FLORAL, FAUNAL, WETLAND AND AQUATIC ASSESSMENT AS PART OF THE ENVIRONMENTAL AUTHORISATION PROCESS FOR THE PROPOSED COMMISSIEKRAAL COLLIERY, KWAZULU-NATAL PROVINCE

Prepared for

SLR Consulting (Africa) (Pty) Ltd.

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Section E: Aquatic Assessment

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

Scientific Aquatic Services (SAS) was appointed to conduct a floral, faunal, wetland and aquatic assessment as part of the Environmental assessment and authorisation process for the proposed Commissiekraal Coal Project; hereafter referred to as the "subject property" (please refer to Figure 1 and 2, Section A). Autumn (April 2013), summer (February 2014) and winter (June 2015) assessments were performed. The subject property is located approximately 28 km north of Utrecht in the eMadlangeni Local Municipality and the Amajuba District Municipality, KwaZulu-Natal. The subject property assessment sites are situated within the Eastern Escarpment Mountains Ecoregion and are located within the W42A quaternary catchment.

According to the ecological importance classification for the quaternary catchment, the system can be classified as a Sensitive system which, in its present state, can be considered a Class A (unmodified, natural) stream. The Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database also indicates high sensitivity and ecological importance with high levels of aquatic biodiversity within the system.

The purpose of this report is to define areas of increased aquatic Ecological Importance and Sensitivity (EIS) and to define the Present Ecological State (PES) of the aquatic resources in the vicinity of the proposed mining development. Furthermore, detailed information is to be provided to guide the activities associated with the proposed mine development, should it proceed, in the vicinity of wetland and riverine areas, to ensure that the ongoing functioning of the wetlands and rivers are facilitated at an acceptable level to meet regional conservation targets and minimise impacts on downstream ecology. The study also aims to identify and quantify any impacts on the aquatic resources in the area and to develop a list of mitigation measures which could be employed to minimise impacts on the receiving aquatic environment.

The sections below summarise the key findings of the baseline study:

Desktop assessment results

Quaternary catchment (QC) level – Kleynhans (1999)					
QC	Resource	EISC	DEMC	PESC	Best AEMC
W42A	Pongolo	High	B	A	A
Sub-quaternary catchment reach (SQR) level – DWS PES/EIS database					
SQR	Resource	PES	Mean EI	Mean ES	Default EC
W42A-02261	Pongolo	C	High	Very high	A
W42A-02328	Pandana	C	High	Very high	A

EISC = Ecological Importance and Sensitivity Category; DEMC = Default Ecological Management Class;
PESC = Present Ecological Status Category; Best AEMC = Best attainable Ecological Management Class;
PES = Present Ecological State; EI = Ecological Importance;
ES = Ecological Sensitivity;
EC = Ecological Category; default based on median PES and highest of EI or ES means.

Physico-chemical water quality

- General water quality can be considered largely natural, as indicated by the low EC concentrations recorded from all sites. All sites also presented with similar pH values and DO concentrations.
- Spatial comparisons were restricted to sites assessed during the same assessment occasions. Percentage change in pH and EC in a downstream direction did not comply with guideline recommendations in the majority of cases indicating a significant degree of variability in basic water chemistry in the system. Changes were often considered to be positive towards more

natural (EC) or neutral (pH) conditions. In terms of absolute values the variation observed is not expected to negatively affect the aquatic communities present under the current conditions;

- Dissolved oxygen levels were above the recommended 80% of saturation recommendation at all sites, with the exception of CK5. However, the absolute value for this site still exceeded 75%. As a result conditions at all sites with reference to DO is considered to be suitable to support diverse and sensitive communities;
- It can thus be concluded that the Pandana River, situated within the project area, exhibits the same undisturbed and largely natural characteristics compared to the Sibabe River.

Biological monitoring indices

Riparian Vegetation Response Assessment Index (VEGRAI)

The results of this assessment indicate that the Pandana River (represented by sites CK1 to CK3, CK5 and CK6) falls within Ecostatus Class E, indicating that the vegetation within the system is seriously modified. The loss of natural habitat, biota and basic ecosystem functions is considered to be extensive, mainly because of alien floral invasion (wattle trees). No deviations as a result of impacted water quality were observed or considered likely.

Riparian zone vegetation condition for the Sibabe River (represented by site CK4) falls within Ecostatus Class B, indicating that the vegetation within the system is largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged. No deviations as a result of impacted water quality were observed.

Invertebrate habitat integrity assessment (IHIA)

- The only in-stream variable for which no impacts were recorded, was exotic macrophytes. Moderate impacts were only recorded for flow modification (Sites CK1, CK2 and CK5) and inundation (CK3 and CK5). Large impacts were recorded for flow modification (CK3), bed modification (CK1, CK2 and CK3) and channel modification (CK1, CK2, CK3 and CK5). In-stream impact scores varied between 62.13% and 95.84%. Classifications awarded were Class C (Moderately modified) for sites CK1, CK2, CK3 and CK5. Class A (Unmodified, natural) was awarded to sites CK4 and CK6.
- Riparian zone impacts recorded for vegetation removal were moderate (sites CK1, CK and CK6) and large (CK2 and CK). For alien encroachment moderate (CK1), large (CK2, CK3 and CK6) and serious (CK5) impacts were recorded. Moderate impacts were recorded for bank erosion at all sites with the exception of CK4. Only slight impacts for water abstraction were reported from all six sites assessed.
- Moderate (CK1, CK2 and CK5) and large (CK3) impacts for flow modification were recorded. Channel modification was recorded as large for sites CK1, CK2, CK3 and CK5. Riparian zone impact scores varied between 52.39% and 94.88%. Classifications awarded were Class C (Moderately modified) for sites CK1, CK2, CK5 and CK6. Class A (Unmodified, natural) was awarded to site CK4, whilst site CK3 was awarded a Class D (Largely modified) classification.
- The total IHIA scores ranged between 57.26% and 95.36%. A Class C (Moderately modified) classification was awarded to sites CK1, CK2 and CK5, a Class D (Largely modified) classification to site CK3, a Class B (Largely natural) classification to site CK6 and a Class A (Unmodified, natural) classification to site CK4.
- The reach of the Pandana River in the vicinity of the proposed mining area can generally be considered moderately modified from what could be expected under unimpacted/unmodified conditions. However, there is some variability in the system with one site presenting with largely natural conditions and another with largely modified conditions.
- Based on the single site assessed on the Sibabe River, this system appears to be unmodified and completely natural.
- It can be concluded that the riverine resources associated with the subject property can be considered moderately modified to largely natural, which is in accordance with the desktop assessment results.

Invertebrate habitat assessment system (IHAS)

From the results of the application of the IHAS index, it is evident that both the Pandana and Sibabe Rivers in the area provide adequate habitat conditions for sustaining a diverse macro-invertebrate community. This is largely due to a good variety of substrate types at all the sites assessed, as well as a good variety of flow types within the system. However, the lack of leafy marginal vegetation at some sites and the absence of aquatic macrophytes in the systems assessed will limit the availability of suitable cover for suitably adapted aquatic macro-invertebrates. Furthermore the systems are shallow and lack strong flow under low flow conditions, reducing the diversity of habitats available for aquatic macro-invertebrates. Considering the above, a macro-invertebrate community of fair to good diversity and abundance can thus be expected but some natural limitations on community sensitivity are also expected (McMillan, 1998).

Aquatic macro-invertebrates

- The Dallas (2007) classification system is sensitive to changes in ASPT. The lowest ASPT score was reported for CK1 in 2013 and also resulted in the lowest classification (class D). For all the other sites the Dallas (2007) classification indicated either class B or class C;
- The Dickens and Graham (2001) class obtained was the same (class E) for sites CK1 to CK4 during the February 2014 assessment which can be ascribed to unsuitable sampling conditions at that time. However, higher SASS5 score resulted in improved class C (CK6) and class B (CK5) classifications during June 2015 when better sampling conditions were available;
- It can therefore be concluded that the macro-invertebrate community of these systems show high levels of variability in terms of both sensitivity and diversity, due to natural events such as high flows and low flows in the system despite the IHAS scores indicating generally adequate conditions. In this regard it is mainly the lack of leafy material and aquatic vegetation at many of the sites that may negatively affect diversity and sensitivity. In addition seasonal changes in flow rate may also affect sensitive taxa. It is considered essential that a quarterly aquatic biomonitoring program be initiated for at least one year prior to the proposed mining commencing to obtain detailed seasonal baseline data for future reference.

River	Site	Assessment	MIRAI score	MIRAI class	SASS5 for comparison	
					Dickens and Graham (2001)	Dallas (2007)
Pandana	CK3	February 2014	41.45	D	E	B
	CK2		42.11	D	E	A/B
	CK1		55.67	D	E	B
	CK1	Apr 2013	55.47	D	D	D
	CK5	June 2015	50.26	D	B	C
	CK6		47.46	D	C	C
Sibabe	CK4	February 2014	54.04	D	E	C

In terms of ecological category classification, the MIRAI Ecostatus tool revealed an ecostatus classification of class D for all sites. The MIRAI is a more robust index and less prone to variability compared to the SASS5 indices, particularly the Dallas (2007) classification system which is very sensitive to changes in ASPT scores. The MIRAI classification indicates a lower class from what can be expected based on the desktop assessment. Over time the aquatic biomonitoring will allow a better understanding of both spatial and temporal trends within the system.

All macro-invertebrate indices indicated a lower diversity than expected, as indicated by the SASS5 score, with variation in the number of sensitive taxa being present, as indicated by the ASPT score. As discussed previously the reasons for this appears not to be current anthropogenic impacts, but rather habitat constraints, lack of flow variability and potentially also seasonal effects in flow rate. Future monitoring efforts will help to identify and elucidate trends in temporal variation which is considered essential for the future monitoring of the system.

Fish response assessment index (FRAI)

<table>
<tr><th>River</th><th>Site</th><th>Species collected or observed</th><th>FROC</th><th>FRAI score</th><th>FRAI ecological classification</th></tr>
<tr><td rowspan="7">Pandana</td><td>CK3</td><td>None</td><td>NA</td><td>16.8</td><td>F</td></tr>
<tr><td>CK2</td><td>None</td><td>NA</td><td>17.3</td><td>F</td></tr>
<tr><td>CK1</td><td>None</td><td>NA</td><td>16.9</td><td>F</td></tr>
<tr><td rowspan="2">CK5</td><td>Chiloglanis emarginatus (Phongolo rock catlet)</td><td>1</td><td rowspan="2">25.9</td><td rowspan="2">E</td></tr>
<tr><td>Barbus anoplus</td><td>2</td></tr>
<tr><td rowspan="2">CK6</td><td>Chiloglanis emarginatus (Phongolo rock catlet)</td><td>1</td><td rowspan="2">28.4</td><td rowspan="2">E</td></tr>
<tr><td>Barbus anoplus</td><td>2</td></tr>
<tr><td>Sibabe</td><td>CK4</td><td>Chiloglanis emarginatus (Phongolo rock catlet)</td><td>1</td><td>22.5</td><td>E</td></tr>
</table>

No fish were captured in the upper Pandana River (sites CK1 to CK3), however, the lack of fish captured may, at least partially be attributed to poor sampling conditions at the time of assessment. Two fish species were captured in the in the Pandana River with one (*Barbus anoplus*) being a common widespread species. It can be concluded that the aquatic ecosystems in the region of the subject property provide suitable habitat for rare and endangered species conservation. Whilst *C. emarginatus* is not considered by the IUCN to be threatened species, they are very sensitive to changes in habitat conditions. This is evident from the fact that *C. emarginatus* has become locally extinct from its type locality, the Lekkerloop stream, due to excessive water extraction by farmers during the dry season (http://www.iucnredlist.org/details/63366/0). This species is also described as "near threatened" by Skelton (2001). Local extinction of any populations that occur in the systems assessed will have a significant impact on the conservation status of the species. Introduction of predacious alien fish species and habitat degradation from impacts such as water extraction, flow modification/river regulation and sedimentation from agro-forestry activities are considered serious threats to this species. Given the largely natural state of the aquatic resources within the larger area, the aquatic ecosystems are considered to be highly sensitive. Any mining activities, if not adequately mitigated, are expected to have a detrimental impact on fish communities in the subject property. Strict control of the mine and related activities will need to take place. In addition special attention will need to be given to separate clean and dirty water systems, as well as other measures to prevent contamination and sedimentation of the Pandana River.

Ecological Importance and Sensitivity Assessment

The Ecological Importance and Sensitivity Assessment analysis for the Pandana River yielded a score of 2.6 whilst a score of 2.5 was obtained for the Sibabe River. Conditions at both sites are thus regarded as highly important and sensitive. The increased importance and sensitivity of the streams are mainly as a result of the largely natural environment and presence of sensitive aquatic species utilising the system, with specific reference to *C. emarginatus*. The system has some importance with regards to use as a migration corridor, and the provision of refugia for species relying on the system. The system has a fair diversity of habitat features. Furthermore the system is considered moderately sensitive to alterations in flow and flow-related water quality changes, with year round water required in the system.

Summary of findings

Variable	Survey	Pandana River					Sibabe River
		CK3	CK2	CK1	CK5	CK6	CK4
VEGRAI	Combined	E					B
IHAS	Combined	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
IHIA	Combined	D	C	C	C	B	A
SASS5 (Dickens and Graham 2001)	April 2013	NA	NA	D	NA	NA	NA
	February 2014	E	E	E	NA	NA	E
	June 2015	NA	NA	NA	B	C	NA
SASS5 (Dallas 2007)	April 2013	NA	NA	D	NA	NA	NA
	February 2014	B	A/B	B	NA	NA	C
	June 2015	NA	NA	NA	C	C	NA
MIRAI	Combined	D	D	D	D	D	D
FRAI	Combined	F	F	F	E	E	E
EIS	Combined	High					High

NA = Not applicable; VEGRAI = Riparian Vegetation Response Assessment Index; IHAS = Invertebrate Habitat Assessment; IHIA = Intermediate Habitat Assessment; SASS5 = South African Scoring System 5; MIRAI = Macro-Invertebrate Response Assessment Index; FRAI = Fish Response Assessment Index

Based on the findings of this study it is evident that despite the fairly limited community diversity, the aquatic resources of the area are of high aquatic Ecological Importance and Sensitivity. This is largely due to the project area being located adjacent to conservancies/protected areas and recreational/tourism areas. In addition, sampling indicated healthy populations of the near threatened Phongolo rock catlet (*C. emarginatus*). Whilst there are also anthropogenic activities in the area which include agricultural activities, farm- and homesteads and associated community activities such as schools, these are considered to pose a very limited threat to ecological function and processes within the project area. Therefore, on this basis, should the project proceed it will have an ecological impact of high significance both within and potentially beyond the boundaries of the project. The potential for post-closure impacts on water quality are of concern. Therefore, unless it is considered economically feasible to treat and/or contain all potential sources of contaminated water which may affect the receiving environment post-closure indefinitely to pre-mining water quality standards in such a way as to support the post closure land use, the project is regarded as posing a very high long term impact on the region. It is highly recommended that should it nonetheless be deemed appropriate to mine the resource, infrastructure required to access the resource must be kept to the absolute minimum. Furthermore, extensive mitigation must be applied during the construction and operational phases of the project to ensure that no impact takes place beyond the surface infrastructure footprint and an acceptable zone of edge effects. In this regard particular mention is made of the management of surface water and the dirty water area of the mine footprint. Exceptionally strict monitoring throughout the life of the mine and post-closure is required in order to ensure the health and functioning of the terrestrial, wetland and aquatic ecosystems is retained, and monitoring data must be utilised to proactively manage any identified emerging issues in a well-managed and overseen BAP, which must be implemented through an automated EMS system. The rehabilitation of the infrastructure during closure of the mine must take place in such a way as to ensure that the post closure land use objectives are met. The wetland and aquatic resources will need to be rehabilitated in such a way as to support the larger wetland systems at the same level as those evident in the pre-mining condition. In order to meet this objective rehabilitation will need to be well planned and a suitably qualified ecologist must form part of the management team through the entire life cycle of the project and to guide the rehabilitation and closure objectives of the mine.

The objective of this study was to provide sufficient information on the ecology of the area, together with other studies on the physical and socio-cultural environment, in order for the Environmental Assessment Practitioner (EAP) and the relevant authorities to apply the principles of Integrated Environmental Management (IEM) and the concept of sustainable development. The needs for conservation as well as the risks to other spheres of the physical and socio-cultural environment need to be compared and considered along with the need to ensure economic development of the country.

It is the opinion of the ecologists that this study provides the relevant information required in order to implement IEM and to ensure that the best long term use of the resources on the subject property will be made in support of the principle of sustainable development.

1. INTRODUCTION

1.1 Background Information

Scientific Aquatic Services (SAS) was appointed to conduct a floral, faunal, wetland and aquatic assessment as part of the Environmental assessment and authorisation process for the proposed Commissiekraal Coal Project. The proposed mining operation is planned on the farm Commissiekraal 90HT covering an area of approximately 2,461 hectares. The proposed Commissiekraal Coal Project is hereafter referred to as the “subject property. Autumn (April 2013), summer (February 2014) and winter (June 2015) assessments were performed.

The subject property is located approximately 28 km north of Utrecht in the eMadlangeni Local Municipality and the Amajuba District Municipality, KwaZulu-Natal. The subject property and surrounds are characterized by agricultural activities (livestock grazing, dryland crops), private farmsteads and communal tenant/farm worker homesteads, remnants of a forestry/small scale plantation, conservancies and protected areas, recreational/tourism areas as well as community activities including schools (SRK scoping report 2015).

The subject property falls within the Usuthu to Mhlathuze Water Management Area and the Eastern Escarpment Mountains ecoregion (quaternary catchment W42A).

The purpose of this report is to define areas of increased aquatic Ecological Importance and Sensitivity (EIS) and to define the Present Ecological State (PES) of the aquatic resources in the vicinity of the proposed development. Furthermore, detailed information is to be provided to guide the activities associated with the proposed mine development, should it proceed, in the vicinity of wetland and riverine areas, to ensure that the ongoing functioning of the wetlands and rivers are facilitated, with specific mention of the following:

- Maintain the Present Ecological State (PES) of the system in support of the Ecological Important and Sensitivity (EIS) of the various aquatic ecosystems;
- Ensure that connectivity of the wetland and river areas are maintained between the areas upstream and downstream of the proposed mining operation areas;
- Ensure that no incision and canalisation of the wetland and river systems takes place as a result of the proposed mining operation activities;
- Ensure that no significant persistent impact on water quality will take place; and
- Minimise impacts on the aquatic ecology of the resources within, adjacent to and downstream of the proposed mining operations.

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

The following aspects were considered in the selection of suitable sites for assessing the level of aquatic ecological integrity and sensitivity in the area of the proposed development.

- Site location and the location of proposed infrastructure and proposed mining areas;
- Consideration was given to the area and position for assessment points on the Pandana River to indicate the aquatic ecological reference conditions, in order to assist in defining the Present Ecological State of the systems and any impacts in this area;
- A point on the Sibabe River system outside the project area was also selected for the purpose of comparison and to indicate the ecology of the drainage features in the broader area;
- The sites were selected based on what was deemed the most representative habitat conditions, with the best level of diversity in relation to the condition of each system assessed. In other words, assessment sites were chosen which were considered suitable for supporting the best representation of the aquatic community likely to be present in each system.
- Accessibility with a vehicle in order to allow for the transport of equipment.

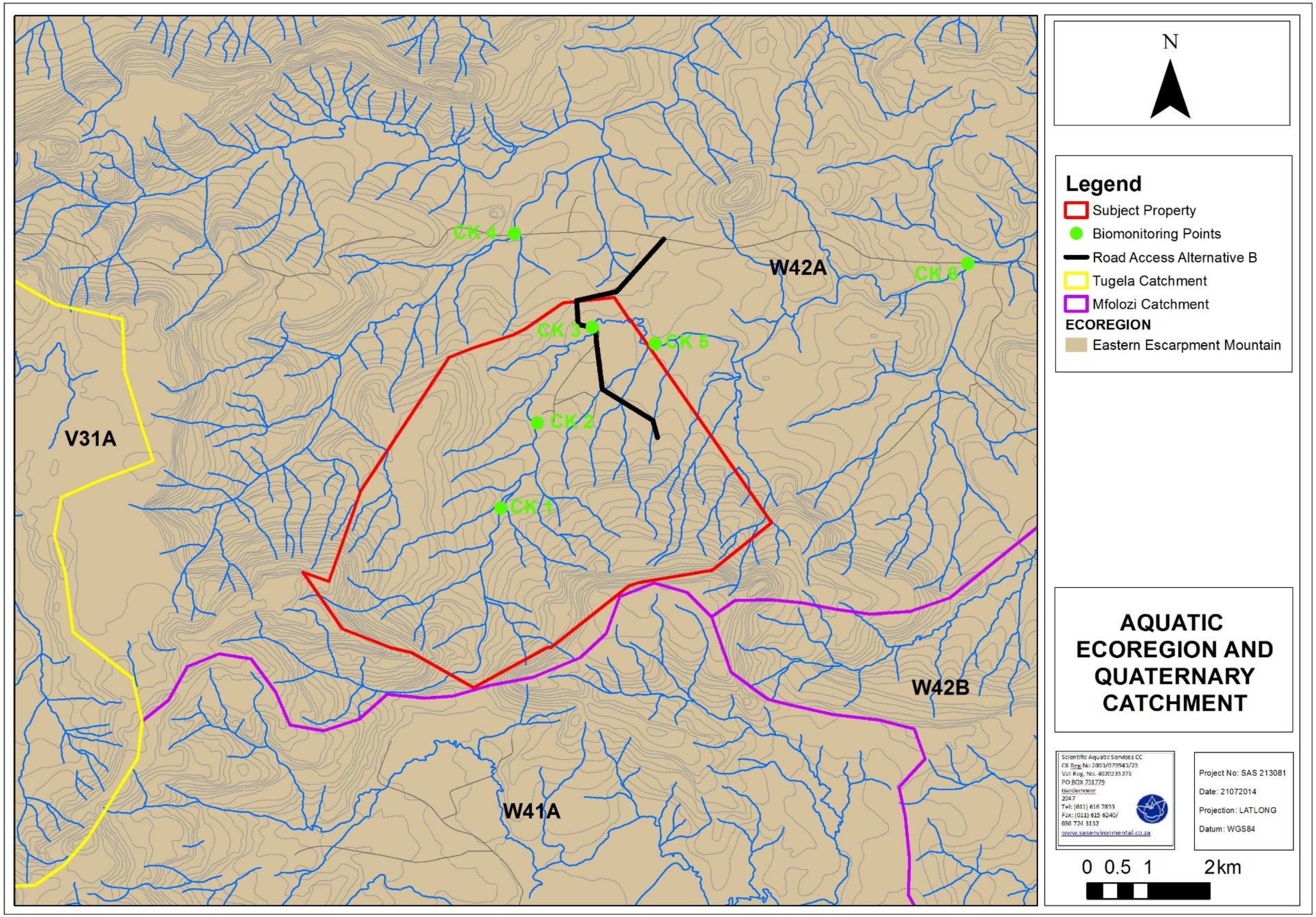


Figure 1: Aquatic ecological Ecoregions and river system indicated within the subject property.

1.2 Project execution and scope

The aquatic assessment includes a survey of general habitat integrity, habitat conditions for aquatic macro-invertebrates as well as aquatic macro-invertebrate and fish community integrity. The protocols of applying the indices were strictly adhered to and all work was performed by a South African River Health Program (SA RHP) accredited assessor or under supervision of such an assessor.

Six aquatic ecological assessment points were identified which were used to define the Present Ecological State of the riverine features in the vicinity of the subject property. 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 three seasons, with assessments performed in autumn (April 2013), summer (February 2014) and winter (June 2015). Both the April 2013 and February 2014 assessments took place during strong rainfall which is likely to have affected the results obtained due to the flushing of the system at these times. Between all the data collected, both spatially and temporally an accurate assessment of the Pandana River was, however, obtained. The position of the reference site is presented in the table below (Table 1) and displayed in Figure 2.

