vehicle in order to allow for the transport of equipment.
- The sites were selected where there was suitable habitat conditions with the best level of diversity in relation to the condition of each stream assessed, which were considered suitable for supporting the best representation of the aquatic community likely to be present in each system.

1.2.3 National Freshwater Ecosystems Priority Areas database (NFEPA 2011)

NFEPA (2011), databases was consulted to define the aquatic ecology of the wetland or river systems close to or within the subject property that may be of ecological importance. Aspects applicable to the subject property and surroundings are discussed below:

- The subject property falls within the Northern Olifants Management Area (WMA). Each Water Management Area is divided into several sub-Water Management Areas (sub-WMA), where catchment or watershed is defined as a topographically defined area which is drained by a stream or river network. The Sub-Water management unit indicated for the subject property is the Upper Olifants sub-WMA.
- The sub-WMA is not regarded important in terms of fish sanctuaries, rehabilitation or corridors.
- The sub-WMA is not considered important in terms of translocation and relocation zones for fish.
- The sub-WMA is not listed as a fish FEPA.
- The Selons River is situated north to north-east of the subject property and only traverses the subject property on the extreme south east of the property. The Selons River is listed as a NFEPA River system and classified as a class D – largely modified system.
- Additional information has been included in Section A of this study.

1.3 Project execution and scope

The aquatic assessment includes a survey of general habitat integrity, habitat conditions for aquatic macro-invertebrates and aquatic macro-invertebrate community integrity. The protocols of applying the indices were strictly adhered to and all work was executed by a South African River Health Program (SA RHP) accredited assessor. Two temporal representative aquatic ecological assessment points were identified which was used to define the Present Ecological State of the riverine features in the vicinity of the proposed colliery. The aquatic assessment section of this report serves to document the condition at the time of sampling to indicate the state of the riverine ecological integrity during October 2011 and January 2014, at a time when low flows were being experienced (October 2011) and high flow were being experienced (January 2014) and prior to the proposed mine being commissioned. The position of the reference site is presented in the table below.

Table 2: Co-ordinates of reference site

Site	Description	GPS co-ordinates	
		South	East
RV1	Temporal Reference site on the Selons River. Serves as a spatial reference for the R2 site (US)	S 25°41.511’	E 29°42.102’
RV2	Temporal Reference site on the Selons River (DS)	S 25°38.860’	E 29°40.183’

1.4 Assumptions and Limitations

The following points serve to indicate the assumptions and limitations with regard to the aquatic assessment:

- ***Reference conditions are unknown:*** The composition of aquatic biota in the aquatic resources associated with the subject property, prior to major disturbance, is unknown. For this reason, reference conditions are hypothetical, and are based on professional judgement and/or inferred from limited data available.
- ***Temporal variability:*** The data presented in this report are based on two site visits, undertaken in early spring (5th October 2011) and mid-summer (21st January 2014). The effects of natural seasonal and long term variation in the ecological conditions and aquatic biota found in the streams are, therefore, unknown.
- ***Ecological assessment timing:*** *A*quatic and terrestrial ecosystems are dynamic and complex. It is likely that aspects, some of which may be important, could have been overlooked. A more reliable assessment of the biota would require seasonal sampling, with sampling being undertaken under both low flow and high flow conditions.

1.5 Legislative requirements

National Water Act

- The water act recognises that the entire ecosystem and not just the water itself in any given water resource constitutes the resource and as such needs to be conserved;
- No activity may therefore take place within a water course unless it is authorised by the Department of Water Affairs (DWA);
- Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from DWA in terms of Section 21 (C&I);
- General Authorization GN 704 of the National Water Act clearly defines how water courses are to be treated and managed in the vicinity of mining operations;
- For details on the general laws of application in the sphere of environmental management please refer to section A of the study.

2 METHOD OF INVESTIGATION

The assessment of the PES of the system, as well as possible impacts due to the proposed development, were based on comparisons between observed conditions and the theoretical reference conditions based on desktop information reviews, and from historical data for the area.

The sections below describe the methodology used to assess the aquatic ecological integrity of the various sites based on water quality, instream and riparian habitat condition and biological impacts and integrity.

2.1 Visual Assessment

The assessment site was investigated in order to identify visible impacts on the site, with specific reference to impacts from surrounding activities and any effects activities occurring upstream in the catchment. Both natural constraints placed on ecosystem structure and function as well as anthropogenic alterations to the system, were identified by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual indications of the conditions at the time of assessment. Factors which were noted in the site specific visual assessments included the following:

- Stream morphology;
- Instream and riparian habitat diversity;
- Stream continuity;

- Erosion potential;
- Depth flow and substrate characteristics;
- Signs of physical disturbance of the area and
- Other life forms reliant on aquatic ecosystems.

2.2 Physico Chemical Water Quality Data

On site testing of biota specific water quality variables took place. Parameters measured include pH, electrical conductivity (EC), dissolved oxygen (DO) concentration and temperature. The results of on-site biota specific water quality analyses were used to aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values aimed at aquatic ecosystems (Volume 7) for South Africa (DWAF, 1996).

In addition the DO will be measured to determine the percentage saturation level at the time of sampling (DWAF, 1996) and tabulated in accordance to the United States Environmental Protection Agency (US EPA) calculations, refer to the following web site; http://water.epa.gov/type/rsl/monitoring/vms52.cfm

2.3 Riparian Vegetation Response Assessment Index (VEGRAI)

Riparian vegetation is described in the NWA (Act No 36 of 1998) as follows: 'riparian habitat' includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

The VEGRAI is designed for qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitative and defensible results (Kleynhans et al, 2007). Results are defensible because their generation can be traced through an outlined process (a suite of rules that convert assessor estimates into ratings and convert multiple ratings into an Ecological Category).

Table 3: Descriptions of the A-F ecological categories.

Ecological category	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are	80-89

Ecological category	Description	Score (% of total)
	essentially unchanged.	
C	Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	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. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible	0-19

2.4 Habitat Suitability (IHAS)

The Invertebrate Habitat Assessment System (IHAS) was applied according to the protocol of McMillan (1998). This index was used to determine specific habitat suitability for aquatic macro-invertebrates, as well as to aid in the interpretation of the results of the South African Scoring System version 5 (SASS5) scores. Scores for the IHAS index were interpreted according to the guidelines of McMillan (1998) as follows:

- <65%: habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community.
- 65%-75%: habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community.
- >75% habitat diversity and structure is highly suited for supporting a diverse aquatic macro-invertebrate community.

2.5 Habitat Integrity (IHIA)

It is important to assess the habitat of each site, in order to aid in the interpretation of the results of the community integrity assessments by taking habitat conditions and impacts into consideration. The general habitat integrity of the site should be discussed based on the application of the Intermediate Habitat Integrity Assessment for (Kemper; 1999). The Intermediate Habitat Integrity Assessment (IHIA) protocol, as described by Kemper (1999), should be used for site specific assessments. This is a simplified procedure, which is based on the Habitat Integrity approach developed by Kleynhans (1996). The IHIA is conducted as a first level exercise, where a comprehensive exercise is not practical. The Habitat Integrity of each site should be scored according to 12 different criteria which represent the most important (and easily quantifiable) anthropogenically induced possible impacts on the system. The instream and riparian zones should be analysed separately, and the final assessment should be made separately for each, in accordance with Kleynhans' (1999) approach to Habitat Integrity Assessment. Data for the riparian zone are, however, primarily interpreted in terms of the potential impact on the instream component. The assessment of the severity of impact of modifications is based on six descriptive categories with ratings. Analysis of the data should be carried out by weighting each of the criteria according to Kemper (1999). By calculating the mean of the instream and riparian Habitat Integrity scores, an overall Habitat Integrity score can be obtained for each site. This method describes the Present Ecological State (PES) of both the in-stream and riparian habitats of the site. The method classifies Habitat Integrity into one of six classes, ranging from unmodified/natural (Class A), to critically modified (Class F).

Table 4: Classification of Present State Classes in terms of Habitat Integrity (Based on Kemper 1999)

Class	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural, with few modifications. A small change in natural habitats and biota may have taken place but the basic ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Extensively modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	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. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible.	<20

2.6 Aquatic Macro-Invertebrates (SASS)

Aquatic Macro-invertebrates were sampled using the qualitative kick sampling method called SASS5 (South African Scoring System version 5) (Dickens and Graham, 2001). The SASS5 method has been specifically designed to comply with international accreditation protocols. This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter. The assessment was undertaken according to the protocol as defined by Dickens and Graham (2001). All work was done by an accredited SASS5 practitioner.

The SASS5 method was designed to incorporate all available biotypes at a given site and to provide an indication of the integrity of the of the aquatic macro-invertebrate community through recording the presence of various macro-invertebrate families at each site, as well as consideration of abundance of various populations, community diversity and community sensitivity. 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, with a pore size of 1000 micron mounted on a 300 mm square frame, over the churned up area several times. In stony bottomed flowing water biotopes (rapids, riffles, runs, etc.) the net downstream of the assessor and the area immediately upstream of the net is disturbed by kicking the stones over and against each other to dislodge benthic invertebrates. The net was also swept under the edge of marginal and aquatic vegetation to cover from 1-2 meters. Identification of the organisms was made to family level (Thirion *et al*., 1995; Davies and Day, 1998; Dickens and Graham, 2001; Gerber and Gabriel, 2002).

Interpretation of the results of biological monitoring depends, to a certain extent, on interpretation of site-specific conditions (Thirion *et.al*, 1995). In the context of this investigation it would be best not to use SASS5 scores in isolation, but rather in comparison with relevant habitat scores. The reason for this is that some sites have a less desirable habitat or fewer biotopes than others do. In other words, a low SASS5 score is not necessarily regarded as poor in conjunction with a low habitat score. Also, a high SASS5 score, in conjunction with a low habitat score, can be regarded as better than a high SASS5 score in conjunction with a high habitat score. A low SASS5 score, together with a high habitat score, would be indicative of poor conditions. The IHAS Index is valuable in helping to interpret SASS5 scores and the effects of habitat variation on aquatic macro-invertebrate community integrity.

Classification of the system took place by comparing the present community status to reference conditions which reflect the best conditions that can be expected in rivers and streams within a specific area and reflect natural variation over time. SASS and ASPT reference conditions were obtained from Dallas (2007), as presented in the figure below. Reference conditions are stated as a SASS score of 240 and an ASPT score of 6.8. Sites were classified according to the classification system for the Highveld Ecoregion according to Dallas (2007), as well as the classification system of Dickens and Graham 2001.

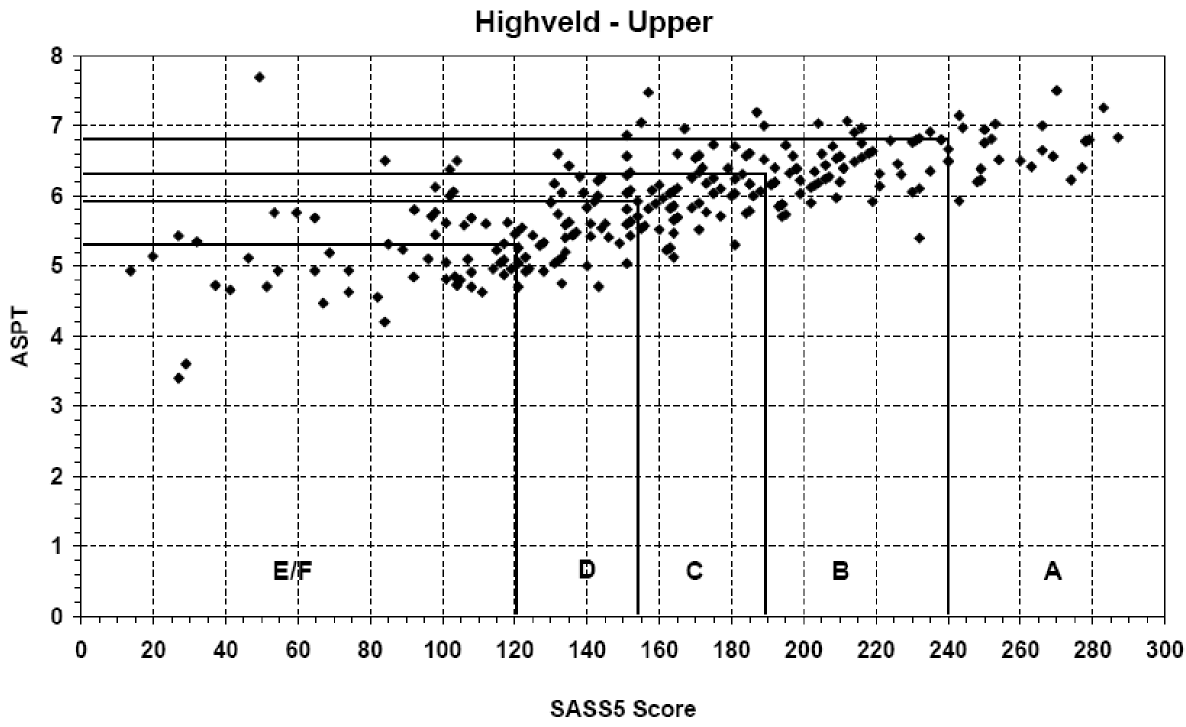

Figure 3: SASS5 Classification using biological bands calculated form percentiles for the Highveld Ecoregion, Dallas, 2007

Table 5: Definition of Present State Classes in terms of SASS scores as presented in Dickens and Graham (2001)

Class	Description	SASS Score%	ASPT
A	Unimpaired. High diversity of taxa with numerous sensitive taxa.	90-100 80-89	Variable >90
B	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.	80-89 70-79 70-89	<75 >90 76-90
C	Moderately impaired. Moderate diversity of taxa.	60-79 50-59 50-79	<60 >75 60-75
D	Largely impaired. Mostly tolerant taxa present.	50-59 40-49	<60 Variable
E	Severely impaired. Only tolerant taxa present.	20-39	Variable
F	Critically impaired. Very few tolerant taxa present.	0-19	Variable

2.7 Aquatic Macro-Invertebrates: Macro-invertebrate Response Assessment Index (MIRAI)

The four major components of a stream system that determine productivity, with particular reference to aquatic organisms, are flow regime, physical habitat structure, water quality and energy inputs. An interplay between these factors (particularly habitat and availability of food sources) result in the discontinuous, patchy distribution pattern of aquatic macro-invertebrate populations. As such aquatic invertebrates shall respond to habitat changes (i.e. changes in driver conditions).

To relate drivers to such changes in habitat and aquatic invertebrate condition, two key elements are required. Firstly habitat preferences and requirements for each taxa present should be obtained. As such reference conditions can be established against which any response to drivers can be measured. Secondly habitat features should be evaluated in terms of suitability and the requirements mentioned in the first point. As a result expected and actual patterns can be evaluated to achieve an Ecostatus Category (EC) rating.

Based on the three key requirements, the MIRAI provides an approach to deriving and interpreting aquatic invertebrate response to driver changes. The index has been applied to the aquatic sites following methodology described by Thirion (2007). Aquatic macro-invertebrates expected at each point were derived both from previous studies of rivers near the area as well as habitat, flow and water parameters (Thirion 2007).

2.8 Fish biota: Habitat Cover Rating (HCR)

This approach was developed to assess habitats according to different attributes that are surmised to satisfy the habitat requirements of various fish species. At each site, the following depth-flow (df) classes are identified, namely:

- Slow (<0.3m/s), shallow (<0.5m) - Shallow pools and backwaters.
- Slow, deep (>0.5m) - Deep pools and backwaters.
- Fast (>0.3m/s), shallow - Riffles, rapids and runs.
- Fast, deep - Usually rapids and runs.

The relative contribution of each of the above mentioned classes at a site was estimated and indicated as:

0 = Absent

1 = Rare (<5%)

2 = Sparse (5-25%)

3 = Moderate (25-75%)

4 = Extensive (>75%)

For each depth-flow class, the following cover features (cf) -considered to provide fish with the necessary cover to utilise a particular flow and depth class- were investigated:

- Overhanging vegetation
- Undercut banks and root wads

- Stream substrate
- Aquatic macrophytes

The amount of cover present at each of these cover features (cf) was noted as:

0 = absent

1 = Rare/very poor (<5%)

2 = Sparse/poor (5-25%)

3 = Moderate/good (25-75%)

4 = Extensive/excellent (>75%)

The fish habitat cover rating (HCR) was calculated as follows:

- The contribution of each depth-flow class at the site was calculated (df/Σdf).
- For each depth-flow class, the fish cover features (cf) were summed (Σcf).

$$HCR = df/\Sigma df \times \Sigma cf.$$

The amount and diversity of cover available for the fish community at the selected sites was graphically expressed as habitat cover ratings (HCR) for different flow-depth classes as a stacked bar chart.

2.9 Fish biota: Fish Response Assessment Index (FRAI)

Whereas macro-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.

The fish sampling was applied according to the protocol of Kleynhans (1999). Fish samples were collected by three main techniques:

- using a hand held net to sample marginal vegetation and rocky areas in strong current.
- Where applicable, areas of more open water were sampled using a cast net with a stretched mesh size of 17.5 mm.
- Use of an Electrofisher which uses electricity to temporally paralyse fish which are then easily captured in a hand held net for identification, inspection and release.

Fish species identified were compared to those expected to be present at the site, which were compiled from a literature survey including Skelton 2001. Biological requirements include food availability as well as flow and cover requirements. All indigenous South African fish species expected to occur within the region of the subject property and surrounding aquatic systems listed in Table 6 are not threatened or listed as RDL species according to Skelton (2001) and the IUCN.

The FRAI (Kleynhans et al, 2007) is based on the premise that "drivers" (environmental conditions) may cause fish stress which shall then manifest as changes in fish species assemblage. The index employs preferences and intolerances of the reference fish assemblage, as well as the response of the actual (present) fish assemblage to particular drivers to indicate a change from reference conditions. Intolerances and preferences are divided into metric groups relating to preferences and requirements of individual species. This allows cause-effect relationships to be understood, i.e. between drivers and responses of the fish assemblage to changes in drivers. These metric groups are subsequently ranked, rated and finally integrated as a fish Ecological Category (EC). Fish expected to occur in the system is summarised in Table 6.

Table 6: Intolerance ratings for naturally occurring indigenous fish species with natural ranges included in the subject property area and surrounding environment (Kleynhans, 2002; Skelton, 2001; Kleynhans et al, 2007 and IUCN 2014).

SPECIES NAME	COMMON NAME	INTOLERANCE RATING	IUCN RDL STATUS	COMMENTS
Barbus anoplus	Chubbyhead bard	2.6	LC	Widely distributed from Highveld Limpopo to upland KZN, Transkei and middle and upper Orange basin including Karoo.
Barbus bifrenatus	Hyphen Barb	2.8	LC	Common in Cunene, Okavango, upper Zambezi, Kafue, Zambian Congo and Limpopo systems.
Barbus lineomaculatus	Linespotted barb	4.1	LC	Cunene, Okavango, Zambezi, Limpopo systems. Common in Zimbabwe and Zambia.
Barbus mattozi	Paper mouth	3.0	LC	Limpopo system, headwaters of Gwa-Zambabwe, Kwando-upper Zambezi and Cunene.
Barbus neefi	Sidespot barb	3.4	LC	Tributaries of the Steelpoort-Limpopo system.
Barbus paludinosis	Straightfin Barb	1.8	LC	Widespread
Barbus trimaculatus	Threespot barb	2.2	LC	Common in many river systems of southern Africa
Barbus unitaeniatus	Longbeard barb	1.7	LC	Widely distributed in southern Africa
Chiloglanis pretoriae	Shortspine Suckermouth or Rock catlet	4.6	LC	Widespread (Incomati, Limpopo and Zambezi)
Chiloglanis paratus [1]	Sawfin Suckermouth or Sawfin rock catlet	3.5	LC	Incomati, Limpopo and Phongola River systems
Clarias gariepinus	Sharptooth Catfish	1.2	NYBA	Most widely distributed fish in Africa.
Labeo cylindricus	Red eye Labeo	3.1	LC	Widespread from East African rivers south through the Zambezi system and east coastal drainages to the Phongolo system.
Labeo molybdinus	Leaden labeo	3.2	LC	Widespread
Labeo rosae	Red nose Labeo	2.4	LC	Lower reaches of the Limpopo, Incomati and Phongolo systems.

SPECIES NAME	COMMON NAME	INTOLERANCE RATING	IUCN RDL STATUS	COMMENTS
Labeobarbus marequensis	Lowveld largescale yellowfish	2.6	LC	Middle and lower Zambezi to Phongolo system.
Micralestes acutidens	Silver robber	2.3	LC	Cunene, Okavango, Zambezi and east coast rivers south to the Phongolo system.
Mesobola brevianalis	River sardine	2.3	LC	Common in Cunene, Okavango, Zambezi and east coast rivers from Limpopo to the Umfolozi River in Natal. Isolated population in Orange River under the Augrabies Falls
Marcusenius macrolepidotus	Bulldog	3.6	LC	Widespread and common Cunene, Okavango, Zambezi and upper Congo. South until the Umhlatuzi River in Natal.
Oreochromis mossambicus	Mozambique tilapia	1.3	*NT	The Mozambique tilapia is native to coastal regions and the lower reaches of rivers in southern Africa, from the Zambezi River delta to Bushman River in the eastern Cape
Pseudocrenilabrus philander	Southern Broodmouth	1.3	NYBA	From the Orange and southern KZN northwards throughout the region. Extends to southern Congo tributaries and into lake Malawi.
Synodontis zambezensis	Brown squeaker	2.3	LC	Middle and lower Zambezi south to the Phongolo system.
Tilapia rendalli	Red breast Tilapia	1.8	LC	Cunene, Okavango, Zambezi and east coast rivers south to the Phongolo system and coastal lakes to lake Sibaya
Tilapia sparrmanii	Banded Tilapia	1.3	LC	Widespread

Tolerant: 1-2 moderately tolerant :> 2-3 Moderately Intolerant: >3-4 Intolerant: >4

LC = Least concerned by IUCN, NYBA = Not yet been assessed by the IUCN (2014),
*NT = Threatened by hybridization with the rapidly spreading *Oreochromis niloticus*. *Oreochromis niloticus* is being spread by anglers and for aquaculture. Hybridization is already occurring throughout the northern part of the species' range, with most of the evidence coming from the Limpopo River system. In terms of locations the threat of *Oreochromis niloticus* is widespread, but probably more than 50% of the locations are not yet affected. Given the rapid spread of *O. niloticus* it is anticipated that this species will qualify as threatened under Criterion A due to rapid population decline through hybridization. The species is therefore assessed as Near Threatened (IUCN, 2014).

3 RESULTS AND INTERPRETATION

3.1 Aquatic Assessment

3.1.1 Visual assessment

The table below summarises the observations for the various criteria made during the visual assessment undertaken at the aquatic assessment sites during October 2011 and January 2014.

Figure 4: Upstream view of the Selons River site RV1 indicating the low flow at the time of assessment (2011).

Figure 5: Downstream view of the Selons River site RV1 indicating bank side erosion (October 2011).

Figure 6: Downstream view of the Selons River site RV2 near the R555 bridge (October 2011).

Figure 7: Upstream view of the Selons River site RV2 (October 2011).

 Figure 8: Upstream view of the Selons River site RV1 indicating the high flow at the time of assessment (2014).	 Figure 9: Downstream view of the Selons River site RV1 indicating good vegetation cover on the right and bank side erosion on the left (January 2014).
 Figure 10: Downstream view of the Selons River site RV2 near the R555 bridge indicating good vegetation (October 2014).	 Figure 11: Upstream view of the Selons River site RV2 indicating high flow (January 2014).

Table 7: Description of the location of the assessment sites in the subject property

SITE	RV1 (US)	RV2 (DS)
Upstream features	Located upstream of the proposed Rietvlei Colliery on the Selons River with agricultural lands adjacent to the point.	Located downstream of the proposed Rietvlei Colliery on the Selons River.
Downstream significance	The water downstream from this point along the Selons River feeds into a farmer's dam which most likely supplies water for irrigation and livestock consumption downstream of the site.	The Selons River downstream from this point joins the Olifants System. Downstream from this point the Selons River is most likely used for irrigation purposes.
Significance of the point	The site serves as a reference point on the system prior to the proposed colliery development. Site serves as a spatial reference site for the RV2.	The site serves as a reference point on the system prior to the proposed colliery development
Riparian zone characteristics	Upstream of the assessment point the riparian zone runs through a relatively valley with a relatively gradual gradient. The stream bed alternates between pools and runs.	Upstream of the assessment point the riparian zone runs through a valley with a relatively gradual gradient.
Algal presence	Low flow conditions indicated no algal presence (2011). Limited algal proliferation was evident at the high flow (2014) period indicating that limited addition of nutrients to the system is likely to be occurring at that period.	Low flow conditions indicated no algal presence (2011). Under the high flow (2014) survey period, algal proliferation was evident indicating that upstream agricultural areas are possibly leading to the eutrophication of the system.
Visual indication of an impact on aquatic fauna	None observed although upstream water abstraction and impoundment may affect the ecology of the system.	Upstream water abstraction and impoundment of the Selons River system for agricultural purposes was observed and may affect the ecology of the system.
Depth characteristics	The system had limited depth diversity with most areas being on average 0.5m deep. Some deeper pools were observed with runs and glides formed within the system under the current flow conditions.	The system had limited depth diversity with most areas being on average 0.5m deep. Some deeper pools were observed.
Flow condition	Under the low flow conditions (2011), there is limited flow present and the flow can be regarded as slow to still throughout the system. The habitat conditions present provide limited habitats for aquatic macro-invertebrates and fish and some species requiring very fast flowing water are likely to be absent from the system. January 2014 site survey included high flow conditions. The habitat conditions during 2014 provided suitable habitat for aquatic macro-invertebrates and fish species.	Under the relatively low flow conditions (2011), there is limited flow present and the flow can be regarded as slow throughout the system. The habitat conditions present provide a fair range of habitats for aquatic macro-invertebrates and fish but some species requiring very fast flowing water are likely to be absent from the system. January 2014 site survey included high flow conditions. Habitat conditions during 2014high flow season provided suitable habitat for aquatic macro-invertebrates and fish species.
Water clarity	Water is slightly silted.	Water is slightly silted.
Water odour	No odours were evident.	No odours were evident.
Erosion potential	High potential for erosion is present, due to the poorly vegetated banks.	Some potential for erosion is present, especially under high flow conditions, however the banks are fairly well vegetated.

3.1.2 Physico-Chemical Water Quality

The table below records the biota specific water quality of the assessment site.

Table 8: Biota specific water quality data along the main drainage feature.

SITE	Year	COND mS/m	pH	DO mg/l	TEMP °C
RV1	2011	23.0	8.10	Na	15.8
RV2	2011	17.8	8.80	Na	16.5
RV1	2014	11.7	8.07	7.38	21.9
RV2	2014	10.9	7.94	6.55	28.1

Na = did not measure

- General water quality can be considered fair although it is evident that dissolved salts are generally elevated in the region and there is some variability in salt concentrations between the two points along the Selons River system.
- Spatially during the spring of 2011, the Electrical Conductivity (EC) data indicates that the RV1 site on the upstream section of the Selons River is 22% higher than the downstream value at RV2 along the Selons River. The summer 2014 EC indicated a 6% difference between the upstream and downstream sites.
- Some additional impact from upstream activities, upstream of site RV1, on this system is deemed likely. The observed values are within the Olifants River Environmental Water Quality Assessment (OREWA, 2001) guidelines for this reach of the Olifants River system.
- It is evident that the EC between the two assessment points on the Selons River during 2011 and 2014 indicate that salinisation of the upper catchment is likely to be occurring, most likely as a result of agricultural activities in the area. The data however indicates that currently there is no addition of dissolved salts between the two assessment points for both 2011 and 2014 surveys.
- In terms of OREWA (2001) guidelines the dissolved salt concentrations in the systems are within the guideline value, supporting the findings, during 2011 and 2014, that there is no osmotic stress on the aquatic communities that may occur within the Selons River system.
- The pH may be considered natural and no impact on the aquatic ecology of the system is deemed likely at the current time and for the 2011 site survey period.
- No Dissolved Oxygen (DO) was conducted during the 2011 monitoring period.
- Along the Selons River the dissolved oxygen at both upstream RV1 (84%) site and the downstream site RV2 (83%) were within the desired 80% to 120% range for aquatic ecosystems (DWAF, 1996);

- The dissolved oxygen concentration is acceptable and can be regarded as suitable for supporting a diverse and sensitive aquatic community (Table 9).

Table 9: Oxygen measured expressed as percentage of maximum for the sites

SITE	DO mg/l	TEMP °C	Maximum oxygen at that temperature (mg/l)	Oxygen measured expressed as percentage of maximum (%)
RV1	7.38	21.9	8.72	84
RV2	6.55	28.1	7.81	83

- Temperatures can be regarded as normal for 2011 and 2014 times of year and time of day when assessment took place.

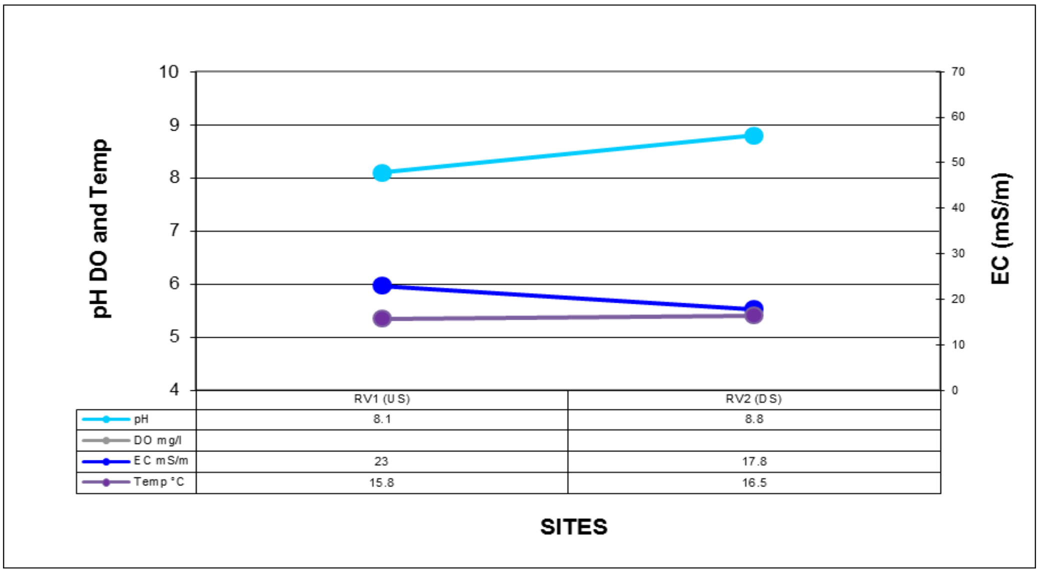

Figure 12: Physico-chemical water quality showing spatial trends for 2011

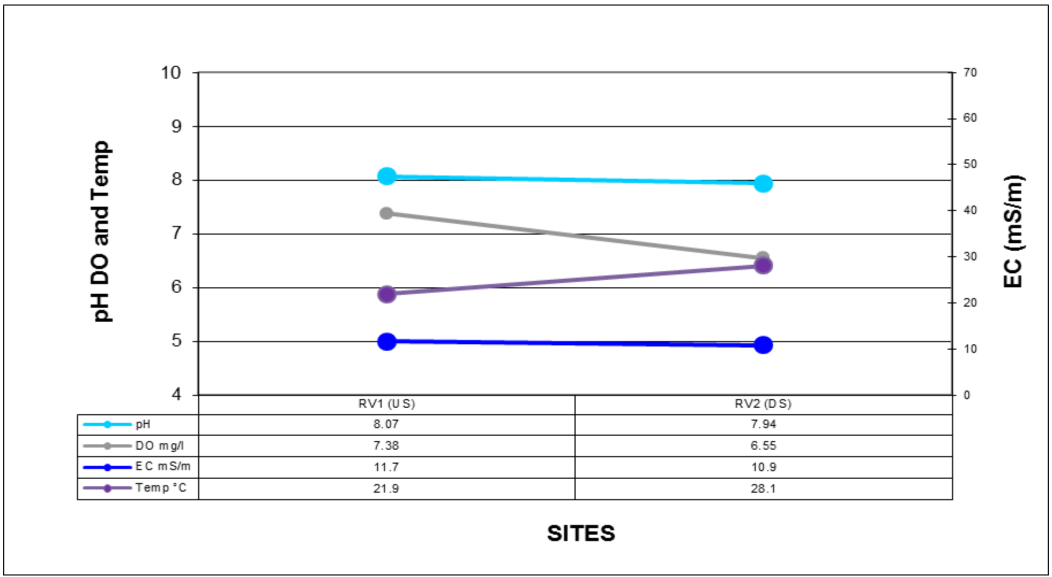

Figure 13: Physico-chemical water quality showing spatial trends for 2014

3.1.3 Riparian Vegetation Response Assessment Index (VEGRAI)

The VEGRAI result for the Selons River sites are presented in Appendix 1 and discussed below for year 2011 and 2014.

Table 10: Results of the VEGRAI assessment

YEAR	2011		2014	
Variable / Index (EC)	RV1 (US)	RV2 (DS)	RV1 (US)	RV2 (DS)
Thirion 2007 (VEGRAI)	C (60%)	C (63.2%)	C (60.7%)	C (65.6%)

EC = Ecological category

The results of this assessment indicate that both the upstream RV1 and downstream RV2 Selons River sites fall within an Ecological Category Class C (Kleynhans et al, 2007) for year 2011 and 2014, indicating a loss and change of natural habitat having occurred, but the basic ecosystem functions are still predominately unchanged (Kleynhans et al, 2007). The primary modifier to this system is likely to be the water quality and flow modification, due to the proximity to historical and current agricultural activities, that include livestock farming, which may contribute to the moderately modified vegetation in the system.

3.1.4 Invertebrate Habitat Integrity Assessment (IHIA)

From the results of the application of the IHIA to the Selons River sites, it is evident that there are several limited, moderate and extensive impacts on the habitat of the aquatic systems at the sites that were evaluated. IHIA data for 2011 and 2014 surveys are presented in Appendix 2.

Instream zone impacts for 2011

Instream impacts included large level impacts, with specific mention of flow modification, bed modifications and channel modification. Overall, the RV1 site achieved a 49% score for instream integrity (Class D) while the RV2 site achieved a score of 64%. Based on the classification system of Kemper 1999. The upstream RV1 site has an instream habitat conditions that can be described as being largely modified (Class D) and the downstream RV2 site a Moderately modified instream habitat (Class C).

Riparian zone impacts for 2011

The impacts on the riparian zone during the 2011 survey were considered moderate to large, with bank erosion, flow and channel modification impacts being evident. Overall, the RV1 site achieved a 48% score for riparian integrity while the RV2 site achieved 43%. Based on the classification system of Kemper 1999 the RV1 and RV2 sites have riparian habitat conditions that can be described as largely modified (Class D).

2011 IHIA summary

The RV1 site achieved an IHIA score of 49% while the RV2 site 54%. Based on the classification system of Kemper 1999 both sites have habitat conditions that can be described as largely modified (Class D), where a loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged refer to appendix 4 for IHIA scores

Instream zone impacts for 2014

- Small to large instream impacts comprise of impacts such as water abstraction, exotic fauna, exotic macrophytes, channel and bed modification, solid waste disposal, inundation, channel and water quality modifications.
- Extensive impacts included flow modification along all the sites assessed.
- Overall, the RV1 site achieved 64% and the downstream Selons River site RV2 a 68% score for instream integrity.
- According to Kemper (1999), the instream zone integrity classification achieved for 2011 and 2014 was moderately modified (class C). This class is defined as where a loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.

Riparian zone impacts for 2014

- Riparian zone impacts were generally small to large impacts.
- Small impacts within the riparian zone comprised of; indigenous vegetation removal, water abstraction, flow, channel and bed modification along with water quality, inundation and exotic vegetation encroachment impacts.
- Large impacts were observed in the form of bank erosion.
- Overall, the RV1 site achieved 76% and the downstream Selons River site RV2 a 75% score for riparian integrity.

Overall 2014 habitat integrity

- During the 2014 site survey, the two Selons River sites achieved an IHIA rating of 70% (RV1) and 72% (RV2), where an increase from class D to a class C has been observed since 2011 early spring late winter survey. Currently in 2014 the habitat is deemed moderately modified indicating a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged (Kemper, 1999).

3.1.5 Invertebrate Habitat Assessment System (IHAS)

From the results of the application of the IHAS to the various assessment points, it is evident that the level of impact between the various points is largely similar (refer to Appendix 3).

The table below is a summary of the results obtained from the application of the IHAS Index to the assessment site. This index determines habitat suitability, with particular reference to the requirements of aquatic macro-invertebrates. The results obtained from this assessment will aid in defining the habitat condition.

During the October 2011 survey, the RV1 site and RV2 site achieved an IHAS score of 46 and 44 respectively. This indicated that during 2011, habitat diversity and structure was considered inadequate for supporting a diverse aquatic macro-invertebrate community under the 2011 flow conditions.

During the 2014 assessment, an IHAS score of 71 and 67 was achieved and the RV1 site and RV2 site. Habitat diversity and structure at this time was adequate for supporting a diverse aquatic macro-invertebrate community at both points (McMillian, 1998) therefore a diverse aquatic macro-invertebrate community can be expected in the Selons River during the 2014 site survey period which is indicative of high flow conditions...

Table 11: Biotope specific summary of the results obtained from the application of the IHAS index to the various sites.

SITE	RV1		RV2	
YEAR	2011	2014	2011	2014
Habitat score	46	71	44	67
Habitat adjustment score (illustrative purposes only)	+30	+14	+29	+13
McMillan, 1998 Habitat description	Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.		Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	
Stones habitat characteristics	Adequate SIC habitat was available for assessment during 2011 and 2014.		Adequate SIC habitat was available for assessment during 2011 and 2014.	
Vegetation habitat characteristics	2011 - Poor bankside vegetation present, unsuitable for supporting a diverse invertebrate community. 2014 – adequate bankside vegetation present for supporting a diverse invertebrate community		2011 - Poor bankside vegetation present, unsuitable for supporting a diverse invertebrate community. 2014 – adequate bankside vegetation present for supporting a diverse invertebrate community	
Other habitat characteristics	Gravel and sand substrate provides habitat for suitably adapted macro-invertebrates. The gravel substrate potentially allows for some sensitive taxa to be supported at the site.		Gravel and sand substrate provides habitat for suitably adapted macro-invertebrates. The gravel substrate potentially allows for some sensitive taxa to be supported at the site.	
IHAS general stream characteristics	2011 - A fairly shallow, narrow stream consisting of slow flowing riffles and pools. The water in the system was very silty at the time of assessment (2011). Bankside cover is poor, bank side erosion has a lower probability under higher flows than site RV1. 2014 - A medium to fast flowing stream consisting of good flowing riffles. Riparian vegetation consists of grasses. Bankside cover is good due to adequate riparian vegetation at the summer period of assessment (2014).		2011 - A fairly shallow, narrow stream consisting of slow flowing riffles and pools. The water in the system was very silty at the time of assessment (2011). Bankside cover is poor, bank side erosion has a lower probability under higher flows than site RV1. 2014 - A medium to fast flowing stream consisting of good flowing riffles. Riparian vegetation consists of grasses. Bankside cover is good due to adequate riparian vegetation at the summer period of assessment (2014).	

3.1.6 Aquatic Macro-invertebrates (SASS)

The results of the aquatic macro-invertebrate assessment according to the SASS5 index are summarised in the tables below. The table below indicates the results obtained at each site per biotope sampled. Table 12 summarises the findings of the SASS assessment for 2011 and Table 13 for 2014 based on the analyses of the data for the sites. Table 14 summarises key findings with the interpretation of the data below.

Table 12: 2011 biotope specific summary of the results obtained from the application of the SASS5 index to the various sites.

PARAMETER	SITE	STONES	VEGETATION	GRAVEL, SAND AND MUD	TOTAL
SASS5 score	RV1	25	0	26	51
	RV2	41	0	9	50
Number of taxa	RV1	5	0	6	11
	RV2	6	0	3	9
ASPT	RV1	5	0	4.3	5
	RV2	7	0	3	6

Table 13: 2014 biotope specific summary of the results obtained from the application of the SASS5 index to the various sites.

PARAMETER	SITE	STONES	VEGETATION	GRAVEL, SAND AND MUD	TOTAL
SASS5 score	RV1	40	34	21	51
	RV2	34	72	41	86
Number of taxa	RV1	9	7	5	11
	RV2	9	14	9	18
ASPT	RV1	4	4.9	4	4.6
	RV2	4	5.1	5	4.8

- During the early spring 2011 assessment, the two assessment sites can be considered as Class D (largely impaired) sites according to the Dickens and Graham (2001). With mostly tolerant taxa present.
- According to Dallas (2007) classification systems the upstream RV1 site and the downstream RV2 sire are classed a Class E/F (severely/critically impaired). This is due to the naturally limited habitat that is available and the lack of flow in the river at the time of assessment (early spring 2011).
- Based on the available habitat conditions with special mention of the lack of flow and the lack of bankside vegetation cover, the poor aquatic macro-invertebrate community score in the system is most likely due to the limited availability of natural habitat at the RV1 and RV2 sites.

Table 14: A summary of the results obtained from the application of the SASS5 indices to the two sites for 2011 and 2014.

YEAR	2011		2014	
SITE	**RV1**	**RV2**	**RV1**	**RV2**
Biotopes sampled	Stones in current, Gravel, sand and mud.	Stones in current, Gravel, sand and mud.	Suitable stone, sand, gravel and vegetation were sampled.	Dominant stone biotope along with GSM and vegetation were sampled
More sensitive macro-invertebrate taxa present	*Aeshnidae*	*Aeshnidae;*	*Aeshnidae; Caenidae;*	*Aeshnidae; Caenidae; Lestidae;*
More sensitive macro-invertebrate taxa absent	*Hydracarina, Caenidae, Ancylidae, Lestidae; Chlorolestidae; Gomphidae; Naucoridae;*	*Hydracarina, Caenidae, Ancylidae, Lestidae; Chlorolestidae; Gomphidae; Naucoridae;*	*Ancylidae; Hydracarina; Chlorolestidae; Gomphidae; Naucoridae; Lestidae;*	*Ancylidae; Hydracarina; Chlorolestidae; Gomphidae; Naucoridae;*
Adjusted Invertebrate assessment Score	81	79	65	99
SASS score as % of reference score (Highveld, 240)	21.2%	20.8%	21.2%	35.8%
ASPT score as % of reference score (Highveld, 6.8)	73.5%	88.2%	67.6%	70.8%
Current Invertebrate assessment classification according to Dallas 2007.	Class D (Largely impaired)	Class D (Largely impaired)	Class D (Largely impaired)	Class D (Largely impaired)
Current Invertebrate assessment classification according to Dickens and Graham 2001.	Class E/F (Severely/Critically impaired)	Class E/F (Severely/Critically impaired)	Class E/F (Severely/Critically impaired)	Class E/F (Severely/Critically impaired)

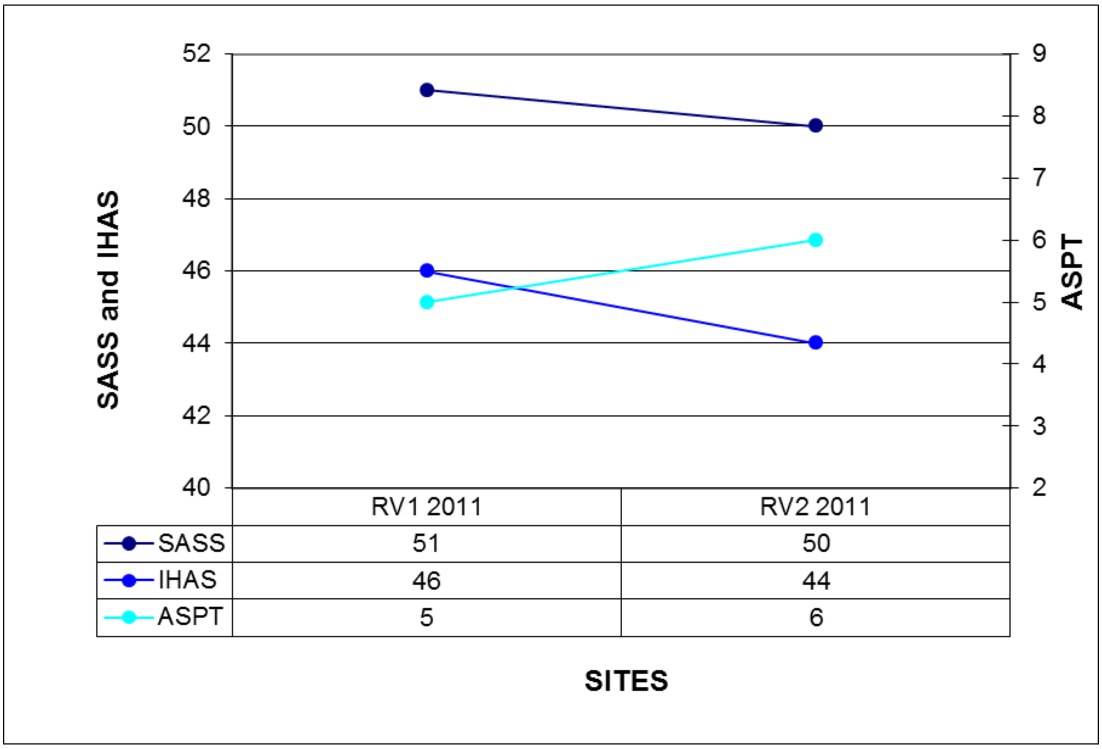

Figure 14: SASS5, IHAS and ASPT scores showing spatial trends for 2011

- At present, during the early 2014 assessment, the two assessment sites can be considered as Class D (largely impaired) sites according to the Dickens and Graham (2001).
- According to Dallas (2007) classification systems both upstream RV1 site and downstream RV2 sites are classed a Class E/F (severely/critically impaired). Even with an increase in flow these classifications have remained the same since the 2011 site survey at both sites.
- Based on the available habitat conditions the poor aquatic macro-invertebrate community score in the system is most likely due to the limited availability of natural habitat at the RV1 and RV2 sites.

The primary impact which may affect macro-invertebrates within the Selons River at the current time which is expressed from farming activities as well as possible mining operations is water quality changes. The significance of this and other impacts can however be reduced with management actions to avoid significant degradation which may lead to additional loss of aquatic communities.

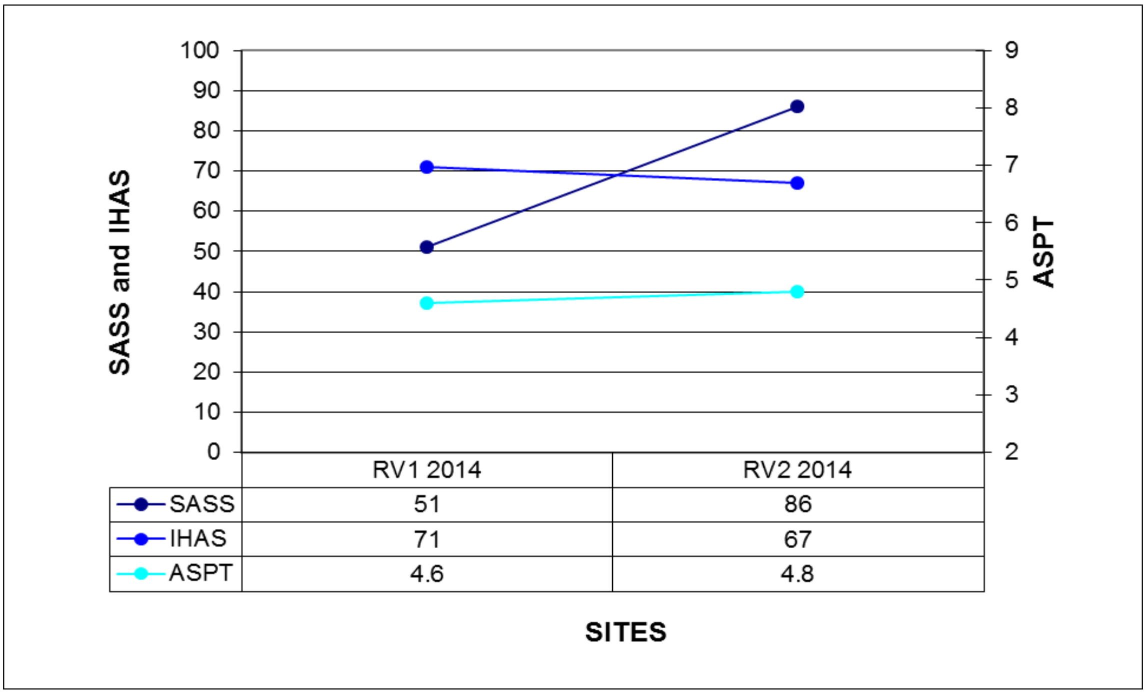

Figure 15: SASS5, IHAS and ASPT scores showing spatial trends for 2014

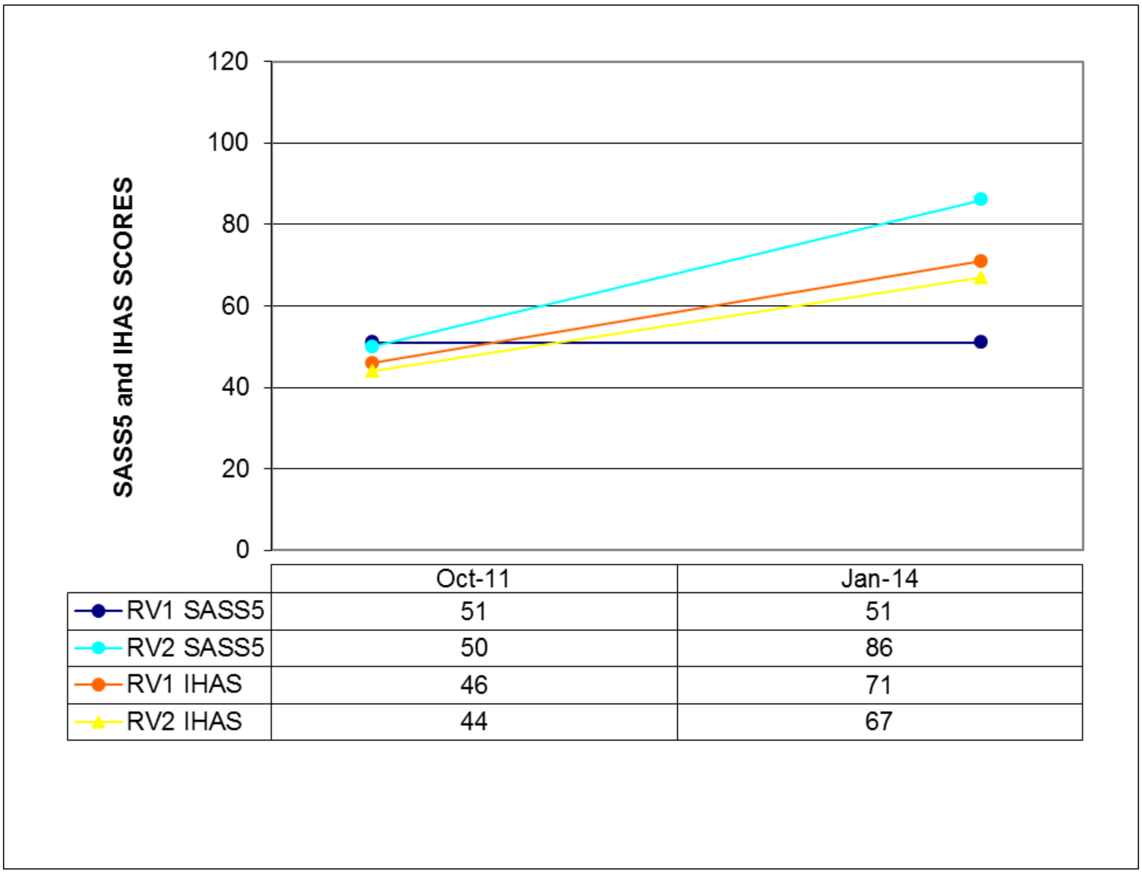

Figure 16: SASS5 and IHAS scores showing temporal trends for 2011 and 2014

3.1.7 Aquatic Macro-invertebrates (MIRAI)

The results obtained after employing the MIRAI ecostatus tool are summarised below. For ease of comparison the classifications obtained using SASS5 are also presented in this section.

Table 15: Summary of the results (ecological categories) obtained from the application of the MIRAI to the assessment sites, compared to classes awarded using SASS5.

YEAR	2011		2014	
Variable / Index (EC)	**RV1**	**RV2**	**RV1**	**RV2**
Thirion 2007 (MIRAI)	D (41%)	D (43%)	D (45%)	D (47%)
Dickens and Graham 2002 (SASS5)	D	D	D	D
Dallas 2007 (SASS5)	E/F	E/F	E/F	E/F

EC = Ecological category

From the table above it is clear that the MIRAI results in terms of (Ecological Category classification) follow similar trends as that obtained using the SASS class classifications. The general deterioration in trend in terms of macro-invertebrate community integrity is clearly evident throughout the two assessment sites along the Selons River.

3.1.8 Fish Community Integrity

2011 fish survey

During the 2011 early spring survey no fish were observed or captured at the RV1 or RV2 site on the Selons River during the survey period. Similarly no fish was observed or sampled within the non-perennial pans which occur within the subject property.

- The absence of fish in the system is indicative of long term impacts on the system, with special mention of loss of spawning habitat due to upstream and downstream migration barriers.
- Some limitations due to natural distribution patterns and constraints are also deemed highly possible.
- Instream modifications such as sedimentation and impacts from impoundments are considered to significantly impact on the fish community of the system and interfering with fish migrations along the rivers.
- Due to the limited integrity, diversity and sensitivity of the fish community, it is not deemed likely that any highly significant additional impacts on the fish community of the aquatic resources in the area due to the proposed mining operation will occur.

