FLORAL, FAUNAL, WETLAND AND AQUATIC ECOLOGICAL ASSESSMENT AS PART OF THE ENVIRONMENTAL ASSESSMENT AND AUTHORISATION PROCESS FOR THE PROPOSED CONSTRUCTION OF A FERROCHROME SMELTER NEAR NORTHAM, LIMPOPO PROVINCE

Prepared for

SLR Consulting (Africa) (Pty) Ltd.

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SECTION E – Aquatic Assessment

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1 INTRODUCTION

1.1 Background

Scientific Aquatic Services (SAS) was appointed to conduct a faunal, floral, wetland and aquatic ecological assessment as part of the environmental assessment and authorisation process for the proposed construction of a new ferrochrome (FeCr) Smelter located immediately adjacent to the existing Union Section Mine on Portion 3 of the farm Grootkuil 409 KQ, in the Thabazimbi Local Municipality, Limpopo Province. The proposed Siyanda ferrochrome smelter (hereafter referred to as the 'Project Infrastructure Area'), which will in broad terms comprise a railway siding, a raw materials offloading area, two 70 MW DC furnaces, crushing and screening plant, slag dump and baghouse slurry dam, as well as related facilities such as material stockpiles, workshops, stores and various support infrastructure and services, is located within the western portion of Portion 3 of the farm Grootkuil 409 KQ. In addition, an overhead powerline as well as one access road is proposed, with two access road alternatives, namely Access Road Corridor Option 2 and Access Road Option 3, being considered for development. The proposed powerline will originate from the Spitzkop substation to the southeast of Portion 3 of the farm Grootkuil 409 KQ, run north towards the southeastern corner of Portion 3 of the farm Grootkuil 409 KQ and from there extend along the southern boundary of the property towards the Project Infrastructure Area. The proposed Project Infrastructure Area, together with the proposed powerline and the two access road alternatives, of which only one will be developed, are hereafter referred to as the 'project site' (Figures 1 & 2). As part of the ecological assessment, the remainder of Portion 3 of the farm Grootkuil 409 KQ was also assessed, and, together with the project site, is hereafter referred to as the 'study area'.

The Project Infrastructure Area is situated approximately 10km to the west of the R510 regional road and 8km to the northwest of the town of Northam, and approximately 1,5km to the south of the Brits Road. The Swartklip Mine Village (developed as part of the Union Section Mine) is located immediately to the southwest of the Project Infrastructure Area.

This section of the report addresses the aquatic ecological conditions in the vicinity of the study area and an assessment of the impacts on the resources as a result of the proposed development activities.

Six sites were assessed, namely SC1 – SC6, located on the unnamed tributary, Brakspruit and Phufane streams. Factors investigated included the visual conditions of the site, including an identification of any impacts on the streams at each point and the physico-chemical water quality variables at each site. Intermediate Habitat Integrity Assessment (IHIA) and habitat suitability for aquatic macro-invertebrates was determined using the Invertebrate Habitat Assessment System (IHAS) method. The integrity of the aquatic macro-invertebrate community was assessed using the South African Scoring System version 5 (SASS5). The sampling points are presented on the maps (Figures 1 & 2) which indicate the area under investigation.

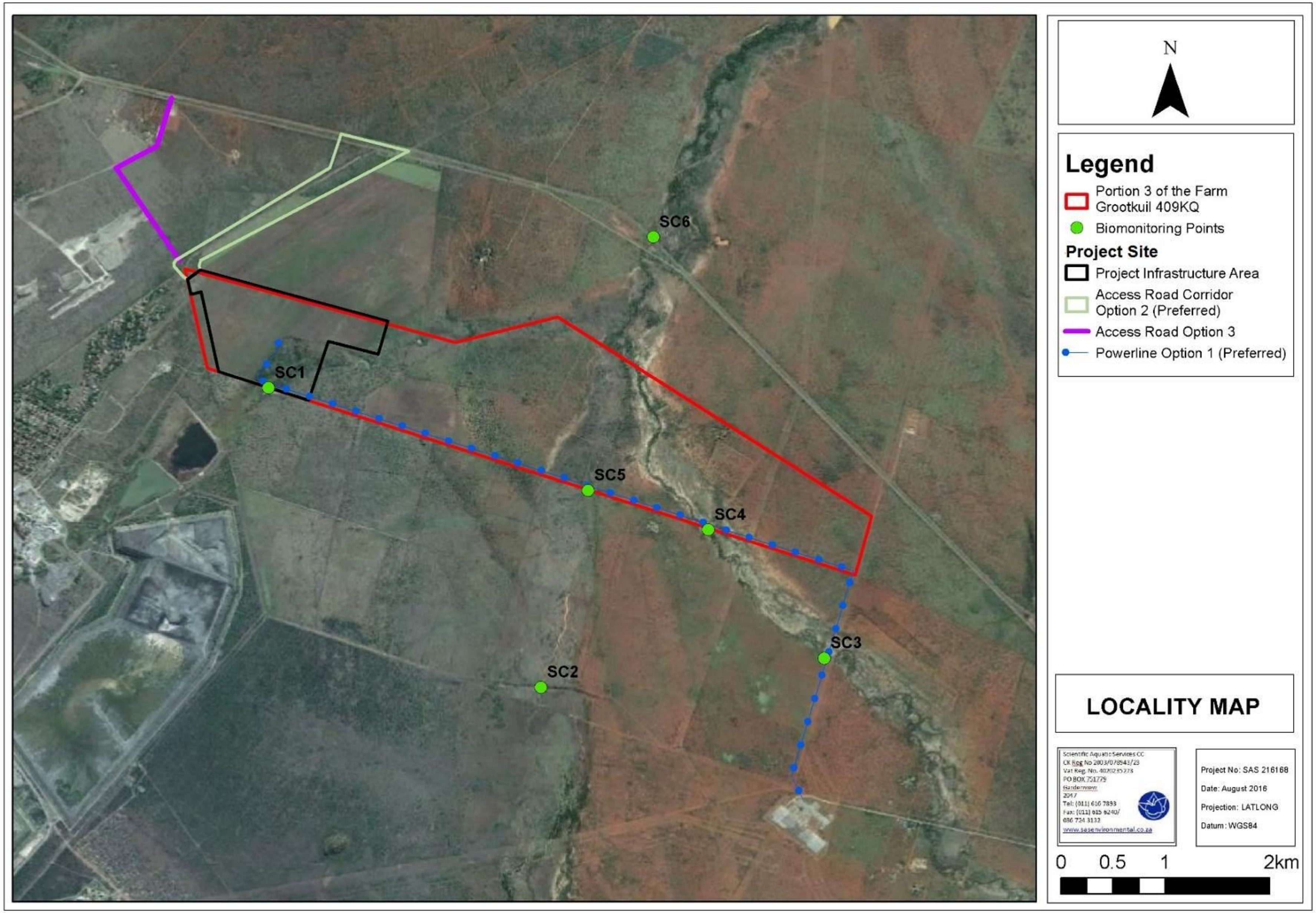


Figure 1: A digital satellite image showing the study area and the biomonitoring points.

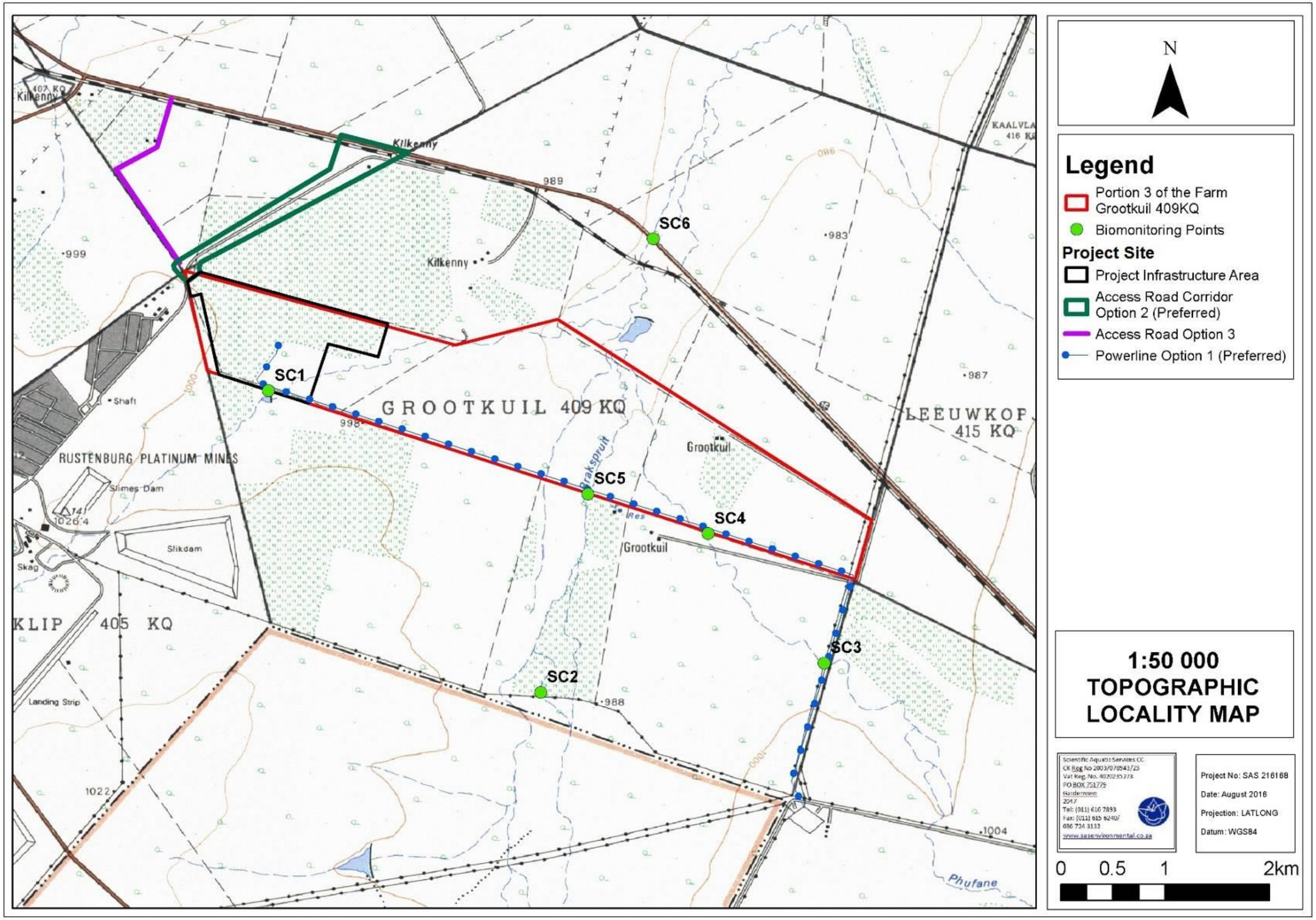


Figure 2: A topographic map showing the location of the study area and biomonitoring points.

