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

Prepared by:	**Scientific Aquatic Services**
Report authors:	**S. van Staden (Pr. Sci. Nat.)**
	M. Hanekom
Report Reference:	**SAS 21*3232***
Date:	**April 2014**

Scientific Aquatic Services CC
CC Reg No 2003/078943/23
Vat Reg. No. 4020235273
91 Geldenhuis Road
Malvern East Ext 1
2007
Tel: 011 616 7893
Fax: 086 724 3132
E-mail: admin@sasenvironmental.co.za

TABLE OF CONTENTS

LIST OF TABLES ..... **iii**
LIST OF FIGURES ..... **iii**
LIST OF APPENDICES ..... **iv**
1 PROJECT OBJECTIVES AND SCOPE **1**
1.1 Background to the study site 2
1.2 Aquatic Ecological Description 2
1.2.1 Ecostatus 2
1.2.2 State of the Rivers Report. Crocodile, Sabie-Sand and Olifants River Systems (DWAF and RHP, 2014) 3
1.2.3 National Freshwater Ecosystems Priority Areas database (NFEPA 2011) 5
1.3 Project execution and scope 6
1.4 Assumptions and Limitations 6
1.5 Legislative requirements 7
2 METHOD OF INVESTIGATION **7**
2.1 Visual Assessment 7
2.2 Physico Chemical Water Quality Data 8
2.3 Riparian Vegetation Response Assessment Index (VEGRAI) 8
2.4 Habitat Suitability (IHAS) 9
2.5 Habitat Integrity (IHIA) 9
2.6 Aquatic Macro-Invertebrates (SASS) 10
2.7 Aquatic Macro-Invertebrates: Macro-invertebrate Response Assessment Index (MIRAI) 12
2.8 Fish biota: Habitat Cover Rating (HCR) 13
2.9 Fish biota: Fish Response Assessment Index (FRAI) 14
3 RESULTS AND INTERPRETATION **17**
3.1 Aquatic Assessment 17
3.1.1 Visual assessment 17
3.1.2 Physico-Chemical Water Quality 20
3.1.3 Riparian Vegetation Response Assessment Index (VEGRAI) 22
3.1.4 Invertebrate Habitat Integrity Assessment (IHIA) 22
3.1.5 Invertebrate Habitat Assessment System (IHAS) 24
3.1.6 Aquatic Macro-invertebrates (SASS) 25
3.1.7 Aquatic Macro-invertebrates (MIRAI) 30
3.1.8 Fish Community Integrity 30
3.1.9 General water quality parameters 34
3.1.10 Aquatic and wetland sensitivity mapping 36
4 IMPACT ASSESSMENT **36**
4.1 Impacts on water quality 37
4.2 Impacts on loss of aquatic habitat 41
4.3 Impacts on loss of aquatic biodiversity and sensitive taxa 43
4.4 Impacts on loss on instream flow 46
4.5 Impact assessment conclusion 49
5 CONCLUSION **51**
6 IMPACT MINIMISATION AND RECOMMENDATIONS **56**
7 REFERENCES **60**

LIST OF TABLES

Table 1: Classification of river health assessment classes in line with the RHP 2
Table 2: Co-ordinates of reference site 6
Table 3: Descriptions of the A-F ecological categories. 8
Table 4: Classification of Present State Classes in terms of Habitat Integrity (Based on Kemper 1999) 10
Table 5: Definition of Present State Classes in terms of SASS scores as presented in Dickens and Graham (2001) 12
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). 15
Table 7: Description of the location of the assessment sites in the subject property 19
Table 8: Biota specific water quality data along the main drainage feature. 20
Table 9: Oxygen measured expressed as percentage of maximum for the sites 21
Table 10: Results of the VEGRAI assessment 22
Table 11: Biotope specific summary of the results obtained from the application of the IHAS index to the various sites. 25
Table 12: 2011 biotope specific summary of the results obtained from the application of the SASS5 index to the various sites. 26
Table 13: 2014 biotope specific summary of the results obtained from the application of the SASS5 index to the various sites. 26
Table 14: A summary of the results obtained from the application of the SASS5 indices to the two sites for 2011 and 2014. 27
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. 30
Table 16: Fish species obtained during the 2014 site visit including IUCN 2014 status and justification. 32
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. 34
Table 18: Water quality test results which are not within acceptable TWQR parameters 35
Table 19: Summary of impact significance. 50