Habitat Cover Rating (HCR) results for the two sites on the Selons River (RV1 and RV2) are provided below for the 2011 site survey period. Habitat conditions during this period were suited for slow flowing shallow and deep water species.

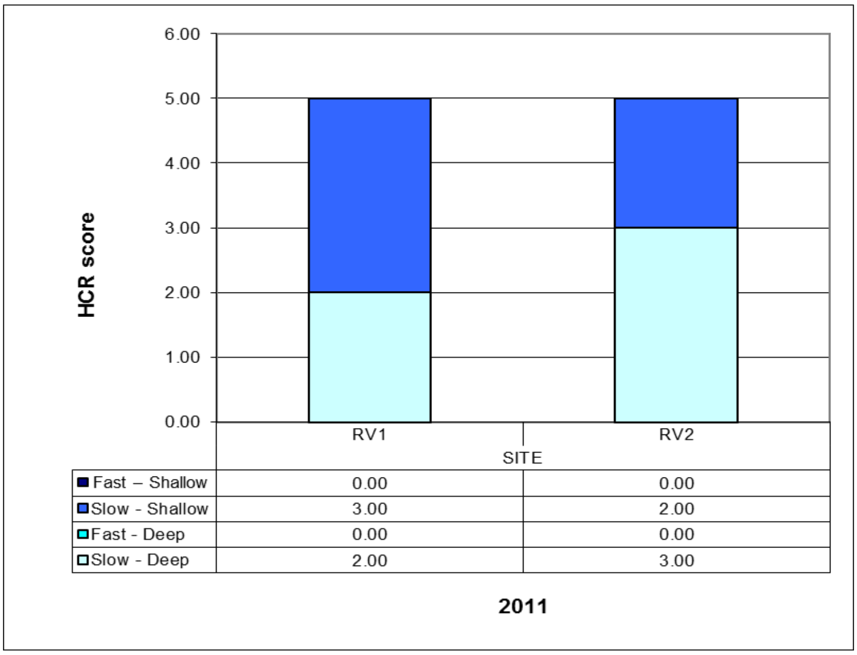

Figure 17: HCR scores for the two sites assessed for 2011

2014 fish survey

During the 2014 site survey period, the HCR results for the two sites on the Selons River (RV1 and RV2) are provided below:

It is clear that shallow-fast conditions predominate in the Selons River system followed by deep-fast conditions. The fish expected in the area will therefore be limited to fish with high intolerance values for slow flowing water habitats and to a lesser degree species with a high intolerance value for shallow slow water habitats and water column cover.

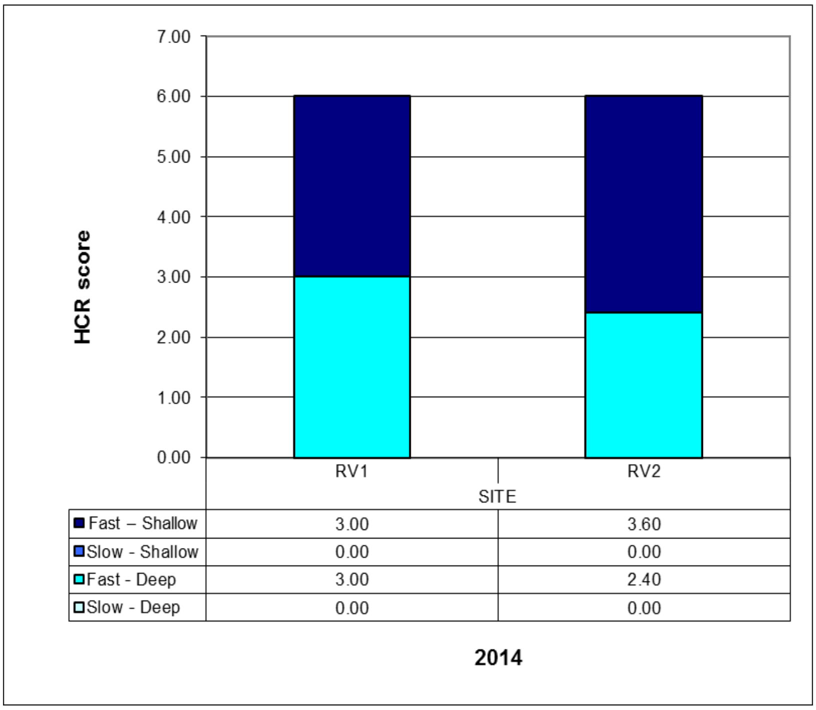

Figure 18: HCR scores for the two sites assessed for 2014

Electro-shocking for fish was conducted within the Selons River within a 100m radius upstream and downstream from the sites over a 20 to 30 minute period. Fish species that were caught were photographed and then released during the survey done within the Selons River sites.

Along the upstream site RV1, *Clarias gariepinus* (Sharptooth Catfish) and *Barbus anoplus* (Chubbyhead barb) species were captured while at the downstream site RV2 *B. anoplus* and *Barbus neefi* (Sidespot barb) were identified in the catch. Refer to figures below. The table below includes each species IUCN conservation status as well as their justification.

Table 16: Fish species obtained during the 2014 site visit including IUCN 2014 status and justification.

Scientific name	Common name	IUCN status	IUCN justification
Clarias gariepinus	Sharptooth Catfish	NYBA	This taxon has not yet been assessed for the IUCN Red List, but is in the Catalogue of Life.
Barbus anoplus	Chubbyhead Barb	LC	The species complex is widespread with no immediate threats. If the current taxonomic study confirms that there are separate species, the assessment as LC may need revision in some cases.
Barbus neefi	Sidespot Barb	LC	This species has a wide distribution, with no known major widespread threats. It is therefore listed as Least Concern. It has also been assessed regionally as Least Concern for central and southern Africa.

LC = Least Concerned, NT = Near Threatened, NYBA = Not yet been assessed by the IUCN.

The sub-WMA, which includes upper Olifants River tributaries (such as the Selons River), is not regarded important in terms of fish sanctuaries, rehabilitation or corridors (NFEPA, 2011).

Figure 19: *Clarias gariepinus* (Sharptooth Catfish) observed at the upstream RV1 site on the Selons River

Figure 20: *Barbus anoplus* (Chubbyhead barb) was observed at the upstream RV1 site on the Selons River

Figure 21: *Barbus anoplus* (Chubbyhead barb) observed at the downstream RV2 site on the Selons River

Figure 22: *Barbus neefi* (Sidespot barb) observed at the downstream RV2 site on the Selons River

Impacts on fish species

- Instream modifications such as sedimentation, bed modification and flow are considered to significantly impact on the fish community in the system and interfering with fish migrations along rivers.
- Water quality changes within the Selons Rivers are one of the chief impacts which may further affect the fish community if contaminated runoff or effluent reaches the receiving environment from the proposed mining development.

The table below summarises the ecological categories obtained using the FRAI. For ease of comparison the EC values obtained by using the MIRAI have again been included.

Table 17: Summary of the results (ecological categories) obtained from the application of the FRAI to the two assessment sites for 2011 and 2014, compared to that obtained using MIRAI.

YEAR	2011		2014	
Variable / Index (EC)	**RV1**	**RV2**	**RV1**	**RV2**
Kleynhans 2007 (FRAI)	E/F (19%)	E/F (20.9%)	E (26%)	E/F (23%)
Thirion 2007 (MIRAI)	E (37%)	E (34%)	E (34%)	E (33%)

EC = Ecological category

From the above it is clear that the EC calculated for the FRAI, along the Selons River sites, largely corresponds to that obtained for the MIRAI which would be expected since the drivers affecting the two assemblages are largely similar.

Drivers of ecological change within the ecoregions are overgrazing throughout the ecoregions, including in the riparian zone which leads to erosion, and causes high silt levels in the rivers. Increased siltation of in-stream habitats and fish gills results may lead to the loss and fish species. Siltation also increases the risk of flooding. Runoff from mines and other activities lowers the water quality in this ecoregion, and conditions are not likely to improve in the short term.

3.1.9 General water quality parameters

The points below summarise the key findings from the analyses of the general water quality parameters data for 2014 along the Selons River at sites RV1 and RV2 as well as three pans (P1, P3 and P4) which are within the subject property. Refer to Section A report for spatial indication of the pans. Concentrations of individual pans are presented Appendix 5 and is correlated to the South African Water Quality Guidelines in accordance to the Target Water Quality Range (TWQR) for safeguarding the health of aquatic ecosystems. Table 18 indicates water parameters which are not within acceptable TWQR parameters.

Target Water Quality Ranges (TWQR) for a particular constituent and water use is defined as the range of concentrations or levels at which the presence of the constituent would have no known adverse or anticipated effects on the fitness of the water assuming long-term continuous use, and for safeguarding the health of aquatic systems.

Table 18: Water quality test results which are not within acceptable TWQR parameters

Analysis and method	Unit	RV1	RV2	P1	P3	P4	Target Water Quality Ranges		
							Aquatic (Vol 7)	Recreational (Vol 2)	Agricultural (Vol 5)
Ph	pH	7.4	7.4	7.8	7.8	7.4	*	*	*
Electrical Conductivity (EC)	mS/m	11.1	10.2	208	15.9	8.3	/ (P1)	/ (P1)	/ (P1)
Total dissolved solids (TDS)	mg/l	98	80	1506	142	82	/ (P1)	NA	/ (P1)
Total Alkalinity	mg $CaCO_3$/l	44	36	506	64	20	NA	NA	NA
Chlorine (Cl)	mg/l	7	8	336	13	5	NA	NA	*
Sulphate (SO_4)	mg/l	<5	<5	6	<5	6	NA	NA	*
Nitrate (NO_3)	mg/l	0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	*
Barium (Ba)	mg/l	0.075	0.089	0.427	0.039	0.139	ND	ND	ND
Fluoride (F)	mg/l	0.2	0.2	0.7	0.2	<0.2	*	*	*
Calcium (Ca)	mg/l	7	6	18	6	5	NA	NA	*
Magnesium (Mg)	mg/l	5	4	11	3	2	NA	NA	*
Sodium (Na)	mg/l	7	8	368	22	4	NA	/ (P1)	/ (P1)
Potassium (K)	mg/l	2.6	<1.0	41	<1.0	4.4	NA	NA	NA
Aluminium (Al)	mg/l	1.64	0.812	0.146	0.1241	0.283	/	NA	NA
Iron (Fe)	mg/l	3.83	3.98	5.74	8.98	9.93	NA	NA	*
Manganese (Mn)	mg/l	0.104	0.048	1.27	0.337	1.89	*	NA	*
Silicon (Si)	mg/l	10.0	5.9	10.3	1.6	4.5	NA	NA	NA
Phosphorous (P)	mg/l	<0.025	<0.025	0.895	0.069	0.065	ND	ND	ND
Sulphur (S)	mg/l	1.18	1.52	4.99	0.981	2.67	NA	NA	NA
Strontium (Sr)	mg/l	0.043	0.051	0.225	0.043	0.034	ND	ND	ND
Titanium (Ti)	mg/l	0.028	<0.025	<0.025	<0.025	<0.025	ND	ND	ND

ND - No Data

NA - Not Available

*** - Within acceptable parameters**

/ - Not within acceptable parameters

- The spatial variation in concentration of various parameters between the upstream RV1 site and the downstream RV2 site along the Selons River are indicated below;
  - decreased by 50% for Al,
  - decreased by 14% for Ca,
  - decreased by 20% for Mg,
  - decreased by 53% for Mn,
  - increased by 18% for Sr and,
  - Ba increased by 19%,

- Fe increased by 4%,
- Na increased by 14%,
- S increased by 29% and
- Si decreased by 41%.

- None of the parameters exceeded the guidelines available for concentrations in the water samples within the Selons River system (TWQR).
- The data does however indicate that there were increases of some metal salts in the system between the upstream RV1 and downstream RV2 sites. In this regard specific mention is made of sodium, strontium and iron. It must however be noted that the absolute value of the change in the parameters is very low. This serves as an indication that small loads of heavy metals are being added by activities occurring either between the sites or from surrounding activities within the region and are entering into the Selons River system, prior to mining activities taking place.
- The data obtained in this study should be used as baseline data to compare monitoring data to as the proposed mining project progresses.

Pan (P1) had significantly greater concentrations of salts indicating that prior to mining in the area it is evident that salts are accumulating in this system. This can be regarded as a normal condition since pans with Endorheic drainage often display concentration of salts since the system has no outflow. The other pans (P3 and P4) as well as the Selons River sites RV1 and RV2 had concentrations that were within the acceptable parameters according to the TWQR guidelines and water in the system can generally be considered good.

3.1.10 Aquatic and wetland sensitivity mapping

Please refer to the wetland delineation report (Section D) for aquatic resource sensitivity mapping.

4 IMPACT ASSESSMENT

The impact assessment exercise was undertaken on all aspects of wetland and aquatic ecology deemed likely to be affected by the proposed Rietvlei Colliery. The sections below present the results of the findings per identified risk/impact for the instream and riparian zones of the subject property. Please note that if all impact mitigation measures are adhered to, all catchment areas (B32B, B12C, B12D and B12E) relating to the subject property will have lower impacts inferred (refer to Figure 2). Note that except for the Selons River that runs through the north eastern section of the subject property boundary there are no river runs through the study area. (refer to Figure 2). The Selons River and other nearby water resources however could be directly affected by mining activity from the proposed Rietvlei Colliery. Runoff and seepage from dirty water areas associated with the proposed Rietvlei mining activity may reach the Selons River system as well as other nearby water resources within catchments B32B, B12C, B12D and B12E. The impacts and mitigation measures highlighted in this report are relevant for all catchments surrounding the subject property.

The study identified that the aquatic resources in the area are of limited ecological importance and sensitivity. From the assessment several current impacts were observed which further limit the importance of the site.

With the proposed construction, operational as well as closure phases of the Rietvlei Colliery impacts on water quality and impacts on instream and riparian habitat are deemed possible which may affect the functionality of the systems surrounding the subject property. The future impacts from the proposed Rietvlei Colliery are assessed in the sections below.

4.1 Impacts on water quality

If all constituents in the cumulative discharge from the proposed Rietvlei mining activities are within the applicable target water quality ranges (DWAF, 1996), then the activities will not contribute significantly to an unacceptable cumulative impact. Thus a conservative approach is to be taken, in this case to account for possible discharge of pollutants by future activities in the river catchment. The Selons River (refer to figure 1) is the most significant aquatic system linked to the proposed Rietvlei colliery which may be impacted on and requires the most attention when considering impacts on reduced water quality and the impact it may have on the aquatic community. Continuous and close monitoring of this systems water quality is advised.

Increased sediment load

Increased erosion of disturbed surfaces means that the run-off contains a higher silt or sediment load which may be discharged in to the Selons River. The current natural state of the subject property comprises of vegetation cover which causes friction to rainfall run-off which reduces flow velocities and consequently shear forces between the water and the ground surface, resulting in the ground surface remaining intact and not being eroded away.

If for any reason the ground surface is disturbed and the flow velocities are increased then there is potential for increased erosion to occur. Increased sediment load contains suspended solids. If there are too many suspended solids in the water this can negatively affect biological life.

The following activities are likely to cause an increase in movement of sediment loads, or directly increase erosion:

- Stripping (vegetation clearance) of mining areas prior to excavation of pits and stockpiles areas
- Construction of hard-standing areas that increase run-off volumes, including roads, buildings and paved areas;
- Canalisation of run-off, particularly if canals do not discharge directly into the Selons River and
- Construction activities that loosen the ground surface.

Impaired water quality due to pollutants discharged from processing plant

Wastewater from the coal ore beneficiation process would contain pollutants in excess of the target water quality ranges (DWAF, 1996) for the water uses of the receiving water body and discharge of this would impact negatively on the surface water quality. A further consideration is the run-off of pollutants from the process plant area following rainfall, due to the activities within that area.

Impaired water quality due to pollutants in run-off from stockpiles

It is likely that run-off from the stockpiles will have a different chemical composition to natural run-off. In this event it is best practice to keep ‘dirty’ water from stockpile run-off separate from ‘clean’ water from natural run-off.

Impaired water quality due to pollutants in water discharged from opencast pits

Overflow of water (decant), whether surface or ground, from the pits could release pollutants to the surface water environment if geochemical testing indicates a possible acid mine drainage or other water quality issue.

Impaired water quality due to petrochemical spills

Fuel or oil spills from vehicles could contaminate surface water resources. Leakages, spills or run-off from vehicle wash bays, workshop facilities, fuel depots or storage facilities of potentially polluting substances could contaminate surface water resources.

Heavy metal contamination

Increase in metal concentrations is commonly associated with tillage and blasting of the upper crust of the earth's surface. This releases metals into the associated surface and ground water systems. Under alkaline conditions, most of the metals remain biologically unavailable, however in the presence of acid mine drainage the metal-speciation changes and they become available. This may alter the species composition of the aquatic biota inhabiting the surrounding rivers especially downstream of the proposed development.

Activities potentially leading to impact

Pre-Construction	Construction	Operational	Decommissioning and Closure
Poor planning leading to extensive and complex dirty water areas which need to be managed may impact on water quality	Clean and dirty water systems not being constructed to the required specifications to prevent contamination of clean water areas may impact on water quality	Mining activities and the establishment of mining waste may impact on water quality and thus needs to be managed to prevent pollution	Inadequate closure and rehabilitation leading to ongoing pollution from contaminating sources such as discard dumps may impact on water quality
Poor planning leading to placement of polluting structures in non-perennial drainage lines which would increase mobility of pollutants and may impact on water quality	Major earthworks and construction activities may lead to impacts on water quality	Clean and dirty water systems not being maintained and operated to the required specifications to prevent contamination of clean water areas may impact on water quality	Clean and dirty water systems not being maintained or decommissioned properly to the required specifications to prevent contamination of clean water areas may impact on water quality
Inadequate separation of clean and dirty water areas leading to contaminated water leaving the defined dirty water area may impact in water quality	Poor housekeeping and management may lead to impacts on water quality	Poor housekeeping and management during operational phase may lead to impacts on water quality	Poor housekeeping and management during decommissioning phase may lead to impacts on water quality
Clean and dirty water systems not being designed adequately to ensure protection of the water resources	Spills and other unplanned events may impact on water quality	Spills and other unplanned events during operational phase may impact on water quality	Spills and other unplanned events during decommissioning phase may impact on water quality

Aspects of instream water quality affected

Construction	Operational	Decommissioning and Closure
Impact on riparian vegetation structures due to impaired water quality	Impact on riparian vegetation structures due to impaired water quality	Impact on riparian vegetation structure due to impaired water quality

Construction	Operational	Decommissioning and Closure
Build-up of contaminants in sediments leading to the creation of a sediment sink and chronic source of potential water contamination	Build-up of contaminants in sediments leading to the creation of a sediment sink and chronic source of potential water contamination	Latent release of contaminants in sediments leading to the formation of an ongoing source of potential water contamination
	Impacts on groundwater quality which could manifest in surface water sources	Impacts on groundwater quality which could manifest in surface water sources

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Rietvlei Colliery	4	4	4	4	4	8	12	96 (Medium-high)

Essential mitigation measures:

- Ensure that as far as possible all infrastructures are placed outside of wetland, riparian, drainage and stream areas. In particular mention is made of the need to not encroach on the riparian systems on the Selons River within the proposed mine area and a minimum buffer of 100m around all wetland and riparian systems should be maintained in line with the requirements of regulation GN704 of the national Water Act;
- Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the national Water Act;
- Pollution control dams must be adequately designed to contain a 1:50 24 hour storm water event;
- All pollution control facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area;
- Permit only essential construction personnel within 32m of all riparian systems;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development;
- All hazardous chemicals must be stored on specified surfaces;
- Ensure that all spills are immediately cleaned up;
- Monitor all pollution control facilities using toxicological screening methods and implement the calculation of discharge dilution factors by means of the Direct Estimation of Ecological Effect Potential (DEEEP) protocol;
- Ongoing aquatic ecological monitoring must take place on a 6 monthly basis by an SA RHP Accredited assessor.

Recommended mitigation measures

- The extent of all operations which may impact the Selons River must be kept to an absolute minimum;
- No infrastructure or open pits should encroach into any major drainage lines.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Rietvlei Colliery	4	3	3	3	4	7	10	70 (Medium-low)

Probable latent impacts

- Ongoing salinisation of the water courses in the area;
- Impacts on pH; dissolved oxygen concentration and saturation;
- Loss of aquatic taxa intolerant to poor quality water.

4.2 Impacts on loss of aquatic habitat

Habitat transformation and destruction is the alteration of a natural habitat to the point that it is rendered unfit to support species dependent upon it as their home territory. Loss of or transformation of habitat may cause a reduction of biodiversity due to organisms previously using the area which are displaced or destroyed. Globally modification of habitats for agriculture is the chief cause of such habitat loss. Other causes of habitat destruction include surface mining, deforestation, slash-and-burn practices and urban development. Habitat destruction is presently ranked as the most significant cause of species population decrease and ultimately species extinction worldwide (IUCN, 2014). Additional causes of habitat destruction include water pollution, introduction of alien species, over grazing and over harvesting of resources such as fishing.

Riverine systems and particularly temporary riverine systems or river systems that have very low flows as part of their annual hydrological cycles are particularly susceptible to changes in habitat condition. The proposed mining activity of the proposed Rietvlei Colliery project has the potential to lead to habitat loss and/or alteration of the aquatic and riparian resources within the subject property and specifically along the Selons River.

Activities potentially leading to impact

Pre-Construction	Construction	Operational	Decommissioning and Closure
Poor planning leading to the placement of infrastructure within non-perennial drainage lines with special mention of the waste stockpile areas and the open pit areas themselves as well as roads, road crossings and bridges all may alter the aquatic habitat	Site clearing and the removal of vegetation leading to increased runoff and erosion may alter the aquatic habitat	Ongoing disturbance of soils during general operational activities may alter the aquatic habitat	Disturbance of soils as part of demolition activities may alter the aquatic habitat
Inadequate design of infrastructure leading to changes to instream habitat	Site clearing and road construction and the disturbance of soils leading to increased erosion may alter the aquatic habitat	Inadequate separation of clean and dirty water areas may alter the aquatic habitat during the operational phase	Inadequate separation of clean and dirty water areas may alter the aquatic habitat during the decommissioning phase

Pre-Construction	Construction	Operational	Decommissioning and Closure
Inadequate design of infrastructure leading to changes to system hydrology may alter the aquatic habitat	Earthworks in the vicinity of drainage systems leading to increased runoff and erosion and altered runoff patterns may alter the aquatic habitat	Mining related activities leading to increased disturbance of soils and drainage lines may alter the aquatic habitat	Ongoing pollution from inappropriately decommissioned structures may alter the aquatic habitat
Inadequate separation of clean and dirty water areas and the prevention of the release of sediment rich water may alter the aquatic habitat within the receiving environment	Construction of bridge crossings altering streamflow patterns and water velocities may alter the aquatic habitat	Any activities which lead to the reduction of flow in the system with special mention of the open pits and the use of surface and groundwater sources for production water may alter the aquatic habitat	Alien vegetation encroachment will impact on and alter the aquatic habitat
	Alien vegetation encroachment will impact on and alter the aquatic habitat	Alien vegetation encroachment will impact on and alter the aquatic habitat	

Aspects of instream habitat affected

Construction	Operational	Decommissioning and Closure
Erosion and incision of riparian zone	Erosion and incision of riparian zone	Erosion and incision of riparian zone
Altered wetting patterns leading to impacts on riparian zone continuity	Altered wetting patterns leading to impacts on riparian zone continuity	Altered wetting patterns leading to impacts on riparian zone continuity
Loss of low flow refugia	Loss of low flow refugia	Loss of low flow refugia
Altered substrate conditions from sandy conditions to more muddy conditions	Altered substrate conditions from sandy conditions to more muddy conditions	Altered substrate conditions from sandy conditions to more muddy conditions
Altered depth and flow regimes in the major drainage systems	Altered depth and flow regimes in the major drainage systems	Alien vegetation proliferation
Alien vegetation proliferation	Alien vegetation proliferation	

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Rietvlei Colliery	4	4	4	3	4	8	11	88 (Medium-high)
Essential mitigation measures:								

- Ensure that as far as possible all infrastructures are placed outside of wetland, riparian, drainage and stream areas. In particular mention is made of the need to not encroach on the riparian systems on the Selons River within the proposed mine area and a minimum buffer of 100m around all wetland and riparian systems should be maintained in line with the requirements of regulation GN704 of the national Water Act;
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of aquatic habitat in the area;
- Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation which may ultimately lead to transformation of aquatic habitat areas;
- Pollution control dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss or transformation of aquatic habitat;
- Permit only essential construction personnel within 100m of all riparian systems;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development as well as during operational phase of the mine;
- Implement alien vegetation control program within wetland and riverine areas with special mention of water loving tree species;
- Ongoing aquatic ecological monitoring must take place on a 6 monthly basis by an SA RHP Accredited assessor.

Recommended mitigation measures

- The extent of all operations which may impact aquatic habitat must be kept to an absolute minimum;
- No infrastructure or open pits should encroach into any major drainage lines;
- Revegetate all disturbed areas with indigenous tree species and make use of indigenous species with an affinity for riparian zones.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Rietvlei Colliery	4	3	3	3	4	7	10	70 (Medium-low)

Probable latent impacts

- Sedimentation of the systems may occur for long after mining is completed;
- Eroded and incised streams are unlikely to be rehabilitated;
- Silted up refuge pools are unlikely to be naturally rehabilitated and are unlikely to be rehabilitated by the mine;
- Altered riparian vegetation structures.

4.3 Impacts on loss of aquatic biodiversity and sensitive taxa

Loss or a decrease of aquatic biodiversity and sensitive taxa is largely driven by impacts stressed by instream flow, altered water quality and habitat loss. The aquatic resources in the area do however support, or potentially support, an aquatic community of significant diversity and sensitivity. The monitoring of aquatic communities such as macro-invertebrates and fish within aquatic systems vary over season and other factors such as weather play a vital role when field studies are conducted. It is thus crucial to implement a regular monitoring strategy which will increase the data set and understanding of the aquatic community within the surrounding aquatic systems linked to the study and mining rights area. It is recommended that a biannual high flow (Summer) and low flow (Winter) biomonitoring strategy be implemented as part of the ongoing monitoring program with an initial quarterly assessment prior to major construction in the area.

The planned mining activities of the proposed Rietvlei Colliery project have the potential to lead to a loss of aquatic biodiversity. Future assessments on the aquatic community will help with management decisions.

Activities potentially leading to impact

Pre-Construction	Construction	Operational	Decommissioning and Closure
Poor planning leading to the placement of infrastructure within non-perennial drainage lines with special mention of the overburden stockpile areas, open pits as well as road crossings and bridges may lead to a loss in aquatic biodiversity	Site clearing and the removal of vegetation may lead to a loss in aquatic biodiversity	Ongoing disturbance of soils with general operational activities may lead to a loss in aquatic biodiversity	Disturbance of soils as part of demolition activities may lead to a loss in aquatic biodiversity
Inadequate design of infrastructure leading to changes to instream habitat may lead to a loss in aquatic biodiversity	Site clearing and road construction may lead to a loss in aquatic biodiversity	Inadequate separation of clean and dirty water areas may lead to a loss in aquatic biodiversity	Inadequate separation of clean and dirty water areas may lead to a loss in aquatic biodiversity
Inadequate design of infrastructure leading to changes to system hydrology may lead to a loss in aquatic biodiversity	Earthworks and other mining construction activities in the vicinity of wetland and riparian areas may lead to a loss in aquatic biodiversity	Loss of instream flow due to abstraction for water for production and the formation of a cone of dewatering from open pits may lead to a loss in aquatic biodiversity	Seepage from any latent discard dumps and dirty water areas may lead to a loss in aquatic biodiversity
Inadequate design of infrastructure leading to contamination of water and sediments in the streams may lead to a loss in aquatic biodiversity	Placement of infrastructure within non-perennial drainage lines with special mention of the overburden stockpile areas, open pits as well as road crossings and bridges may lead to a loss in aquatic biodiversity	Seepage from the discard dumps and overburden stockpiles may lead to a loss in aquatic biodiversity	Inadequate closure leading to post closure impacts on water quality may lead to a loss in aquatic biodiversity
	Inadequate separation of clean and dirty water areas may lead to a loss in aquatic biodiversity	Discharge from the mine process water system with special mention of RWD and any PCD's may lead to a loss in aquatic biodiversity	Ongoing erosion of disturbed areas that have not been adequately rehabilitated may lead to a loss in aquatic biodiversity

Pre-Construction	Construction	Operational	Decommissioning and Closure
		Sewage discharge from mine offices and camps may lead to a loss in aquatic biodiversity	
		Nitrates form blasting leading to eutrophication of the receiving environment and may lead to a loss in aquatic biodiversity	

Aspects of aquatic biodiversity affected

Construction	Operational	Decommissioning and Closure
Sedimentation and loss of natural substrates	Sedimentation and loss of natural substrates	Sedimentation and loss of natural substrates
Altered stream channel forms	Altered stream channel forms	Altered stream channel forms
Increased turbidity of water	Increased turbidity of water	Loss of refugia
Loss of refugia	Loss of refugia	Deterioration in water quality with special mention of impacts from cyanide, heavy metals and salinisation
Deterioration in water quality	Deterioration in water quality with special mention of impacts from cyanide, heavy metals, AMD And	Eutrophication of the aquatic ecosystems
Loss of flow sensitive macro-invertebrates and fish	Eutrophication of the aquatic ecosystems	Loss of flow sensitive macro-invertebrates and fish
Loss of water quality sensitive macro-invertebrates and fish	Loss of flow sensitive macro-invertebrates and fish	Loss of water quality sensitive macro-invertebrates and fish
Loss of riparian vegetation species	Loss of water quality sensitive macro-invertebrates and fish	Loss of riparian vegetation species
	Loss of riparian vegetation species	

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Rietvlei Colliery	4	4	4	3	4	8	11	88 (Medium-high)

Essential mitigation measures:

- Ensure that as far as possible all infrastructure is placed outside of sensitive wetland areas, streams and rivers;

- Pollution control dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts form inundation and siltation;
- Permit only essential construction personnel within 100m of the wetland habitat;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development;
- Use of water must be minimised as far as possible in order to minimise the loss of recharge of the Selons River system;
- Limit the footprint area of the construction activity to what is absolutely essential in order to disturbance of soils leading to runoff, erosion and sedimentation and loss of instream flow and stream recharge;
- Prevent run-off from dirty water areas entering stream and river systems through ensuring clear separation of clean and dirty water areas;
- Ensure that the mine process water system is managed in such a way as to prevent discharge to the receiving environment and to prevent discharge of dirty water;
- Implement measures to contain seepage as far as possible to prevent contamination of the groundwater regime;
- Implement alien vegetation control program within wetland and riparian areas;
- Monitor all systems for erosion and incision;
- Any areas where active erosion is observed must be rehabilitated and berms utilised to slow movement of water;
- Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment;
- Toxicological monitoring of the receiving and process water systems on a quarterly basis.

Recommended mitigation measures

- The extent of all operations which may impact aquatic habitat must be kept to an absolute minimum;
- No infrastructure or open pits should encroach into any major drainage lines.
- Monitoring of sediment heavy metal concentrations.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Rietvlei Colliery	4	3	3	3	4	7	10	70 (Medium-low)

Probable latent impacts

- Loss of some flow dependent species is likely;
- Loss of some species less tolerant of water quality changes is likely;
- Loss of some low flow refugia is possible.

4.4 Impacts on loss of instream flow

Impacts which may alter the hydrology and geology of aquatic systems may have a huge impact on the instream aquatic communities. Impacts which may lead to reduced instream flow and aquatic refugia may ultimately lead to the loss of flow dependant taxa along with water quality. Activities relating to the Rietvlei Colliery and activities within the subject property (refer to figure 2) should not lead to any hydrological or geological alterations within any aquatic system within or surrounding the subject property. Other drainage lines, within all catchment regions, surrounding the subject property should also be taken into account when planning of the proposed mine takes place.

It is expected that activity proposed to take place within the subject property (refer to figures 1 and 2) may lead to changes to peak flows in the Selons River. Factors which may play a role are indicated below:

- Change in surface coverage. Development within the subject property will change the surface coverage in some areas from vegetated soil to buildings, hardened gravel roads, paved areas (parking), and compacted earth.
- Impacts of opencast pit mining would lower instream flow in the receiving environment and may lead to catchment yield changes.
- Inadequate separation and management of clean and dirty water may lead to unnatural instream flow changes which may affect the flow characteristics and ultimately lead to loss of catchment yield.
- Capture of run-off and capture of rainfall in the 'dirty' area would lower instream flow in the receiving environment.
- Canalisation of run-off. Intercepting run-off around mining activities and infrastructure could reduce the amount of time that water would take to reach the Selons River. This is likely to occur due to the decreased friction on the water associated with concentrated flow in a concrete-lined canal as opposed to sheet flow on a hill slopes, and the consequently lower flow velocities.

The above factors are likely to lead to altered riverine recharge flood peaks and a general loss of runoff volumes successfully reaching the Selons River system as well as the other drainage systems in the area. This in turn may lead to the loss of aquatic biota such as fish and aquatic macro-invertebrates which rely on the presence of clean and fresh surface water within the Selons River.

Activities potentially leading to impact

Pre-Construction	Construction	Operational	Decommissioning and Closure
Poor planning leading to extensive dirty water areas which need to be managed which may reduce the MAR to the non-perennial drainage systems in the area	Construction of possible small stream diversions may impact on the instream flow of the receiving systems	Loss of MAR from dirty water areas may impact on the instream flow of the receiving systems	Loss of MAR from latent dirty water areas may still impact on the flow even after operational phase

Pre-Construction	Construction	Operational	Decommissioning and Closure
Inadequate design of temporary stream diversions which may lead to loss of recharge of the larger systems	Construction of clean and dirty water separation structures for pollution control purposes may lead to altered flow levels	Loss of water through clean and dirty water separation may alter instream flow on the receiving systems	Loss of water to inadequately rehabilitated areas such as discard dumps and open pits may still have an impact on the flow post operational phase
Encroachment of open pits into non-perennial drainage features which may lead to reduced instream flow in downstream areas and potentially the Selons River	Clearing of areas for the initiation of the production pits may lead to reduced instream flow	The formation of a cone of dewatering created by open pits may lead to loss of stream flow	The formation of a cone of dewatering created by final voids may impact on the flow in the post operational phase
Open pits positioned too near to non-perennial drainage features may lead to loss of stream flow and baseflow due to the formation of a cone of dewatering by the open pits	Use of surface water runoff and groundwater as a water supply during construction mining project may alter the flow in the receiving systems	Use of surface water runoff and groundwater as a water supply during the operational phase of the mine may lead to reduced instream flow	Use of surface water runoff and groundwater as a water supply during the closure phase of the mine may impact on the flow
Design of canals leading to rapid release of water which in turn may lead to a loss of streamflow regulation capabilities in the area		Impact on natural streamflow regulation and stream recharge due to altered hydrology in the area may lead to altered instream flow	Impact on natural streamflow regulation and stream recharge due to altered hydrology in the area may impact on the flow post operational phase
Use of surface runoff and groundwater sources for the supply of production water for the mining project may alter the flow in the receiving systems			

Aspects of instream flow affected

Construction	Operational	Decommissioning and Closure
Loss of instream surface and base flow	Loss of instream surface and base flow	Loss of instream surface and base flow
Loss of streamflow regulation and stream recharge	Loss of streamflow regulation and stream recharge	Loss of streamflow regulation and stream recharge
Loss of aquatic habitats for aquatic macro-invertebrates and fish	Loss of aquatic habitats for aquatic macro-invertebrates and fish	Loss of aquatic habitats for aquatic macro-invertebrates and fish
Increased moisture stress on riparian vegetation	Increased moisture stress on riparian vegetation	Increased moisture stress on riparian vegetation

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Rietvlei Colliery	4	3	3	4	5	7	12	84 (Medium-high)

Essential mitigation measures:

- Ensure that as far as possible all infrastructures are placed outside of drainage and river areas. In particular mention is made of the need to not encroach on the riparian systems near the Selons River with a minimum buffer of 100m around all wetland and riparian systems should be maintained in line with the requirements of regulation GN704 of the national Water Act;
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas;
- No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Selons River;
- Very strict control of water consumption must take place and detailed monitoring must take place and where all water usage must continuously be optimised;
- Upstream dewatering boreholes should be utilised to minimise the creation of dirty water and this clean water should be used to recharge the natural systems downstream of the mining rights areas;
- Pollution control dams should be off stream and tributary structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge;
- Permit only essential construction personnel within 32m of all riparian systems;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development;
- Implement alien vegetation control program within wetland areas with special mention of water loving tree species;
- Monitor all affected riparian systems for moisture stress;
- Monitor all potentially affected riparian zones for changes in riparian vegetation structure;
- Ongoing aquatic ecological monitoring must take place on a 6 monthly basis by an SA RHP Accredited assessor;

Recommended mitigation measures

- The extent of the operations in the mining rights area must be kept to an absolute minimum
- No infrastructure or open pits should encroach into any major drainage lines

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Rietvlei Colliery	4	3	3	3	4	7	10	70 (Medium-low)

Probable latent impacts

- Reduced availability of refugia for aquatic biota;
- Altered riparian vegetation structures.

4.5 Impact assessment conclusion

Based on the above assessment it is evident that there are four possible impacts that may have an effect on the overall aquatic integrity of the aquatic resources in the vicinity of the subject property for the proposed Rietvlei Colliery. The table below summarises the findings indicating the significance of the impacts before mitigation takes place as well as the significance of the impacts if appropriate management and mitigation takes place. From the table it is evident that prior to mitigation, most of the impacts are Medium - High level impacts, while if mitigation takes place the majority of the impacts can be reduced to Medium - Low level impacts.

Table 19: Summary of impact significance.

No	Impact	Unmanaged	Managed
1	Impacts on water quality	Medium - High	Medium - Low
2	Loss of Aquatic habitat	Medium - High	Medium - Low
3	Loss of Aquatic Biodiversity and sensitive taxa	Medium - High	Medium - Low
4	Loss on Instream flow	Medium - High	Medium - Low
	SUMMARY	**Medium - High**	**Medium - Low**

The construction footprint should as far as possible be limited, and mitigation measures (with emphasis on effective rehabilitation) should be implemented to minimise the construction impacts associated with the proposed Rietvlei Colliery. The majority of the negative impacts associated with the facility will be experienced during the lifetime of the mine, most of which are predicted to have a Medium - High significance. It is envisaged that impacts can be well mitigated leading to a Medium - Low significance for each of the impacts.

According to the State of the Rivers Report for the Olifants River Systems, the upper parts of the Olifants River catchment, mining-related disturbances are the main causes of impairment of river health (DWAF and RHP, 2014). The Olifants River catchment experiences extreme demand for natural resources, and associated land modification and pollution. Thus river ecosystems in this area are generally in a fair to poor condition (DWAF and RHP, 2014). There is also an extensive invasion by alien vegetation, and to a lesser extent alien fauna. The biodiversity of the Olifants River is under threat as a result of the cumulative impacts throughout the catchment and within the Olifants River tributaries such as the Selons River. These impacts are apparent in water pollution, siltation and reduced stream flows as a result of agriculture, mining, industry and power generation. Ecologically insensitive releases of water and sediment from storage dams are another major cause of environmental degradation downstream, which is particularly relevant in the middle and lower parts of the Olifants River catchment.

Priority actions for the Olifants River catchment include as per (DWAF and RHP, 2014) recommendations:

- Wetland protection and rehabilitation in the areas of the headwaters of these rivers;
- Control of alien plants especially in riparian zones, in all catchments;
- Control of effluent and mining related seepage in the upper reaches of the Olifants Catchment; and
- Release from storage dams should be based on ecological flow requirements, especially in the Olifants River catchment.

5 CONCLUSION

The aquatic assessment section of this report serves to document the condition at the times of sampling to indicate the state of the riverine ecological integrity at a low flow (October 2011) and high flow (January 2014) period prior to the proposed mine being commissioned. This data is considered baseline data and represents the state of the river prior to mining activities.

The following sections indicate the key findings of the study:

Physico-Chemical Water Quality

- General water quality can be considered fair although it is evident that dissolved salts are generally elevated in the region and there is some variability in salt concentrations between the two points along the Selons River system.
- Spatially during the spring of 2011, the Electrical Conductivity (EC) data indicates that the RV1 site on the upstream section of the Selons River is 22% higher than the downstream value at RV2 along the Selons River. The summer 2014 EC indicated a 6% difference between the upstream and downstream sites.
- Some additional impact from upstream activities, upstream of site RV1, on this system is deemed likely. The observed values are within the Olifants River Environmental Water Quality Assessment (OREWA, 2001) guidelines for this reach of the Olifants River system.
- It is evident that the EC between the two assessment points on the Selons River during 2011 and 2014 indicate that salinisation of the upper catchment is likely to be occurring, most likely as a result of agricultural activities in the area. The data however indicates that currently there is no addition of dissolved salts between the two assessment points for both 2011 and 2014 surveys.
- In terms of OREWA (2001) guidelines the dissolved salt concentrations in the systems are within the guideline value, supporting the findings, during 2011 and

2014, that there is no osmotic stress on the aquatic communities that may occur within the Selons River system.

- The pH may be considered natural and no impact on the aquatic ecology of the system is deemed likely at the current time and for the 2011 site survey period.
- No Dissolved Oxygen (DO) was conducted during the 2011 monitoring period.
- Along the Selons River the dissolved oxygen at both upstream RV1 (84%) site and the downstream site RV2 (83%) were within the desired 80% to 120% range for aquatic ecosystems (DWAF, 1996);
- The dissolved oxygen concentration is acceptable and can be regarded as suitable for supporting a diverse and sensitive aquatic community.
- Temperatures can be regarded as normal for the time of year and time of day when assessment took place.

General water quality parameters

The general water quality parameters within the Selons River and pans P3 and P4 are within the acceptable parameters in accordance to TWQR guidelines (DWAF, 1996). The water quality in pan P1 indicates that there may be adverse or negative effects taking place on the fitness of the water and the health of the aquatic system.

VEGRAI assessment

The results of this assessment indicate that both the upstream RV1 and downstream RV2 Selons River sites fall within an Ecological Category Class C (Kleynhans et al, 2007) for year 2011 and 2014, indicating a loss and change of natural habitat having occurred, but the basic ecosystem functions are still predominately unchanged (Kleynhans et al, 2007). The primary modifier to this system is likely to be the water quality and flow modification, due to the proximity to historical and current agricultural activities, that include livestock farming, which may contribute to the moderately modified vegetation in the system.

Invertebrate Habitat Integrity Assessment (IHIA)

2011 IHIA summary

The RV1 site achieved an IHIA score of 49% while the RV2 site 54%. Based on the classification system of Kemper 1999 both sites have habitat conditions that can be described as largely modified (Class D), where a loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged refer to appendix 4 for IHIA scores.

2014 IHIA summary

During the 2014 site survey, the two Selons River sites achieved an IHIA rating of 70% (RV1) and 72% (RV2), where an increase from class D to a class C has been observed since 2011 early spring late winter survey. Currently in 2014 the habitat is deemed moderately modified indicating a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged (Kemper, 1999).

Invertebrate Habitat Assessment System (IHAS)

During the October 2011 survey, the RV1 site and RV2 site achieved an IHAS score of 46 and 44 respectively. This indicated that during 2011, habitat diversity and structure was considered inadequate for supporting a diverse aquatic macro-invertebrate community under the 2011 flow conditions.

During the 2014 assessment, an IHAS score of 71 and 67 was achieved and the RV1 site and RV2 site. Habitat diversity and structure at this time was adequate for supporting a diverse aquatic macro-invertebrate community at both points (McMillian, 1998) therefore a diverse aquatic macro-invertebrate community can be expected in the Selons River during the 2014 site survey period which is indicative of high flow conditions.

Aquatic Macro-Invertebrates (SASS5)

2011

- During the early spring 2011 assessment, the two assessment sites can be considered as Class D (largely impaired) sites according to the Dickens and Graham (2001). With mostly tolerant taxa present.
- According to Dallas (2007) classification systems the upstream RV1 site and the downstream RV2 sire are classed a Class E/F (severely/critically impaired). This is due to the naturally limited habitat that is available and the lack of flow in the river at the time of assessment (early spring 2011).
- Based on the available habitat conditions with special mention of the lack of flow and the lack of bankside vegetation cover, the poor aquatic macro-invertebrate community score in the system is most likely due to the limited availability of natural habitat at the RV1 and RV2 sites.

2014

- During the early 2014 assessment, the two assessment sites can be considered as Class D (largely impaired) sites according to the Dickens and Graham (2001).
- According to Dallas (2007) classification systems both upstream RV1 site and downstream RV2 sites are classed a Class E/F (severely/critically impaired). Even

with an increase in flow these classifications have remained the same since the 2011 site survey at both sites.

- Based on the available habitat conditions the poor aquatic macro-invertebrate community score in the system is most likely due to the limited availability of natural habitat at the RV1 and RV2 sites.

- The primary impact which may affect macro-invertebrates within the Selons River at the current time which is expressed from farming activities as well as possible mining operations is water quality changes. The significance of this and other impacts can however be reduced with management actions to avoid significant degradation which may lead to additional loss of aquatic communities

Aquatic Macro-invertebrates (MIRAI)

The MIRAI results in terms of (Ecological Category classification) follow similar trends as that obtained using the SASS class classifications. The PES obtained from the application of MIRAI (Thirion, 2007) were as follows; for 2011 RV1 was a class D (41%) and RV2 class D (43%). During the 2014 site survey, RV1 was a class D (45%) and RV2 a class D (47%). The overall general deterioration in terms of macro-invertebrate community integrity is clearly evident throughout the two assessment sites along the Selons River at both low flow as well as the high flow periods. The MIRAI results confirm the SASS results for these sites.

Fish community integrity

Habitat Cover Rating (HCR) results for the two sites on the Selons River (RV1 and RV2) are provided for the 2011 early spring survey as well as the 2014 site survey period. Habitat conditions during the 2011 period were suited for slow flowing shallow and deep water species. For the 2014 HCR it is clear that shallow-fast conditions predominate in the Selons River system followed by deep-fast conditions.

Electro-shocking for fish was conducted within the Selons River within a 100m radius upstream and downstream from the sites over a 20 to 30 minute period. Fish species that were caught were photographed and then released during the survey done within the Selons River sites

No fish were caught during the 2011 site survey. During the 2014 site survey the fish expected in the area will be limited to fish with high intolerance values for slow flowing water habitats and to a lesser degree species with a high intolerance value for shallow slow water habitats and water column cover.

- Along the upstream site RV1, *Clarias gariepinus* (Sharptooth Catfish) and *Barbus anoplus* (Chubbyhead barb) species were captured while at the downstream site RV2 *B. anoplus* and *Barbus neefi* (Sidespot barb) were identified in the catch.

Impacts on fish species

- Instream modifications such as sedimentation, bed modification and flow are considered to significantly impact on the fish community in the system and interfering with fish migrations along rivers.
- Water quality changes within the Selons Rivers are one of the chief impacts which may further affect the fish community if contaminated runoff or effluent reaches the receiving environment from the proposed mining development

It is clear that the EC calculated for the FRAI (Kleynhans, 2007), along the Selons River sites, for 2011 RV1 (19%) and RV2 (20.9%) as well as for 2014 RV1 (26%) and RV2 (23%), largely corresponds to that obtained for the MIRAI which would be expected since the drivers affecting the two assemblages are largely similar

Drivers of ecological change within the ecoregions are overgrazing throughout the ecoregions, including in the riparian zone which leads to erosion, and causes high silt levels in the rivers. Increased siltation of in-stream habitats and fish gills results may lead to the loss and fish species. Siltation also increases the risk of flooding. Runoff from mines and other activities lowers the water quality in this ecoregion, and conditions are not likely to improve in the short term

Impact assessment

The aquatic resources in the vicinity of the subject property occur in open farm lands and have been slightly affected by farming activities in the area resulting in inundation and some erosion. These impacts have, however, been small. Many of the impacts which occur as a result of the colliery development will affect the local area for a long duration and are likely to increase the existing impacts on the receiving environment. If mitigation measures are implemented, the likelihood of further impacts occurring and the consequence of the impacts are significantly reduced to a significantly lower levels and the duration of impacts becomes significantly reduced.

The construction footprint should as far as possible be limited, and mitigation measures (with emphasis on effective rehabilitation) should be implemented to minimise the construction impacts associated with the proposed Rietvlei Colliery. The majority of the negative impacts associated with the facility will be experienced during the lifetime of the mine, most of which are predicted to have a Medium - High significance. It is envisaged that impacts can be well mitigated leading to a Medium - Low significance for each of the impacts.

Cumulative impacts

According to the State of the Rivers Report for the Olifants River Systems, the upper parts of the Olifants River catchment, mining-related disturbances are the main causes of impairment of river health (DWAF and RHP, 2014). The Olifants River catchment experiences extreme demand for natural resources, and associated land modification and pollution. Thus river ecosystems in this area are generally in a fair to poor condition (DWAF and RHP, 2014). There is also an extensive invasion by alien vegetation, and to a lesser extent alien fauna. The biodiversity of the Olifants River is under threat as a result of the cumulative impacts throughout the catchment and within the Olifants River tributaries such as the Selons River. These impacts are apparent in water pollution, siltation and reduced stream flows as a result of agriculture, mining, industry and power generation. Ecologically insensitive releases of water and sediment from storage dams are another major cause of environmental degradation downstream, which is particularly relevant in the middle and lower parts of the Olifants River catchment.

Priority actions for the Olifants River catchment include as per (DWAF and RHP, 2014) recommendations:

- Wetland protection and rehabilitation in the areas of the headwaters of these rivers;
- Control of alien plants especially in riparian zones, in all catchments;
- Control of effluent and mining related seepage in the upper reaches of the Olifants Catchment; and
- Release from storage dams should be based on ecological flow requirements, especially in the Olifants River catchment.

6 IMPACT MINIMISATION AND RECOMMENDATIONS

Based on the findings of this assessment several recommendations are made to minimise the impact on the wetland and aquatic ecology of the area, which are presented in the points below:

- Measures to contain and reuse as much water as possible within the mine process water system and water from underground dewatering activities should be sought.
- A return water structure should be developed where mine process water is stored in a lined dam in order to prevent impacts on the receiving aquatic environment.
- As far as possible all mining infrastructures should remain out of the riparian zone and associated buffer in line with the requirements of Regulation GN704 of the National water Act.
- No dirty water runoff must be permitted to reach the wetland and riverine resources during the entire life of mine, and clean and dirty water management systems must be put in place to prevent the contaminated runoff (suspended solids and salts and water with low pH) from entering the receiving aquatic environment. All dirty water containment structures should be designed to contain a minimum storm event of a 24 hour 1 in 50 year flood event.
- Any dirty water runoff containment facilities must remain outside of the defined wetland areas and their buffers as a measure to minimise the footprint areas of mining within sensitive wetland areas.
- Adequate stormwater management must be incorporated into the design of the proposed development in order to prevent erosion and the associated sedimentation of the riparian and instream areas, as these systems have aquatic communities which rely on stream substrates clear of sediment and on clear, fast flowing water. In this regard special mention is made of:
    - Sheet runoff from cleared areas, paved surfaces and access roads needs to be curtailed.
    - Runoff from paved surfaces should be slowed down by the strategic placement of berms.
- During any construction phase or exploration drilling activities no vehicles should be allowed to indiscriminately drive through the wetland areas and vehicles must remain on designated roadways.
- All areas of increased ecological sensitivity near to mining operations should be clearly marked as “out of bounds” areas for all mining staff.
- During the construction and operational phases of the proposed mining development erosion berms should be installed to prevent gully formation and siltation of the wetland resources. The following points should serve to guide the placement of erosion berms:
    - Where the track has slope of less than 2%, berms every 50m should be installed.

- Where the track slopes between 2% and 10%, berms every 25m should be installed.
- Where the track slopes between 10%-15%, berms every 20m should be installed.
- Where the track has slope greater than 15%, berms every 10m should be installed.

- No dumping of waste should take place within the riparian zone. If any spills occur, they should be immediately cleaned up.
- Upon closure it is deemed essential that all MRD's be rehabilitated and stabilised using a suitable grass mix to prevent sedimentation of the aquatic resources in the area.
- Throughout the life of mine measures to control alien vegetation must be implemented and specific attention to riverine features should be paid.
- Upon closure all haul and access roads as well as all unnecessary mining infrastructures should be removed in order to minimise the impacts on the aquatic resources of the area beyond the life of mine.
- Close monitoring of water quality must take place. Monitoring of water quality should take place at a minimum frequency of once a month during which time major salts and basic metals, are monitored along with basic parameters such as pH, TSS and TDS, dissolved oxygen and EC.
- Ongoing biomonitoring of the aquatic resources in the vicinity of the mine must take place. Biomonitoring should take place at points located upstream and downstream of the mining activities on the Selons Rivers as long as there is sufficient habitat to do so. Biomonitoring should take place on 6 monthly basis as a minimum in the summer and winter of each year. Biomonitoring should take place using the SASS5 and IHAS indices. Biomonitoring should take place throughout the life of the mine, including the closure and aftercare phases. The results of the biomonitoring program should be compared to the results of this study to allow any temporal trends to be observed. Should any problems be indicated measures to minimise or prevent the impact should be implemented.
- Toxicity testing of the proposed mines underground and open pit discharge should take place concurrently with the biomonitoring program in order to monitor the toxicological risk of the process water system to the receiving environment. Tests should include the following test organisms as a minimum:
  - Vibrio fischeri
  - Daphnia pulex
  - Algal Growth Potential

- Definitive toxicological testing according to the DEEEP protocol should take place should it become evident that process water discharge or decant of underground water will occur.