2 METHOD OF ASSESSMENT

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

2.1 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 Programme (RHP), are presented in the table below and will be used as the basis of classification of the system in the current as well as future field studies.

Table 1: Classification used to evaluate degree of modification or level of impairment of water resources as employed by the River Health Programme (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 (ECat) classification will be employed using the eco-status A to F continuum approach (Kleynhans & Louw, 2007). This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 3.

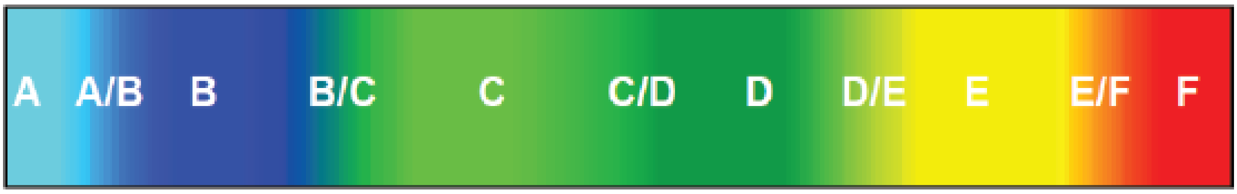


Figure 3: Ecological categories eco-status A to F continuum approach employed (Kleynhans & Louw, 2007)

2.2 Visual Assessment

Each site was investigated in order to identify visible impacts on the site with specific reference to impacts from surrounding activities. Both natural constraints placed on ecosystem structure and function, as well as anthropogenic alterations to the system were assessed by observing conditions and relating them to professional experience.

Photographs of each site were taken to provide visual indications of the conditions at the time of assessment. Factors which were noted in the site-specific visual assessments included the following:

- Stream morphology;
- Instream and riparian habitat diversity;
- Stream continuity;
- Erosion potential;
- Depth flow and substrate characteristics;
- Signs of physical disturbance of the area;
- Other life forms reliant on aquatic ecosystems and
- Signs of impact related to water quality.

2.3 Physico Chemical Water Quality Data

On site testing of biota specific water quality variables took place. Parameters measured include pH, Electrical Conductivity (EC) and Dissolved Oxygen (DO). The results of the biota specific water quality analyses were used to aid in the interpretation of the data obtained by the bio-monitoring where possible. Results are discussed against the guideline water quality values for aquatic ecosystems (DWAF, 1996 vol. 7).

2.4 Habitat Integrity

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 IHIA (Kemper, 1999). The IHIA protocol, as described by Kemper (1999), should be used for site specific assessments. This is a simplified procedure, which is based on the Habitat Integrity approach developed by Kleynhans (1996). The IHIA is conducted as a first level exercise, where a comprehensive exercise is not practical. The Habitat Integrity of each site should be scored according to 12 different criteria which represent the most important (and easily quantifiable) anthropogenically induced possible impacts on the system. The instream and riparian zones should be analyzed separately, and the final assessment should be made separately for each, in accordance with Kleynhans' (1996) 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 intensity 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 2: 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 have taken place but the basic ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Extensively modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible.	<20

2.5 Habitat for Aquatic Macro-Invertebrates

The 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%: inadequate for supporting a diverse aquatic macro-invertebrate community;
- 65%-75%: adequate for supporting a diverse aquatic macro-invertebrate community; and
- >75%: highly suited for supporting a diverse aquatic macro-invertebrate community.

2.6 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 defendable 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 National Water Act (NWA; Act 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 3: Descriptions of the A-F ecological categories.

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

2.7 Aquatic Macro-Invertebrates

Aquatic macro-invertebrate communities of the selected sites were investigated according to the method, which is 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 undertaken by an accredited SASS5 practitioner.

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 also reflect natural variation over time. The perceived reference state for the local streams was determined as a SASS5 score of 120 and an Average Score Per Taxon (ASPT) of 5.6 based on general conditions of streams in the Upper Bushveld Basin Ecoregions. Interpretation of the results, in relation to the reference scores, was made according to the classification by Dickens & Graham (2001).

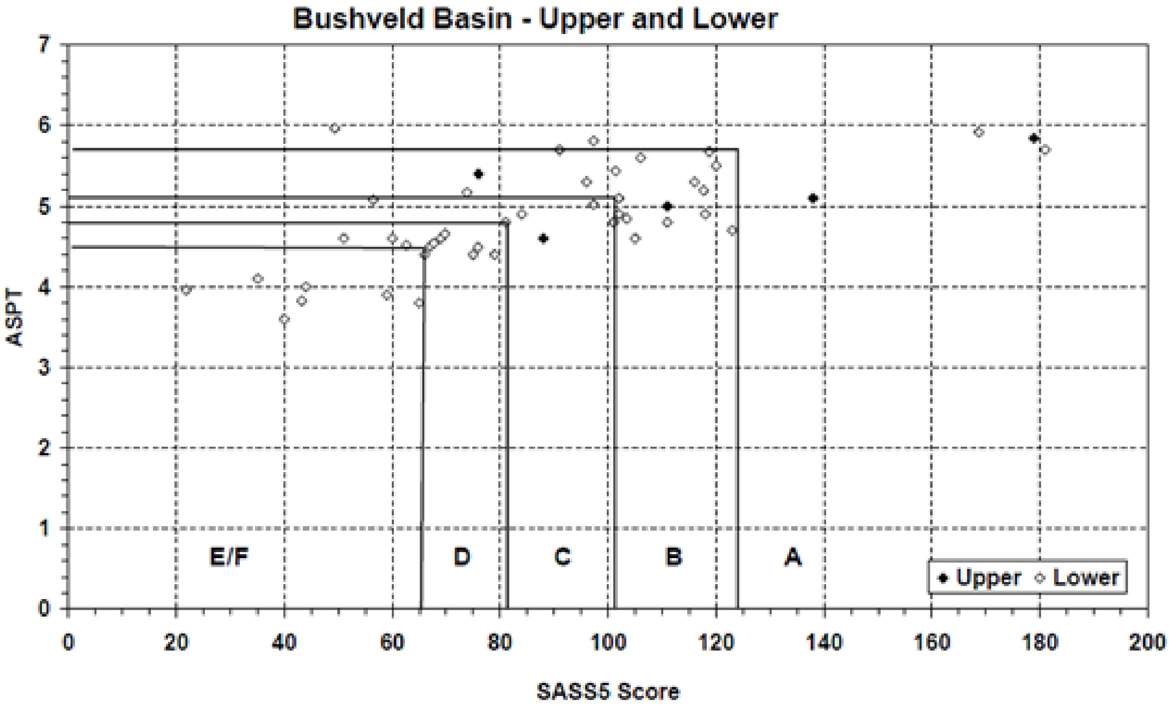


Figure 4: Biological Bands for the Bushveld ecoregion, calculated using percentiles.

Table 4: Definition of Present State Classes in terms of SASS5 scores as presented in Dickens & Graham (2001).

Class	Description	SASS5 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

Table 5: Description of the discussion points used for the discussion of data for each site.

Aspect	Definition
Biotopes sampled	Refers to the various biotopes sampled for aquatic macro-invertebrates during the collection of the SASS5 samples.
Sensitive taxa present	A list of the taxa that were captured during SASS5 sampling regarded as being sensitive taxa relevant to the conditions in the area.
Sensitive taxa absent	A list of the taxa that were not captured during SASS5 sampling of the site but that were captured at other sites in the program and regarded as sensitive taxa.
Adjusted SASS5 score	The adjusted SASS5 value based on the adjustment figure in the IHAS index for variances in habitat conditions.
SASS5 % of reference score	The result compared to the reference SASS5 score of (120).
ASPT % of reference score	The result for the site compared to the reference ASPT score of (5.6)
Dallas, 2007 classification	The classification of the site into ecological bands/categories based on data from the Bushveld Basin.
Dickens and Graham, 2001 SASS5 classification	The classification of each site into one of five classes, based on the degree of impairment observed in the aquatic macro-invertebrate community.
McMillan, 1998 IHAS description	Description of the adequacy of habitat according to the guidelines of McMillan 1998
IHAS stones biotopes results	Discussion of the suitability of the stones biotopes of the site for supporting an aquatic macro-invertebrate community.
IHAS vegetation biotopes results	Discussion of the suitability of the vegetation biotopes of the site for supporting an aquatic macro-invertebrate community.
IHAS other biotopes results	Discussion of the suitability of the gravel, sand and mud biotopes of the site for supporting an aquatic macro-invertebrate community.
IHAS general stream characteristics	A summary of the notes made from the general stream characteristics section of the IHAS index.
Previous assessment IHAS score	The IHAS score obtained in the previous assessment.
Current IHAS score	The current score.
Current IHAS Adjustment score	The adjustment score from the IHAS index based on stream conditions.

2.8 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 ECat rating.

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

2.9 Aquatic EIS assessment

The Ecological Importance and Sensitivity (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 (Table 6). The median of the resultant score is calculated to derive the EIS category.

