

PRESENT ECOLOGICAL STATE ASSESSMENT OF THE AQUATIC RESOURCES IN THE VICINITY OF THE PROPOSED EXTENTION OF THE ASH DISPOSAL FACILITIES AT THE CAMDEN POWER STATION, MPUMALANGA

Prepared for:

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EXECUTIVE SUMMARY



Scientific Aquatic Services was appointed by Zitholele Consulting (Pty) Ltd to assess the integrity of the aquatic resources in the vicinity of the proposed extension of ash disposal facilities and associated infrastructure for the Camden Power Station. The assessment includes an aquatic ecological assessment as well as an assessment of the impacts deemed likely as a result of the proposed expansion.

The purpose of the assessment was to survey the general habitat integrity, habitat conditions for aquatic macro-invertebrates, aquatic macro-invertebrate and fish community integrity. The protocols of applying the necessary indices were strictly adhered to and all work was undertaken by a South African River Health Program accredited assessor.



The following key findings are highlighted pertaining to the study:

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|-----------------------|----------------------------------|--|--|--|--|----|------|--------------|-----------|-------------|---------|-----------------------------|--|-------------------|---------------|-------------------|---------------|---------------------|--|--------------------------------|----------------|--------------------|------------------|-------------|----|-------------|---|------------|-----|----------------------------|--|---------|--|--|
| <table border="1" style="width: 100%;"> <tr> <td>Catchment Vaal</td> </tr> <tr> <td>Quaternary Catchment C11B</td> </tr> <tr> <td>Ecoregion Highveld</td> </tr> <tr> <td>Weather condition: Hot and Cloudy</td> </tr> </table> | Catchment Vaal | Quaternary Catchment C11B | Ecoregion Highveld | Weather condition: Hot and Cloudy | <p>Aerial photograph of the subject property.</p>  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Catchment Vaal | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Quaternary Catchment C11B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ecoregion Highveld | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Weather condition: Hot and Cloudy | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1" style="width: 100%;"> <tr> <td colspan="2">Site CB1</td> </tr> <tr> <td colspan="2">Site description: Unknown tributary 1 of the Vaal River. Upstream of confluence with Unknown tributary 2.</td> </tr> <tr> <td colspan="2">Water quality:</td> </tr> <tr> <td>pH</td> <td>8.72</td> </tr> <tr> <td>Conductivity</td> <td>33.6 mS/m</td> </tr> <tr> <td>Temperature</td> <td>28.3 °C</td> </tr> <tr> <td colspan="2">Habitat suitability:</td> </tr> <tr> <td>IHAS Score</td> <td>60 Inadequate</td> </tr> <tr> <td>IHIA Score</td> <td>77.1% Class B</td> </tr> <tr> <td colspan="2">SASS5 Index:</td> </tr> <tr> <td>Dickens and Graham 2001</td> <td>Class E</td> </tr> <tr> <td>Dallas 2007</td> <td>Class E/F</td> </tr> <tr> <td>SASS5 Score</td> <td>64</td> </tr> <tr> <td>No. of Taxa</td> <td>9</td> </tr> <tr> <td>ASPT Score</td> <td>5.1</td> </tr> <tr> <td colspan="2">Impacts and Threats</td> </tr> <tr> <td colspan="2">Erosion</td> </tr> </table> | Site CB1 | | Site description: Unknown tributary 1 of the Vaal River. Upstream of confluence with Unknown tributary 2. | | Water quality: | | pH | 8.72 | Conductivity | 33.6 mS/m | Temperature | 28.3 °C | Habitat suitability: | | IHAS Score | 60 Inadequate | IHIA Score | 77.1% Class B | SASS5 Index: | | Dickens and Graham 2001 | Class E | Dallas 2007 | Class E/F | SASS5 Score | 64 | No. of Taxa | 9 | ASPT Score | 5.1 | Impacts and Threats | | Erosion | |  |
| Site CB1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Site description: Unknown tributary 1 of the Vaal River. Upstream of confluence with Unknown tributary 2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Water quality: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| pH | 8.72 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Conductivity | 33.6 mS/m | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Temperature | 28.3 °C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Habitat suitability: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IHAS Score | 60 Inadequate | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IHIA Score | 77.1% Class B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SASS5 Index: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dickens and Graham 2001 | Class E | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dallas 2007 | Class E/F | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SASS5 Score | 64 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| No. of Taxa | 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ASPT Score | 5.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Impacts and Threats | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Erosion | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |



| | |
|--|---|
| <p>Site CB2</p> |  |
| <p>Site description: Unknown tributary 1 of the Vaal River. Downstream of confluence with the Unknown tributary 2.</p> | |
| <p>Water quality: pH 8.80 Conductivity 37.0 mS/m Temperature 26.3 °C</p> | |
| <p>Habitat suitability: IHAS Score 65 Adequate IHIA Score 83.3% Class A</p> | |
| <p>SASS5 Index: Dickens and Graham 2001 Class D Dallas 2007 Class E/F SASS5 Score 68 No. of Taxa 14 ASPT Score 4.9</p> | |
| <p>Impacts and Threats Sedimentation and inundation</p> | |
| <p>Site CB3</p> |  |
| <p>Site description: Unknown tributary 2 confluencing with Unknown tributary 1 of the Vaal River.</p> | |
| <p>Water quality: pH 9.99 Conductivity 34.4 mS/m Temperature 31.5 °C</p> | |
| <p>Habitat suitability: IHAS Score 49 Inadequate IHIA Score 94.6% Class A</p> | |
| <p>SASS5 Index: Dickens and Graham 2001 Class D Dallas 2007 Class E/F SASS5 Score 59 No. of Taxa 12 ASPT Score 4.9</p> | |
| <p>Impacts and Threats Inundation. High pH</p> | |



| | | |
|---|---------------|---|
| Site CB4 | |  |
| Site description: Downstream on the Humanspruit | | |
| Water quality: | | |
| pH | 5.55 | |
| Conductivity | 100.7 mS/m | |
| Temperature | 29.3 °C | |
| Habitat suitability: | | |
| IHAS Score | 74 Adequate | |
| IHIA Score | 83.9 Class A | |
| SASS5 Index: | | |
| Dickens and Graham 2001 | Class E | |
| Dallas 2007 | Class E/F | |
| SASS5 Score | 40 | |
| No. of Taxa | 11 | |
| ASPT Score | 3.6 | |
| Impacts and Threats | | |
| Low pH | | |
| High dissolved salt concentration | | |
| Site CB5 | |  |
| Site description: Upstream on the Humanspruit | | |
| Water quality: | | |
| pH | 6.38 | |
| Conductivity | 74.7 mS/m | |
| Temperature | 24.4 °C | |
| Habitat suitability: | | |
| IHAS Score | 60 Inadequate | |
| IHIA Score | 45.2 Class D | |
| SASS5 Index: | | |
| Dickens and Graham 2001 | Class E | |
| Dallas 2007 | Class E/F | |
| SASS5 Score | 49 | |
| No. of Taxa | 11 | |
| ASPT Score | 4.5 | |
| Impacts and Threats | | |
| Access road causing loss of habitat at this point. | | |
| Some reduction in pH and some elevation in salts observed | | |

Fish community integrity

- The FAIL data indicates that the fish communities in this area have suffered a critical loss in integrity, and when compared to the reference score for a pristine Highveld Ecoregion stream, falling into a Class F indicating critically modified conditions.
- The absence of fish in these systems is indicative of long term impacts on the system, with special mention of loss of spawning habitat, upstream and downstream migration barriers and poor water quality as a result of mining and agricultural activities.
- Instream modifications and impacts from impoundments are considered to significantly impact on the indigenous fish community of the system and interfering with fish migrations along the rivers. In addition, many of the systems are non-perennial and are not ideal for supporting diverse and sensitive fish communities in the area.