LIST OF FIGURES

Figure 1: Ecological categories (EC) eco-status A to F continuum approach employed 2
Figure 2: Aquatic ecological Ecoregions, biomonitoring points on the Selons River system and quaternary catchments indicated within the proposed Rietvlei subject property. 4
Figure 3: SASS5 Classification using biological bands calculated form percentiles for the Highveld Ecoregion, Dallas, 2007 12
Figure 4: Upstream view of the Selons River site RV1 indicating the low flow at the time of assessment (2011). 17
Figure 5: Downstream view of the Selons River site RV1 indicating bank side erosion (October 2011). 17
Figure 6: Downstream view of the Selons River site RV2 near the R555 bridge (October 2011). 17
Figure 7: Upstream view of the Selons River site RV2 (October 2011). 17
Figure 8: Upstream view of the Selons River site RV1 indicating the high flow at the time of assessment (2014). 18

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). 18
Figure 10: Downstream view of the Selons River site RV2 near the R555 bridge indicating good vegetation (October 2014).. 18
Figure 11: Upstream view of the Selons River site RV2 indicating high flow (January 2014). 18
Figure 12: Physico-chemical water quality showing spatial trends for 2011 21
Figure 13: Physico-chemical water quality showing spatial trends for 2014 21
Figure 14: SASS5, IHAS and ASPT scores showing spatial trends for 2011 28
Figure 15: SASS5, IHAS and ASPT scores showing spatial trends for 2014 29
Figure 16: SASS5 and IHAS scores showing temporal trends for 2011 and 2014 29
Figure 17: HCR scores for the two sites assessed for 2011.. 31
Figure 18: HCR scores for the two sites assessed for 2014.. 32
Figure 19: Clarias gariepinus (Sharptooth Catfish) observed at the upstream RV1 site on the Selons River 33
Figure 20: Barbus anoplus (Chubbyhead barb) was observed at the upstream RV1 site on the Selons River 33
Figure 21: Barbus anoplus (Chubbyhead barb) observed at the downstream RV2 site on the Selons River 33
Figure 22: Barbus neefi (Sidespot barb) observed at the downstream RV2 site on the Selons River 33

LIST OF APPENDICES

Appendix 1: VEGRAI Score Sheets
Appendix 2: IHIA Score Sheets
Appendix 3: IHAS Score Sheets
Appendix 4: SASS5 Score Sheets
Appendix 5: General water quality parameters