Table 6: Ecological importance and sensitivity categories (DWAF, 1999)

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 is 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

3 RESULTS

Based on the results of the site selection effort, six sites (SC1 – SC6) were visually assessed of which three out of the six (SC2, SC4 and SC6) were subjected to further detailed aquatic assessment due to the presence of water at the time of the assessment. The field assessment took place on the 14th of April 2015.

3.1 Visual Assessment

A photographic record of each site was made in order to provide a visual record of the condition of each assessment site as observed during the field assessment. The photographs taken at each site are presented in the sections below. The tables in each section summarise the observations for the various criteria made during the visual assessment undertaken at each site.

Figure 5: Local view of site SC1. The system was dry at the time of the assessment.

Figure 6: View of site SC2 located on the Brakspruit stream.

Figure 7: General view of site SC3 located on the Phufane stream. The site was dry at the time of the assessment.

Figure 8: View of site SC4 located on the Phufane stream.

Figure 9: General view of site SC5 located on the Brakspruit stream. The site was dry at the time of the assessment.

Figure 10: View of site SC6 located on the Brakspruit.

Table 7: Visual description of the aquatic resources in the vicinity of the study area.

SITE	SC1	SC2	SC3	SC4	SC5	SC6
Upstream features	Located in an area in which livestock grazing and crop cultivation are the dominant activities in the landscape. This site will be crossed by the proposed powerline and will be representative of the system for future monitoring.	Located in a remote area with little surrounding activities. The site is located on the Brakspruit system and will serve as an upstream reference point to site SC5.	Located in a remote area with little surrounding activities. The site is located on the Phufane system and will serve as an upstream reference point to site SC4. The site will be crossed by the proposed powerline.	Located in a remote area with little surrounding activities. The site is located on the Phufane system and will serve as downstream reference point to site SC3. The site will be crossed by the proposed powerline.	Located in a remote area with little surrounding activities. The site is located on the Brakspruit system and will serve as downstream reference point to site SC2. The site will be crossed by the proposed powerline.	This site is located on the Brakspruit, downstream of the confluence of the Brakspruit and Phufane systems. The site is located at a bridge crossing on Brits Road to the west of the town of Northam.
Downstream significance	Located downstream of existing mining activities, on an unnamed tributary of the Brakspruit.	Catchment driven impacts such as sedimentation and abstraction leading to low flow, as well as riparian zone/stream bank impacts are also visible on the Brakspruit River.	Catchment driven impacts such as sedimentation and abstraction leading to low flow, as well as riparian zone/stream bank impacts are also visible on the Phufane River.	Catchment driven impacts such as sedimentation and abstraction leading to low flow, as well as riparian zone/stream bank impacts are also visible on the Phufane River.	Catchment driven impacts such as sedimentation and abstraction leading to low flow, as well as riparian zone/stream bank impacts are also visible on the Brakspruit River.	Catchment driven impacts such as sedimentation and abstraction leading to low flow, as well as riparian zone/stream bank impacts are also visible on the Brakspruit River.
Riparian zone characteristics	Riparian areas indicate some disturbance has taken place as a result of overgrazing and agricultural activities. Impacts from alien and invasive vegetation encroachment is evident. Riparian zone is dominated by hardy grasses.	Riparian zone is limited in extent due to moderate incision and erosion of the stream. Incision of the stream means that the extent of the riparian zone is limited in most areas. Riparian zone is dominantly hardy grasses.	Riparian zone is limited in extent due to moderate incision and erosion of the stream. Incision of the stream means that the extent of the riparian zone is limited in most areas. Riparian zone is dominated by hardy grasses.	Riparian zone is limited in extent due to extensive incision and erosion of the stream. Incision of the stream means that the extent of the riparian zone is limited in most areas. Riparian zone is dominated by grasses and thorn trees.	Riparian zone is limited in extent due to moderate incision and erosion of the stream. Incision of the stream means that the extent of the riparian zone is limited in most areas. Riparian zone is dominated by hardy grasses.	Riparian zone is limited in extent due to extensive incision and erosion of the stream. Incision of the stream means that the extent of the riparian zone is limited in most areas. Riparian zone is dominated by hardy grasses and thorn trees.
Algal presence	System was dry at the time of assessment.	No algae present at the time of assessment.	System was dry at the time of assessment.	No algae present at the time of assessment.	System was dry at the time of assessment.	No algae present at the time of assessment.
Visual indication of and impact on aquatic fauna	Upstream of the area impoundments and other water abstraction activities may lead to reduced instream flow at this point, in turn impacting on aquatic biota.					

SITE	SC1	SC2	SC3	SC4	SC5	SC6
Depth characteristics	System was dry at the time of assessment.	The system at this point is dominated by shallow pools.	System was dry at the time of assessment.	The system at this point is dominated by shallow pools.	System was dry at the time of assessment.	The system at this point is dominated by shallow pools.
Flow condition	System was dry at the time of assessment.	There is no diversity of flow; water was stagnant at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community.	System was dry at the time of assessment.	There is no diversity of flow; water was stagnant at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community.	System was dry at the time of assessment.	There is no diversity of flow; water was stagnant at the time of the assessment. This will have some limit on the diversity and sensitivity of the aquatic community.
Water clarity	System was dry at the time of assessment	Water was opaque at the time of the assessment.	System was dry at the time of assessment	Water was opaque at the time of the assessment.	System was dry at the time of assessment	Water was opaque at the time of the assessment.
Odour	No odors were evident at the time of the assessment.					
Erosion potential	There is low potential for erosion due to the presence of reasonably well vegetated banks which will assist in maintaining their integrity.	There is a moderate to high potential for erosion, particularly during flood conditions, due to the presence of steep and bare banks.	There is a moderate to high potential for erosion due to the presence of steep banks. The banks are however reasonably well vegetated which will assist in maintaining their integrity. During flood condition erosion may occur.	There is a moderate to high potential for erosion due to the presence of steep and bare banks. During flood condition erosion may occur.	There is a moderate to high potential for erosion due to the presence of steep banks. The banks are however reasonably well vegetated which will assist in maintaining their integrity. During flood condition erosion may occur.	There is a moderate to high potential for erosion due to the presence of bare banks. During flood condition erosion may occur.

3.2 Biota Specific Water Quality

Table 8 below records the biota specific water quality of the assessed sites.

Table 8: Biota specific water quality variables

Site	EC (mS/m)	pH	Temperature (°C)	DO (mg/l)
SC2	21.0	8.29	20.7	5.86
SC4	20.3	7.92	20.3	5.63
SC6	42.0	8.43	24.7	7.46

- The water quality can be considered as fair at the SC2 and SC4 sites with low dissolved salt concentrations at the time of the assessment, this is likely due to the remote location of the two sites, while the Electrical Conductivity (EC) can be considered as slightly elevated at the SC6 site. The elevated EC concentration at site SC6 is most likely due to runoff from the tarred road and bridge crossing located at the site. Site SC6 is also located downstream of existing mining activities which is likely to affect the EC;
- The pH values can be considered as largely natural at each of the sites. The pH value is slightly elevated at site SC6, again, this is likely due to runoff from the bridge crossing present at the site;
- According to the DWS Target Water Quality Requirements (TWQR) for aquatic ecosystems (DWAF, 1996), it states that Dissolved Oxygen (DO) concentrations should range between 80% and 120% of saturation;
- Saturation (i.e. maximum dissolved oxygen concentrations) shall in turn depend on the temperature of the water sampled Environmental Protection Agency (EPA) website as indicated in Table 9 footnote). The current readings were expressed as a percentage of the potential maximum (Table 9);

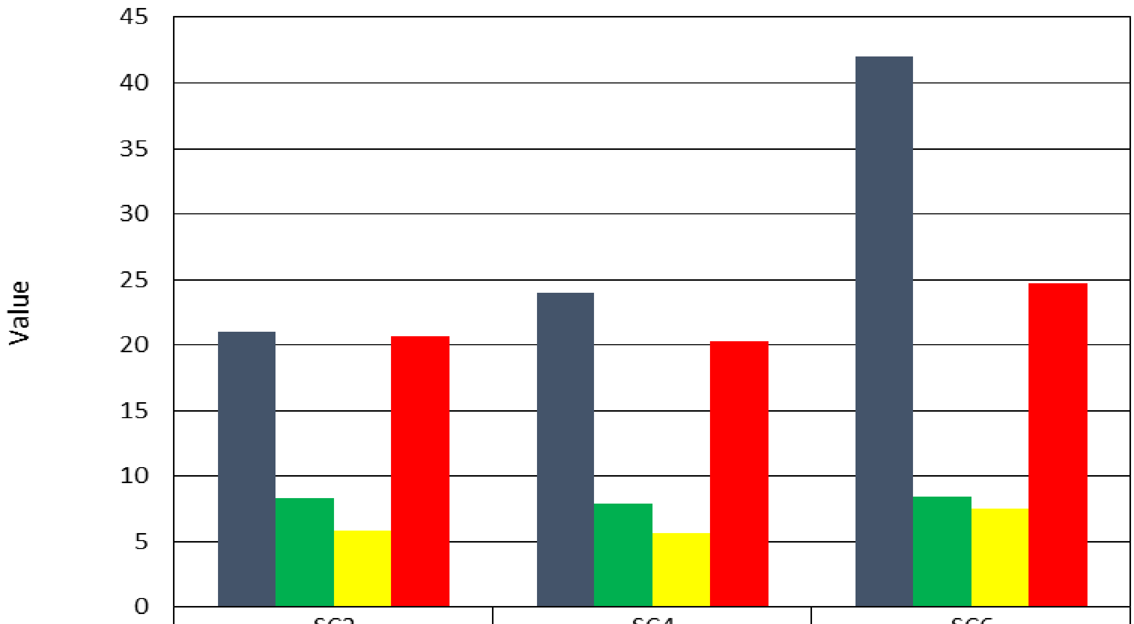
Table 9: Oxygen measured expressed as a percentage of maximum concentration at the temperature measured.