Table 1: Co-ordinates of biomonitoring reference sites

Site	Description	Dates sampled	GPS co-ordinates	
			South	East
CK3	Most upstream reference site on the Pandana River.	February 2014	27°26'8.45"S	30°24'28.35"E
CK2	Site downstream of CK3 but upstream of CK1 on the Pandana River.	February 2014	27°25'23.56"S	30°24'47.68"E
CK1	Site downstream of CK2 but upstream of CK5 on the Pandana River.	April 2013 and February 2014	27°24'32.99"S	30°25'16.69"E
CK5	Site downstream of CK1 but upstream of CK6 on the Pandana River.	June 2015	27°24'41.58"S	30°25'50.08"E
CK6	Most downstream stream reference site on the Pandana River.	June 2015	27°23'59.22"S	30°28'35.30"E
CK4	Site on the Sibabe River outside the subject property, serving as an indication of aquatic resource status in the surrounding area.	February 2014	27°23'43.51"S	30°24'35.62"E

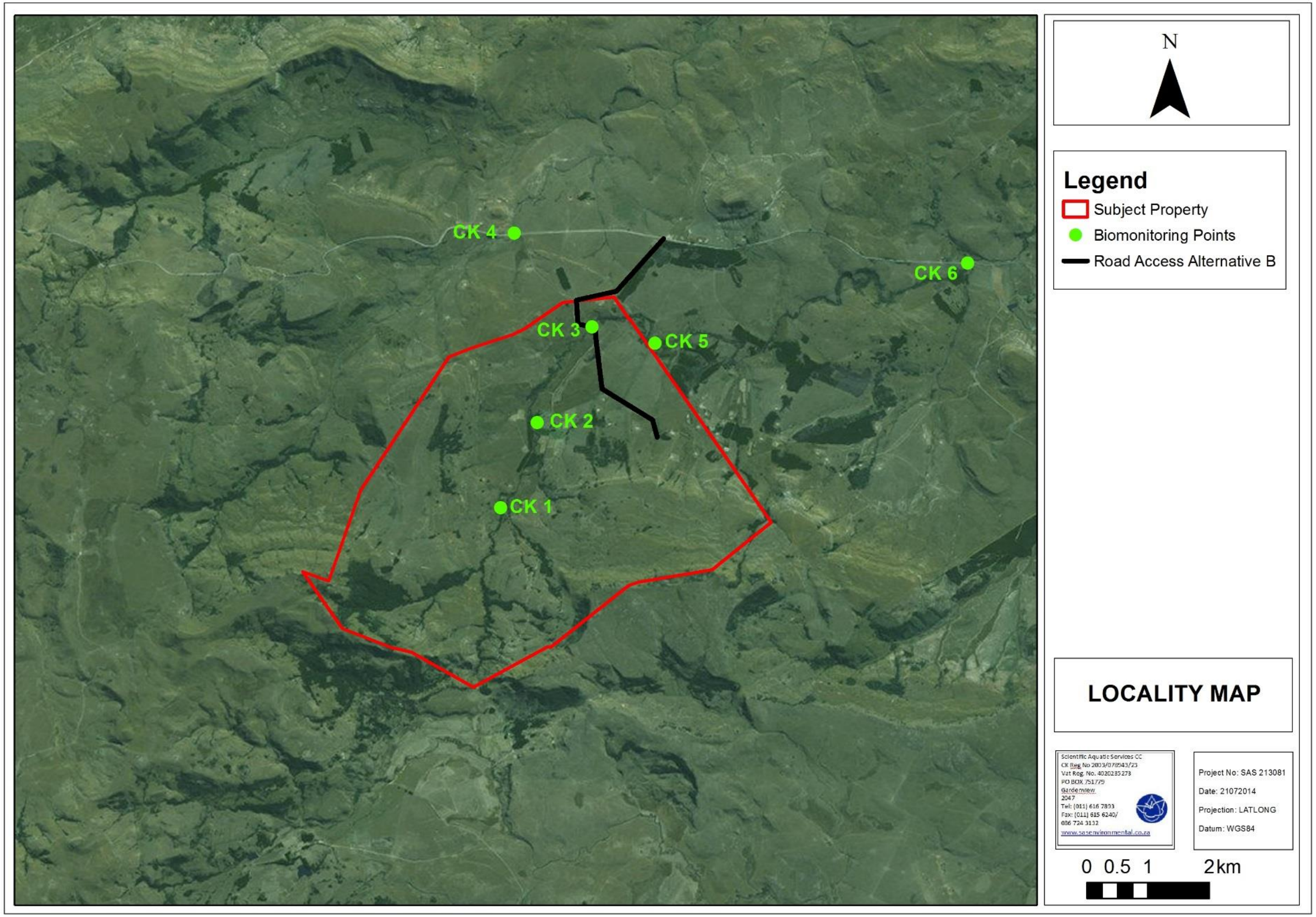


Figure 2: Aquatic ecological assessment points presented on a digital satellite image

1.3 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 aquatic resources associated with the subject property, prior to disturbance due to agricultural activities and impacts from alien vegetation, is limited to quaternary catchment and sub-quaternary catchment reach level data. For this reason, reference conditions are largely hypothetical, as based on professional judgement and/or inferred from limited data available. Based on the reference data available and based on the observations on site, the information available is, however, deemed adequate to provide the required level of understanding of the systems for the study;
- ***Temporal variability:*** The data presented in this report are based on three assessments performed in three different seasons: autumn (April 2013), summer (February 2014) and winter (June 2015). Furthermore only one site, CK1, was assessed on more than one occasion (2013 and 2014). The reason for this was due to changes in weather during both the 2013 and 2014 assessments when the Pandana River came down in spate. Temporal comparison is thus limited and largely precludes identification of seasonal trends. The spatial variation and long term variation in the ecological conditions and aquatic biota found in the streams are, therefore, largely unknown. Based on the reference data available and based on the observations on site the information available is, however, deemed adequate to provide the required level of understanding of the systems for the study;
- ***Ecological assessment timing:*** Aquatic 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 routine seasonal sampling, with sampling being undertaken on a quarterly basis to cover seasonal variability Based on the reference data available and based on the observations on site the information available is, however, deemed adequate to provide the required level of understanding of the systems for the study;
- ***Accessibility:*** The area is relatively remote within the subject property and this along with extensive overgrown areas along the Pandana River made access to sampling points limited. For this reason access to sampling sites was hampered and site localities were in some cases not ideal. Due to the limitations some aspects of the aquatic ecology of the area, some which may be important, may have been overlooked. Based on the reference data available and based on the observations on

site the information available is, however, deemed adequate to provide the required level of understanding of the systems for the study.

1.4 Legislative requirements

National Water Act (NWA; Act 36 of 1998)

- The NWA; Act 36 of 1998 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 watercourse unless it is authorised by the Department of Water and Sanitation (DWS) formerly (DWA and DWAF).

GN 704 – Regulations on use of water for mining and related activities aimed at the protection of water resources, 1999

- These Regulations, forming part of the NWA, were put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining.
- It is recommended that the proposed project complies with Regulation GN 704 of the NWA, 1998 (Act no. 36 of 1998) which contains regulations on use of water for mining and related activities aimed at the protection of water resources. GN 704 states that:

No person in control of a mine or activity may-

(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become waterlogged, undermined, unstable or cracked;

According to the above, the activity footprint must fall outside of the 1:100 year floodline of the drainage feature or 100m from the edge of the feature, whichever distance is the greatest.

National Environmental Management Act, 1998

- The National Environmental Management Act (Act 107 of 1998) and the associated Regulations (Listing No R. 544, No R. 545 and R. 546) as amended in June 2010, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment process or the Environmental Impact Assessment (EIA) process depending on the nature of the activity and scale of the impact.

National Environmental Management: Biodiversity Act (NEMBA) (Act No. 10 of 2004)

The objectives of this Act are (within the framework of NEMA) to provide for:

- the management and conservation of biological diversity within the Republic of South Africa and of the components of such diversity;
- the use of indigenous biological resources in a sustainable manner;
- the fair and equitable sharing among stakeholders of benefits arising from bio prospecting involving indigenous biological resources;
- to give effect to‘ ratified international agreements relating to biodiversity which are binding to the Republic;
- to provide for co-operative governance in biodiversity management and conservation; and
- to provide for a South African National Biodiversity Institute to assist in achieving the objectives of this Act.

This act alludes to the fact that management of biodiversity must take place to ensure that the biodiversity of surrounding areas are not negatively impacted upon, by any activity being undertaken, in order to ensure the fair and equitable sharing among stakeholders of benefits arising from indigenous biological resources.

The Protected Areas Act (Act No. 57 of 2003)

To provide for the protection and conservation of ecologically viable areas representative of South Africa’s biological diversity and its natural landscapes and seascapes; for the establishment of a national register of all national, provincial and local protected areas; for the management of those areas in accordance with national norms and standards; for intergovernmental co-operation and public consultation in matters concerning protected areas; and for matters in connection therewith.

This Act as alludes to the fact that the conservation status of all river types needs to be considered when any development is taking place to ensure that the adequate conservation of all vegetation types is ensured.

2. AQUATIC ECOLOGICAL DESCRIPTION

2.1 Ecoregion and water management area

When assessing the ecology of any area (aquatic or terrestrial), it is important to know which ecoregion the subject property is located within. This knowledge allows for improved interpretation of data to be made, since reference information and representative species lists are often available on this level of assessment, which aids in guiding the assessment.

The subject property assessment sites are situated within the Eastern Escarpment Mountains Ecoregion and are located within the W42A quaternary catchment (refer to Figure 1). Key attributes of this ecoregion are tabulated below.

Table 2: Key Attributes of the Eastern Escarpment Mountains Ecoregion (Source: A level 1 river ecoregional classification system for South Africa, Lesotho and Swaziland, DWAF 2005)

Main Attributes	Northern Escarpment Mountains
Terrain Morphology: Broad division (dominant types in bold) (Primary)	Plains; Moderate Relief; **Closed Hills; Mountains; Moderate and High Relief**
Vegetation types (dominant types in bold) (Primary)	**North Eastern Mountain Grassland;** Sour Lowveld Bushveld; Mixed Bushveld (limited) Patches of Afromontane Forest
Altitude (m a.m.s.l) (Secondary)	500-900 (limited) 900-2300
MAP (mm) (modifying)	500 to 1000
Coefficient of Variation (% of annual precipitation)	<20 to 35
Rainfall concentration index	50 to 65
Rainfall seasonality	Early to mid summer
Mean annual temp. (°C)	10 to 22
Mean daily max. temp. (°C): February	16 to 30
Mean daily max. temp. (°C): July	12 to 24
Mean daily min. temp. (°C): February	8 to 20
Mean daily min temp. (°C): July	0 to 8
Median annual simulated runoff (mm) for quaternary catchment	40 to >250

The project area also falls within the Usutu to Mhlatuze Water Management Area (WMA). The following information on this WMA has been gleaned from Appendix D of the National water resource strategy (DWAF 2004).

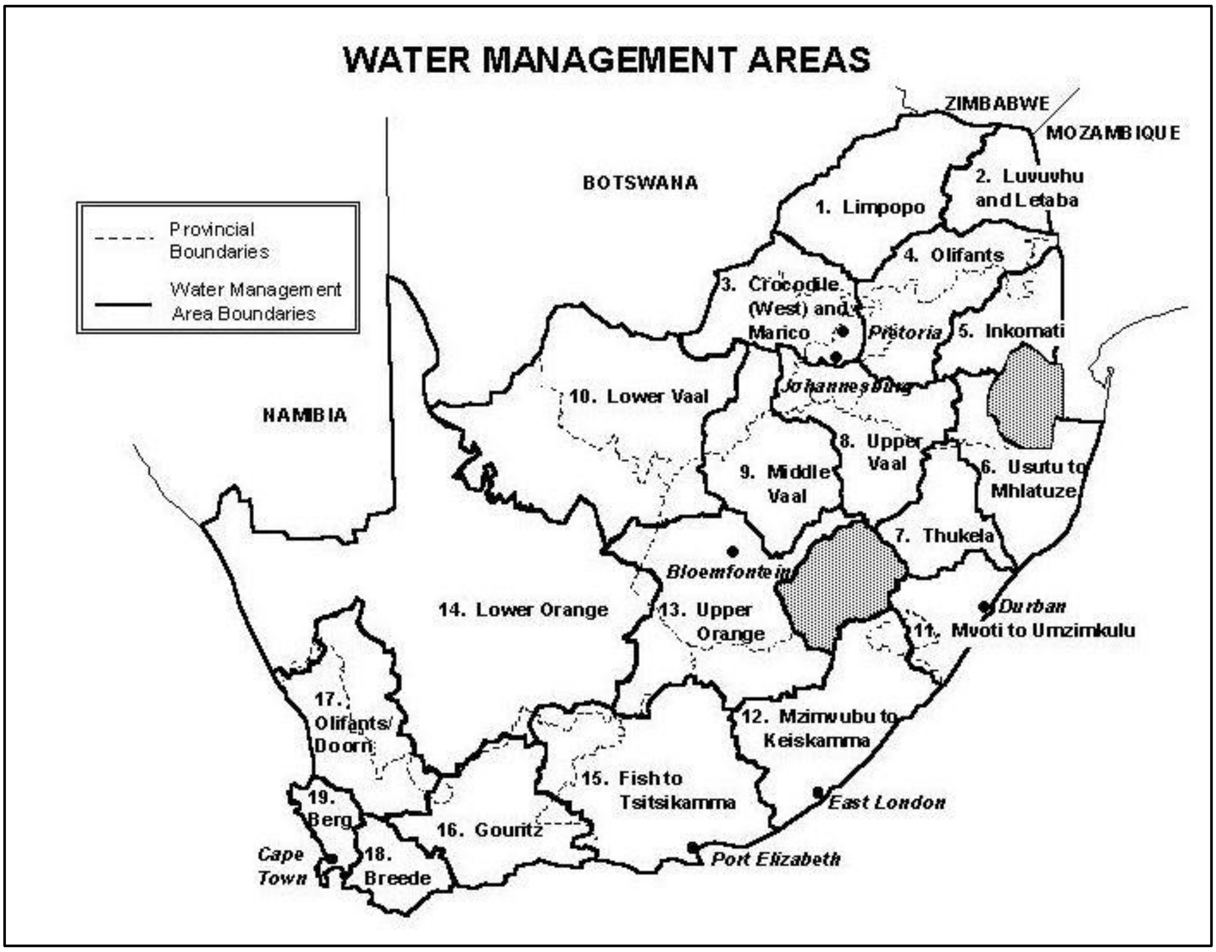


Figure 3: Map showing the position of the Water Management Areas (WMAs). In South Africa Source: http://www.africanwater.org/SAPolicyEnv_and_water.htm

The Usutu to Mhlatuze WMA falls predominantly within northern KwaZulu-Natal. However, a part of it extends into Mpumalanga and borders on Swaziland and Mozambique. Two rivers are shared with these countries, in that the Usutu River has its headwaters in South Africa but flows into Swaziland, whilst part of the Pongola River catchment also lies in the latter country. The two rivers confluence in South Africa to form the Maputo River just prior to entering Mozambique.

Climate in the region varies considerably, with sub-humid to humid conditions and mean annual rainfall ranging between 600 mm and 1500 mm. Economic activity is diverse and includes rain fed and subsistence farming, irrigation, afforestation and ecotourism.

Water resources have been well developed in the Upper Usutu, Mkuze and Mhlatuze catchments. However, undeveloped potential exists in the Pongola and Mfolozi catchments. Ground water utilisation in most parts of the water management area is relatively limited and can be developed further.

Strong interdependencies between surface and groundwater occur in many areas, with groundwater levels, together with surface flows, being particularly important to water balances in the ecologically sensitive coastal lakes and wetlands, some of which are internationally recognised conservation areas.

2.2 Ecostatus

2.2.1 Ecostatus classification

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 Table 3 and will be used as the basis of classification of the systems in this field and desktop study as well as future field studies.

Table 3: 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 4.

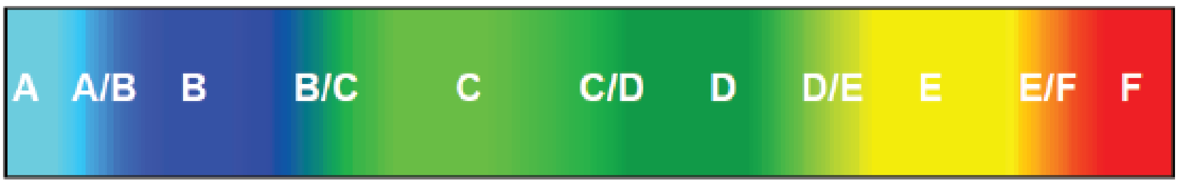


Figure 4: Ecological categories (EC) eco-status A to F continuum approach employed

2.2.2 Historical Quaternary catchment information (Kleynhans 1999)

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.

In order to define the EIS, PEMC and DEMC, a study undertaken by Kleynhans (1999) helped define the quaternary catchments of concern (W42A, refer to Figure 1).
The findings by Kleynhans (1999) are based on 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 Table 4.

Table 4: Quaternary catchment information.

Catchment	Province	Resource	EISC	DEMC	PESC	Best AEMC
W42A	KwaZulu-Natal	Pongolo	HIGH	B (Sensitive system, small risk allowed)	A (Unmodified, natural)	A (Unmodified, natural)

EISC = Ecological Importance and Sensitivity Category; DEMC = Default Ecological Management Class;
PESC = Present Ecological Status Category; Best AEMC = Best attainable Ecological Management Class.

W42A

According to the ecological importance classification for the quaternary catchment, the system can be classified as a *Highly Sensitive* system which, in its present state, can be considered a Class A (unmodified, natural) stream.

The points below summarise the impacts on the aquatic resources in the quaternary catchment W42A (Kleynhans 1999):

In terms of the **present ecological state** of the catchment, the following is applicable:

- The aquatic resources within this quaternary catchment are largely natural and approximates natural conditions;
- There are no discernible impacts with regard to bed modifications, flow modifications, inundation or impaired riparian zones and stream bank conditions, with the scoring guideline indicating natural, unmodified conditions. These impacts can thus be considered to be very low;
- Trout (*Oncorhynchus mykiss*) have been introduced to this catchment resulting in a low introduced instream biota impact. However, the scoring guideline still indicate largely natural conditions;
- The PESC (Present Ecological Status Category) awarded is Class A (Unmodified or approximates natural condition).

In terms of **ecological functions, importance and sensitivity**, the following points summarise the conditions in this catchment:

- The riverine systems in this catchment have a high diversity of habitat types which include rapids, riffles and mountain torrent riffles;
- The quaternary catchment has a very low importance in terms of conservation and natural areas;

- Species within the quaternary catchment have a high intolerance to changes in flow and flow related water quality, with special mention of *Chiloglanis anoterus* (pennant-tail suckermouth or rock catlet) and *Chiloglanis emarginatus* (Pongolo suckermouth or rock catlet);
- The quaternary catchment is regarded as having a very high importance for rare and endangered species conservation with special mention of *Chiloglanis emarginatus* (Pongolo suckermouth or rock catlet);
- The quaternary catchment is considered of high importance in terms of provision of migration routes for species in the instream and riparian environments, with specific reference to bird fauna;
- The quaternary catchment has a high importance in terms of providing refugia for aquatic community members within river channels;
- The quaternary catchment can be considered to have a high sensitivity to changes in water quality;
- The quaternary catchment can be considered to have a very high sensitivity to changes in water flow;
- The quaternary catchment is of very low importance in terms of species richness;
- The EISC (Ecological Importance and Sensitivity Category) is “High” and the DEMC (Default Ecological Management Class) classified as a B (Sensitive system).

2.2.3 Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database

The PES/EIS database, as developed by the DWS RQIS department, was utilised to obtain additional background information on the project area. The PES/EIS database has been made available to consultants since mid-August 2014. The information from this database is based on information at a sub-quaternary catchment reach (subquat reach) level with the descriptions of the aquatic ecology based on the information collated by the DWS RQIS department from all reliable sources of reliable information such as SA RHP sites, EWR sites and Hydro WMS sites. In this regard Information for the following sub-quaternary catchment reach (SQR) is applicable:

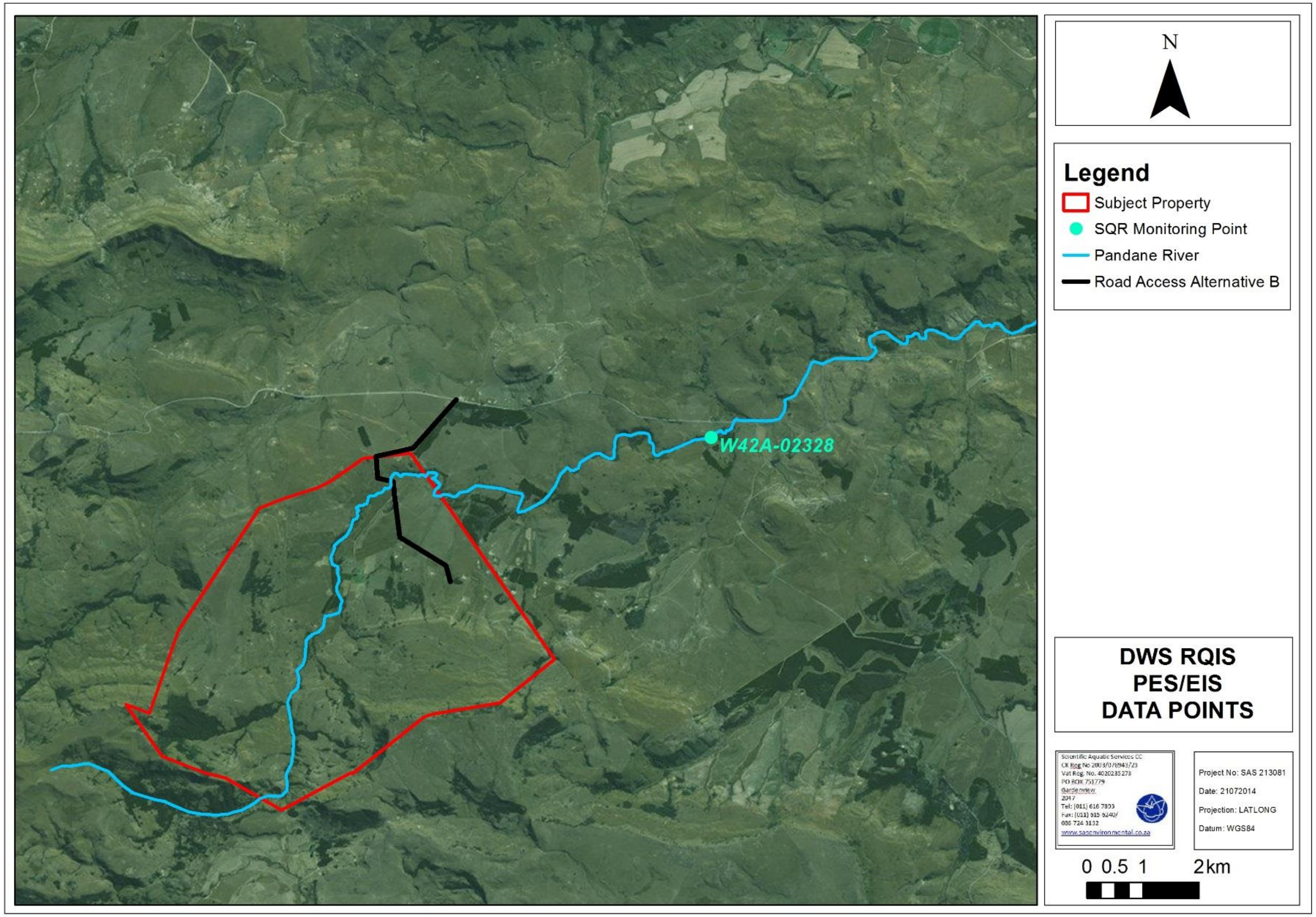


Figure 5: DWS RQIS PES/EIS data points associated with the subject property.

W42A-02328 Pandana

Note that sites CK1, CK2, CK3, CK5 and CK6 are located on the Pandana stream. Site CK4 is outside the subject property and is an additional reference along the Sibabe River. However, no SQR data point was available for the Sibabe River. The Pandana stream and Sibabe River both form tributaries of the Pongolo River.

Key information on background conditions within the subject property, as contained in this database and pertaining to the Present Ecological State (PES), ecological importance and ecological sensitivity for the various systems are tabulated in Table 5.