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

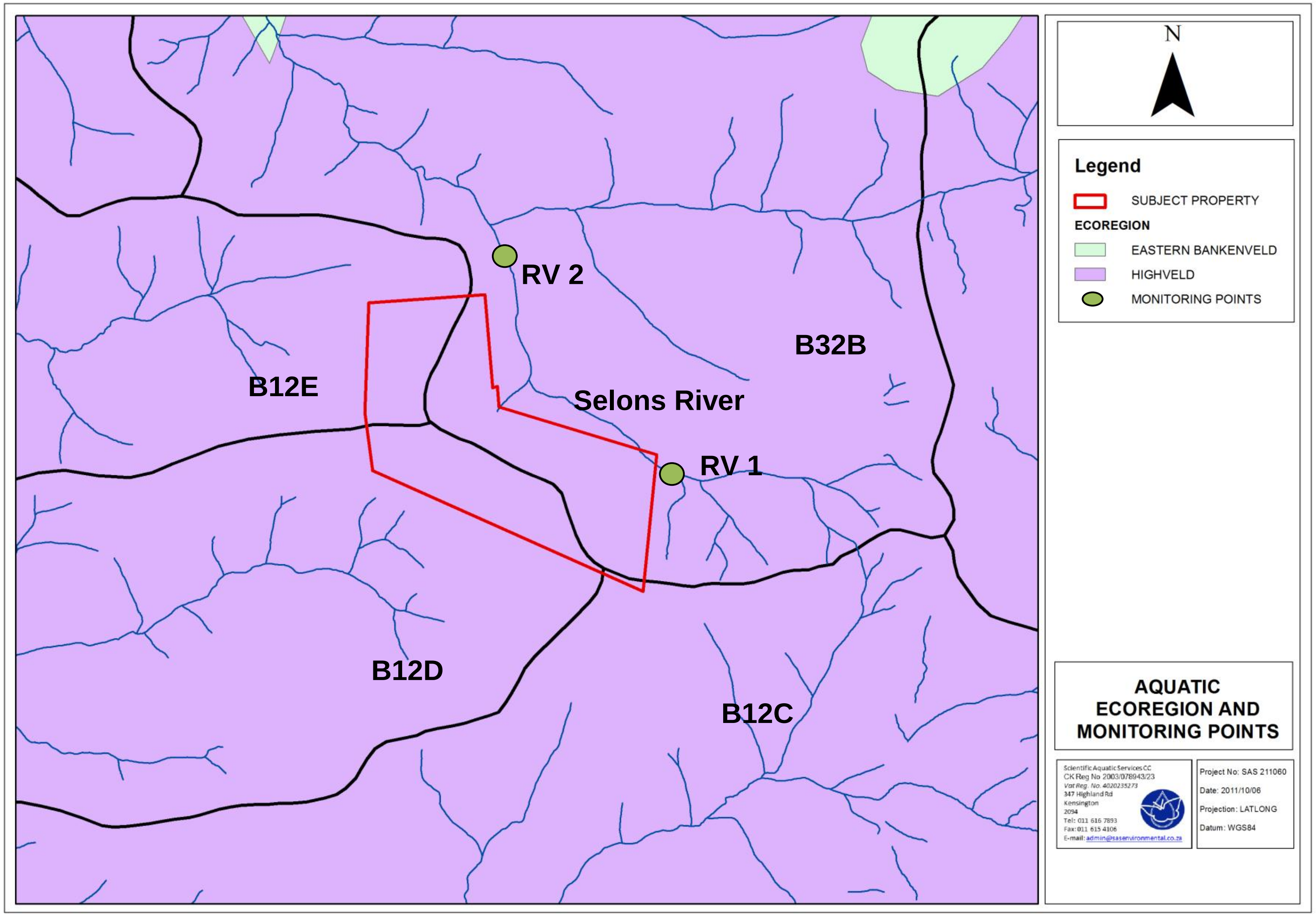

Figure 2: Aquatic ecological Ecoregions, biomonitoring points on the Selons River system and quaternary catchments indicated within the proposed Rietvlei subject property.

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 (5^{th} October 2011) and mid-summer (21^{st} 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.