Site	Oxygen (mg/L)	Temperature when measured (°C)	Maximum oxygen at that temperature (mg/L)*	Oxygen measured expressed as percentage of maximum
SC2	5.86	20.7	9.07	64.6
SC4	5.63	20.3	9.07	62.1
SC6	7.46	24.7	8.40	88.8

* http://water.epa.gov/type/rsl/monitoring/vms52.cfm

- The DO concentrations at site SC2 and SC4 do not comply with the recommended guideline and will likely limit the macro-invertebrate diversity and sensitivity present at these sites. This is likely due to the stagnant water as well as the high turbidity present at both sites. The DO concentration at site SC6 exceeds 80% saturation and can therefore be considered as suitable in sustaining a diverse and sensitive macro-invertebrate community;

- The temperature at each site can be regarded as natural for the time of year and time of day during which sampling took place. The variation between the values can be ascribed to diurnal variation between sampling times.



	SC2	SC4	SC6
EC (mS/m)	21	24	42
pH	8.29	7.92	8.43
DO (mg/l)	5.86	5.63	7.46
Temp (°C)	20.7	20.3	24.7

Figure 11: Biota specific water quality variables of the assessment sites.

3.3 Habitat Assessment

3.3.1 Invertebrate Habitat Integrity Assessment (IHIA)

An Invertebrate Habitat Integrity Assessment was applied to each of the aquatic systems (Brakspruit and Phufane). Moderate, large and serious impacts were recorded for each system (Appendix 1).

Moderate instream impacts included water quality modification and indigenous vegetation removal within all three systems. Large instream impacts included water abstraction within all three systems. Flow modification, bed modification and channel modification were considered as serious impacts at all aquatic resources. The Brakspruit and Phufane systems both achieved Class C (moderately impaired) conditions.

Moderate riparian zone impacts within the aquatic resources included indigenous vegetation removal along with water abstraction. Large impacts recorded at the sites include alien vegetation encroachment and water abstraction. Serious riparian zone impacts included channel modification, flow modification and erosion. The sites all achieved a class D (largely modified) classification for riparian habitat integrity.

Overall, for habitat integrity the upstream Brakspruit scored 59.0% (Class D), the Phufane scored 58.8% (Class D), and the downstream Brakspruit scored 56.1% (Class D). Future development planning should ensure that activities do not lead to a reduction of stream flow or dewatering of any aquatic/ wetland/ riparian areas and connectivity of the aquatic features in the vicinity of the study area should be maintained.

3.3.2 Invertebrate Habitat Assessment (IHAS)

Table 10 provides a summary of the results obtained from the application of the IHAS Index to the three assessment 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 interpreting the SASS data.

- The habitat structure and diversity of each site can be regarded as inadequate for supporting a diverse and sensitive aquatic community;
- Lack of flowing water, suitable rocky habitat and marginal or aquatic vegetation will severely impact the macro-invertebrate community diversity and sensitivity expected at each site.

Table 10: A summary of the results obtained from the application of an IHAS index to the assessment sites.

Type of Result	SC2	SC4	SC6
McMillan, 1998 IHAS description	Habitat structure and diversity was inadequate for supporting a diverse aquatic macro-invertebrate community.	Habitat structure and diversity was inadequate for supporting a diverse aquatic macro-invertebrate community.	Habitat structure and diversity was inadequate for supporting a diverse aquatic macro-invertebrate community.
IHAS stones biotopes results	There was no rocky substrate available at any of the sites.		
IHAS vegetation biotopes results	No marginal or aquatic vegetation was present to provide habitat for aquatic macro-invertebrates at any of the sites.		
IHAS other biotopes results	Gravel, sand and predominantly mud deposits were present at all of the sites.		
IHAS general stream characteristics	The sites each consisted of shallow pools of stagnant water, discoloured due to the muddy nature of the substrate present in the system. The bank riparian vegetation is severely lacking at all three sites and erosion is evident at all of the sites.		
IHAS score	32%	36%	29%
Current IHAS Adjustment score	+43	+39	+46

3.4 Riparian Vegetation Response Assessment Index: VEGRAI

Tables 11 to13 below present the overall VEGRAI results of the assessment sites.

Table 11: Results of the VEGRAI assessment for the upstream Brakspruit system

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	53.3	33.3	3.3	1	100.0
NON MARGINAL	46.7	17.5	0.0	2	60.0
	2.0				160
LEVEL 3 VEGRAI (%)				50.8	
VEGRAI EC				**D**	
AVERAGE CONFIDENCE				1.7	

Table 12: Results of the VEGRAI assessment for the Phufane system

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	57.1	35.7	3.3	1	100.0
NON MARGINAL	53.3	20.0	0.0	2	60.0
	2.0				160.0
LEVEL 3 VEGRAI (%)				55.7	
VEGRAI EC				**D**	
AVERAGE CONFIDENCE				1.7	

Table 13: Results of the VEGRAI assessment for the downstream Brakspruit.

LEVEL 3 ASSESSMENT					
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT
MARGINAL	47.1	29.5	3.3	1.0	100.0
NON MARGINAL	54.3	20.4	0.0	2.0	60.0
	2.0				160.0
LEVEL 3 VEGRAI (%)				49.8	
VEGRAI EC				**D**	
AVERAGE CONFIDENCE				1.7	

Because the riparian vegetation was very similar along all sites assessed on the various drainage systems, VEGRAI was applied to each system as a whole and not to individual sites. The scores attained for the VEGRAI assessment indicate that the riparian systems along the study area fall within a PES category D for the Brakspruit and Phufane systems. The ecological category D attained within the Brakspruit and Phufane systems indicate that the riparian vegetation has undergone large modifications, with a large loss of natural habitat, biota and basic ecosystem functions. This is due to the significant erosion and modification of water flow at all three sites.

3.5 Aquatic Macro-invertebrate Community Assessment

3.5.1 South African Scoring System (SASS5)

Tables 14 &15 provide a summary of the results obtained from the application of the SASS5 (Appendix 2) and IHAS (Appendix 3) indices to the sites.

Table 14: Biotope specific summary of the results obtained from the application of the SASS5 index to the assessment sites.

PARAMETER	Site	STONES	VEGETATION	GRAVEL, SAND AND MUD	TOTAL
SASS5 Score	SC2	-	-	12	12
	SC4	-	-	26	26
	SC6	-	-	19	19
Taxa	SC2	-	-	4	4
	SC4	-	-	6	6
	SC6	-	-	6	6
ASPT	SC2	-	-	3.00	3.00
	SC4	-	-	4.33	4.33
	SC6	-	-	3.17	3.17

Table 15: A summary of the results obtained from the application of the SASS5 and IHAS indices to the assessment sites.

Type of Result	SC2	SC4	SC6
Biotopes sampled	Gravel, sand and mud.	Gravel, sand and mud.	Gravel, sand and mud.
Sensitive taxa present	*None*	*Caenidae*	*Hydracarina;*
Sensitive taxa absent	*Ancylidae; Caenidae; Gomphidae; Naucoridae Hydracarina; Aeshnidae.*	*Ancylidae; Gomphidae; Hydracarina; Aeshnidae; Naucoridae.*	*Ancylidae; Gomphidae; Aeshnidae; Naucoridae; Caenidae.*
SASS5 score	12	26	19
Adjusted SASS5 score	55	65	65
SASS5 % of theoretical reference score*	10.0%	21.7%	15.8%
ASPT score	3.0	4.3	3.17
ASPT % of theoretical reference score**	53.6%	76.8%	56.6%
Dickens & Graham, 2001 SASS5 classification	Class F: Critically Modified	Class E: Seriously Modified	Class F: Critically Modified
Dallas 2007 classification	Class E/F	Class E/F	Class E/F

***SASS5 reference score = 120 **ASPT reference score = 5.6**

- Sites SC2, SC4 and SC6 may be considered to be in a Class E/F (severely impaired) condition according to the Dallas (2007) classification system;
- Sites SC2 and SC6 can be classified as critically modified (Class F) according to the Dickens & Graham (2001) classification system, while site SC4 can be classified as a Class E (seriously impaired) condition;
- The aquatic macro-invertebrate community in the systems can be regarded as having low diversity and sensitivity in relation to the expected conditions for the Bushveld Basin ecoregion as a result of the lack of perennial flow and limited habitat present at the sites. The aquatic community members present were generally present in low abundances with a relatively low diversity of taxa present;
- Due to the relatively poor habitat conditions, the Dallas (2007) classification of the site is regarded as being a more accurate description of the PES of the aquatic macro-invertebrates of the systems and indicates that the Brakspruit and Phufane

systems are in severely modified conditions and could be considered to be largely to moderately modified from the naturally constrained systems; and

- Care should be taken not to further impact on the aquatic ecosystems with the proposed activities with specific mention of measures to ensure that streamflow reduction activities and loss of catchment yield are kept to an absolute minimum.