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Appendix 1: VEGRAI Score Sheets

Site RV1 (US)

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	66.7	37.0	3.3	1.0	100.0
NON MARGINAL	53.3	23.7	0.0	2.0	80.0
	2.0				180.0
LEVEL 3 VEGRAI (%)				60.7	
VEGRAI EC				**C/D**	
AVERAGE CONFIDENCE				1.7	

Site RV2 (DS)

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	70.0	38.9	3.3	1.0	100.0
NON MARGINAL	60.0	26.7	0.0	2.0	80.0
	2.0				180.0
LEVEL 3 VEGRAI (%)				65.6	
VEGRAI EC				**C**	
AVERAGE CONFIDENCE				1.7	

Appendix 2: IHIA Score Sheets

Instream Habitat Integrity

Weights	14	13	13	13	14	10	9	8	6		
SITE	**Water abstraction**	**Flow modification**	**Bed modification**	**Channel modification**	**Water quality**	**Inundation**	**Exotic macrophytes**	**Exotic fauna**	**Solid waste disposal**	**Total Score (%)**	**Classification**
RV1 2011	7	15	13	11	9	5	9	6	3	49	D Largely modified
RV2 2011	8	10	11	10	6	6	7	3	4	64	C Moderately modified
RV1 2014	8	12	9	10	9	7	1	1	6	64	C Moderately modified
RV2 2014	6	11	9	6	8	8	2	1	7	68	C Moderately modified

None (0)	Small (1-5)	Moderate (6 – 10)	Large (11 – 15)	Serious (16 – 20)	Critical (21 – 25)

Riparian Zone Habitat Integrity

Weights	13	12	14	12	13	11	12	13		
SITE	**Vegetation removal**	**Alien encroachment**	**Bank erosion**	**Water abstraction**	**Flow modification**	**Channel modification**	**Water quality**	**Inundation**	**Total Score (%)**	**Classification**
RV1 2011	9	8	15	7	11	12	9	6	48	D Largely modified
RV2 2011	9	10	11	6	12	11	8	9	43	D Largely modified
RV1 2014	3	1	10	5	8	5	8		76	C Moderately modified
RV2 2014	2	3	8	8	6	5	9		75	C Moderately modified

None (0)	Small (1-5)	Moderate (6 – 10)	Large (11 – 15)	Serious (16 – 20)	Critical (21 – 25)

Combined Habitat Integrity (Kemper, 1999)

SITE	*INSTREAM HABITAT*	*RIPARIAN ZONE*	*IHI SCORE*	*CLASS*
RV1 2011	49	48	*49*	D Largely modified
RV2 2011	64	49	*54*	D Largely modified
RV1 2014	64	76	70	C Moderately modified
RV2 2014	68	75	72	C Moderately modified

Appendix 3: IHAS Score Sheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:
Site Name: RV1
Date: 05/10/2011

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3

(* NOTE: up to 25% of stone is usually embedded in the stream bottom)

SIC Score (max 20): 10

VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75

Vegetation Score (max 15): 0

OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over

(** NOTE: you must still fill in the SIC section)

Other Habitat Score (max 20): 15

HABITAT TOTAL (MAX 55): 25

STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		

(*** NOTE: if more than one option, choose the lowest)

STREAM CONDITIONS TOTAL (MAX 45): 21

TOTAL IHAS SCORE (%): 46

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:

Site Name: RV2 **Date**: 05/10/2011

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3

(* NOTE: up to 25% of stone is usually embedded in the stream bottom)

SIC Score (max 20): 10

VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75

Vegetation Score (max 15): 0

OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over

(** NOTE: you must still fill in the SIC section)

Other Habitat Score (max 20): 16

HABITAT TOTAL (MAX 55): 26

STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		

(*** NOTE: if more than one option, choose the lowest)

STREAM CONDITIONS TOTAL (MAX 45): 18

TOTAL IHAS SCORE (%): 44

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: SELONS (US)
Site Name: RV1
Date: 21/01/2014

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC Score (max 20):				15		
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none	0	1-25	26-50	51-75	>75
Vegetation Score (max 15):					11	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
Other Habitat Score (max 20):					15	
HABITAT TOTAL (MAX 55):					41	
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX						30
TOTAL IHAS SCORE (%):					71	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: SELONS RIVER (DS)
Site Name: RV2
Date: 21/01/2014

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	SIC Score (max 20):			14		
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none	0	1-25	26-50	51-75	>75
	Vegetation Score (max 15):				13	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				15	
	HABITAT TOTAL (MAX 55):				42	

STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX					25
	TOTAL IHAS SCORE (%):				67	

Appendix 4: SASS5 Score Sheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 05/10/2011	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3					Athericidae	10				
E: °	**TURBELLARIA**	3					Corixidae*	3	1		A	A	Blepharoceridae	15				
SITE CODE: RV1	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER:	Oligochaeta	1			1	1	Hydrometridae*	6					Chironomidae	2			1	A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: Overcast	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 15 °C	Amphipoda	13					Notonectidae*	3			1	1	Empididae	6				
Ph: 8.10	Potamonautidae*	3	1			1	Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 23 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5			1	1
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6	A			A	Hydropsychidae 2 sp	6			1	A	Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9			A	A	Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		25	0	29	51
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		5	0	7	11
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		5	0	4.1	5
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		46%			
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5	1			A	SWC = South Western Cape					
	Aeshnidae	8	1			1	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 05/10/2011	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3					Athericidae	10				
E: °	**TURBELLARIA**	3					Corixidae*	3			1	A	Blepharoceridae	15				
SITE CODE: RV2	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5	1			1
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	1			A
SITE DESCRIPTION:	Leeches	3			1	A	Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: Rain	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 16.5 °C	Amphipoda	13					Notonectidae*	3			1	A	Empididae	6				
Ph: 8.5	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 17.8 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	1			A	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9	1			A	Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		41	0	9	50
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		6	0	3	9
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		7	0	3	6
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		44%			
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5	1			1	SWC = South Western Cape					
	Aeshnidae	8	A			A	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
DATE: 21/01/2014	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3			**A**	**A**	Athericidae	10				
E: °	**TURBELLARIA**	3					Corixidae*	3	**A**	**A**	**A**	**B**	Blepharoceridae	15				
SITE CODE: RV1	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: SELONS (US)	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7	**A**			**A**	Culicidae*	1	**1**			**1**
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 21.9 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 8.07	Potamonautidae*	3	**A**	**1**		**A**	Pleidae*	4					Ephydridae	3				
DO: 7.38 mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 11.7 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5	**A**	**1**		**A**
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6	**A**	**A**	**A**	**B**	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	**A**			**A**	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		40	34	21	51
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		9	7	5	11
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		4	4.9	4	4.6
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	71%				
	Coenagrionidae	4	**A**	**A**	**A**	**B**	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8		**A**		**A**	**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5	**A**	**A**	**A**	**B**	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 21/01/2014	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S:°	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E:°	TURBELLARIA	3		1	1	A	Corixidae*	3	A	A	A	B	Blepharoceridae	15				
SITE CODE: RV2	ANNELIDA:						Gerridae*	5		A		A	Ceratopogonidae	5		1		1
RIVER: SELONS (DS)	Oligochaeta	1	1		A	A	Hydrometridae*	6					Chironomidae	2	A	A		B
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1	A	1		A
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: 28.1 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.94	Potamonautidae*	3					Pleidae*	4	1			1	Ephydridae	3				
DO: 6.55 mg/l	Atyidae	8					Veliidae/M..veliidae*	5		A	1	A	Muscidae	1				
Cond: 10.9 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5		A		A
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6	A		A	B	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12		A		A	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	B	A	A	B	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3	A			A
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		34	72	41	86
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		9	14	9	18
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		4	5.1	5	4.8
	Chlorolestidae	8					Pisuliidae	10					IHAS:	67%				
	Coenagrionidae	4		B	A	B	Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8		A		A	COLEOPTERA:											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					COMMENTS:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5		B	A	B	SWC = South Western Cape					
	Aeshnidae	8	A	A	1	B	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

Appendix 5: General water quality parameters

Sample Origin	Sample ID	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu
		Note: all results in parts per million (ppm) unless specified otherwise											
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Lowest Reported Concentration		<0.025	<0.100	<0.010	<0.025	<0.025	<0.025	<0.025	<2	<0.005	<0.025	<0.025	<0.025
P1	28581	<0.025	0.146	<0.010	<0.025	0.427	<0.025	<0.025	18	<0.005	<0.025	<0.025	<0.025
P3	28582	<0.025	0.241	<0.010	<0.025	0.039	<0.025	<0.025	6	<0.005	<0.025	<0.025	<0.025
P4	28583	<0.025	0.283	<0.010	<0.025	0.136	<0.025	<0.025	5	<0.005	<0.025	<0.025	<0.025
RV1	28584	<0.025	1.64	<0.010	<0.025	0.075	<0.025	<0.025	7	<0.005	<0.025	<0.025	<0.025
RV2	28585	<0.025	0.812	<0.010	<0.025	0.089	<0.025	<0.025	6	<0.005	<0.025	<0.025	<0.025

Sample Origin	Sample ID	Fe	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Lowest Reported Concentration		<0.025	<1.0	<0.025	<2	<0.025	<0.025	<2	<0.025	<0.025	<0.020	<0.100	<0.010
P1	28581	5.74	41	<0.025	11	1.27	<0.025	368	<0.025	0.895	<0.020	4.99	<0.010
P3	28582	8.98	<1.0	<0.025	3	0.337	<0.025	22	<0.025	0.069	<0.020	0.981	<0.010
P4	28583	9.93	4.4	<0.025	2	1.89	<0.025	4	<0.025	0.065	<0.020	2.67	<0.010
RV1	28584	3.83	2.6	<0.025	5	0.104	<0.025	7	<0.025	<0.025	<0.020	1.18	<0.010
RV2	28585	3.98	<1.0	<0.025	4	0.048	<0.025	8	<0.025	<0.025	<0.020	1.52	<0.010

Sample Origin	Sample ID	Se	Si	Sn	Sr	Ti	V	W	Zn	Zr
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Lowest Reported Concentration		<0.020	<0.2	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
P1	28581	<0.020	10.3	<0.025	0.225	<0.025	<0.025	<0.025	<0.025	<0.025
P3	28582	<0.020	1.6	<0.025	0.043	<0.025	<0.025	<0.025	<0.025	<0.025
P4	28583	<0.020	4.5	<0.025	0.034	<0.025	<0.025	<0.025	<0.025	<0.025
RV1	28584	<0.020	10.0	<0.025	0.043	0.028	<0.025	<0.025	<0.025	<0.025
RV2	28585	<0.020	5.9	<0.025	0.051	<0.025	<0.025	<0.025	<0.025	<0.025

Appendix 2: Rietvlei Colliery Surface Water Study, dated July 2014, undertaken by Aqua Earth Consulting

RIETVLEI COLLIERY

Surface Water Study

Final

07-2014

water earth life

We put Science into Practice

Report prepared for
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RIETVLEI COLLIERY

Surface Water Study

Final

07-2014

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Project Number		AEC0199
Report Number		AEC0199/04/07-2014

. Executive Summary

Aqua Earth Consulting (AEC) was appointed by WSP on behalf of Butsanani Joint Venture (Anglo Operations Limited), to carry a surface water study as part of an environmental impact assessment (EIA) for the proposed Greenfields Open Cast Coal Mining Operation at Rietvlei. The site is located northeast of Mhluzi (formerly Middelburg) in the Mpumalanga Province, and will be call “proposed Rietvlei Mine” in the report.

Aqua Earth has completed the surface water study and the following conclusions are reached:

- The site straddles mainly three surface three surfaces run off catchments.
- Available information for this project included a limited number of surface water samples and publicly available topography, regional flow and rainfall data;
- Local storm water runoff model has been set up for the site, from a regional rainfall-runoff model;
- 1:100, flood line has also been calculated for the main three surface water drainage line;
- The main catchment of impact is considered to be catchment B32B;
- The 1:100, flood line is likely going to intersect the pit on the southern side.
- Managing dirty and clean water will be important for each considered run off catchment and the water management plan has been developed taking this into consideration;
- Water storage facilities proposed in this document are based on calculated volumes, and no designs are included for the individual facilities;
- Water balance was developed with the available information (regional meteorological data, flow simulation from groundwater and surface water numerical model) for 20 years of operation;
- The water balance developed during this investigation is considered a preliminary water balance and should be refined once more specific site information (storage facilities) and water use (for operating and processing) monitoring data will be available;
- Focus areas for data collection have been identified and actions recommended;
- A water management and monitoring plan has been developed and it would be important to populate and update this on a regular basis.
- Generally, impacts on surface water are manageable and with a strict application of the proposed mitigation measures, impact significances would be reduced to between very low and medium low.

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1 Introduction

Originally appointed by Mindset Mining Consultants (Pty) on behalf of Butsanani Joint Venture (Anglo Operations Limited), to carry out a surface water impact assessment as part of an environmental impact assessment (EIA) for the proposed Greenfields Open Cast Coal Mining Operation at Rietvlei ; Aqua Earth Consulting (AEC) was then subsequently appointed by WSP to update the studie. The site is located northeast of Mhluzi (formerly Middelburg) in the Mpumalanga Province, and will be call "proposed Rietvlei Mine" in the report.

The present report follows the comment made by WSP on the original surface water study conducted by Aqua Earth.

1.1 Scope of the works

The present baseline assessment did not include any field investigation except the site visit. It aims to use the available environmental specialists' studies on the proposed mining site at Rietvlei Colliery, together with publicly available information to develop a comprehensive environmental impact assessment (EIA) that would include:

- Summary on background information,
- A detailed description of the surface water features;
- Determination of storm water runoff from the proposed site;
- Determination of flood line;
- Projects Impacts and cumulative Impacts on surface water assessments;
- Proposition of surface water management infrastructures;
- Development of Initial Water Balance; and
- Development of Initial surface water management plan.

This report outlines the results of the environmental assessment of the various mining targets at Rietvlei colliery and provides recommendations for the protection of the surface water resources that may be impacted once the mining activities starts.

1.2 Specific tasks

Subsequent to the above objectives, the following tasks have been conducted in the baseline surface water assessment:

- Desktop studies including review of existing monitoring data, maps and reports;

- Surface water modelling including regional surface water model, local storm water runoff model, and flood peaks calculation;
- Impacts risk asessment;
- Compilation of the monitoring and management plan; and
- Final Reporting.

1.3 Sources of information

The following existing specialist studies on the project area were used to gain background information and an understanding of the present surface water baseline conditions:

- Faunal, Floral, Wetland and Aquatic Assessment as part of the EIA process for the the proposed Rietvlei colliery, Milddelburg. Sections (A,B,C,D,E) by Scientific Aquatic Services, 2011;
- Rietvlei colliery Geotechnical investigation, Leo Consulting 2012;
- Feasibility Report, Section 5 Mining on the Rietvlei colliery Asset; by Mindset Mining Consulting (PTY) LTD, April 2013;
- Soil, land capability and land use assessment of the proposed Rietvlei Opencast Mine footprint, situated on the remaining portion of the farm Rietvlei 397 JS, near Middelburg, Mpumalanga Province. By Rehab Green, November 2012.
- Groundwater Baseline Assessment: Rietvlei. (Aqua Earth C, July 2012);

In addition of these specialists' reports on specific to the proposed mining site, publically available information has been used and these include:

- "1/250 000 Geological Series: 2528 Pretoria published in 1978 by the Government Printer;
- An Exploration of the 1:500 000 general hydrogeology map by H.C. Barnard – October 2000;
- SA Explorer for climatic data;
- DWA rain gauging stations;
- Schulze, R.E. 2006. Soils: A grohydrological Information Needs Information Sources and Decision Support; In: Schulze, R.E. (Ed). 2006. South African Atlas of Climatology and Agrohydrology. Water Research Commission, Pretoria, RSA, WRC Report 1489/1/06, Section 4.1.;

- South African National Biodiversity Institute (SANBI), 2009. Updating National Land Cover.
- Water Resources of South Africa 2005 (WR2005) (WRC Report No.: K5/1491)
- Shuttle Radar Topography Mission (SRTM); 90

1.4 Legal aspects

Section 26 of the National Water Act, 1998 (Act 36 of 1998) regulates any activity that may have an impact on a water resource and the conservation and protection of this water resource. Legislative requirements relevant to surface water as administrated by the Department of Water Affairs (DWA) are:

- National Water Act, 1998 (Act 36 of 1998) (NWA, 1998).
- Government Notice (GN) 704, dated June 1999, in terms of the NWA (1998);
- General authorisations in terms of the NWA: GN 398 and 399, dated March 2004
- DWA Best Practice Guidelines, dated 2007;
- General authorisations in terms of the NWA GN 1199, dated December 2009, in terms of the NWA, 1998;
- Government Notice Regulation (GNR) 77, dated June 1999, in terms of the NWA.

The following overarching legislation was taken into account in the present surface water assessment:

- National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA).
- NWA, 1998 (Act 36 of 1998) ;
- National Environmental Management: Waste Act, 2008 (Act 59 of 2008) (NEM: WA);
- Mineral and Petroleum Resources Development Act (No 28 of 2002) (MPRDA).

1.5 Details of specialists

The following surface water study has been conducted under by an experienced water specialists' team, and is managed by a fully qualified Professional Engineer that have been involved in leading several Water Research Commission (WRC) projects. The consultant details are giving as follow:

The following surface water study project has been conducted by experienced water specialists' team, and is managed by a fully qualified professional water scientist, who has been involved in leading relevant projects. The consultant details are giving as follow:

Table 1 : Specialist details

PROJECT TITLE: Surface water impact assessment-.			
Specialist:	AQUA EARTH CONSULTING		
Nature of specialist study compiled:	Surface Water Study		
Contact person:	AHOKPOSSI D P		
Postal address:	PO.BOX :1747 North Riding		
Postal code:	2162	**Cell:**	0735721424
Telephone:	0117913490	**Fax:**	0115076612
E-mail:	pacome@aquaearth.co.za		
Qualifications & relevant experience:	Bsc Civil Engineering - Msc Geohydrology (10 years)		
Professional affiliation(s) (if any)	SACNASP		

1.1 Declaration of Independence

Aqua Earth was appointed to conduct a specialist surface water study as part of EIA and act as the independent specialist in this application. Aqua Earth will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. Aqua Earth has the expertise in conducting the specialist report relevant to this application and will not engage in conflicting interests in the undertaking of this study

Signed: ________________________________

Name:__________________________________

Position:_________________________________

2 General Physical description of the receiving environment

2.1 Location

The study area lies approximately 50km northeast of the town of Emalahleni and 22km northeast of Mhluzi (formerly Middelburg) in the Mpumalanga Province (

Figure 1). It is linked to Mhluzi by the R555 provincial roadway. The prospecting area lies within a farming area and is bordered by private properties on all sides.

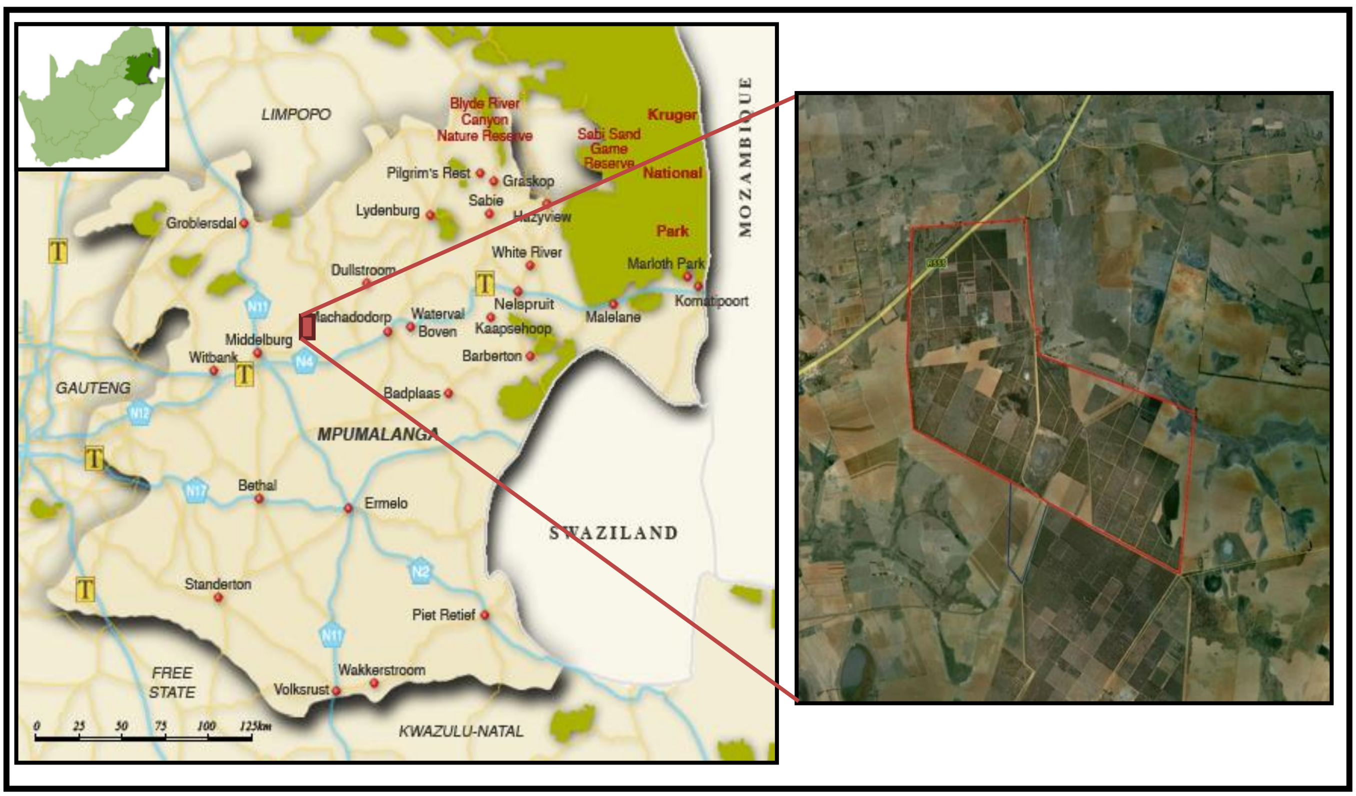


Figure 1: Locality of Rietvlei Colliery

2.2 Mining infrastructures

The positions of the surface infrastructure as reported in section 5 of the Rietvlei mining feasibility report are shown together with local runoff catchments and drainage in Figure 2. This map will be used in the establishment of surface water management plans related to each surface infrastructure.

The mining sequence (layout) and the associated mining schedule as designed by Mindset are presented respectively in and Figure 4.

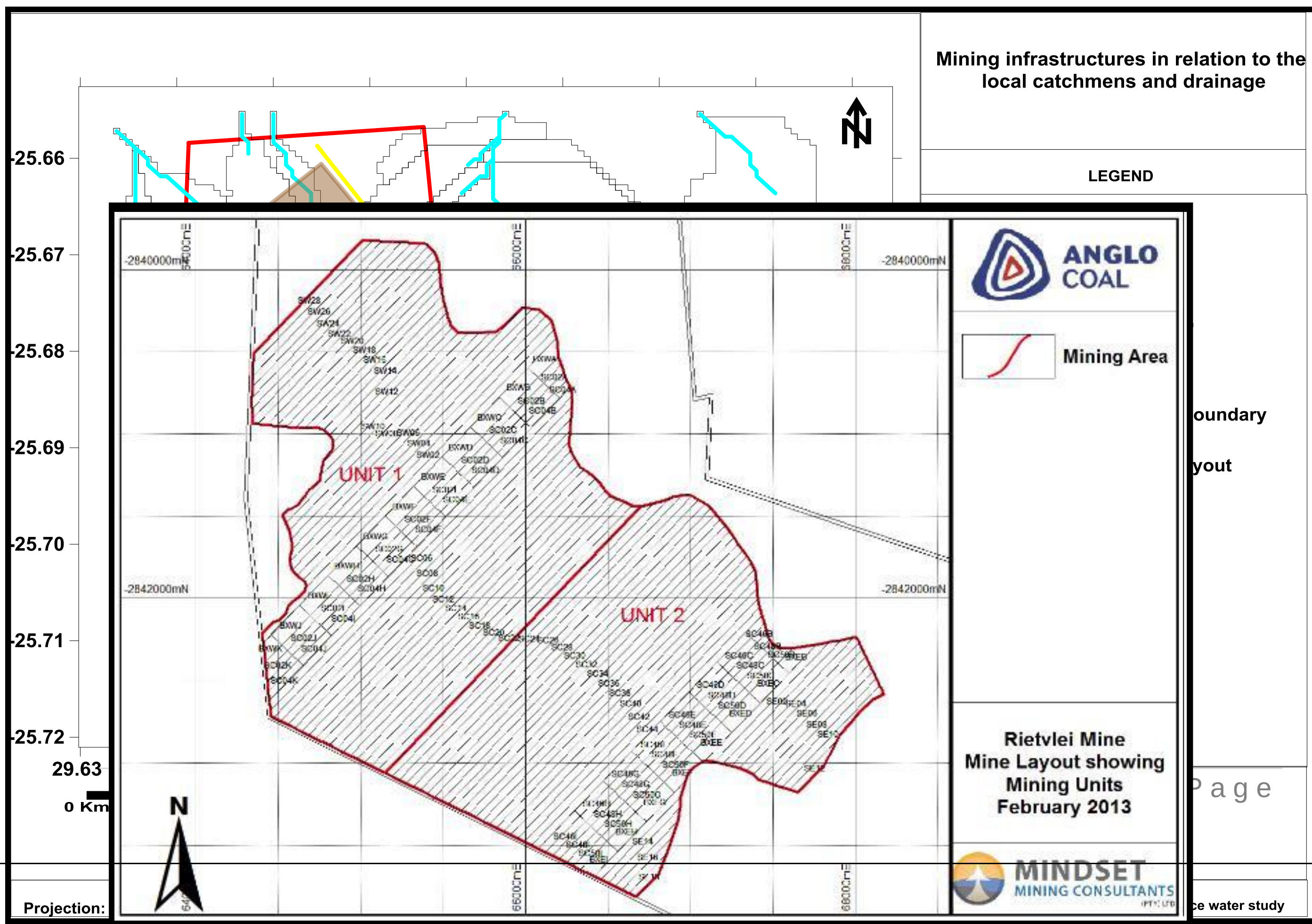
Figure 2: Surface infrastructure and local drainage

Figure 3 : Mining Layout (from section 5 of the Rietvlei mining feasibility)

Figure 4 : Mining schedule (from section 5 of the Rietvlei mining feasibility)

2.3 Climate

Based on data provided by SA explorer, the climate is typical of the Highveld, with warm summers and cold winters. The area experiences an average of 8.3 hours of sunshine a day. The mean annual temperature is approximately 23oC (Figure 6). The area falls into the summer



rainfall region with most rain occurring between October and March (Figure 7). The mean average annual rainfall for Optimum Mine (in close proximity of Rietvlei Colliery) is approximately 680 -700 mm. The mean monthly evaporation for a Class "A" pan is shown in Figure 5.

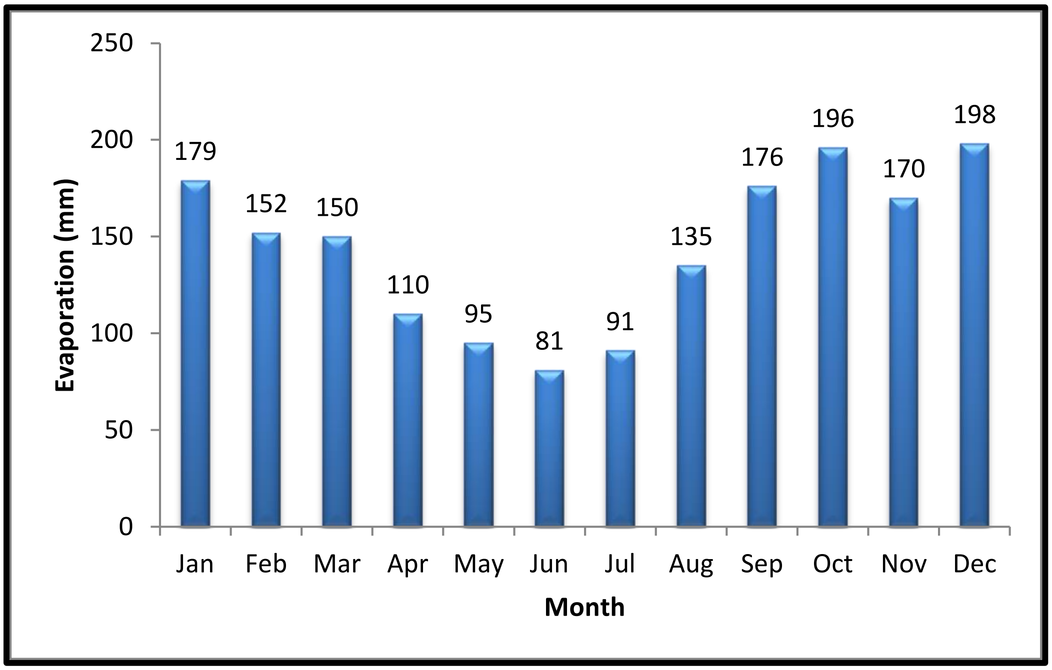


Figure 5: Average evaporation (SA Explorer)

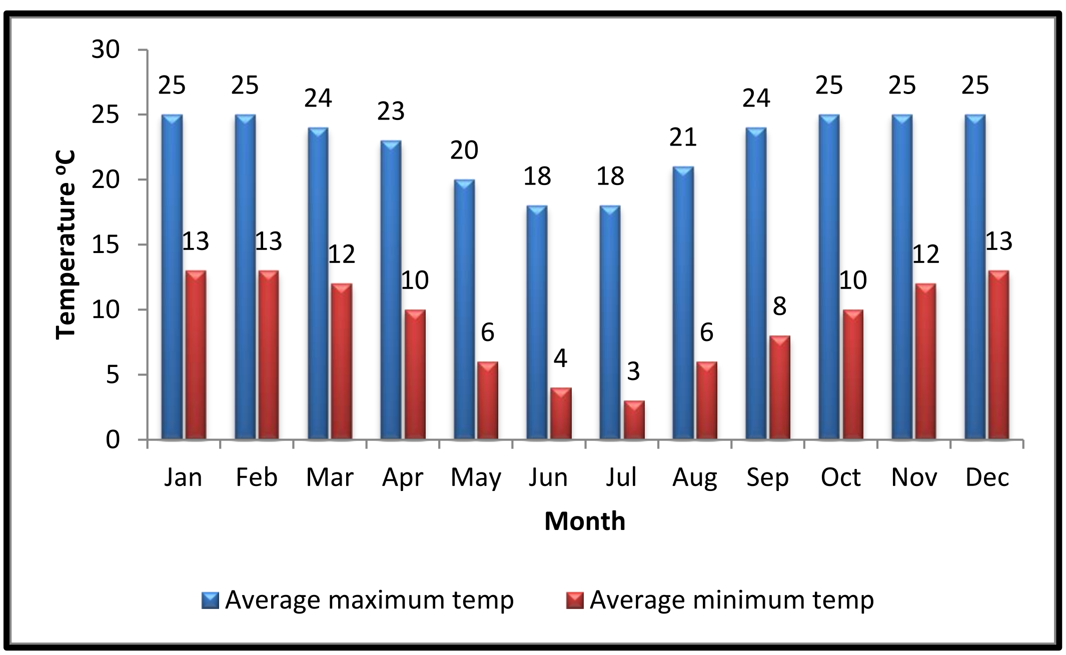


Figure 6: Average monthly temperatures (SA Explorer)

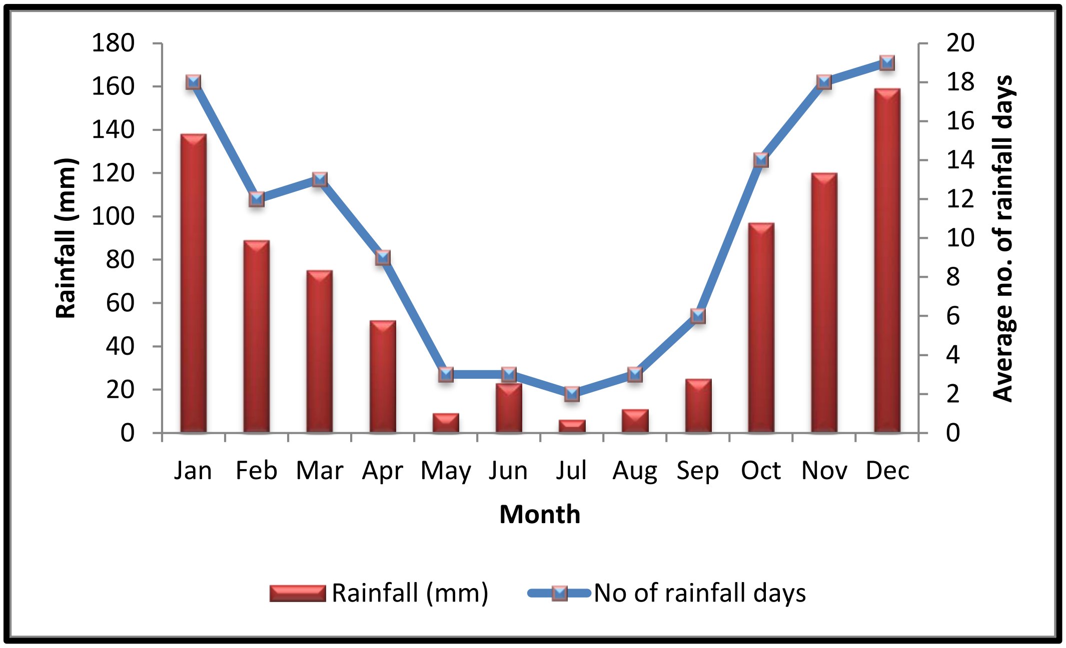


Figure 7: Average monthly rainfall with average number of rainfall days (SA Explorer)

Data from the available DWA rain gauging stations have also been consulted. All the rain gauging stations available from DWA is shown in (Figure 8) and listed in Table 2. The closest rainfall station, B1E003 was chosen as a representative rain gauge for the area.

Table 2: List of rainfall stations

Station ID	Place	Lat	Long
B1E001	Witbank @ Witbank Dam	-25.88807	29.29973
B1E002	Rondevalley	-25.92557	29.69141
B1E003	Rondebosch @ Middelburg Dam	-25.77557	29.54557
B1E004	Rietfontein	-26.35776	29.21640
B1E005	Naauwpoort @ Witbank Dam	-25.97473	29.28057
B3E002	Loskop Nat. Res. @ Loskop Dam	-25.41310	29.36640
B3E003	Loskop Nat. Res. @ Loskop Dam	-25.42143	29.35807

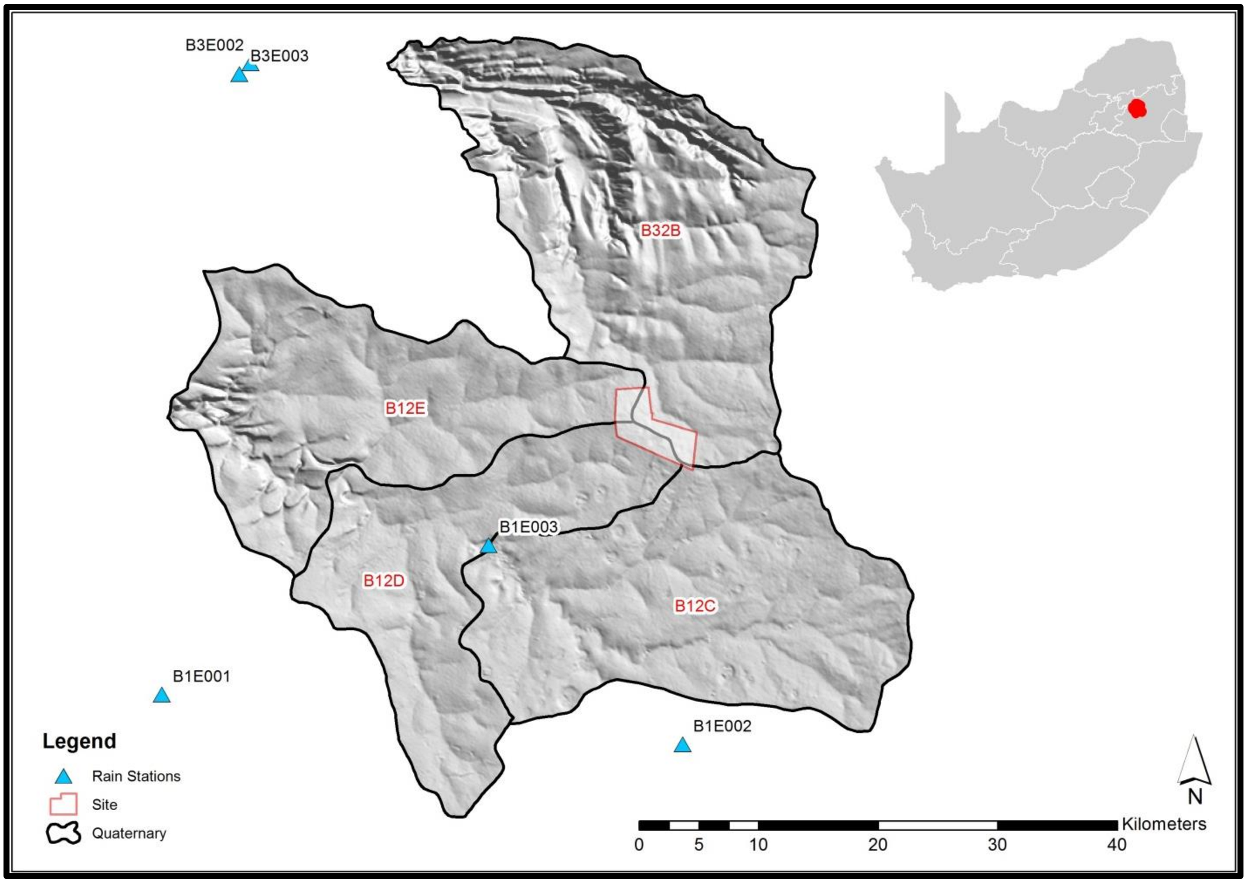


Figure 8: Quaternaries and available DWA rainfall stations around Rietvlei site

Reliable continues daily rainfall data was available from 1980 to 2004 from B1E003 with the following quality DWA code distribution over this period:

- 86% good continuous data;
- 12% good monthly reading; and
- 2% unaudited data.

The rainfall record for the above mentioned period is shown in

Figure **9**. The associated average daily evaporation is shown in

Figure **10**.

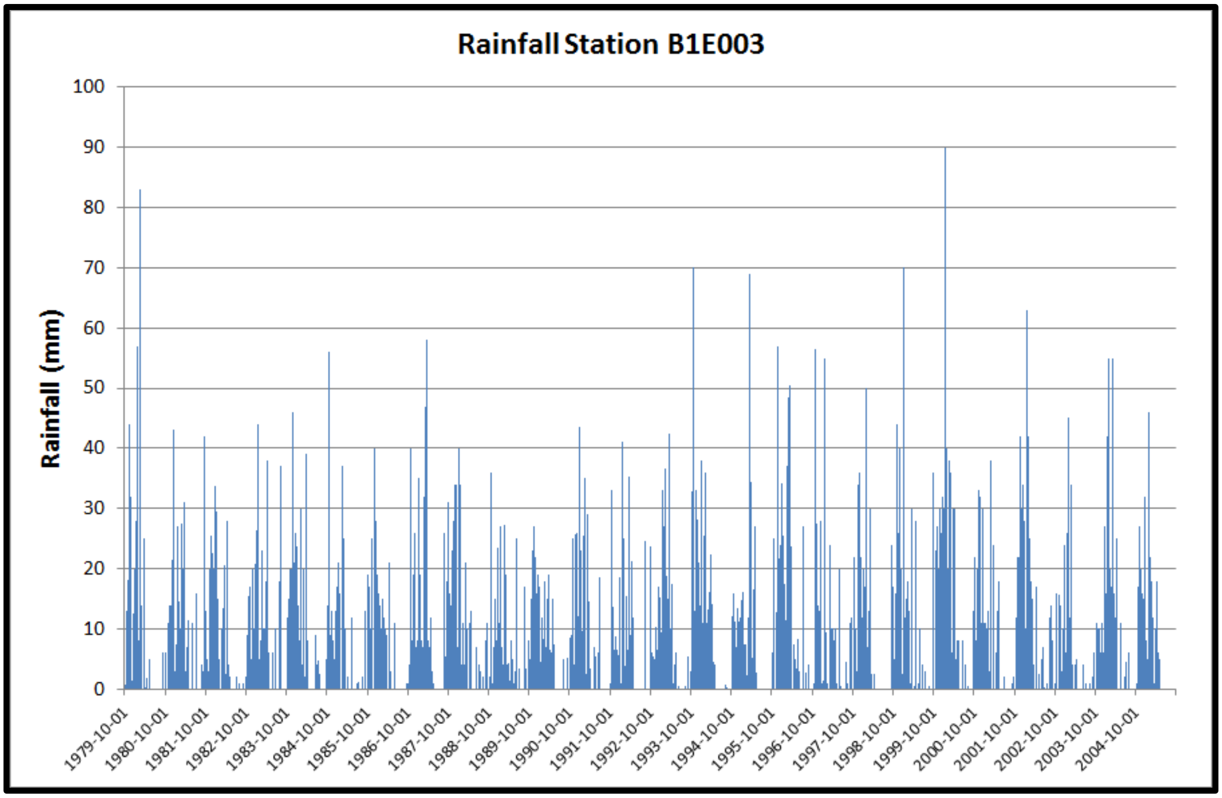


Figure 9: Rainfall record for B1E003 from 1980 to 2005 (DWA)

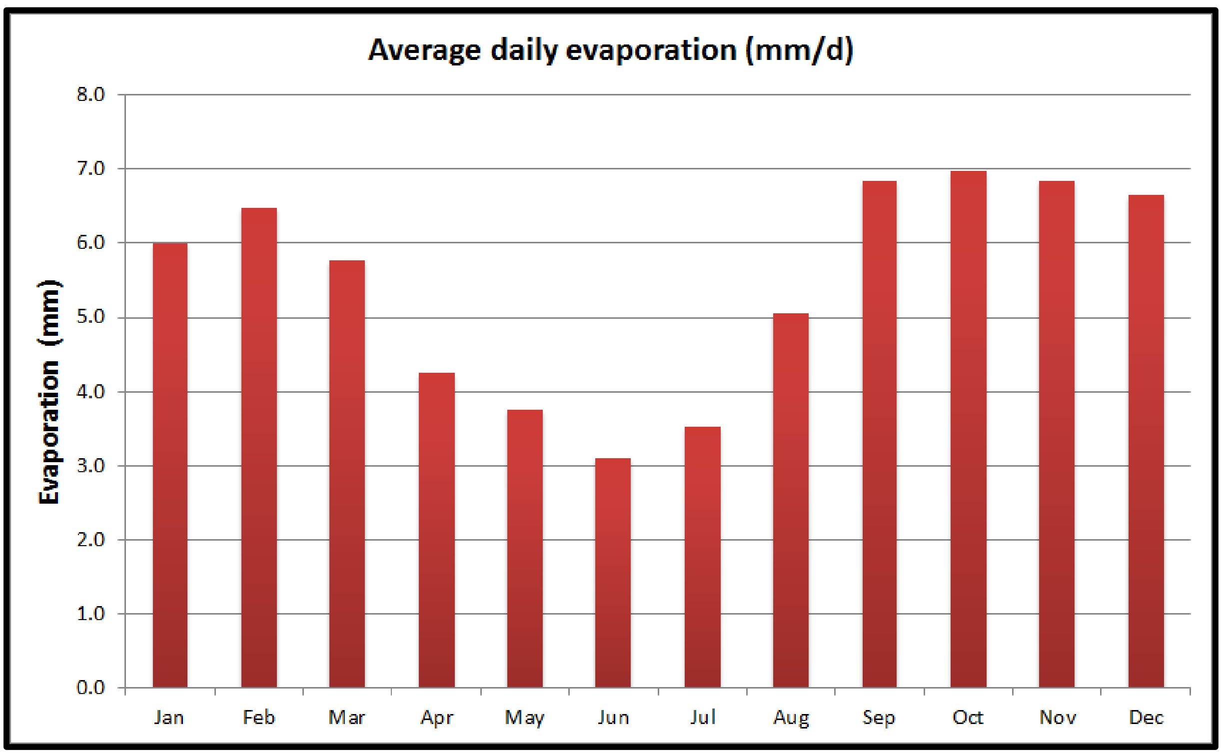


Figure 10: Average daily evaporation

2.4 Geology

The analysis of the 1/250000 Geological Series: 2528 Pretoria has been used to describe the main geology that may be encounter at the mine site.

The mine is located on the Karoo Sequence (Vryheid Formation). The Vryheid Formation comprises mudrock, shales, rhythmite, siltstone and fine- to coarse-grained sandstone (pebbly in places). The Formation contains up to five (mineable) coal seams. The different lithofacies are mainly arranged in upward coarsening deltaic cycles. Since the shales are very dense, they are often overlooked as significant sources of groundwater. The permeability of these sandstones also is usually very low. The main reason for this is that the sandstones are usually poorly sorted, and that their primary porosities have been lowered considerably by diagenesis. These sedimentary formations have been extensively intruded by dolerite dykes.

The Karoo dolerite, which includes a wide range of petrological facies, consists of an interconnected network of dykes and sills and it is nearly impossible to single out any particular intrusive or tectonic event. Dolerite dykes are vertical to sub-vertical discontinuities that, in general, represent thin, linear zones of a lower permeability sandwiched between fracture zones. These fracture zones can have a relatively higher permeability and can therefore act as conduits for groundwater flow within the aquifer. The dykes on the other hand may also act as semi- to impermeable barriers to the movement of groundwater. The dykes are commonly expressed on the surface as a line of green bushes, which can be readily observed during the dry season. The generalised stratigraphy is summarised in Table 3.

Table 3: Generalized stratigraphy

Stratigraphic section	Description
Transport and residual soils	- topsoil - clayey hillwash - clayey siltstone and sandstone

Increasing with depth

Vryheid Formation	-silty, laminated shale - laminated siltstone with sandstone - No 2 seam (coal) - ripple cross-bedded fine grained sandstone
Dwyka Group	Tillite, diamictite and glacial shales
Pre-Karoo basement	Paleo-weathered Selonsrivier felsite

There are numerous fractures within the study area - these fractures can form conduits for groundwater flow. The depth of the coal seam is on average 40mbgl. Figure 11depicts a typical borehole log of the area, while geology of the area is shown in Figure 12.

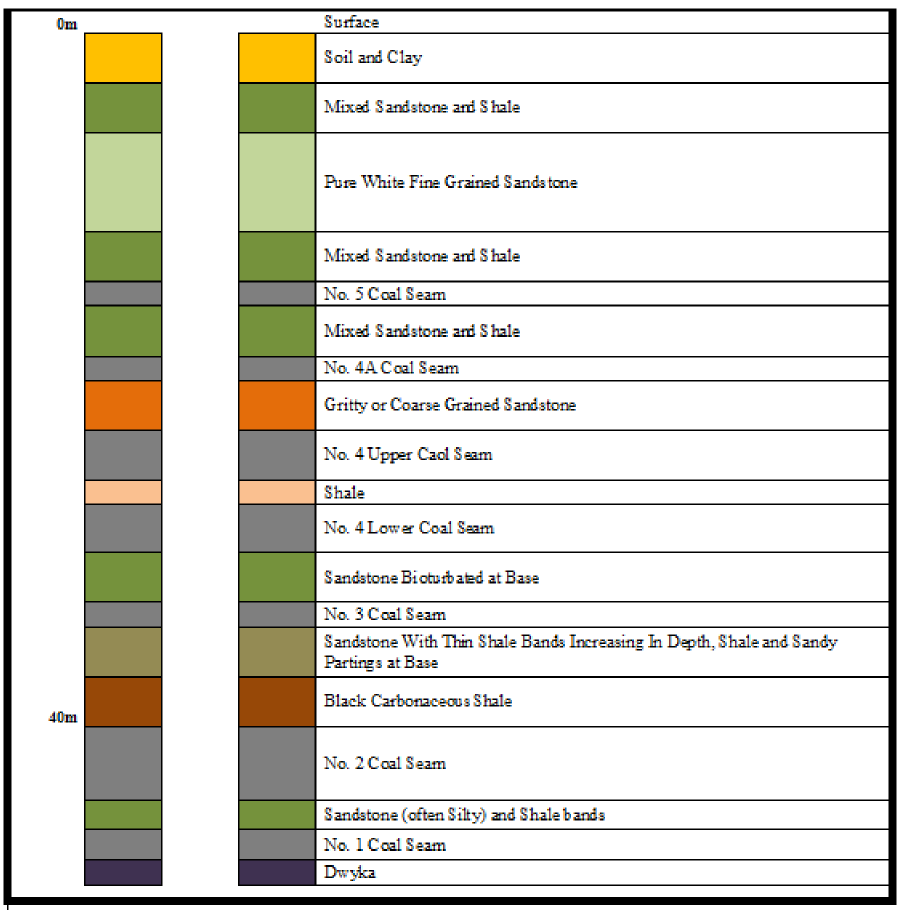


Figure 11: Typical borehole log (site investigation: drilling)

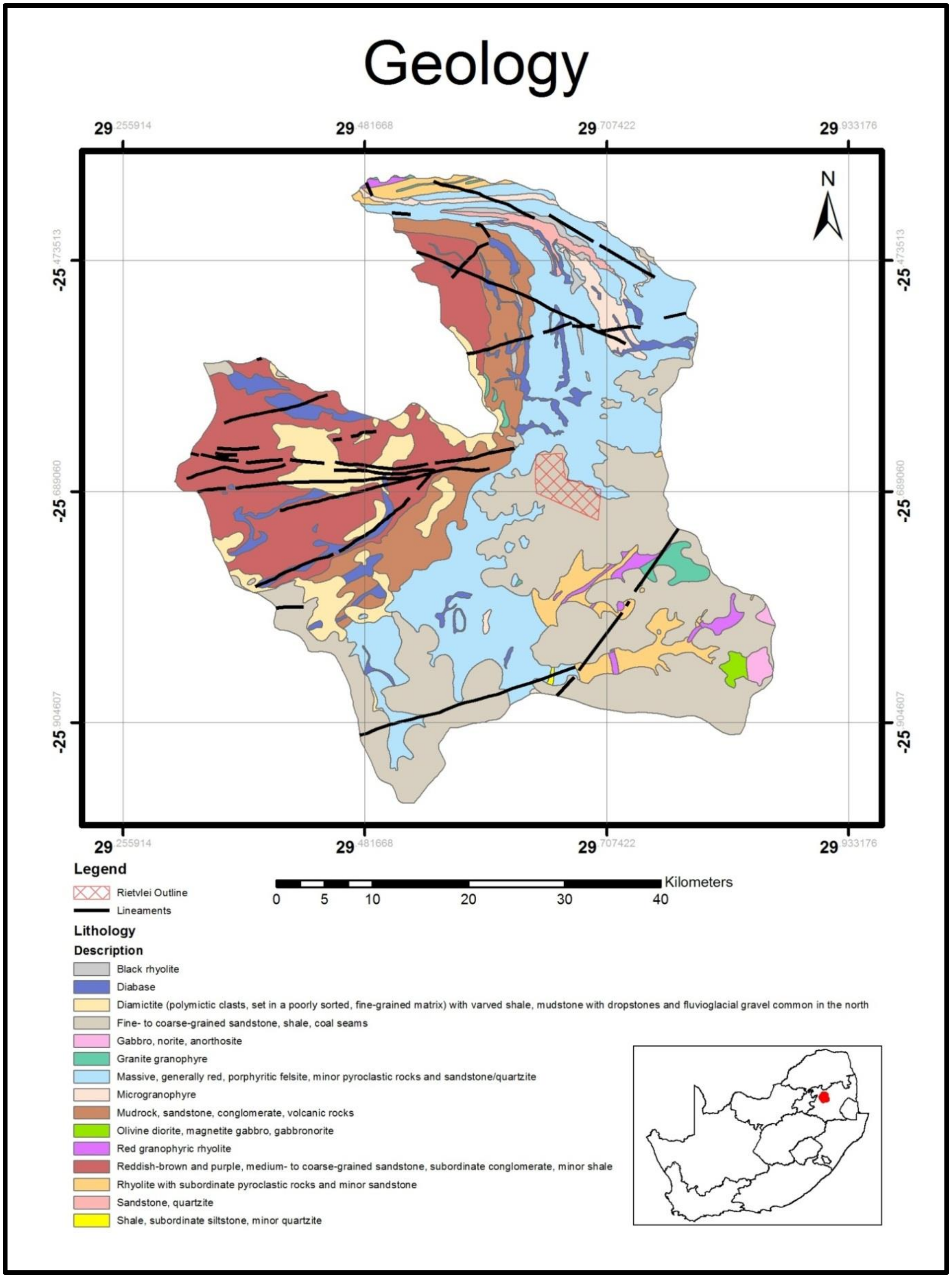


Figure 12: Regional geology (modified from the 1/250000 Geological Series: 2528 Pretoria)

2.5 Soils and land cover

Rehab Green Monitoring Consultants cc conducted a detailed soil, land capability and land use assessment as well as wetland delineation during June 2011 and updated in 2014. The classification and mapping of soil forms (types) according to the South African Taxonomic Soil Classification System as documented is described in that report.

Soil background information and land cover distribution are useful in understanding the behaviour of surface water over the study area.