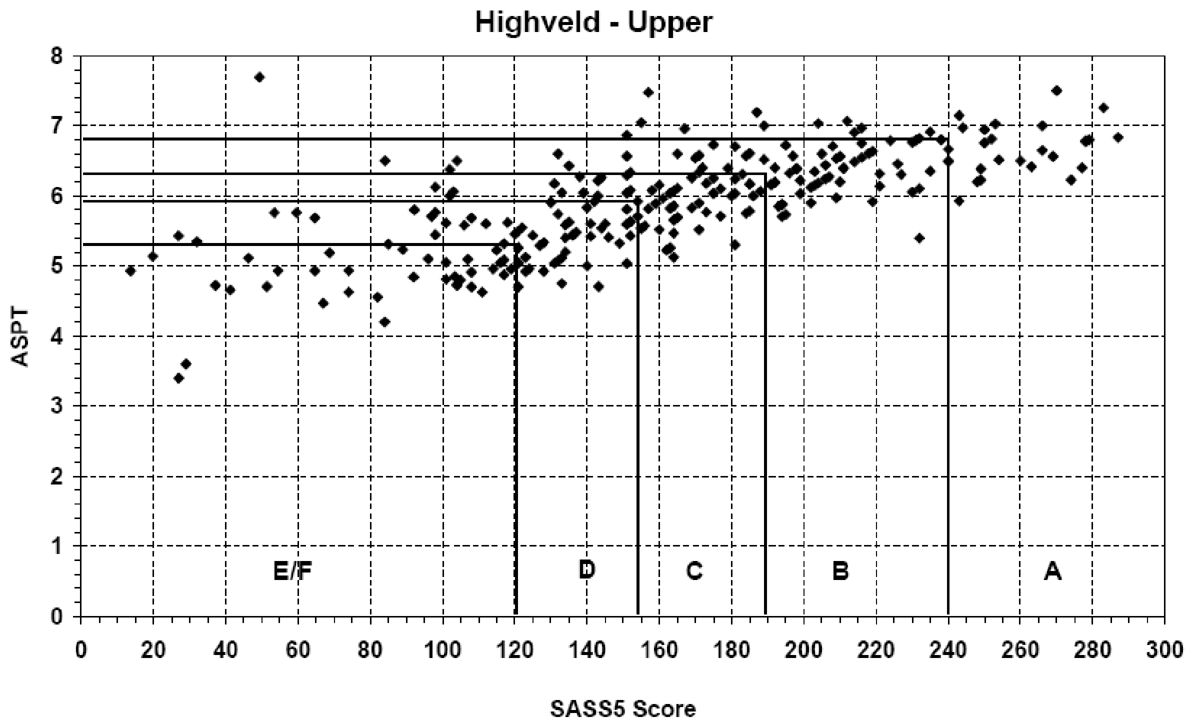

Figure 3: SASS5 Classification using biological bands calculated form percentiles for the Highveld Ecoregion, Dallas, 2007

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 ($df/\Sigma df$).
- 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.