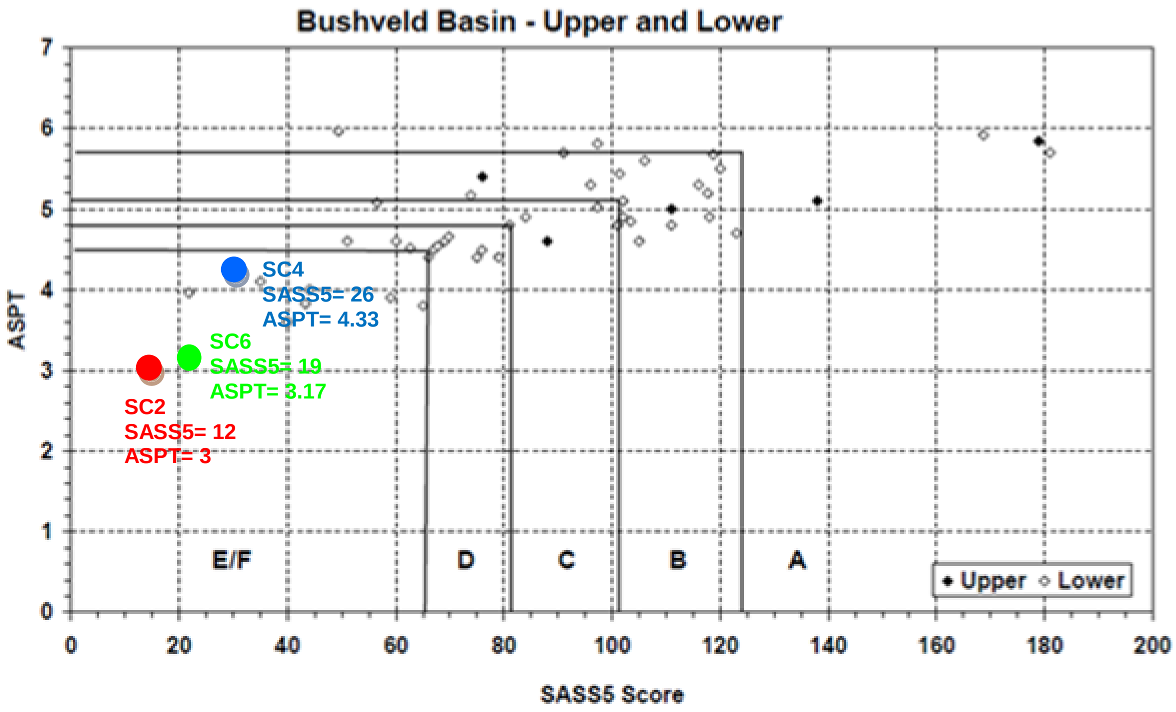


Figure 12: SASS and ASPT scores plotted on the Bushveld Basin Upper and Lower biological bands graph (Dallas, 2007).

3.6 Aquatic Macro-Invertebrates: MIRAI

The number of taxa actually present was expressed as a percentage of the number of taxa expected. The latter list was compiled using the Manual for Ecostatus Classification (Thirion, 2007) according to the habitat available at each site and supplemented with taxa actually collected at the sites assessed. Percentage occurrence for each of the preference variables are tabulated (Table 16).

For the purposes of the MIRAI assessment itself, the percentage of taxa exhibiting flow, habitat and water quality preferences (Table 16) was taken into consideration. Results are tabulated in Table 17.

Table 16: Percentage of taxa (actually present expressed as percentage of expected) showing flow, habitat and water quality preferences at each of the sites assessed.

Variable	Criteria	Percentage occurrence of taxa showing preferences at each of the sites		
		SC2	SC4	SC6
Flow	Very Fast (>0.6 m/s)	0.00	0.00	0.00
	Moderately Fast (0.3-0.6 m/s)	0.00	0.00	0.00
	Slow (0.1-0.3 m/s)	12.50	25.00	25.00
	Very Slow (<0.1 m/s)	10.53	15.79	5.26
Habitat	Bedrock	0.00	0.00	0.00
	Cobbles	50.00	50.00	50.00
	Vegetation	12.50	25.00	0.00
	Gravel, Sand, Mud	7.69	7.69	23.08
	Water	25.00	25.00	25.00
Water quality	High	50.00	50.00	50.00
	Moderate	0.00	0.00	50.00
	Low	7.69	30.77	7.69
	Very Low	25.00	16.67	33.33

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

Table 17: Summary of the results (ecological categories) obtained from the application of the MIRAI to the assessment sites, compared to classes awarded using SASS5.

Variable / Index	SC2	SC4	SC6
Ecological category (MIRAI)	D	D	D
Dickens and Graham (SASS5)	F	E	F
Dallas (SASS5)	E/F	E/F	E/F

The MIRAI results indicate that the sites can be considered as having largely modified conditions, as measured by the Ecological Category classification. A trend of general deterioration from expected natural conditions in terms of macro-invertebrate community integrity is clearly evident. This is due to the modified flow conditions and limited habitat availability at the biomonitoring sites. The inadequate habitat availability and lack of flowing water will severely limit the macro-invertebrate community diversity and sensitivity expected at each of the sites. This general deterioration in integrity is evident at all sites assessed, indicating that the entire system suffers from negative impacts. Due to the relatively poor habitat conditions, the Dallas (2007) classification of the site is regarded as being a more accurate description of the PES of the aquatic macro-invertebrates of the systems and indicates that the Brakspruit and Phufane systems are in severely modified conditions.

3.7 Aquatic EIS Determination

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

Table 18: Aquatic EIS determination for the Phufane, Brakspruit and Bierspruit systems.

Biotic Determinants	Upstream Brakspruit	Phufane	Downstream Brakspruit	Bierspruit
Rare and endangered biota	0	0	0	0
Unique biota	0	0	0	0
Intolerant biota	0	0	0	1
Species/taxon richness	0	0	0	1
Aquatic Habitat Determinants				
Diversity of aquatic habitat types or features	0	0	0	1
Refuge value of habitat type	1	1	1	1
Sensitivity of habitat to flow changes	1	1	1	1
Sensitivity of flow-related water quality changes	0	0	0	1
Migration route/corridor for instream and riparian biota	0	0	0	1
Nature Reserves, Natural Heritage sites, Natural areas, PNEs	0	0	0	0
RATING AVERAGE	**0.2**	**0.2**	**0.2**	**0.7**
EIS CATEGORY	**Low**	**Low**	**Low**	**Low**

The aquatic EIS determination yielded a low EIS for the Brakspruit and Phufane and systems as well as for the bigger Bierspruit located north of the study area, indicating that these systems are not unique on a provincial or local scale due to biodiversity. However, whilst the Bierspruit (in terms of biota and habitat) is not usually very sensitive to flow modifications and often has substantial capacity for use, the smaller Brakspruit and Phufane can be considered to be at risk due to their smaller size and smaller systems generally being more susceptible to stress and less able to adjust to new impacts.

4 IMPACT ASSESSMENT

The tables below serve to summarise the significance of perceived impacts on the aquatic ecology and biodiversity of the study area. Summaries for all potential pre-construction, construction, operational phase as well as decommissioning and closure phase impacts are provided for the Smelter development whereas for the Powerline only the pre-construction,

construction and operational phase summaries are provided. The tables present the impact assessment according to the method described in Section A.

This section also indicates the recommended mitigatory measures required to minimise any perceived impacts. In addition the tables present an assessment of the significance of the impacts taking into consideration the available mitigatory measures assuming that they are fully implemented.

4.1 Smelter and Access Roads Impact Assessment

4.1.1 Impact 1: Loss of Aquatic Habitat and Ecological Structure

Aspects and activities register

Pre-Construction	Construction	Operational	Decommissioning & Closure
Inappropriate design of infrastructure leading to changes to aquatic habitat	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils as a result of general operational activities	Disturbance of soils as part of demolition activities
	Earthworks in the vicinity of riparian areas leading to increased loss of habitat	Spillages and seepage of toxicants material into the groundwater	Ongoing seepage and runoff from the development area to the groundwater regime beyond closure
	Topsoil stockpiling adjacent to riparian areas and runoff from stockpiles	Runoff, seepage and potential discharge from the operational area	Ongoing erosion and sedimentation of riparian areas
	Movement of construction vehicles within riparian areas	Sedimentation and incision leading to altered habitats and loss of aquatic biodiversity	Potential contamination of riparian areas from the decommissioning of infrastructure
	Dumping of hazardous waste and spills into the riparian areas resulting in soil and water contamination	Dumping of hazardous and non-hazardous waste into the riparian areas leading to soil and water contamination	Ineffective rehabilitation may lead to habitat transformation and alien vegetation encroachment
	Widening or upgrading of existing stream crossings leading to loss of aquatic habitat and disturbance to stream banks		

Construction related activities, such as the removal of the topsoil and disturbance of vegetation, have the potential to lead to habitat destruction beyond the proposed development footprint and in turn may lead to overall loss of habitat within the riparian areas. All these activities may result in permanent impact on the features and may extend to downstream areas as well. In addition the edge effects from the development could lead to the introduction of alien species.

Operational activities such as dumping of waste and oil leaks from vehicles may occur, which could result in the contamination of riparian soils and water, which will lead to the alteration or loss of habitat for aquatic species.

If left unmitigated, impacts on the riparian features will lead to significant impacts on riparian habitat and ecological structure, however with the implementation of mitigation measures the intensity, extent and overall severity of the potential impact can be reduced.

It is important to note that the two access road alternatives are not located in the vicinity of watercourses and development of the proposed access road is therefore unlikely to impact on wetland habitat.

Unmanaged	Intensity	Duration of impact	Extent	Consequence	Probability	Significance
Construction phase	L	L	VL	L	H	M
Operational phase	L	H	VL	M	M	M
Decommissioning and closure phase	L	L	VL	L	H	M

Essential construction phase mitigation measures:

- The dirty water management area must be kept as small as possible.
- Clean and dirty water separation systems needs to be very well planned, executed and managed in order to minimise the loss of catchment yield and minimise the loss of instream flow.
- Keep infrastructure within designated low sensitivity areas as far as possible.
- If possible, avoid placement of infrastructure in the sensitive riparian and wetland areas.
- Restrict vehicles to travelling only on designated roadways to limit the ecological footprint of the proposed project activities.
- All soils compacted as a result of construction activities falling outside of the proposed project footprint should be ripped and profiled.
- To prevent the erosion of top soils, management measures may include berms, soil traps, hessian curtains and storm water diversion away from areas susceptible to erosion. It must be ensured that topsoil stockpiles are located outside of any drainage lines and areas susceptible to erosion.

Recommended construction phase mitigation measures:

- Ensure that the proposed project footprint areas remain as small as possible.

Essential operation phase mitigation measures:

- Ensure that operational related activities are kept strictly within the development footprint.
- Alien and invasive vegetation control should take place throughout the operational phase of the development.
- In the event of a breakdown, maintenance of vehicles must take place with care and the recollection of spillage should be practiced to prevent the ingress of hydrocarbons into the topsoil.

Essential decommissioning and closure phase mitigation measures:

- All development footprint areas and areas affected by closure and decommissioning of the smelter should remain as small as possible and should not encroach onto surrounding more sensitive wetland and riparian areas and their associated buffer zones. It must be ensured that these areas are off-limits to construction vehicles and personnel.
- Proliferation of alien and invasive species is expected within any disturbed areas. These species should be eradicated and controlled to prevent their spread beyond the development / decommissioning footprint. Alien plant seed dispersal within the top layers of the soil within footprint areas, that will have an impact on future rehabilitation, has to be controlled.
- Upon closure and decommissioning, reseeding with indigenous grasses should be implemented in all affected areas.