2.5.1 Hydrological soil

The hydrological soil grouping for each of the quaternaries is shown in

Figure 13 with a dominant grouping of B for B12E, B12D, B12C and the site itself. The classification of the hydrological soil grouping is given in Table 4.

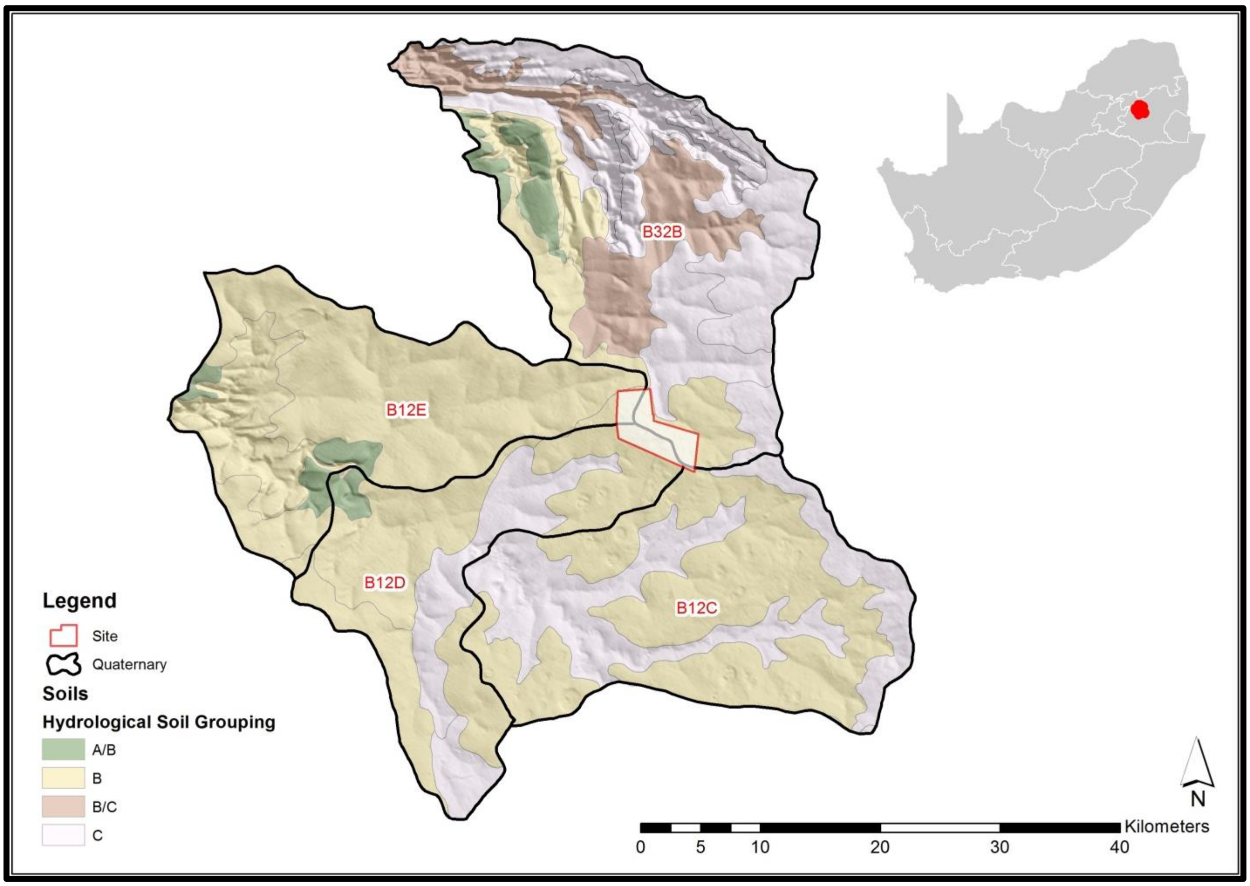


Figure 13: Hydrological soil groupings (modified from Shultze, 2006)

Table 4: Classification of the hydrological soil grouping (taken from Shultze, 2006)

Soil group	Description	Storm flow potential	Infiltration rate	Permeability rate
			mm/h	mm/h
A	Infiltration is High and permeability is rapid. Overall drainage is excessive to well-drained	Low	~25	7.6
B	Moderate infiltration rates, effective depth and drainage, with slightly restricted permeability.	Moderately low	~13	3.8-7.6
C	Low infiltration rate or deteriorate rapidly, with restricted permeability	Moderately high	~6	.3-3.8
D	Low infiltration and highly restricted permeability, with high shrink-swell potential	High	~3	<1.3

2.5.2 Land cover

The land cover distribution for the quaternaries is shown in Figure 14 with the major land cover being cultivation followed by natural veld. The site itself has a large percentage classified as plantations.

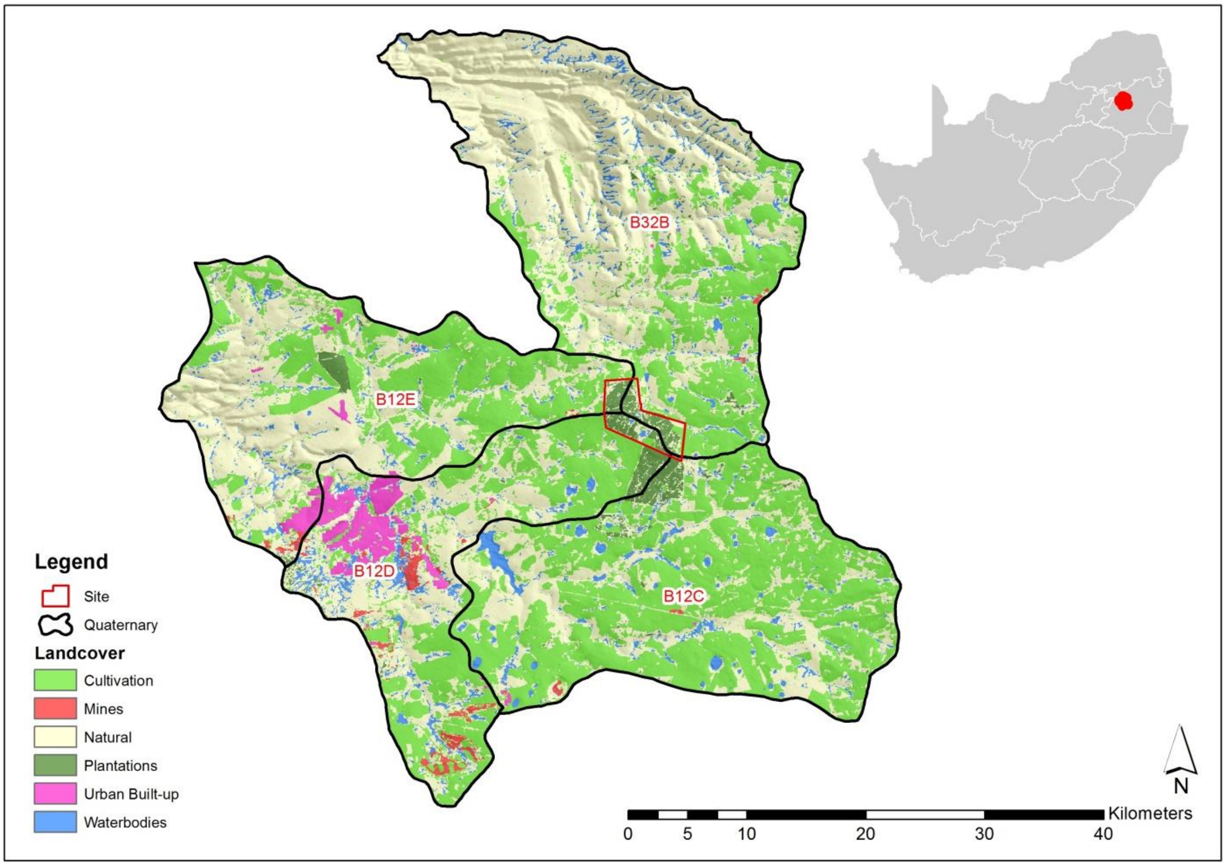


Figure 14: Land cover distribution (modified from SANBI, 2009)

2.5.3 Vegetation

The study area is located in the Grassland Biome of South Africa, across one regional vegetation unit, namely Eastern Highveld Grassland.

The site is covered by plantations, which in some areas have been cut and/or burned, and a number of "vlei" or wetland areas. Three habitat units were identified during the assessment, namely wetlands, grasslands and transformed habitats with historic disturbance as a result of cultivation, plantations and alien floral encroachment.

2.6 Wetlands

In 2011, Scientific Aquatic Services (SAS cc) conducted a wetland assessment. The report has been updated in 2014 as part of the EIA process for the proposed Rietvlei Colliery. The delineated wetlands inside the prospecting area are shown in Figure 15. Only the permanent wetlands in the study area have been considered sensitive and should be treated as required by Mpumalanga Biodiversity Conservation Plan. The varying sensitivities ascribed to the wetlands on site, range from Low Sensitivity to High Sensitivity, and are based on the varying degrees of degradation of the wetlands on site (Figure 15).

Wetlands present outside the boundary of the study area, have not been taken into account in the existing wetland mapping. This will however need to be considered in the mine water management and monitoring plans. Wetlands are connected to many of the streams on site and downstream sites.

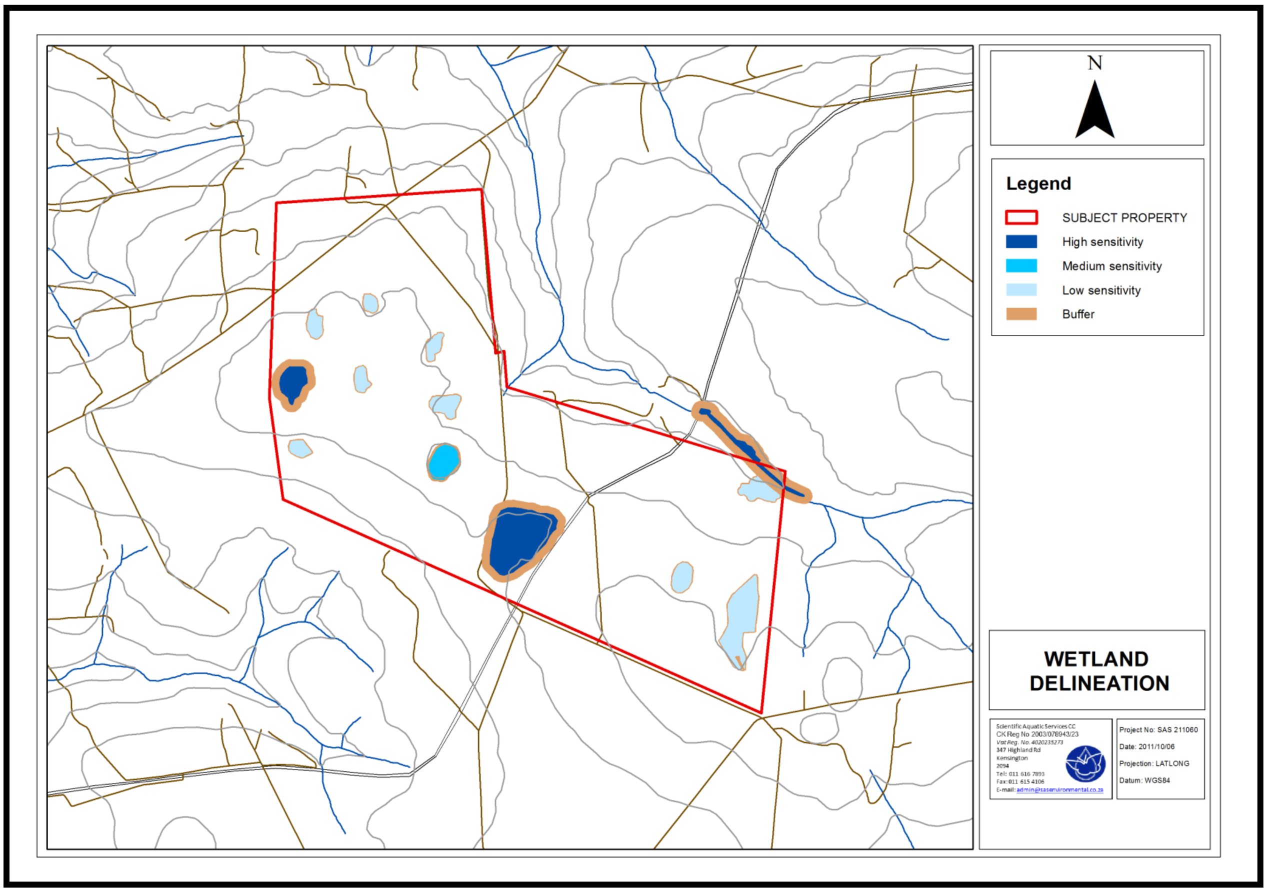


Figure 15: Wetland delineation with associated buffers (after SAS cc)

2.7 Topography and hydrology

The project area is located on the intersection of 3 quaternary catchments B12D, B12E and B32B (Table 5), with a small part (0.255km^2) of the prospect area falling under B12C. The landscape slopes gently towards the different streams and rivers. The general elevations in the concerned catchments range between 1043 mamsl (metre a bove mean sea level) and 1831 mamsl (

Figure 16). The study area is characterised by a land use of mainly agriculture, with blue gum plantations as the main agricultural activity.

Table 5: Information concerning quaternary catchment

Catchment	B12D	B12E	B32B
Area (km²)	362.3	435.8	613.8
Mean annual runoff (mm/a)	38	53	51
Groundwater contribution to baseflow (mm/a)	7	18	16

The present study focuses on the three main catchments. Rietvlei forms the headwaters of:

- The Olifants River in B12D: A number of small sized dams intercept the South-West furrows (Figure 18) that feed into Olifants River.
- The Selons River in B32B which flows North-West into Olifants River;
- The Keerom stream (B12E) which flows West-West-South into Olifants River; number of small sized dams intercept the South-West furrows (Figure 18) that feed into Keerom stream.

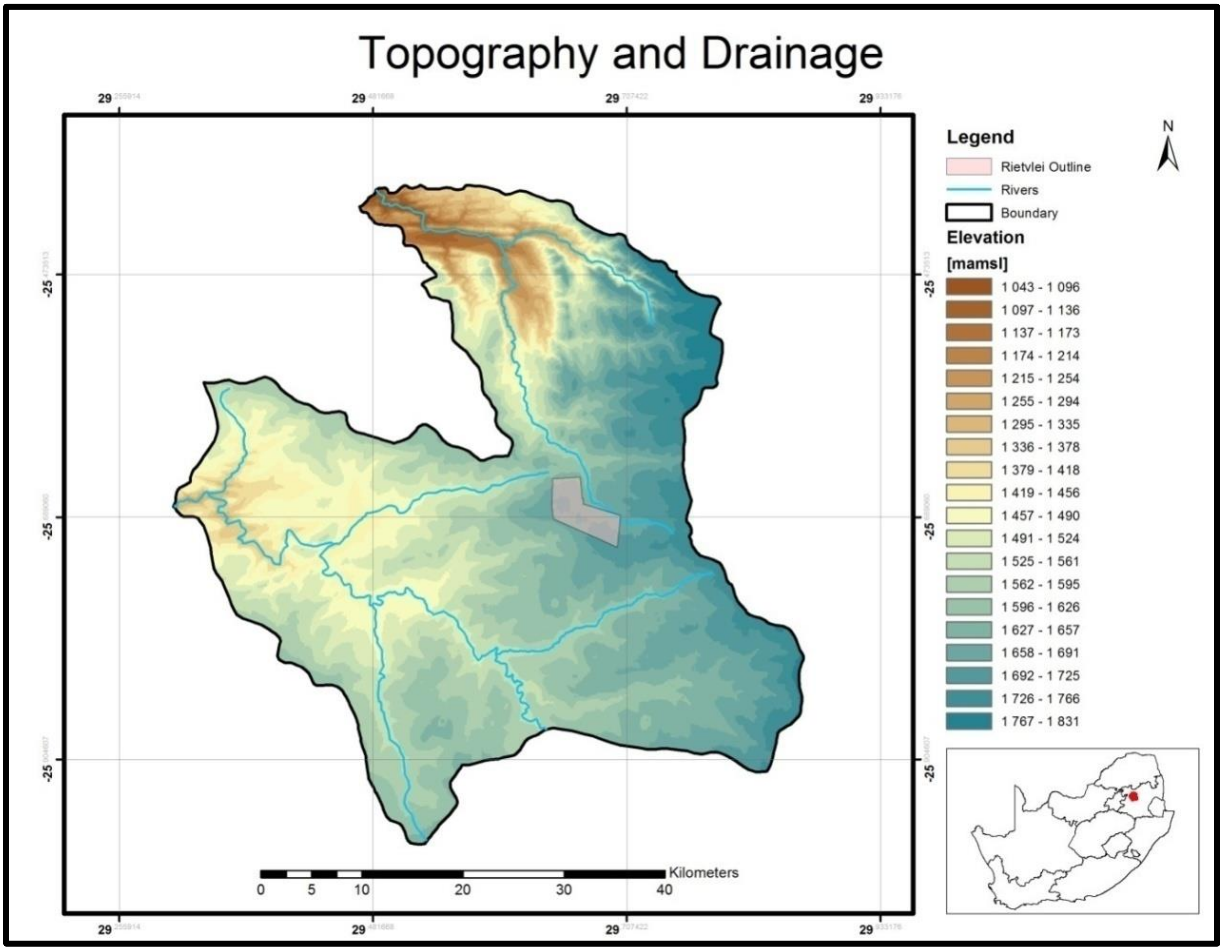


Figure 16: General Topography and drainage

The local elevations prior to mining ranges from 1590mamsl to 1720mamsl as indicted on Figure 17. The maximum fall in elevation (from the highest point on site towards the lowest) is approximately 230m.

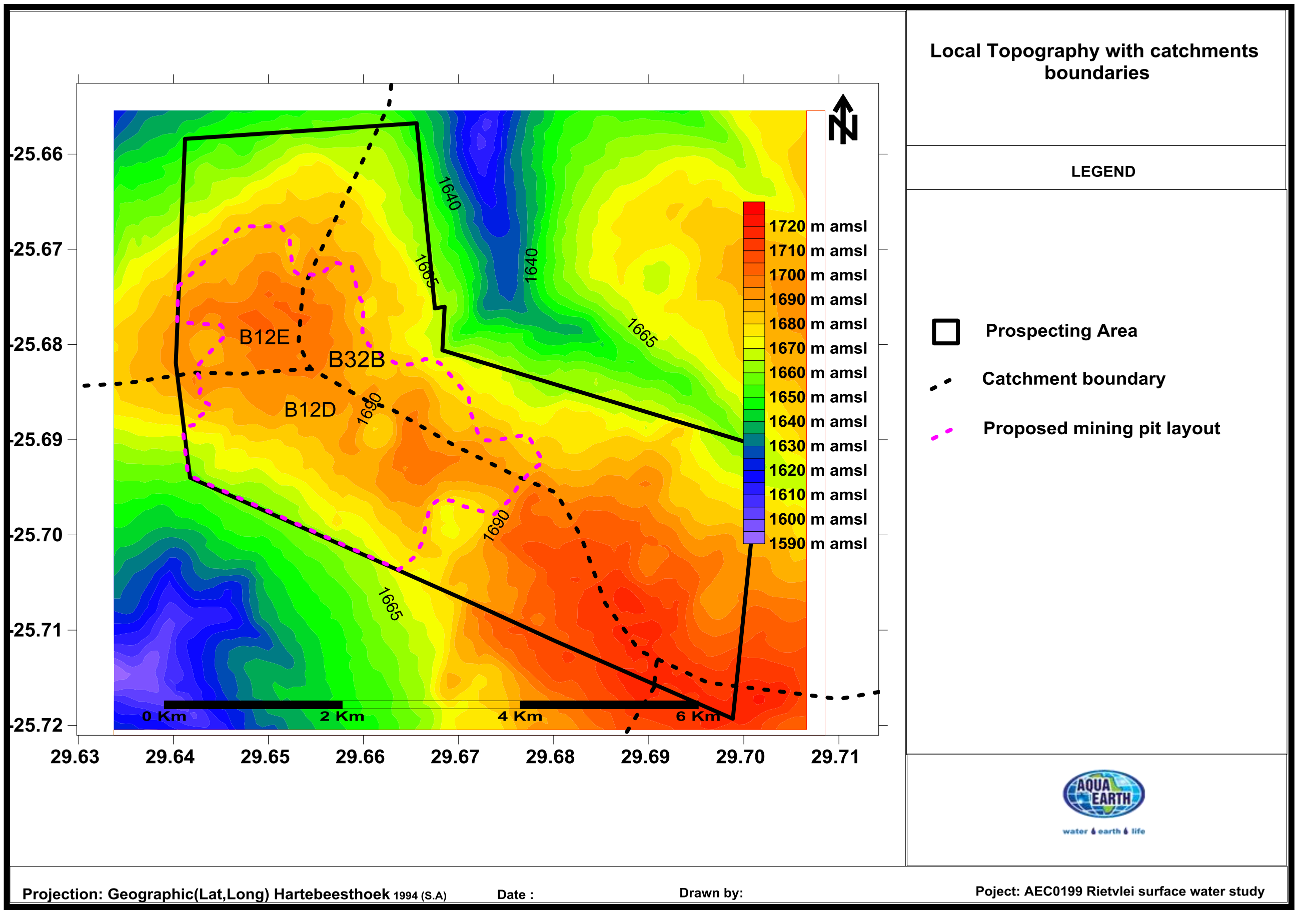


Figure 17: Local topography with catchments boundaries and mining.

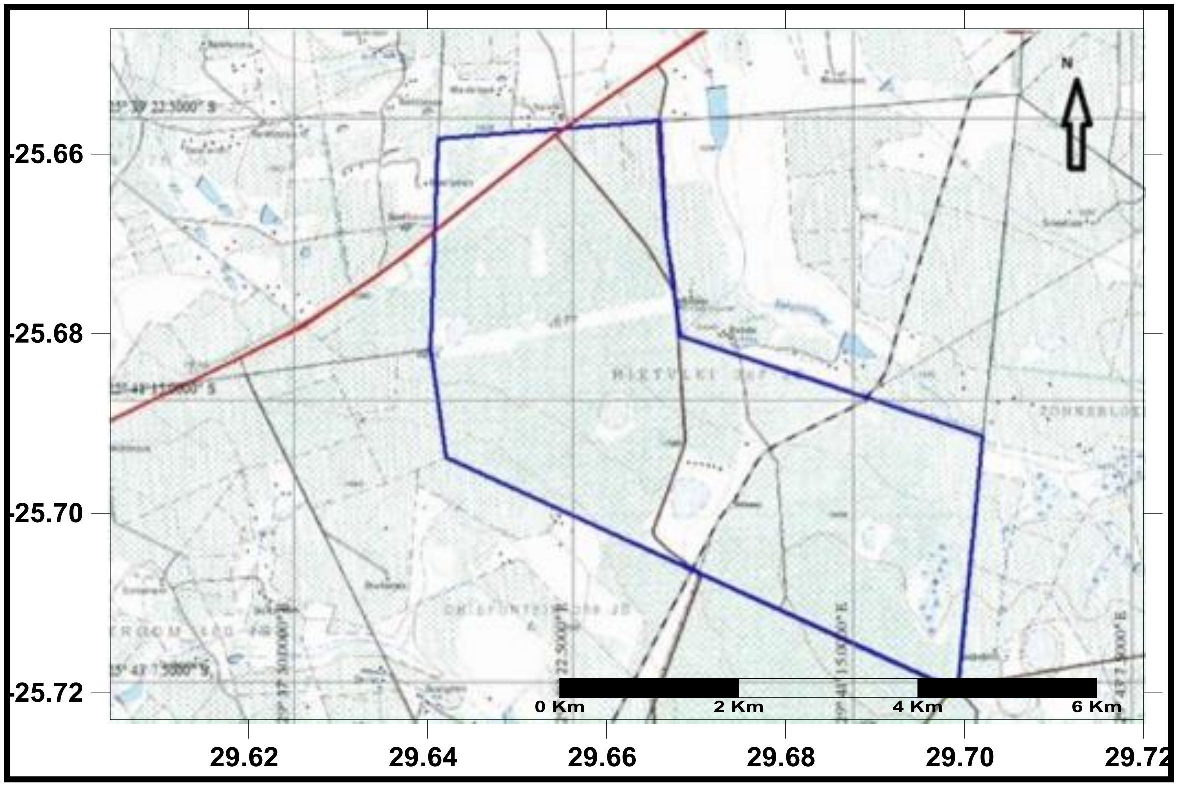


Figure 18: Non perennial rivers and dams surrounding the Rietvlei mine lease area.

Local surface runoff catchments with the associated local drainage are shown together with the mining layout in Figure 19. The way that such local drainage is connected to the pans on the prospecting area is also illustrated.

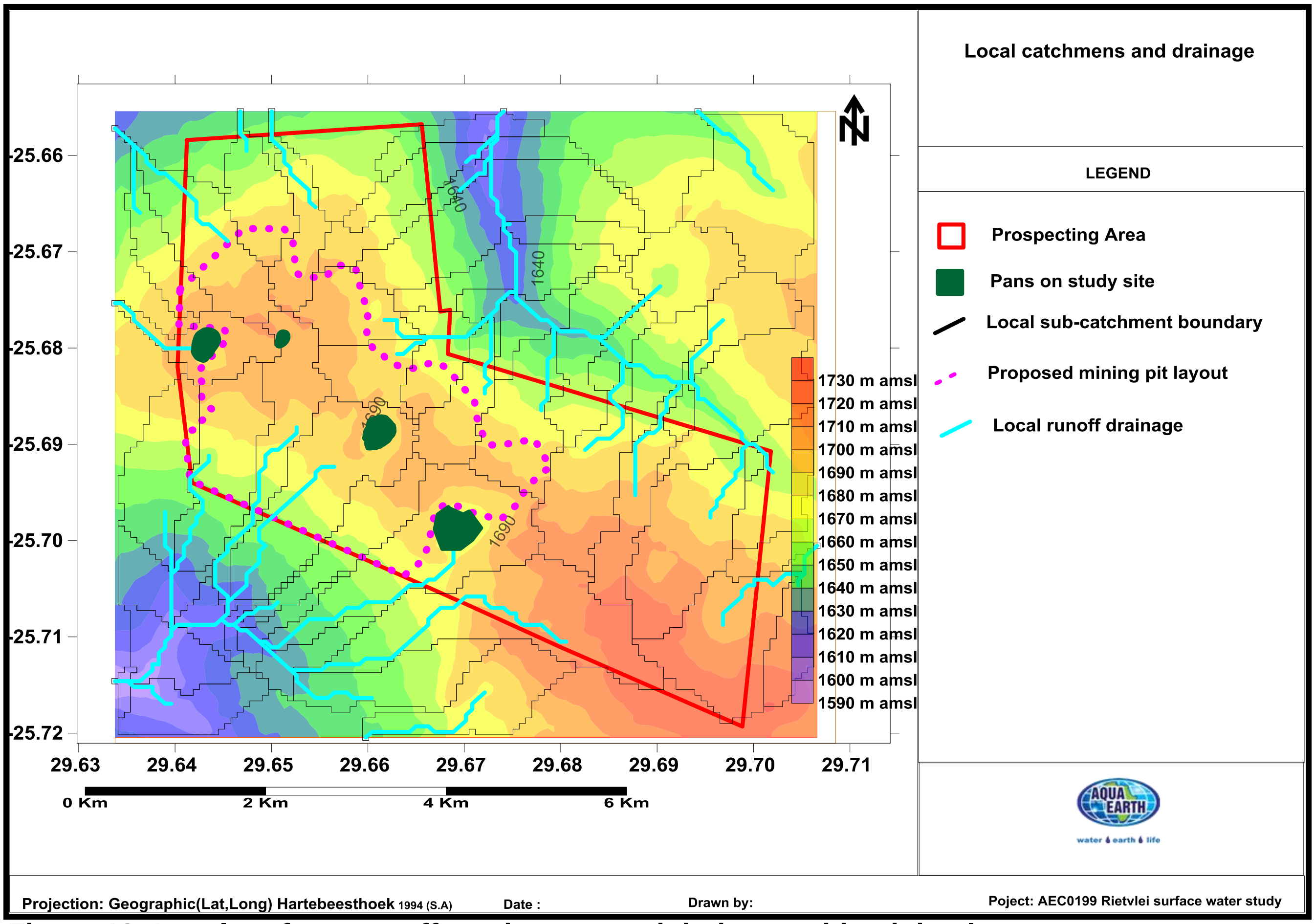


Figure 19: Local surface run-off catchments and drainage with mining layout

2.8 Surface water quality

During a hydrocensus carried out in early 2011, 2 surface water points had been visited and located (Table 6).

Table 6 : Information collected during hydrocensus

Farm Name Owner/ Addr/Te	Water Body	Geographic Coordinate (WGS 84)	
		Latitude	Longitude
Rietvlei	Dam	25°40'47.11"	29°41'12.52"
Wonderhoek	Selons River	25°38'50.56"	29°40'10.28"

Water samples had been collected and sent to an accredited laboratory for analysis. Both samples showed a relatively neutral pH (7.12 and 7.46) and low electrical conductivity values (11mS/m and 13mS/m). The returned results indicated that all the major and minor constituents analysed fall within the recommended operational limits for drinking water (SANS 241; 2005) except for Aluminium (Table 7). The Aluminium concentrations at both monitoring points exceeded the maximum allowable limit.

The Piper (Figure 20) and Expanded Durov (

Figure 21) diagrams show that the water quality within the Selons River showed no sign of pollution, while the one from the dam showed mining or power station related water.

Table 7 : Comparison of results against drinking water quality standards

Sample Number	pH []	EC [mS/m]	TDS [mg/l]	P Alk. [mg/l CaCO3]	M Alk. [mg/l CaCO3]	Al [mg/l]	Ca [mg/l]	Cr [mg/l]	K [mg/l]	Mg [mg/l]	Mn [mg/l]	Na [mg/l]	Si [mg/l]	Zn [mg/l]	F [mg/l]	Cl [mg/l]	NO_3-N [mg/l]	PO_4 [mg/l]	SO_4 [mg/l]
Dam	7.12	11	68	<0.6	19.4	4.29	4.03	<0.05	3.46	2.5	<0.05	11	9.7	<0.05	0.517	11.1	0.88	<0.8	8.67
Selons River	7.46	13	78	<0.6	40.2	1.79	7.64	<0.05	2.92	6.14	<0.05	9.52	7.61	<0.05	0.526	6.18	0.77	<0.8	7.94

SANS 241; 2005

CLASS 1: Recommended Operational Limit																			
CLASS 2: Max Allowable	5-9.5	<150	<1000			<0.3	<150	<0.1	<50	<70	<0.1	<200		<5	<1	<200	<10		<400
Above Class 2 Limits	4-10	150-370	1000-2400			0.3-0.5	150-300	0.1-0.5	50-100	70-100	0.1-1	200-400		5-10	1-1.5	200-600	10-20		400-600

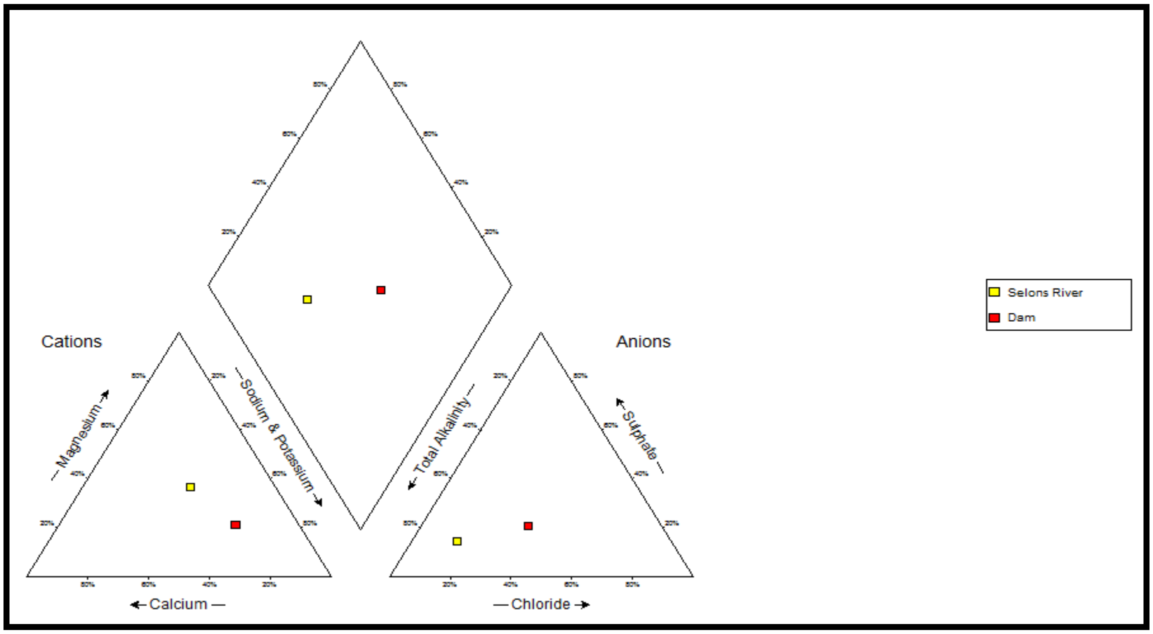


Figure 20: Piper Diagram of Rietvlei surface water quality

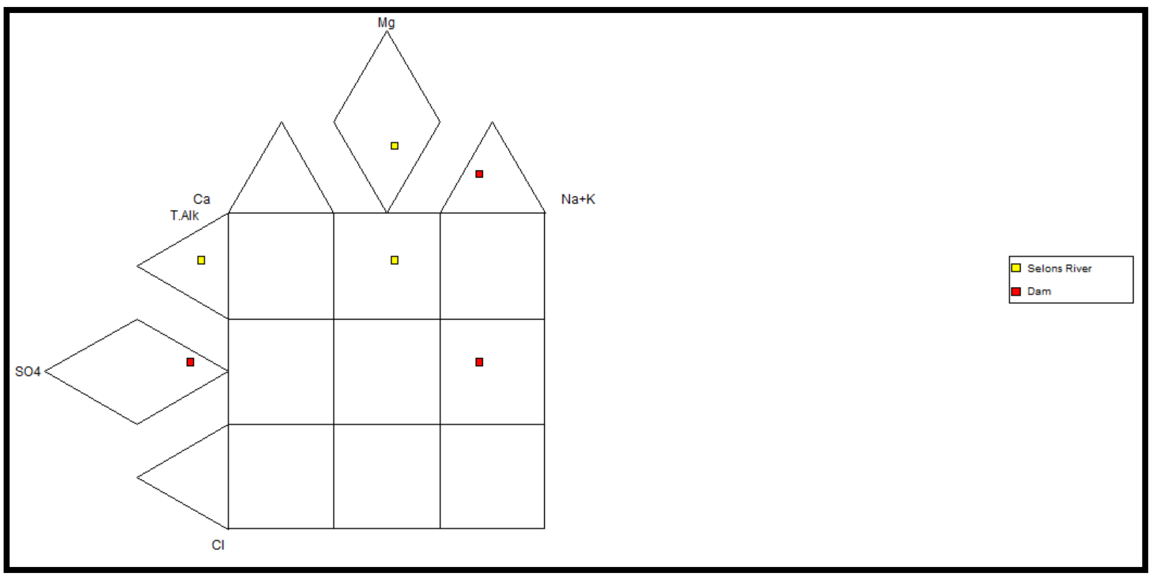


Figure 21: Expanded Durov diagram of Rietvlei surface water quality

3 Base line storm water modelling

3.1 Critical data requirement for surface water modelling

3.1.1 Flow and rain gauging stations

Rain gauge and flow gauge data are required for calibration of surface runoff modelling purposes. The closest flow and rainfall station in the vicinity that had daily records available was used in the present initial site assessment.

As no site specific rain gauge exists, the representative (closest) rainfall station, B1E003 has been used in the surface water modelling.

In the absence of a flow gauge in close vicinity of the study area, calibrated data from WR2005 was utilised as observed data for each of the quaternaries for the surface water model.

3.1.2 Soil and land cover

For surface water modelling (Regional, Local storm water, and Flood peak and lines) purposes, hydrological soil groupings from Shultze (2006) have been used. Land cover distributions as described by SANBI (2009) have also been considered.

3.1.3 Surface elevations and channel cross section

As no detailed field topographic survey (cross sections) was available at the time of the study, a detailed digital elevation model (DEM) was making use of SPOT (Satellite Pour l'Observation de la Terre) heights and existing 5m contours.

3.2 Model purpose and methodology,

The purpose of the surface water modelling is to determine storm water runoff from the proposed site as well as floodline determination. This is accomplished through the use of three surface water models:

- Regional surface water runoff model on quaternary catchment scale
- Local storm water runoff model on site scale based on catchment model parameter
- Flood peak determination through the SCS-SA in conjunction with a channel flow model (HEC-RAS)

3.2.1 Regional surface water model methodology

In the absence of relevant local surface water data (observed flow), the regional surface runoff model was setup to show that calibration could be achieved with the model implemented (WR 2005), and downscaled to the proposed site for storm water modelling. Hydrological response units (HRU) have been delineated in the four quaternaries involved in the proposed mining site, and were used in the model network development.

3.2.1.1 Hydrological response unit

The four quaternaries comprising the regional surface water model was divided into fourteen HRUs as shown in Figure 22.

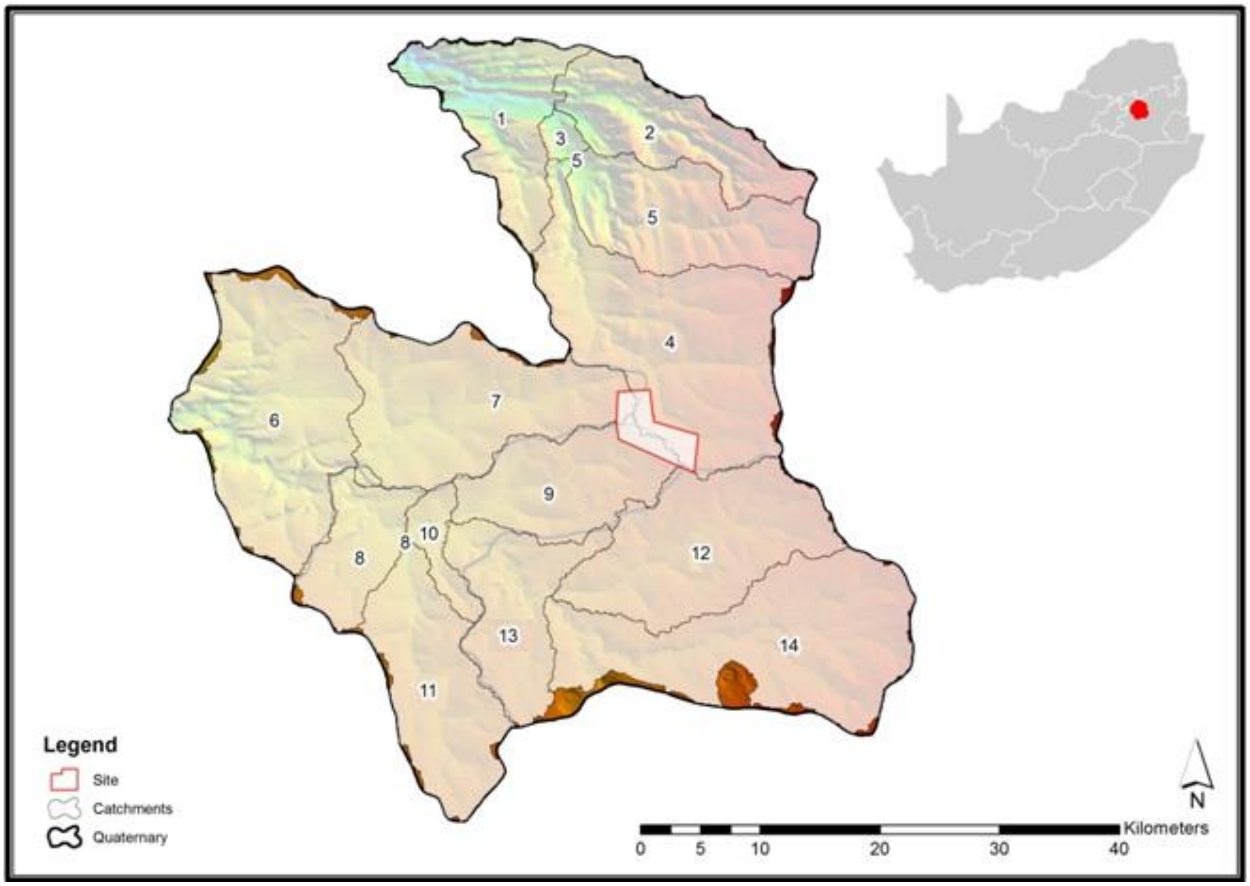


Figure 22: Hydrological response units for regional surface water model

3.2.1.2 Regional surface water model network

The model network representing the regional surface water model is shown in Figure 23. Note that HRUs 12-14 do not form part of the model network as the combined outflow of these three HRUs are represented as the inflow to quaternary B12D and the WR2005 data was used for this input. Three outflows (Out1, Out2 and Out3) are modelled and compared with the WR2005 data for the same catchments.

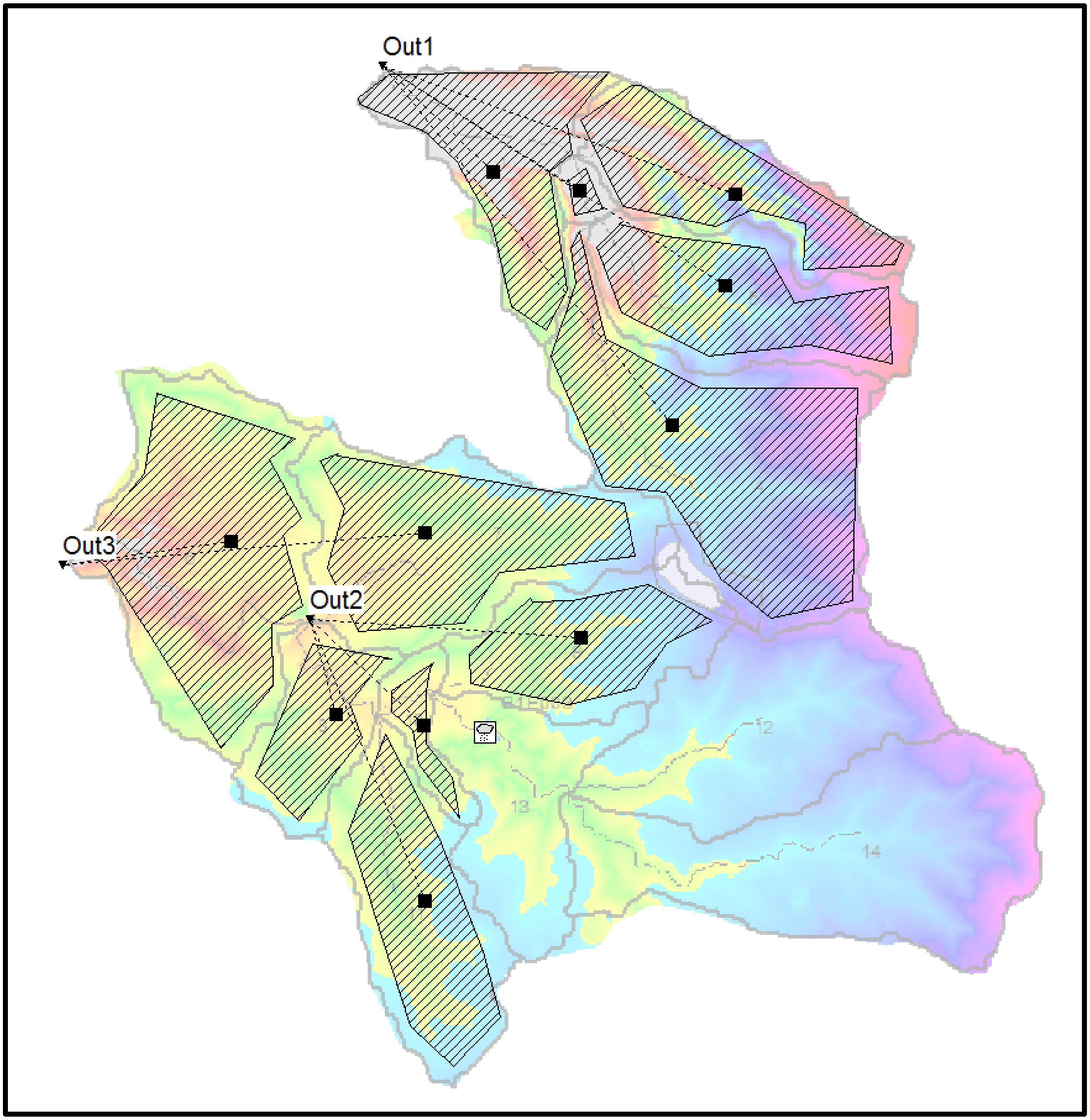


Figure 23: Regional surface water model network

The HRU parameters implemented in the model are presented in

Table 8 and Table 9 respectively. Note that it was assumed that the urban land cover will represent the impervious areas.

Table 8: Land cover distribution per HRU

Class	HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8	HRU9	HRU10	HRU11
Bare Rock & Soil	0.0%	0.0%	0.0%	0.0%	0.0%	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cultivated	7.7%	8.8%	0.6%	56.5%	31.4%	32.4%	66.2%	9.5%	65.1%	29.8%	54.0%
Planted Grasslands	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	0.0%	0.0%	0.0%
Forest Plantations	0.0%	0.6%	0.0%	2.8%	1.1%	1.9%	1.2%	1.5%	5.6%	0.3%	0.3%
Mines & Quarries	0.0%	0.0%	0.0%	0.2%	0.0%	0.5%	0.1%	0.9%	0.2%	2.3%	7.3%
Natural Grassland	38.0%	72.1%	16.2%	39.1%	59.7%	52.2%	31.3%	33.9%	28.0%	56.1%	36.5%
Thicket, Bushland, Bush Clumps	54.1%	18.4%	83.1%	0.9%	7.7%	5.9%	0.3%	0.2%	0.2%	0.0%	0.2%
Urban	0.0%	0.1%	0.0%	0.0%	0.0%	4.2%	0.7%	52.5%	0.0%	11.4%	1.4%
Waterbodies	0.2%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.3%	0.7%	0.1%	0.4%
Wetlands	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Soil Group	B/C	C	B/C	C	B/C	B	B	B	B/C	B	B/C

Table 9: HRU parameters

HRU	Area(ha)	Slope (%)	Imperv (%)	n-Imperv	n-Pervious
1	11418	1.38	0.0	0.01	0.70
2	10898	1.38	0.1	0.01	0.60
3	1048.2	1.38	0.0	0.01	0.60
4	24721	1.38	0.0	0.01	0.70
5	13488	1.38	0.0	0.01	0.60
6	23108	0.54	4.2	0.02	0.50
7	19068	0.54	0.7	0.02	0.45
8	6814.1	0.31	52.5	0.02	0.60
9	11347	0.31	0.0	0.02	0.80
10	2722	0.31	11.4	0.02	0.80
11	13597	0.31	1.4	0.02	0.80

3.2.2 Local storm water runoff model methodology

The purpose of the storm water model is to assist in the establishment of a storm water management plan. Runoff from the site needs to be managed in terms of clean water and dirty water. Storm water channels are required to divert the runoff to the specified dams. The model results (runoff flows and volumes) will be used to suggest sizes for both the channels and dams which should contain peak flow on the site without any releases (or overflow) taking place.

To accomplish this, the site boundary is used as the storm water model boundary, and proposed mining surface infrastructures were considered as can be seen in Figure 50

Three (3) clean water dams (CWD1, CWD2, and CWD3) are placed at critical positions to intercept clean water and five (5) dirty water dams (DWD1, DWD2, DWD3, DWD4, and DWD5) are also placed strategically to intercept the dirty water.

3.2.2.1 Local storm water model Network

The model network for the site is shown in Figure 24. Catchment parameters were scaled down from the regional surface water model. The proposed pit area was removed from modelled area for the purpose of storm water runoff, since storm water runoff will be mostly driven by groundwater seepage once in operation. The areas comprising of waste dumps and the plant were assigned a Manning's Coefficient of Perviousness (MCP) of 0.024 associated with that of cement and rubble surfaces to give a conservative estimate of the storm water runoff on the site.

The model was subject to the same rainfall sequence as that used in the regional surface water model as well as the same daily evaporation.

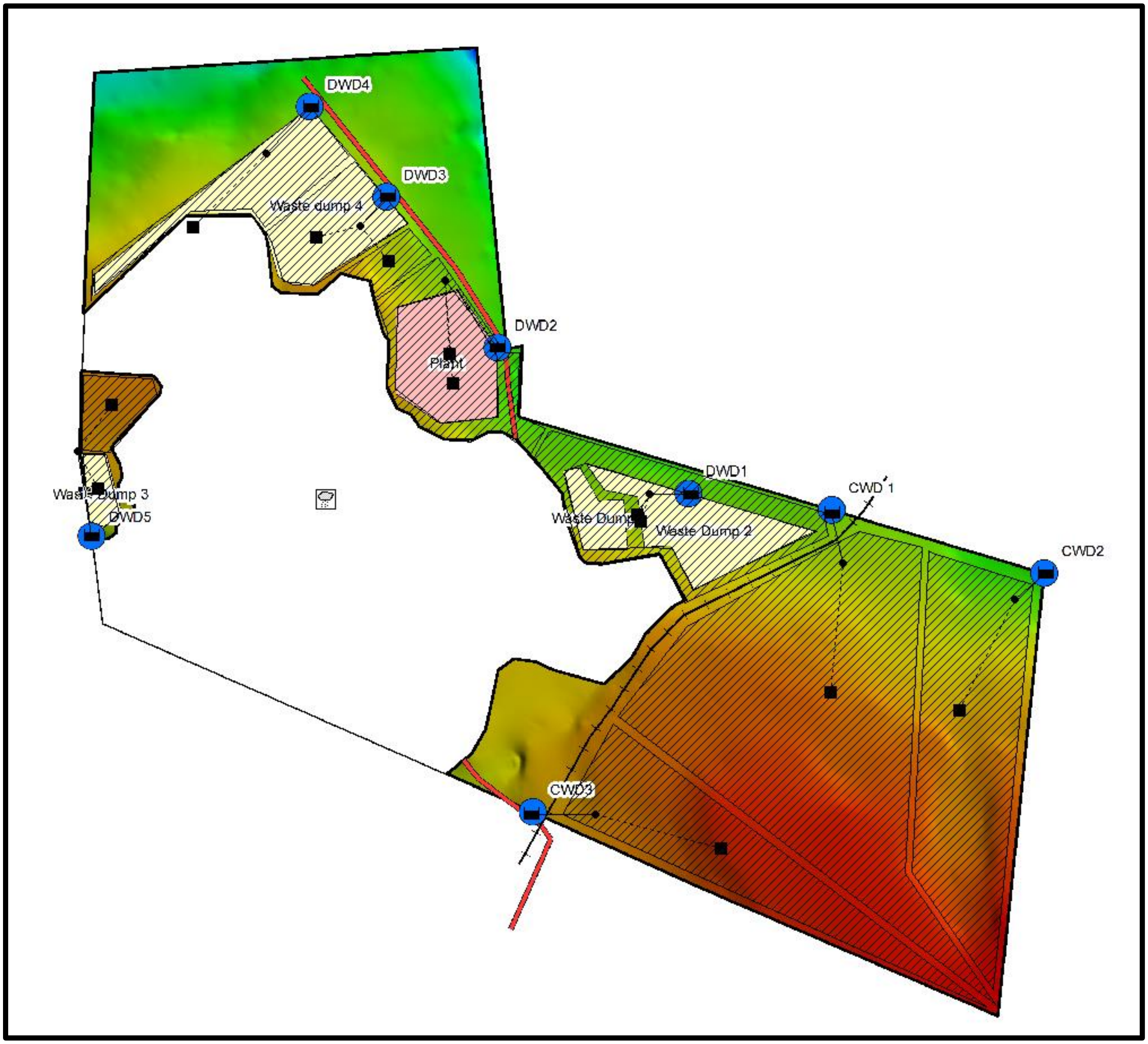


Figure 24: Storm water model network

3.2.3 Flood line calculation methodology

Floodline determination is done in and around the site to ensure that the proposed mine pit will not be affected by surface water flooding and to augment the storm water plan accordingly.

The built DEM (SPOT heights + 5m contours) was used for stream definition and to obtain a cross section.

3.2.3.1 Flood line catchment characteristics

A stream definition of 1 km^2 was applied to the DEM to delineate three catchments (1, 2, and 3) around the site as shown in Figure 26. Elevations over the area range between 1760 and 1555 mamsl.

The longest water course for each of the catchments is shown in Figure 27, Figure 28 and Figure 29 respectively.