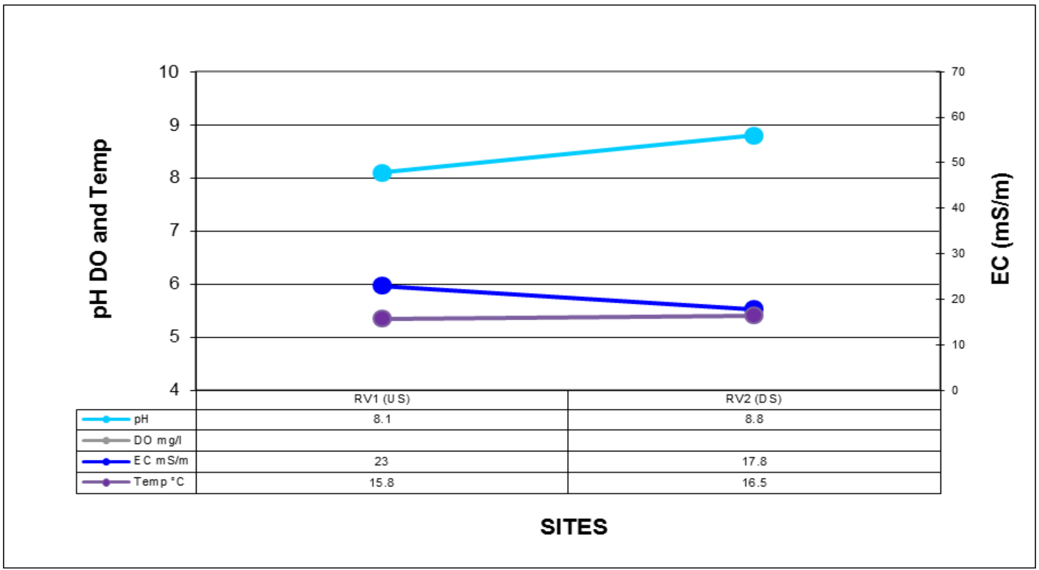

Figure 12: Physico-chemical water quality showing spatial trends for 2011

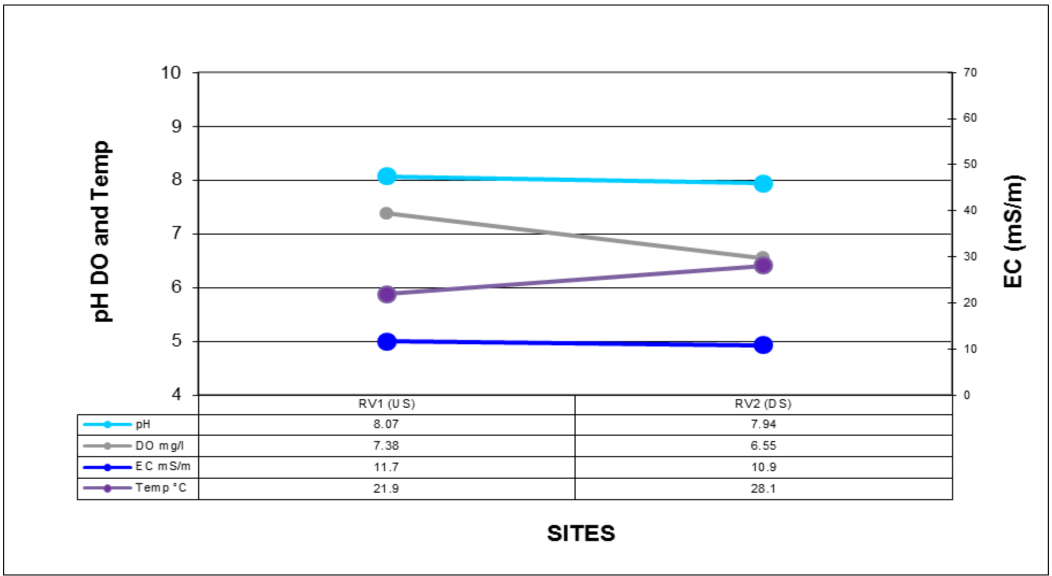

Figure 13: Physico-chemical water quality showing spatial trends for 2014

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)

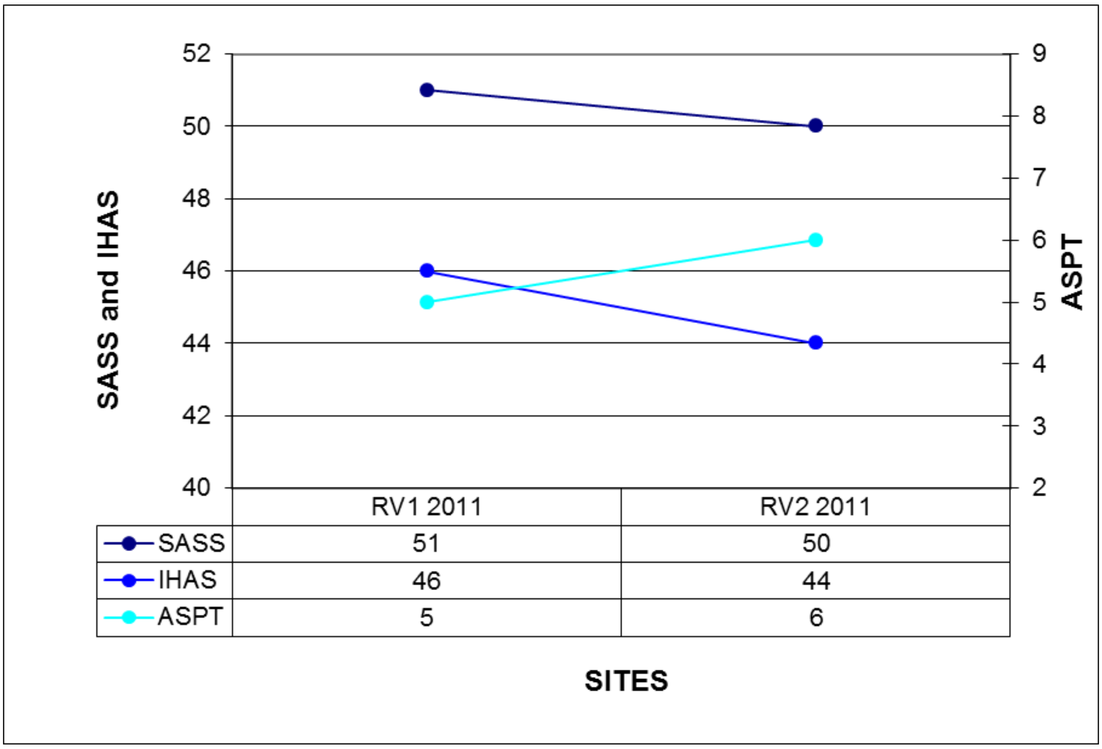

Figure 14: SASS5, IHAS and ASPT scores showing spatial trends for 2011

- 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.