Managed	Intensity	Duration of Impact	Extent	Consequence	Probability	Significance
Construction phase	VL	L	VL	VL	M	L
Operational phase	VL	L	VL	VL	L	L
Decommissioning and closure phase	VL	L	VL	VL	M	L

Probable latent impacts

- Sedimentation of the features may lead to altered riparian habitats.
- Ineffective rehabilitation may lead to the permanent transformation of the riparian habitat.
- Proliferation of alien weed species in disturbed areas will lead to altered vegetation communities.

4.1.2 Impact 2: Impacts on Aquatic Hydrological Function and Sediment Balance

Aspect and activities register

Pre-Construction	Construction	Operational	Decommissioning & Closure
Inappropriate design of infrastructure leading to changes in hydrological function and sediment control capacity	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils due to general operational activities	Disturbance of soils as part of demolition activities
Potentially poor design of the facility and the facility as well as clean and dirty water management systems leading to reduced catchment yield and instream flow	Slag dump establishment adjacent to riparian areas and runoff from stockpiles leading to sedimentation of the riparian areas	Slag dump establishment adjacent to riparian areas and runoff from stockpiles leading to sedimentation of the aquatic resources	Altered hydrology due to stormwater channels and dams
	Earthworks in the vicinity of riparian areas leading to altered runoff patterns	Movement of operational vehicles within riparian areas leading to soil compaction which results in increased runoff	Ongoing erosion and sedimentation of riparian areas
	Movement of construction vehicles within riparian areas leading to soil compaction which results in increased runoff	Altered runoff patterns due to construction of stormwater channels and dams	Potential contamination of riparian areas from the decommissioning of infrastructure
	Increased runoff volumes due to increased paved and other impervious surfaces leading to erosion and sedimentation	Increased runoff volumes due to increased paved and other impervious surfaces leading to erosion and sedimentation	Ineffective rehabilitation may lead to habitat transformation and alien vegetation encroachment
	Concentration of flow and incision of riparian areas		
	Placement of access roads through riparian areas resulting in alteration of runoff patterns		

The significance of the impact on the features increases where the proposed project occurs longitudinally or adjacent to the features such as the unnamed tributary. Construction activities such as vegetation removal and excavations may alter the hydrology and sediment balance of the features.

An increase in runoff from disturbed areas may also alter flow patterns and may result in the severity of floods downstream. In addition, sediment deposition as a result of the disturbance of soils and increased sediment runoff during the construction may result in an impact on the sediment balance of the features.

During the operational phase, hardened surfaces and compacted soil will increase surface runoff, which in turn will alter the hydrology of the features. Waste dumping will result in the deposition of toxins into the water, leading to the reduction of water quality.

Unmanaged	Intensity	Duration of Impact	Extent	Consequence	Probability	Significance
Construction phase	L	L	VL	L	VH	H
Operational phase	L	H	VL	M	VH	H
Decommissioning and closure phase	L	L	VL	L	VH	H

Essential construction phase mitigation measures:

- It is recommended that the sensitivity maps be considered during the planning/ pre-construction and construction phases of the proposed project activities to aid in the conservation of ecology within the project area.
- It must be ensured that planning of smelter infrastructure includes consideration of adjacent riparian and drainage line areas to ensure that these areas are avoided as far as possible.
- Keep all demarcated sensitive zones outside of the construction area off limits during construction phase.
- Limit the footprint area of the proposed project and closure activity to what is absolutely essential in order to minimise environmental damage and loss of catchment yield.
- Implement effective waste management in order to prevent construction related waste from entering the riparian environment.
- Planning for the proposed project should not lead to a reduction of stream flow or dewatering of any wetland or water source areas and connectivity of the riparian features should be maintained.
- Erosion berms may be installed in any areas where soil disturbances within the vicinity of the riparian features have occurred to prevent gully formation and siltation of the aquatic resources. The following points should serve to guide the placement of erosion berms:
  - Where the track has slope of less than 2%, berms every 50m should be installed.
  - Where the track slopes between 2% and 10%, berms every 25m should be installed.
  - Where the track slopes between 10% and 15%, berms every 20m should be installed.
  - Where the track has slope greater than 15%, berms every 10m should be installed.

Recommended construction phase mitigation measures

- Desilt all adjacent riparian areas affected by the proposed project and runoff from dirty water areas; and
- Revegetate all disturbed areas with indigenous grass species upon closure.

Essential operational mitigation measures

- Prevent run-off from dirty water areas entering wetland and riparian areas.
- Ensure that seepage from dirty water systems is prevented as far as possible to maintain good water quality within riparian habitats.
- Ensure that the smelter process water system is managed in such a way as to prevent discharge to the receiving environment.

Essential decommissioning and closure phase mitigation measures

- It must be ensured that all activities potentially impacting on geohydrological resources are managed according to the relevant DWS Licensing regulations and groundwater monitoring requirements.
- Decommissioning should take place in such a way as to reinstate catchment yield with water which is not contaminated so as to reinstate catchment yield as far as possible.
- All wetland and riparian areas must be rehabilitated upon decommissioning.

Recommended decommissioning and closure phase mitigation measures

- Post closure groundwater management will need to be very carefully managed to ensure that no impact on the wetland areas and aquatic resources in the area takes place after smelter closure has taken place.

Managed	Intensity	Duration	Extent	Consequence	Probability	Significance
Construction phase	VL	L	VL	VL	VH	M
Operational phase	VL	L	VL	VL	VH	M
Decommissioning and closure phase	VL	L	VL	VL	VH	M

Probable latent impacts

- Loss of catchment yield.
- Sedimentation of the features may lead to altered riparian habitats.
- Ineffective rehabilitation may lead to the permanent transformation of the riparian habitat.
- Proliferation of alien weed species in disturbed areas will lead to altered vegetation communities.

4.1.3 Impact 3: Impacts on Instream Biota

Aspect and activities register

Pre-Construction	Construction	Operational	Decommissioning & Closure
Placement of infrastructure in the vicinity of riparian areas resulting in alteration of runoff patterns	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils due to general operational activities	Disturbance of soils as part of demolition activities
Potentially poor design of the facility and the facility as well as clean and dirty water management systems leading to reduced catchment yield and instream flow	Slag dump establishment adjacent to riparian areas and runoff from stockpiles leading to sedimentation of the riparian areas	Slag dump establishment adjacent to riparian areas and runoff from stockpiles leading to sedimentation of the aquatic resources	Ongoing erosion and sedimentation of riparian areas
	Earthworks in the vicinity of riparian areas leading to altered runoff patterns	Increased runoff volumes due to increased paved and other impervious surfaces leading to erosion and sedimentation	Potential contamination of riparian areas from the decommissioning of infrastructure
	Movement of construction vehicles within riparian areas leading to soil compaction which results in increased runoff		Ineffective rehabilitation may lead to habitat transformation and alien vegetation encroachment
	Increased runoff volumes due to increased paved and other impervious surfaces leading to erosion and sedimentation		

Construction activities such as vegetation removal, earthworks and the establishment of the mineralised waste facility around the riparian area with special mention of the unnamed tributary may alter the hydrology and sediment balance of the features. An increase in runoff from disturbed areas may also alter flow patterns. In addition, sediment deposition as a result of the disturbance of soils and increased sediment runoff during the construction may result in an impact on the sediment balance of the features, which can lead to an inability to support biotic biodiversity as a result of changes to water quality, increased sedimentation and alteration of natural hydrological regimes.

During the operational phase, hardened surfaces and compacted soil may lead to increased surface runoff, which may then alter the hydrology of the riparian and wetland features. The mineralised waste facility may result in the sedimentation and possible contamination of riparian habitat, leading to the reduction of water quality.

Unmanaged	Intensity	Duration of Impact	Extent	Consequence	Probability	Significance
Construction phase	L	L	VL	L	H	M
Operational phase	L	H	VL	M	M	M
Decommissioning and closure phase	L	L	VL	L	H	M

Essential construction phase mitigation measures:

- Keep all demarcated sensitive zones outside of the construction area off limits during construction phase.
- Limit the footprint area of the proposed project and closure activity to what is absolutely essential in order to minimise environmental damage.
- Implement effective waste management in order to prevent construction related waste from entering the wetland and riparian environment.
- All spills should be immediately cleaned up and treated accordingly.
- No fires should be permitted on site.
- Appropriate sanitary facilities must be provided for the duration of the proposed development and all waste removed to an appropriate waste facility.
- Planning for the proposed project should not lead to a reduction of stream flow or dewatering of any wetland or water source areas and connectivity of the wetland features should be maintained.
- Erosion berms may be installed in any areas where soil disturbances within the vicinity of the riparian features have occurred to prevent gully formation and siltation of the aquatic resources.

Recommended construction phase mitigation measures

- Desilt all adjacent wetland and riparian areas affected by the proposed project and runoff from dirty water areas; and
- Revegetate all disturbed areas with indigenous grass species upon closure.

Essential operational mitigation measures

- Prevent run-off from dirty water areas entering wetland and riparian areas.
- Ensure that seepage from dirty water systems is prevented as far as possible to maintain good water quality within riparian habitats.

Recommended operational mitigation measures

- Ensure that the smelter process water system is managed in such a way as to prevent discharge to the receiving environment.

Essential decommissioning and closure phase mitigation measures

- It must be ensured that all activities potentially impacting on geohydrological resources are managed according to the relevant DWS Licensing regulations and groundwater monitoring requirements.
- All wetland and riparian areas must be rehabilitated upon decommissioning.

Recommended decommissioning and closure phase mitigation measures

- Post closure biomonitoring is recommended to ensure that no impact on the aquatic resources in the area takes place after smelter closure has taken place.