Toxicological testing

- A statistically significant level of toxicity was observed at all four sites in the more sensitive lower trophic levels, *Vibrio fischeri* and *Selenastrum capricornutum*.
- *Vibrio fischeri* indicated a statistically significant degree of inhibition in each of the samples, which indicates that a toxicological effect is expressed on a bacterial level.



- *Selenastrum capricornutum* indicated a significant degree of inhibition at the CT1 site, however, at each of the other sites (CT2 and CB3) the test indicated a significant degree of stimulation, which may indicate that farming activities in the area may be leading to eutrophication of the aquatic resources in the area.
- In the higher trophic levels, a statistically significant level of toxicity was observed for both the *Daphnia pulex* and *Poecilia reticulata* at the CT1 site, while at the CB3 site, a statistically significant toxicological response was observed only in the *Poecilia reticulata* test.
- No response was observed in either of the higher trophic levels at the CT2 site, indicating that it is unlikely that seepage from the existing Camden Ash dump has reached this area to the degree that an acute toxicological response is observed.
- The toxicological effect observed at the CB3 site may be a combination of farming activities as well as a result of a pollution plume as a result of seepage from the existing ash dump at the Camden Power Station.
- In general, a slight toxicological impact (Class 2) is currently expressed on the tributaries of the Vaal River and its associated underground resources, which in turn may lead to a chronic impact on the aquatic community in this system. At the CT1 site, however, a high toxicological impact (Class 4) was observed, which will significantly impact on the surrounding aquatic resources with the degree of impact dependant on the volume of water reaching the receiving aquatic environment and the degree to which dilution of the impaired water quality occurs.
- It is considered essential that the toxicological monitoring of these points continue and that an additional point at the CB4 biomonitoring site be implemented so as to determine the extent of the pollution plume in the vicinity of the current ash dump and if toxicity levels are to decline further with the proposed expansion, immediate mitigatory action will be required.
- It may be necessary to select additional toxicological monitoring points based on the final placement of the proposed ash dam.

Impact Assessment

The aquatic resources in the vicinity of the study area have already been significantly disturbed by mining and agricultural activities in the area, as well as some impacts as a result of the existing ash dam at the Camden Power Station. Many of the impacts which occur will affect the local area permanently and are likely to increase the existing impacts on the receiving environment. If mitigation measures are implemented, the likelihood of further impacts occurring and the consequence of the impacts are significantly reduced to moderate and low levels.

The points below serve to summarise the measures deemed necessary in order to ensure protection of the riparian and aquatic resources, and to ensure environmental protection in the vicinity of the proposed expansion:

- No surface structures or construction should occur in the vicinity of any riverine systems in the study area and it must be ensured that downstream impacts on the ecology of the system do not occur. Special mention is made of the following:
 - Stream flow continuity needs to be maintained downstream of any disturbed areas in order to ensure the ongoing viability of the instream aquatic communities in these areas.
 - Water quality with special mention of pH, dissolved salts and specific problem substances like sulphate need to be managed, and monitored in order to ensure that reasonable water quality occurs downstream of the proposed expansion area in order to allow for the ongoing survival of an aquatic community of some diversity and reasonable sensitivity.



- The ash dam should not be placed within an aquatic resource in the study area or within the 1:100 year floodline in compliance of the requirements of regulation GN 704 of the National Water Act (Act 26 of 1998).
- Ensure that all activities take the wetland and riverine boundaries into account. No activities are to infringe upon the wetland and riverine boundaries unless it is absolutely unavoidable. In this regard specific mention is made of the following:
 - Wherever , no activities should take place within 100m of the aquatic resources;
 - As an absolute minimum no infrastructure should be placed within 32m of any aquatic resources except for bridge crossings;
 - Roadways and crossings should cross any features encountered at a 90 degree angle to minimise the footprint of the impact on these resources;
 - Demarcate all wetland and riverine boundaries;
 - No vehicles are to enter or drive through demarcated areas except at designated roadways;
 - Vehicles should be restricted to travelling only on designated roadways to limit the ecological footprint of the proposed development activities.
 - No dumping of waste or any other materials is allowed within these areas. If any spills occur, they should be immediately cleaned up;
 - No activities are to infringe upon the riverine boundaries. Should this be absolutely unavoidable that activities occur within these areas, relevant authorisation should be obtained according to the National Environmental Management Act (NEMA) 107 of 1998 and Section 21 c and i of the National Water Act 36 of 1998.
- No dirty water runoff from the ash dam must be permitted to reach the drainage features in the study area and the requirements of regulation GN 704 of the National Water Act (Act 36 of 1998) need to be strictly adhered to.
- Regularly inspect all vehicles for leaks. Re-fuelling of vehicles must take place on a sealed surface area surrounded by berms to prevent ingress of hydrocarbons into topsoil.
- Close monitoring of water quality must take place and adequate pH treatment and desalination of coal ash should take place.
- Ongoing monitoring of the groundwater resources in the vicinity of the proposed resources should take place on an ongoing basis.
- Dewatering boreholes should be situated down-gradient of the proposed ash dam so as to prevent any contaminated water from reaching the receiving environment further down-gradient.
- Adequate stormwater management must be incorporated into the design of the proposed development in order to prevent erosion and the associated sedimentation of the riparian and instream areas, as these systems have aquatic communities which rely on stream substrates clear of sediment and on clear, fast flowing water.
 - Sheet runoff from cleared areas, paved surfaces and access roads needs to be curtailed.
 - Runoff from paved surfaces should be slowed down by the strategic placement of berms.
 - During the construction and operational phases of the proposed expansion, erosion berms should be installed to prevent gully formation and siltation of the riparian resources. The following points should serve to guide the placement of erosion berms:
 - Where the track has slope of less than 2%, berms every 50m should be installed.
 - Where the track slopes between 2% and 10%, berms every 25m should be installed.
 - Where the track slopes between 10%-15%, berms every 20m should be installed.