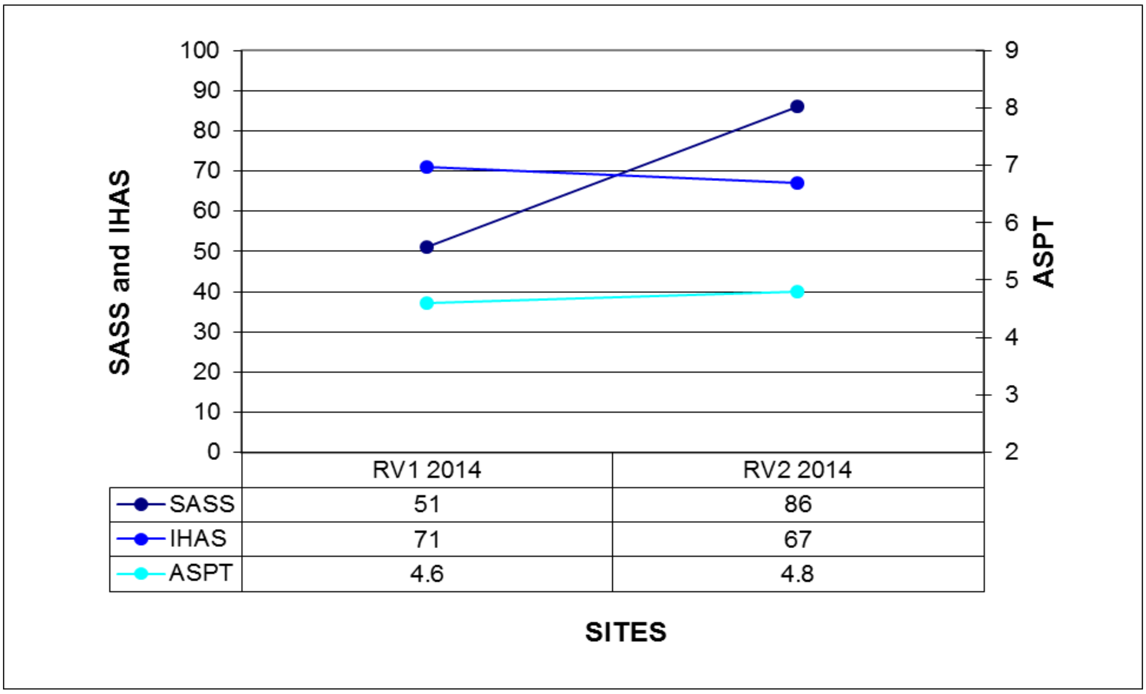

Figure 15: SASS5, IHAS and ASPT scores showing spatial trends for 2014

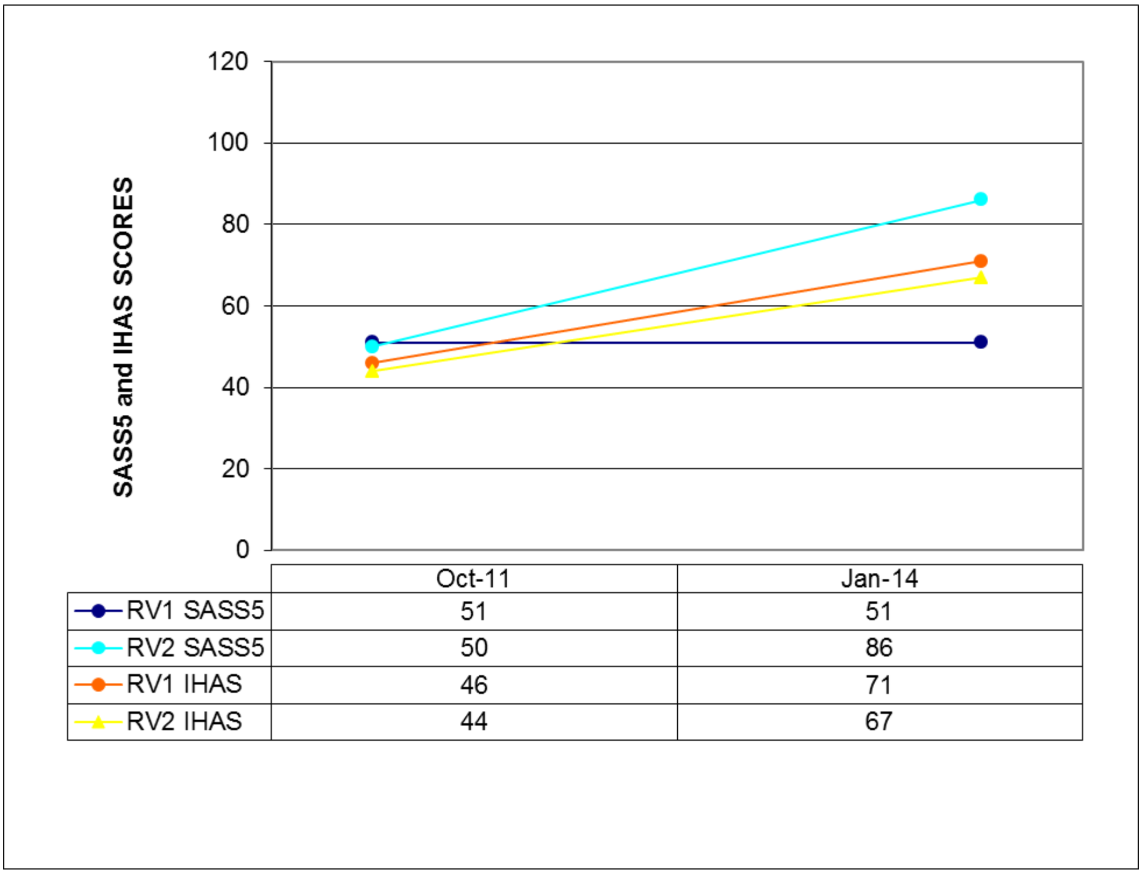

Figure 16: SASS5 and IHAS scores showing temporal trends for 2011 and 2014

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.