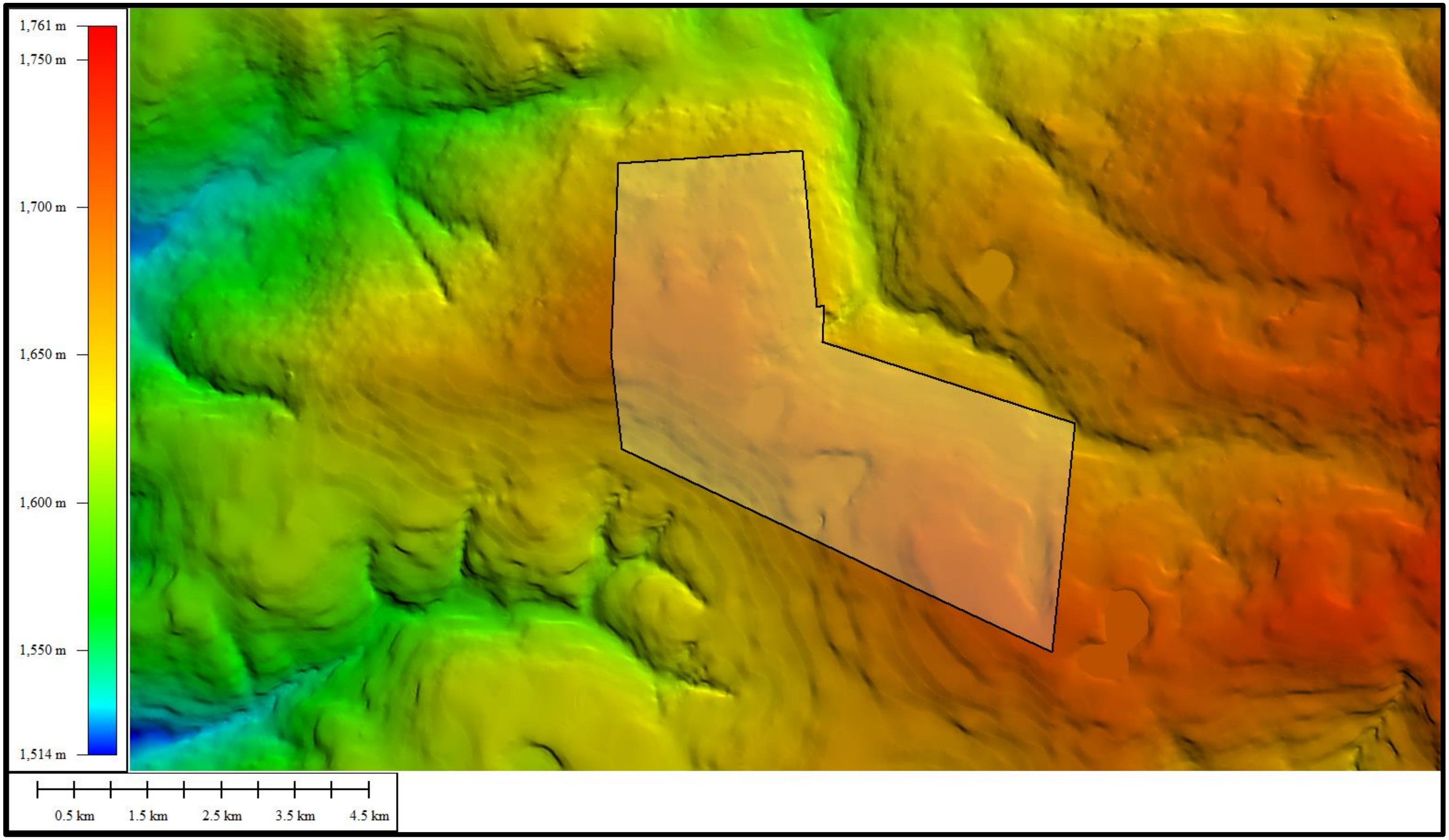


Figure 25: Digital Elevation Model around site (SPOT heights + 5m contours)

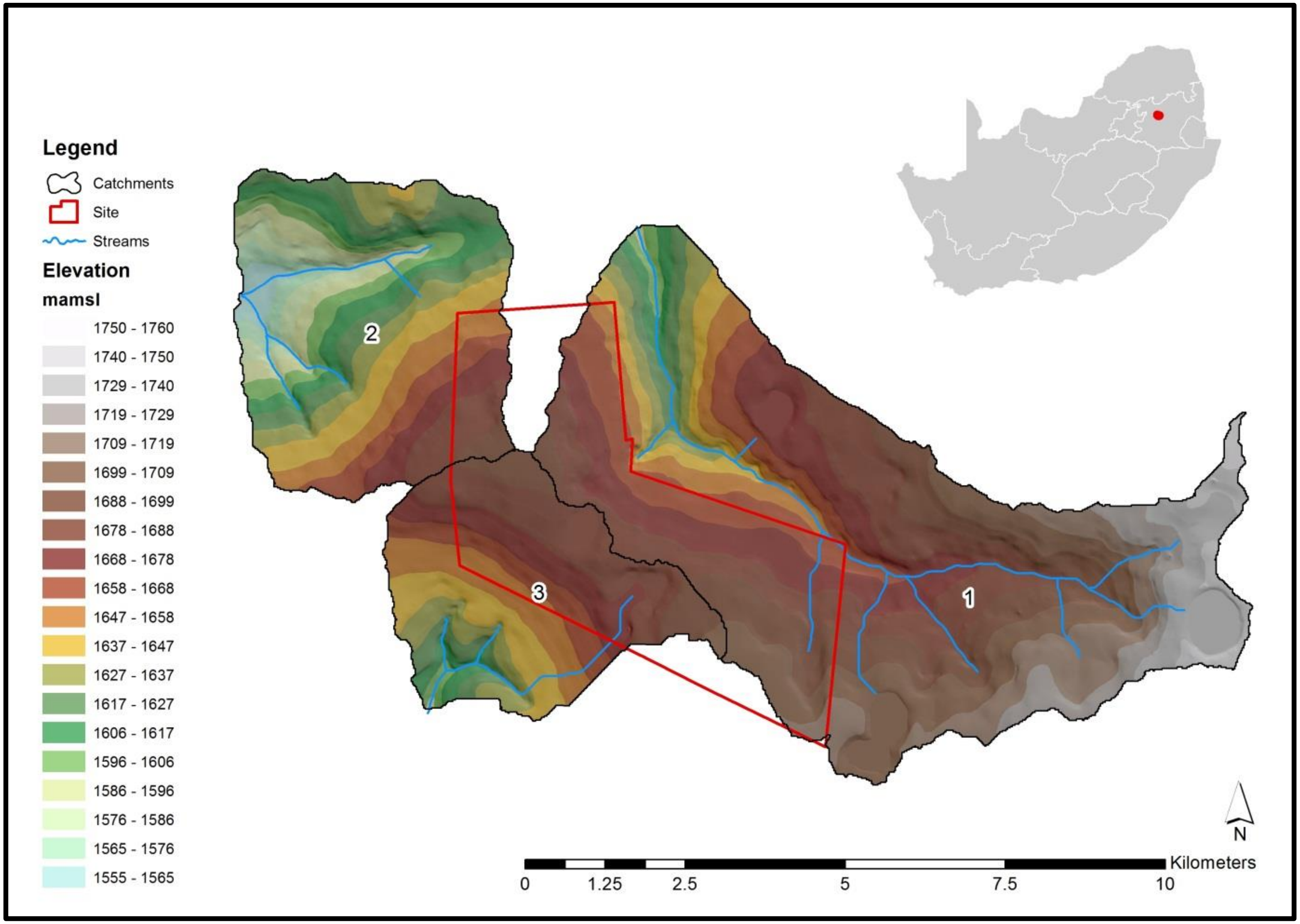


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Figure 26: Flood line catchments based on 1km^2 stream definition

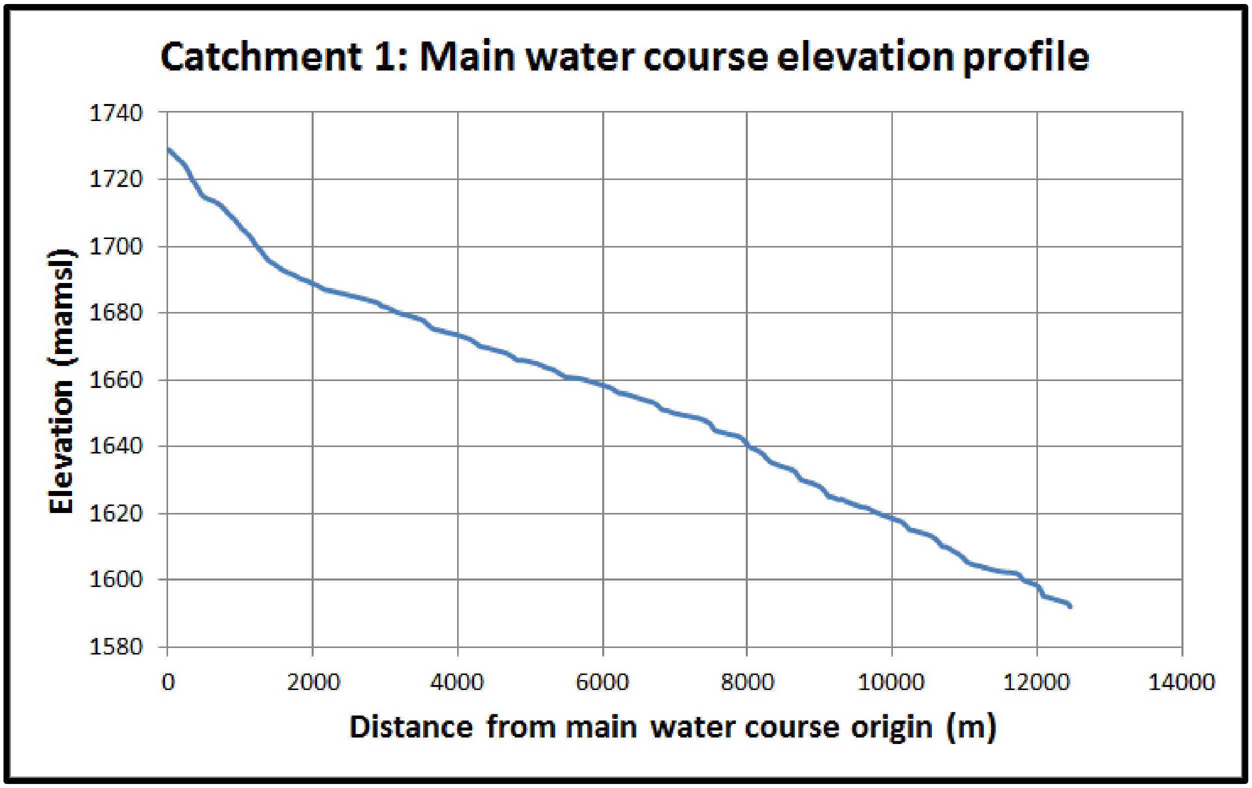


Figure 27: Catchment 1 longest water course

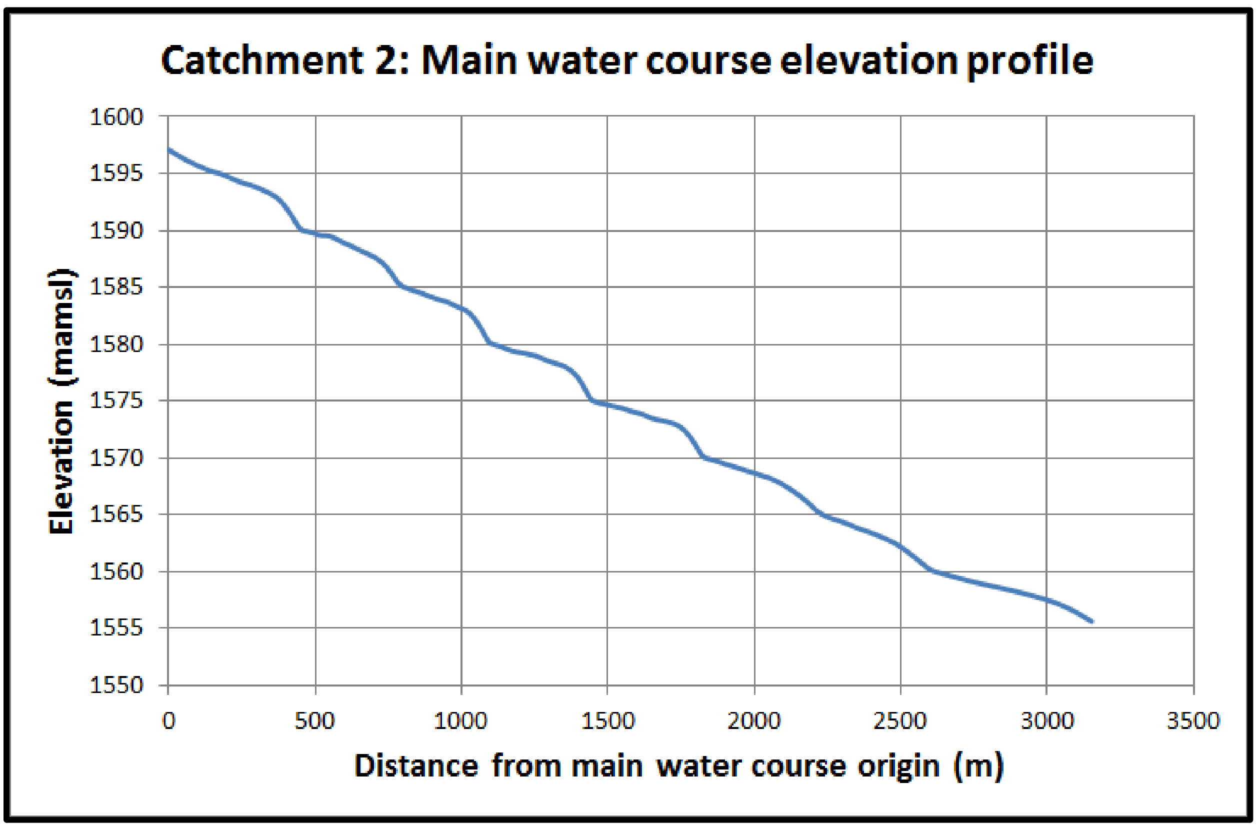


Figure 28: Catchment 2 longest water course

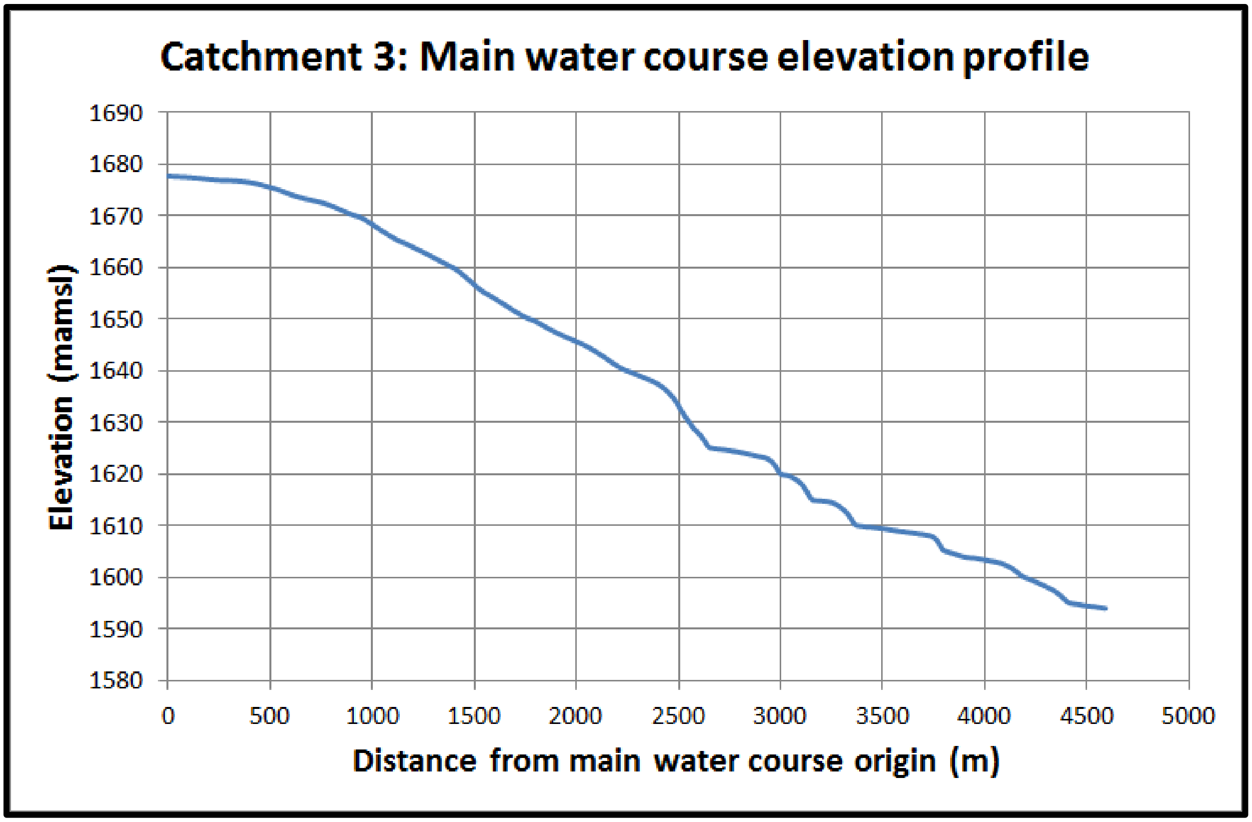


Figure 29: Catchment 3 longest water course

3.2.3.2 Cross section used in flood line calculation

Cross sections obtained from a DEM only represent the "surface profiles" and not the channels itself; therefore the flood lines will be a conservative estimate. Determined cross sections are presented in Appendix 2.

3.2.3.3 Hydrological soil and land cover

The hydrological soils and land cover for the three catchments as derived respectively from Shultze 2006 and SANBI 2009 are shown in Figure 30 and Figure 31 respectively.

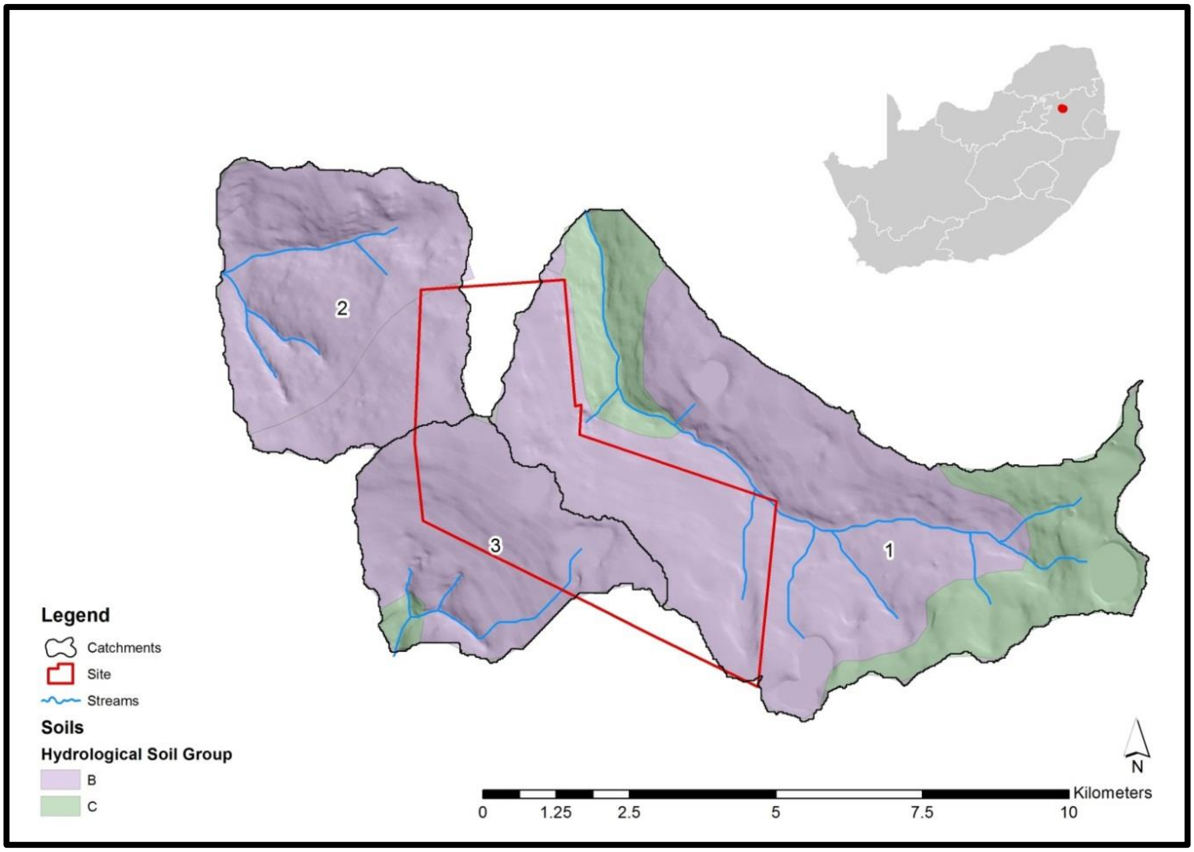


Figure 30: Hydrological soil grouping for floodline catchments

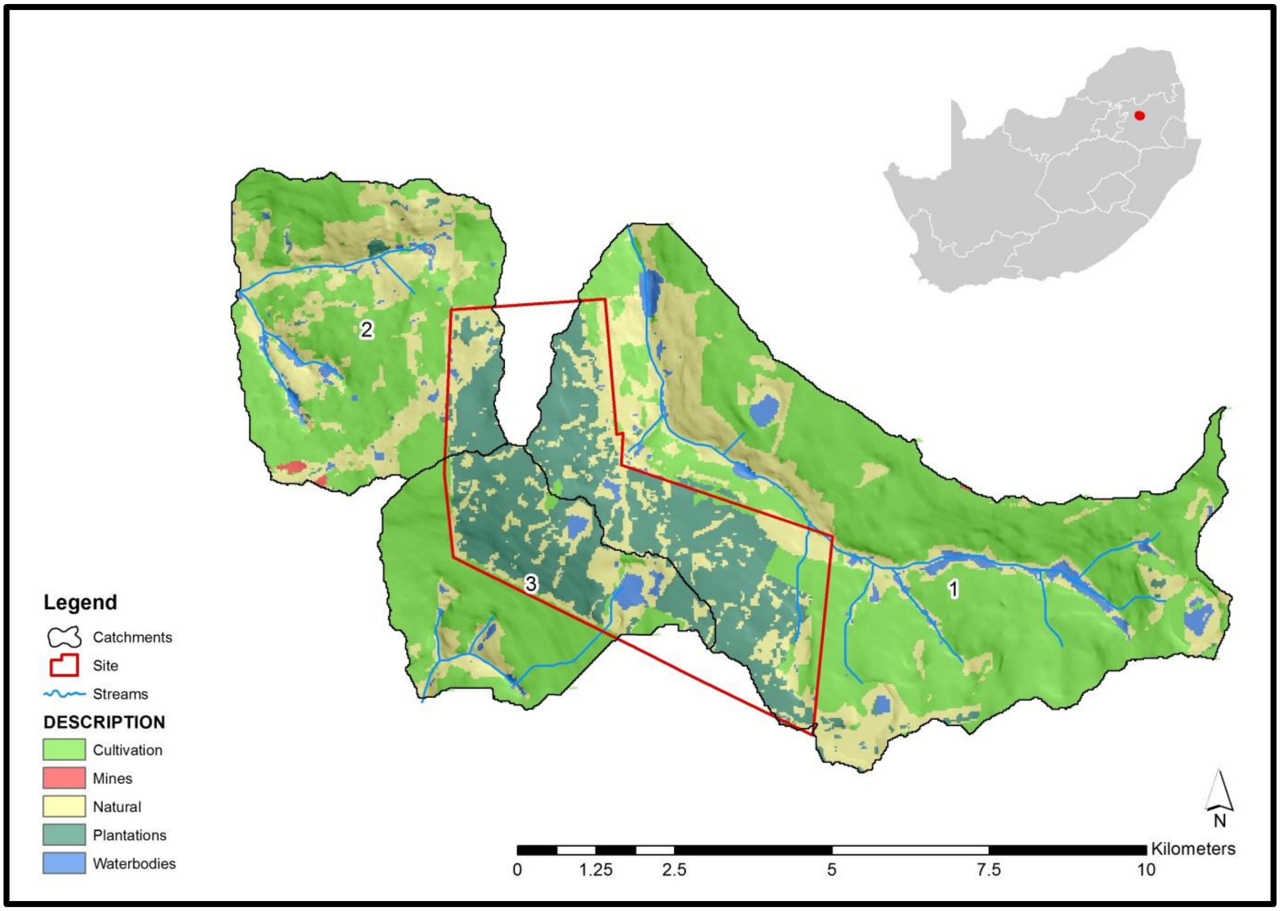


Figure 31: Land cover for floodline catchments

3.2.3.4 Flood peak calculation

To be able to generate flood lines, flood peak values are required. Various methods exist to accomplish this without the use of a rainfall runoff model and the method chosen here is the SCS-SA method. Aerial reduction factors were applied to the catchments making use of the following relationship as described in the SANRAL Drainage Manual:

$$ARF = (9000 - 12800\ln(A) + 9830\ln(60T_C))^{0.4}$$

Where: ARF denotes aerial reduction factor, *Tc* denotes the time of concentration and *A* denotes the area of the catchment. Other catchment parameter was obtained through the use of the soils and land cover maps. The detail calculations are presented Appendix A.

3.3 Models results

3.3.1 Regional surface water model results

The results of the regional surface water model compared to that of the WR2005 are shown in Figure 32, Figure 33 and Figure 34 for Outputs 1 to 3 as shown in Figure 23. Good comparison is obtained for both Output 2 and 3 over all ranges of flow. Output 1 has good calibration with peak flows which is important for storm water simulations, but shows a slightly weaker comparison for the low flow conditions.

The overall results compare very well to that of the WR2005 data in the absence of actual flow gauging data. If assumed that proper calibration was done in the WR2005 project then the regional surface water model can also be considered a well calibrated model. The catchment parameters are scaled down to site level to setup the local storm water model.

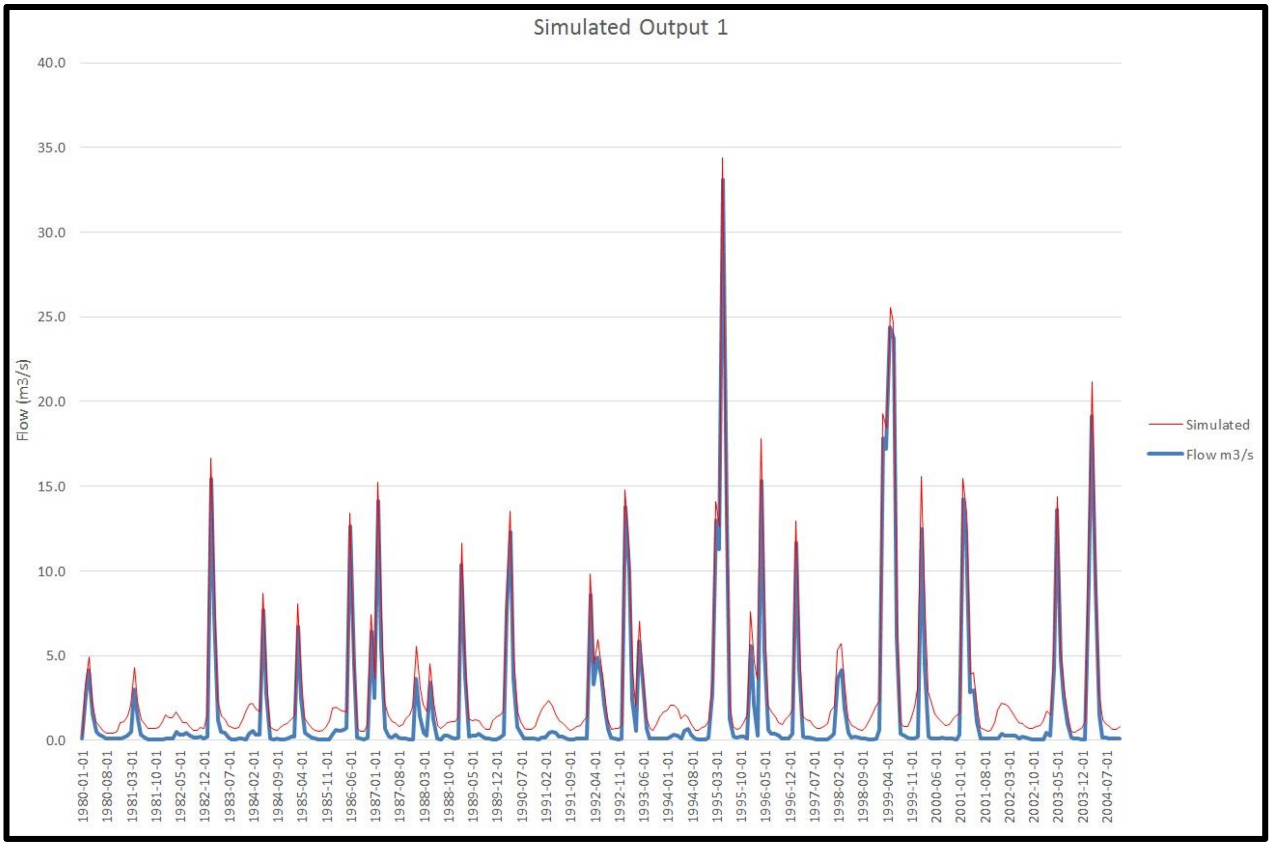


Figure 32: Simulated flow for Output 1

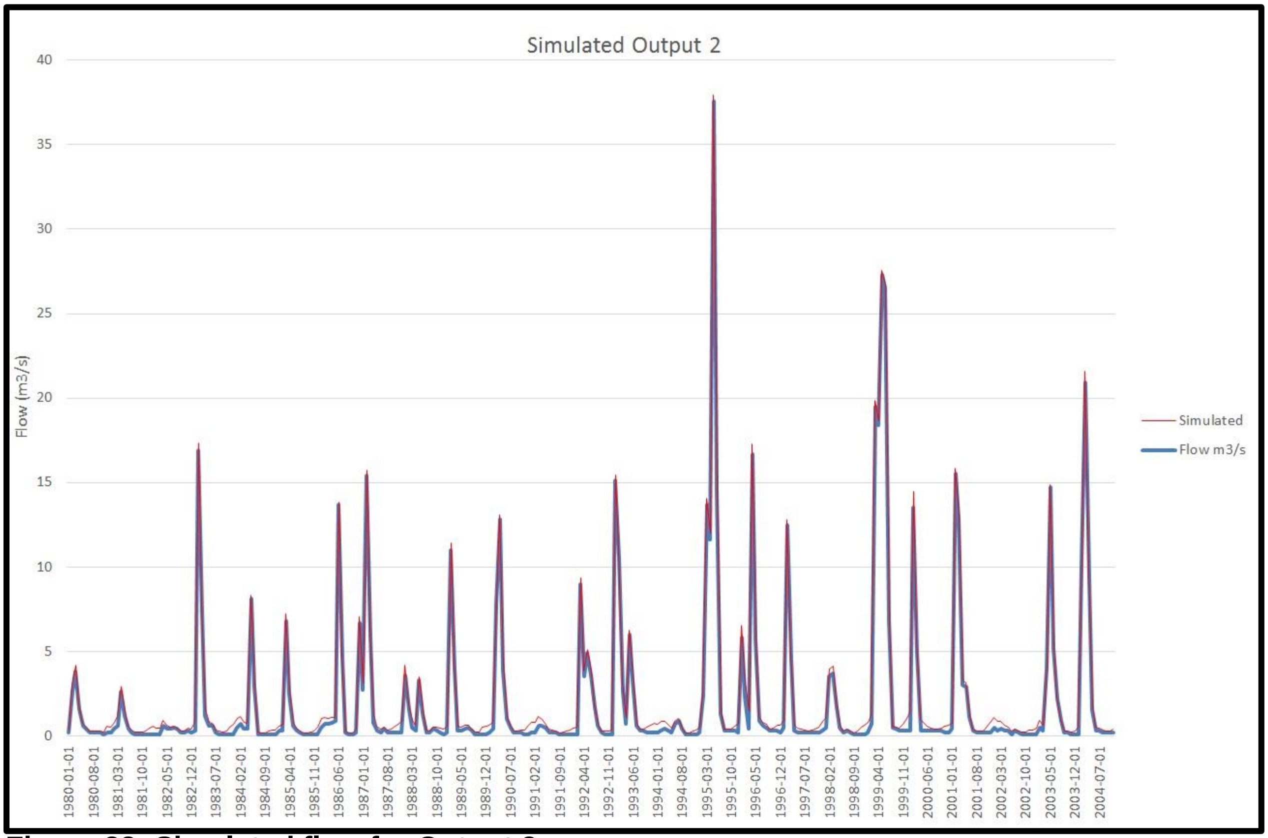


Figure 33: Simulated flow for Output 2

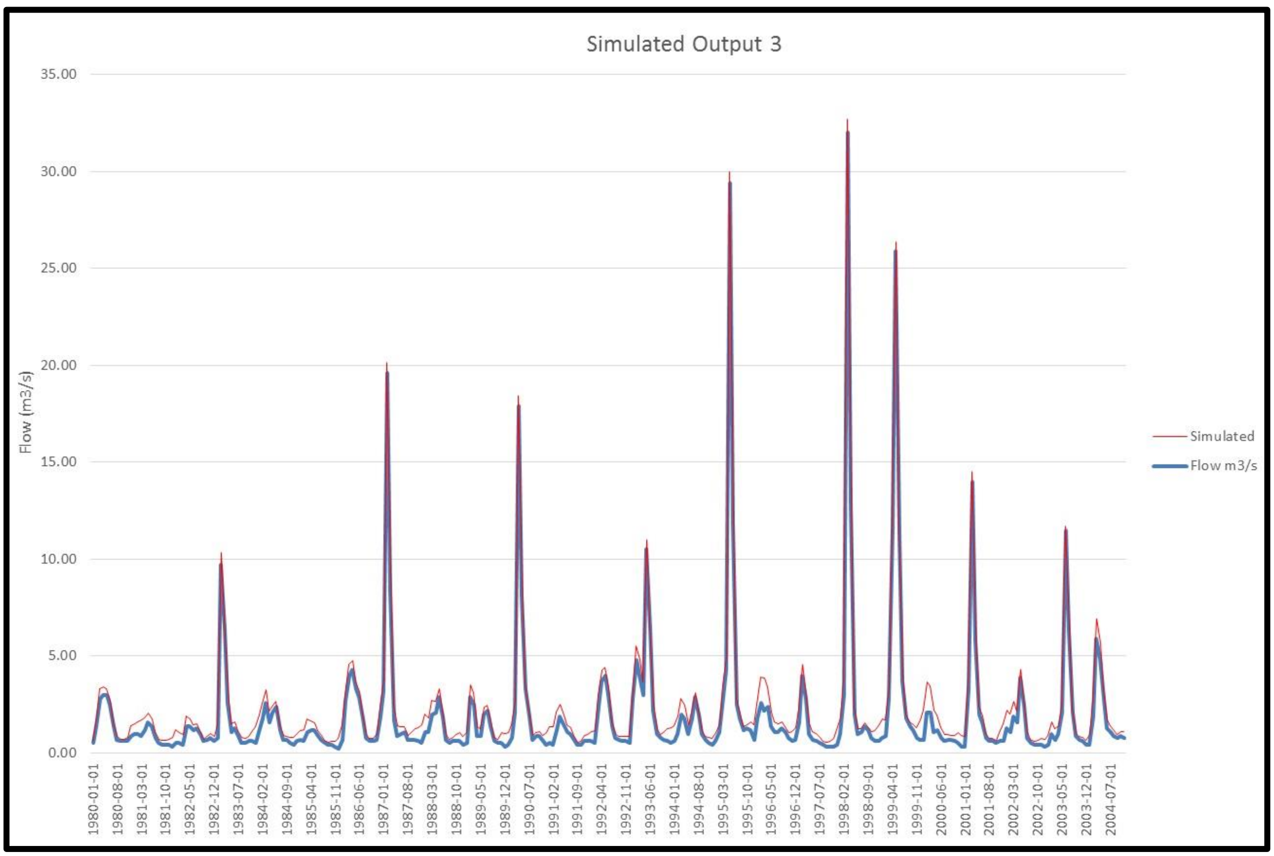


Figure 34: Simulated flow for Output 3

3.3.2 Local storm water model results

The simulated monthly averages for the clean and dirty water dams are presented in Figure 35 and Figure 36 respectively.

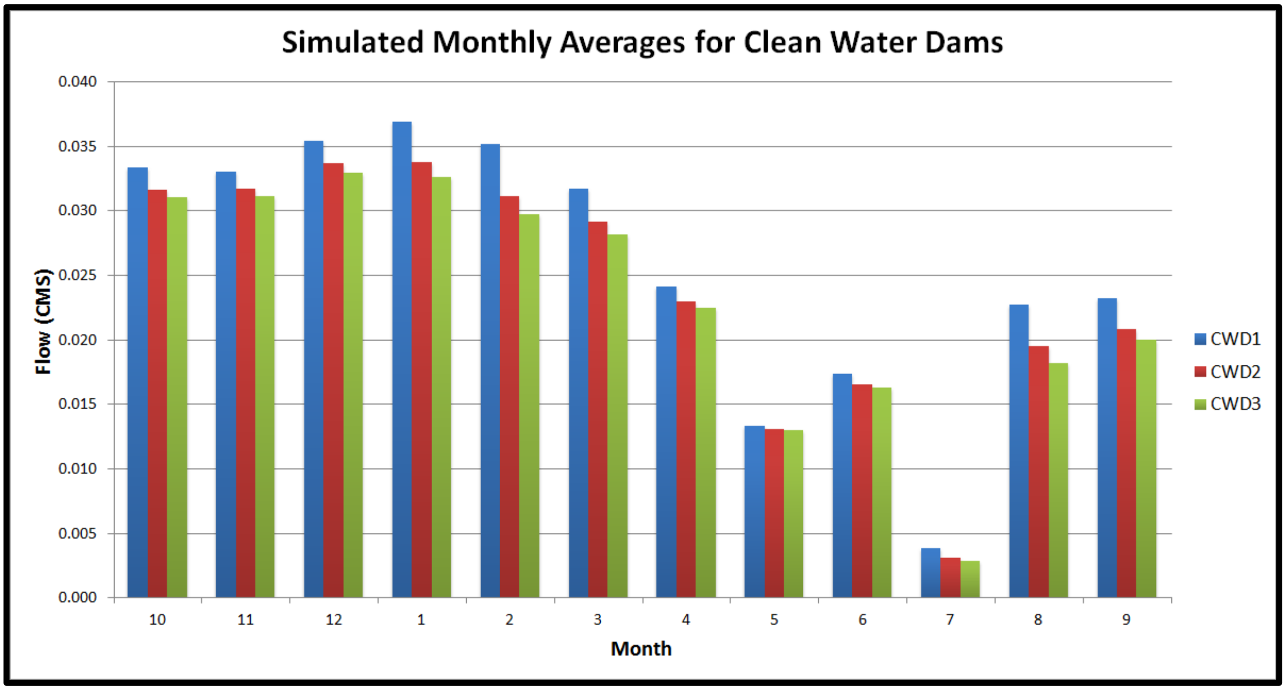


Figure 35: Simulated monthly averages for the clean water dams

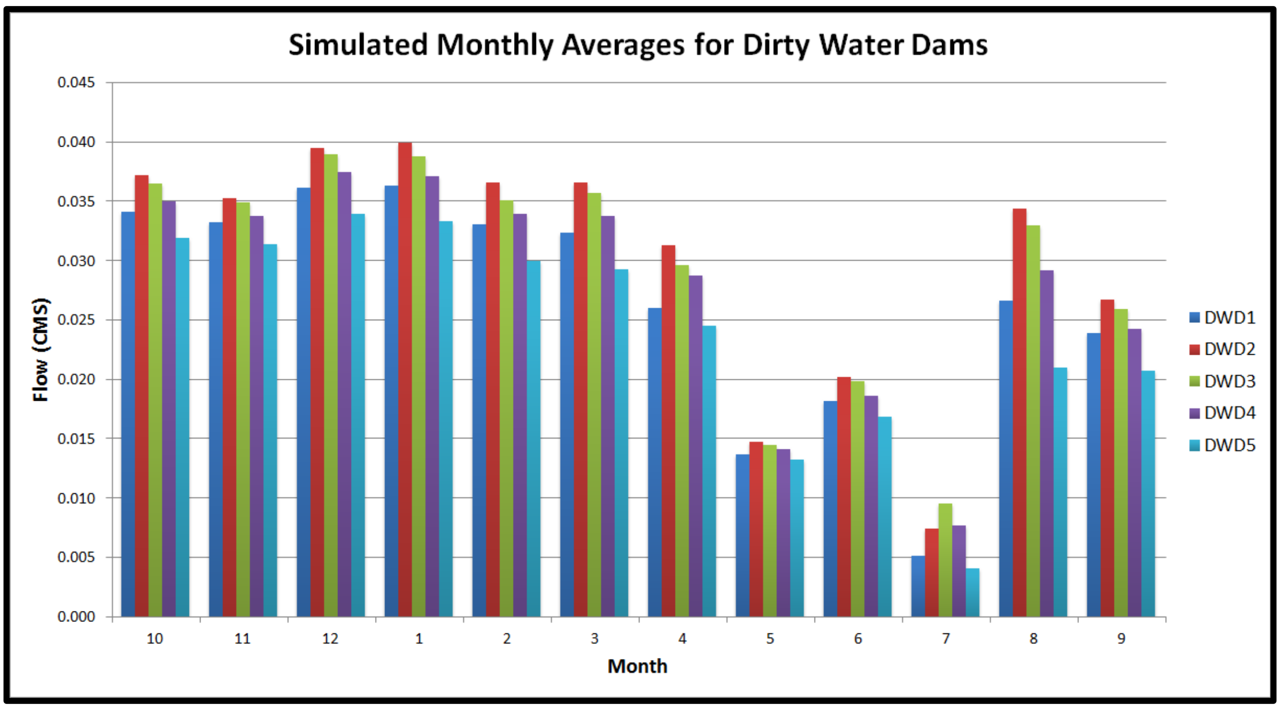


Figure 36: Simulated monthly averages for dirty water dams

A monthly comparison of the total clean water vs. the total dirty water is presented in Figure 37 and the total clean water flow is an estimated 34% of all flow on the site as shown in Figure 38. Note that the total flow on the site presented here excludes the water to be pumped from the pit during operation.

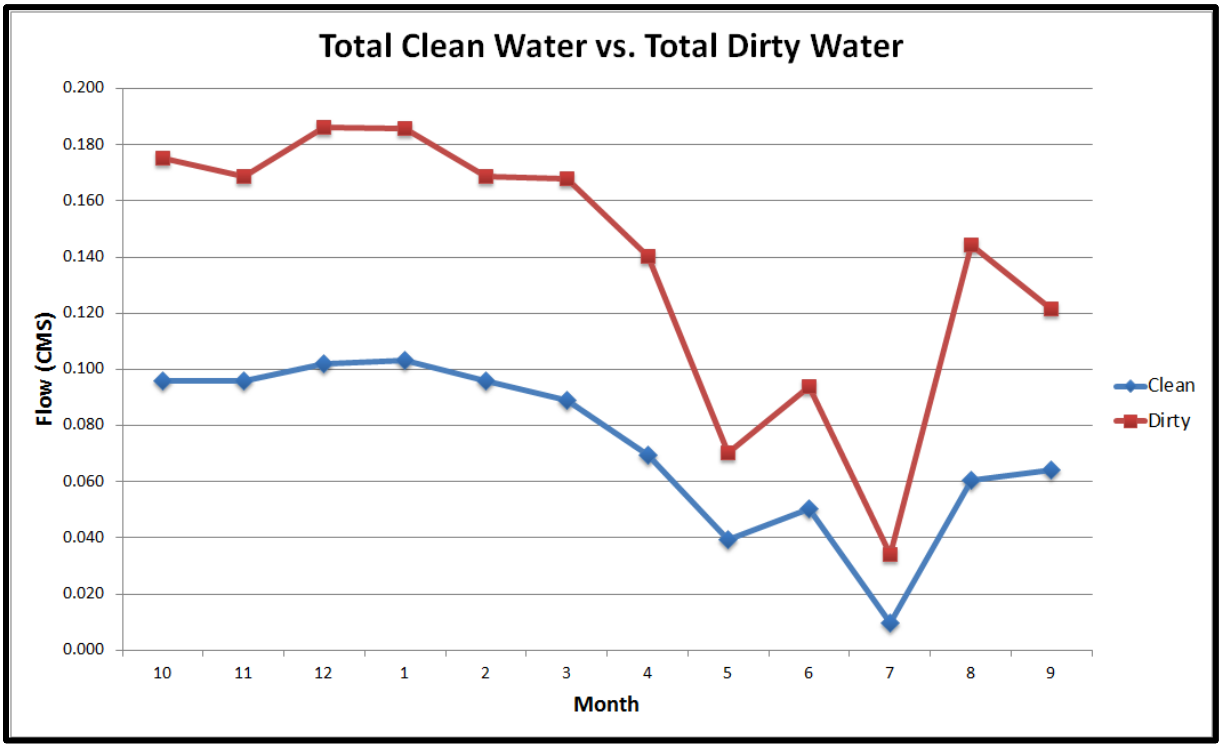


Figure 37: Total clean water vs. total dirty water on monthly basis

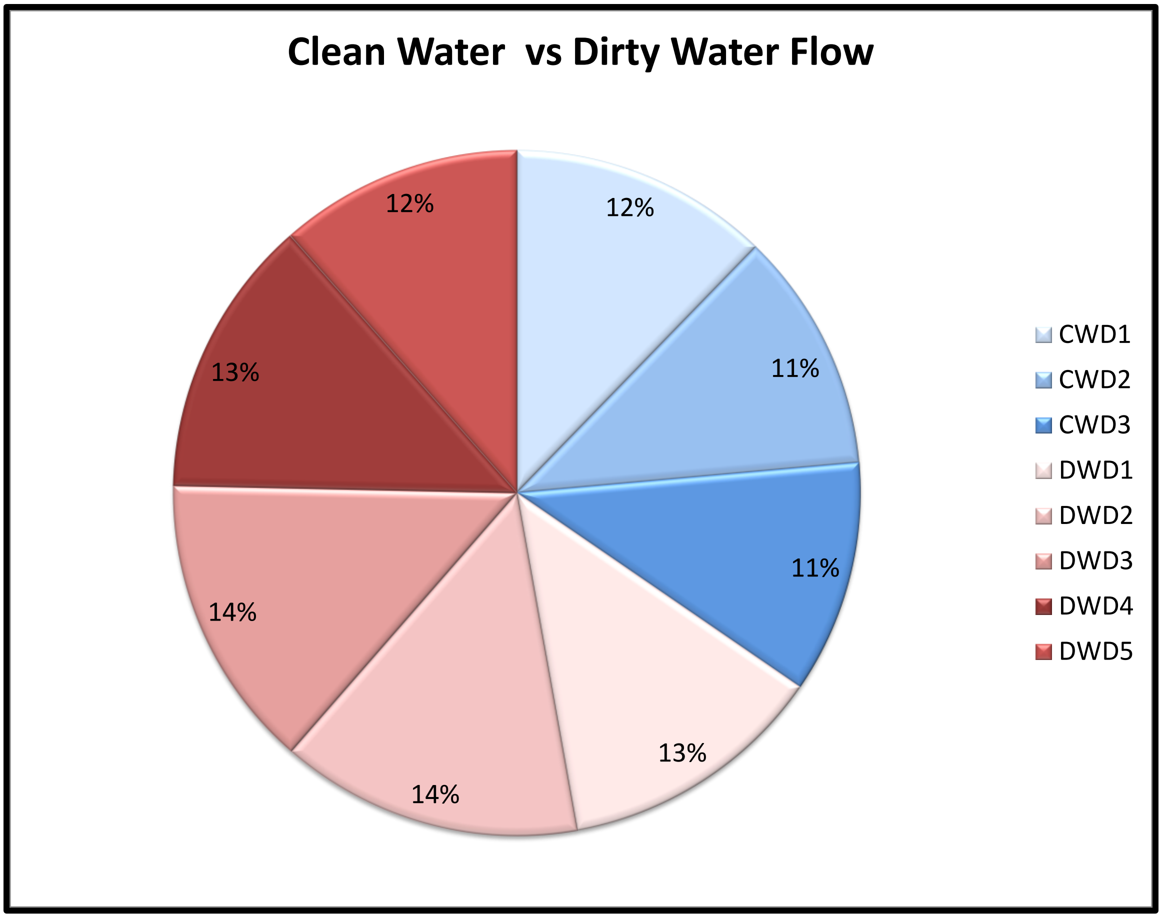


Figure 38: Contribution of flow to each dam

Assuming a general trapezoidal channel shape for all channels as shown in Figure 39, the required sizes to contain peak flow are presented in Table 10

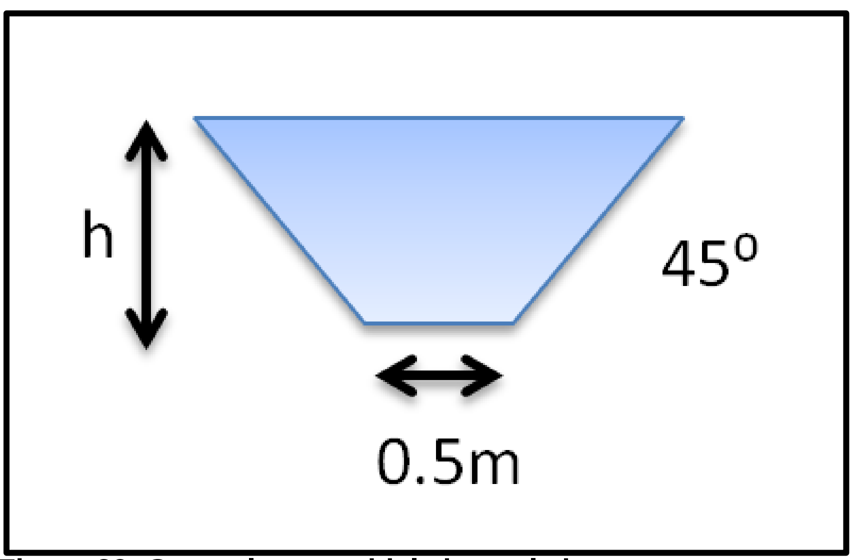


Figure 39: General trapezoidal channel shape

Table 10: Channel sizing based on generic trapezoidal shape

Canal to Dam	h(m) Based on peak flow
CWD 1	0.16
CWD 2	0.12
CWD 3	0.48
DWD 1	0.12
DWD 2	0.14
DWD 3	0.12
DWD 4	0.12
DWD 5	0.09

The individual dam sizes based on a dam with a maximum depth of 1 m that will contain the peak flow in the simulated rainfall records are presented in Table 11. The same evaporation sequences were applied to the storm water model as what was applied in the regional surface water model.

Table 11: Dam capacities to contain peak flow

Dam	Volume (m3)
CWD 1	140,000
CWD 2	55,000
CWD 3	35,000
DWD 1	50,000
DWD 2	82,000
DWD 3	60,000
DWD 4	44,000
DWD 5	18,000

3.3.3 Flood lines calculation results

A summary of the calculated flood peaks (using SCS-SA) per catchment is presented Table 12.

Table 12: Summary of flood peak calculations (m^3/s)

Catchment	Return Period (years)					
	1:2	1:5	1:10	1:20	1:50	1:100
1	4.43	7.52	9.96	12.60	16.39	19.52
2	7.61	12.89	17.07	21.55	28.00	33.32
3	3.35	5.78	7.73	9.84	12.89	15.43

The 1:100 year flood line is shown in Figure 40. Selected cross sections for the three catchments are presented in Appendix B.

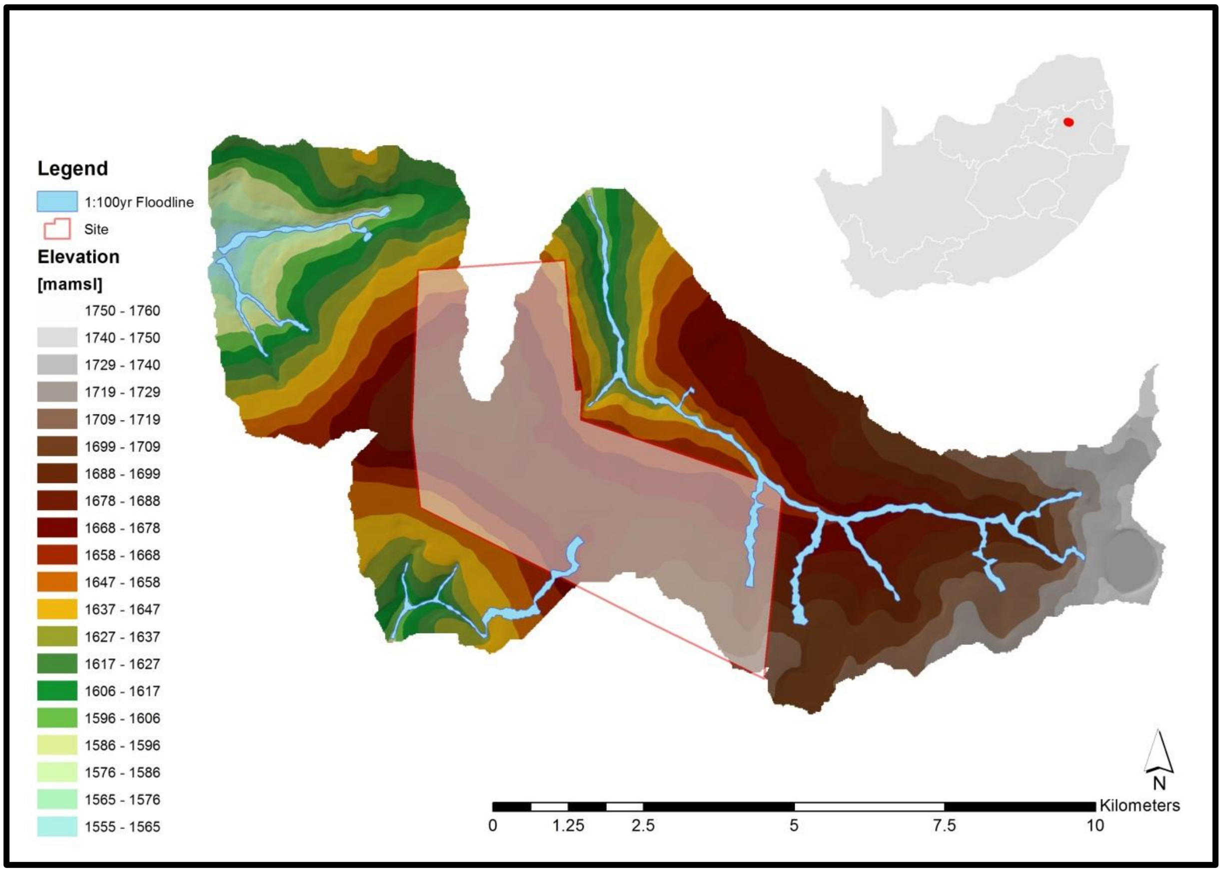


Figure 40: 1:100year flood line

The flood lines in relation to the infrastructure are shown in Figure 41. The flood line in catchment "3" (southern side of mine lease area) is running close to the pit. The flood line profile is broad in these areas because the natural channel is not well defined as it is situated on the watershed. Furthermore, the calculated flood peak is applied to the whole of the catchment resulting in an over estimation of the flood lines upstream. It is proposed to divert part of this water to clean water dam 3 (CWD3) through the use of a storm water channel.