- Where the track has slope greater than 15%, berms every 10m should be installed.
- Any river crossings must ensure that the creation of turbulent flow in the system is minimised, in order to prevent downstream erosion. No support pillars should be constructed within the active channel.
 - The duration of impacts on any drainage feature should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised.
 - All areas affected by any river crossing should be rehabilitated upon completion of the construction phase of the development. Areas should be reseeded with indigenous grasses as required.
 - During the construction phase, no vehicles should be allowed to indiscriminately drive through any riparian areas.
- All riparian areas of disturbed and compacted soils need to be ripped, reprofiled and reseeded with indigenous grasses.
- All riparian areas affected by construction should be rehabilitated upon completion of the expansion project. Areas should be reseeded with indigenous grasses as required. All rehabilitated areas should be rehabilitated to a point where natural processes will allow the pre-development ecological functioning and biodiversity of the area to be re-instated.
- Ongoing alien vegetation removal should take place in any riparian areas where disturbance of the soil takes place.
- Ongoing biomonitoring of the aquatic resources in the vicinity of the proposed development must take place. Biomonitoring should take place at points located upstream and downstream of the activities. Biomonitoring should take place on a six monthly basis in the autumn and spring of each year. Biomonitoring should take place using the SASS5 and IHAS indices. Biomonitoring should be undertaken by a South African River Health Program (SARHP) accredited practitioner and extended contracts should be set up for this monitoring in order to ensure that good interpretation of complex biological data takes place.
- Toxicity testing of any features which contain water which may come into contact with the receiving environment as well as key areas indicating a pollution plume as a result of the proposed expansion project should be tested on a 6 monthly basis in conjunction with the biomonitoring surveys. Toxicity tests should be run on four trophic levels including *Poecilia reticulata*, *Daphnia pulex*, *Selenastrum capricornutum* and *Vibrio fischeri*.
- The results of the biomonitoring surveys should be compared to this baseline data in order to determine if any impacts on the aquatic ecosystems on the subject property are occurring. In addition if any impacting trends are observed, measures to prevent the impacts from occurring should be immediately sought.
- Four alternative sites for the placement of the proposed ash dam and its associated infrastructure have been previously selected. With regard to the protection of the aquatic resources in the vicinity of the proposed project, it is recommended that either alternatives 2 or 3 are given preference rather than either alternative 1 or 4 as these are situated well away from any of the aquatic resources of the area. Additional biomonitoring or toxicological assessment sites may need to be selected, or existing assessment sites adjusted based on the final alternative chosen for future monitoring purposes.



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Appendix 2: IHAS score sheets January 2012

Appendix 3: SASS5 score sheets January 2012



1. PROJECT OBJECTIVES AND SCOPE

Scientific Aquatic Services was appointed by Zitholele Consulting (Pty) Ltd to assess the integrity of the aquatic resources in the vicinity of the proposed extension of ash disposal facilities and associated infrastructure for the Camden Power Station. The assessment includes an aquatic ecological assessment as well as an assessment of the impacts deemed likely as a result of the proposed expansion.

The purpose of the aquatic ecological assessment was to survey the general habitat integrity, riparian vegetation integrity, habitat conditions for aquatic macro-invertebrates, aquatic macro-invertebrate community integrity and fish community integrity. The study area is located within the Highveld Water Management Area (quaternary catchment C11B). The study site is located 12.0 km from Ermelo, in the Mpumalanga Province. This report serves to document the condition at the time of sampling to indicate the state of the riverine ecological integrity in summer, at a time when high flows are experienced and prior to the proposed development taking place.

The following was considered in the selection of suitable sites for assessing the level of aquatic ecological integrity in the vicinity of the study area:

- The site location in relation to the existing infrastructure and activities in the area.
- Consideration was given to the position of the proposed development site in order to assist in defining the Present Ecological State and any impacts in this area.
- Accessibility with a vehicle in order to allow for the transport of equipment.
- The sites were selected where the best possible habitat conditions with a good level of diversity occurred, suitable for supporting the most diverse aquatic community which could occur in the area.



Five biomonitoring sites and two toxicological sites representative of the aquatic resources in the area were assessed and are indicated in the figure below, which shows each biomonitoring point in red and the toxicological points in yellow.

Table 1: Geographic information pertaining to the assessment site

| Site | Description | GPS co-ordinates | |
|------|--|------------------|--------------|
| | | South | East |
| CB1 | This site is situated on the Unknown tributary 1 of the Vaal River downstream of the confluence of this river with a small Unknown tributary 2 shortly upstream of this point. | S26°38'54.0" | E30°02'11.9" |
| CB2 | This site is situated on the Unknown tributary 1 of the Vaal River upstream of the confluence of this river with the small Unknown tributary 2 shortly downstream of this point. | S26°40'06.7" | E30°03'00.0" |
| CB3 | Small Unknown tributary 2 of the Vaal River. | S26°38'33.4" | E30°02'50.6" |
| CB4 | Downstream point on the Humanspruit River. Any impacts as a result of the activities of the proposed expansion will be evident at this point. | S26°35'18.8" | E30°04'00.3" |
| CB5 | Upstream point on the Humanspruit River. This site may be used as a reference point indicating the condition of the stream before any impacts as a result of the activities of the Camden Power Station. | S26°35'13.6" | E30°02'40.5" |
| CT1 | Representative. This site will indicate the impacts of the Camden Power Station ash dump on the adjacent water body. | S26°37'20.1" | E30°04'10.4" |
| CT2 | Representative. This site will indicate the degree to which the toxicological pollution plume extends downstream of the Camden Power Station. | S26°39'00.0" | E30°03'01.7" |

It is the objective of the study to provide detailed information of the aquatic resources in the vicinity of the study area to guide the proposed development and to ensure that the ongoing functioning of the aquatic resources is facilitated with specific mention of the following:

- ongoing availability of suitable instream and riparian habitat to support aquatic biota;
- ongoing functionality of the aquatic community;
- to ensure ongoing functioning of the aquatic resources in the vicinity of the proposed development.