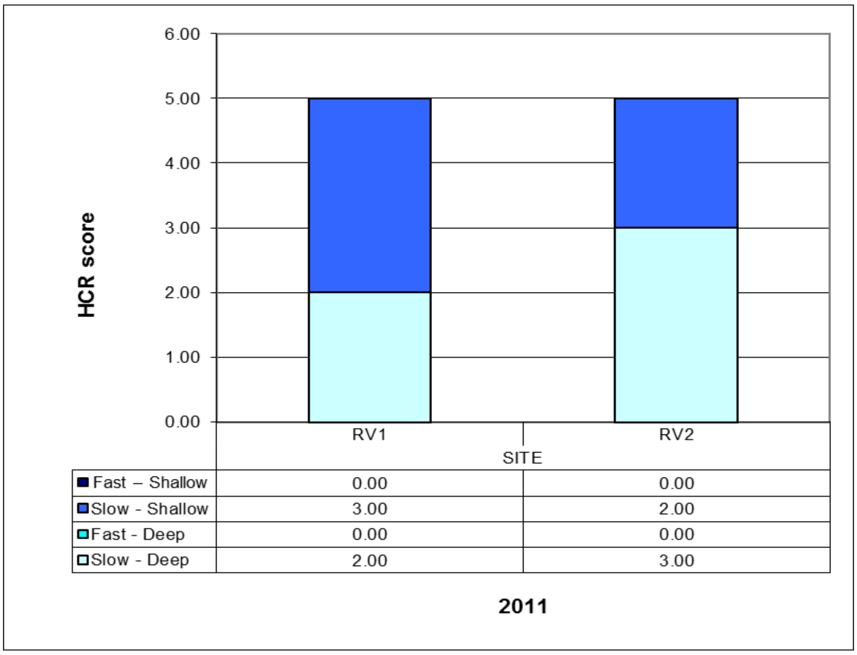

Figure 17: HCR scores for the two sites assessed for 2011

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.

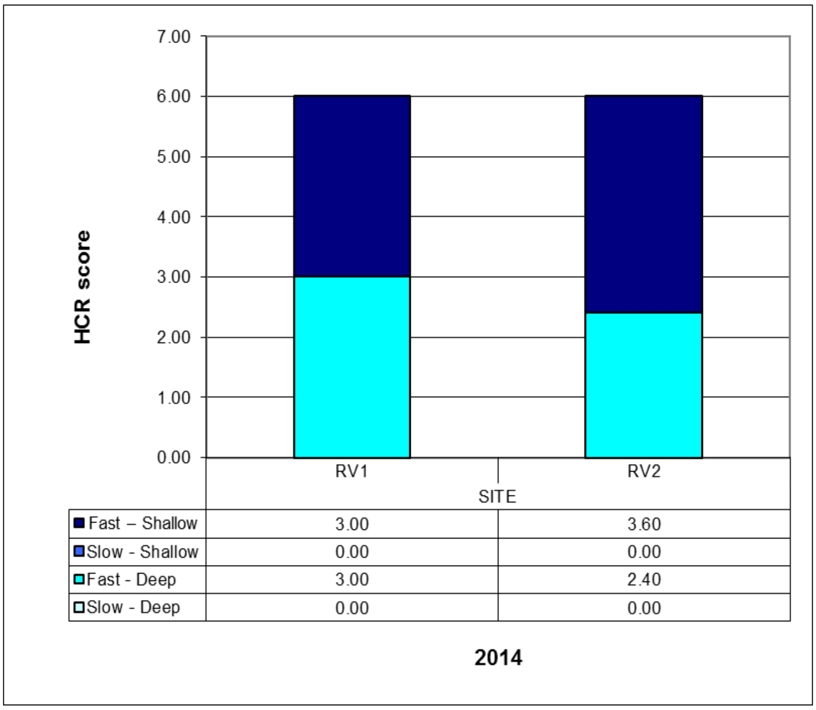

Figure 18: HCR scores for the two sites assessed for 2014

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.