From the assessment of the PES/EIS data the following points are highlighted which summarise the data:

The Ecological Importance (EI) data for SQR W42A-02328 (Pandana River) indicate that the following fish species are expected to occur:

Anguilla mossambica Peters 1852
Amphilius natalensis Boulenger, 1917
Amphilius uranoscopus, (Pfeffer, 1889)
Barbus anoplus Weber, 1897
Barbus argenteus Günther, 1868
Chiloglanis anoterus Crass 1960
Chiloglanis emarginatus Jubb & le Roux, 1969
Clarias gariepinus (Burchell, 1822)
Labeobarbus marequensis Smith, 1841
Labeobarbus polylepis Boulenger, 1907
Pseudocrenilabrus philander (Weber, 1897)
Tilapia sparrmanii Smith, 1840
Varicorhinus nelspruitensis Gilchrist & Thompson, 1911

The Ecological Importance (EI) data for SQR W42A-02328 (Pandana River) indicate that the following macro-invertebrate species are expected to occur:

Aeshnidae	Gyrinidae	Oligochaeta
Ancylidae	Gomphidae	Oligoneuridae
Athericidae	Gerridae	Perlidae
Baetidae 2 spp.	Heptageniidae	Potamonautidae
Belostomatidae	Hirudinea	Pleidae
Chlorocyphidae	Hydracarina	Planorbinae
Chlorolestidae	Hydroptilidae	Philopotamidae
Caenidae	Hydrophilidae	Psephenidae
Coenagrionidae	Hydropsychidae 2 spp	Prosopistomatidae
Corixidae	Hydraenidae	Pyralidae
Ceratopogonidae	Haliplidae	Turbellaria
Chironomidae	Libellulidae	Tricorythidae
Culicidae	Lepidostomatidae	Tabanidae
Dytiscidae	Leptophlebiidae	Tipulidae
Dixidae	Lymnaeidae	Simuliidae
Ecnomidae	Leptoceridae	Sphaeriidae
Elmidae/Dryopidae	Lestidae	Veliidae/Mesoveliidae
Naucoridae	Notonectidae	Nepidae

Table 5: Summary of the ecological status of the sub-quaternary catchment (SQ) reach SQR W42A-02328 (Pandana River) based on the DWS RQIS PES/EIS database

<table>
<tr><th colspan="6">Synopsis (SQ reach W42A-02328 Pandana River)</th></tr>
<tr><th>PES[1] category median</th><th>Mean EI[2] class</th><th>Mean ES[3] class</th><th>Length</th><th>Stream order</th><th>Default EC[4]</th></tr>
<tr><td>C</td><td>High</td><td>Very high</td><td>0.14</td><td>1</td><td>A</td></tr>
<tr><th colspan="6">PES details</th></tr>
<tr><td colspan="2">Instream habitat continuity MOD</td><td>Moderate</td><td colspan="2">Riparian/wetland zone MOD</td><td>Moderate</td></tr>
<tr><td colspan="2">RIP/wetland zone continuity MOD</td><td>Large</td><td colspan="2">Potential flow MOD activities</td><td>Large</td></tr>
<tr><td colspan="2">Potential instream habitat MOD activities</td><td>Small</td><td colspan="2">Potential physico-chemical MOD activities</td><td>Small</td></tr>
<tr><th colspan="6">EI details</th></tr>
<tr><td colspan="2">Fish spp/SQ</td><td>13</td><td colspan="2">Fish average confidence</td><td>3.92</td></tr>
<tr><td colspan="2">Fish representivity per secondary class</td><td>Low</td><td colspan="2">Fish rarity per secondary class</td><td>High</td></tr>
<tr><td colspan="2">Invertebrate taxa/SQ</td><td>54</td><td colspan="2">Invertebrate average confidence</td><td>3.00</td></tr>
<tr><td colspan="2">Invertebrate representivity per secondary class</td><td>Low</td><td colspan="2">Invertebrate rarity per secondary class</td><td>Very high</td></tr>
<tr><td colspan="2">EI importance: riparian-wetland-instream vertebrates (excluding fish) rating</td><td>Not available</td><td colspan="2">Habitat diversity class</td><td>High</td></tr>
<tr><td colspan="2">Habitat size (length) class</td><td>Very low</td><td colspan="2">Instream migration link class</td><td>High</td></tr>
<tr><td colspan="2">Riparian-wetland zone migration link</td><td>Moderate</td><td colspan="2">Riparian-wetland zone habitat integrity class</td><td>High</td></tr>
<tr><td colspan="2">Instream habitat integrity class</td><td>Very high</td><td colspan="2">Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m</td><td>High</td></tr>
<tr><td colspan="5">Riparian-wetland natural vegetation rating based on expert rating</td><td>High</td></tr>
<tr><th colspan="6">ES details</th></tr>
<tr><td colspan="2">Fish physical-chemical sensitivity description</td><td>Very high</td><td colspan="2">Fish no-flow sensitivity</td><td>Very high</td></tr>
<tr><td colspan="2">Invertebrates physical-chemical sensitivity description</td><td>Very high</td><td colspan="2">Invertebrates velocity sensitivity</td><td>Very high</td></tr>
<tr><td colspan="5">Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description</td><td>Low</td></tr>
<tr><td colspan="5">Stream size sensitivity to modified flow/water level changes description</td><td>Low</td></tr>
<tr><td colspan="5">Riparian-wetland vegetation intolerance to water level changes description</td><td>High</td></tr>
</table>

[1] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;
[2] EI = Ecological Importance;
[3] ES = Ecological Sensitivity
[4] EC = Ecological Category; default based on median PES and highest of EI or ES means.

The **Present Ecological State (PES)** of the Pandana River (SQR W42A-02328) is categorised as Class C: Moderately modified.

- The potential instream habitat modification and the potential physico-chemical modification levels have a small impact rating, meaning that the modifications are only present at a small number of localities and the impact on the habitat quality, diversity, size and variability are also very small;
- The riparian/wetland zone modification and instream habitat continuity modification have a moderate impact rating, meaning that the modifications are only present at a small number of localities and the impact on the habitat quality, diversity, size and variability are limited;
- ,The riparian/wetland zone habitat continuity modification has and potential instream flow modification have a large impact rating, meaning that the modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability limited to a few localities and the impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced;

The **Ecological Importance (EI)** is considered high.

- The number of fish species estimated per sub quaternary reach is 13;
- The fish representivity per secondary class (FREP) is considered low;
- The fish rarity per secondary class (IRAR) is considered high;
- The Ecological Importance of the riparian-wetland-instream vertebrates (excluding fish) rating is not available;
- The riparian-wetland natural vegetation importance, which is based on the percentage of natural vegetation within 500m is considered high;
- The riparian-wetland natural vegetation importance based on expert rating is considered high;
- The number of invertebrate taxa per sub quaternary reach is 54;
- The invertebrate representivity per secondary class (IREP) is considered low;
- The invertebrate rarity per secondary class (IRAR) is considered very high;
- The habitat diversity class is considered high;
- The habitat size (Length) class is considered very low;
- The instream migration link class is high;
- The riparian-wetland zone migration link is moderate;
- The riparian-wetland zone habitat integrity class is high;
- The instream habitat integrity class is very high.

The **Ecological Sensitivity (ES)** is considered very high.

- Both the fish and invertebrate physico-chemical sensitivity descriptions are very high. Fish and macro-invertebrate species are thus intolerant, with species being able to survive and breed only under largely unmodified physico-chemical conditions;
- The fish no-flow sensitivity description and invertebrate velocity sensitivity description is very high These species require flow during all phases of the life cycle for breeding purposes. Generally fast flows and clear water conditions are required;
- The riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description is low, meaning that with a low sensitivity to water level or flow are expected to occur. Suitable water level and flow will benefit such taxa but they do not have a crucial dependence on such conditions.
- The stream size sensitivity to modified flow/water level changes description is low;
- The riparian-wetland vegetation intolerance to water level changes is high;

2.2.4 SANBI Wetland Inventory and NFEPA databases

The SANBI Wetland Inventory (2006) and National Freshwater Ecosystem Priority Areas (NFEPA) (2011) databases were consulted to define the aquatic ecology of the wetland or river systems close to or within the subject property and 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 Usuthu to Mhlathuze Water Management Area (WMA). Each Water Management Area is divided into several sub-Water Management Areas (subWMA), 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 Pongola sub-WMA.
- The north western border of the subject property falls within a Fish Fresh Water Ecosystem Priority Area (FISHFEPA) (Figure 6). River FEPAs achieve biodiversity targets for river ecosystems and threatened fish species, and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicates that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources.
- The remainder of the subject property falls within a Fish Support Area (FSA) (Figure 6) which is regarded important in terms of a fish sanctuary for threatened fish species.
- The Pandana River runs through the centre of the subject property from the south to the north.
- The Pandana River is a perennial river classified as a Class A (unmodified, natural) river. It is not free flowing and is not classified as a flagship river.

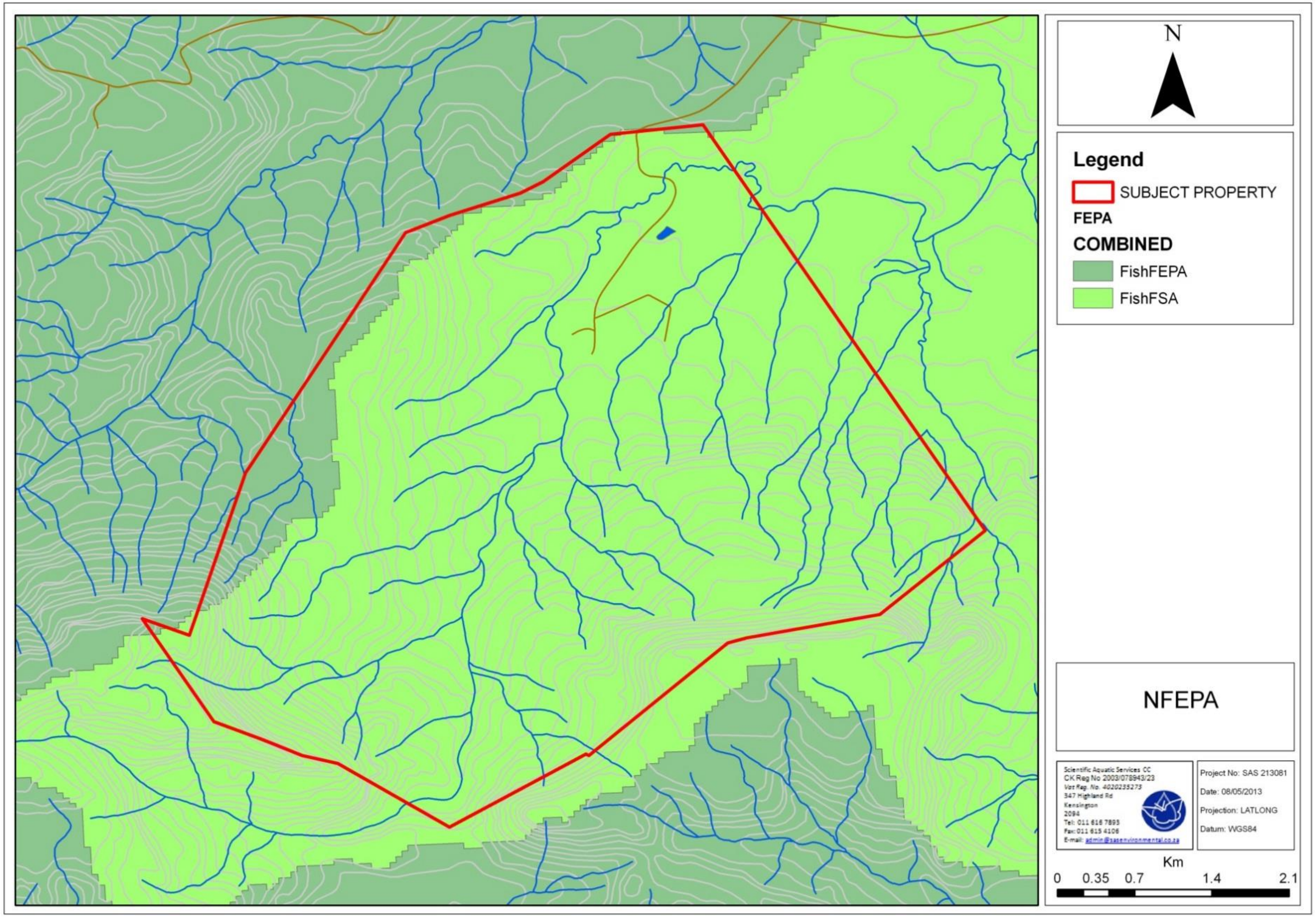


Figure 6: Fish FEPAs and Fish FSAs associated with the subject property.

2.2.5 The Kwa-Zulu Natal Freshwater Systematic Conservation Plan (2007)

The Kwa-Zulu Natal Freshwater Systematic Conservation Plan (2007) was consulted in order to determine whether any freshwater conservation areas will be affected by the proposed mining development. According to the database, the subject property falls within a freshwater catchment earmarked for conservation. Areas earmarked for conservation are optimal biodiversity areas required to meet biodiversity targets.

3. METHOD OF INVESTIGATION

The assessment of the PES of the system, as well as possible impacts due to the proposed development, was based on comparisons between observed conditions and the theoretical reference conditions based on desktop information reviews, and from historical data for the area from the Department of Water and Sanitation Resource Quality Information Services (RQIS), which presents data available on a sub-quaternary catchment reach level and with some filed, verified background information available.

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.

3.1 Visual Assessment

The assessment sites were investigated in order to identify visible impacts, with specific reference to impacts from surrounding activities and any effects resulting from activities occurring upstream in the catchment. Both natural constraints placed on ecosystem structure and functions, 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 and pollution of the area and
- Other life forms reliant on aquatic ecosystems.

3.2 Physico Chemical Water Quality Data

On site testing of biota specific water quality variables took place. Parameters measured include pH, electrical conductivity, dissolved oxygen concentration and temperature.

The results of both on-site biota specific as well as water quality analyses during toxicity testing were considered to aid in the interpretation of the data obtained in the aquatic ecological assessment. Results are discussed against the DWS (formerly DAFF) guideline water quality values for aquatic ecosystems (DWAF 1996 vol. 7).

In addition the dissolved oxygen concentration was compared to known levels of saturation at specific temperatures, as tabulated by the United States Environmental Protection Agency (US EPA, http://water.epa.gov/type/rsl/monitoring/vms52.cfm), in order to determine the percentage saturation level at the time of sampling.

3.3 Riparian Vegetation Response Assessment Index (VEGRAI)

The Riparian Vegetation Response Assessment Index (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.

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.

Table 6: 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 essentially unchanged.	80-89
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

3.4 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.

3.5 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 (IHIA) for (Kemper, 1999). The IHIA protocol, as described by Kemper (1999), should be used for site specific assessments. 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 7: 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

3.6 Aquatic Macro-Invertebrates: South African Scoring System (SASS5)

Aquatic Macro-invertebrates were sampled using the qualitative kick sampling method called SASS5 (South African Scoring System version 5) (Dickens & 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 (1998). The assessment was undertaken according to the protocol as defined by Dickens & 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 & Day, 1998; Dickens & Graham, 2001; Gerber & 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 (Figure 7). Reference conditions are stated as a SASS score of 190 and an ASPT score of 7. Sites were classified according to the classification system for the Eastern Escarpment Mountains aquatic ecoregion according to Dallas (2007), as well as the classification system of Dickens & Graham 2001.

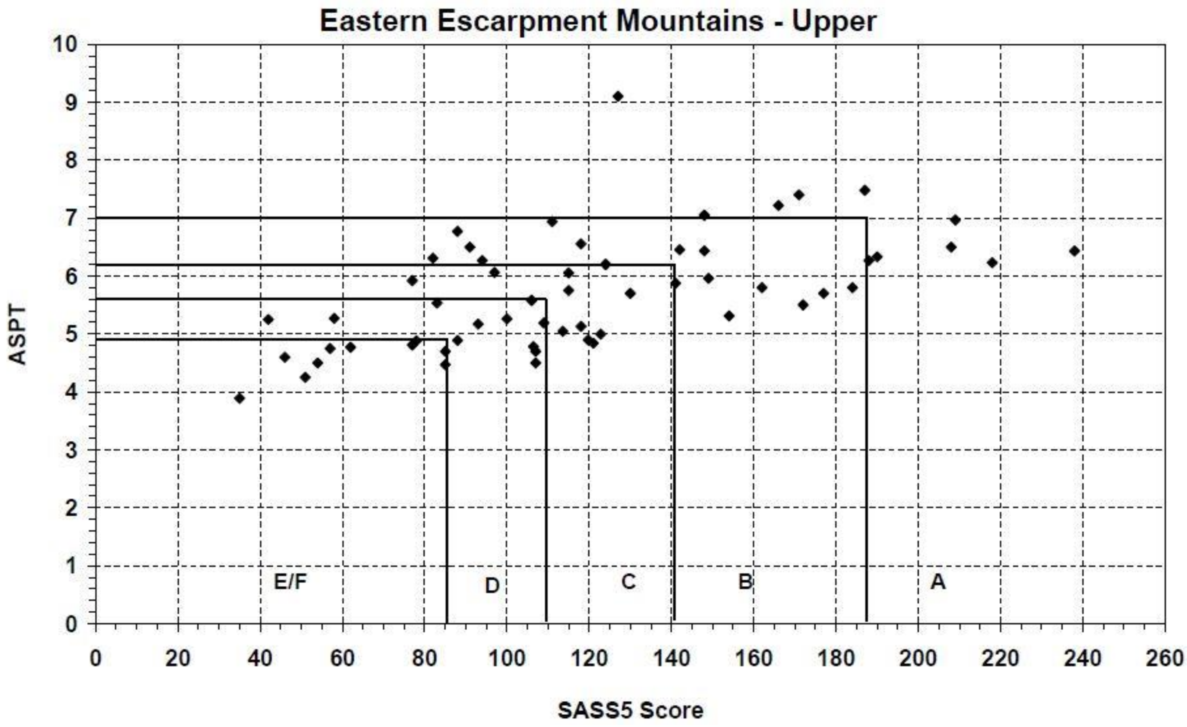


Figure 7: SASS5 Classification using biological bands calculated form percentiles for the Eastern Escarpment Mountains ecoregion, Dallas, 2007

Table 8: Definition of Present State Classes in terms of SASS scores as presented in Dickens & 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

3.7 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 sites FM1 and FM2 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).

3.8 Fish biota: Habitat Cover Rating (HCR)

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

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

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

0 = Absent

1 = Rare (<5%)

2 = Sparse (5-25%)

3 = Moderate (25-75%)

4 = Extensive (>75%)

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

- Overhanging vegetation
- Undercut banks and root wads

- Stream substrate
- Aquatic macrophytes

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

0 = absent

1 = Rare/very poor (<5%)

2 = Sparse/poor (5-25%)

3 = Moderate/good (25-75%)

4 = Extensive/excellent (>75%)

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

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

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

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

Fish species identified were compared to those expected to be present at the site, which were compiled from a literature survey including the DWS RQIS PES/EIS database and Skelton (2001). Fish sampling was performed by means of a fixed generator driven electro-fishing device.

3.9 Fish biota: Fish Response Assessment Index (FRAI)

The FRAI (Kleynhans 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 9.

Table 9: Intolerance ratings for naturally occurring indigenous fish species with natural ranges included in the subject property (Kleynhans, 2002; Skelton, 2001; Kleynhans et al, 2007, DWS RQIS PES/EIS database).

SPECIES NAME	COMMON NAME	INTOLERANCE RATING	FROC score	COMMENTS
Amphilius natalensis	Natal mountain catfish	4.9	1	Escarpment streams from the Eastern Highlands of Zimbabwe (lower Zambezi) to KwaZulu-Nata Drakensberg (Umkomaas system).
Anguilla mossambica	*Longfin eel*	*2.8*	2	East coast rivers from Kenya south to Cape Agulhas, also Madagascar and adjacent islands
Amphilius uranoscopus	*Stargazer (mountain catfish)*	4.8	2	Okovango and Zambezi systems, east coast rivers south to Mkuze in northern Kwa-Zulu Natal
Barbus anoplus	Chubbyhead Barb	2.6	2	Widely distributed from Highveld, Limpopo to upland KwaZulu-Natal, Transkei and the Orange Basin including the Karoo.
Barbus argenteus	Rosefin barb	4.2	1	Escarpment streams of Incomati and Phongolo systems.
Barbus unitaeniatus	Longbeard barb	1.7	2	Widely distributed in southern Africa
Chiloglanis anoterus	Pennant-tailed suckermouth	4.8	2	Endemic to escarpment streams of Incomati and Phongolo systems.
Chiloglanis emarginatus	Phongolo suckermouth	5.0	2	Tributaries of the Incomati and Phongolo Rivers. Also in the Pungwe as well as middle and lower Zambezi Rivers.
Clarias gariepinus	Sharptooth Catfish	1.4	1	Widespread throughout southern Africa.
Labeo cylindricus	Redeye labeo	3.1	1	Widespread East-African rivers down to Phongolo system in KwaZulu-Natal
Labeo molybdinus	Leaden labeo	3.2	1	Middle and lower Zambezi down to Tugela system in KwaZulu-Natal
Labeobarbus marequensis	Largescale yellowfish	2.6	2	Widely distributed from the middle and lower Zambezi south to the Phongolo system.
Labeobarbys polylepis	Smallscale yellowfish	3.1	2	Restricted to the southern tributaries of the Limpopo and the Incomati and Phongolo systems.
Pseudocrenilabrus philander	Southern mouthbrooder	1.3	1	From the Orange and southern KwaZulu-Natal northwards throughout the region. Extends to southern Congo tributaries and Lake Malawi.
Tilapia sparrmanii	Banded Tilapia	1.3	1	Extensively translocated south of the Orange in the Cape.
Varicorhinus nelspruitensis	Incomati chiselmouth	3.1	1	Escarpment streams of Incomati and Phongolo systems.

Intolerance ratings: Tolerant: 1-2; Moderately tolerant :> 2-3; Moderately Intolerant: >3-4;Intolerant: >4

Frequency of occurrence (FROC) score not listed for W42A in Kleynhans *et al.* 2007. However, it was listed for W42D (Pongolo) and these were adopted for the purposes of this report. Where FROC scores were not available, a score of 1 was allocated.

The expected species list was compiled using the Department of Water and Sanitation (DWS) Resource Quality Services (RQS) PES/EIS database, as listed for the Pandana and Pongolo Rivers, as well as from distribution maps in Skelton (2001).

3.10 Ecological Importance and Sensitivity Assessment

The EIS method considers a number of biotic and habitat determinants surmised to indicate either importance or sensitivity. The determinants are rated according to a four-point scale specific to each element. The median of the resultant score is calculated to derive the EIS category (Table 10).

Table 10: Ecological importance and sensitivity categories (DWAF, 1999a)

EISC	General Description	Range of median
Very high	Quaternaries/delineations that are considered to be unique on a national and international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3-4
High	Quaternaries/delineations that are considered to be unique on a national scale based on their biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases may have substantial capacity for use.	>2-≤3
Moderate	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.	>1-≤2
Low/ marginal	Quaternaries/delineations that are not unique on any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

4. RESULTS AND INTERPRETATION

The sections below describe the results obtained for the aquatic ecological integrity of the various sites based on water quality, instream and riparian habitat condition and biological impacts and integrity. Consideration was given to the position of the aquatic site selection in order to assist in defining the PES and any impacts in this area. The six aquatic assessment sites results are presented below and cover the aquatic resources in the vicinity of the subject property.

Please note that sites CK3, CK2, CK1, CK5 and CK6 (upstream to downstream order) are located on the Pandana River. Site CK4 is located on the Sibabe River. However, for ease of discussion all sites assessed will be discussed together in the same sections.

4.1 Visual assessment

A photographic record of each assessment site was captured in order to provide visual record of condition, as observed during the field assessments. The photographs taken at the six sites are presented below. These are representative of general conditions encountered during field site visits. The table below summarises the observations for the various criteria made during the visual assessment undertaken at the respective sites.