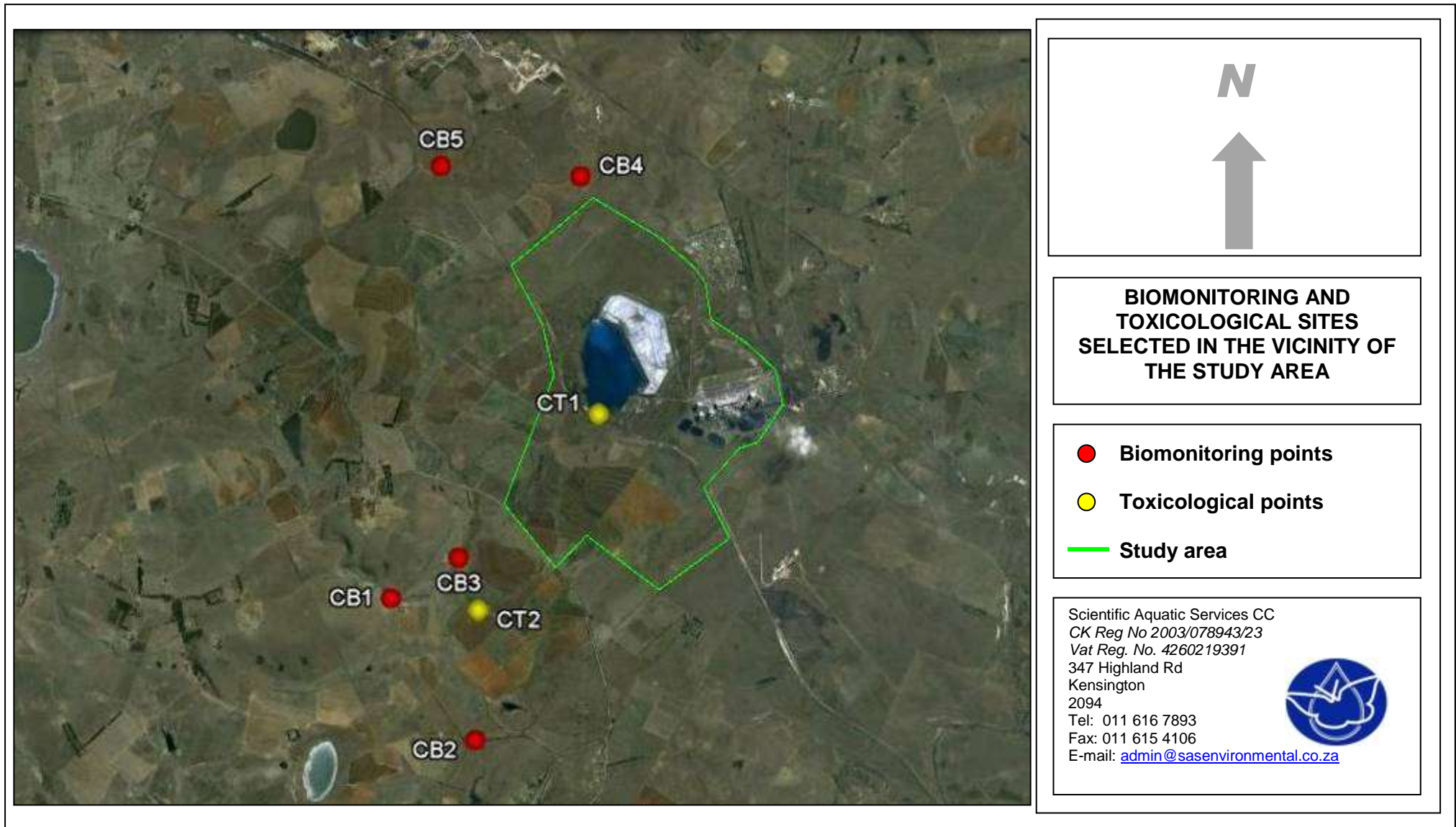


Figure 1: Aerial photograph depicting the bio-monitoring (red) and toxicological (yellow) sites selected in the vicinity of the study area.



2. AQUATIC ECOLOGICAL DESCRIPTION

2.1 *Ecoregions*

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

The study area falls within the Highveld Ecoregion, which can be considered to contain high aquatic biodiversity and a fairly sensitive aquatic community. The study area falls within the C11B quaternary catchment. Refer to the figure below.

2.2 *Ecstatus*

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

Table 2: Classification of river health assessment classes in line with the RHP

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

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

This database was searched for the quaternary catchment of concern (C11B) in order to define the EIS, PEMC and DEMC. The findings are based on a study undertaken by Kleynhans (1999)



as part of “A procedure for the determination of the ecological reserve for the purpose of the national water balance model for South African rivers”. The results of the assessment are summarised in the table below.

Table 3: Summary of the ecological status of quaternary catchment C11B based on Kleynhans 1999

| Catchment | Resource | EISC | PESC | DEMC |
|-----------|----------|----------|--|---------------------------------------|
| C11B | Vaal | Moderate | CLASS B (Class C based on desktop certainty) | Class C: Moderately sensitive systems |

The points below summarise the impacts on the aquatic resources in the C11B quaternary catchment (Kleynhans 1999):

- The aquatic resources within this quaternary catchment have been highly affected by bed modification due to impacts from sedimentation as a result of farming and grazing.
- Very high flow and bed modifications have taken place.
- A very high impact from the introduced fish species, *Cyprinus carpio* is likely.
- A very high impact from inundation, caused by weirs, is likely.
- Riparian zones and stream bank conditions are considered to be highly impacted due to the presence of alien trees and agricultural activities leading to erosion.
- A high impact on water quality from the surrounding agricultural and mining activities is likely.

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

- The riverine systems in this catchment have a moderate diversity of habitat types increasing their ecological importance and sensitivity. The riverine systems in this quaternary catchment contain a good structure of riffles and pools, with the floodplains consisting of wetlands.
- The site has a low importance in terms of conservation.
- The riverine resources have a moderate sensitivity to flow requirements and changes in water quality, with the species, *Barbus kimberleyensis* and *Barbus aeneus*, being flow dependant.
- The area has a low importance in terms of migration of aquatic species.
- The area has a high importance in terms of rare and endemic species conservation with species such as *Austroglanis sclateri*, present in the system.
- The ecology of the area is considered to be moderately sensitive to changes in water quality.



- The area has moderate importance as a source of refugia for aquatic species.
- The catchment can be considered to be moderately sensitive to flow changes.