7 REFERENCES

Chutter, F. M. (1998). *Research on the Rapid Biological Assessment of Water Quality Impacts in Streams and Rivers*. Report to the Water Research Commission by Environmentek, CSIR, WRC report No 422/1/98. Pretoria: Government printer

Crafford, D. (2000). Application of a Fish Health Assessment Index and Associated Parasite Index on *Clarias gariepinus* (Sharptooth Catfish) in the Vaal River System with reference to Heavy Metals. Rand Afrikaans University, M.Sc. Dissertation

Dallas, H.F. (1997). A preliminary evaluation of aspects of SASS (South African Scoring System) for the rapid bioassessment of water in rivers with particular reference to the incorporation of SASS in a national biomonitoring programme. *South African Journal of Aquatic Science*, 23: 79-94.

Davies, B. and DAY, J. (1998).*Vanishing Water*. Cape Town: UCT Press.

Dickens, C. and Graham, M. (2001).*South African Scoring System (SASS) version 5. Rapid Bio Assessment for Rivers May 2001*. CSIR.http://www.csir.co.za/rhp/sass.html

DWAF (1996). Department of Water Affairs and Forestry. *South African Water Quality Guidelines* vol. 7, Aquatic ecosystems.

DWAF and RHP (2014). Olifant River System catchment overview. http://www.dwa.gov.za/iwqs/rhp/state_of_rivers/state_of_crocsabieolif_01/olif_eco.html

IUCN (2014). IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>.

Kemper, N. 1999.Intermediate Habitat Integrity assessment for use in rapid and intermediate assessments. RDM Manual version 1.0.

Kleynhans, CJ. (1996).A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo System, South Africa*).Journal of Aquatic Ecosystem Health*. 5: 41-54.

Kleynhans, CJ (1999). *The Development of a Fish Index to Assess the Biological integrity of South African Rivers*. Water SA 25(3) 265-278.

Kleynhans C, J. (2000). Procedure for desktop estimate of the water quantity component of the ecological reserve, for use in the national water balance. Institute for Water Quality Studies, Department of Water Affairs and Forestry.

Kleynhans, CJ. (2002). Fish Intolerance ratings. Proceedings resulting from the National Fish Workshop held at the WRC during 2001.

Kleynhans CJ. (2007). Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2) Joint Water

Research Commission and Department of Water Affairs and Forestry report. WRC Report No

Kleynhans, CJ, Thirion, C and Moolman, J (2005). A Level I River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa

Kleynhans CJ, Louw MD, Moolman J. (2007). Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

McMillan, P. H. (1998). *An Integrated Habitat Assessment System (IHAS v2) for the Rapid Biological Assessment of Rivers and Streams*. A CSIR Research Project. Number ENV-P-I 98132 for the Water Resources Management Programme. CSIR.ii +44 ppin Solids.http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html

OREWRA (2001). Olifants River Ecological Water Requirements Assessment. Report No.PB-000-00-5299

Skelton, P. H. (2001). A complete guide to freshwater fishes of Southern Africa. Southern Book Publishers (Pty) Ltd. Halfway House. 388pp

Thirion, C.A., Mocke, A. and Woest, R. (1995). *Biological monitoring of streams and rivers using SASS4.A Users Manual*. Internal Report No.N 000/00REQ/1195.Institute for Water Quality Studies. Department of Water Affairs and Forestry. 46.

Thirion, C. (2007). Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No

Uys M. C., Goetch P. A. and O'keeffe J. H. (1996). National Biomonitoring Program for Riverine Ecosystems: Ecological Indicators, a review and recommendations. NBP Report Series No 4. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria

United States Environmental Protection Agency (US EPA, 1996). Ecological effects test guidelines. Fish acute toxicity test, Freshwater and marine. OPPTS 850.1075. Report number EPA-712-C-96-118

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 45):						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					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

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: 219 °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: 117 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