Figure 8: Upstream view of the CK1 site indicating the flow of clear water at the site (February 2014)

Figure 9: Downstream view of the CK1 site (February 2014)

Figure 10: Upstream view of the CK2 site indicating the severe bank erosion and invasion by *Acacia mearnsi* at this point (February 2014)

Figure 11: Downstream view of the CK2 site indicating the informal low water crossing at this point (February 2014)

Figure 12: Upstream view of the CK3 site indicating strong flows at the time of assessment (February 2014)

Figure 13: Downstream view of the CK3 site with excellent rocky habitat (February 2014)

Figure 14: Upstream view of the CK4 site indicating the rocky substrate and diversity of flow in the system (February 2014)

Figure 15: Downstream view of the CK4 site (February 2014)

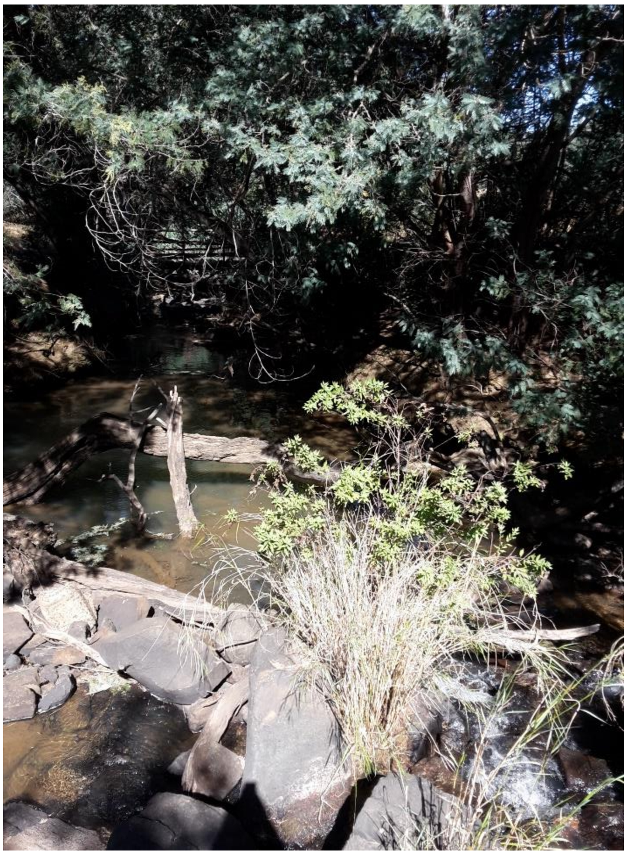
 **Figure 16: Upstream view of the CK5 site indicating the slow flow at this point at the time of assessment (June 2015)**	 **Figure 17: Downstream view of the CK5 site showing severe invasion by *Acacia mearnsii* (June 2015)**
 **Figure 18: Upstream view of the CK5 site at the point where velocity metering took place**	 **Figure 19: Downstream view of the CK5 site at the point in September 2015**

	
Figure 20: Upstream view of the CK6 site indicating the very low flows at the time of assessment (June 2015)	**Figure 21: Downstream view of the CK6 site with invasion by *Acacia mearnsii* (June 2015)**

Table 11: Description of the location of the assessment sites in the subject property

SITE	CK1	CK2	CK3	CK4	CK5	CK6
Location of site and significance	This site is upstream of site CK5 but downstream of Site CK2 on the Pandana River system and allows for additional baseline information on the system to be gathered in order to define the PES and EIS of the system.	This site is upstream of site CK1 but downstream of Site CK3 on the Pandana River system and allows for additional baseline information on the system to be gathered in order to define the PES and EIS of the system.	This site is the most upstream point assessed on the Pandana River system. Results from this site will be used a reference for other sites on the Pandana River.	The site is located on the Sibabe River. The data gathered serves as temporal baseline data prior to any proposed mining taking place in order to define the ecology of the river system	This site is in the lower areas of the Pandana River system and allows for additional baseline information on the system to be gathered in order to define the PES and EIS of the system. It is located downstream of CK1 but upstream of CK6.	This site is the most downstream point on the Pandana River system and will indicate any impacts from all upstream activities in the future. The data gathered serves as temporal baseline data prior to any proposed mining taking place.
Riparian zone characteristics	The riparian zone is fairly narrow. Severe impact from alien vegetation (*Acacia* mearnsii) encroachment has occurred. The riparian vegetation is in a poor condition.			Good levels of riparian vegetation cover were present and limited invasion by alien vegetation was observed	The riparian zone is fairly narrow. Severe impact from alien vegetation (*Acacia* mearnsii) encroachment has occurred. The riparian vegetation is in a poor condition.	
Algal presence	No algal growth was observed					
Visual indication of an impact on aquatic fauna	The most significant impact at the current time is due to impacts associated with alien vegetation which affect the levels of sunlight reaching the system and the amount of detritus in the system. The system is also affected by low level crossings.		The most significant impact at the current time is due to impacts associated with alien vegetation which affect the levels of sunlight reaching the system and the amount of detritus in the system.	The system has seen limited impact and limited impact in the instream community is deemed likely	The most significant impact at the current time is due to impacts associated with alien vegetation which affect the levels of sunlight reaching the system and the amount of detritus in the system. The system is also affected by low level crossings.	The most significant impact at the current time is due to impacts associated with alien vegetation which affect the levels of sunlight reaching the system and the amount of detritus in the system.
Depth characteristics	The system was generally shallow but some diversity in depth was present.	The system was generally shallow but some diversity in depth was present.	The point had a wide variety of depth classes from deep pools to very shallow runs and glides	The system was generally shallow but some diversity in depth was present.	The point had a wide variety of depth classes from deep pools to very shallow runs and glides	The system was generally shallow at this point with small deeper pools present
Flow condition	There was a good diversity of flow which will support a high diversity of aquatic biota	There was a good diversity of flow which will support a high diversity of aquatic biota	There was a good diversity of flow which will support a high diversity of aquatic biota	There was a good diversity of flow which will support a high diversity of aquatic biota	Flow was mostly slow which may limit the diversity of the aquatic community to some degree.	Flow was mostly slow which may limit the diversity of the aquatic community to some degree.

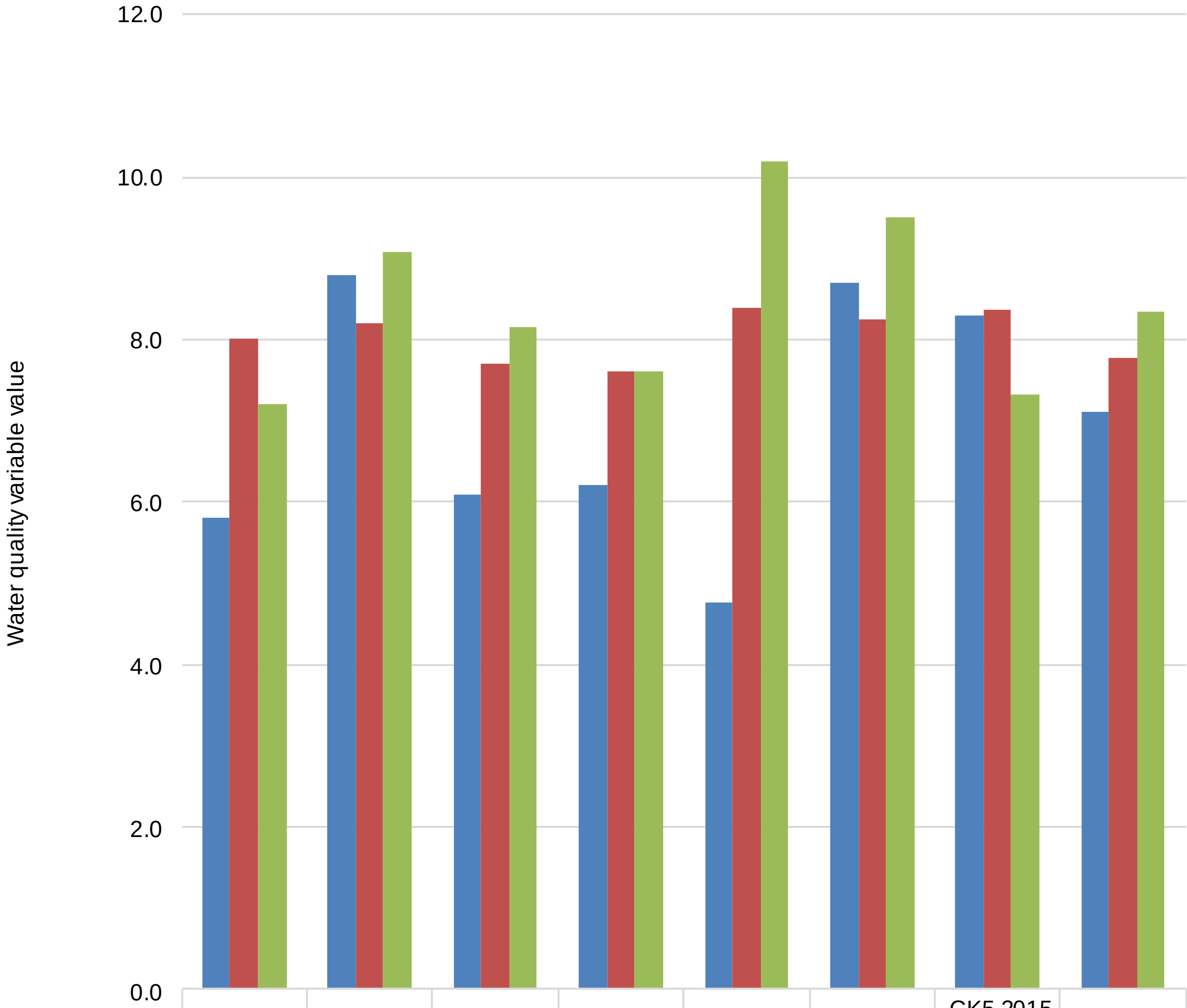
SITE	CK1	CK2	CK3	CK4	CK5	CK6
Water clarity	Some discoloration due to recent rains was evident	Some discoloration due to recent rains was evident	Some discoloration due to recent rains was evident	Water was clear	Water was relatively clear	Water was clear
Water odour	None	None	None	None	None	None
Erosion potential	Under high flow conditions the system will erode rapidly due to the fast flow of the water and the unstable steep banks of the river.		Limited bank instability is evident at this point.	Banks are stable and well vegetated.	Under high flow conditions the system will erode rapidly due to the fast flow of the water and the unstable steep banks of the river.	Limited bank instability is evident at this point but some erosion of stream banks in high flows is likely.

4.2 Physico-Chemical Water Quality

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

Table 12: Biota specific water quality data along the Pandana (CK3, CK2, CK1, CK5 and CK6 from upstream to downstream position) and Sibabe (CK4) Rivers.

SITE	COND mS/m	pH	TEMP °C	DO mg/l
CK4 2014	5.8	8.01	7.20	24.1
CK3 2014	8.8	8.20	9.07	15.2
CK2 2014	6.1	7.70	8.15	18.4
CK1 2014	6.2	7.60	7.60	20.6
CK1 2013	8.6	8.40	10.2	18.2
CK5 2015	8.7	8.24	9.50	9.4
CK5 2015	8.3	8.36	16.1	7.31
CK6 2015	7.1	7.78	8.35	11.5



	CK4 2014	CK3 2014	CK2 2014	CK1 2014	CK1 2013	CK5 2015	CK5 2015 (Sept)	CK6 2015
Cond (mS/m)	5.8	8.8	6.1	6.2	4.8	8.7	8.3	7.1
pH	8.01	8.20	7.70	7.60	8.40	8.24	8.36	7.78
DO (mg/L)	7.20	9.07	8.15	7.60	10.20	9.50	7.31	8.35

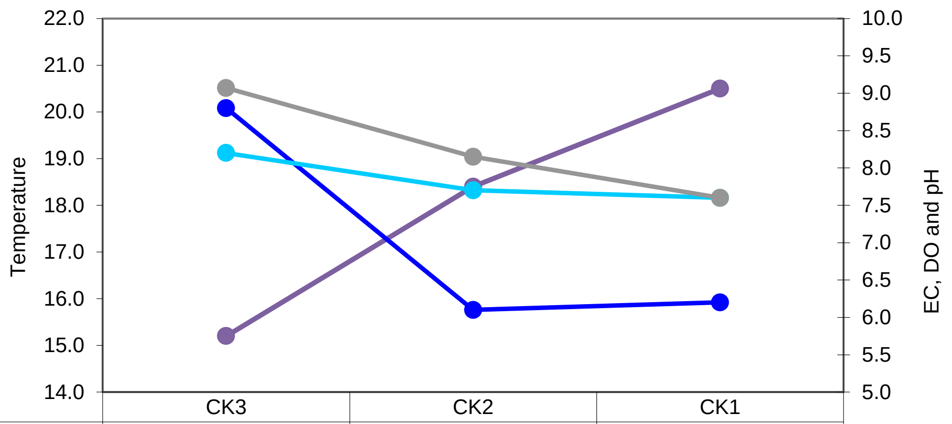
Figure 22: Graphic depiction of water quality criteria for all assessment sites along the Pandana (CK3, CK2, CK1, CK5 and CK6 from upstream to downstream position) and Sibabe (CK4) Rivers as measured during all assessments

- General water quality can be considered largely natural, as indicated by the low EC concentrations recorded from all sites. All sites also presented with similar pH values and DO concentrations. Trends will be further discussed with reference to the specific assessment periods.

Pandana River April 2013 (Site CK1)

- Results will be discussed in terms of temporal comparisons with the February 2014 assessments in the points that follow.

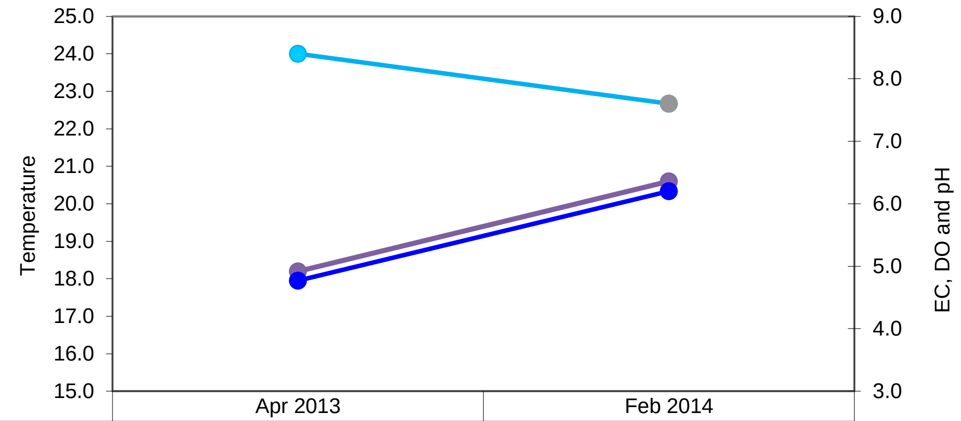
Pandana River February 2014 (Sites CK1, CK2 and CK3)



	CK3	CK2	CK1
Temp °C	15.2	18.4	20.5
Cond (ms/m)	8.8	6.1	6.2
pH	8.20	7.70	7.60
DO (mg/L)	9.07	8.15	7.60

Figure 23: Graphic depiction of water quality criteria as measured in February 2014 at sites CK1, CK2 and CK3 on the Pandana River

- The water quality guideline for aquatic ecosystems (DWAF 1996) states that: 1) Total dissolved salts (TDS) concentrations (i.e. as indicated by the EC measurements) should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and 2) the amplitude and frequency of natural cycles in TDS concentrations should not be changed;
- From a spatial perspective, EC decreased by 30.7% and 29.5% in a downstream direction between sites CK3 and CK2 and CK3 and CK1, respectively. Whilst these changes do not comply with the guideline recommendation, it is considered a positive change with no additional salts being added to the system at the current time. The variation observed also indicates a significant degree of variability in basic water chemistry in the system. Between sites CK2 and CK1 EC increased by 1.6%. The change complies with the guideline recommendation;
- The absolute value of dissolved salts in the system is very low and dissolved concentrations in the system can still be considered largely natural.



	Apr 2013	Feb 2014
Temp °C	18.2	20.6
Cond (ms/m)	4.8	6.2
pH	8.40	7.60
DO (mg/L)		7.60

Figure 24: Graphic depiction of water quality criteria temporal comparison as measured in April 2013 and February 2014 at site CK1 on the Pandana River

- From a temporal perspective at site CK1, EC increased by 30% between April 2013 and February 2014. Whilst this change does not comply with the guideline recommendation, the absolute value at site CK1 in February 2015 is below 7 mS/m and can still be considered largely natural. However, should further biological monitoring be performed in this area, this trend needs to be closely monitored;
- Given the unimpacted state of the environment, dissolved salts present in the system correlates with perceived natural conditions. Thus EC are not expected to have a negative impact on the aquatic community;
- The pH is largely neutral (sites CK1 and CK2) to slightly alkaline (site CK3) but can be regarded as suitable for supporting a diverse and sensitive aquatic community;
- The water quality guideline for aquatic ecosystems (DWA 1996) states that pH values should not be allowed to vary from the range of the background pH values for a specific site by > 5 %;
- From a spatial perspective, pH decreased by 6.1% and 7.3% in a downstream direction between sites CK3 and CK2 and CK3 and CK1, respectively. Whilst these changes do not comply with the guideline recommendation, it is considered a positive change towards more neutral conditions. The variation observed also indicates a significant degree of variability in basic water chemistry in the system. Between sites CK2 and CK1 EC increased by 1.6%. The change complies with the guideline recommendation;
- As for EC, historical baseline data is not available for comparison. However, from a temporal perspective, pH at site CK1 decreased by 9.5% between April 2013 and June 2014 surveys.
- Whilst this change does not comply with the guideline recommendation, it is

considered a positive change towards more neutral conditions. The variation observed also indicates a significant degree of variability in basic water chemistry in the system;

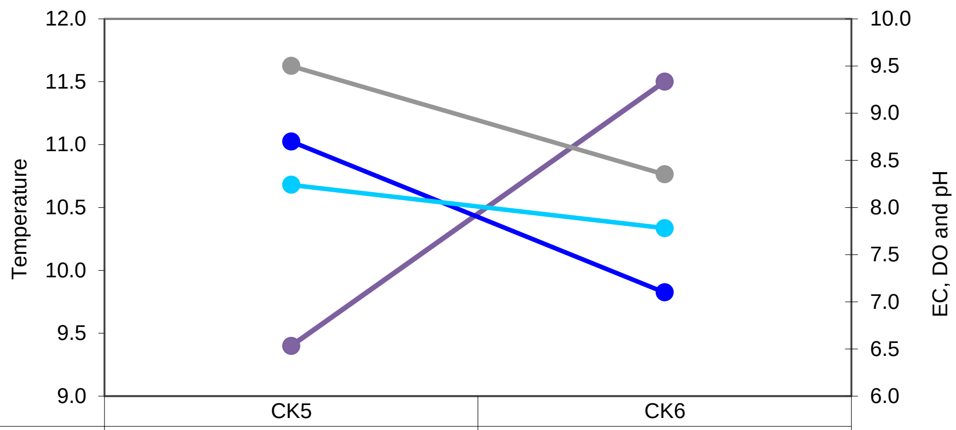
- The DO percentage of saturation during February 2014 was within the desired 80% to 120% range for aquatic ecosystems (DWAF, 1996) at all sites. DO can thus be regarded as suitable for supporting a diverse and sensitive aquatic community (Table 13). DO was not measured at site CK1 during April 2013. The variation observed during the February 2014 assessment can be attributed to natural variation between sampling times.

Table 13: Oxygen measured expressed as percentage of maximum for the sites CK1 to CK3 as assessed in February 2014

SITE	DO mg/l	TEMP °C	Maximum oxygen at that temperature (mg/L)	Oxygen measured expressed as percentage of maximum
CK3 2014	9.07	15.2	10.07	90.07
CK2 2014	8.15	18.4	9.45	86.24
CK1 2014	7.60	20.6	8.90	85.39
CK1 2013	Not measured	18.2	9.45	Not applicable

- Temperatures can be regarded as normal for the time of year and time of day when assessment took place.
- Limited temporal comparison (site CK1 only) indicate that, water quality parameters assessed during April 2013 and February 2014 remained largely the same. It can be deduced that current agricultural and other anthropogenic activities (rural settlements) have little negative impact on water quality.

Pandana River June 2015



	CK5	CK6
Temp °C	9.4	11.5
Cond (ms/m)	8.7	7.1
pH	8.24	7.78
DO (mg/L)	9.50	8.35

Figure 25: Graphic depiction of water quality criteria as measured in June 2015 on the Pandana River (CK5 and CK6)

- The water quality guideline for aquatic ecosystems (DWAF 1996) states that: 1) Total dissolved salts (TDS) concentrations (i.e. as indicated by the EC measurements) should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and 2) the amplitude and frequency of natural cycles in TDS concentrations should not be changed;
- From a spatial perspective, EC decreased by 18.4% in a downstream direction between sites CK5 and CK6. Whilst this change does not comply with the guideline recommendation, it is considered a positive change towards more natural conditions. The variation observed also indicates a significant degree of variability in basic water chemistry in the system. In addition the absolute value at site CK5 and Ck6 are below 9 mS/m and can still be considered largely natural;
- Low dissolved salt concentrations in the system correlates with perceived natural conditions. Thus EC are not expected to have a negative impact on the aquatic community;
- The pH is largely neutral (site CK6) to slightly alkaline (site CK5) but can be regarded as suitable for supporting a diverse and sensitive aquatic community under the current conditions;
- The water quality guideline for aquatic ecosystems (DWA 1996) states that pH values should not be allowed to vary from the range of the background pH values for a specific site by > 5 %;

- The pH value decreased by 5.6% in a downstream direction between sites CK5 and CK6. Whilst this change does not comply with guideline recommendations, it is considered a positive change towards more natural conditions;
- As for EC, historical pH baseline data is not available for comparison;
- The DO percentage of saturation during June 2015 was within the desired 80% to 120% range for aquatic ecosystems (DWAF, 1996) at site CK5. DO at this site can thus be regarded as suitable for supporting a diverse and sensitive aquatic community (Table 14). Whilst percentage of saturation at site CK6 did not reach 80%, the absolute value of 75.8% is still considered high enough not to have any negative impact on aquatic communities. The variation observed during the June 2015 assessment can potentially be attributed to natural variation between sampling times.

Table 14: Oxygen measured expressed as percentage of maximum for sites CK5 and CK6 as assessed in June 2015

SITE	DO mg/l	TEMP °C	Maximum oxygen at that temperature (mg/L)	Oxygen measured expressed as percentage of maximum
CK5 2015	9.50	9.4	11.55	82.25
CK5 2015 (Sept)	7.31		9.80	74.2
CK6 2015	8.35	11.5	11.01	75.84

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

Sibabe River February 2015 (Site CK4)

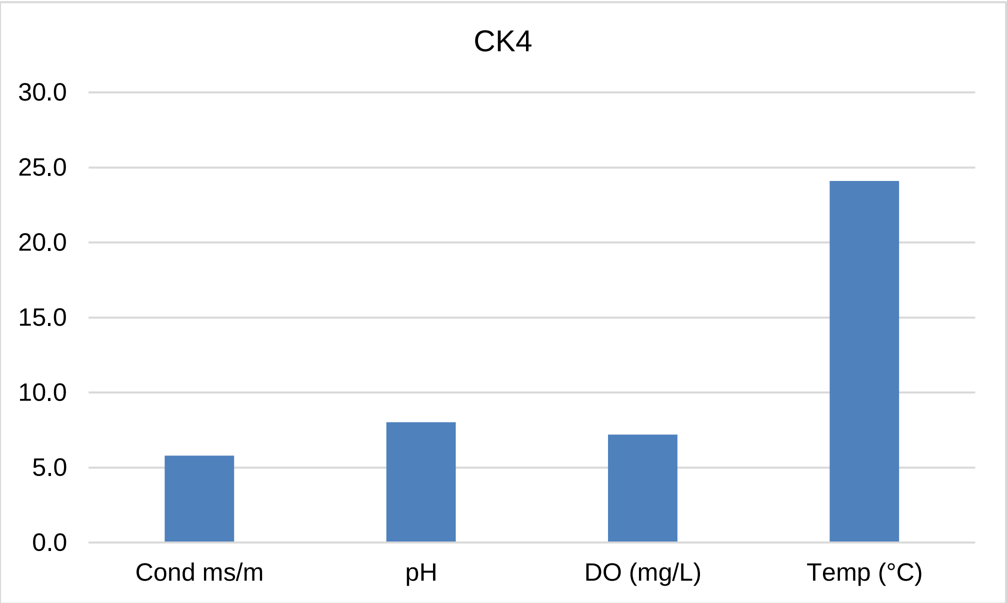


Figure 26: Graphic depiction of water quality criteria as measured in February 2014 on the Sibabe River

- Results indicate that water quality in the Sibabe River is comparable to that in the Pandana River, more specifically to that of sites CK2 and CK1;

Table 15: Oxygen measured expressed as percentage of maximum for site CK4 on the Sibabe River as assessed in February 2014

Site	DO mg/L	Temp ºC	Maximum oxygen at that temperature (mg/L)	Oxygen measured expressed as percentage of maximum
CK4 2014	7.20	24.1	8.40	85.71

- Percentage dissolved oxygen exceeded the 80% guideline recommendation. Conditions with regard to DO concentrations were thus adequate to support a diverse aquatic community;
- It can thus be concluded that the Pandana River, situated within the subject property, exhibits the same undisturbed and largely natural characteristics compared to the Sibabe River.

4.3 Riparian Vegetation Response Assessment Index (VEGRAI)

The VEGRAI assessment results for the Pandana and Sibabe Rivers are presented in Table 16.