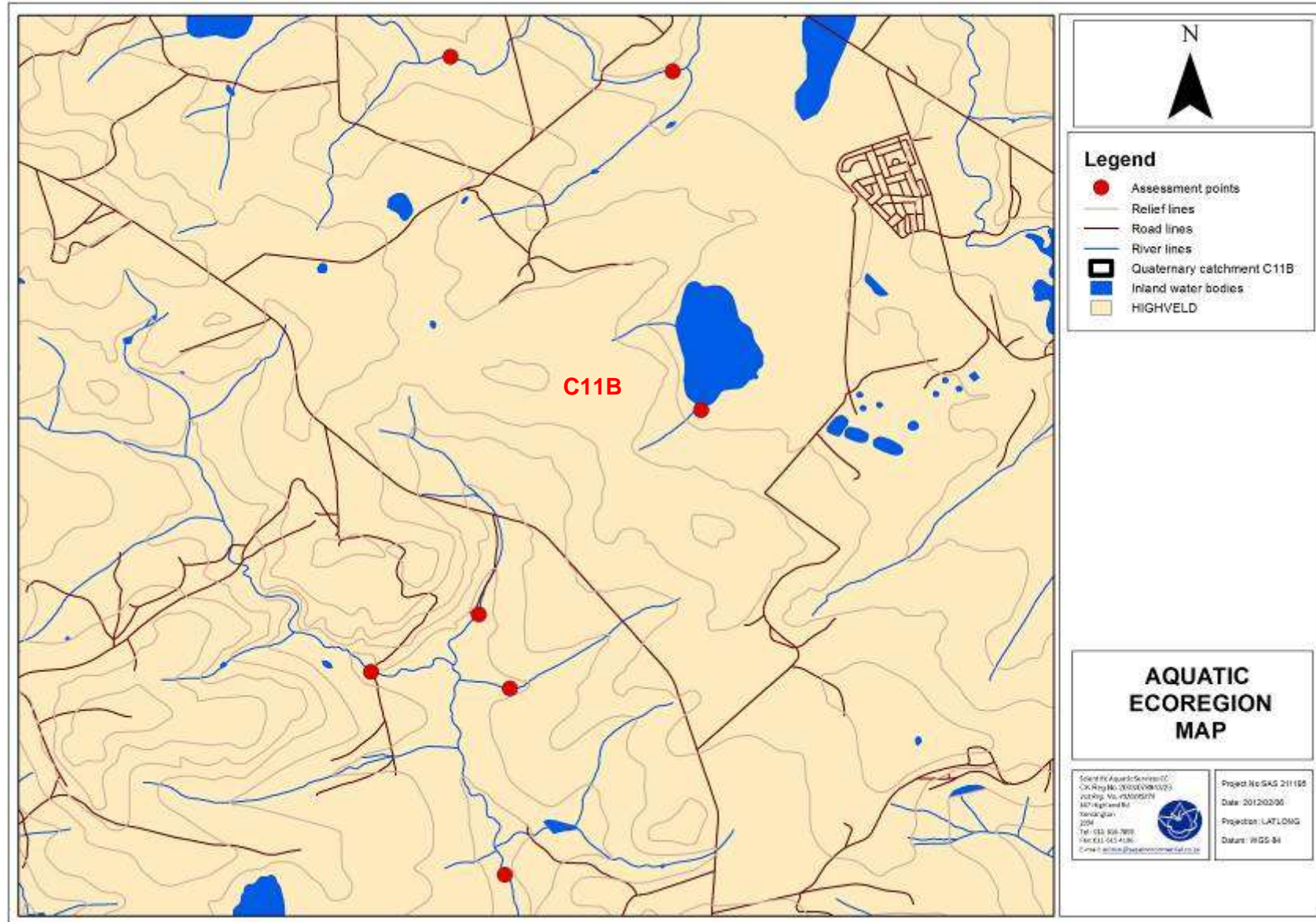


Figure 2: A map of the ecoregions of the area.



3. METHOD OF INVESTIGATION

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

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

3.1 *Visual Assessment*

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

- stream morphology;
- instream and riparian habitat diversity;
- stream continuity;
- erosion potential;
- depth flow and substrate characteristics;
- signs of physical disturbance of the area; and
- other life forms reliant on aquatic ecosystems.



3.2 Physico Chemical Water Quality Data

On site testing of biota specific water quality variables took place. Parameters measured include pH, electrical conductivity, dissolved oxygen concentration and temperature. The results of on-site biota specific water quality analyses were used to aid in the interpretation of the data obtained by the bio-monitoring. Results are discussed against the guideline water quality values for aquatic ecosystems (DWAF 1996 vol. 7) and the Olifants river ecological water requirements assessment (OREWRA) (DWAF, 2001).

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



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

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

3.4 Habitat Suitability

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

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



3.5 Aquatic Macro-Invertebrates

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

The SASS5 method was designed to incorporate all available biotypes at a given site and to provide an indication of the integrity of the of the aquatic macro-invertebrate community through recording the presence of various macro-invertebrate families at each site, as well as consideration of abundance of various populations, community diversity and community sensitivity. Each taxon is allocated a score according to its level of tolerance to river health degradation (Dallas, 1997).

This method relies on churning up the substrate with your feet and sweeping a finely meshed SASS net, with a pore size of 1000 micron mounted on a 300 mm square frame, over the churned up area several times. In stony bottomed flowing water biotopes (rapids, riffles, runs, etc.) the net downstream of the assessor and the area immediately upstream of the net is disturbed by kicking the stones over and against each other to dislodge benthic invertebrates. The net was also swept under the edge of marginal and aquatic vegetation to cover from 1-2 meters. Identification of the organisms was made to family level (Thirion *et al.*, 1995; Davies & Day, 1998; Dickens & Graham, 2001; Gerber & Gabriel, 2002).

Interpretation of the results of biological monitoring depends, to a certain extent, on interpretation of site-specific conditions (Thirion *et.al*, 1995). In the context of this investigation it would be best not to use SASS5 scores in isolation, but rather in comparison with relevant habitat scores. The reason for this is that some sites have a less desirable habitat or fewer biotopes than others do. In other words, a low SASS5



score is not necessarily regarded as poor in conjunction with a low habitat score. Also, a high SASS5 score, in conjunction with a low habitat score, can be regarded as better than a high SASS5 score in conjunction with a high habitat score. A low SASS5 score, together with a high habitat score, would be indicative of poor conditions. The IHAS Index is valuable in helping to interpret SASS5 scores and the effects of habitat variation on aquatic macro-invertebrate community integrity.

Classification of the system took place by comparing the present community status to reference conditions which reflect the best conditions that can be expected in rivers and streams within a specific area and reflect natural variation over time. SASS and ASPT reference conditions were obtained from Dallas (2007), as presented in the figure below. Reference conditions are stated as a SASS score of 140 and an ASPT score of 6 to allow for low habitat diversity. Sites were classified according to the classification system for the higher Highveld Ecoregion according to Dallas (2007), as well as the classification system of Dickens & Graham 2001.

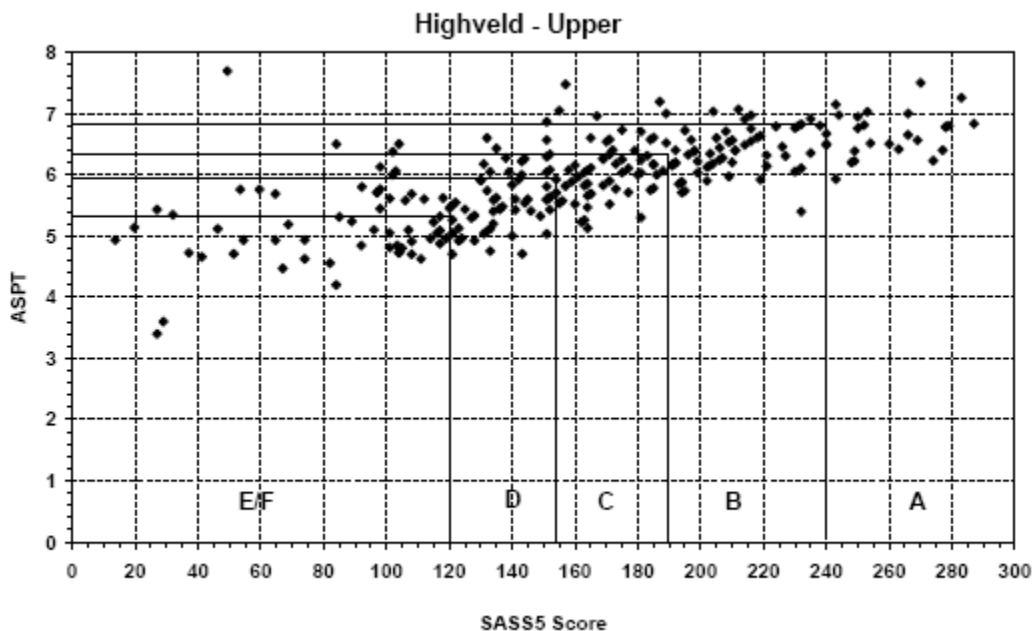


Figure 3: SASS5 Classification using biological bands calculated from percentiles for the lower Highveld Ecoregion, Dallas, 2007