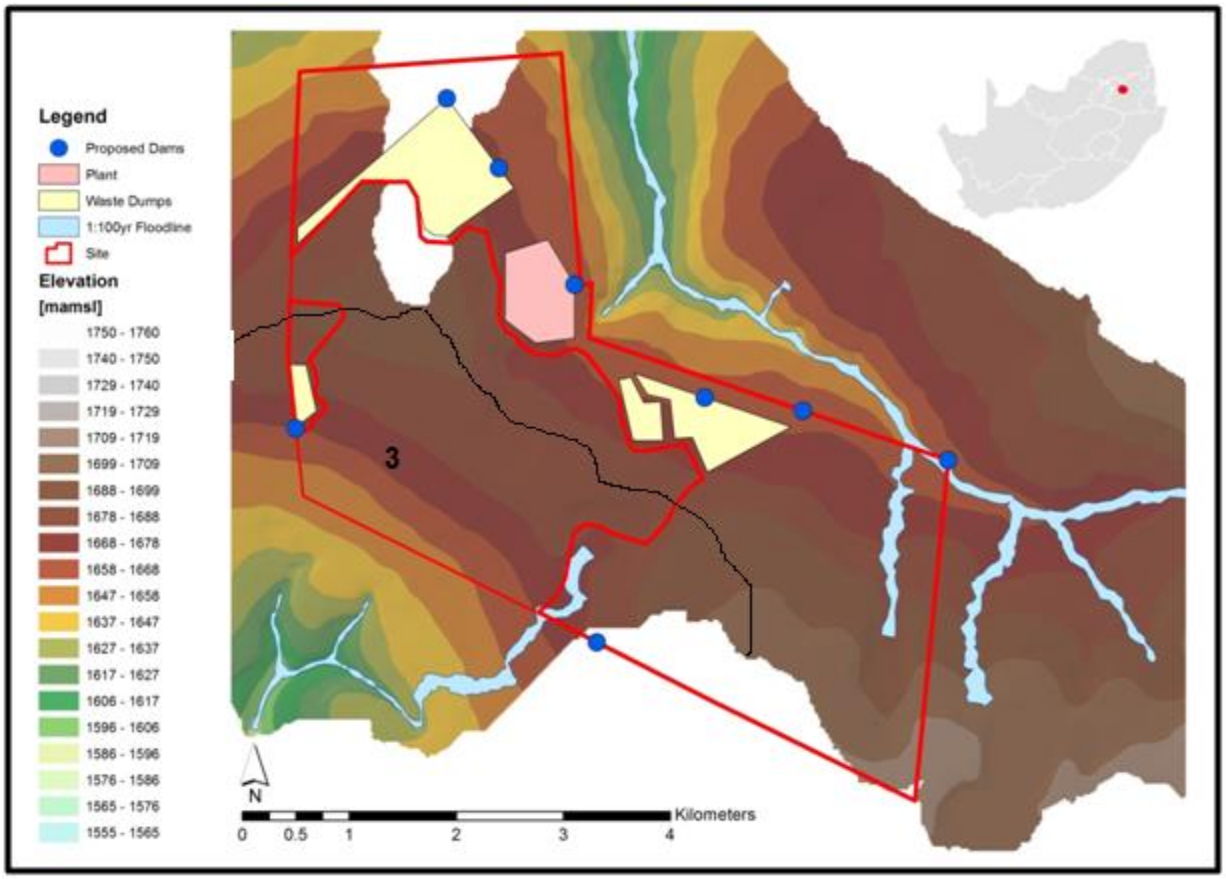


Figure 41: 1:100year flood line in relation to infrastructure

3.4 Key Constraints

The key constraints at this point include:

- DEM data are not sufficient to accurately calculate flood lines. This may results in misestimating of the real cross section, which was supposed to be surveyed.
- Limited flow gauge information, which results in using of WR2005 to set up a regional flow model, and subsequently downscaled to local storm water flow model. Field observation would result in more reliable results.

4 Impacts on surface water

The environmental impact assessment has been undertaken based on DEAT's (1998) Guideline Document: EIA Regulations (Appendix 1).

The overall objective of this assessment is to provide recommendations on how to prevent or minimise impacts arising from the proposed Rietvlei Mine development. The specific actions needed to meet this objective for each project phase are set out. The potential impacts are discussed in light of the following:

- potential surface water impact : the effect on the surface water with respect to who or what will be impacted and how this impact will be felt;
- natural and existing mitigation conditions : natural conditions, conditions inherent in project design and proposed management measures that modify impacts (control, moderate, enhance);
- significance of impact : the significance of the unmanaged and managed impacts taking into consideration the probability of the impact occurring, the extent over which the impact will be experienced, and the intensity/severity of the impacts (requires consideration of unknown risks, reversibility, violation of laws, precedents for future action and cumulative effects).

4.1 Potential project impacts

The potential impacts on are associated with activities during the construction phase, operation phase, and the closure and post-closure phases of the coal mining project.

4.1.1 Construction phase

The mine is situated in the headwater of the catchments and no major build-up of flows is expected to happen,

The clearing of topsoil for footprint areas associated with construction activities (waste site, water control infrastructures, cut and fill) can increase siltation to the surface water resource during soil turning activities. Drainage lines flowing into the mining area will however have to be diverted to prevent clean water from entering the mining area and increase the risk of flooding. Slope associated with berms, and rerouting of the storm water runoff may enhance erosion and siltation, and flood risk at the receiving stream (river)

The construction activities are likely to be associated with accidental spills of hydrocarbons (oils, diesel etc) from the construction vehicles, and other potentially hazardous chemicals during the construction phase. Such spills together with the construction waste constitute potential source of surface water contamination if not properly handled.

The design of the site infrastructure (rock dumps, discard dump, washing crushing plant) should take into account the specification stipulated in GN 36784. Thus construction may result in and the disturbance of Sub-catchment storm water runoff.

The following impacts have been considered and quantified during the construction phase:

- Siltation due to soil disturbance;
- Erosion due to berms and rerouting of natural surface drainage
- Deterioration of water quality due to :
    - construction waste (Chemical in construction material);
    - Hydrocarbon spills and/or leaking from storage (organic contaminants), construction vehicles and equipments.

Without any mitigation measures the impacts significance from construction of the proposed Rietvlei Mine are rated from very low to low (Table 13).

4.1.2 Operational phase

During mining phase, surface water runoff may enter the operating (open pit, crushing/washing plant, stockpiles, etc...) and waste disposal area if not properly managed. This would result on the deterioration of clean surface water runoff. Water (groundwater, rainfall) will need to be pumped from the pit and groundwater, and store at the surface, for mine safety. Water from the operating areas, is considered dirty, and when not stored adequately constitutes a potential source of surface water pollution. Exposed disposed water may increase evaporation rate on site.

Mine activities that may impact on surface water are:

- Overburden dumping: the exposure of rock dumps, result in dirty water that may contaminate surface water, if not properly managed.
- Stockpiling and transport: the exposure of stockpiling and transporting of coal, to water and oxygen, together with hydrocarbon spills from storage (organic contaminants) may also result in contamination of surface water.
- Coal processing: coal will be exposed at the washing plant area to water (with chemical) and oxygen, resulting in dirty water, and spills/slurry from the site can contaminate surface water;
- Tailing disposal: residual from coal processing will be disposed of onsite at designated are or in pit. Such disposal when not handled correctly, constitute a potential source of water contamination;
- Septic tank: spillage from septic may constitute source of bacteriological contamination to surface water. If not properly managed.

Dirty water from any of these activities should be drained, or pumped (where required) to pollution control dams. Pollution control dams, and contaminated water drains constitute potential sources of surface water contamination as result of leakage trough improper barrier system (absent, or leaking).

Handling and transport of waste material have some potential of contaminating surface water, including domestic waste, sewage water, hydrocarbons (storage).

The following impacts have been considered and quantified during the operation phase:

- Erosion due to change in sub catchment drainage disturbance (Increased runoff speed and velocity);
- Siltation due to change in sub catchment drainage disturbance (Increased runoff speed and velocity);
- Water quality deterioration due to :
    - Mining operation (blasting, crushing, washing);
    - Spillage, leaking from hydrocarbon or other hazardous substance storage;
    - Spillage, seepage and/or leak from waste disposal, storage, handling facility;
    - Spillage of septic tank

Without any mitigation measures the impacts significance from the proposed Rietvlei Mine operation activities are rated from Very Low to Medium High (Table 14) with a predominance of low medium. The Medium High impact significance is associated with the potential clean surface water runoff deterioration.

4.1.3 Closure phase

The closing of mining activities and rehabilitation will be concurrently undertaken. Compaction equipment will include driving vehicle. All disused infrastructure will be demolished, and waste from demolition has to be removed from site and disposed at designated site.

Surface water contaminants from the mine (including backfilled opencast pits and return water dams) can be enhanced.

Activities such as covering of the spillages with sand and collection and possibly treatment etc are likely to be associated with accidental spills of hydrocarbons (oils, diesel etc).

Dewatering would be stopped at that stage, and open pit flooding will occur, as recovering of groundwater levels, and subsequent decant to the surface is expected at the lowest mining area. The closure phase is usually too short to see the any evidence of decant. Decommissioning/closure is only complete once the proponent demonstrates no significant impacts. The following impacts have been considered and quantified during the closure phase:

- Erosion due to increase runoff speed and velocity (compaction, shaping);
- Siltation due to increase runoff speed and velocity (compaction, shaping);
- Deterioration of surface water quality due to:
    - Spillage, leaking of hydrocarbon product
    - waste, and spills related to closure activities;

Without any mitigation measures the impacts significance from closure of the proposed Rietvlei Mine are rated from Very Low to Low Medium (Table 15).

4.1.4 Post-Closure phase

At post closure phase, the main potential surface water impacts to be considered and quantify are:

- Deterioration of surface water quality by decanting water,
- Flooding due to decanting water;
- Erosion associated with runoff of decanting water

Without any mitigation measures the impacts significance from closure of the proposed Rietvlei Mine are rated from Very Low to Very High (Table 16).

4.2 Cumulative impacts

No significant pollution source has been identified on site or surrounding, that may cumulatively with the project, impacts on background water quality. However the background water quality as established from two sampling points (Selons River, Dam) is assumed to be related to surrounding activities (agricultural). As no historical observation is available locally, the background flow variation is not known, but it is assumed that flow may be reducing as regional trend. The following impacts have been considered as cumulative impacts:

- Cumulating of reduction of water flow as result of water management (storage, diversion);
- Cumulating of water quality deterioration from mine activities with existing contaminants.

4.3 Mitigation measures

- The development of proposed Rietvlei Mine poses risks to surface water as assessed. The proper design, construction and operation, and maintenance of the appropriate draining and storing facilities, as well as the rehabilitation of the open mine, are part of the key focus areas to mitigate surface water impacts. The following precautions have to be taken into consideration to reduce possible surface water risks posed by the development of proposed Rietvlei Mine:
- Surface water management strategic plan must be implemented to prevent risk of water pollution;

- Surface water monitoring network should be installed before the starting of any construction activities on site and monitoring network can be updated according to the DWA minimum requirements, if required;
- Waste classification is required in order to influence design parameters and make recommendations with regards to design and monitoring requirements. These must be adhered to in order to prevent or minimise seepage from waste disposal areas;
- Any waste and spills (specially during construction, operation and closure) need to be cleaned up immediately according to the DWA minimum requirements;
- Authorities need to be notified in the event of a spill or leachate during construction, operation and closure;
- Clean and dirty water is to be separated;
- Regular maintenance of vehicles must be implemented;
- Trucks need to be capped to minimise spillage of coal or wastes, on roads;
- The reusing dirty water from mine activities must be assessed and implemented as much as possible;
- All hazardous substances must be handle according to the requirements of relevant legislation relating to the transport, storage and use of the substance;
- The area to be used for storage of any hazardous waste and items which contains hazardous substance must be lined with bounded walls to prevent pollution of surface water should a leakage/spillage occur;

4.3.1 Prior to construction

- During design phase, the waste and water management infrastructures at proposed Rietvlei Mine (included dams, drains, waste area) must be designed with the appropriate water barrier system if required, and comply with the DWA minimum requirements (1998/2012/2013), with special focus on the R634, R635, R636 of the NEMWA 2008;
- Design of the mine facilities to be conducted by an accredited or recognised professional designer;
- All dirty surface water control facilities (dam, drain) must be designed to have a minimum freeboard above full supply level, at such manner that they can always handle 1:50 year flood-event on top of its mean operational level;
- Water management infrastructure (separate clean and dirty water systems) should be in place before the commencement of construction activities.

4.3.2 During construction

- A proper construction phase should be carried out under the supervision of an accredited or recognised professional civil engineer, as approved by the designer;
- Storage area for hydrocarbons or any toxic construction material should be bounded according to DWA minimum requirement;
- Compaction of the area should take place during base preparation. t on top of its mean operation level;
- Sloping of the area as to allow for free runoff, towards designated pollution control structure;
- Management of speed versus velocity aspects if and when required as to prevent erosion gullies from forming.

4.3.3 During operation

- Contaminated water drain (within the waste site) and dam must be properly operated and maintained;
- All surface dirty water control facilities (dam, drain) must be operated to have a minimum freeboard above full supply level, at such manner that they can always handle 1:50 year flood-event on top of its mean operation level;
- Keep contamination to a minimum by keeping the pit as dry as possible (dewatering) to reduce contact time of water and oxygen with exposed strata;
- Reduce the amount of water to be removed from the pit area by keeping the operating pit area as small as possible, and by continuously rehabilitating the closed pit area;
- Equip trenches and gullies with energy dissipater, and conduct frequent inspections and maintenances;
- Suspended solids should filter out (silt trap) before dirty water enters pollution control dams, and regular inspections and maintenances should follow;
- Routing of sewage to the municipality sewage works;
- Water and mass balance should be determined and updated regularly.

4.3.4 At the closure and post closure

- Implement closure of open pit progressively;
- Effectiveness of existing monitoring network should be re-evaluated;
- Rubble from waste or contaminated areas should be dismantled and disposed of accordingly;

- Backfill material to be fully compacted and covered, and the entire foot print of waste to be shaped for free-draining;
- Rehabilitation to follow backfilling compaction;
- Rehabilitation should consist of re-vegetating the site using appropriately chosen indigenous grasses. Control of vegetation cover over the rehabilitated area;
- A rehabilitation plan must be implemented and the plan should be done in the line with the contents of NWA (Act No 36 of 1998), to avoid subsequent negative environmental impacts that may occur;
- Continue monitoring until it can be demonstrated that vegetation is self-sustaining and no erosion channels exist;
- Clean water system and dirty water system should be maintained on site;
- Inspection and maintenance should be implemented after removal of materials associated with mining on site.

Table 13: Construction phase impacts

Potential impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Construction																	
Siltation due to soil disturbance	1	1	2	4	1	4	5	20	Water management infrastructure (separate clean and dirty water systems) should be in place before the commencement of construction activities. Compaction of the area during base preparation.	1	1	1	3	1	2	3	9
Erosion due to rerouting of storm water runoff	1	1	2	4	1	4	5	20	Sloping of the area as to allow for free runoff, either towards pollution controls structure or away from the site pending on whether the water is clean or dirty. Management of speed versus velocity aspects if and when required as to prevent erosion gullies from forming. Inspections and maintenance.	1	1	1	3	1	2	3	9
Water quality deterioration due to Spill and /or leaking of hydrocarbon product from construction vehicles,	3	3	1	7	2	3	5	35	Hydrocarbon product storage area should be bounded, and collected rainwater to be removed to keep the area dry	1	1	1	3	1	1	2	6

equipments, and storage																
Water quality deterioration due to seepage from construction waste site to the surface water resource	3	2	3	8	3	2	5	40	Waste classification is required in order to influence design parameters and make recommendations with regards to design and monitoring requirements. These must be adhered to in order to prevent or minimise seepage from waste disposal areas.	1	1	1	3	1	2	3	9

Table 14: Operation phase impacts

Potential impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Operation																	
Deterioration of clean storm water runoff quality	3	3	4	10	4	5	9	90	Separate clean water from dirty water at upstream and divert clean water around the operating area (screening and crushing areas, stockpile area) and disposal areas as to prevent it from entering these areas. Contaminated run-off water from the operating area should be drained to a pollution control dam. Waste classification and management will be of great importance	1	1	2	4	1	2	3	12
Increasing of water removal activities due to in pit dewatering	2	2	2	6	2	3	5	30	Reduce the amount of water to be removed from the pit area by means of effective clean and dirty water system, by keeping the operating pit area as small as possible, and by continuously rehabilitating the closed pit area.	1	1	1	3	1	2	3	9
Ponding due to storm water falling onto operating (mining pit, crushing and screening, stockpiling) areas	2	2	2	6	2	3	5	30	Contaminated storm water from operating area (mining pit, crushing and screening, stockpiling) should be drained to a pollution controlled dam, which should be design according to appropriate regulations.	1	1	1	3	1	1	2	6

Erosion due to surface water runoff rerouting	1	1	2	4	1	4	5	20	Equip trenches and gullies with energy dissipater, and conduct frequent inspections and maintenances.	1	1	1	3	1	1	2	6
Siltation due to surface water runoff rerouting	1	1	2	4	1	4	5	20	Suspended solids should filter out (silt trap) before dirty water enters pollution control dams, and regular inspections and maintenances should follow.	1	1	1	3	1	1	2	6
Water quality deterioration due spill and/or leaking of hydrocarbon	3	2	3	8	2	5	7	56	Hydrocarbon product storage area should be bounded, and collected rainwater to be removed to keep the area dry	1	1	1	3	1	2	3	9
Water quality deterioration due to septic tank	2	2	3	7	2	5	7	49	Routing of sewage to the municipality sewage works	1	1	2	4	1	2	3	12
Water quality deterioration due to seepage from waste disposal facility to the surface water resource	3	2	3	8	3	5	8	64	Waste classification is required in order to influence design parameters and make recommendations with regards to design, nd monitoring requirements. These must be adhered to in order to prevent or minimise seepage from waste disposal areas.	1	2	2	5	1	2	3	15
Water quality deterioration due to spillage, seepage and/or leak from waste disposal, storage, handling facility	3	2	3	8	3	5	8	64	Waste classification is required in order to influence design parameters and make recommendations with regards to design, and monitoring requirements. These must be adhered to in order to prevent or minimise seepage from	1	2	1	4	1	2	3	12

to surface water								waste disposal areas.								
Water quality deterioration due to Spillage of dirty water from dirty water control system (Dams, trenches, berms ect..)	3	2	3	8	3	5	8	64	All the different components of the dirty water control system should be design according to appropriate regulations. Water and mass balance should be determined and updated regularly.	1	2	1	4	1	2	3	12

Table 15: Closure phase impacts

Potential impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Closure/Decommission																	
Erosion due to increase of runoff speed and velocity	1	1	2	4	1	4	5	20	Rehabilitation should consist of re-vegetating the site using appropriately chosen indigenous grasses. Control of vegetation cover over the rehabilitated area.	1	1	1	3	1	1	2	6
Siltation related to erosion	1	1	2	4	1	4	5	20	Clean water system and dirty water system should be maintained on site. Inspection and maintenance should implemented after removal of material s associated with mining on site	1	1	1	3	1	1	2	6
Deterioration of water quality due to spill and/or leaking from hydrocarbon storage are	3	3	3	9	3	5	8	72	Hydrocarbon product storage area should be bounded, and collected rainwater to be removed to keep the area dry	1	1	2	4	1	2	3	12
Deterioration of water quality due to seepage and/or spillage from waste site facility	3	3	3	9	3	5	8	72	Waste classification is required in order to influence design parameters and make recommendations with regards to design, and monitoring requirements. These must be adhered to in order to prevent or minimise	1	1	2	4	1	2	3	12

									seepage from waste disposal areas.								

Table 16: Post closure phase impacts

Potential impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Post closure																	
Deterioration of the surface water quality due decanting water	4	4	5	13	5	5	10	130	Decant water should be contained (pollution control dam) or treated. Clean water runoff from decant area must be maximised by sloping the decant area , to minimise ingress of storm water.	2	3	2	7	2	2	4	28
Flood risk due decant to surface	3	3	4	10	3	4	7	70	Decant water should be drain to a specific pollution control dam.	2	1	1	4	1	2	3	12
Erosion due decant water runoff	1	1	2	4	1	3	4	16	Water run-off direction, and velocity as well as the geophysical conditions of the rehabilitated areas should be measured trough field surveys. A modelling simulation may be useful as management tool. The rehabilitated areas should be covered of vegetation and maintained	1	1	1	3	1	1	2	6

Table 17: Cumulative impacts

Potential cumulative impacts to surface water	Environmental significance score								Recommended mitigation measures	Environmental significance score							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Construction																	
Reduction of water flow as result of water management (storage, diversion)	1	3	3	7	3	4	7	49	Controlled release of diverted water and treated water into the natural system	1	2	2	5	2	2	4	20
surface water quality deterioration from mine activities with existing contaminants	1	3	3	7	3	5	8	56	Only clean or treated water should be release into natural system	1	2	2	5	2	2	4	20

5 Primary Water balance

5.1 Water balance principles

As a mass balance concept, the water balance concept relies on the basic principle of mass conservation and can be illustrated as in the following illustrative equation:

Total water in = Total water out

5.2 Water balance Objectives and boundaries

As the project is still in design phase, the purpose of the preliminary water balance is to develop an initial water management tool to determine areas to be targeted for water management and assess possible water management measures, for the whole mine (pits, plant, water dams, etc...). It will assist in highlighting information gaps and in identifying points of metering and monitoring in order to develop a realistic and site specific water balance.

This preliminary water balance will first be used by the design team, but also provide a first estimation of the quantity of water that will be used (intake) and of waste water (disposed and discharge) to the regulatory authorities (Department of Water Affair, Department of Environmental Affair).

Due to a lack in data available for the mining project water reticulation system at this time, it is clear that the current objectives should be reviewed and assessed on a regular basis as additional data becomes available.

The water balance is not to be considered as a once off investigation, but rather an iterative process to be updated as the mine's activities commence. The balances should be updated regularly to reflect the dynamic process of change at the mine.

Although the water balance is of a preliminary nature and intends to cover the entire proposed mine site, and includes the following management units:

- Mining pit
- Crushing/washing plant and offices
- Rock waste dumps
    - Waste dump 1 (WD1)
    - Waste dump 2 (WD2)
    - Waste dump 3 (WD3)

    - Waste dump 4 (WD4)
    - Waste dump 5 (WD5)
- Dewatering dam
- Dirty water dam
    - Dirty water dam 1 (DWD1)
    - Dirty water dam 2 (DWD2)
    - Dirty water dam 3 (DWD3)
    - Dirty water dam 4 (DWD4)
    - Dirty water dam 5 (DWD5)
- Clean water dam
    - Clean water dam 1
    - Clean water dam 2
    - Clean water dam 3

5.3 Available data

To develop a water balance it is necessary to collect data of flow rates (pumping, and runoff water), and dam volumes relevant to the identified water circuits.

At present stage of the project, the main information available on flow rates and dam volumes are from groundwater and storm water runoff model simulations. In addition of the model results, meteorological (rainfall, evaporation) data, mining sequence (layout) and mining schedule as designed presented in section 2.2 of the current report, and the process design plans and criteria as provided in section 6 (Process and metallurgy) of feasibility report by Mindset were also used in the development of the preliminary water balance.

5.4 Water circuits and schematic flow diagram

These defined management units have been used to identify all the main water process units and flow paths.

The general preliminary water balance flow diagram is given in Figure 42, whereas the details respective to each water circuit are given accordingly below.

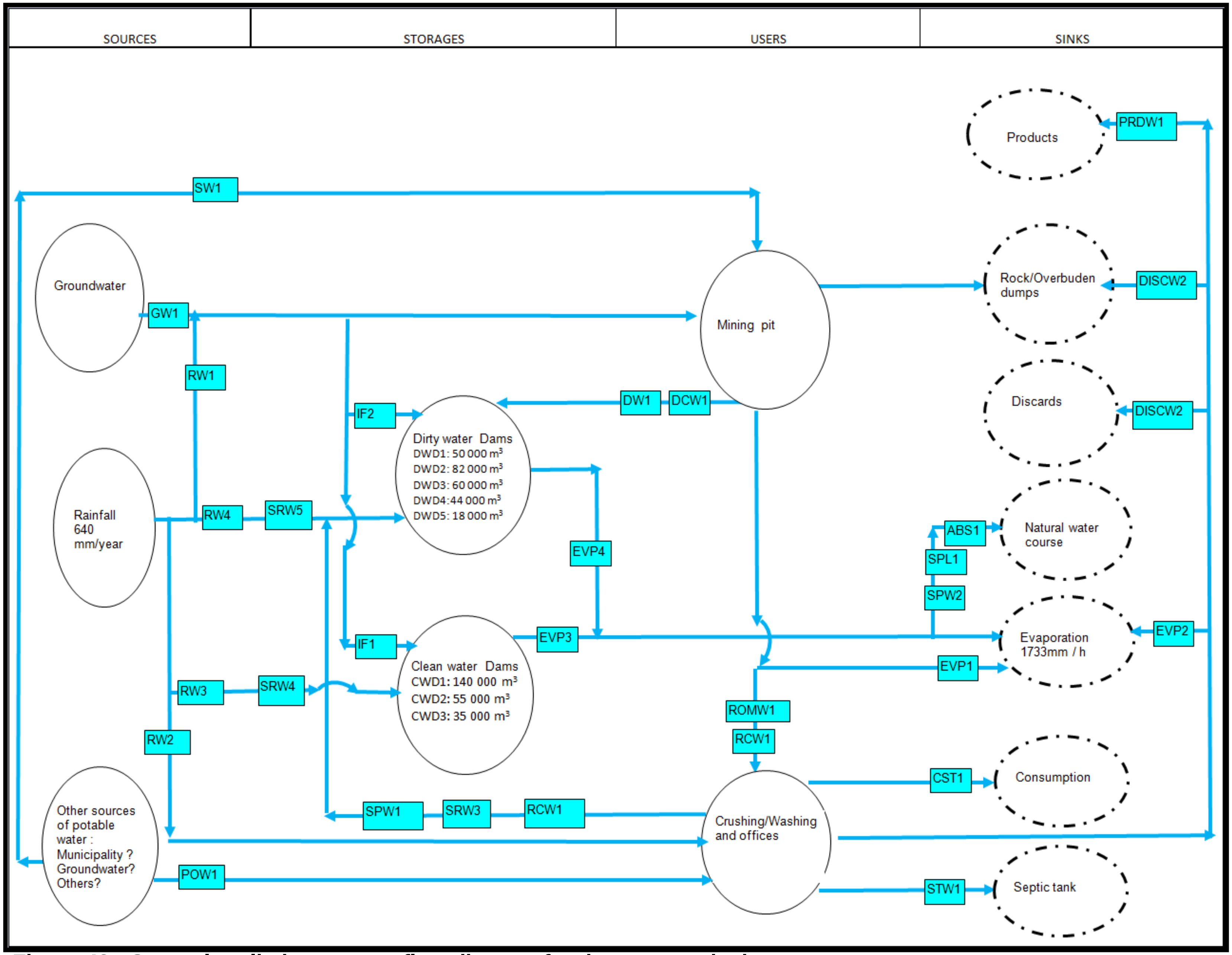


Figure 42 : General preliminary water flow diagram for the proposed mine

5.4.1 Open cast mining circuit

Although concurrent rehabilitation is recommended, the rate of its implementation is not clear at the moment, making difficult to determine the operating pit area when mining will reach steady state. The mining areas as presented in mining schedule have been assumed as operating areas in the preliminary water balance.

As the water management principle does not allow any surface runoff from the clean area to enter into the dirty areas, the surface water (runoff) input and output of mining pit unit has been considered equal to zero (0).

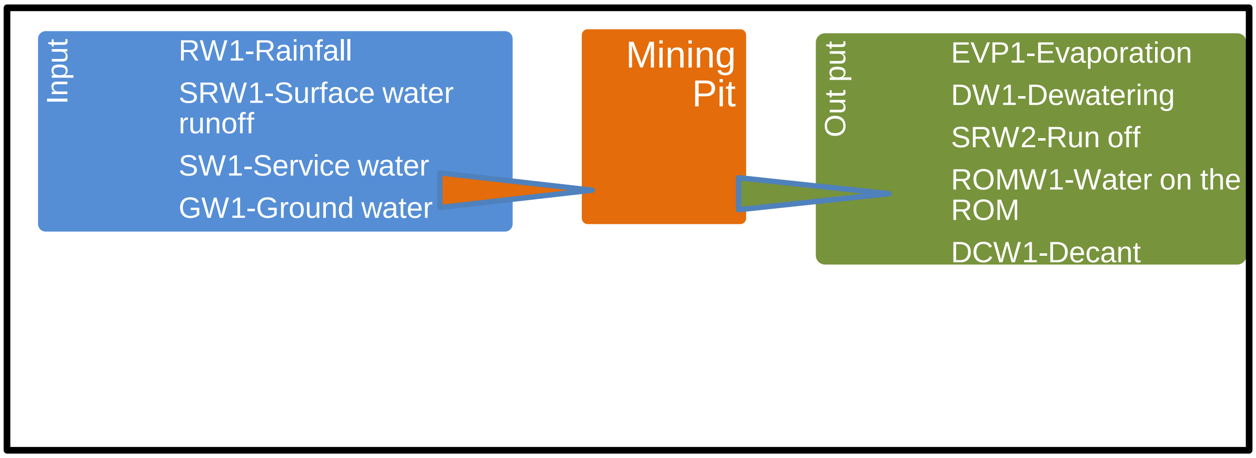


Figure 43: Open cast mining circuit

Water content of the ROM used for coal yield calculations in section 6 (Process and metallurgy) of feasibility report was assumed correct and used in the water balance model. As preliminary water balance it does not yet account for pit flooding and decant of pit water to surface. In pit dewatering volume is found to be for now very sensitive to the high rate of evaporation. Without removing volumes of probable decant water and evaporated water, simulated annual average in pit water dewatering volume is shown together with forecasted class A pan evaporation in Figure 44.

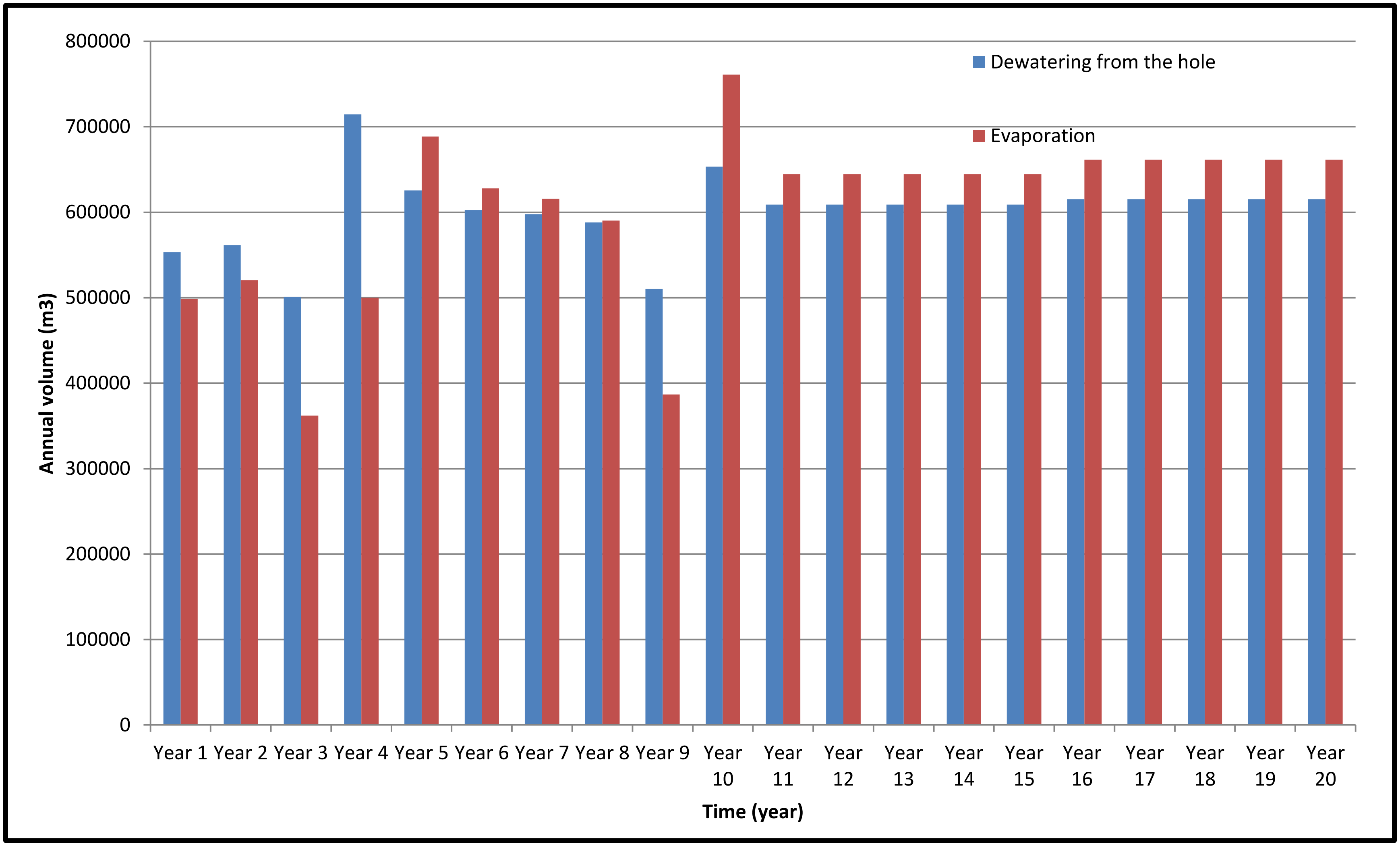


Figure 44: Estimated in pit dewatering and class A pan evaporation as per mining schedule

5.4.2 Crushing/Washing plant and offices circuit

Between 1,000 to 2,000m^3/day are estimated (Section 6 Feasibility study) required as make-up water supplied for coal processing. Water content of the products (Eskom, and Export), had been sourced from coal yield calculations in section 6 (Process and metallurgy) of feasibility report. One of the biggest challenges in ore processing planning and design is the source of water for processing. The coal processing design at the proposed Rietvlei Mine make provision of a standard magnetite recirculation / recovery system and intend to make a maximum use of recycling of available water. If 30 % of total water engaged in coal washing plant is recycled, the potable water demand (for processing) would decrease (Figure 46) to 500000 m^3/year (1370m^3/day). Such remaining demand may be sourced from the dirty water dams. Recirculation/recovery system efficiency may allow up 50% of recycle water, in which case the remaining demand would even be lesser.

It has been assumed that the processing plant and office will be used by a maximum of 150 persons with a maximum need of 50 litres per person per day. Considering such need, a total volume of 1642.5 m^3 is expected per year for human consumption. A maximum of 985.5 m^3 of the waste water will be disposed to in site septic tank per year.

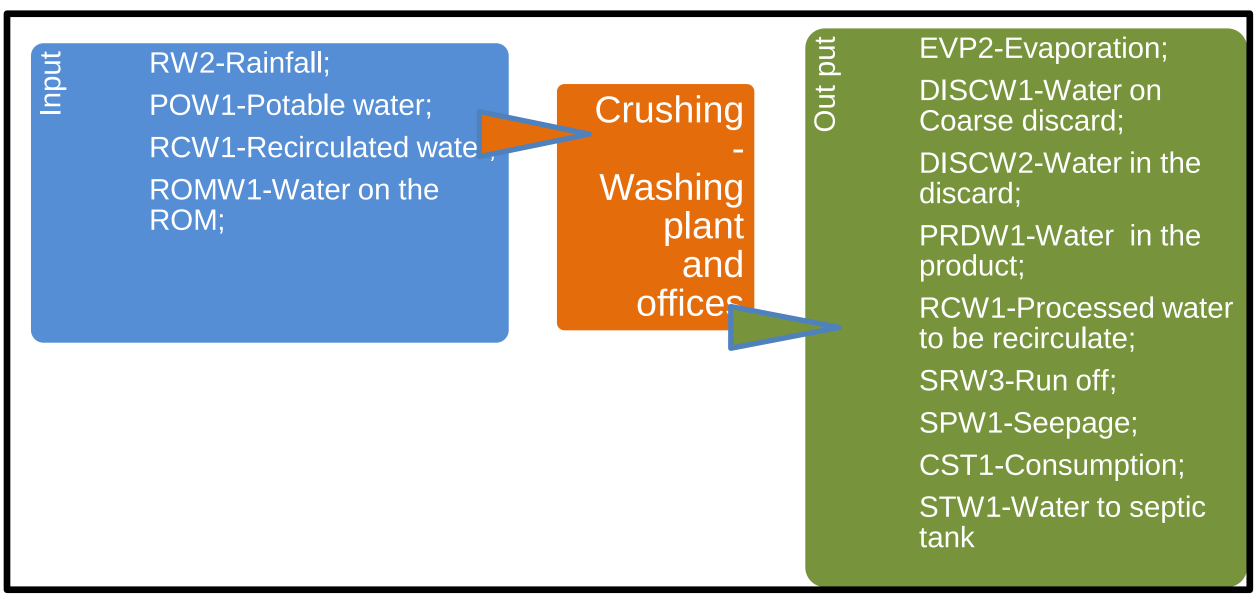


Figure 45: Crushing/washing and Offices mining circuit

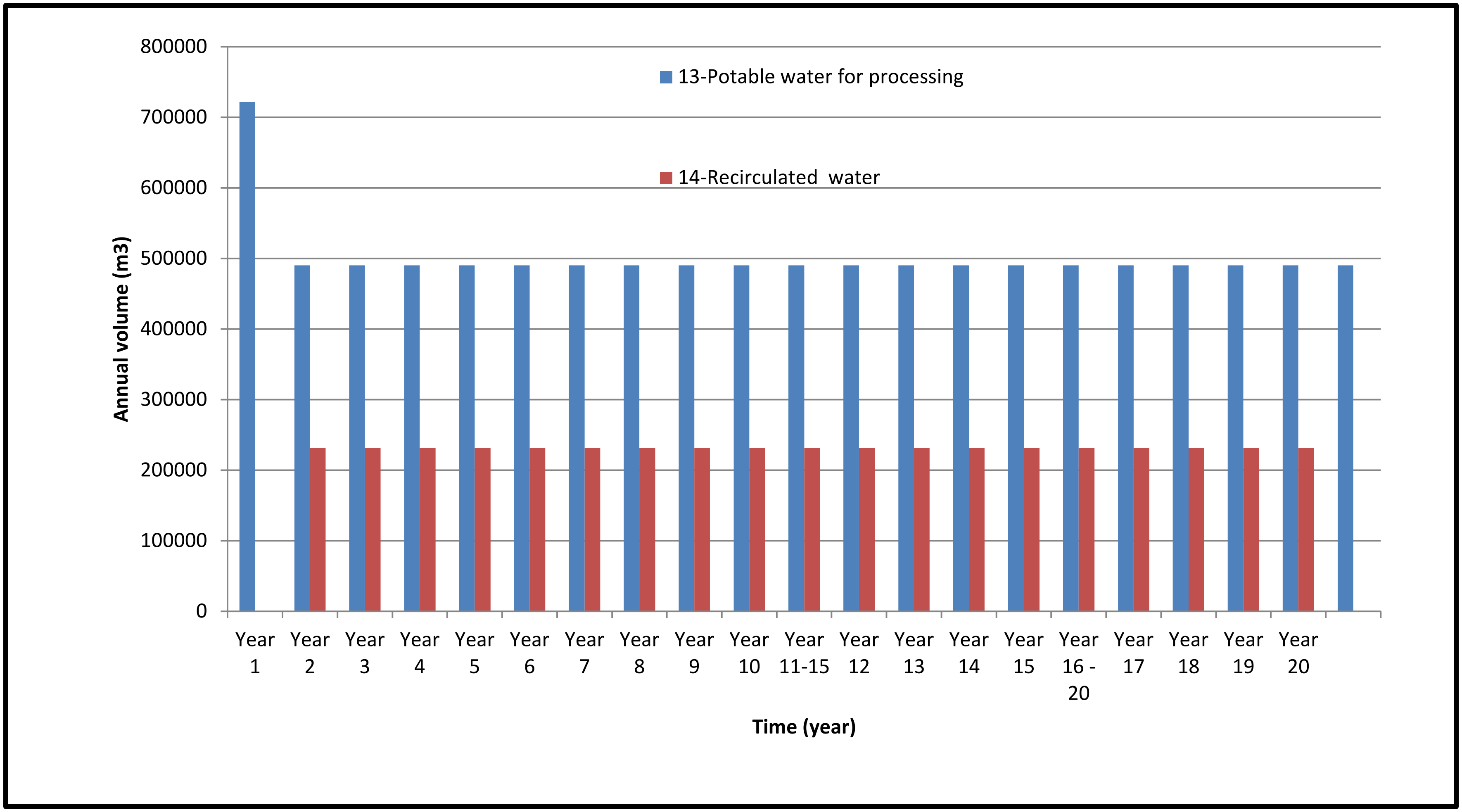


Figure 46 : Estimated need in potable water versus re-circulated water (30%) as per mining schedule

5.4.3 Water storage dam circuits (Clean and dirty water dam)

Only the number of clean and dirty storm water dam have been considered in the preliminary water balance. Volumes of dewatered water (clean and dirty) are assumed to be disposed in proposed clean and dirty water dam. No dewatering dam is proposed for now, but may be required as volumes to be disposed may be measured and/or determined during operation phase. The simulated monthly average runoff flow into the different surface water dams (clean and dirty) constitutes the runoff (input). It is estimated that 4344155 m^3 of dirty storm water runoff and 2 726834 m^3 of clean storm water runoff would be collected in the pollution control dams. Part of such water would be evaporated, but the rest would be available for the mining and processing demand.

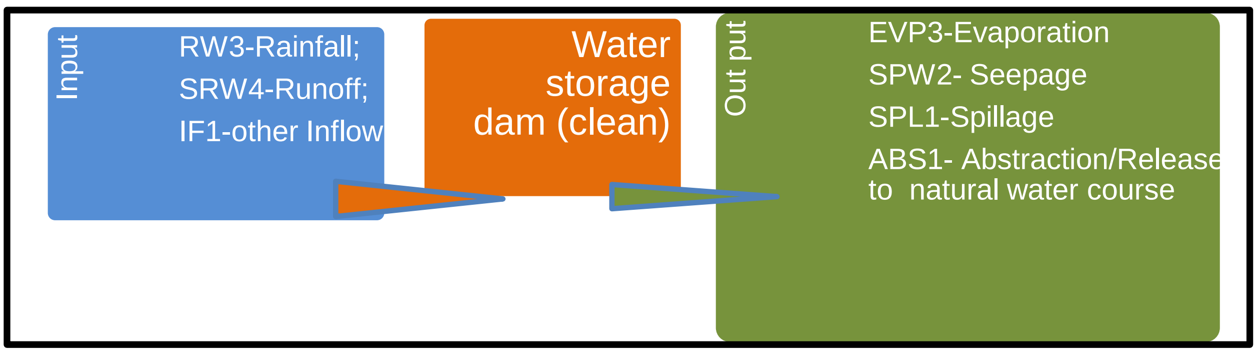


Figure 47: Clean surface water dam circuit

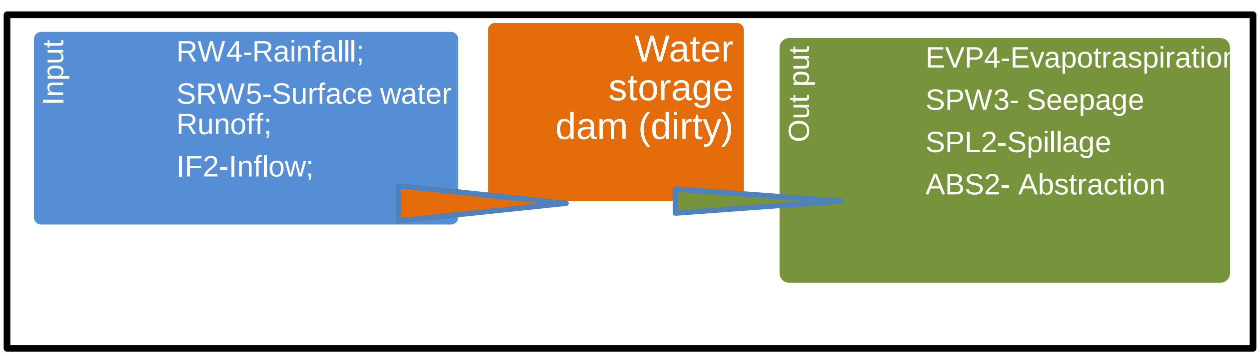


Figure 48: Dirty surface water dam circuit

5.5 Ongoing management of water balance

The water unit circuits considered in the preliminary water balance are based mostly on available information. Most of the inputs to water balance are simulated from groundwater and surface water flow models which have are associated with different sources of uncertainties (homogenisation, downscaling, etc...). It is very important to ensure that the water balance is regularly updated with the latest data according to a defined monitoring programme. To ensure that this happens, the following focus areas for data collection are put forward:

Table 18 : Focus areas for data collection for water balance management

Focus area	Action
Open Pit	Dewatering rate (of in pit water and/or groundwater) should be monitored on daily basis together with water level drop.
Crushing/Washing plant	Inflow and Outflow should be monitored on a daily basis
Water Storage (Clean and dirty)	Inflow and Outflow should be monitored on a daily basis
Rock Dumps	Water content should be monitored
ROM	Water content should be monitored
Products	Water content should be monitored
Discard	Water content should be monitored
Rainfall	Local rainfall measurement station should be installed and rainfall recorded
Evaporation	Evaporation rate should be investigated and recorded

6 Storm water Management Plan (SWMP)

The content of the storm water management plan was informed by the Best Practice Guideline - G1: Storm Water Management (2006). Storm water management and drainage planning are critical components of integrated water and waste management at mining sites. Although the objectives of a SWMP are site-specific, common objectives include:

- Protection of life (prevent loss of life) and property (reduce damage to infrastructure) from flood hazards;
- Planning for drought periods in a mining operation;
- Prevention of land and watercourse erosion (especially during storm events);
- Protection of water resources from pollution;
- Ensuring continuous operation and production through different hydrological cycles;
- Maintaining the downstream water quantity and quality requirements;
- Minimizing the impact of mining operations on downstream users;
- Preservation of the natural environment (water courses and their ecosystems).

The complexity of the SWMP depends largely on the size and nature of the mining operation, the characteristics of the hydrological cycle at the site, and the sensitivity of the area in which the mine is located to environmental impacts.

The SWMP must cover the life cycle of the mine from exploration, through construction, operation, decommissioning, and up to post-closure.

6.1 General principles of storm water management

6.1.1 PRINCIPLE 1: Keep clean water clean

Identify and where possible, maximize areas of the mine that will result in clean storm water runoff as well as infrastructure associated with the mine and ensure that runoff from these areas is routed directly to natural watercourses and not contained or contaminated. Ensure that clean storm water is only contained if the volume of the runoff poses a risk (erosion, siltation due to high speed and velocity), if the water cannot be discharged to watercourses by gravitation, for attenuation purposes, or when the clean area is small and located within a large dirty area. This contained clean water should then be released into natural watercourses under controlled conditions.

6.1.2 PRINCIPLE 2: Collect and contain dirty water

Ensure the minimization of contaminated areas, reuse of dirty water wherever possible and planning to ensure that clean areas are not lost to the catchment unnecessarily.

Ensure that seepage losses from storage facilities (such as polluted dams) are minimized and overflows are prevented.

Ensure that all possible sources of dirty water have been identified and that appropriate collection and containment systems have been implemented and that these do not result in further unnecessary water quality deterioration.

Ensure that less polluted water or moderately polluted water is not further polluted. Where possible less and more polluted water should be separated. This will assist in the reuse water strategy and improve possibilities for reuse based on different water quality requirements by different mine water uses.

6.1.3 PRINCIPLE 3: Sustainability over mine life cycle

Ensure a commitment from management and staff, including making available adequate human resources and adequate financial resources for both the design and implementation of the SWMP.

Ensure that the SWMP is formulated concurrently with the mine planning and layout of infrastructure and that it takes account of all life cycle phases of the mine from planning through to post-closure.

Identify and quantify the risk of failure of components of the SWMP and the consequences of such failure.

6.1.4 PRINCIPLE 4: Consideration of regulations and stakeholders

Identify items of legislation relevant to the environment and water resources and ensure compliance with these.

Include effective liaison with the Department of Water Affairs, Catchment Management Agencies and all other interested and affected parties.

6.1.5 Considerations for opencast pits

The size of unrehabilitated areas (pit, spoils, and vegetated areas) that produce contaminated runoff should be minimized.

Development of the pit should be planned to promote maximum diversion of clean water. The diversion works may therefore need to be moved as the mine develops.

Rehabilitation should be planned to promote free drainage and to minimize or eliminate ponding of storm water. On-going rehabilitation as mining operations progress is required.

The capacity to rapidly pump water out of the pit into storage dams should be maintained. This will assist in minimizing water quality deterioration due to long-term retention of storm water in contact with materials that may cause water quality deterioration.

6.2 Preliminary storm water management plan

The proposed SWMP states all that are needed to be included in the detailed plan, by considering surface infrastructures as proposed in Figure 7.2 of “Section 7 : feasibility study report”. Once more information becomes available, the plan must be updated and detail included. Areas that need to be taken into account are discussed in Table 19.

Table 19: Areas that need to be addressed in SWMP

Classification	Area	Potential type of contamination
Clean water	Undisturbed land area	Regional geology or agricultural practices may contaminate runoff.
	Administrative offices	Generally only suspended solids (SS) to consider
	Tarred roads	Tarred roads are not expected to be contaminated by waste, coal or discard, but may have a run off volume implication.
	Newly rehabilitated areas Clean water dams	SS to be considered
Moderately dirty water	Poorly rehabilitated areas	SS and other contaminants to consider
	Roads	If it carries traffic that bears coal, discard, slurry, waste rock, slimes, etc.
Dirty water	Workshops and storage yards where oil is handled or ground is covered in fines	Oils, grease and soap, dissolved and suspended Contaminants
	Opencast pits	SS and other contaminants to consider

Classification	Area	Potential type of contamination
	Residue deposits	Includes coal discard, slurry facilities, slimes dams, waste rock dumps and sand dumps.
	Raw material or product stockpiles	Dissolved and suspended contaminants
	Unrehabilitated areas	Dissolved and suspended contaminants
	Haul roads	Dissolved and suspended contaminants
	Pollution control dams	Depends on contents of dams

Basic issues that must be included in the SWMP are:

- **Operating areas**

These areas will include stockpiles, roads, workshop, stores and refuelling areas. Pollution sources include runoff from the stockpiles and haul roads spills of hydrocarbons and other chemicals within the workshops, stores and refuelling areas. To limit the impact to surface water bodies, water flow from this area will be directed through dirty water drainage system (earth channels, beams and culverts) towards a silt trap just upslope of a pollution control dam. The silt trap will remove suspended solids, while the lined pollution control dam will contain any polluted runoff.

Groundwater is expected to decant. Decant rates are provided in the groundwater report and the pH of the ground water is expected to drop. Capturing and returning of decant water as a minimum measure should be implemented, while consideration could be given to for the design of a water treatment system (plant) based on the expected decant volumes and associated water quality.