Table 16: Results of the VEGRAI assessment for the Pandana (CK3 to CK1, CK5 and CK6) and Sibabe (CK4) River systems

LEVEL 3 ASSESSMENT: Pandana River (sites CK3 to CK1, CK5 and CK6)					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	28.9	14.4	2.5	1.0	100.0
NON MARGINAL	20.0	10.0	0.0	1.0	100.0
	2.0				200.0
LEVEL 3 VEGRAI (%)				24.4	
VEGRAI EC Pandana				**E**	
AVERAGE CONFIDENCE				1.3	
LEVEL 3 ASSESSMENT: Sibabe River (site CK4)					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	86.7	43.3	2.5	1.0	100.0
NON MARGINAL	86.7	43.3	0.0	1.0	100.0
	2.0				200.0
LEVEL 3 VEGRAI (%)				86.7	
VEGRAI EC Sibabe				**B**	
AVERAGE CONFIDENCE				1.3	

Because the riparian vegetation flora was very similar along all sites assessed on the Pandana River, VEGRAI was applied to this system as a whole and not to individual sites. The results of this assessment indicate that the Pandana River (represented by sites CK3 to CK1, CK5 and CK6) falls within Ecostatus Class E, indicating that the vegetation within the system is seriously modified. The loss of natural habitat, biota and basic ecosystem functions is considered to be extensive, mainly because of alien floral invasion (wattle trees). No deviations as a result of impacted water quality were observed or considered likely.

The results of this assessment indicate that the Sibabe River (represented by site CK4) falls within Ecostatus Class B, indicating that the vegetation within the system is largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged. No deviations as a result of impacted water quality were observed or considered likely.

4.4 Intermediate Habitat Integrity Assessment (IHIA)

Instream and riparian zone impacts results classified for sites assessed on the Pandana River and Sibabe River in the vicinity of the proposed mining project are described below. Results are tabulated in Appendix 3.

- The only **in-stream** variable for which no impacts were recorded, was exotic macrophytes. Moderate impacts were only recorded for flow modification (Sites CK1, CK2 and CK5) and inundation (CK3 and CK5). Large impacts were recorded for flow modification (CK3), bed modification (CK1, CK2 and CK3) and channel modification (CK1, CK2, CK3 and CK5). In-stream impact scores varied between 62.13% and 95.84%. Classifications awarded were Class C (Moderately modified) for sites CK1, CK2, CK3 and CK5. Class A (Unmodified, natural) was awarded to sites CK4 and CK6.
- **Riparian zone** impacts recorded for vegetation removal were moderate (sites CK1, CK and CK6) and large (CK2 and CK). For alien encroachment moderate (CK1), large (CK2, CK3 and CK6) and serious (CK5) impacts were recorded. Moderate impacts were recorded for bank erosion at all sites with the exception of CK4. Only slight impacts for water abstraction were reported from all six sites assessed.

  Moderate (CK1, CK2 and CK5) and large (CK3) impacts for flow modification were recorded. Channel modification was recorded as large for sites CK1, CK2, CK3 and CK5. Riparian zone impact scores varied between 52.39% and 94.88%.

  Classifications awarded were Class C (Moderately modified) for sites CK1, CK2, CK5 and CK6. Class A (Unmodified, natural) was awarded to site CK4, whilst site CK3 was awarded a Class D (Largely modified) classification.

- The **total IHIA** scores ranged between 57.26% and 95.36%. A Class C (Moderately modified) classification was awarded to sites CK1, CK2 and CK5, a Class D (Largely modified) classification to site CK3, a Class B (Largely natural) classification to site CK6 and a Class A (Unmodified, natural) classification to site CK4.
- The reach of the Pandana River in the vicinity of the proposed mining area can generally be considered moderately modified from what could be expected under unimpacted/unmodified conditions. However, there is some variability in the system with one site presenting with largely natural conditions and another with largely modified conditions.
- Based on the single site assessed on the Sibabe River, this system appears to be unmodified and completely natural.
- It can be concluded that the riverine resources associated with the subject property can be considered moderately modified to largely natural, which is in accordance with the desktop assessment results reported earlier.

4.5 Invertebrate Habitat Assessment System (IHAS)

Table 17 summarises of the results obtained from the application of the Invertebrate Habitat Assessment Index (IHAS) to the bio-monitoring sites. 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 and interpreting SASS results (Appendix 1). From the results of the application of the IHAS index it is evident that both the Pandana and Sibabe Rivers in the area provide adequate habitat conditions for sustaining a diverse macro-invertebrate community. This is largely due to a good variety of substrate types at all the sites assessed, as well as a good variety of flow types within the system. However, the lack of leafy marginal vegetation at some sites and the absence of aquatic macrophytes in the systems assessed will limit the availability of suitable cover for suitably adapted aquatic macro-invertebrates. Furthermore the systems are shallow and lack strong flow under low flow conditions, reducing the diversity of habitats available for aquatic macro-invertebrates. Considering the above, a macro-invertebrate community of fair to good diversity and abundance can thus be expected but some natural limitations on community sensitivity are also expected (McMillan, 1998).

Table 17: Biotope specific summary of the results obtained from the application of the IHAS index to the various sites on the Pandana River (sites CK3, CK2, CK1, CK5 and CK6) and Sibabe River (CK4)

SITE	Pandana River			
	CK3 2014	**CK2 2014**	**CK1 2014**	**CK1 2013**
IHAS Habitat score	66	65	72	72
Habitat adjustment score (illustrative purposes only)	+13	+17	+15	+17
McMillan, 1998 Habitat description	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community
Stones habitat characteristics	Stones in and out of current present at the time of assessment.	Stones in and out of current present at the time of assessment.	Stones in current present but no stones out of current.	Stones in current present but no stones out of current.
Vegetation habitat characteristics	Marginal fringing vegetation present with a small amount (1% to 25%) of leafy material. No aquatic vegetation present.	Marginal fringing vegetation present with a small amount (1% to 25%) of leafy material. No aquatic vegetation present.	Marginal fringing vegetation present with a small amount (1% to 25%) of leafy material. No aquatic vegetation present.	Marginal fringing vegetation present with a good amount (51% to 75%) of leafy material. No aquatic vegetation present.
Other habitat characteristics	Sand, mud and gravel substrate available for colonisation by suitably adapted organisms.	Sand, mud and gravel substrate available for colonisation by suitably adapted organisms.	Sand, mud and gravel substrate available for colonisation by suitably adapted organisms.	Sand and mud substrate available for colonisation by suitably adapted organisms.
IHAS general Stream characteristics	The river at this point was clear, fairly wide (>2 to 5 m wide), on average shallow (0.5 m) with medium flow. There was a fair diversity in flow types (two mix) at the site. The surrounding vegetation consisted mainly of grasses providing poor (0% to 50%) bank cover. The dominant activity in the area is farming.	The river at this point was discoloured, fairly wide (>2 to 5 m wide), on average shallow (0.5 m) with medium flow. There was low diversity in flow types (run only) at the site. The surrounding vegetation consisted mainly of grasses providing good (81% to 95%) bank cover. The dominant activity in the area is farming.	The river at this point was discoloured, fairly narrow (1 to 2 m wide), on average shallow (0.5 m) with slow flow. There was a fair diversity in flow types (two mix) at the site. The surrounding vegetation consisted mainly of grasses providing excellent (>95%) bank cover. The dominant activity in the area is farming.	The river at this point was clear, fairly narrow (1 to 2 m wide), on average shallow (0.25 to 0.5 m) with medium flow. There was a fair diversity in flow types (two mix) at the site. The surrounding vegetation consisted mainly of mixed grasses and shrubs providing excellent (>95%) bank cover. The dominant activity in the area is farming.

Table17 (continued): Biotope specific summary of the results obtained from the application of the IHAS index to the various sites on the Pandana River (sites CK3, CK2, CK1, CK5 and CK6) and Sibabe River (CK4)

SITE	CK5 2015	CK5 2015 (Sept)	CK6 2015	CK4 2014
IHAS Habitat score	73	58	74	65
Habitat adjustment score (illustrative purposes only)	+15	+28	+17	+17
McMillan, 1998 Habitat description	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community	Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community largely as a result of limited flow and the lank of bankside vegetation cover	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community
Stones habitat characteristics	Stones in and out of current present at the time of assessment providing good habitat for aquatic macro-invertebrates.	Stones in and out of current present at the time of assessment providing good habitat for aquatic macro-invertebrates.	Stones in and out of current present at the time of assessment providing good habitat for aquatic macro-invertebrates.	Stones in and out of current present at the time of assessment providing good habitat for aquatic macro-invertebrates.
Vegetation habitat characteristics	Marginal fringing vegetation present with a small amount (1% to 25%) of leafy material. No aquatic vegetation present.	No bankside or aquatic vegetation was present in the system at the time of assessment due to the eroded banks, impacts of alien vegetation and seasonal lack of growth	Marginal fringing vegetation present with a small amount (1% to 25%) of leafy material. No aquatic vegetation present.	Marginal fringing vegetation present with a fair amount (25% to 50%) of leafy material. No aquatic vegetation present.
Other habitat characteristics	Sand, mud and gravel substrate available for colonization by suitably adapted organisms.	Sand, available for colonization by suitably adapted organisms.	Sand, mud, gravel and some bedrock substrate available for colonization by suitably adapted organisms.	Sand, mud and gravel substrate available for colonization by suitably adapted organisms. Algal growth on rocks.
IHAS general Stream characteristics	The river at this point was clear, fairly wide (>2 to 5 m wide), on average shallow (0.5 m) with slow flow. There was a good diversity in flow types (three mix) at the site. The surrounding vegetation consisted of a mix of shrubs and grasses providing good (51% to 80%) bank cover. The dominant impact in the area is the presence of trees in the riparian zone.	The river at this point was clear, fairly wide (>2 to 5 m wide), on average shallow (0.5 m) with slow flow. There was little diversity in flow types due to the low flow at the time of assessment. The surrounding vegetation The dominant impact in the area is the presence of alien trees in the riparian zone.	The river at this point was clear, fairly wide (>2 to 5 m wide), on average shallow (<0.5 m) with slow flow. There was a good diversity in flow types (three mix) at the site. The surrounding vegetation consisted of mostly grasses, providing excellent (>95%) bank cover. The dominant impact in the area is the presence of trees in the riparian zone.	The river at this point was clear, fairly wide (>2 to 5 m wide), on average shallow (<0.5 m) with medium flow. There was a low diversity in flow types (run only) at the site. The surrounding vegetation consisted of a mix of shrubs and grasses providing fair (51% to 80%) bank cover. The dominant activity in the area is farming.

4.6 Aquatic Macro-invertebrates: SASS5

The results of the aquatic macro-invertebrate assessment according to the SASS5 index, as well as the IHAS scores, are graphically presented below for all sites assessed.

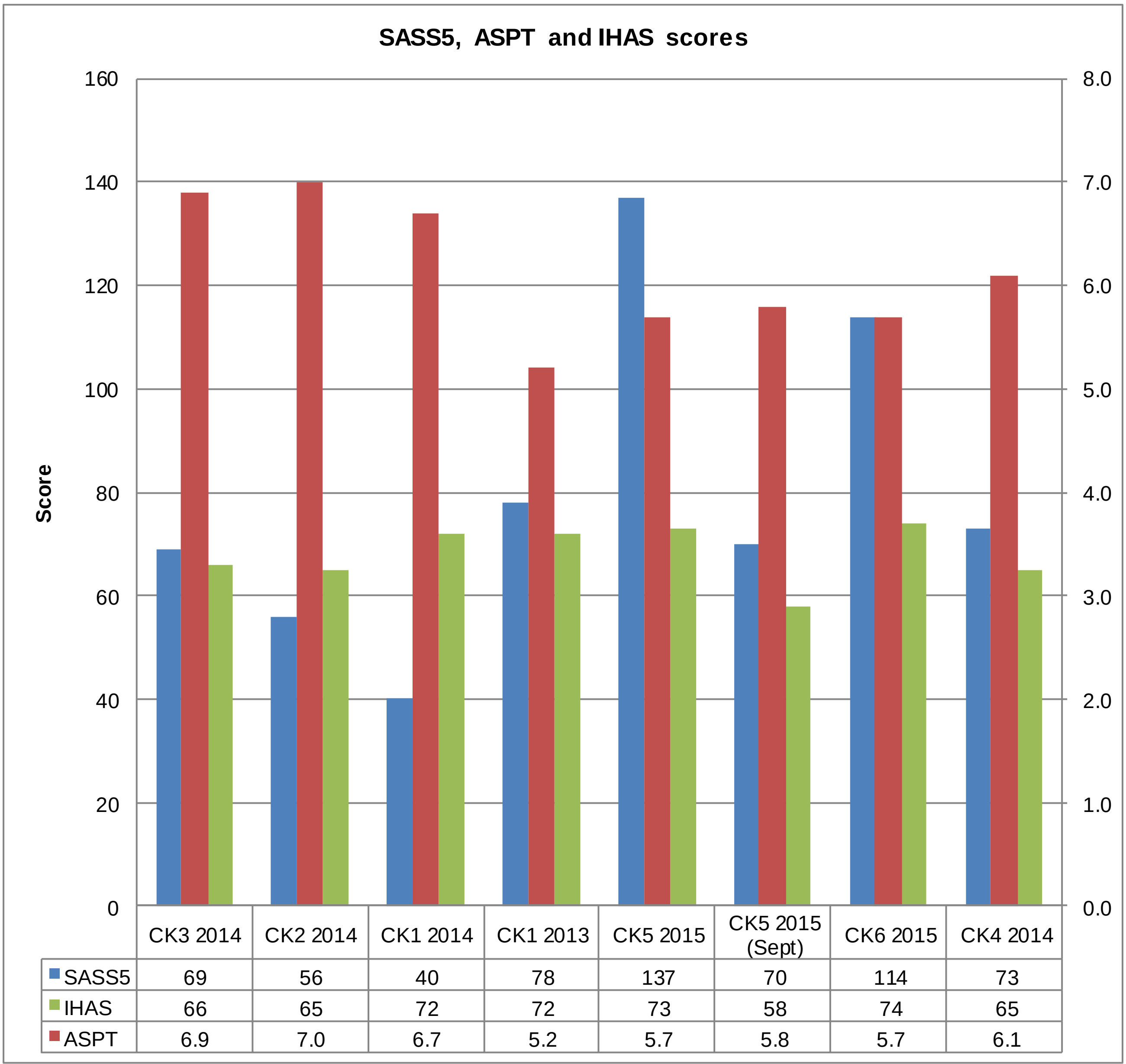


Figure 27: Graphic depiction of SASS5, ASPT and IHAS scores for all sites assessed on the Pandana (CK3, CK2, CK1, CK5 and CK6) and the Sibabe (CK4) Rivers

During all sites and for all assessments ASPT scores were very similar, with values ranging between 5.2 and 7.0. SASS5 scores for sites CK1, CK2, CK3 and CK4 were similar, with higher scores reported at CK5 and CK6. This suggests that seasonal effects may be involved and that conditions at the time of sampling sites CK1 to Ck4 were not ideal due to freshets occurring during the sampling periods. However, should the development proceed, baseline biomonitoring should take place in all four seasons, representing different flow and environmental conditions, prior to any mining activity taking place. IHAS scores were very similar at all sites during all assessments, suggesting that variability in SASS5 scores cannot be attributed to differences in habitat suitability.

The results obtained at each site per biotope sampled are presented in the table that follows. In addition the findings of the SASS5 assessment based on the analyses and interpretation of the data for each site, will also be presented and discussed for each assessment occasion. SASS score sheets are presented in Appendix 2.

Table 18: Biotope specific summary of the SASS5 and ASPT scores obtained from the application of the SASS5 index to the various sites in 2013, 2014 and 2015.

PARAMETER	SITE	STONES	VEGETATION	GRAVEL, SAND AND MUD	TOTAL
SASS5 SCORE	CK3 2014	54	17	63	69
Number of taxa		7	2	9	10
ASPT		8	8.5	7	6.9
SASS5 SCORE	CK2 2014	33	0	44	56
Number of taxa		4	0	6	8
ASPT		8	0	7	7.0
SASS5 SCORE	CK1 2014	24	17	35	40
Number of taxa		3	2	5	6
ASPT		8	8.5	7	6.7
SASS5 SCORE	CK1 2013	39	44	35	78
Number of taxa		7	8	7	15
ASPT		5.57	5.5	5.0	5.2
SASS5 SCORE	CK5 2015 (June)	105	45	56	137
Number of taxa		18	9	11	24
ASPT		6	5.0	5	5.7
SASS5 SCORE	CK5 2015 (Sept)	70		17	70
Number of taxa		12		4	12
ASPT		5.8		4.3	5.8
SASS5 SCORE	CK6 2015	76	36	63	114
Number of taxa		12	9	10	20
ASPT		6	4.0	6	5.7
SASS5 SCORE	CK4 2014	69	22	57	73
Number of taxa		11	3	10	12
ASPT		6	7.3	6	6.1

Pandana River April 2013 (site CK1)

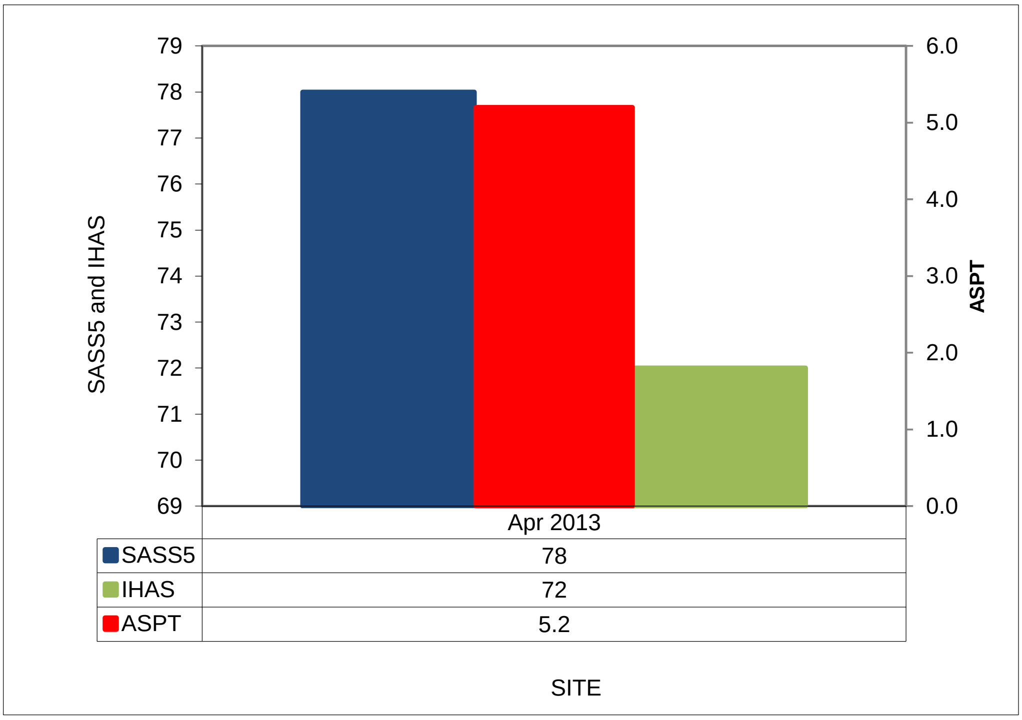


Figure 28: Graphic depiction of water quality criteria as measured in April 2013 at site CK1 on the Pandana River

➢ Results will be discussed together with that obtained in February 2014 in the points that follow.

Pandana River February 2014 (sites CK3, CK2 and CK1))

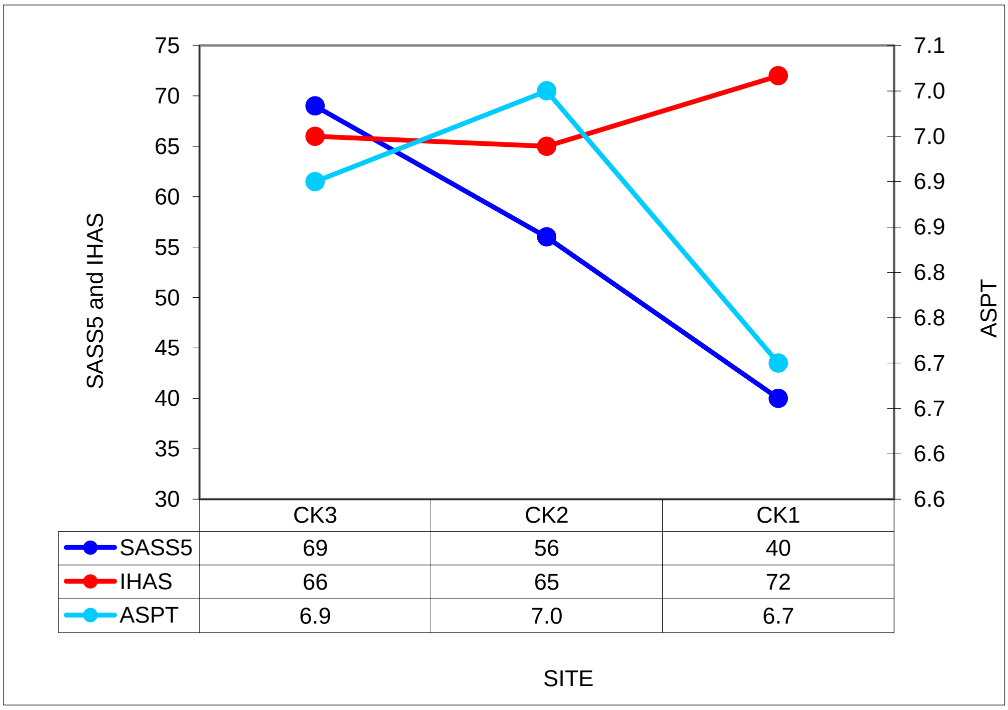


Figure 29: Graphic depiction of water quality criteria as measured in February 2014 at sites CK3, CK2 and CK1 on the Pandana River

- SASS5 scores decreased in a downstream direction by 42.0% when comparing site CK3 to site CK1, indicating deteriorating macro-invertebrate diversity in a downstream direction;
- ASPT score first increased by negligibly by 1.4% between sites CK3 and CK2, then decreased by 4.3% between sites CK2 and CK1. However, absolute values varied between 6.7 and 7.0 and these changes are thus not considered significant. It can be concluded that there was little variation in macro-invertebrate sensitivity within this system;
- IHAS score first decreased negligibly by 1.5% between sites CK3 and CK2, then increased by 10.8% between sites CK2 and CK1. However, absolute values varied between 65 and 72 and these changes are thus not considered significant. It can be concluded that there was little variation in habitat suitability within this system;
- The decreasing trend in SASS5 scores and to a lesser degree also the ASPT scores can thus not be attributed to deteriorating habitat conditions but rather due to the effects of freshets occurring during the sampling of the system which flushed the system and impacted on the sampling undertaken. However, despite this variation similar SASS5 classifications were obtained in February 2015;

Table 19: Tabulated results obtained from the application of the SASS5 index to sites (CK1, CK2 and CK3) on the Pandana River.