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

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

3.6 *Fish Community Integrity*

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

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

The Fish Assemblage Integrity Index (FAII) was applied according to the protocol of Kleynhans (1999). Fish species identified were compared to those expected to be present at the sites assessed. Assessing the state of the fish community at a site can provide an indication of the long-term biological integrity of a stream segment. The expected fish species list was developed from a literature survey and included sources such as Skelton; (2001). The expected fish assemblage for each site was determined using these specific species known to occur in the area along with an assessment of availability of habitats, at each site. An expected species list was compiled for the region (Table 3). The integrity of the site was assessed according to the classification system of Kleynhans; (1999). See table 5.



Table 6: Intolerance ratings for naturally occurring indigenous fish species with natural ranges included in the study area (Kleynhans, 2003; Skelton, 2007).

| SPECIES NAME | COMMON NAME | INTOLERANCE RATING | COMMENTS |
|------------------------------------|-----------------------|--------------------|---|
| <i>Austroglanis sclateri</i> | Rock catfish | 2.7 | Rare, endemic to the Orange-Vaal system |
| <i>Barbus paludinosus</i> | Straightfin barb | 1.8 | Widespread |
| <i>Barbus anoplus</i> | Chubbyhead barb | 2.6 | Widespread |
| <i>Labeobarbus aeneus</i> | Smallmouth yellowfish | 2.5 | Widespread in the Orange-Vaal system |
| <i>Labeobarbus kimberleyensis</i> | Largemouth yellowfish | 2.5 | Widespread in the Orange-Vaal system but is becoming scarce |
| <i>Labeo capensis</i> | Orange river mud fish | 3.2 | Widespread in the Orange-Vaal system |
| <i>Labeo umbratus</i> | Moggel | 2.3 | Widespread in the Orange-Vaal system |
| <i>Pseudocrenilabrus philander</i> | Southern mouthbrooder | 1.3 | Widely distributed in southern Africa |
| <i>Tilapia Sparrmanii</i> | Banded tilapia | 1.3 | Widely distributed in southern Africa |
| <i>Clarias gariepinus</i> | Sharptooth catfish | 1.2 | Most widely distributed fish in Africa. |
| <i>Cyprinus carpio</i> | Carp | 1.4 | Widespread alien species |
| <i>Micropterus salmoides</i> | Largemouth bass | 2.2 | Widespread alien species |
| <i>Gambusia affinis</i> | Mosquito fish | 2 | Widespread |

Tolerant: 1-2

moderately tolerant :> 2-3

Moderately Intolerant: >3-4

Intolerant: >4

Table 7: Definition of Present State Classes in terms of FAIL scores according to the protocol of Kleynhans (1999)

| Class | Description | Relative FAIL score (% of expected) |
|-------|---|-------------------------------------|
| A | Unmodified, or approximates natural conditions closely. | 90-100 |
| B | Largely natural, with few modifications. | 80-89 |
| C | Moderately modified. A lower than expected species richness and the presence of most intolerant species. | 60-79 |
| D | Largely modified. A clearly lower than expected species richness and absence of intolerant and moderately tolerant species | 40-59 |
| E | Seriously modified. A strikingly lower than expected species richness and a general absence of intolerant and moderately intolerant species | 20-39 |
| F | Critically modified. An extremely lowered species richness and an absence of intolerant and moderately intolerant species | <20 |

3.7 Toxicological Assessment

Whole Effluent Toxicity (WET) procedures have been used successfully worldwide (SETAC, 1995) in countries such as the United States (USEPA, 1993; 1994), Canada (MISA, 1992) and in Europe (OECD, 1987). Governmental, industrial and international agencies have increasingly adopted single-species toxicity tests to predict potential



effects on the environment. These tests are scientifically sound and in conjunction with chemical and ecological measurements can identify, monitor and serve as basis to implement control measures on the discharge of complex effluents. The Department of Water Affairs and Forestry (DWAF) has for the past four decades controlled water pollution by managing levels of single substances in water. However, experience shows that substance-specific methods are not in themselves able to fully assess the ecological and toxicity hazard that may be posed by complex industrial wastewater discharges. Such methods are not effective in assessing the direct environmental toxicity hazard of discharges containing mixtures of substances (DWAF, 1996). For some time now, water managers and scientists have called for a more comprehensive approach to assess in a holistic manner the potential toxicity hazard of complex industrial wastewater discharges as a means to protecting the ecological integrity of aquatic ecosystems. This call is particularly relevant in light of Chapter 3 of the National Water Act (Act 36 of 1998), which focuses on the protection of the water resource itself. Indeed, a number of industries in their quest to improve environmental management, to ensure compliance to regulations and to avoid or reduce unnecessary spending on treatment and disposal of wastewater, have begun to investigate more holistic methodologies for directly assessing the ecological hazard of complex industrial wastewater discharges. To address the mentioned holistic approach DWAF is currently reviewing a discussion document (DWAF, 2003) in which the current situation related to complex industrial wastewater discharges, pointing out the current approach and methods, as well as the shortcomings and remaining challenges in protecting the ecological integrity of aquatic ecosystems are investigated. In particular, it introduces the Direct Estimation of Ecological Effect Potential (DEEEP) method. For the protection of aquatic life against the toxic effects of effluents and receiving waters a battery approach is recommended by Slabbert *et al.* (1998). According to DWAF, WET tests are important additions to chemical-specific measurements because:

- Test organisms respond to compounds, which are not readily identifiable or measured by analytical techniques.
- Test organisms respond to unknown compounds.
- Effects due to chemical interaction, e.g. synergism, antagonism and addition are detected.



- Information on the type of hazardous chemical activity in an effluent, i.e. toxicity is provided.
- Information on the impact on particular groups of target organisms is provided.

In order to qualify and quantify the potential impact of the past spills on the associated aquatic environment and to assess possible acute effects on aquatic organisms, acute WET tests were performed. The battery of WET tests included *Vibrio fischeri* (representing bacteria), *Selenastrum capricornutum* (representing aquatic vegetation) *Daphnia pulex* (representing aquatic macro-invertebrates) and *Poecilia reticulata* (representing fish).

Test organisms were exposed to water samples under controlled laboratory conditions. Tests were run along strictly defined protocols of the US EPA (1993) for the daphnia test, US EPA (1996) for the guppy test, EN ISO 11348-3 (1998) for the *Vibrio fischeri* bioluminescent test, OECD Guideline 201 (1984) for the *Selenastrum capricornutum* growth inhibition test. The results from these tests would indicate if there is any risk to the aquatic ecological integrity of the receiving environment on any one of four trophic levels should discharge or seepage occur. Interpretation of data took place by classifying the results for each site into one of five categories. These categories are indicated in the table below.