Managed	Intensity	Duration of Impact	Extent	Consequence	Probability	Significance
Construction phase	VL	L	VL	VL	M	L
Operational phase	VL	L	VL	VL	L	L
Decommissioning and closure phase	VL	L	VL	VL	M	L

Probable latent impacts

- Sedimentation of the features may lead to altered riparian habitats.
- Ineffective rehabilitation may lead to the permanent transformation of the riparian habitat.
- Proliferation of alien weed species in disturbed areas will lead to altered vegetation communities.

4.2 Powerline Impact Assessment

4.2.1 Impact 1: Loss of Aquatic Habitat and Ecological Structure

Aspects and activities register

Pre-Construction	Construction	Operational
Planning of infrastructure within riparian areas	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils as a result of general operational activities
Inappropriate design of infrastructure leading to changes of riparian habitat	Movement of construction vehicles within riparian area resulting in soil compaction	Sedimentation and incision leading to altered habitats and loss riparian biodiversity

Construction related activities, such as the removal and disturbance of vegetation, may lead to habitat alteration and loss of biodiversity within the riparian areas and it can also lead to erosion and increased runoff in the area. All these activities may result in permanent impact on the features and may extend to downstream areas as well.

Operational activities such as oil leaks from vehicles and maintenance of the powerline may result in the contamination of riparian soils and water, which will lead to the alteration or loss of habitat for aquatic species.

If left unmitigated, impacts on the riparian features will lead to significant impacts on riparian habitat and ecological structure, however with the implementation of mitigation measures the intensity and extent of the impact can be reduced.

Unmanaged	Intensity	Duration	Extent	Consequence	Probability	Significance
Construction phase	L	VL	VL	VL	L	L
Operational phase	L	M	VL	L	L	L

Essential construction phase mitigation measures:

- No support structures should be constructed within the riparian areas or within the active stream channel. If at all possible all support structures should be developed above the 1: 100 year flood line and above the 1:50 year flood line as a minimum.
- No upstream ponding or downstream erosion/ scouring as a result of the powerline crossing construction should be allowed.
- River banks must be appropriately re-profiled and re-vegetated with indigenous grasses and trees.
- Restrict vehicles to travelling only on designated roadways to limit the ecological footprint of the proposed project activities.
- All soils compacted as a result of construction activities falling outside of the development footprint areas should be ripped and profiled.
- To prevent the erosion of riparian areas, management measures may include berms, soil traps, hessian curtains and storm water diversion away from areas susceptible to erosion.

Recommended construction phase mitigation measures:

- Vehicles should not traverse drainage lines at new points but should cross on existing roads or low water crossings
- During construction phase erosion berms should be installed to prevent gully formation and siltation of the aquatic resources. The following points should serve to guide the placement of erosion berms.
  - Where the track has a slope of less than 2%, berms every 50m should be installed.
  - Where the track slopes between 2% and 10%, berms every 25m should be installed.
  - Where the track slopes between 10%-15%, berms every 20m should be installed.
  - Where the track has a slope greater than 15%, berms every 10m should be installed.
- Ensure that the proposed project footprint areas remain as small as possible.

Essential operation phase mitigation measures:

- Ensure that operational related activities are kept strictly to tower positions.
- Alien and invasive vegetation control should take place throughout the operational phase of the development.
- In the event of a breakdown, maintenance of vehicles must take place with care and the recollection of spillage should be practiced to prevent the ingress of hydrocarbons into the topsoil.
- Restrict vehicles to travelling only on designated roadways to limit the ecological footprint of the proposed project activities.
- River banks must be appropriately re-profiled and re-vegetated with indigenous grasses and trees.

Managed	Intensity	Duration of Impact	Extent	Consequence	Probability	Significance
Construction phase	VL	VL	VL	VL	VL	VL
Operational phase	VL	L	VL	VL	VL	VL

Probable latent impacts

- Sedimentation of the features may lead to altered riparian habitats.
- Ineffective rehabilitation may lead to the permanent transformation of the riparian habitat.
- Proliferation of alien weed species in disturbed areas will lead to altered vegetation communities.

4.2.2 Impact 2: Changes to Riparian Hydrological Function and Sediment Balance

Aspects and activities register

Pre-Construction	Construction	Operational
Planning of infrastructure within riparian areas	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils due to general operational activities
Inappropriate design of infrastructure leading to changes of riparian habitat	Movement of construction vehicles within riparian areas leading to soil compaction which results in increased runoff	Movement of operational and maintenance vehicles within riparian areas leading to soil compaction which results in increased runoff
Inappropriate design of infrastructure leading to vehicles traversing drainage lines		

Construction activities such as vegetation removal and excavations may alter the hydrology and sediment balance of the features. In addition, sediment deposition as a result of the disturbance of soils and increased sediment runoff during the construction may result in an impact on the sediment balance of the features.

During the operational phase, hardened surfaces and compacted soil will increase surface runoff, which then alter the hydrology of the features.

Unmanaged	Intensity	Duration of Impact	Extent	Consequence	Probability	Significance
Construction phase	L	VL	VL	VL	L	L
Operational phase	L	M	VL	L	L	L

Essential construction phase mitigation measures:

- No support structures should be constructed within the riparian areas or within the active stream channel. If at all possible all support structures should be developed above the 1: 100 year flood line and above the 1:50 year flood line as a minimum.
- During construction all construction materials should be kept out of the riparian areas as well as the active stream channels.
- All waste and remaining building materials should be removed from site on completion of the project.
- No vehicles should be allowed to indiscriminately drive through the riparian areas or within the active stream channels.

Recommended construction phase mitigation measures:

- As far as possible no activities, with special mention of access roads, should occur within the riparian zones of stream channels as well as the stream channels themselves.
- Concurrent rehabilitation is to take place as far as possible and footprint areas should be minimised as far as possible.
- All areas affected by construction should be rehabilitated upon completion of the construction phase of the development.
- River banks must be appropriately re-profiled and re-vegetated with indigenous grasses and trees.
- During construction phase erosion berms should be installed to prevent gully formation and siltation of the aquatic resources.

Managed	Intensity	Duration of Impact	Extent	Consequence	Probability	Significance
Construction phase	VL	VL	VL	VL	VL	VL
Operational phase	VL	L	VL	VL	VL	VL

Probable latent impacts

- Sedimentation of the features may lead to altered riparian habitats.
- Ineffective rehabilitation may lead to the permanent transformation of the riparian habitat.
- Proliferation of alien weed species in disturbed areas will lead to altered vegetation communities.

4.2.3 Impact 3: Impacts on Instream Biota

Aspect and activities register

Pre-Construction	Construction	Operational
Placement of infrastructure within riparian areas resulting in alteration of runoff patterns	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils due to general operational activities
Inappropriate design of infrastructure leading to changes in hydrological function and sediment control capacity	Movement of construction vehicles within riparian areas leading to soil compaction which results in increased runoff	Increased runoff volumes due to increased paved and other impervious surfaces leading to erosion and sedimentation
Movement of construction vehicles within riparian areas leading to soil compaction which results in instream habitat disturbance	Pollution such as litter and any spills (both chemical and organic) may occur during the construction phase.	Movement of maintenance vehicles within riparian areas leading to soil compaction which results in instream habitat disturbance

Construction activities may alter the hydrology and sediment balance of the features. An increase in runoff from disturbed areas may also alter flow patterns. In addition, sediment deposition as a result of the disturbance of soils and increased sediment runoff during the construction may result in an impact on the sediment balance of the features, which can lead to an inability to support biotic biodiversity as a result of changes to water quality and increased sedimentation.

During the operational phase, hardened surfaces and compacted soil will increase surface runoff, which then alter the hydrology of the features.

<table>
<tr><th>Unmanaged</th><th>Intensity</th><th>Duration of Impact</th><th>Extent</th><th>Consequence</th><th>Probability</th><th>Significance</th></tr>
<tr><td>Construction phase</td><td>L</td><td>VL</td><td>VL</td><td>VL</td><td>L</td><td>L</td></tr>
<tr><td>Operational phase</td><td>L</td><td>M</td><td>VL</td><td>L</td><td>L</td><td>L</td></tr>
<tr><td colspan="7">Essential construction phase mitigation measures:
• No unnecessary support structures should be constructed within the riparian zones or active stream channels.
• During construction all construction materials should be kept out of the riparian or wetland zones.
• All waste and remaining building materials should be removed from site on completion of the project.
• No dumping should take place in or near the construction site.
• All spills should be immediately cleaned up and treated accordingly.
• No fires should be permitted on site.
• Appropriate sanitary facilities must be provided for the duration of the proposed development and all waste removed to an appropriate waste facility.</td></tr>
<tr><th>Managed</th><th>Intensity</th><th>Duration of Impact</th><th>Extent</th><th>Consequence</th><th>Probability</th><th>Significance</th></tr>
<tr><td>Construction phase</td><td>VL</td><td>VL</td><td>VL</td><td>VL</td><td>VL</td><td>VL</td></tr>
<tr><td>Operational phase</td><td>VL</td><td>L</td><td>VL</td><td>VL</td><td>VL</td><td>VL</td></tr>
<tr><td colspan="7">Probable latent impacts
• Sedimentation of the features may lead to altered riparian habitats.
• Ineffective rehabilitation may lead to the permanent transformation of the riparian habitat.
• Proliferation of alien weed species in disturbed areas will lead to altered vegetation communities.</td></tr>
</table>

4.3 Impact Assessment Conclusion

Based on the above assessment it is evident that there are three possible impacts that may have an effect on the overall riparian and aquatic integrity for both the proposed Smelter and access road construction and the construction of the proposed Powerline. The tables below summarise the findings indicating the likely significance of the impacts before mitigation takes place and the significance of the impacts if appropriate management and mitigation takes place. In the consideration of mitigation, it is assumed that a high level of mitigation will take place without prohibitively high costs.

Table 19: A summary of the results obtained from the assessment of aquatic ecological impacts arising from development of the proposed smelter.