Type of Result	April 2013	February 2014	February 2014	February 2014
	CK1 Apr 2013	**CK1 Feb 2014**	**CK2 Feb 2014**	**CK3 Feb 2014**
Biotopes sampled	Stones in current; Fringing vegetation; Sand; Mud	Stones in current; Fringing vegetation; Sand; Mud; Gravel;	Stones in current; Fringing vegetation; Stones out of current; Sand; Mud; Gravel	Stones in current; Fringing vegetation; Stones out of current; Sand; Mud; Gravel
Sensitive taxa present	*Caenidae; Tricorythidae; Aeshnidae;*	*Caenidae; Gomphidae;*	*Caenidae; Leptophlebiidae; Tricorythidae; Gomphidae; Ancylidae*	*Caenidae; Leptophlebiidae; Tricorythidae; Gomphidae; Ancylidae*

Type of Result	April 2013	February 2014	February 2014	February 2014
	CK1 Apr 2013	**CK1 Feb 2014**	**CK2 Feb 2014**	**CK3 Feb 2014**
Sensitive taxa absent	*Hydracarina; Heptageniidae; Leptophlebiidae; Prosopistomatidae; Chlorocyphidae; Chlorolestidae; Lestidae; Gomphidae; Pyralidae; Naucoridae; Ecnomidae; Philopotamidae; Hydroptilidae; Lepidostomatidae; Lepoceridae; Elmidae; Hydraenidae; Psephenidae; Athericidae; Dixidae; Ancylidae;*	*Hydracarina; Heptageniidae; Leptophlebiidae; Prosopistomatidae; Tricorythidae; Chlorocyphidae; Chlorolestidae; Lestidae; Aeshnidae; Pyralidae; Naucoridae; Ecnomidae; Philopotamidae; Hydroptilidae; Lepidostomatidae; Lepoceridae; Elmidae; Hydraenidae; Psephenidae; Athericidae; Dixidae; Ancylidae*	*Hydracarina; Heptageniidae; Prosopistomatidae; Chlorocyphidae; Chlorolestidae; Lestidae; Aeshnidae; Pyralidae; Naucoridae; Ecnomidae; Philopotamidae; Hydroptilidae; Lepidostomatidae; Lepoceridae; Elmidae; Hydraenidae; Psephenidae; Athericidae; Dixidae;*	*Hydracarina; Heptageniidae; Prosopistomatidae; Chlorocyphidae; Chlorolestidae; Lestidae; Aeshnidae; Pyralidae; Naucoridae; Ecnomidae; Philopotamidae; Hydroptilidae; Lepidostomatidae; Lepoceridae; Elmidae; Hydraenidae; Psephenidae; Athericidae; Dixidae;*
SASS5 score	78	40	56	69
Adjusted SASS5 score	95	55	73	82
SASS5 % of theoretical reference score*	41.1	21.1	29.5	36.3
ASPT score	5.2	6.7	7.0	6.9
ASPT % of theoretical reference score**	74.3	95.7	100.0	98.6
Dickens & Graham, 2001 SASS5 classification	D (Largely impaired)	E (Severely impaired)	E (Severely impaired)	E (Severely impaired)
Dallas 2007 classification	D	B	Borderline A/B	B

*SASS5 reference score = 190; **ASPT reference score = 7

- The SASS data indicates that the aquatic macro-invertebrate community of this system, prior to mining, supports an aquatic community of limited abundance and diversity (but high sensitivity) when compared to the reference score for a pristine Eastern Escarpment Mountain ecoregion stream;
- The results of the aquatic assessment thus partially correlate with the existing data available for the system from the DWS RQIS PES/EIS database, depending on the classification system used;

- SASS5 scores resulted in a class D (largely impaired, site CK1 in April 2013) and class E (severely impaired, sites CK1, CK2 and CK3 in February 2014) classification according to the Dickens and Graham (2001) classification system;
- According to the Dallas (2007) classification system, a class D (CK1, April 2013), class B (CK1 and CK3, February 2014) and class A/B (CK2, February 2014) were obtained. The latter three classifications are in agreement with the DWS RQIS PES/EIS database;
- This apparent discrepancy, both with reference to difference in the Dallas (2007) classification between 2013 and 2014 obtained for CK1, as well as the differences between the Dickens and Graham (2001) and Dallas (2007) classifications, pertains to the high ASPT scores, as the Dallas (2007) classification systems is more sensitive to changes in ASPT score;
- Even though the SASS5 score was 48.7% higher at CK1 in 2013 compared to 2014, ASPT score was 28.8% higher in 2014, resulting in an improved Dallas (2007) classification;
- In similar fashion the very high ASPT scores achieved resulted in higher classifications being recorded when using the Dallas (2007) system, compared to the Dickens and Graham (2001) system;
- The SASS scores were thus variable and lower compared to that expected, whilst the ASPT values were high and less variable which led to the variations in class observed;
- With the IHAS index indicating habitat conditions adequate to sustain diverse aquatic communities, the limited community diversity observed can only partially be ascribed to natural limitations;
- The lack of leafy marginal vegetation at some sites and the absence of aquatic macrophytes in the systems assessed will limit the availability of suitable cover for suitably adapted aquatic macro-invertebrates. Furthermore the systems are shallow, reducing the water column area available for colonisation by suitably adapted macro-invertebrates. Thus lack of suitable habitat and cover for aquatic macro-invertebrates may pose limitations in the system to some degree;
- Due to the effects of the freshets on the system in the April 2013 and February 2014 surveys which flushed the systems during the assessments, the Dallas (2007) classification system is considered more accurate in classifying the system;
- Future SASS5 and ASPT results should be monitored and any alterations in the scores should be identified, with particular reference to potential seasonal/annual variations in SASS score which seem relatively stable in the data collected to date scores, in an attempt to elucidate trends and potential causal factors;

- Water contamination, habitat destruction and instream habitat changes associated with the proposed mining activity will have a significant effect on the aquatic community within the system. Such potential impacts should be mitigated and close monitoring of trends must take place.

Pandana River June 2015 (sites CK5 and CK6)

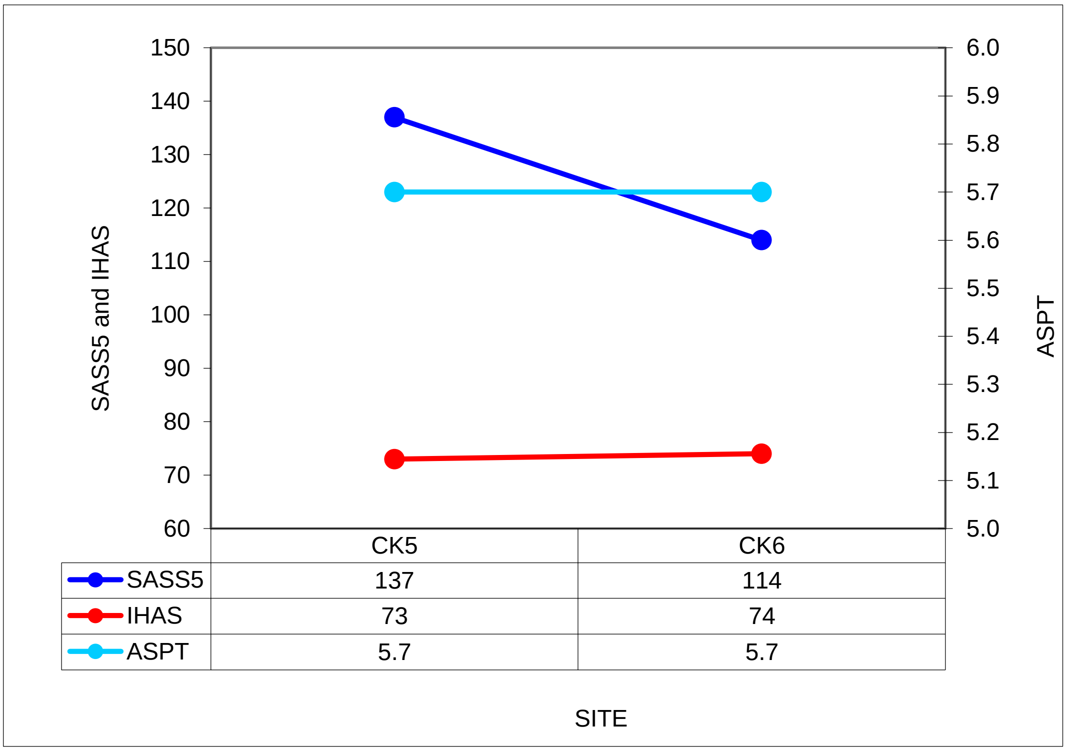


Figure 30: Graphic depiction of water quality criteria as measured in June 2015 at sites CK5 and CK6 on the Pandana River

- IHAS score increased negligibly by 1.4% between sites CK5 and CK6. It can be concluded that there was little variation in habitat suitability within this system although the lack of cobbles a the downstream site would affect the aquatic community to some degree;
- Although the results are not directly comparable the CK5 results show significant variation between June 2015 and September 2015. The most significant driver of change is the lack of aquatic vegetation during the September 2015 assessment a the velocity and flow assessment point;
- SASS5 scores decreased in a downstream direction by 16.8% when comparing site CK5 to site CK6, indicating deteriorating macro-invertebrate diversity in a downstream direction;
- ASPT score remained unchanged. It can be concluded that there was little variation in macro-invertebrate sensitivity within this system;
- The decreasing trend in SASS5 scores can thus not be attributed to deteriorating habitat conditions. However, despite this variation similar SASS5 classifications were obtained in February 2015;

Table 20: Tabulated results obtained from the application of the SASS5 index to sites (CK5 and CK6) on the Pandana River.

Type of Result	June 2015	September 2015	June 2015
	CK5	CK5	CK6
Biotopes sampled	Stones in current; Fringing vegetation; Stones out of current; Sand; Mud; Gravel	Stones in current; Stones out of current; Sand;	Stones in current; Fringing vegetation; Stones out of current; Sand; Mud; Gravel; Bedrock
Sensitive taxa present	*Caenidae; Leptophlebiidae; Tricorythidae; Lestidae; Aeshnidae; Philopotamidae; Elmidae; Psephenidae;*	*Caenidae; Leptophlebiidae; Tricorythidae; Helodidae;*	*Caenidae; Heptageniidae; Leptophlebiidae; Tricorythidae; Elmidae; Lepoceridae; Dixidae;*
Sensitive taxa absent	*Hydracarina; Heptageniidae; Prosopistomatidae; Chlorocyphidae; Chlorolestidae; Gomphidae; Pyralidae; Naucoridae; Ecnomidae; Hydroptilidae; Lepidostomatidae; Lepoceridae; Hydraenidae; Athericidae; Dixidae; Ancylidae*	*Hydracarina; Heptageniidae;* Prosopistomatidae; Chlorocyphidae; Chlorolestidae; Gomphidae; Pyralidae; Naucoridae; Ecnomidae; Hydroptilidae; Lepidostomatidae; Lepoceridae; Hydraenidae; Athericidae; Dixidae; Ancylidae Lestidae; Aeshnidae; Philopotamidae; Elmidae; Psephenidae	*Hydracarina; Prosopistomatidae; Chlorocyphidae; Chlorolestidae; Lestidae; Aeshnidae; Gomphidae; Pyralidae; Naucoridae; Ecnomidae; Philopotamidae; Hydroptilidae; Lepidostomatidae; Hydraenidae; Psephenidae; Athericidae; Ancylidae*
SASS5 score	137	70	114
Adjusted SASS5 score	152	98	131
SASS5 % of theoretical reference score*	72.1	36.8	60.0
ASPT score	5.7	5.8	5.7
ASPT % of theoretical reference score**	81.4	82.9	81.4
Dickens & Graham, 2001 SASS5 classification	B (Slightly impaired)	E (Seriously impaired)	C (Moderately impaired)
Dallas 2007 classification	C	C	C

*SASS5 reference score = 190; **ASPT reference score = 7

- The SASS data indicates that the aquatic macro-invertebrate community of this system, prior to mining, supports an aquatic community of moderate diversity and sensitivity, when compared to the reference score for a pristine Eastern Escarpment Mountain ecoregion stream;
- Compared to the upstream sites (CK3, CK2 and CK1) assessed in February 2015, there was an increase in SASS5 score but a decrease in ASPT score.

However, as the same sites were not assessed results are not directly comparable. Should future assessment be performed temporal trends should be monitored and elucidated;

- The results of the June 2015 aquatic assessment partially correlate with the existing data available for the system from the DWS RQIS PES/EIS database;
- SASS5 scores resulted in a class B (slightly impaired, site CK5) and class C (moderately impaired, site CK6) classification according to the Dickens and Graham (2001) classification system in June 2015 while in September 2015 the CK5 site assessed at the velocity determination point obtained a Class E (seriously impaired rating. The Class C scores lower than that expected based on the DWS RQIS PES/EIS database;
- According to the Dallas (2007) classification system, a class C classification was obtained for both sites including the September 2015 assessment of the CK5 site at the velocity reading site. This classification is lower than that expected based on the DWS RQIS PES/EIS database;
- With the IHAS index indicating habitat conditions adequate to sustain diverse aquatic communities in June 2015, the limited community diversity observed can only partially be ascribed to natural limitations;
- With the IHAS index indicating habitat conditions which are inadequate to sustain diverse aquatic communities in September 2015 it indicates that low flows and the impacts of stream incision and alien vegetation encroachment leading to a loss of bankside vegetation cover significantly impact on the aquatic macro-invertebrate community of the system;
- The lack of leafy marginal vegetation and the absence of aquatic macrophytes in the systems assessed will limit the availability of suitable cover for suitably adapted aquatic macro-invertebrates. Furthermore the system is shallow, reducing the water column area available for colonisation by suitably adapted macro-invertebrates. Thus lack of suitable habitat and cover for aquatic macro-invertebrates may pose limitations in the system to some degree;
- It must, however, be noted that the conditions in the system are natural and limited impact on the aquatic ecosystem from anthropogenic impacts is deemed likely at the current time e4xscept for the impact caused by alien vegetation encroachment which is considered significant;
- It can therefore be concluded that the macro-invertebrate community of the system was characterised by a moderate level of diversity and sensitivity as assessed in June 2015 when better sampling conditions were available. Variation observed can at least

be partially attributed to natural constraints in the system, with specific reference to flow variability;

- Future SASS5 and ASPT results should be monitored and any alterations in the scores should be identified, with particular reference to potential seasonal/annual variations in SASS score which seem relatively stable in the data collected to date scores, in an attempt to elucidate trends and potential causal factors;
- Water contamination, habitat destruction and instream habitat changes, dewatering of the Pandana River and potential impacts from discharge of decant associated with the proposed mining activity will potentially have a significant effect on the aquatic community within the system. Such potential impacts should be mitigated and close monitoring of trends must take place.

Sibabe River February 2014 (site CK4)

- Results for the Sibabe River (site CK4) were comparable to that from sites CK1, CK2 and CK3 for the same assessment occasion;
- However, the SASS5 score was highest at site CK4 and most comparable with that of site CK3 (only 5.8% higher at CK3). However, ASPT was lowest at CK4(absolute value 6.1 with those of sites CK1 to CK3 varying between 6.7 and 7.0);

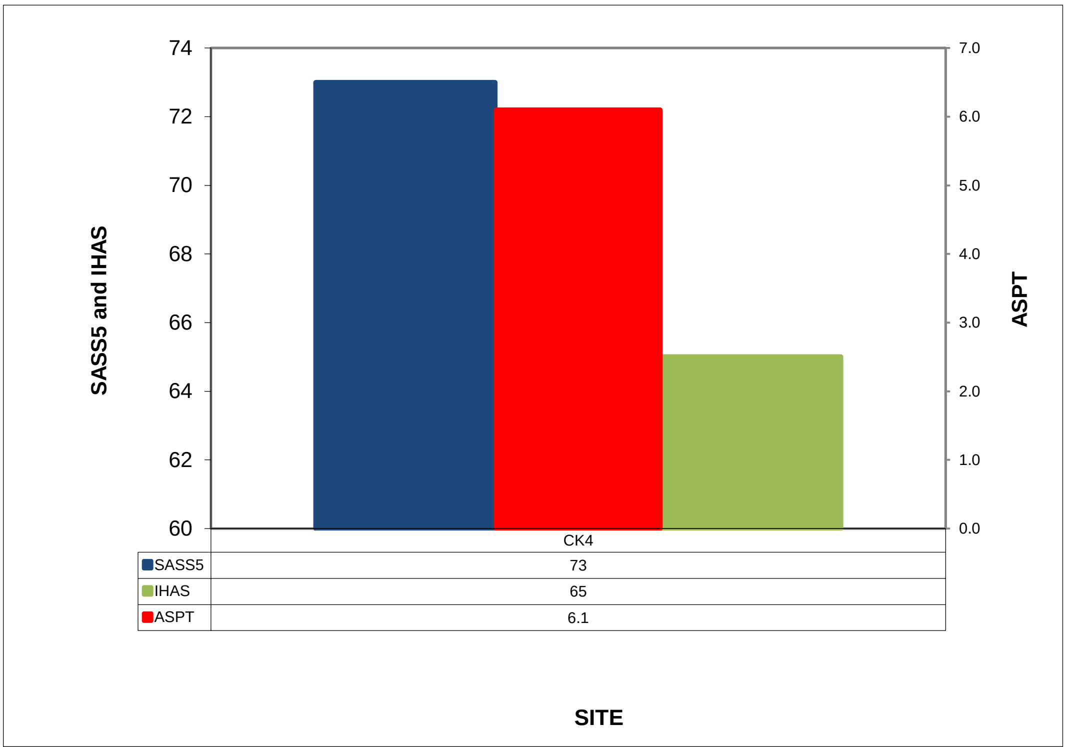


Figure 31: Graphic depiction of water quality criteria as measured in February 2014 at site CK4 on the Sibabe River

- When compared to results from the Pandana River also assessed in February 2014, similar trends are evident;

- The high ASPT score resulted in a more favourable Dallas (2007) classification (class C) compared to the Dickens and Graham (2001) classification (class E). The reason for this apparent discrepancy has been discussed previously in the Pandana River February 2014 section;
- The Dickens and Graham (2001) class obtained was the same as that reported for the other three sites on the Pandana River during the same assessment. Despite the slightly higher SASS5 score reported from CK4, the lower (compared to CK1 to CK3) ASPT score resulted in a lower Dallas (2007) classification;

Table 21: Tabulated results obtained from the application of the SASS5 index to sites (CK5 and CK6) on the Pandana River.

Type of Result	February 2014
	CK4 Feb 2014
Biotopes sampled	Stones in current; Fringing vegetation; Stones out of current; Sand; Mud; Gravel
Sensitive taxa present	*Caenidae; Tricorythidae; Aeshnidae; Gomphidae; Psephenidae;*
Sensitive taxa absent	*Hydracarina; Heptageniidae; Leptophlebiidae; Prosopistomatidae; Chlorocyphidae; Chlorolestidae; Lestidae; Pyralidae; Naucoridae; Ecnomidae; Philopotamidae; Hydroptilidae; Lepidostomatidae; Lepoceridae; Elmidae; Hydraenidae; Athericidae; Dixidae; Ancylidae*
SASS5 score	73
Adjusted SASS5 score	90
SASS5 % of theoretical reference score*	38.4
ASPT score	6.1
ASPT % of theoretical reference score**	87.1
Dickens & Graham, 2001 SASS5 classification	E (Severely impaired)
Dallas 2007 classification	C

*SASS5 reference score = 190; **ASPT reference score = 7

- It can thus be concluded that conditions on the Sibabe River (site CK4) in February 2014 was largely similar to that of the Pandana River (sites CK1 to CK3) for the same period. Compared to the other sites, CK4 (Sibabe River) presented with slightly increased diversity (higher SASS5 score) but slightly decreased sensitivity (lower ASPT score).

Synopsis

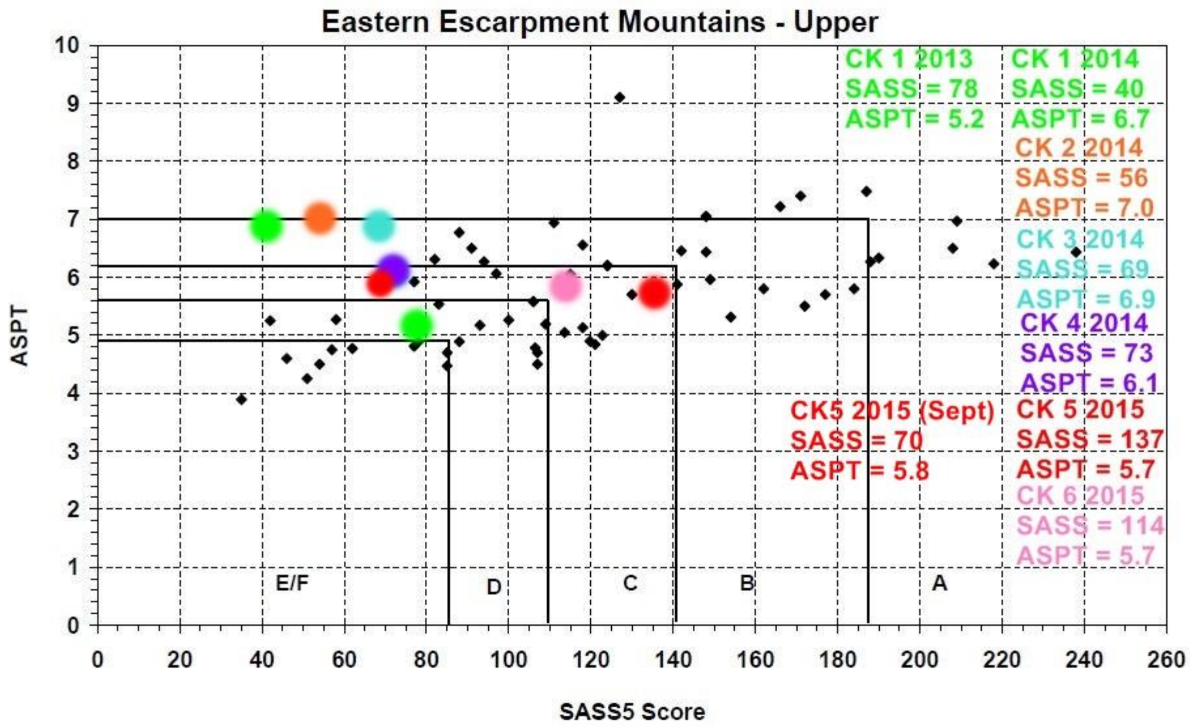


Figure 32: Scatterplot of SASS5 and ASPT values according to the Dallas (2007) classification system for all sites assessed on the Pandana (CK1 to Ck3, CK5 and CK6) and Sibabe (CK4) Rivers for the respective assessments.

- The Dallas (2007) classification system is sensitive to changes in ASPT. The lowest ASPT score was reported for CK1 in 2013 and also resulted in the lowest classification (class D). For all the other sites the Dallas (2007) classification indicated either class B or class C;
- The Dickens and Graham (2001) class obtained was the same (class E) for sites CK1 to CK4 during the February 2014 assessment. However, higher SASS5 scores resulted in improved class C (CK6) and class B (CK5) classifications during June 2015;
- It can therefore be concluded that the macro-invertebrate community of these systems show high levels of variability in terms of both sensitivity and diversity, due to natural events such as high flows and low flows in the system despite the IHAS scores indicating generally adequate conditions. In this regard it is mainly the lack of leafy material and aquatic vegetation at many of the sites that may negatively affect diversity and sensitivity as well as the effects of freshets and low flows in the system. In addition seasonal changes in flow rate may also affect sensitive taxa.

  It is considered essential that a quarterly aquatic biomonitoring program be initiated for at least one year prior to the proposed mining commencing to obtain detailed seasonal baseline data for future reference.

4.7 Aquatic Macro-invertebrates: MIRAI

The MIRAI assessment was applied to each site. The DWS PES/EIS database were consulted to identify expected macro-invertebrate taxa, supplemented with all taxa collected from the combined spreadsheets of all the sites assessed. The calculated percentage contribution of taxa actually present for each of the preference criteria are tabulated in the discussions that follow. Calculations were performed by dividing number of taxa actually present, dividing it by number of taxa expected to occur and multiplying by 100 to express the ratio as a percentage.

Table 22: Percentage of taxa represented for each preference criterion listed per site in the Pandana (CK1 to CK3) and Sibabe (CK4) River for the April 2013 (CK1 only) and February 2014 assessment.

Variable	Criteria	Percentage occurrence of taxa showing preferences at each of the sites				
		CK4 Feb14	CH3 Feb14	CH2 Feb14	CH1 Feb14	CH1 Apr13
Flow	Very Fast (>0.6 m/s)	22.22	11.11	11.11	0.00	11.11
	Moderately Fast (0.3-0.6 m/s)	10.00	20.00	20.00	10.00	0.00
	Slow (0.1-0.3 m/s)	0.00	0.00	0.00	0.00	0.00
	Very Slow (<0.1 m/s)	6.25	12.50	12.50	6.25	6.25
Habitat	Bedrock	0.00	100.00	100.00	0.00	0.00
	Cobbles	11.76	11.76	11.76	0.00	5.88
	Vegetation	0.00	0.00	0.00	0.00	0.00
	Gravel, Sand, Mud	28.57	28.57	28.57	28.57	14.29
	Water	0.00	0.00	0.00	0.00	0.00
Water quality	High	0.00	0.00	0.00	0.00	0.00
	Moderate	11.76	11.76	11.76	0.00	5.88
	Low	10.00	15.00	15.00	10.00	5.00
	Very Low	0.00	0.00	0.00	0.00	0.00

Table 23: Percentage of taxa represented for each preference criterion listed per site in the Pandana (CK5 and CK6) for the June 2015 assessment.