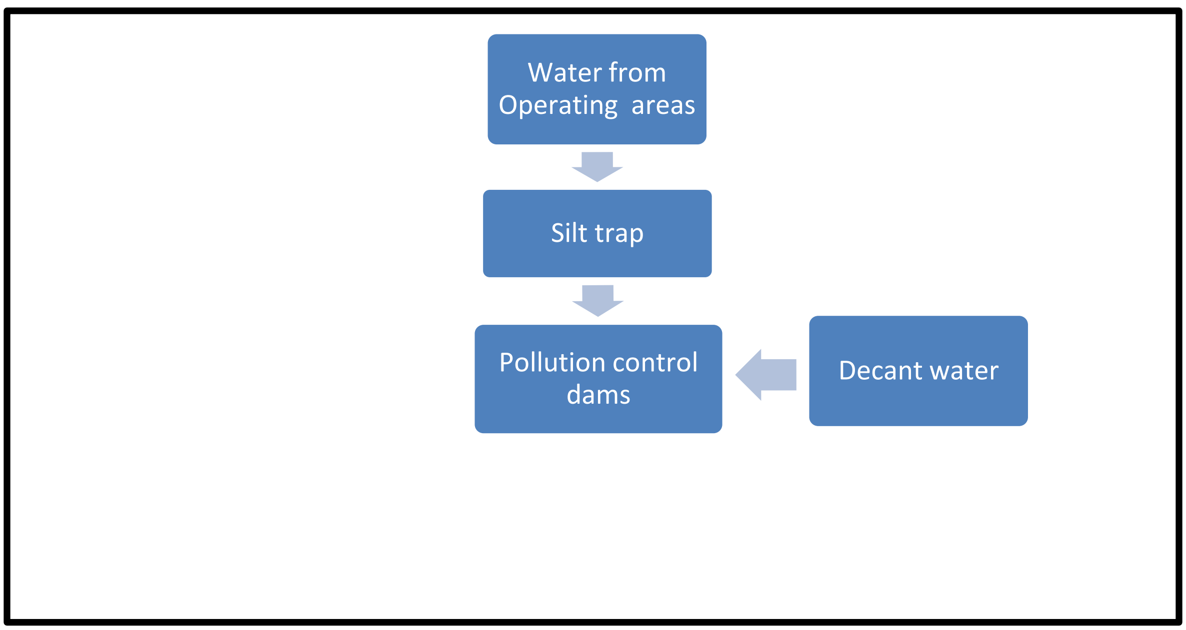


Figure 49: Operation water process

- **Clean water dam**

Although the main undisturbed areas (none polluted) would allow discharging diverted clean storm water to watercourses by gravitation, a system of clean water dams is proposed to control potential risks (erosion, flooding, etc.) that the volume of runoff may pose. Irrigation water during rehabilitation may also be sourced from the clean water dam.

The dam should be fed by water filtered through a silt trap to remove suspended solids. The clean water dam(s) will not overflow for recurrence events up to the 1:50 year event. In addition, the dam embankments will also not overflow for the 1:200 year recurrence event. The clean water dam should then be released into natural watercourses under controlled conditions.

- **Pollution control dam**

The pollution control dam(s) will not overflow for recurrence events up to the 1:50 year event. In addition, the dam embankments will also not overflow for the 1:200 year recurrence event. The dam(s) must be lined with a 1.5mm thick HDPE liner. A sub-surface drainage system will be installed to ensure that all seepage water within the dam area is also collected.

- **Stockpiles (Dumps)**

An erosion containment and dirty water berm must be constructed around the outside of each stockpile. Containment berms must also be constructed perpendicular to the outside berm to ensure that dirty water "coffers" are created. The area between the berms and stockpile will be vegetated to promote rapid evaporation, to reduce ponding within these areas. A 15m wide thickly vegetated "buffer" zone must also be constructed around the outside of berms to contain sediment.

Overburden stockpiles must be separated, with one portion containing carbonaceous waste and the other containing inert materials. The treatment of each of these stockpiles will differ:

- Carbonaceous stockpiles: Surface water will be contained within the stockpile and berms. Groundwater contamination will be prevented by placing a 125mm clay liner at the bottom of the stockpile. Captured water will be lost through evaporation.
- Inert stockpiles: Dirty water will be contained within the stockpile and berms. Surface water seepage through the containment berms can be accommodated, with the provision that siltation is prevented.

- **Mining area**

Dirty water containment berms will need to be constructed around the mine to separate dirty water from clean water. Dirty water should be diverted back into the pit whilst clean water will be directed into the clean water catchment areas.

The pit must be rehabilitated as work progresses. Rehabilitated areas can be vegetated and contour berms will be constructed to slow surface water and to prevent erosion from taking place. It should furthermore be ensured during rehabilitation that buffer zones, containing thick vegetation, are established downstream of the rehabilitated areas. This will ensure that erosion and subsequent sedimentation is minimised. Rehabilitated areas will be classified as clean water areas and the surface water will be released into clean water areas.

Coffer dams will also be constructed along the mining areas to prevent a significant amount of surface water from being concentrated at one specific point.

- **Haul roads**

Pit access roads could either traverse rehabilitated or mining areas and may exhibit some pollution potential. Wherever pit access roads traverse rehabilitated areas, small coffer dams, constructed adjacent to the road, are proposed. This will prevent pollution from entering newly defined clean water areas.

6.3 Proposed water management infrastructures

Subsequent to the proposed management plan, the infrastructure that needs to be considered is summarised in Table 20. It is anticipated that each pollution control dam will be joined through silt traps located at upslope of the dam.

Table 20 : Proposed water management infrastructure

Basic management issues	Proposed infrastructure
Operations area	Earth channels Containment berms Culverts
Pollution control dam	Silt trap Water treatment plant
Stockpiles	Erosion containment Dirty water berms Containment berms

	Vegetated “buffer” zone
Mining area	Depression (coffers) Containment berms (clean and dirty waters) Dewatering dam
Haul roads	Small coffer dams
Dewatering dam	Water treatment plant

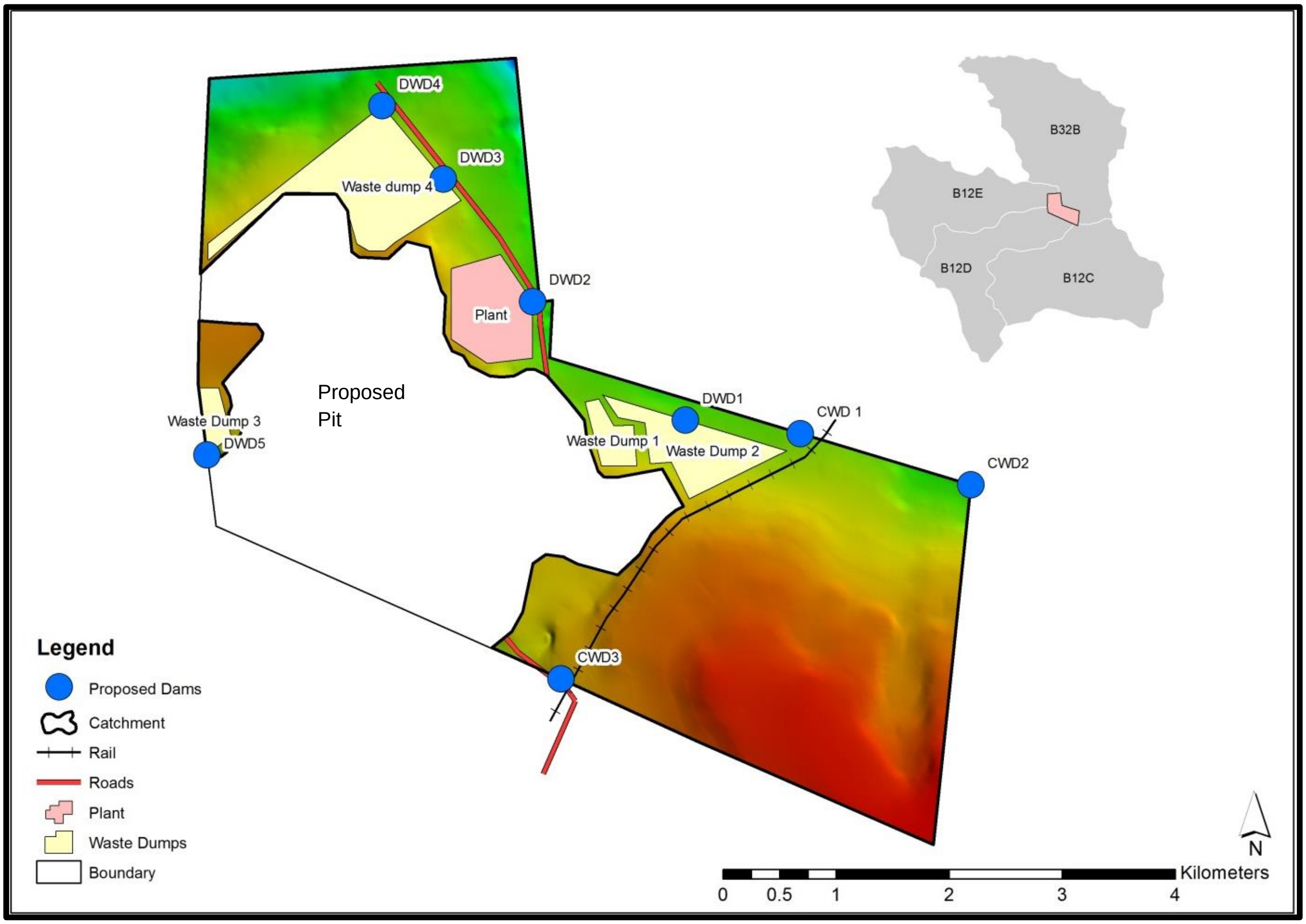


Figure 50: Proposed water management infrastructures

7 Monitoring Plan

7.1 Preamble

A long-term monitoring programme has been developed based on the guideline documented in *Best Practice Guideline G3. Water Monitoring Systems (2007)* available from DWA.

A monitoring plan is necessary for the following reasons (DWA, 2006):

- Accurate and reliable data forms a key component of many environmental management actions;
- Water monitoring is a legal requirement;
- The most common environmental management actions require data and thus the objectives of water monitoring include the following:
    - Development of environmental and water management plans based on impact and incident monitoring (facilitate in decision-making, serve as early warning to indicate remedial measures or that actions are required in certain areas) for the mine and region;
    - Generation of baseline/background data before project implementation;
    - Identification of sources of pollution and extent of pollution (legal implications or liabilities associated with the risks of contamination moving off site);
    - Monitoring of water usage by different users (control of cost and maximizing of water reuse);
    - Calibration and verification of various prediction and assessment models (planning for decommissioning and closure);
    - Evaluation and auditing of the success of implemented management actions (ISO 14000, compliance monitoring);
    - Assessment of compliance with set standards and legislation (EMPs, water use licenses);
    - Assessment of impact on receiving water environment.

7.2 General Principals of Monitoring

Monitoring on a mine consists of various components as illustrated by the overall monitoring process (Figure 51). It must be recognized and understood that the successful development and implementation of an appropriate, accurate and reliable monitoring programme requires that a defined structured procedure be followed. A monitoring programme must include the location of all monitoring points (indicated on a map), the type of data to be collected, as well as the data collection (protocol/procedure/methodology, frequency of monitoring and parameters determined, quality control and assurance), management (database and assessment) and reporting procedures. This programme must then be implemented. The results from the monitoring programme should be representative of the actual situation. To ensure that the monitoring programme functions properly, an operating and maintenance programme should be developed and implemented. A data management system is necessary to ensure that data is stored/ used optimally and is accessible to all the relevant users. The monitoring programme must include quality control measures. It is important to note that this programme is dynamic and should change as the mine and water management needs change.

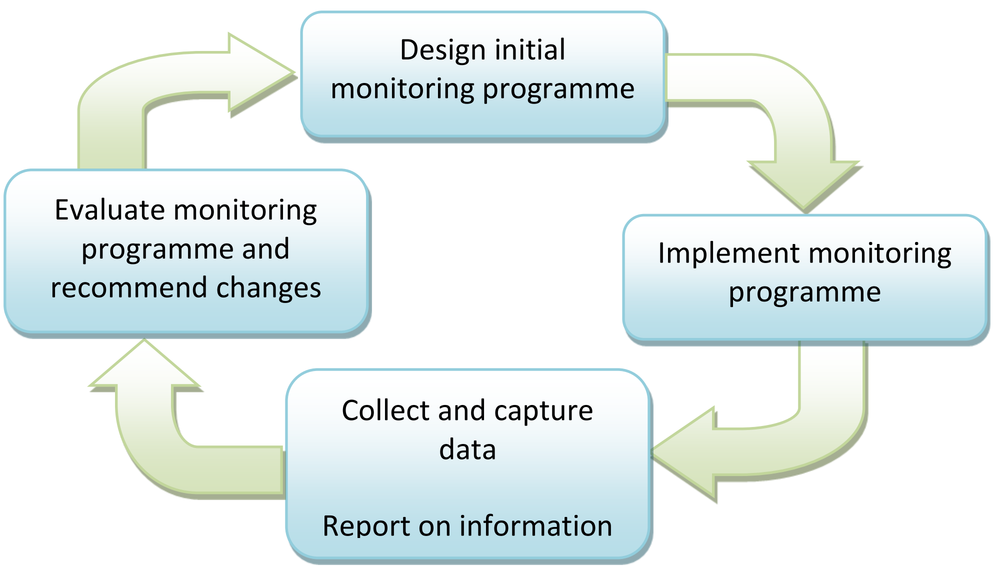


Figure 51: Monitoring process (DWA, 2007)

Effective surface water monitoring systems on a mine consist of the following components:

- Surface water quality monitoring system.
- Surface water flow monitoring system.
- Data and information management system.

When designing the monitoring system the following issues must also be taken into consideration:

- Potential or actual water use

- Catchment vulnerability
- Toxicity of chemicals
- Potential for seepage or releases
- Quantities and frequency of release to the environment (point and non-point).
- Management measures in place to minimize risk.

7.3 Surface water monitoring plan for the project area

7.3.1 Management action

As part of the water management at the project area, it is necessary to understand:

- The changes in surface water flow within the mine boundaries and to monitor how this changes with time.
- The pollution on the mine and to monitor how the pollution changes with time.

The overarching water management action that is of interest for this specific mine can, therefore, be defined as:

- Develop an understanding of the current surface water flow patterns on the mine and monitor how it changes over time.
- Assess impacts of the changes of these flow patterns on the receiving environment and the performance of associated prevention measures.
- Prevent pollution and thereby protect the receiving water environment.
- Develop an understanding of the current pollution on the mine and monitor how it changes over time.
- Assess performance of pollution prevention measures, i.e. compliance with license conditions and catchment objectives.

7.3.2 Objectives of intended management action

The objectives of the management action are defined as:

- Identify, quantify and monitor surface water flow in the vicinity of the mine.
- Identify, quantify and monitor all point and diffuse pollution sources and associated plumes on the mine.

These objectives must adhere to the requirements of being specific, measurable and feasible.

7.3.3 Data requirements

The data requirements are dictated by:

- Area influenced by changes in surface water flow and associated quality.
- Point and diffuse sources of pollution and associated pathways.

7.3.4 Location of monitoring points

The potential monitoring points are chosen to:

- Determine any changes in surface water flow and quality on the mining property before affecting the down gradient environment.
- Perform a regional surface water screening to ensure that the monitoring points on site are sufficient.

The positions of the proposed initial monitoring points are presented in Table 21 and their locations indicated on Figure 52

Table 21: Proposed initial surface water monitoring points

SW Points inside Rietvlei colliery property	SW Points outside Rietvlei colliery property
Pollution water control Dam 1	SWM1
Pollution water control Dam 2	SWM2
Pollution water control Dam 3	SWM3
Pollution water control Dam 4	SWM4
Pit water (?)	SWM5
Clean water dam	SWM6
Dewatering dam	SWM7
--	SWM8
--	SWM9
--	SWM10
--	SWM11
--	SWM12
--	SWM13

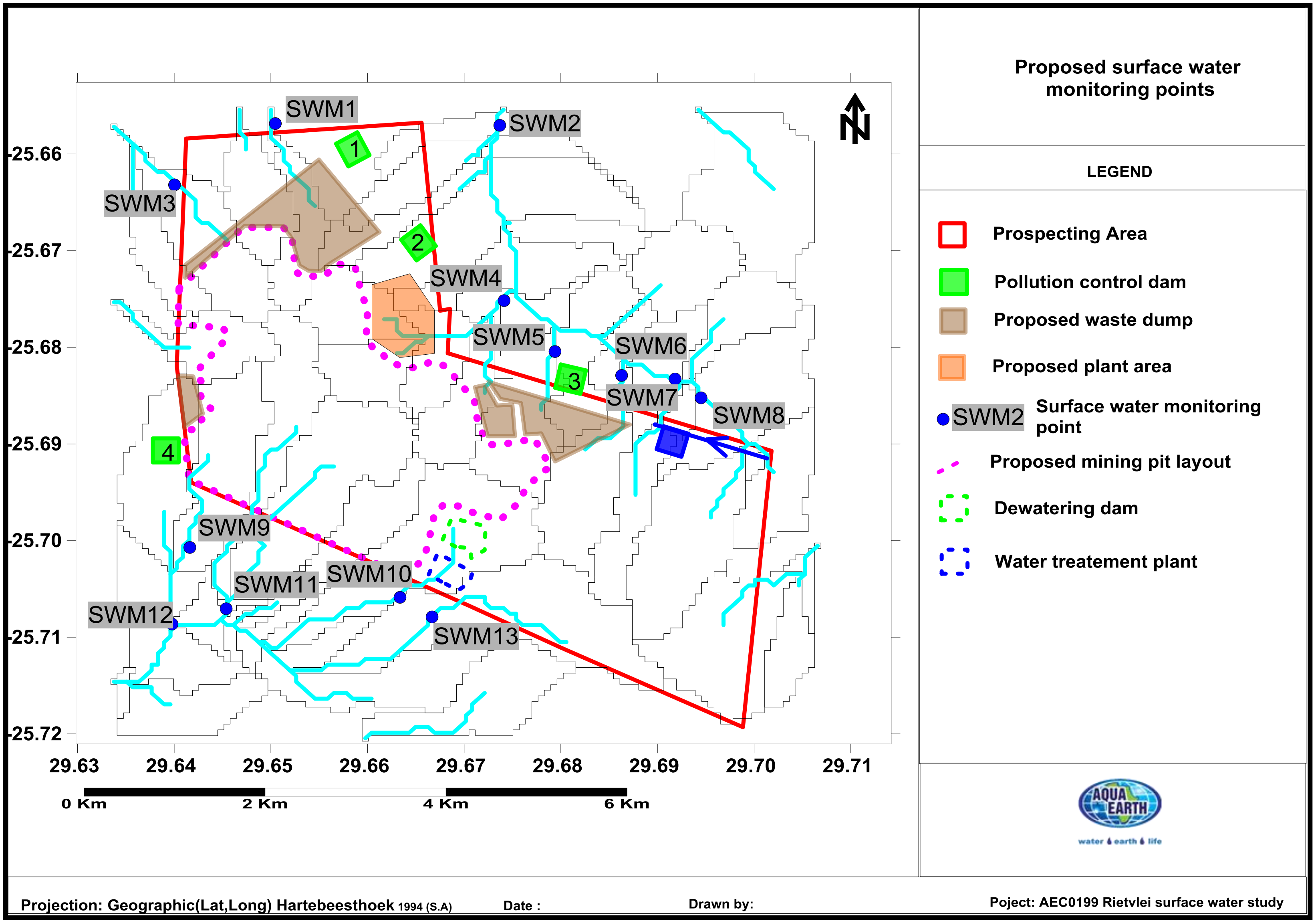


Figure 52 : Proposed initial surface water monitoring points

7.3.5 Parameters to be measured and frequency of measurements

There are two sets of monitoring parameters. A comprehensive analysis must be conducted on surface water points within or close to the mine and a screening analysis must be conducted on surface water points further away. In addition samples must be tested for trace elements once mining commences. The parameters that must be sampled for are listed in Table 22.

Table 22: Sampling parameters

A (Standard set of parameters)	B (Screening parameters)	C (Trace elements)
pH	pH	Ba
EC	EC	As
Ca		Co
Mg		Cr
Na		Ni
K		Pb
Total Alk		Se
F		Sr
Cl		V
NO_2(N)		Zn
NH_4 (N)		Nb
NO_3(N)		Mn
PO_4		Cu
SO_4		Ga
Al		Ge
Fe		Rb
Mn		Y
		Zr
		Sn
		W
		Bi
		Th
		U
		Hg

The frequency and type of sampling is summarised in Table 23.

Table 23: Frequency and type of sampling

Sampling point	Parameter list[1]	Type of sampling	Type of measurement/	Frequency
Surface water points within mine boundaries	A, C*	Grab	Flow	A = Every 4 months C = Once per annum
Surface water points outside mine boundaries	B**	Grab	Flow	Once every 6 months

*** If any parameters exceed SANS241-1: 2011 guidelines (or WHO guidelines if no SANS guideline available) then that parameter must become part of list A.**
****If any parameters * If any parameters exceed SANS241-1: 2011 guidelines (or WHO guidelines if no SANS guideline available) then that borehole must be sampled according to the A, C list.**

IMPORTANT NOTES: Laboratory analysis techniques will comply with SABS guidelines. Laboratories must be accredited.

7.3.6 Data storage and reporting

Data must be stored electronically. It is suggested that a well-known database such as WISH, Aquabase or Access be used. A backup of the data base must be stored in a safe place. Backups should be made every time the database is updated.

On the completion of every sampling run a monitoring report must be written. Included in the report must be time series trends, Piper and Durov diagrams. These will be used to determine if there are any changes in the system. These changes must be flagged and explained in the report.

It is recommended that Rietvlei colliery submit a compliance report to DWA on an annual basis.

[1] A, B and C are parameters documented in Table 22

8 Conclusions

Following this investigation, the following conclusions can be made:

- The site straddles mainly three surface three surfaces run off catchments.
- Available information for this project included a limited number of surface water samples and publicly available topography, regional flow and rainfall data;
- Local storm water runoff model has been set up for the site, from a regional rainfall-runoff model;
- 1:100, flood line has also been calculated for the main three surface water drainage line;
- The main catchment of impact is considered to be catchment B32B;
- The 1:100, flood line is likely going to intersect the pit on the southern side.
- Managing dirty and clean water will be important for each considered run off catchment and the water management plan has been developed taking this into consideration;
- Water storage facilities proposed in this document are based on calculated volumes, and no designs are included for the individual facilities;
- Water balance was developed with the available information (regional meteorological data, flow simulation from groundwater and surface water numerical model) for 20 years of operation;
- The water balance developed during this investigation is considered a preliminary water balance and should be refined once more specific site information (storage facilities) and water use (for operating and processing) monitoring data will be available;
- Focus areas for data collection have been identified and actions recommended;
- A water management and monitoring plan has been developed and it would be important to populate and update this on a regular basis.
- Generally, impacts on surface water are manageable and with a strict application of the proposed mitigation measures, impact significances would be reduced to between very low and medium low.

9 Recommendations

Based on the results from this assessment the following recommendations are put forward for consideration:

- Once the final decision has been made on mining, the monitoring network in terms of surface water monitoring should be revisited and the monitoring points confirmed.
- When more detailed digital elevation data becomes available the model could be re-run to confirm flood lines and confirm surface water management infrastructures. In this regard topographical surveys like for example a Lidar survey, providing higher density DEM data are strongly recommended.
- The water management plan developed during this study should be considered a baseline and further development thereof should take place in conjunction with the infrastructure development, keeping the water management plan relevant and updated in real time.
- The water balance developed should be considered a baseline water balance and special effort should be made to have sufficient measuring points to collect real data for updating the water balance on a regular basis.
- A water treatment facility has been recommended for consideration, but further investigation into the feasibility and costs benefits is recommended.

10 Appendixes

10.1 Appendix I: Impacts assessment methodology

Environmental impacts which could result from the project activities are described in this section. The following terms are used in describing the environmental impacts:

- Environmental issues – an "environmental issue" is an environmental concern encompassing a number of similar or related impacts that have been grouped under the issue heading;
- Environmental impact – a discrete (definable) interaction between a project activity and one or more components of the environment (biophysical and social);
- Natural and existing mitigation – natural conditions, conditions inherent in the project activities and existing management measures that alleviate (control, moderate, curb) impacts;
- Significance – the significance of the unmanaged and managed impacts is assessed through the consideration of the probability of the impact occurring, the extent of the area over which the impact will be experienced, the timing of the onset and the duration of the impact, and the intensity/severity of the impact.

The environmental impact assessment has been undertaken according to SRK Consulting's standard criteria for impact assessment which are detailed below.

The first stage of impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change.

The above terms, used in relation to significance, are defined in Table 9-1. The cut-off points have been defined in relation to characteristics of mining, but those for Probability, Severity/Intensity and Significance are subjective, based on rule-of-thumb and experience.

The significance of the impact is then assessed by rating each variable numerically according to defined criteria as outlined in Table 9-1. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read off a significance rating matrix as shown in Figure 9-1.

The results are tabulated for each identified impact. In the tables, a negative significant rating (results) indicates a negative impact while a positive rating indicate a positive impact, or benefit.

The assessment of significance has been undertaken twice. Initial significance should be based on only natural and existing mitigation measures (including built-in engineering designs). The subsequent assessment takes into account the recommended management measures required to mitigate the impacts.

Some of the specialist consultants have used variations of these procedures.

Table 9-1: Criteria for assessing significance of impacts

SEVERITY OF IMPACT	RATING
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful	5

SPATIAL SCOPE OF IMPACT	RATING
Activity specific	1
Project specific (within the project boundary)	2
Local area (within 5 km of the activity boundary)	3
Regional	4
National	5

DURATION OF IMPACT	RATING
One day to one month	1
One month to one year	2
One year to ten years	3
Life of operation	4
Post decommissioning / permanent	5

CONSEQUENCE

FREQUENCY OF ACTIVITY / DURATION OF ASPECT	RATING
Annually or less / low	1
6 monthly / temporary	2
Monthly / infrequent	3
Weekly / life of operation / regularly / likely	4
Daily / permanent / high	5

FREQUENCY OF IMPACT	RATING
Almost never / almost impossible	1
Very seldom / highly unlikely	2
Infrequent / unlikely / seldom	3
Often / regularly / likely / possible	4
Daily / highly likely / definitely	5

LIKELIHOOD

Figure 9-1: Significance Rating Matrix

CONSEQUENCE (Severity + Spatial Scope + Duration)

LIKELIHOOD (Frequency of activity + Frequency of impact)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

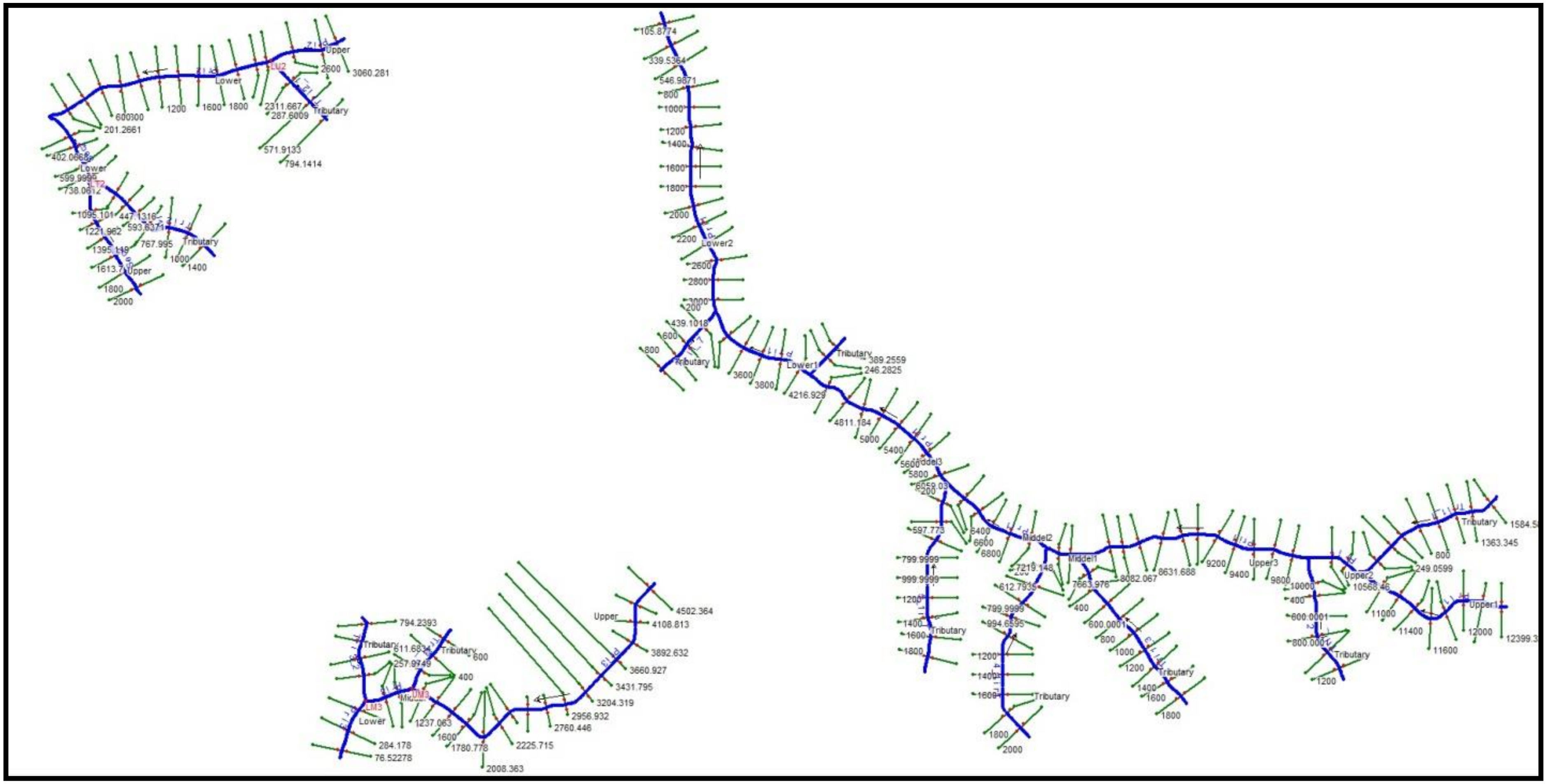
NEMO/SMTN August 2013

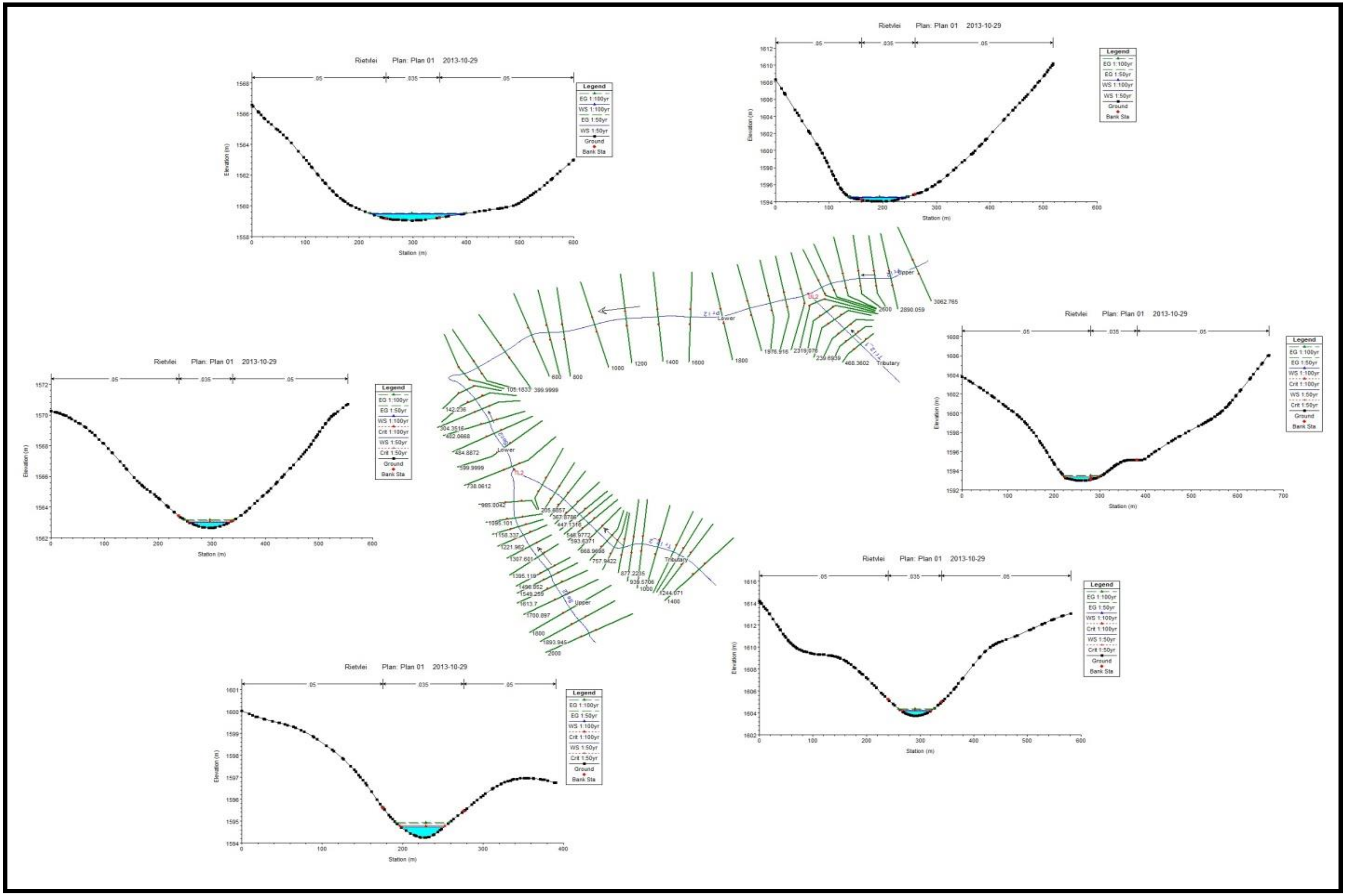
Table 9-2: Positive / negative migration ratings

Colour Code	Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
	Very high	126-150	Improve current management	Maintain current management
	High	101-125	Improve current management	Maintain current management
	Medium-high	76-100	Improve current management	Maintain current management
	Low-medium	51-75	Maintain current management	Improve current management
	Low	26-50	Maintain current management	Improve current management
	Very low	1-25	Maintain current management	Improve current management

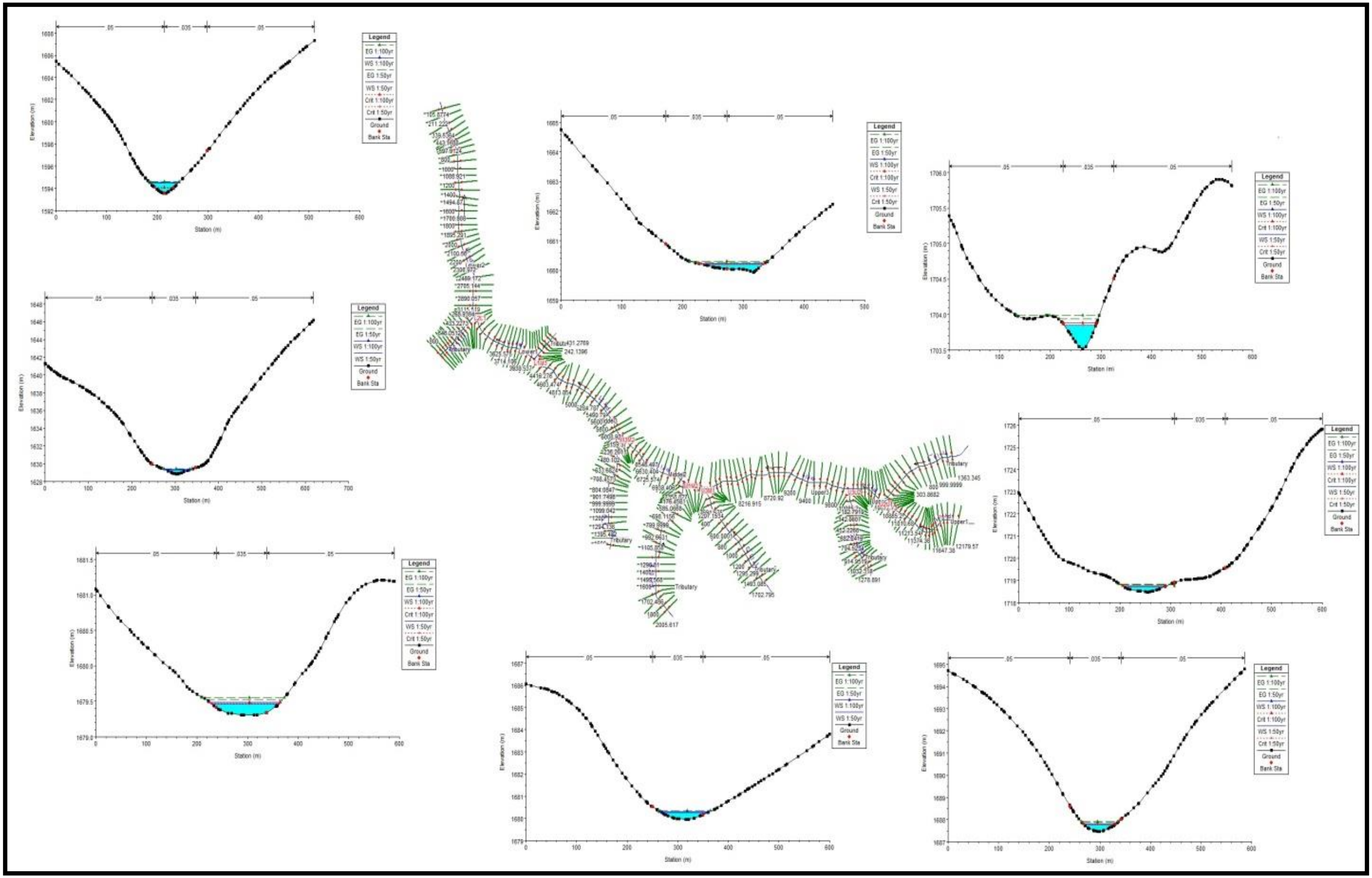
The impacts described below under the various environmental components are assessed for the different phases of the project, from preconstruction through to decommissioning and closure.

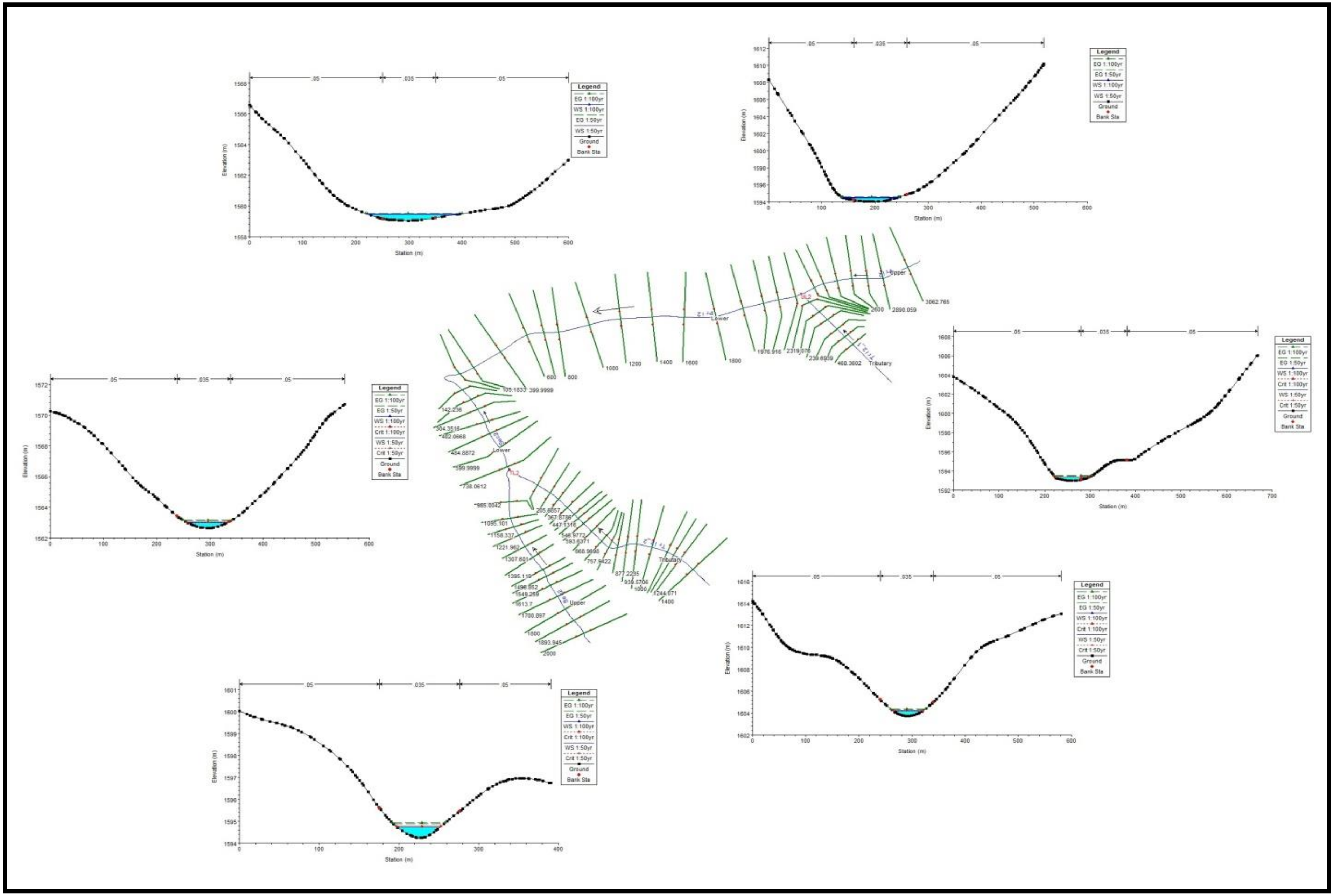
10.2 Appendix II: Cross sections for flood line calculations

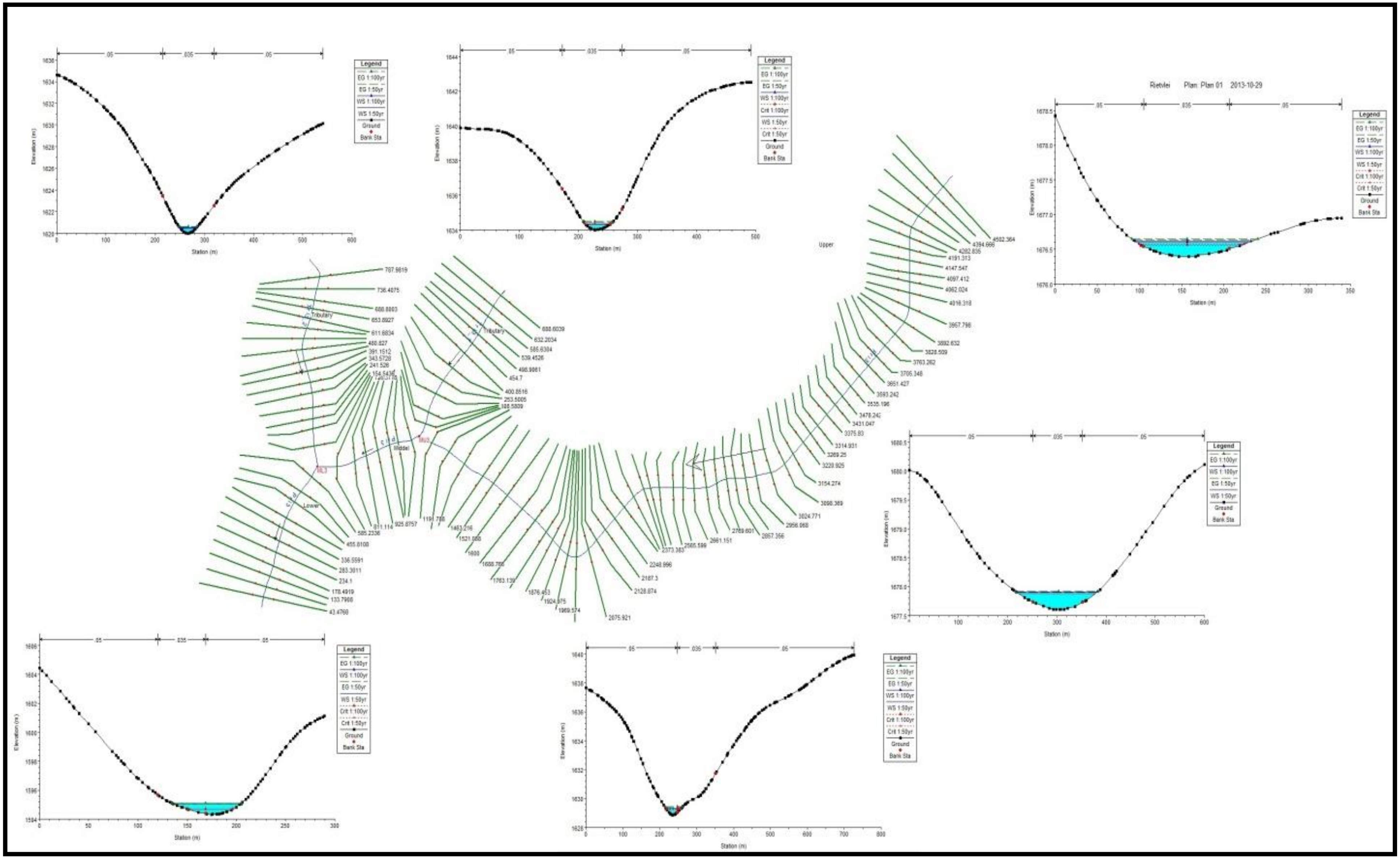




Rietvlei Plan: Plan 01 2013-10-29
Legend
Elevation (m)
Station (m)
Lower
Upper
Tributary







Appendix 3: Groundwater Assessment

RIETVLEI COLLIERY

DETAILED GEOHYDROLOGICAL INVESTIGATION

Final

07-2014

We put Science into Practice

Report prepared for

WSP Environmental (Pty) Ltd

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RIETVLEI COLLIERY

DETAILED GEOHYDROLOGICAL INVESTIGATION

Final

07-2014

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Contact Person	Terry HARCK	DP AHOKPOSSI
Project Number		AEC0120
Report Number		AEC0120/04/07-2014

Executive Summary

Aqua Earth Consulting (AEC) was appointed by WSP on behalf of Butsanani Joint Venture (Anglo Operations Limited), to carry out a detailed groundwater impact assessment as part of an environmental impact assessment (EIA) for the proposed Greenfields Open Cast Coal Mining Operation at Rietvlei. The site is located northeast of Mhluzi (formerly Middelburg) in the Mpumalanga Province, and will be call "proposed Rietvlei Mine" in the report.

The study was instigated by comment made by WSP on an existing baseline groundwater study conducted by Aqua Earth. Aqua Earth has completed a detailed groundwater impact assessment and the following conclusions are reached:

- Field investigations have been conducted according to WSP gap analysis recommendation;
- The conceptual model of the site has been updated base on field investigations results;
- The potential impacts (quality, quantity) have been identified and assessed accordingly;
- The overall project impacts (construction, operation, closure) significance is expected to be from Low to Very High without any appropriate mitigation;
- Thorough planning, design, suitable investment, management measures, workplace procedures and good housekeeping will generally mitigate the potential impacts rising from proposed Rietvlei Mine development will de reduced to Low, Except the for impacts at post closure phase;
- Specific measures have been proposed for certain infrastructure units to address particular potential impacts;
- Monitoring will be necessary to ensure that any impacts on water quality and quantity that do arise are dealt with rapidly;
- An initial monitoring network has been proposed for the management of groundwater resources.

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1 Introduction

Aqua Earth Consulting (AEC) was appointed by WSP on behalf of Butsanani Joint Venture (Anglo Operations Limited), to carry out a detailed groundwater impact assessment as part of an environmental impact assessment (EIA) for the proposed Greenfields Open Cast Coal Mining Operation at Rietvlei. The site is located northeast of Mhluzi (formerly Middelburg) in the Mpumalanga Province, and will be call “proposed Rietvlei Mine” in the report.

The present study follows the comment made by WSP on the baseline groundwater study conducted by Aqua Earth.

1.1 Location

The study area lies approximately 50km northeast of the town of Emalahleni and 22km northeast of Mhluzi (formerly Middelburg) in the Mpumalanga Province (

Figure 1). It is linked to Mhluzi by the R555 provincial roadway. The prospecting area lies within a farming area and is bordered by private properties on all sides.

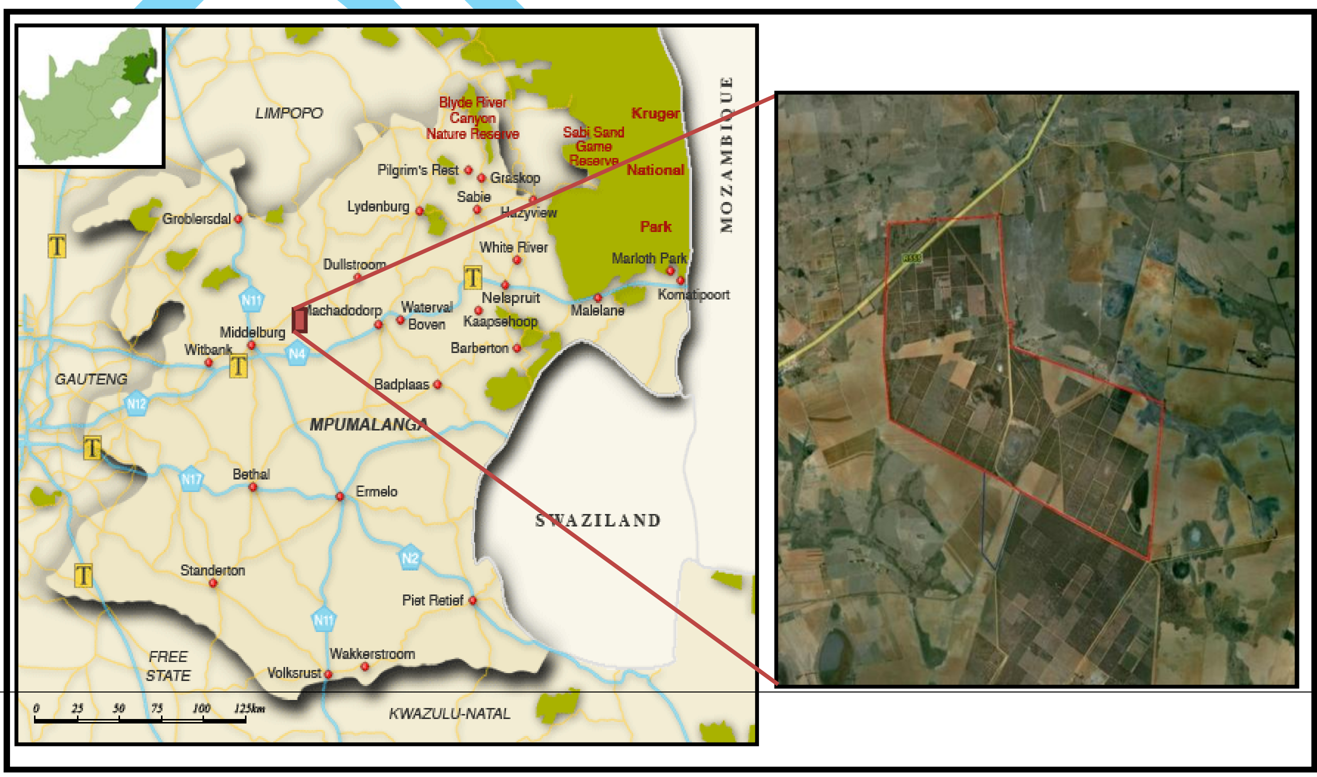

Figure 1: Locality of Rietvlei Colliery

1.2 Scope of the works and specific tasks

The present detailed study aims mainly to fill the gaps in the baseline groundwater studies conducted by Aqua Earth in 2011. The main objective here is the characterisation and the impacts assessment of the two aquifer systems identified from the previous studies. The following tasks have then been set to reach such objective:

- Review of existing geological and hydrogeological information;
- Geophysical survey to identify potential flow paths for preferential groundwater/contaminant migration;
- Siting and drilling of groundwater exploration/monitoring boreholes (at least four) to collect hydrogeological information over the study area. The additional boreholes should be sited with the aim of acquiring more information in the southern and eastern quadrant of the area under investigation. New borehole should allow accessing shallow (0m to 25 mbgl) and deep aquifers (up to 50 mbgl)separately;
- Sampling and testing of drill chips for Acid Potential Drainage;
- Sampling and analysis of water intercepted in all the additional boreholes;
- Aquifer testing to estimate hydraulic parameters of all aquifers present within and surrounding the study area;
- Update of the baseline numerical model with new characterisation information;
- Update the project (open cast mining) impacts assessments.

The report describes the study on groundwater management issues that may be associated with the development of proposed Rietvlei Mine. It also gives a prediction on the potential impacts to ground arising from different phases of the project (construction, the operation and closure).

1.3 Background information

The following existing specialist studies on the project area were consulted to gain background information and an understanding of the present groundwater baseline conditions:

- Rietvlei Groundwater Baseline Assessment. Aqua Earth Consulting, 2011;
- Rietvlei Colliery Geohydrological Modelling. Aqua Earth Consulting, 2011;
- Gap Analysis of the Environmental Studies Undertaken for the Proposed Greenfields Rietvlei Open Cast Coal Mining Operation. WSP, 09-2013;
- Feasibility Report Section 3 Geology on Rietvlei Coal Asset For Anglo American Thermal Coal. Mindset Mining Consultants (Pty) Ltd, 04-2013;

In addition of these specialists' reports on specific to the proposed mining site, information has also been sourced from publically available map:

- 1/250 000 Geological Series: 2528 Pretoria published in 1978 by the Government Printer;
- An Exploration of the 1:500 000 general hydrogeology map by H.C. Barnard – October 2000;
- SRTM 90

1.4 Legal aspects

Section 26 of the National Water Act regulates any activity that may have an impact on a water resource and the conservation and protection of this water resource. Legislative requirements relevant to groundwater as administrated by the Department of Water Affairs (DWA) are:

- National Water Act, 1998 (Act 36 of 1998) (NWA, 1998);
- DWA Best Practice Guidelines, dated 2007;

The following overarching legislation was taken into account in the present groundwater assessment:

- National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA).
- National Water Act, 1998 (Act 36 of 1998) (NWA).
- National Environmental Management: Waste Act, 2008 (Act 59 of 2008)
- (NEM: WA);
- Mineral and Petroleum Resources Development Act (No 28 of 2002) (MPRDA).