CONSTRUCTION PHASE		
Impact	**Unmanaged**	**Managed**
1: Loss of aquatic habitat and ecological structure	M	L
2: Impacts on aquatic hydrological function and sediment balance	H	M
3: Impacts on instream biota	M	L
OPERATIONAL PHASE		
Impact	**Unmanaged**	**Managed**
1: Loss of aquatic habitat and ecological structure	M	L
2: Impacts on aquatic hydrological function and sediment balance	H	M
3: Impacts on instream biota	M	L
DECOMMISSIONING AND CLOSURE PHASE		
Impact	**Unmanaged**	**Managed**
1: Loss of aquatic habitat and ecological structure	M	L
2: Impacts on aquatic hydrological function and sediment balance	H	M
3: Impacts on instream biota	M	L

Table 20: A summary of the results obtained from the assessment of aquatic ecological impacts arising from development of the proposed powerline.

CONSTRUCTION PHASE		
Impact	**Unmanaged**	**Managed**
1: Loss of aquatic habitat and ecological structure	L	VL
2: Impacts on riparian hydrological function and sediment balance	L	VL
3: Impacts on instream biota	L	VL
OPERATIONAL PHASE		
Impact	**Unmanaged**	**Managed**
1: Loss of aquatic habitat and ecological structure	L	VL
2: Impacts on riparian hydrological function and sediment balance	L	VL
3: Impacts on instream biota	L	VL

Based on the findings of the impact assessment it is clear that the development of the proposed Smelter may have a high to medium impact on the receiving aquatic environment prior to mitigation, while the development of the proposed Powerline will have a low impact on the receiving environment should no mitigation or management measures be implemented. No impact as a result of development of one of the two proposed access road alternatives are expected. The aquatic resources in the area have suffered large modifications due to the lack of flowing water and high erosion in the area and can be considered as having low biotic diversity and sensitivity. Erosion and sedimentation of the aquatic systems is deemed as the most significant impact regarding both the Smelter and access road and the proposed Powerline construction. If suitable mitigation measures are applied, the possible impacts as a result of the Smelter and Access Road and proposed Powerline construction will be alleviated to medium, low and very low impacts on the receiving environment.

5 ALTERNATIVES ASSESSMENT

A map indicating the location of the various infrastructure site layout alternatives is included in Section A: Figure 3 of this report.

Project Infrastructure Area

As a site layout alternative to Project Infrastructure Area Option 1 (preferred), which has been included as part of this assessment, Project Infrastructure Area Option 2 has been identified. As with Project Infrastructure Area Option 1 (with the exception of the southeastern portion of the Proposed Infrastructure Area, where no or very limited infrastructure is expected to be placed), Project Infrastructure Area Option 2 is located within an area where no aquatic resources appear to be present. Both Project Infrastructure Area Options 1 and 2 are therefore expected to have similar aquatic ecological impact levels, provided that the infrastructure footprint areas do not encroach on aquatic habitat.

Access Road

Neither Access Road Corridor Option 2 (preferred) nor Access Road Option 3 are located in the vicinity of wetland features and both these options are expected to have no impact on aquatic ecology in the region. Access Road Option 3 will require upgrades to several stream crossings and is therefore the least preferred alternative, with some aquatic impact expected (although it should be kept in mind that the Proposed Powerline Option 1 follows a similar alignment and watercourse crossings are therefore unlikely to be avoided).

Powerline

In addition to Powerline Option 1 (preferred), three other alternatives have been identified, namely Powerline Option 2, Powerline Option 3 and Powerline Option 4. All powerline alignments will involve the crossing of several watercourses and therefore are expected to have similar impact levels on the aquatic ecology of the area. Powerline Option 3 is however not located on an existing dirt road, where some impacts on the watercourses is likely to have occurred historically, and this is therefore the least preferred alternative in terms of aquatic ecology.

6 CONCLUSION AND RECOMMENDATIONS

Aquatic EIS determination yielded a low EIS for the Brakspruit and Phufane systems as well as for the bigger Bierspruit located north of the study area, indicating that these systems are not unique on a provincial or local scale due to biodiversity. However, whilst the Bierspruit (in terms of biota and habitat) is not usually very sensitive to flow modifications and often have substantial capacity for use, the smaller Brakspruit and Phufane can be considered to be at risk due to its smaller size and smaller systems generally being more susceptible to stress and less able to adjust to new impacts.

The aquatic habitat structure and diversity of each site can be regarded as inadequate for supporting a diverse and sensitive aquatic community. Lack of flowing water, suitable stones habitat and marginal or aquatic vegetation will severely impact the macro-invertebrate community diversity and sensitivity expected at each site.

The water quality can be considered as fair and largely natural at the SC2 and SC4 sites, while the EC and pH can be considered as slightly elevated at the SC6 site. The elevated EC concentration and pH value at site SC6 is likely due to runoff from the tarred main road and bridge crossing located at the site.

Based on the available habitat conditions the aquatic macro-invertebrate community in the systems can be regarded as having low diversity and sensitivity in relation to the available habitat on site. The aquatic community members present were generally present in low abundances with a relatively low diversity of taxa present. Due to the relatively poor habitat conditions, the Dallas (2007) classification of the site is regarded as being a more accurate description of the PES of the aquatic macro-invertebrates of the systems and indicates that both the upstream Brakspruit and Phufane systems are in severely modified conditions and that the downstream Brakspruit is in a largely modified condition. Care should be taken not to further impact on the aquatic ecosystems with the proposed activities.

It is the opinion of the environmental consultant that if suitable mitigation measures are applied, the possible impacts as a result of development of the smelter/ access roads and powerline will be alleviated to very-low, low and medium impacts on the receiving environment.

Implementation of the following recommendations should be strongly considered:

- Since the aquatic systems within the study area lacked flowing water at the time of the aquatic assessment, it is recommended that a high flow aquatic ecological assessment be undertaken in the future to provide improved insight on the local aquatic ecological conditions;
- On-going aquatic ecological monitoring must take place on an annual basis in the high flow season by a suitably qualified assessor focusing on aquatic macro-invertebrates, habitat integrity and biota specific water quality; and
- Future development planning should ensure that activities do not lead to a reduction of stream flow or dewatering of any aquatic/ wetland/ riparian areas and connectivity of the aquatic features in the vicinity of the study area should be maintained.

7 REFERENCES

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APPENDIX 1: IHIA SCORESHEET

Instream Zone Habitat Integrity

Weights		14	13	13	13	14	10	9	8	6	N/A	N/A
Reach	DATE	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
Upstream Brakspruit	April 2015	8	13	12	11	6	0	0	0	0	60.6	Class C (Moderately modified)
Phufane	April 2015	8	13	11	11	6	0	0	0	0	61.1	Class C (Moderately modified)
Downstream Brakspruit	April 2015	9	13	11	12	9	0	0	0	2	57.9	Class D (Largely modified)

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

Riparian Zone Habitat Integrity

Weights		13	12	14	12	13	11	12	13	N/A	N/A
Reach	DATE	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
Upstream Brakspruit	April 2015	4	8	11	8	12	11	6	0	57.6	Class D (Largely modified)
Phufane	April 2015	5	8	12	8	12	11	6	0	56.5	Class D (Largely modified)
Downstream Brakspruit	April 2015	6	8	12	8	12	11	8	0	54.4	Class D (Largely modified)

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

REACH	ASSESSMENT DATE	INSTREAM HABITAT	RIPARIAN ZONE	IHI SCORE	CLASS
Upstream Brakspruit	April 2015	60.6	57.6	59.1	Class D (Largely modified)
Phufane	April 2015	61.1	56.5	58.8	Class D (Largely modified)
Downstream Brakspruit	April 2015	57.9	54.4	56.1	Class D (Largely modified)

APPENDIX 2: SASS5 SCORESHEET

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 14/04/2015	**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**	**A**	Blepharoceridae	15				
SITE CODE: SC2	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER:	Oligochaeta	1			**1**	**1**	Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 20.7 °C	Amphipoda	13					Notonectidae*	3			**A**	**A**	Empididae	6				
Ph: 8.29	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 5.80 mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 210 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		0	0	12	12
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	0	4	4
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	0.0	3.00	3.00
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	32%				
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**						DAPHNIA					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5			**A**	**A**	**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					MUD ONLY					
	Zygoptera juvs.	6					Gyrinidae*	5					WATER OPAQUE					
	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					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 14/04/2015	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	A	Blepharoceridae	15				
SITE CODE: SC4	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 20.3 °C	Amphipoda	13					Notonectidae*	3			A	A	Empididae	6				
Ph: 7.92	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 5.63 mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 24.0 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			A	A	Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					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:	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:**		0	0	26	26
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	0	6	6
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	0.0	4.33	4.33
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	36%				
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**						DAPHNIA					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5			B	B	**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					MUD AND SAND ONLY					
	Zygoptera juvs.	6					Gyrinidae*	5					RAIN PUDDLE					
	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			A	A	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					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 14/04/2015	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	A	Blepharoceridae	15				
SITE CODE: SC6	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER:	Oligochaeta	1			B	B	Hydrometridae*	6					Chironomidae	2			B	B
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1			1	1
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 24.7 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 8.43	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 7.46 mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 42.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8			1	1	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			A	A	Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		0	0	19	19
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	0	6	6
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	0.0	3.17	3.17
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		29%			
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					MUD ONLY					
	Zygoptera juvs.	6					Gyrinidae*	5										
	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: IHAS SCORESHEET

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:

Site Name: SC2

Date: 14/04/2015

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):			0			
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):					0	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
Other Habitat Score (max 20):					12	
HABITAT TOTAL (MAX 55):					12	

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						20
TOTAL IHAS SCORE (%):					32	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name:						
Site Name: SC4	**Date**: 14/04/2015					
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):			0		
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):				0	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				16	
	HABITAT TOTAL (MAX 55):				16	
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				**20**	
	TOTAL IHAS SCORE (%):				**36**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name:						
Site Name: SC6	**Date**: 14/04/2015					
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):		0			
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):				0	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				9	
	HABITAT TOTAL (MAX 55):				9	
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					20
	TOTAL IHAS SCORE (%):				29	