Variable	Criteria	Percentage occurrence of taxa showing preferences at each of the sites	
		CK5 Jun 2015	CK6 Jun 2015
Flow	Very Fast (>0.6 m/s)	44.44	22.22
	Moderately Fast (0.3-0.6 m/s)	10.00	30.00
	Slow (0.1-0.3 m/s)	0.00	0.00
	Very Slow (<0.1 m/s)	18.75	18.75
Habitat	Bedrock	0.00	0.00
	Cobbles	29.41	23.53
	Vegetation	7.69	0.00
	Gravel, Sand, Mud	14.29	14.29
	Water	0.00	10.00
Water quality	High	0.00	20.00
	Moderate	35.29	23.53
	Low	5.00	10.00
	Very Low	0.00	0.00

Table 24: Summary of the results (ecological categories) obtained from the application of the MIRAI to the various assessment sites on the Pandana and Sibabe Rivers.

River	Site	Assessment	MIRAI score	MIRAI class	SASS5 for comparison	
					Dickens and Graham (2001)	Dallas (2007)
Pandana	CK3	February 2014	41.45	D	E	B
	CK2		42.11	D	E	A/B
	CK1		55.67	D	E	B
	CK1	Apr 2013	55.47	D	D	D
	CK5	June 2015	50.26	D	B	C
	CK6		47.46	D	C	C
	CK5	Sept 2015	47.25	D	E	C
Sibabe	CK4	February 2014	54.04	D	E	C

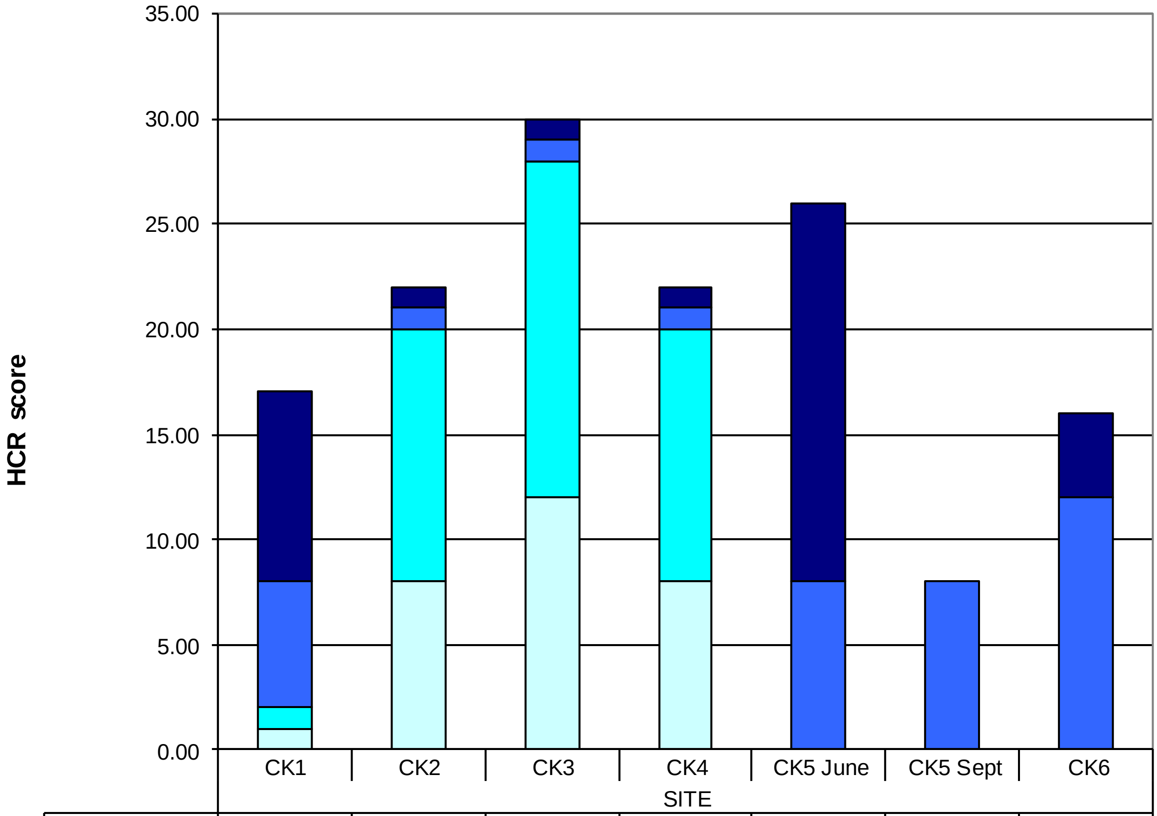
In terms of ecological category classification, the MIRAI Ecostatus tool revealed an ecostatus classification of class D for all sites. The MIRAI is a more robust index and less prone to variability compared to the SASS5 indices, particularly the Dallas (2007) classification system which is very sensitive to changes in ASPT scores. The MIRAI classification indicates a lower class from what can be expected based on the desktop assessment. Over time the aquatic biomonitoring will allow a better understanding of both spatial and temporal trends within the system.

All macro-invertebrate indices indicated a lower diversity than expected, as indicated by the SASS5 score, with variation in the number of sensitive taxa being present, as indicated by the ASPT score. As discussed previously the reasons for this appears not to be current anthropogenic impacts, but rather habitat constraints, lack of flow variability and potentially also seasonal effects in flow rate and the effects of freshets during the assessments undertaken. Some impact from alien vegetation encroachment is likely and can be considered a significant driver of change in the system. Long term, natural variation of biological activities within the system may also affect macro-invertebrate community dynamics. Future monitoring efforts will help to identify and elucidate trends in temporal variation which is considered essential for the future monitoring of the system.

4.8 Fish Community Integrity

The HCR (Habitat Cover Rating) results for the various sites assessed on the Pandana and Sibabe Rivers are graphically presented in Figure 33.

It is clear that the systems are characterised by a wide variety of flow and depth types. Sites CK1, CK5 and CK6 were dominated by slow flow conditions with both deep and shallow areas, the former providing additional cover to fish fauna. Sites CK2, CK3 and CK4 presented with faster flow conditions, once again with both deep and shallow habitat types. The system has a good balance between pools and riffle areas and the system therefore provides good foraging and breeding habitat as well as an abundance of refugia under low flow conditions.



	CK1	CK2	CK3	CK4	CK5 June	CK5 Sept	CK6
Slow - Deep	9.00	1.00	1.00	1.00	18.00	0.00	4.00
Slow - Shallow	6.00	1.00	1.00	1.00	8.00	8.00	12.00
Fast - Deep	1.00	12.00	16.00	12.00	0.00	0.00	0.00
Fast – Shallow	1.00	8.00	12.00	8.00	0.00	0.00	0.00

Figure 33: HCR scores for the sites assessed on the Pandana (CK1 to CK3, CK5 and CK6) and Sibabe (CK4) Rivers

Sampling for fish was conducted over a 30 minute period using electronarcosis methods as well as cast netting and using a hand held sweep net. Results of the collection are summarised below:

Table 25: Fish collected from the various sites on the Pandana and Sibabe Rivers

River	Site	Species collected or observed	FROC	FRAI score	FRAI ecological classification
Pandana	CK3	None	NA	16.8	F
	CK2	None	NA	17.3	F
	CK1	None	NA	16.9	F
	CK5	*Chiloglanis emarginatus* (Phongolo rock catlet)	1	25.9	E
		Barbus anoplus	2		
	CK6	*Chiloglanis emarginatus* (Phongolo rock catlet)	1	28.4	E
		Barbus anoplus	2		
Sibabe	CK4	*Chiloglanis emarginatus* (Phongolo rock catlet)	1	22.5	E

NA = Not applicable

No fish specimens were collected from sites CK1 to CK3 located on the Pandana River within the project area (Ck1 assessed April 2013 and February 2014 and CK2 and CK3 assessed February 2014).

However, *Chiloglanis emarginatus* (Phongolo rock catlet) was collected from the Sibabe River (site CK4, assessed February 2014) and also at sites CK5 and CK6 on the Pandana River (assessed June 2015). The former (CK4) is situated outside and to the north-west of the subject property. In addition *Barbus anoplus* specimens were also collected from sites CK5 and CK6 (assessed June 2015). Below (Figures 34 and 35) are pictures of the specimens collected.

Figure 34: *Chiloglanis emarginatus* (Phongolo rock catlet) collected from the Sibabe River (site CK4) in February 2014.

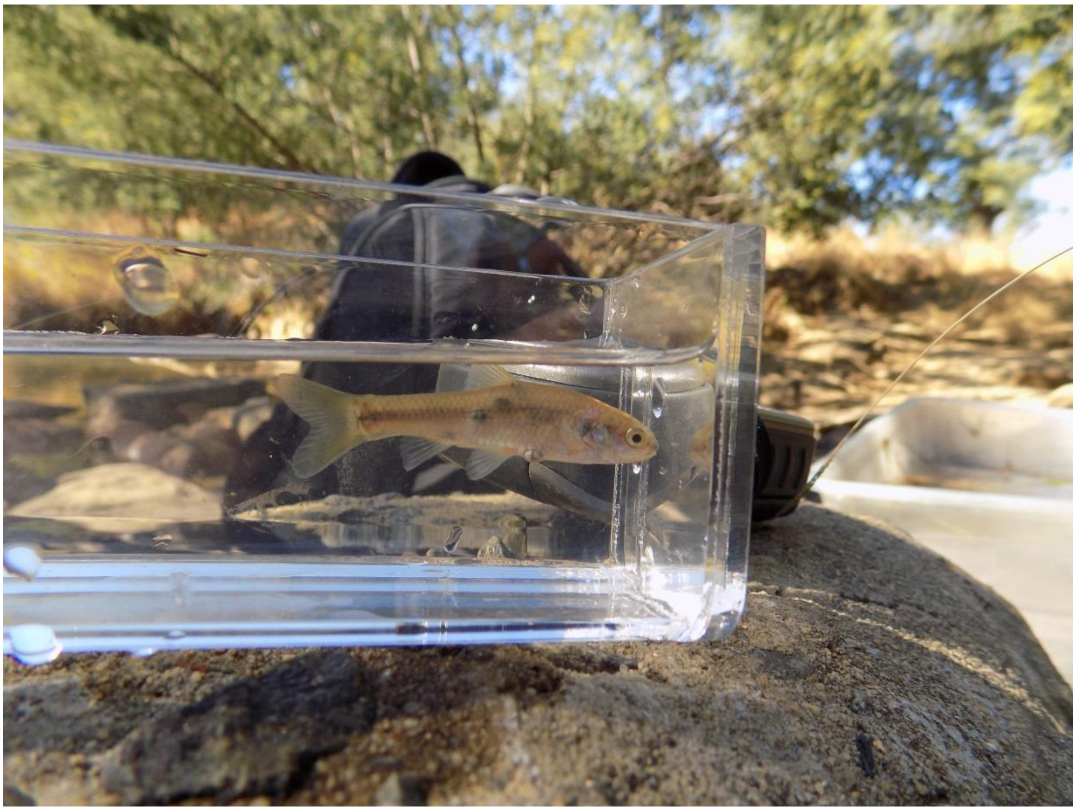


Figure 35: ***Chiloglanis emarginatus*** **(Phongolo rock catlet) at the top and** ***Barbus anoplus*** **(chubbyhead barb) at the bottom, collected from the Pandana River (sites CK5 and CK6) in June 2015.**

Fewer fish species were observed/captured than expected based on the available DWS RQIS PES/EIS data available:

- ➢ The most likely reasons for the lower than expected diversity of fish species collected in the systems are most probably related to:
  - deep habitat at some of the sites which makes fish collection and effective sampling difficult;
  - fish migration, with specific reference to eel species, is likely to occur within free flowing river systems and some seasonal variation in fish community assemblage is deemed likely; and
  - the effects of freshets which affected sampling during the 2013 and 2014 assessments
- ➢ Due to the lower than expected fish community diversity in the system, the use of aquatic macro-invertebrates is considered more appropriate as future biological monitoring tool;
- ➢ However, it is recommended that fish sampling be continued to monitor the populations of *Chiloglanis* spp. within these systems, as further discussed below. Both *Chiloglanis anoterus* and *C. emarginatus* are listed in the DWS PES/EIS database. These two species and their importance from a conservation point of view will be discussed in the paragraphs that follow.

Chiloglanis anoterus **(pennant-tailed rock catlet) and** ***Chiloglanis emarginatus*** **(Phongolo rock catlet)**

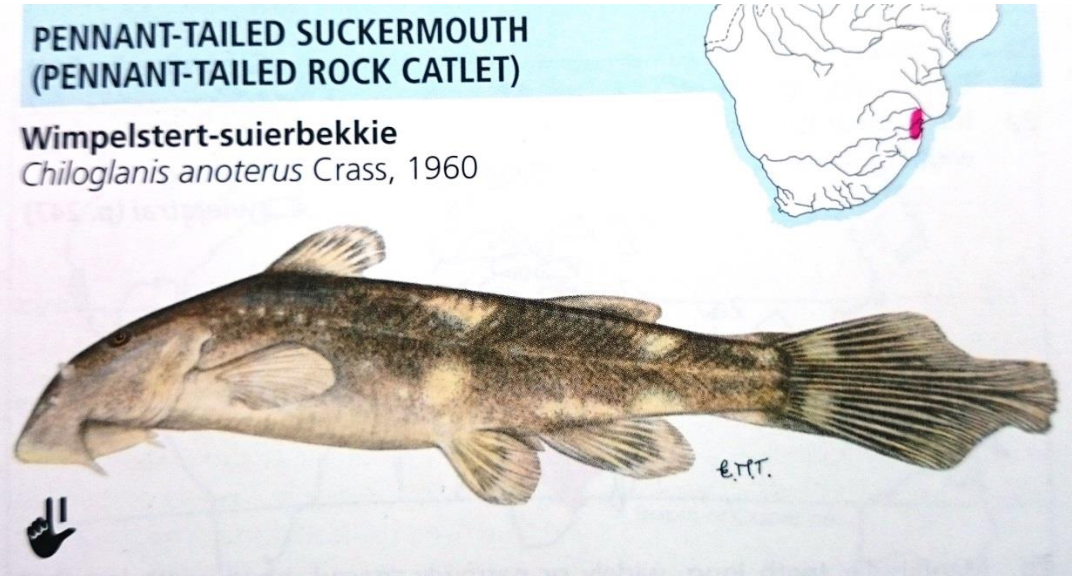


Figure 36: ***Chiloglanis anoterus*** **(pennant-tailed rock catlet) as depicted in Skelton (2001).**

Figure 37: *Chiloglanis emarginatus* (Phongolo rock catlet) as depicted in Skelton (2001).

Both fish species found within tributaries of the Pongola River system (Skelton, 2001) and are categorised to fall in the "Least Concern" category, being considered widespread within their distribution range. However, considering the very limited distribution of *C. emarginatus*, it is described as "near threatened" by Skelton (2001). *Chiloglanis anoterus* occurs in upper catchments in fast flows of rocky habitats, typically in the fastest and often shallowest riffles. In turn *C. emarginatus* occurs in larger streams and rivers over cobbles and rocks, often in deeper water when compared to habitat preferences of *C. anoterus* and *Chiloglanis pretoriae* (http://www.iucnredlist.org/details/63365/0).

It can be concluded that the aquatic ecosystems in the region of the subject property provide suitable habitat for rare and endangered species conservation. Whilst neither of the *Chiloglanis* spp. discussed in the sections above is considered by the IUCN to be threatened species, they are very sensitive to changes in habitat conditions. This is evident from the fact that *C. emarginatus* has locally gone extinct from its type locality, the Lekkerloop stream, due to excessive water extraction by farmers during the dry season (http://www.iucnredlist.org/details/63366/0). This species is also described as "near threatened" by Skelton (2001). As can be seen from the Skelton (2001) distribution maps, it is populations of both *C. emarginatus* and *C. anoterus* that may potentially be at risk. Local extinction of any populations that occur in the systems assessed, with specific reference to *C. emarginatus*, will have a significant impact on the conservation status of the species.

Introduction of predacious alien fish species and habitat degradation from impacts such as water extraction, flow modification/river regulation and sedimentation from agro-forestry activities are considered serious threats to these species. Given the largely natural state of the aquatic resources within the larger area, the aquatic ecosystems are considered to be highly sensitive. Any mining activities, if not adequately mitigated, are expected to have a detrimental impact on aquatic ecosystems function, including fish communities, in the subject property. Mining in the direct vicinity of any aquatic ecosystems is thus discouraged.

4.9 Stream profiling and velocity assessments

A point near to the CK5 aquatic biomonitoring point was selected in order to calculate streamflow velocities and discharge volumes. The GPS co-ordinates captured for the cross section are: Left Bank Peg 27°24'44.0"S, 301°25'54.2"E. Refer to the figure below for photographs taken of the profile point. During the site visit the following activities were undertaken:

- A survey of the cross sectional profile of the site using basic measurements of the bed profile and water depth;
- Velocity measurements were rapidly measured in the field using the Velocity head Plate (VHP) every 200mm across the channel; and
- Discharge was calculated based on the VHP data and the depth of the stream;

Velocity was assessed at two cross sections in order to improve the reliability of the assessment under the low flow conditions. The site selected for this assessment is located downstream of all proposed mining operations and is characterised by a cobble-dominated riffle within a fairly incised channel which would allow volume under higher flows to be easily calculated. Habitat at this point consisted of eroded incised banks with a cobble substrate and with limited sandy deposits and not bankside vegetation. It must be noted that the velocity and flow measurement cross section point was not completely ideal with some individual cross section points measured having low flows which made measurements using the Velocity Head Plate VHP inaccurate, due to small to negligible head readings;

Based on the cross sections undertaken two total volume readings were obtained at cross section 1 and 2. The two values were 29.07 and 29.97 l/s for cross section 1 and 2 respectively giving an average measured discharge of 29.5l/s showing a variance of 3%. At the time of assessment the river was experiencing extremely low flows. Based on the observations made it is tentatively considered that should the flow in the Pandana River at the CK5 site decrease by more than 15% (<25/l/s) significant impacts on the aquatic ecology of the system would occur with the fish and aquatic macro-invertebrate community becoming strained.

CK5 (CS point)
GHRU 2 VERY FAST RAPID WITH DENSE FISH POPULATION

UPSTREAM

DOWNSTREAM

LEFT BANK

RIGHT BANK

Figure 38: Various photographs of the Cross Section point site

Figure 39: Photograph of the Transect point at the Cross Section site

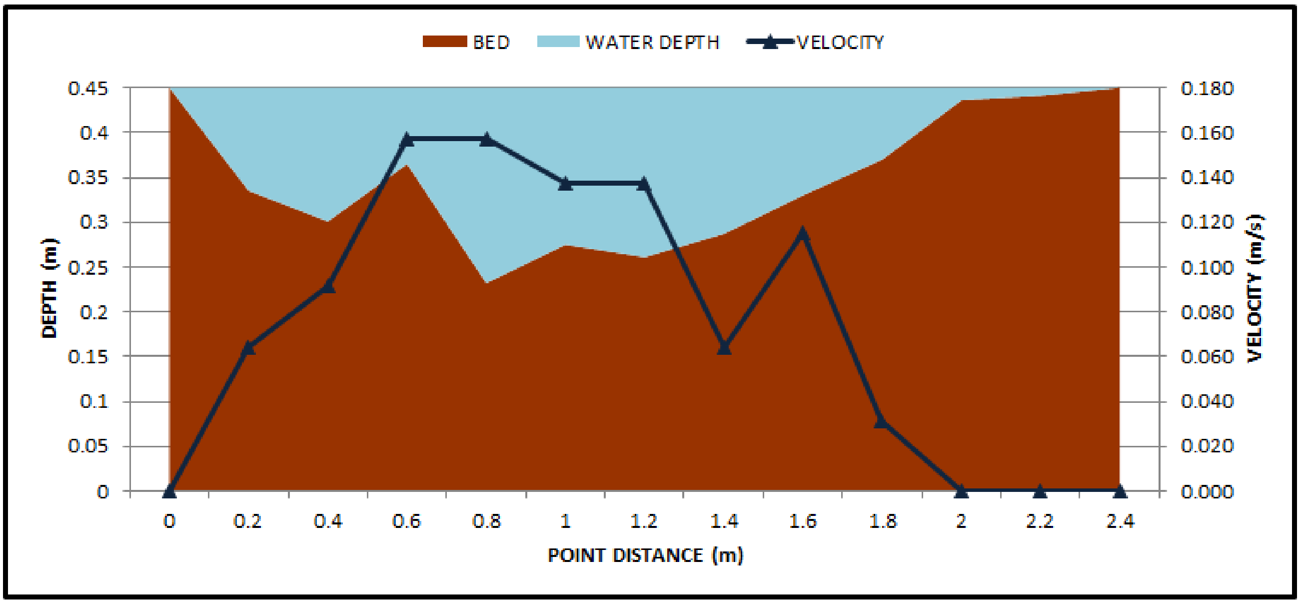


Figure 40: The cross sectional profile of the Cross Section point site and the stream velocity across the stream based on VHP data for cross section 1

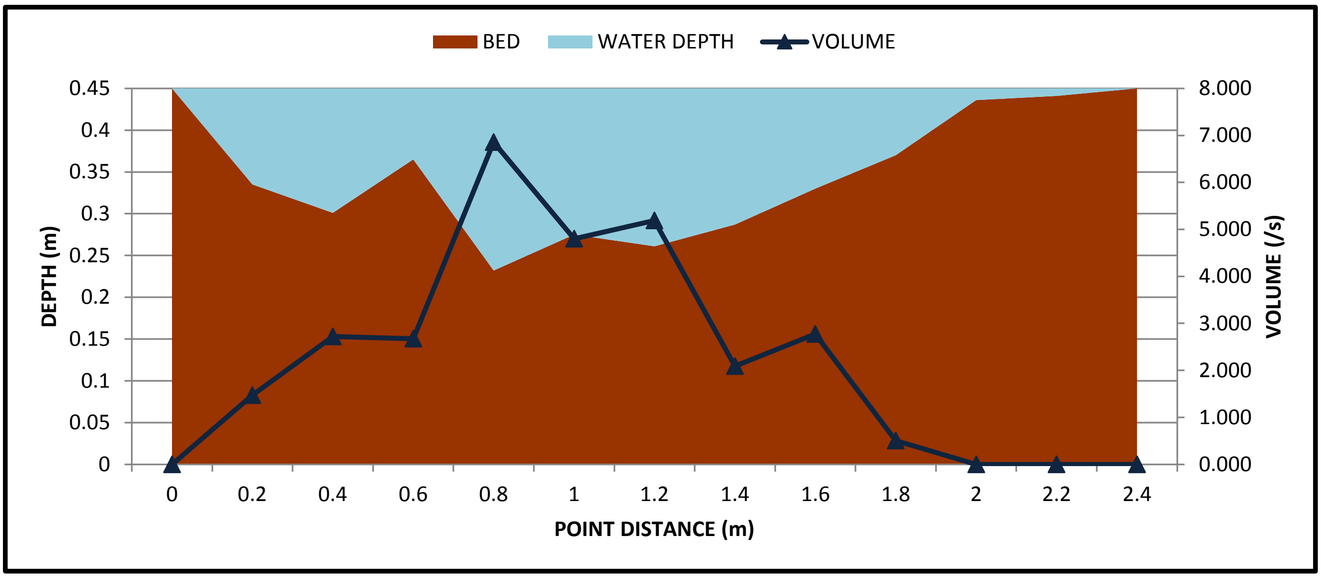


Figure 41: The cross sectional profile of the Cross Section point site and the stream volume across the stream based on VHP data for cross section 1