Table 8: Definition of Hazard classes in terms of acute screening level toxicity tests

| CLASS | DESCRIPTION | % MORTALITY |
|-------|---------------------|--|
| 1 | No acute hazard | None of the tests shows a toxic effect (i.e. an effect value that is significantly higher than that in the controls) |
| 2 | Slight acute hazard | A statistically significant EP is reached in at least one test, but the effect level is below 50% |
| 3 | Acute hazard | The 50% Effect Percentage (EP50) is reached or exceeded in at least one test, but the effect level is below 100% |
| 4 | High acute hazard | The EP100 is exceeded in at least one test |
| 5 | Severe acute hazard | The EP100 is exceeded in all tests |

Table 9: Summary of the test conditions and test acceptability criteria for the *Daphnia pulex* (US EPA 1993) and *Poecilia reticulata* (US EPA 1996) acute toxicity screening tests

| | DAPHNIA PULEX ACUTE TOXICITY TEST | POECILIA RETICULATA ACUTE TOXICITY TEST |
|---------------------------------------|---|--|
| Test endpoint | % mortality /LC ₅₀ | % mortality/LC ₅₀ |
| Exposure period | 48h | 96h |
| Deviation from reference method | None | None |
| Test chamber type | 50 mℓ disposable polystyrene cups | 500mℓ glass container |
| Test sample volume | 25mℓ | 200mℓ |
| Number of test organisms per chamber | 5 | 5 |
| Number of replicates per sample | 4 | 2 |
| Feeding frequency | None | None |
| Test temperature | 21±2°C | 24±3°C |
| Test organism species name and source | <i>Daphnia pulex</i> <24h old obtained from in-house cultures | <i>Poecilia reticulata</i> 7-21 days old purchased from supplier |
| Test protocol | % mortality /LC ₅₀ | % mortality/LC ₅₀ |



Table 10: Summary of the test conditions and test methods for the *Vibrio fischeri* EN ISO 11348-3 (1998) screening tests and *Selenastrum capricornutum* growth potential test EN ISO 11348-3 (1998)

| | VIBRIO FISCHERI ACUTE TOXICITY TEST | SELENASTRUM CAPRICORNUTUM GROWTH POTENTIAL TEST |
|---------------------------------------|--|--|
| Test endpoint | % growth inhibition relative to control r | % growth inhibition relative to control |
| Exposure period | 15 and 30 minutes | 72h |
| Deviation from reference method | None | None |
| Test chamber type | Polystyrene cuvettes for luminometer | 10 cm path length long cells |
| Test sample volume | 500 ul | 25 ml |
| Number of replicates per sample | 2 | 2 |
| Test temperature | 17°C | 21-25°C |
| Test organism species name and source | Lyophilized <i>Vibrio fischeri</i> luminescent bacteria (NRRL B-11177) | <i>Selenastrum capricornutum</i> , Printz algae beads (CCAP 278/4 Cambridge, UK) |
| Luminescent measurement | Luminoskan TL, Hygiene Monitoring System | Jenway 6300 Spectrophotometer |
| Reagent batch number | VF2607 | SC 251108 |
| Statistical method | Bio Orbit software | Regression analyses |

3.8 Impact Assessment and Impact Minimisation

The impact assessment is conducted by determining how the proposed activities will affect the state of the environment previously described. Specific requirements are:

- Undertake a comparative assessment of the three feasible facility alternatives, identifying and quantifying the environmental and/or social aspects of the various activities associated with the proposed project;
- Assess the impacts that may accrue and the significance of those impacts using the methodology as described below in Figure 4; and
- Identify and assess cumulative impacts utilising the same rating system.



To ensure uniformity, the assessment of impacts is addressed in a standard manner so that a wide range of impacts can be compared with each other. For this reason a clearly defined significance rating scale is provided to assess the significance (importance) of the associated impacts. The scale embraces the notion of extent and magnitude, but does not always clearly define these since their importance in the rating scale is very relative. For example, the magnitude (i.e. the size) of an area affected by atmospheric pollution may be extremely large (1000 km²) but the significance of this effect is dependent on the concentration or level of pollution. If the concentration were great, the significance of the impact would be HIGH or VERY HIGH, but if it were dilute it would be LOW or VERY LOW. Similarly, if 60 ha of a grassland type are destroyed the impact would be VERY HIGH if only 100 ha of that grassland type was known. The impact would be VERY LOW if the grassland type were common.

The potential significance of every environmental impact identified is determined by using a ranking scale, based on the following (the terminology is extracted from the DEAT guideline document on EIA Regulations, April 1998):

Occurrence

- Probability of occurrence (how likely is it that the impact may occur?), and
- Duration of occurrence (how long may it last?)

Severity

- Magnitude (severity) of impact (will the impact be of high, moderate or low severity?), and
- Scale/extent of impact (will the impact affect the national, regional or local environment, or only that of the site?)

In order to assess each of these factors for each impact, the following ranking scales were used:

Probability:

5 – Definite/don't know
4 – Highly probable
3 – Medium probability
2 – Low probability
1 – Improbable
0 – None

Duration:

5 – Permanent
4 – Long-term (ceases with the operational life)
3 – Medium-term (5-15 years)
2 – Short-term (0-5 years)
1 – Immediate

Scale:

5 – International
4 – National
3 – Regional (>5km)
2 – Local (<5km)
1 – Site only
0 – None

Magnitude:

10 – Very high/don't know
8 – High
6 – Moderate
4 – Low
2 – Minor

Once the above factors had been ranked for each impact, the environmental significance of each was assessed using the following formula:

$$SP = (\text{magnitude} + \text{duration} + \text{scale}) \times \text{probability}$$

The maximum value is 100 significance points (SP). Environmental effects were rated as either of high, moderate or low significance on the following basis:

- More than 60 significance points indicated high environmental significance.
- Between 30 and 60 significance points indicated moderate environmental significance.
- Less than 30 significance points indicated low environmental significance.



Please note that **only negative impact will be ranked**

The degree of certainty of the assessment was judged on the following criteria:

| | |
|------------------|--|
| Definite: | More than 90% sure of a particular fact. |
| Probable: | Between 70 and 90% sure of a particular fact, or of the likelihood of that impact occurring. |
| Possible: | Between 40 and 70% sure of a particular fact or of the likelihood of an impact occurring. |
| Unsure: | Less than 40% sure of a particular fact or the likelihood of an impact occurring. |

Figure 4: Impact Assessment Methodology provided by Zitholele Consulting (Pty) Ltd.



3.9 Assumptions and Limitations

The following points serve to indicate the assumptions and limitations of this study.