1.5 Details of specialist

The following groundwater study project has been conducted by experienced water specialists' team, and is managed by a fully qualified professional water scientist, who has been involved in leading relevant projects. The consultant details are giving as follow:

Table 1 : Specialist details

PROJECT TITLE: Detailed groundwater impact assessment-.			
Specialist:	AQUA EARTH CONSULTING		
Nature of specialist study compiled:	Groundwater Assessment.		
Contact person:	AHOKPOSSI D P		
Postal address:	PO.BOX :1747 North Riding		
Postal code:	2162	**Cell:**	0735721424
Telephone:	0117913490	**Fax:**	0115076612
E-mail:	pacome@aquaearth.co.za		
Qualifications & relevant experience:	Bsc Civil Engineering - Msc Geohydrology (10 years)		
Professional affiliation(s) (if any)	SACNASP		

1.6 Declaration of Independence

Aqua Earth was appointed to conduct a specialist groundwater study as part of EIA and act as the independent specialist in this application. Aqua Earth will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. Aqua Earth has the expertise in conducting the specialist report relevant to this application and will not engage in conflicting interests in the undertaking of this study.

2 Methodology

2.1 Climate

Climatic data was collected from SA Explorer and DWA rainfall station. The closest DWA rainfall station, B1E003 (15 km south-west) was considered as a representative rain gauge for the area.

Table 2: List of rainfall stations

Station ID	Place	Lat	Long
B1E001	Witbank @ Witbank Dam	-25.88807	29.29973
B1E002	Rondevalley	-25.92557	29.69141
B1E003	Rondebosch @ Middelburg Dam	-25.77557	29.54557
B1E004	Rietfontein	-26.35776	29.21640
B1E005	Naauwpoort @ Witbank Dam	-25.97473	29.28057
B3E002	Loskop Nat. Res. @ Loskop Dam	-25.41310	29.36640
B3E003	Loskop Nat. Res. @ Loskop Dam	-25.42143	29.35807

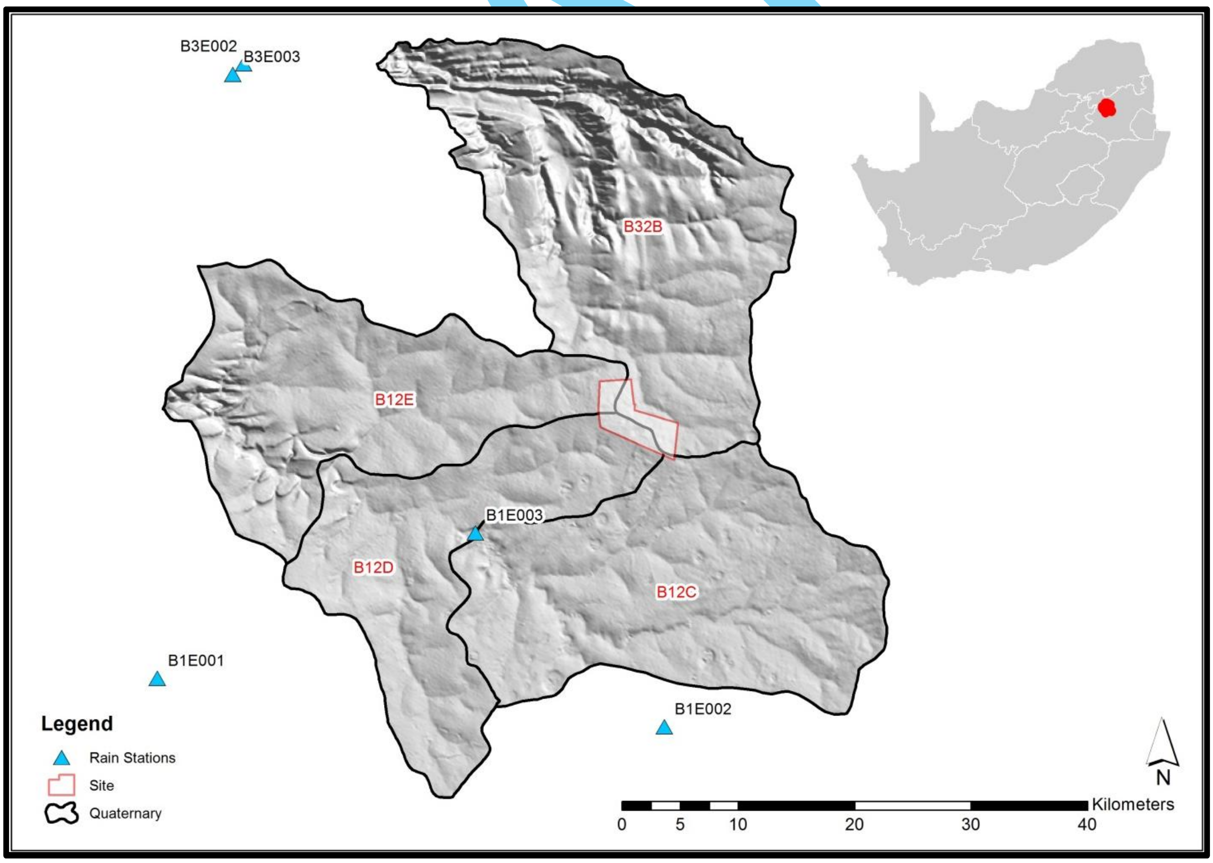

Figure 2: Quaternaries and available DWA rainfall stations around Rietvlei site

Good continue daily rainfall data was available from 1980 to 2004 from B1E003 with the following quality DWA code distribution over this period:

- 86% good continuous data;
- 12% good monthly reading;
- 2% unaudited data;

2.2 Topography and drainage

Digital information from the following 1:50 000 topographical maps were used together with the “Water Ressources of South Africa” (WR2005-Midgley et al., 1990) for the demarcation of the catchments as well as for the hydrological description of the area:

- 2529CB:
- 2529CD
- 2529DA
- 2529DB
- 2529DC
- 2529DD

2.3 Geophysical surveys

In sum, 6 geophysical survey traverses have been conducted, using magnetic method (Scintrex-G5-Magnetometer). Magnetometers are instruments used for measuring the magnetic field and by virtue of their sensitivity and range are able to measure the changes of magnetic field between two rock types with only small differences in magnetic content.

Analysis of geohydrological maps in this area has shown that the probability of striking water is greater on the fracturing associated with discontinuities and contact zones, in the saturated zones. Linear features depicted from the local aeromagnetic map strike NE-SW (Figure 3). The Southern, and Eastern, parts of proposed Rietvlei Mine property was prioritised for locating new monitoring borehole as not sufficient observation boreholes were located in these areas of the proposed Rietvlei mine. These targets have been used in combination with the accessibility to the sites and location of boundary fences to define the geophysical traverses.

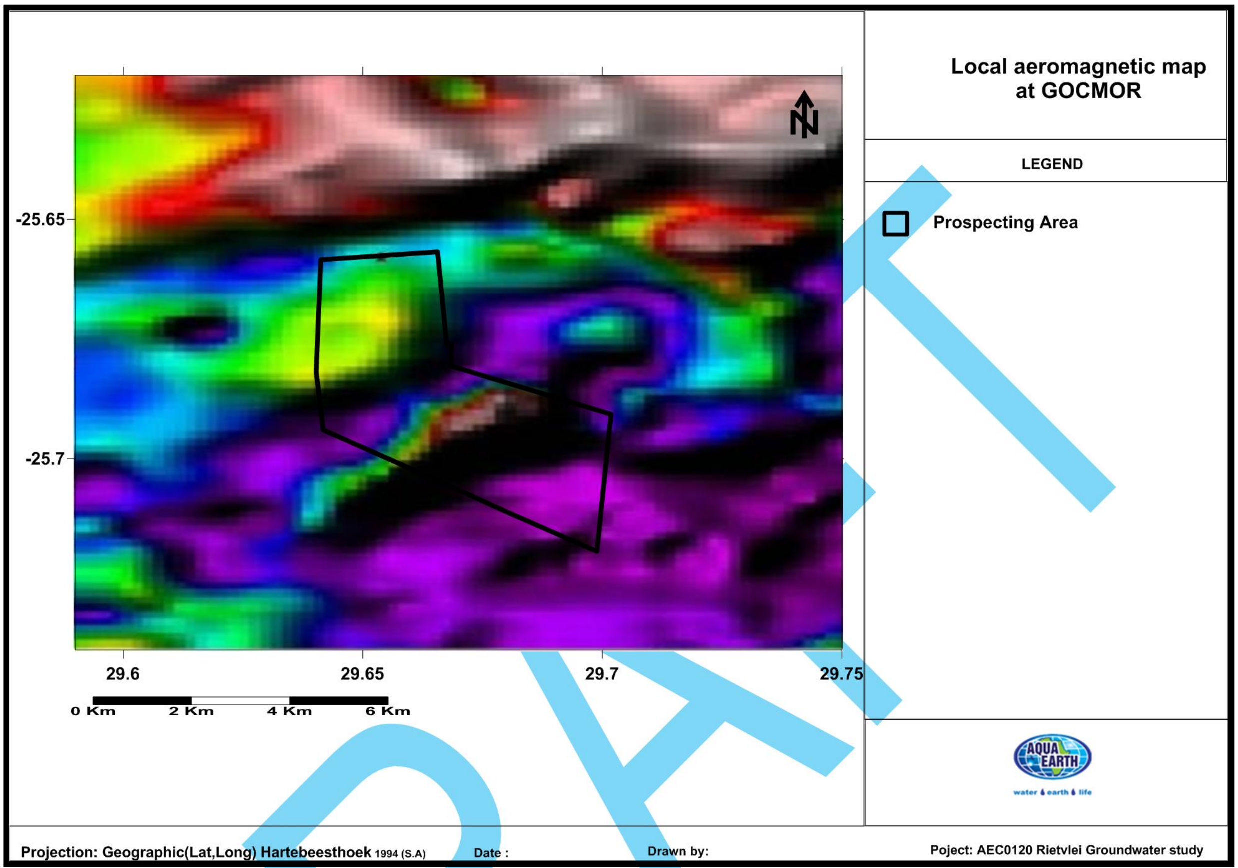

Figure 3: Local Aeromagnetic map (From Council of Geo-Science)

The geophysical traverses were set out in the following manner:

- Lines were set out perpendicular to the possible structures (dolerite intrusion) as indicated on the geological map and aeromagnetic map;
- Lines were walked with a station spacing of 10m in areas;
- Coordinates were taken at each station at the beginning and end of each traverses line.

Walked traverses are illustrated in Figure 4

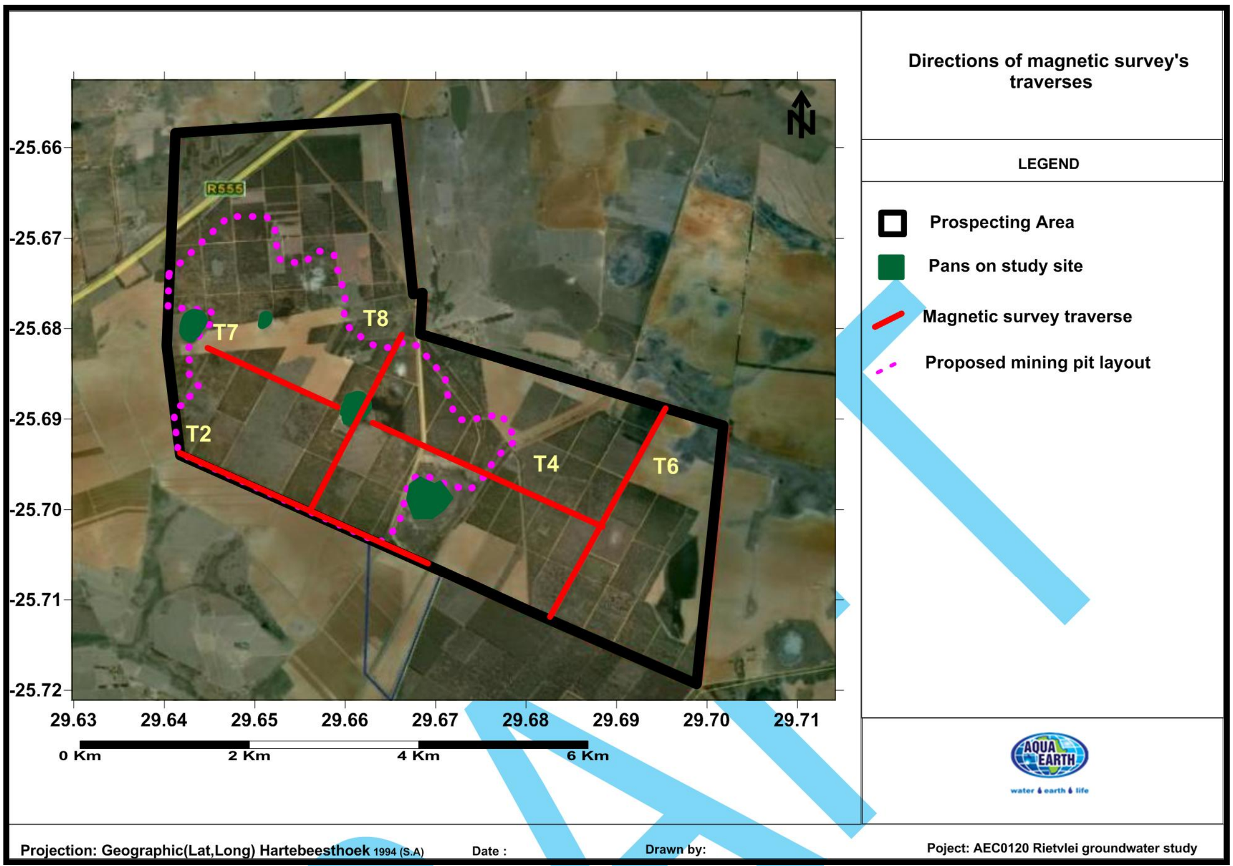

Figure 4: Geophysical survey lines

2.4 Drilling of boreholes

Borehole drilling was carried out, using an air percussion drill rig with a 900cfm compressor with full time supervision by a geohydrologist. All the boreholes were drilled with a drill bit with a diameter of 6 inch. During drilling, the following information was recorded:

- Penetration rates at every 1m drilling;
- Water strikes;
- Borehole construction information;
- Geological formations intersected during drilling;
- Water level.

2.5 Rock chips sampling

During drilling, grab samples of rocks ship were taken, at prescribed depths for Acid drainage potential analysis. The samples were collected in 1L plastic bags and stored in a cooler box under appropriate conditions. The samples were recorded according to AEC's chain of custody requirements (Appendix 1.) and submitted to a SANAS (South African National Accreditation Standards) accredited laboratory (WATERLAB (PTY) LTD) in Pretoria on the 14 February 2014.

Based on agreement with WSP geochemist, the following geochemical analyses have been requested from the Laboratory:

- Acid Base Accounting (ABA)
- Distilled water leach at liquid to solid ratio of 4 to 1 on all samples (pH; TDS (analysed, not by conductivity); alkalinity; Cl, F, SO4; ICP-scan for cations (Na, K, Ca, Mg, Fe, Mn, Al and trace metals)).

2.6 Water sampling

Grab water samples were collected from the new boreholes by using a "single-check valve weighed poly" nylon bailers (1.6" OD, 36 "Length) and a labelled rope. Water samples were collected in standard 01 litre plastic sample bottles, and were stored in a cooler box together with ice packs (for preservation) conditions. They were submitted to UIS Laboratory, a SANAS accredited laboratory (South African National Accreditation Standards) in Pretoria on the 18 January 2013 for analysis.

The bailer was lowered to the possible sample depth. As the bailer is being lowered, valve located at the bottom opens, allowing water to flow through the sampler. When, reaching the possible sampling depth, the bailer is raised using the support cable. The weight of water and upward movement of the bailer keep the ball valve closed. The bottom ball valve keeps the water in the bailer. Once at the surface, the bailer is emptied by opening the valve with a sample release device, and allowing the water to drain slowly through the sample release device into the sample container.

The list of constituent measurements requested from the laboratory is given in Table 3

Table 3: List of constituents analyzed for new boreholes water samples

Physical constituents	Macro-constituents	Micro-constituents	Microbiological constituents
pH, Electrical Conductivity (EC), Turbidity, Dissolved Solids, Suspended Solids	Chemical Oxygen Demand (COD), Dissolved Oxygen, Total Alkalinity as CaCO3, Total Hardness as CaCO3, Fluoride (F), Sodium (Na), Potassium (K), Chloride (Cl), Nitrite (NO2), Nitrate (NO3), Sulphate (SO4), Calcium (Ca), Magnesium (Mg), Ammonia as N	Aluminium (Al), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Bromide (Br), Cadmium (Cd), Cesium (Cs), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Lithium (Li), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Silver (Ag), Strontium (Sr), Tellurium (Te), Thallium (Tl), Tin (Sn), Titanium (Ti), Tungsten (W), Uranium (U), Vanadium (V)	Total Coliforms; Faecal Coliforms; and *E.Coli*

2.7 Aquifer testing

All the newly drilled boreholes were tested together with some selected existing boreholes. Based on the current knowledge of the site geohydrologicall conditions, the drilling results, and tests requirements, the following tests were proposed for the design of constant rate pumping test:

- Slug test;
- Calibration test;
- Step tests

Each calibration was systematically followed by a "recovery test" where the borehole was emptied, and recovery recorded.

2.8 Slug test

The slug test was proposed mainly for the determination of the yield of the boreholes present at site. It will also serve for the first estimate of the hydraulic conductivity values on relatively low yielding boreholes. The test is useful for a first approximation of the yield of the borehole (Van Tonder *et al.*, 2001).

A slug test involves the sudden addition, removal, or displacement of a known volume of water and the subsequent measurements (and records) of changes in water level in the well, as equilibrium conditions return. Slug tests were conducted by displacing water. Water displacement was done instantaneously by lowering manually the slug. The static water level in the borehole was measured prior to slug introduction. Water level measurements were taken with a dip meter (Solinst) and automatic data logger (Solinst). Manually, water level was measured every minute up to 10 minutes, and every 05 to 10 minutes (according to the response) after 10 minutes. The automatic water level logger was set to record water level every minute. Two slugs (closed PVC filled with concrete) constructed by AEC, and of different volumes (0.28 m^3, 0.35 m^3) were used. Prior to the application of the slug, depth to water level has been measured in each borehole, and is used as static water level. No pre-test water level stabilisation has been assessed. The water level recording was continued until at least 85 percent of the initial (prior to test) water level measurement is obtained. The time required for a slug test to be completed is a function of the volume of the slug, the hydraulic conductivity of the formation and the type of well completion (Environmental Protection Agency, 1994).

Figure 5 Slug test equipment setup

The graph below (Figure 6) was drawn from results obtained by testing 32 boreholes. On the graph, a straight line is obtained with the log-log scale. If the recession time for the borehole is entered on the x-axis, the possible yield can be read from the y-axis. The recession time to recover to at least 90% of its initial value was used in a formula (Vivier *et al.*, 1995) to determine the possible yield of a borehole.

$$Y = 117155X^{-0.824}$$

Where: X= recession time in seconds and Y= Yield of the borehole.

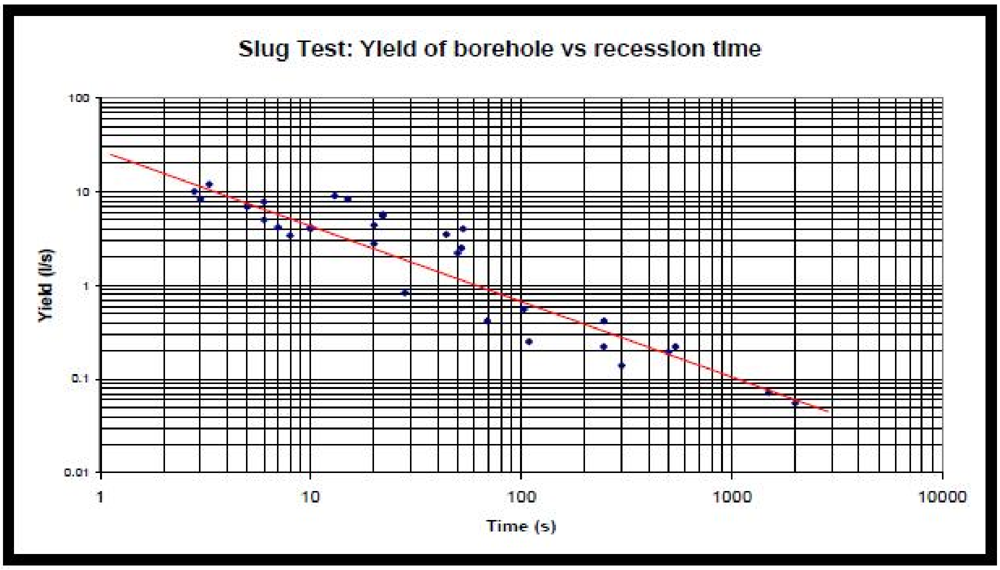

Figure 6 Yield of borehole vs recession time (Vivier et al, 1995)

The rate of water level changes is a function of the K of the formation and the geometry of the well or screened interval. It is only possible from slug test to determine the characteristics of a small volume of aquifer material surrounding the well, although fairly accurate parameters can be obtained from it (Kruseman and de Ridder, 1994). Well design information that were considered in the design of the tests are summarised in Table 4.

Table 4: Borehole construction information considered in the design of the slug test

BH Number	Well depth	Length of screen	Screen slot size	Distribution of the filter pack
	m	m	mm	mm
T4S	24	6	1.0	3
T4D2	50	36	1.0	3
T6D	50	18	1.0	3
T8D	50	15	1.0	3
t7D	50	33	1.0	3
T7S	24	3	1.0	3
Gw Obs BH3	30		1.0	3
Gw Obs BH4	30		1.0	3
Gw Obs BH2	30		1.0	3
Gw Obs BH1	30		1.0	3

2.8.1 Calibration and recovery tests

Calibration tests have been conducted on the 10 selected boreholes to confirm their yielding capacity. Groundwater was pumped from the borehole sequentially at least two higher pumping rates over short periods of time. A Grundfox submersible pump (2kw) with a maximum capacity of 3.5l/s at 50m was used. Pumping rates during calibration tests generally varied between 0.06l/s to 1.2l/s depending on the boreholes. The pump was generally set at 2 m above the bottom of each pumped borehole. Each sequential period was about 15 minutes, and the total testing period was not more than 1 hour. Response (drawdown rate) to each pumping rate was then used to determine possible yielding capacity of the boreholes.

2.8.2 Step tests

Prior to the CDT step tests were conducted on the 4 best yielding boreholes, to set up their respective CDT pumping rate.

The step drawdown test is a single-well test and it is performed that can be used to give an indication of the optimum yield at which the borehole can be subjected to CDT. Groundwater was pumped from the borehole sequentially at least two higher pumping rates over prescribed periods of time. During each step a steady state drawdown was observed prior to increasing of the pumping rate for the next step.

A positive displacement (mono diesel BP 12 HRCL-500RPM-7.5kw) pump, which can yield up to 100m^3/hour at 300m head, was used. The selected boreholes were pumped at rates between 0.03l/s to 0.45l/s depending on the boreholes. Summary of field procedure is given in Table 5.

Table 5 : Summary on the Step test field procedure

BH Name	S.W.L	Pump Depth	Pumping Rate			Pumping Length	Recovery(90 %)
	(mbgl)	(mbgl)	(l/s)			(min)	(min)
GW OBS BH 1	17.02	27.50	0.04	0.15	0.45	75	30
GW OBS BH4	11.05	24.50	0.04	0.10	0.17	60*3	180
T4D2	11.80	39.00	0.03	0.08	0.11	60*3	120
T6D	13.47	39.00	0.09	0.18	0.27	60*3	60

***Description:** BH – borehole; S.W.L – Static Water Level; l/s– Litres per second; m – metre; min – minutes; mbgl- meters below ground level*

2.8.3 Constant discharge tests

Based on results from the step tests, 3 boreholes were chosen to be pumped constantly for 12 hours (CDT). The testing period was decided by considering the low yielding capacity of the aquifer, and in the aim to record responses in closest observations within the proposed Rietvlei Mine. The outlet pipe should be at least 150 m length (50 + 100). During pumping of each tested borehole, the groundwater level responses were recorded in the closest accessible boreholes. The summary of field procedure is given in Table 6. Each CDT was followed by a recovery phase where residual drawdown was recorded up to at least 90% of recovery (except for GW OBS BH4). As for the calibration test a positive displacement (mono diesel BP 12 HRCL-500RPM-7.5kw) pump was used.

Table 6: Constant discharge test and Observation boreholes

BH Name	OBS BH	S.W.L	Pump Depth	Pumping Rate	Pumping Length	Recovery
		(mbgl)	(mbgl)	(l/s)	(min)	(min)
GW OBS BH 1	T7D(1852), T7S(1837)	17.02	27.50	0.25	720	600
GW OBS BH4	T7D(1282), T7S(1318)	11.05	24.50	0.11	720	--
T6D	T4D2(762) T4S(1032), T8D(2974)	13.47	39.00	0.28	720	180
Description: *BH – borehole; S.W.L – Static Water Level; l/s– Litres per second; m – metre; min – minutes; mbgl- meters below ground level*						

The response (drawdown) of the aquifer during the aquifer constant pumping tests were analysed with different methods provided in the program "Flow Calculation" (FC) developed by the Institute of Groundwater Studies (IGS/UFS).

3 Description of the study area

3.1 General description of the study area

The present section makes use of existing general, and background hydrogeological information prior to current investigations, to describe physically the study area.

3.1.1 Climate

Based on data provided by SA Explorer, the climate is typical of the Highveld, with warm summers and cold winters. The area experiences an average of 8.3 hours of sunshine a day. The mean annual temperature is approximately 23°C (Figure 8). The area falls in the summer rainfall region with most rain occurring between October and March (Figure 9). The mean average annual rainfall for Optimum Mine (in close proximity of Rietvlei Colliery) is approximately 680 -700 mm. The mean monthly evaporation for a Class "A" pan is shown in Figure 7.

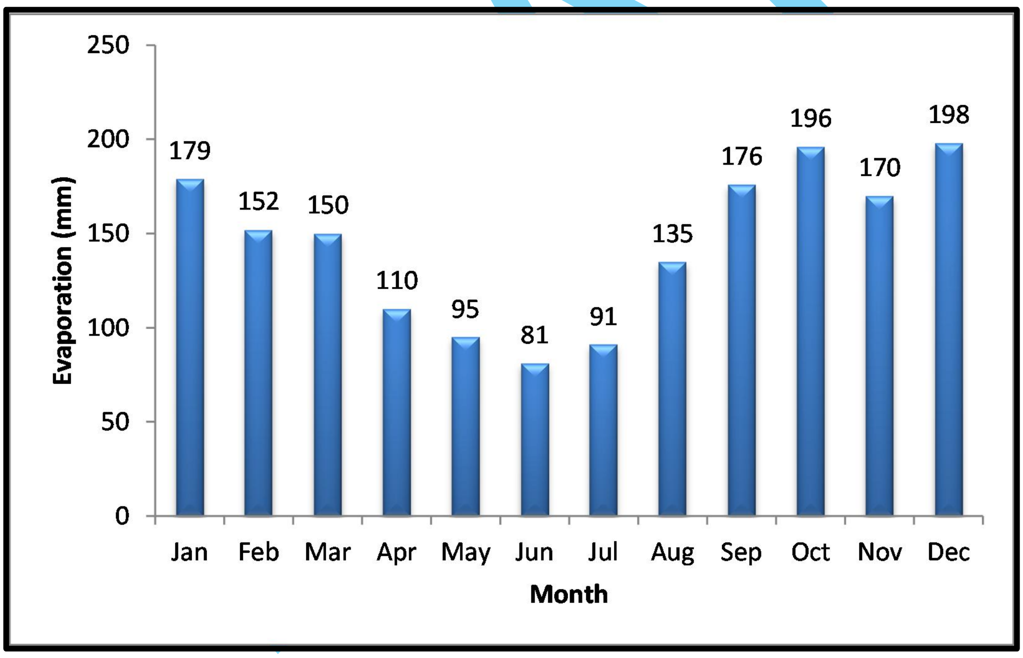

Figure 7: Average evaporation (SA Explorer)

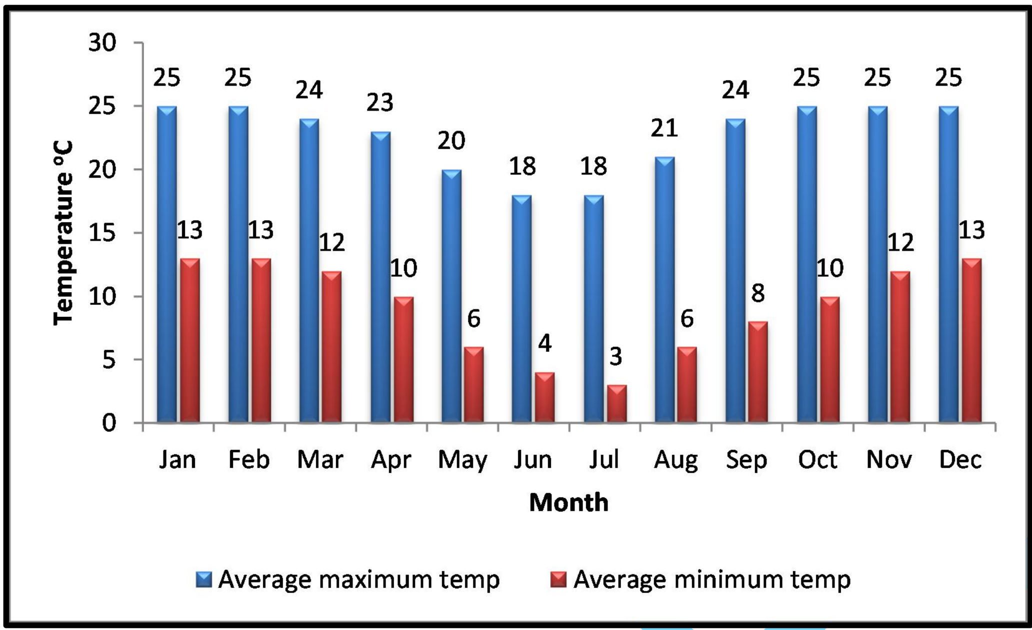

Figure 8: Average monthly temperatures (SA Explorer)

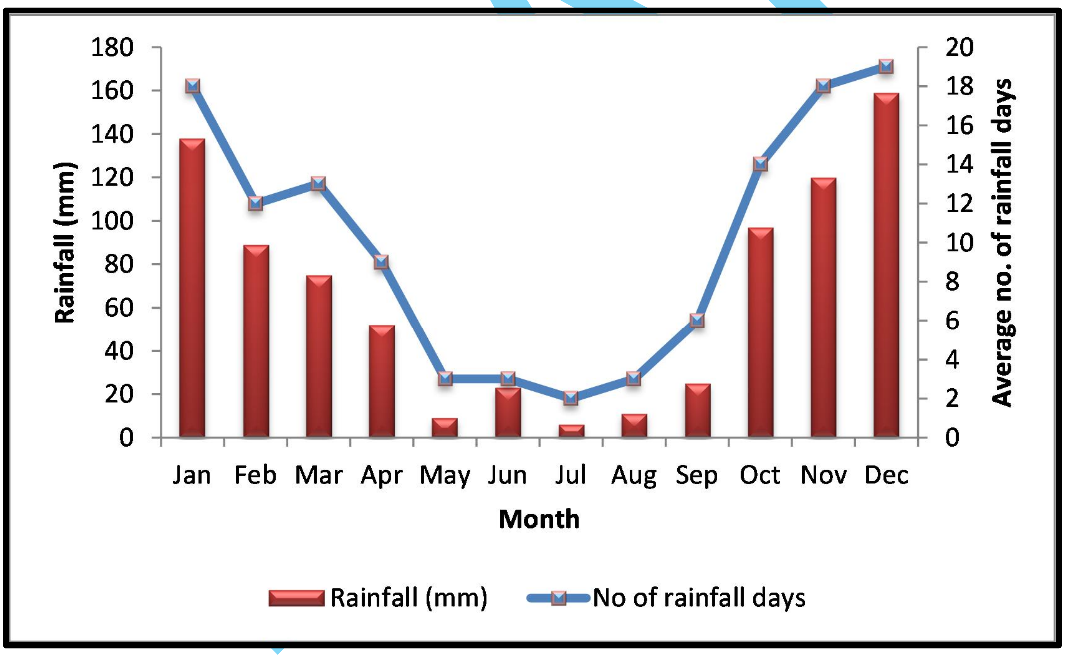

Figure 9: Average monthly rainfall with average number of rainfall days (SA Explorer)

The rainfall record at B1E003 (DWA gauging station) for the above mentioned period, is shown in Figure 10. The associated average daily evaporation is shown in Figure 11.

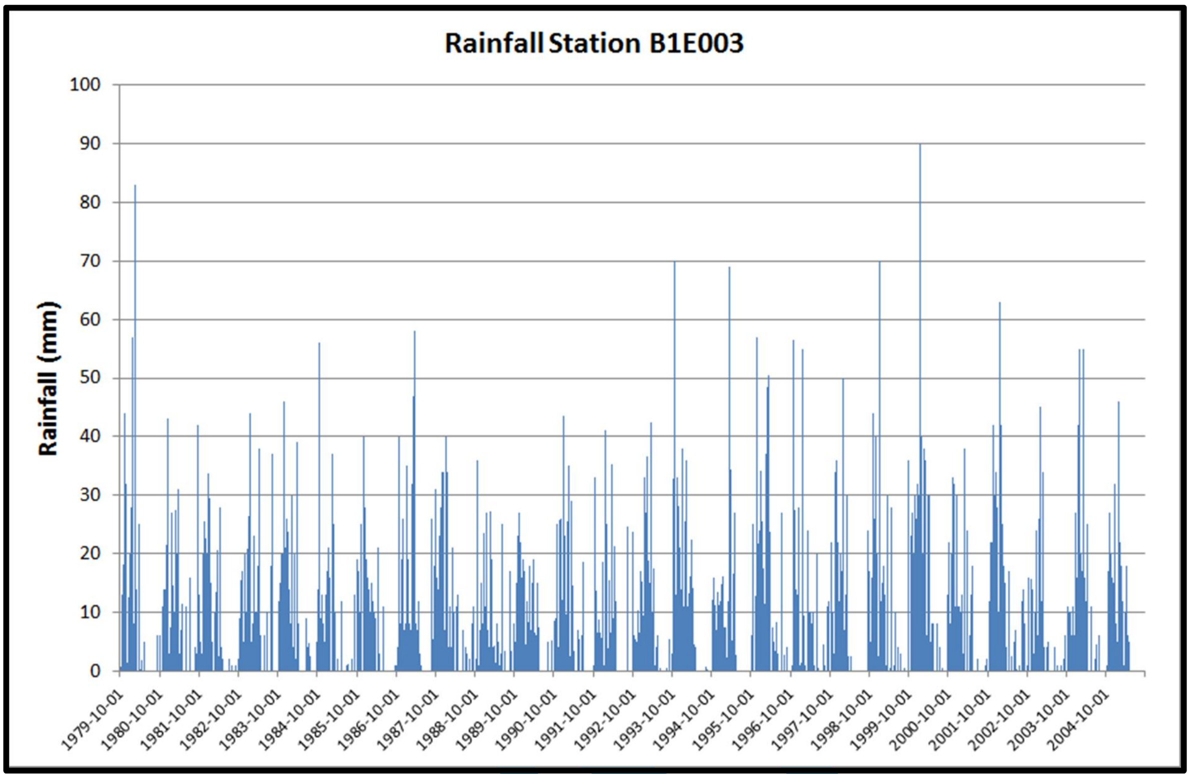

Figure 10: Rainfall record for B1E003 from 1980 to 2005 (DWA)

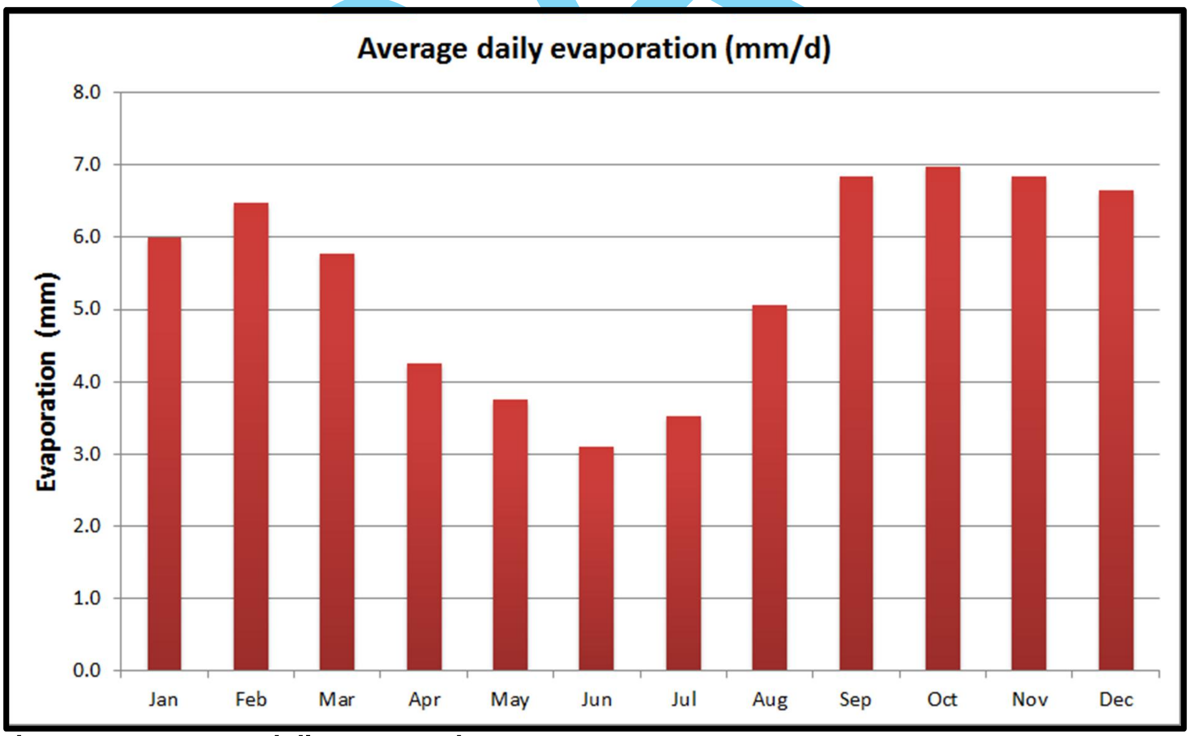

Figure 11: Average daily evaporation

3.2 Soils and land cover

Rehab Green Monitoring Consultants cc conducted a detailed soil, land capability and land use assessment as well as wetland delineation during June 2011. The classification and mapping of soil forms (types) according to the South African Taxonomic Soil Classification System as documented is described in that report.

Soil background information and land cover distribution are useful in understanding the behaviour of surface water over the study area.

3.2.1 Vegetation

The study area is located in the Grassland Biome of South Africa, across one regional vegetation unit, namely Eastern Highveld Grassland.

The site is covered by plantations, which in some areas have been cut and / or burned, and a number of "vlei" or wetland areas. Three habitat units were identified during the assessment, namely wetlands, grasslands and transformed habitats with historic disturbance as a result of cultivation, plantations and alien floral encroachment.

3.3 Wetlands

In 2011, Scientific Aquatic Services (SAS cc) conducted a wetland assessment as part of the EIA process for the proposed Rietvlei Colliery. The delineated wetlands inside the prospecting area are shown in Figure 12. All the wetlands in the study area have been considered sensitive and should be treated as required by Mpumalanga Biodiversity Conservation Plan. The varying sensitivities ascribed to the wetlands on site, range from Low Sensitivity to High Sensitivity, and are based on the varying degrees of degradation of the wetlands on site (Figure 12).

Wetlands present outside the boundary of the study area, have not been taken into account in the existing wetland mapping. This will however need to be considered in the mine water management and monitoring plans. Wetlands are connected to many of the streams on site and downstream sites.

Wetlands form where the water movement through the landscape slows down on or near the soil surface for a sufficient period to allow wetland conditions to develop. They are directly dependant on the water they receive from their catchment. Permanent and seasonal wetlands are present on site. Seasonal wetlands are firstly dependant on the surface water runoff from upstream areas and secondly, on the infiltrated water through soils (percolation) in these areas that end up in the ground water. The role of direct precipitation inputs in maintaining the seasonal wetlands is undoubtedly not less important. Permanent wetlands are likely to be firstly supported by water percolating trough different soil horizons, and a shallow perched water table mainly in winter and autumn. There could of course also be deeper groundwater inputs that may be associated with structural features.

The degree to which these wetlands depend on the groundwater seepage was not established and would require some form of eco-hydrological modelling of flows through the soil profile.

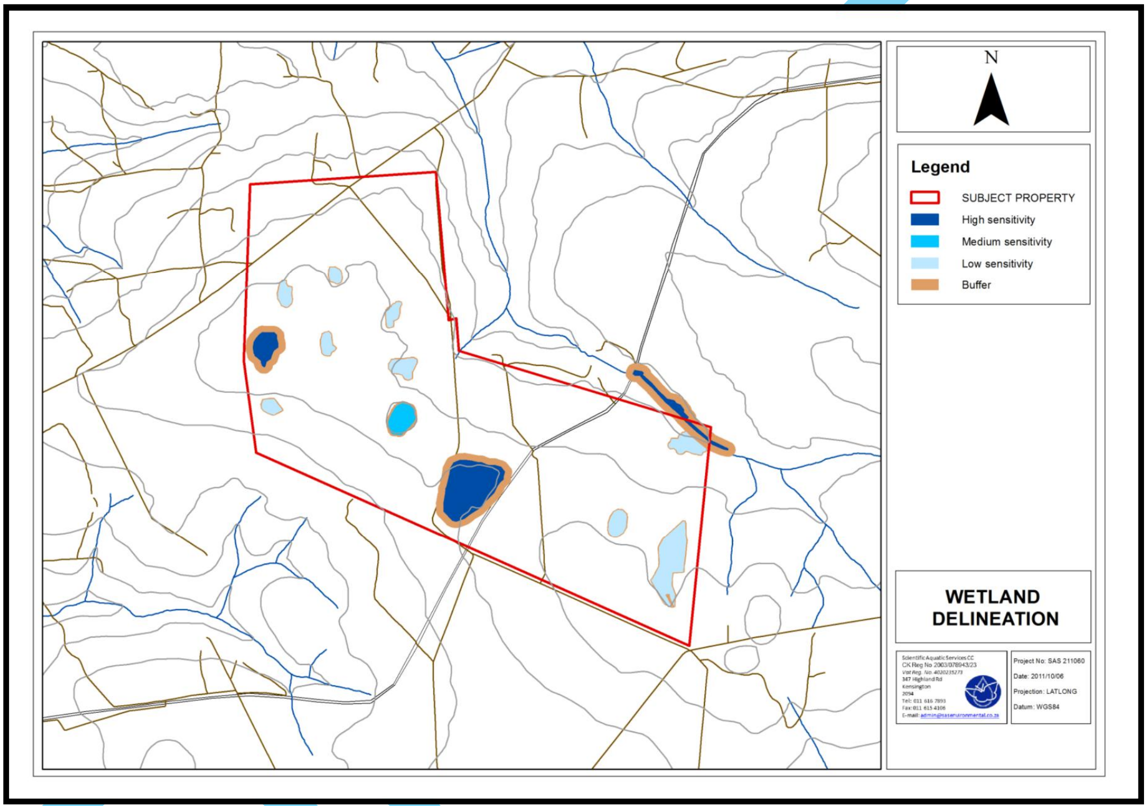

Figure 12: Wetland delineation with associated buffers (SAS) cc

3.4 Topography and drainage

The project area is located on the intersection of 03 quaternary catchments B12D, B12E and B32B (Table 7), with a small part (0.255km^2) of the prospect area falling under B12C. The landscape slopes gently towards the different streams and rivers. The general elevations in the concerned catchments range between 1043 mamsl and 1831 mamsl (

Figure **13**). The study area is characterised by a land use of mainly agriculture, with blue gum plantations as the main agricultural activity.

Table 7: Information concerning quaternary catchment

Catchment	B12D	B12E	B32B
Area (km^2)	362.3	435.8	613.8
Mean annual runoff (mm/a)	38	53	51
Groundwater contribution to base flow (mm/a)	7	18	16

The present study focuses on the three main catchments. Rietvlei forms the headwaters of:

- The Olifants River in B12D: number of small sized dams, intercepts the West-South-West furrows (Figure 15) that feed into Olifants River.
- The Selons River in B32B which flows North-West into Olifants River;
- The Keerom stream (B12E) which flows West-South-West into Olifants River: number of small sized dams, intercepts the South-West furrows (Figure 15) that feed into Keerom stream.

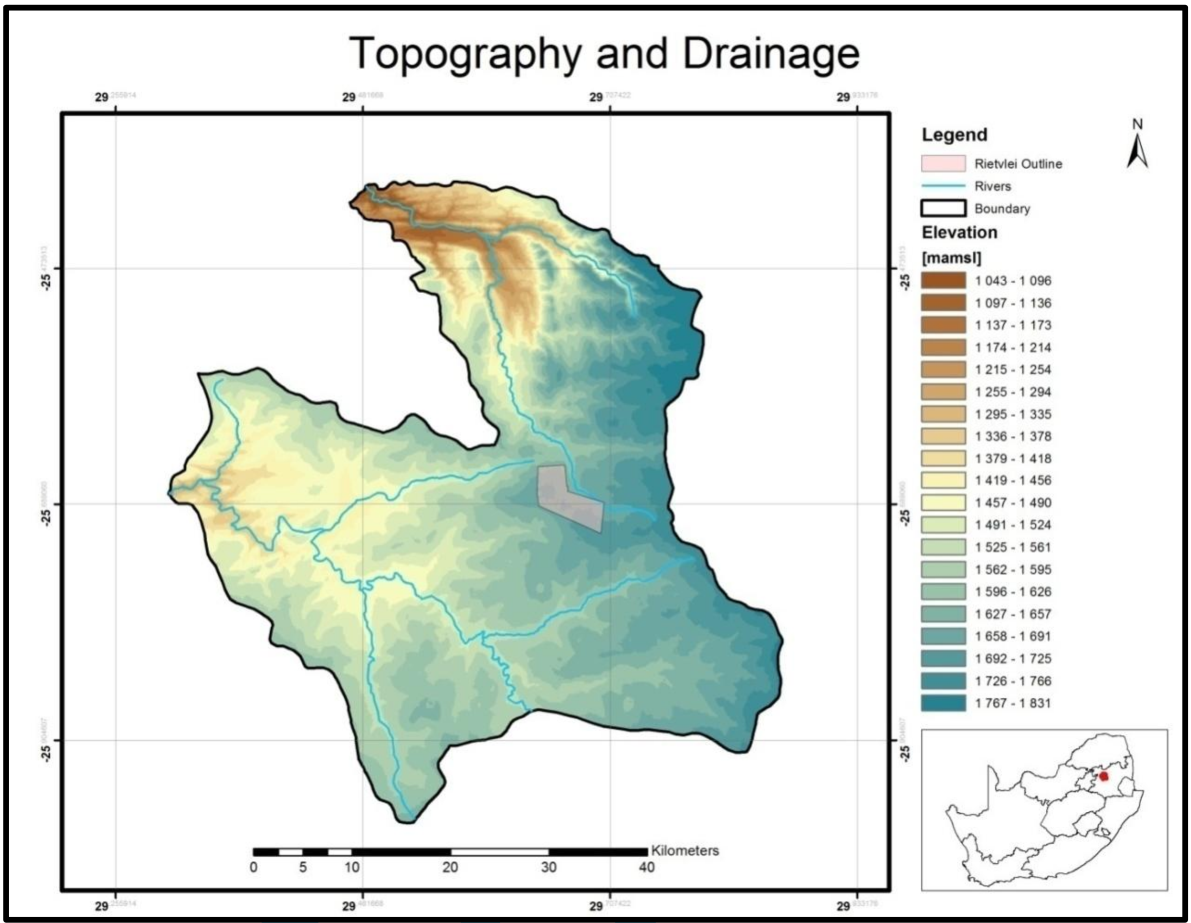

Figure 13: General Topography and drainage

The local elevations prior to mining ranges from 1590mamsl to 1720mamsl as indicted on Figure 14. The maximum decrease in elevation (from the highest point on site towards the lowest) is approximately 230m.

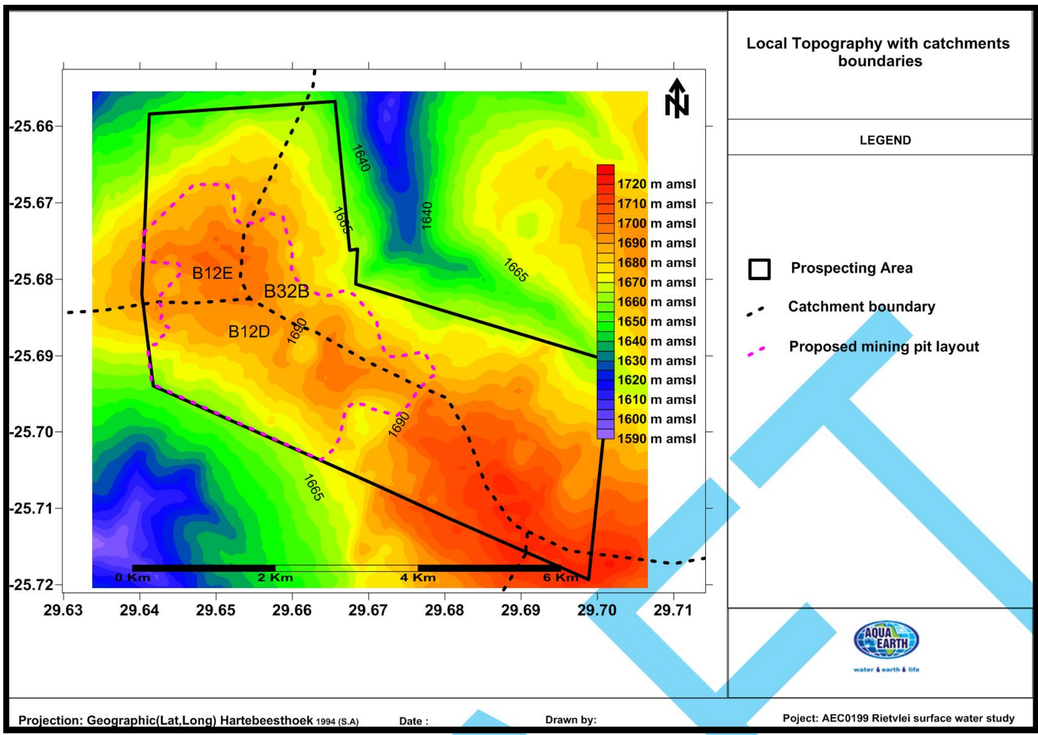

Figure 14: Local topography with catchments boundaries and mining pit.

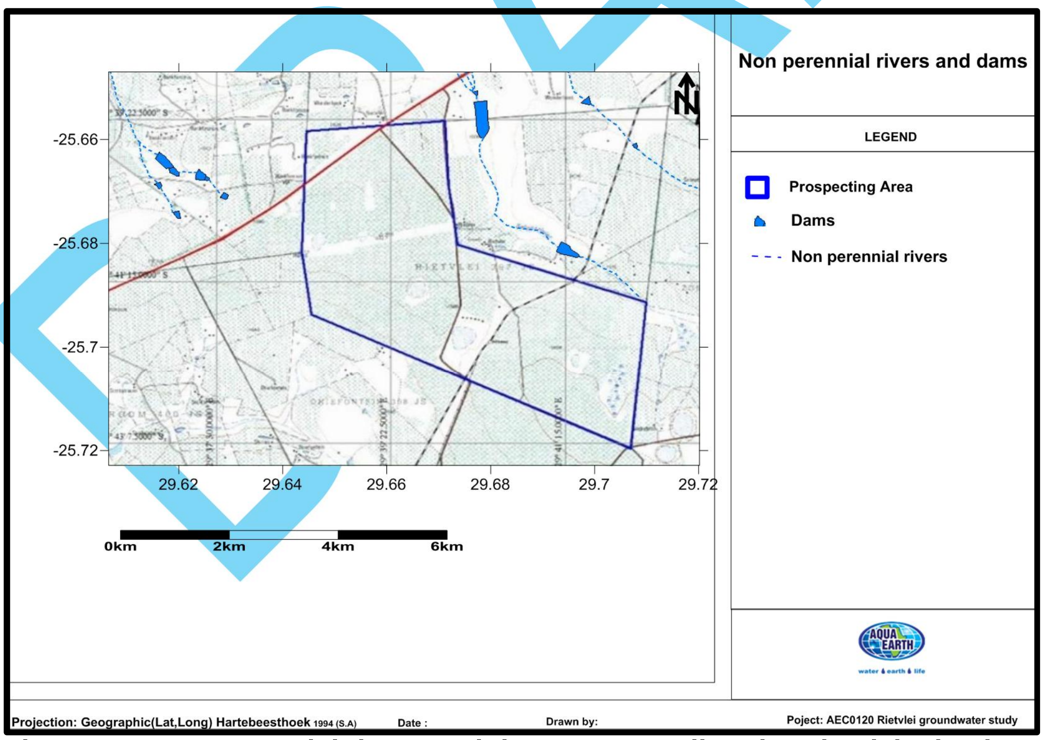

Figure 15: Non perennial rivers and dams surrounding the Rietvlei mine lease area.