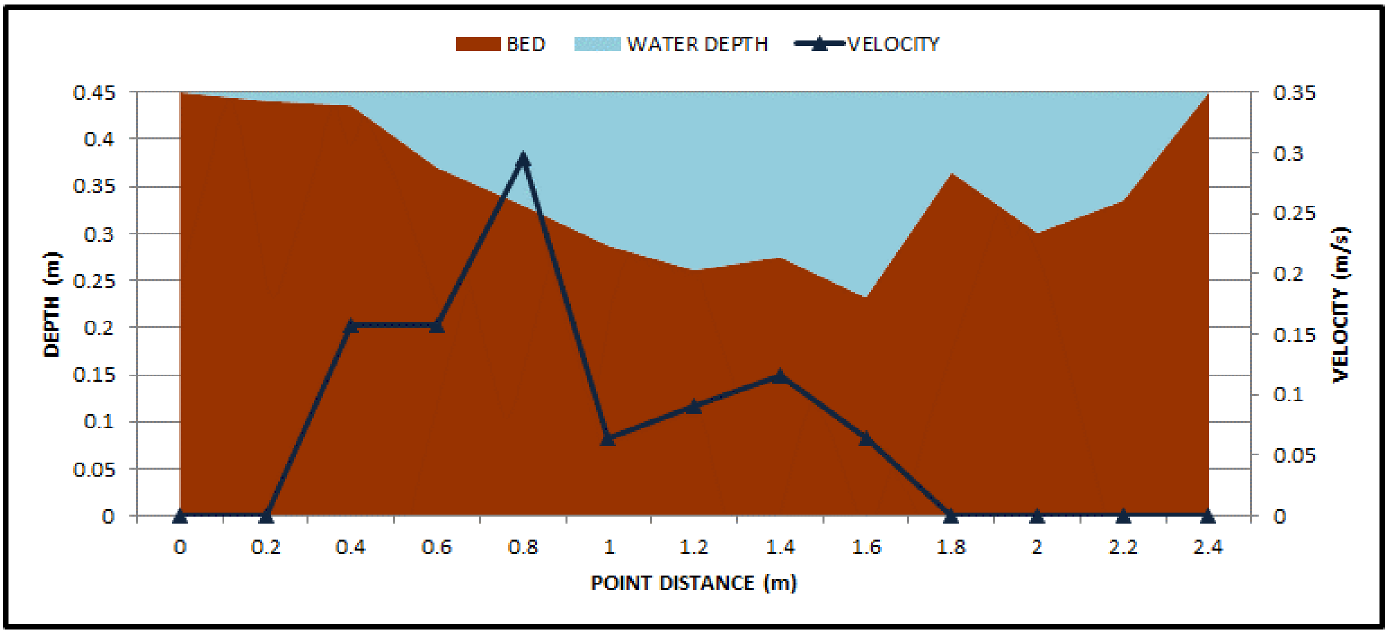


Figure 42: The cross sectional profile of the Cross Section point site and the stream velocity across the stream based on VHP data for cross section 2

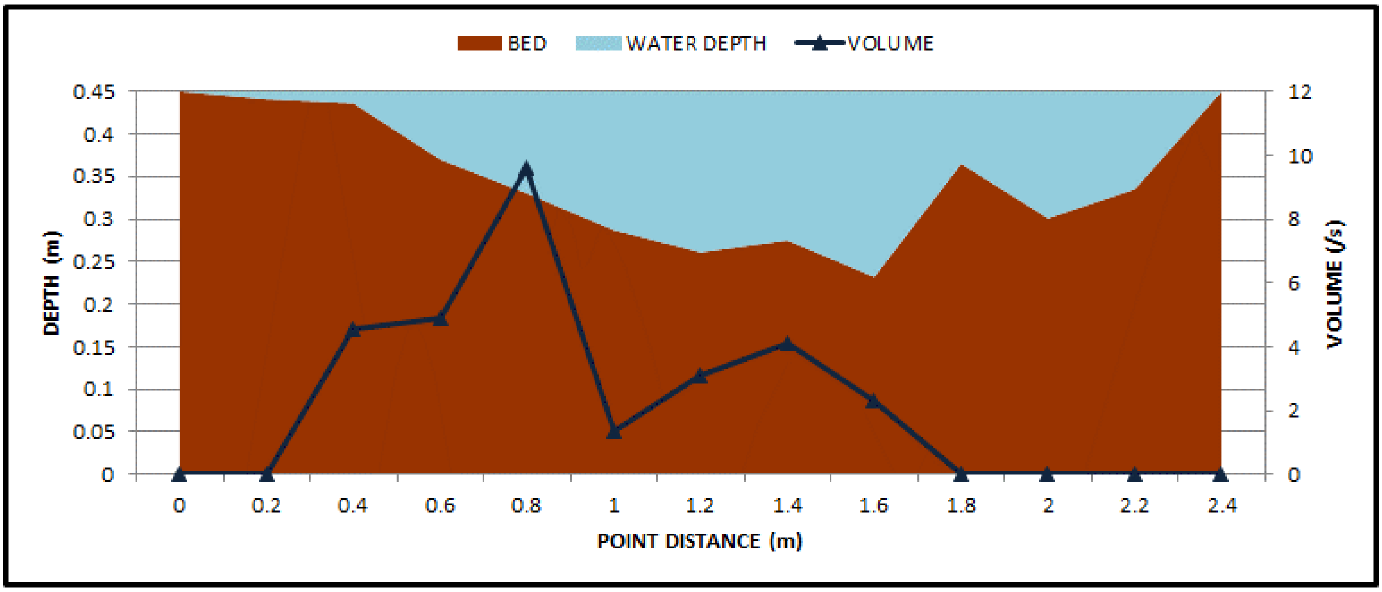


Figure 43: The cross sectional profile of the Cross Section point site and the stream volume across the stream based on VHP data for cross section 2

4.10 Aquatic Ecological Importance and Sensitivity

The EIS method was applied to the Pandana and Sibabe Rivers in order to ascertain the current sensitivity and importance of the systems. The results of the assessment are presented in the table below.

Table 26: Results of the EIS assessment for the Pandana River inside the subject property and the Sibabe River outside the subject property.

Biotic Determinants	**Pandana River**	**Sibabe River**
Rare and endangered biota	4	4
Unique biota	3	3
Intolerant biota	3	3
Species/taxon richness	2	2
Aquatic Habitat Determinants	-	-
Diversity of aquatic habitat types or features	3	3
Refuge value of habitat type	3	2
Sensitivity of habitat to flow changes	3	3
Sensitivity of flow-related water quality changes	1	1
Migration route/corridor for instream and riparian biota	2	2
Nature Reserves, Natural Heritage sites, Natural areas, PNEs	2	2
RATING AVERAGE	**2.6**	**2.5**
EIS CATEGORY	**High**	**High**

The Ecological Importance and Sensitivity Assessment analysis for the Pandana River yielded a score of 2.6 whilst a score of 2.5 was obtained for the Sibabe River. Conditions at both sites are thus regarded as highly important and sensitive. The increased importance and sensitivity of the streams are mainly as a result of the largely unimpacted environment and presence of sensitive aquatic species utilising the system, with specific reference to *C. emarginatus*. The system has some importance with regards to use as a migration corridor, and the provision of refugia for species relying on the system. The system has a fair diversity of habitat features.

Furthermore the system is considered moderately sensitive to alterations in flow and flow-related water quality changes, with year round water required in the system.

4.11 Aquatic Ecological Trends

The trend in ecological status gives an idea whether the present state is realistic and would stay the same if the management of the catchment were to continue in the same way that gave rise to the present state. Thus the definition of the trend is *"…viewed as a directional change in the attributes of the drivers and biota (as a response to drivers) at the time of the PES assessment. A trend can be absent (close to natural or in a changed state but stable), negative (moving away from reference conditions) or positive (moving back towards natural - when alien vegetation is cleared, for instance). The ultimate objective is to determine if the biota have adapted to the current habitat template or are still in a state of flux",* Kleynhans and Louw (2008).

The ecological trends are presented in Table 27 below if the proposed mining development was not to take place.

Table 27: Ecological trends for the Pandana and Sibabe River systems

Component	Trend	Reason	Confidence (0-5)*
Fish	Stable	Upstream impacts not expected to change significantly in the foreseeable future	2
Macro-invertebrates	Stable	Upstream impacts not expected to change significantly in the foreseeable future	2
Riparian Vegetation	Decline	Alien vegetation encroachment and harvesting of vegetation may increase over time.	2
Fluvial geomorphology	Decline	Further erosion and sedimentation of the river is deemed likely	3
Hydrology	Stable	Upstream impacts not expected to change significantly in the foreseeable future	2
Physico-chemical	Stable	Upstream impacts not expected to change significantly in the foreseeable future	2

*** 0 – no confidence to 5 – high confidence**

4.12 Aquatic sensitivity mapping

Please refer to the wetland delineation report (Section D) for aquatic resource sensitivity mapping which has been included in the wetland sensitivity mapping.

5. CONCLUSION ON AQUATIC ASSESSMENT

The following tables and associated summary provides the key findings of the study:

Table 28: Summary of desktop assessment PES/EIS results for the Pandana and Sibabe River systems (tributaries of the Pongolo River)

Quaternary catchment (QC) level – Kleynhans (1999)					
QC	**Resource**	**EISC**	**DEMC**	**PESC**	**Best AEMC**
W42A	**Pongolo**	**High**	**B**	**A**	**A**
Sub-quaternary catchment reach (SQR) level – DWS PES/EIS database					
SQR	**Resource**	**PES**	**Mean EI**	**Mean ES**	**Default EC**
W42A-02261	**Pongolo**	**C**	**High**	**Very high**	**A**
W42A-02328	**Pandana**	**C**	**High**	**Very high**	**A**

EISC = Ecological Importance and Sensitivity Category; DEMC = Default Ecological Management Class;
PESC = Present Ecological Status Category; Best AEMC = Best attainable Ecological Management Class;
PES = Present Ecological State; EI = Ecological Importance;
ES = Ecological Sensitivity;
EC = Ecological Category; default based on median PES and highest of EI or ES means.

Table 29: Summary of aquatic assessment results for the Pandana and Sibabe River systems

Variable	**Survey**	**Pandana River**					**Sibabe River**
		CK3	**CK2**	**CK1**	**CK5**	**CK6**	**CK4**
VEGRAI	Combined	**E**					**B**
IHAS	Combined	**Adequate**	**Adequate**	**Adequate**	**Adequate**	**Adequate**	**Adequate**
IHIA	Combined	**D**	**C**	**C**	**C**	**B**	**A**
SASS5 (Dickens and Graham 2001)	April 2013	NA	NA	**D**	NA	NA	NA
	February 2014	**E**	**E**	**E**	NA	NA	**E**
	June 2015	NA	NA	NA	**B**	**C**	NA
SASS5 (Dallas 2007)	April 2013	NA	NA	**D**	NA	NA	NA
	February 2014	**B**	**A/B**	**B**	NA	NA	**C**
	June 2015	NA	NA	NA	**C**	**C**	NA
MIRAI	Combined	**D**	**D**	**D**	**D**	**D**	**D**
FRAI	Combined	**F**	**F**	**F**	**E**	**E**	**E**
EIS	Combined	**High**					**High**

NA = Not applicable; VEGRAI = Riparian Vegetation Response Assessment Index; IHAS = Invertebrate Habitat Assessment; IHIA = Intermediate Habitat Assessment; SASS5 = South African Scoring System 5; MIRAI = Macro-Invertebrate Response Assessment Index; FRAI = Fish Response Assessment Index

Based on the findings of this study it is evident that the aquatic resources of the area are of high aquatic Ecological Importance and Sensitivity.

This is largely due to the project area being located adjacent to conservancies and protected areas and recreational/tourism areas. In addition, sampling indicated healthy populations of the near threatened Phongolo rock catlet (*C. emarginatus*).

Whilst there are also anthropogenic activities in the area which include agricultural activities, farm- and homesteads and associated community activities such as schools, these are considered to pose a very limited threat to ecological function and processes within the project area. Impacts from erosion and sedimentation as well as impacts from alien vegetation encroachment in the system are considered to be highly significant. Therefore, on this basis, should the project proceed it will have an ecological impact of high significance both within and potentially beyond the boundaries of the project.

The potential for post-closure impacts on water quality are of concern. With a simulated steady-state groundwater inflow rate of 20.1 l/s), it would take theoretically 22 years before the mine voids are completely flooded. It is widely accepted that the underground mines also decant, usually at the same rate as recharge (inflows) and a significant impact on water quality can be expected which in turn will impact on the aquatic ecology of the Pandana River system.

Therefore, unless it is considered economically feasible to treat and/or contain all potential sources of contaminated water which may affect the receiving environment post-closure indefinitely to pre-mining water quality standards in such a way as to support the post closure land use and the ecological reserve, the project is regarded as posing a very high long term impact on the region.

It is highly recommended that should the proposed mining development proceed, infrastructure required to access the resource must be kept to the absolute minimum. Furthermore, extensive mitigation must be applied during the construction and operational phases of the project to ensure that no impact takes place beyond the surface infrastructure footprint and an acceptable zone of edge effects. In this regard particular mention is made of the management of surface water and the dirty water area of the mine footprint.

Exceptionally strict monitoring throughout the life of the mine and post-closure is required in order to ensure the health and functioning of the terrestrial, wetland and aquatic ecosystems is retained, and monitoring data must be utilised to proactively manage any identified emerging

issues in a well-managed and overseen BAP, which must be implemented through an automated EMS system. The rehabilitation of the infrastructure during closure of the mine must take place in such a way as to ensure that the post closure land use objectives are met and which ensure that no long term impacts on the aquatic biota of the Pandana River occur. The wetland and aquatic resources will need to be rehabilitated in such a way as to support the larger wetland systems at the same level as those evident in the pre-mining condition.
In order to meet this objective rehabilitation will need to be well planned and a suitably qualified ecologist must form part of the management team through the entire life cycle of the project and to guide the rehabilitation and closure objectives of the mine.

The objective of this study was to provide sufficient information on the ecology of the area, together with other studies on the physical and socio-cultural environment, in order for the Environmental Assessment Practitioner (EAP) and the relevant authorities to apply the principles of Integrated Environmental Management (IEM) and the concept of sustainable development. The needs for conservation as well as the risks to other spheres of the physical and socio-cultural environment need to be compared and considered along with the need to ensure economic development of the country.

It is the opinion of the ecologists that this study provides the relevant information required in order to implement IEM and to ensure that the best long term use of the resources on the subject property will be made in support of the principle of sustainable development.

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APPENDIX 1: IHAS Score Sheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Pandana						
Site Name: CK1	19/04/2013					
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):			13		
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):				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):				14	
	HABITAT TOTAL (MAX 55):				38	
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):				34	
	TOTAL IHAS SCORE (%):				72	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: PANDANA						
Site Name: CK1(DS)	**Date**: 26/02/2014					
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):			16		
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):				6	
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):				18	
	HABITAT TOTAL (MAX 55):				40	
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)	>2	>1-2	1	>½-1	½	<½
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)***	flood	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	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX					**32**
	TOTAL IHAS SCORE (%):				72	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: PANDANA						
Site Name: CK2 MIDSTREAM (AT THE FARM)	**Date**: 26/02/2014					
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):			16		
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):				5	
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):				17	
	HABITAT TOTAL (MAX 55):				38	
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)	>2	>1-2	1	>½-1	½	<½
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)***	flood	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	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX 45):				27	
	TOTAL IHAS SCORE (%):				65	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: PANDANA (US)
Site Name: CK3
Date: 26/02/2014

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):	19					
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):	5					
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):	18					
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)	>2	>1-2	1	>½-1	½	<½
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)***	flood	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	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX	24					
TOTAL IHAS SCORE (%):	66					

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: SIBABE RIVER
Site Name: CK4 (REFERENCE SITE)
Date: 26/02/2014

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): 19						
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): 7						
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): 12						
HABITAT TOTAL (MAX 55): 38						
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)	>2	>1-2	1	>½-1	½	<½
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)***	flood	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	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX 45): 27						
TOTAL IHAS SCORE (%): 65						

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: PANDANE
Site Name: CK5
Date: 08/06/2015

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):	17					

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):	9					

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):	14					
HABITAT TOTAL (MAX 55):	40					

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)	>2	>1-2	1	>½-1	½	<½
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)***	flood	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	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX 45):	33					
TOTAL IHAS SCORE (%):	73					

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: PANDANE
Site Name: CK6
Date: 08/06/2015

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): 9

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: ('1-2m^2 = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m^2	rocks	1-2m^2	<1m^2	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): 38

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)	>2	>1-2	1	>½-1	½	<½
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)***	flood	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	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						

STREAM CONDITIONS TOTAL (MAX 45): 36

TOTAL IHAS SCORE (%): 74

APPENDIX 2: SASS5 Score Sheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 19/04/2013	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		1		1	Athericidae	10				
E: °	TURBELLARIA	3			1	1	Corixidae*	3					Blepharoceridae	15				
SITE CODE: CK1	ANNELIDA:						Gerridae*	5					Ceratopogonidae	5	1			1
RIVER: PANDANA	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	A		1	A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: Overcast & Cool	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: 18.2 °C	Amphipoda	13					Notonectidae*	3		A		A	Empididae	6				
Ph: 18.4	Potamonautidae*	3	A	1	A	B	Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 28.6 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			1	1	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	1			1	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: MEDIUM	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY: MEDIUM	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	1	A	B	Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		39	44	35	78
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		7	8	7	15
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		5.57	5.50	5.00	5.20
	Chlorolestidae	8					Pisuliidae	10					IHAS:	72%				
	Coenagrionidae	4		A		A	Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						TADPOLES					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5		A		A	COMMENTS:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5		A		A	SWC = South Western Cape					
	Aeshnidae	8	A		A	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					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 26/02/2014	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					Corixidae*	3					Blepharoceridae	15				
SITE CODE: CK1(DS)	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: PANDANA	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 20.6 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.6	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 7.6 mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 6.2 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			A	A
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			A	A	Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	A	A	A	B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	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				
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:**		24	17	35	40
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		3	2	5	6
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		8	8.5	7	6.7
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	72%				
	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		A		A	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6	A		A	B	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: 26/02/2014	**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					Corixidae*	3					Blepharoceridae	15				
SITE CODE: CK2 (AT THE FARM)	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: PANDANA	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 18.4 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.7	Potamonautidae*	3	**1**			**1**	Pleidae*	4					Ephydridae	3				
DO: 8.15 mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 6.1 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			**A**	**A**
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	**A**		**A**	**B**	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	**A**			**A**	**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**	**B**	Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		33	0	44	56
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		4	0	6	8
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		8	###	7	7.0
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	65%				
	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			**A**	**A**	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6			**A**	**A**	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: 26/02/2014	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					Corixidae*	3					Blepharoceridae	15				
SITE CODE: CK3 (US)	ANNELIDA:						Gerridae*	5					Ceratopogonidae	5				
RIVER: PANDANA	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: OVERCAST AND DR	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: 15.2 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 8.2	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 9.07 mg/l	Atyidae	8					Veliidae/M..veliidae*	5		A	A	B	Muscidae	1				
Cond: 8.8 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			1	1
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6	A		A	B
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6	A		A	B	Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	A	A	A	B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	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				
FLOW:	Leptophlebiidae	9	A		A	B	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	B	Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		54	17	63	69
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		7	2	9	10
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		8	8.5	7	6.9
	Chlorolestidae	8					Pisuliidae	10					IHAS:	66%				
	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					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6	A			A	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: 26/02/2014	**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	**A**		**A**	**B**	Corixidae*	3					Blepharoceridae	15				
SITE CODE: CK4	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: SIBABE RIVER	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION: (REFERENCE SITE)	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 24.1 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 8.01	Potamonautidae*	3	**A**		**A**	**B**	Pleidae*	4					Ephydridae	3				
DO: 7.2 mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1	**A**		**A**	**B**
Cond: 5.8 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	**A**		**A**	**B**
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		**A**	**A**	**B**	Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6	**A**			**A**	Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	**A**	**A**	**A**	**B**	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	**A**	**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				
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**	**B**	Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		69	22	57	73
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		11	3	10	12
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		6	7.3	6	6.1
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	65%				
	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					SWC = South Western Cape					
	Aeshnidae	8	**A**		**A**	**B**	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6	**A**		**A**	**B**	Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10	**A**			**A**	1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 08/06/2015	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	Corixidae*	3	A	B	B	B	Blepharoceridae	15				
SITE CODE: CK5	ANNELIDA:						Gerridae*	5		1		1	Ceratopogonidae	5				
RIVER: PANDANE	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	A		A	B
SITE DESCRIPTION: D/S MINE	Leeches	3					Naucoridae*	7					Culicidae*	1		1		1
WEATHER CONDITION: COOL AND DRY	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: 9.4 °C	Amphipoda	13					Notonectidae*	3		A	A	A	Empididae	6				
Ph: 8.24	Potamonautidae*	3	1	A		A	Pleidae*	4					Ephydridae	3				
DO: 9.50 mg/l	Atyidae	8					Veliidae/M..veliidae*	5			A	A	Muscidae	1				
Cond: 8.7 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5	A		1	A
SIC: 3 TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC: 2	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5	1			1
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4	A		1	A	Ancylidae	6				
M VEG OOC: 3 DOM SP:	Baetidae 2 sp	6	A		B		Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12		B		B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND: 3	Caenidae	6	A	A	A	B	Philopotamidae	10	1			1	Lymnaeidae*	3				
MUD: 2	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS: YES	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9	B		A	B	CASED CADDIS:						Thiaridae*	3				
TURBIDITY: LOW	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	B		A	B	Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		105	45	56	137
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		18	9	11	24
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		6	5.0	5	5.7
	Chlorolestidae	8					Pisuliidae	10					IHAS:	73%				
	Coenagrionidae	4	1	A		A	Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8		1		1	COLEOPTERA:						CHILOGLANIS / BARBUS					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					COMMENTS:					
	Protoneuridae	8					Elmidae/Dryopidae*	8	A			A						
	Zygoptera juvs.	6					Gyrinidae*	5	A			A						
	Aeshnidae	8	1			1	Halipidae*	5										
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					SWC = South Western Cape T = Tropical					
	Libellulidae	4			1	1	Hydrophilidae*	5	1			1	VG = all vegetation ST = Sub-tropical					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud S = Stone & rock					
	Pyralidae	12					Psephenidae	10	1			1	1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 08/06/2015	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		A	B	B	Blepharoceridae	15				
SITE CODE: CK6	ANNELIDA:						Gerridae*	5	A			A	Ceratopogonidae	5	1			1
RIVER: PANDANE	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	A	A	A	B
SITE DESCRIPTION: D/S ON MAIN ROAD	Leeches	3					Naucoridae*	7					Culicidae*	1		1		1
WEATHER CONDITION: COLD AND DRY	CRUSTACEA:						Nepidae*	3		1		1	Dixidae*	10			1	1
TEMP: 11.5 °C	Amphipoda	13					Notonectidae*	3			1	1	Empididae	6				
Ph: 7.78	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 8.35 mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 7.1 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1			1	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	A			A	Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6	A	B			Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12			B	C	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	A	A	B	B	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS: YES	Heptageniidae	13	A		A	A	Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9	B			B	CASED CADDIS:						Thiaridae*	3				
TURBIDITY: LOW	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:		76	36	63	114
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6		A		A	NO OF TAXA:		12	9	10	20
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		6	4.0	6	5.7
	Chlorolestidae	8					Pisuliidae	10					IHAS:	74%				
	Coenagrionidae	4	A	A		A	Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					COMMENTS:					
	Protoneuridae	8					Elmidae/Dryopidae*	8	A		A	A						
	Zygoptera juvs.	6					Gyrinidae*	5		A		A						
	Aeshnidae	8					Halipidae*	5										
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					SWC = South Western Cape T = Tropical					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation ST = Sub-tropical					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud S = Stone & rock					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

APPENDIX 3: IHIA Score Sheets

Instream Zone Habitat Integrity

Weights		14	13	13	13	14	10	9	8	6	N/A	N/A
Reach	ASSESSMENT DATE	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
CK1	Apr 13, Feb 14	1	8	11	11	4	1	0	1	1	72.00	Class C
CK2	Feb 14	1	8	12	12	4	1	0	1	1	71.02	Class C
CK3	Feb 14	1	11	13	13	4	6	0	1	1	62.13	Class C
CK4	Feb 14	1	1	1	2	2	1	0	0	0	95.84	Class A
CK5	Jun 15	1	8	4	13	4	6	0	0	0	77.51	Class C
CK6	Jun 15	1	3	3	4	4	1	0	0	0	91.60	Class A

None *Small* *Moderate* *Large* *Serious* *Critical*

Riparian Zone Habitat Integrity

Weights		13	12	14	12	13	11	12	13	N/A	N/A
Reach	ASSESSMENT DATE	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
CK1	Apr 13, Feb 14	8	8	6	1	7	11	2	3	74.00	Class C
CK2	Feb 14	11	13	7	1	8	11	2	2	60.76	Class C
CK3	Feb 14	11	12	8	1	11	13	2	5	52.39	Class D
CK4	Feb 14	2	1	2	1	2	1	0	1	94.88	Class A
CK5	Jun 15	6	18	9	1	6	11	2	3	60.69	Class C
CK6	Jun 15	7	12	7	1	2	3	2	0	78.92	Class C

None *Small* *Moderate* *Large* *Serious* *Critical*

REACH	ASSESSMENT DATE	INSTREAM HABITAT	RIPARIAN ZONE	IHI SCORE	CLASS
CK1	Apr 13, Feb 14	72.00	74.00	73.00	Class C (Moderately modified)
CK2	Feb 14	71.02	60.76	65.89	Class C (Moderately modified)
CK3	Feb 14	62.13	52.39	57.26	Class D (Largely modified)
CK4	Feb 14	95.84	94.88	95.36	Class A (Unmodified/natural)
CK5	Jun 15	77.51	60.69	69.10	Class C (Moderately modified)
CK6	Jun 15	91.60	78.92	85.26	Class B (Largely natural)