- **Reference conditions are unknown:** The composition of aquatic biota in the study area, prior to major disturbance, is unknown. For this reason, reference conditions are hypothetical, and are based on professional judgement and/or inferred from limited data available.
- **Temporal variability:** The data presented in this report are based on a single site visit, undertaken in summer (January 2012). The effects of natural seasonal and long term variation in the ecological conditions and aquatic biota found in the streams are, therefore, unknown.
- **Ecological assessment timing:** Aquatic and terrestrial ecosystems are dynamic and complex. It is likely that aspects, some of which may be important, could have been overlooked. A more reliable assessment of the biota would require seasonal sampling, with sampling being undertaken under both low flow and high flow conditions.



4. RESULTS AND INTERPRETATION

4.1 *The Unknown tributaries 1 and 2 of the Vaal River (Sites CB1, CB2 and CB3)*

4.1.1 *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 are presented below together with a table summarising the observations for the various criteria made during the visual assessment undertaken at each site.



Figure 5: Downstream view of the CB2 site, indicating the bedrock and pool-like nature of this Unknown tributary 1 of the Vaal River.



Figure 6: Upstream view of the CB2 site indicating the grasses dominating the riparian zone at this point.



Figure 7: Upstream view of the CB1 site, indicating the rocky nature of the substrate on this Unknown tributary 1 of the Vaal River at this point.



Figure 8: Downstream view of the CB1 site indicating the grasses that dominate the riparian zone at this point.



Figure 9: Upstream view of the CB3 site, indicating the marginal and aquatic vegetation on this Unknown tributary 2 of the Vaal River.



Figure 10: Downstream view of the CB3 site indicating the nature of the stream at this point which has no active channel.

Table 11: Description of the location of each assessment site in the study area

| SITE | CB2 | CB1 | CB3 |
|--------------------------------------|--|--|---|
| Riparian zone characteristics | The riparian zone is considered to be in relatively good condition at this point with mainly natural vegetation occurring. Grasses dominate the riparian zone at this point. | The riparian zone is considered to be in relatively good condition at this point with mainly natural vegetation occurring. Grasses dominate the riparian zone at this point. | The riparian zone is considered to be undisturbed and from this point, the stream flows into a well-functioning wetland system. |



| SITE | CB2 | CB1 | CB3 |
|---|---|---|--|
| Algal presence | Some algal proliferation was observed at this point. | No algal proliferation was observed at this point. | Some algal proliferation was observed at this point. |
| Visual indication of impact on aquatic fauna | Some instream sedimentation was observed. | Some erosion took place at this point. | None |
| Depth characteristics | The stream consisted of shallow glides and pools. | The stream consisted of shallow pools, riffles and glides at this point. | The stream consisted of a moderately deep pool at this point. |
| Flow condition | The stream consisted of slow flowing glides and still pools. | The site consisted of slow flowing pools with faster flowing riffles and glides. | Flow was very slow at this point. |
| Water clarity | Water is discoloured | Water is clear | Water is clear |
| Water odour | None | None | None |
| Erosion potential | There is little potential for erosion under high flow conditions due to the low gradient of the banks and the stable nature of the riparian vegetation. | There is some potential for erosion in high flow conditions due to the steep and incised nature of the banks at this point. | No potential for erosion under high flow conditions due to the low gradient and abundant vegetation at this point. |

4.1.2 *Physico-Chemical Water Quality*

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

Table 12: Biota specific water quality data along the main drainage feature.

| SITE | COND mS/m | pH | TEMP °C |
|------|-----------|------|---------|
| CB2 | 37.0 | 8.80 | 26.3 |
| CB1 | 33.6 | 8.72 | 28.3 |
| CB3 | 34.4 | 9.99 | 31.5 |

- General water quality at each of the sites may be considered good.
- Dissolved salts present in the system are considered to be slightly elevated in relation to the natural conditions expected to occur and fall within the limits stipulated by the DWAF TWQR for aquatic ecosystems.
- The data indicates that there may have been some impact from the activities of the power station as well as agricultural and mining activities on the dissolved salt concentrations within these drainage systems.
- The pH levels at each of the sites may be considered to be slightly alkaline and this may limit some of the more sensitive aquatic species from colonising these sections of stream. The alkalinity of ash dam associated with the Camden Power



Station may be contributing to the increased pH levels observed in these streams, with special mention of the CB3 site, where the pH is 14.6% higher than that observed at the CB1 site and 13.5% higher than that observed at the CB2 site. These differences exceed the DWAF TWQR for aquatic ecosystems and some impact on the aquatic communities as a result is deemed likely.

- Temperatures can be regarded as normal for the time of year and time of assessment at each point.

4.1.3 Habitat Assessment

- According to the IHIA, there are some moderate impacts at each point with regard to the instream habitat as well as the riparian zone.
- At the CB2 site, instream impacts included moderate impacts as a result of water quality modifications and inundation. Smaller impacts from flow, bed and channel modifications were also observed. Riparian zone impacts included only small impacts from exotic vegetation encroachment, bank erosion and inundation.
- At the CB1 site, instream impacts included moderate channel and water quality modifications with smaller impacts from flow and bed modifications, while riparian impacts were limited to bank erosion and channel modifications.
- Impacts at the CB3 site were limited to small impacts as a result of water quality modifications and inundation.
- Overall, an IHIA rating of 83.3%, 77.1% and 94.6% was achieved at the CB2, CB1 and the CB3 sites, which indicates natural (class A conditions) at the CB1 and CB3 sites and minimally modified (class B conditions) at the CB2 site. The sites therefore fall within the DEMC for the quaternary catchment. The proposed expansion project may result in a decline in the aquatic ecological integrity of these systems.
- Impacts on the aquatic resources in this area should be limited. Any impacts from further activities in the area should be managed in such a way as to limit the impact on habitat integrity and to limit impacts on aquatic habitat.



The table below is a summary of the results obtained from the application of the IHAS Index to each assessment site in the vicinity of the study area. This index determines habitat suitability, with particular reference to the requirements of aquatic macro-invertebrates. The results obtained from this assessment will aid in defining the habitat condition and thereby assist in the interpretation of the other biological data for the area.



Table 13: A summary of the results obtained from the application of the IHAS index to the assessment sites.

| SITE | CB2 | CB1 | CB3 |
|---|---|---|---|
| IHAS score | 65 | 60 | 49 |
| IHAS Adjustment score (illustrative purposes only) | +23 | +31 | +34 |
| McMillan, 1998 IHAS description | Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community. | Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community. | Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community. |
| Stones habitat characteristics | Bedrock and some large boulders were present at this point. The absence of small interstitial spaces may limit the communities likely to occur at this point. | Bedrock and some large boulders were present at this point. The absence of small interstitial spaces may limit the communities likely to occur at this point. | No rocky habitat was available at this point. |
| Vegetation habitat characteristics | Adequate marginal and aquatic vegetation was present. | Some marginal vegetation was present at the time of the assessment. The absence of leafy overhanging vegetation will limit the aquatic macro-invertebrate communities likely to occur at this point. | Some instream vegetation was present at the time of the assessment. |
| Other habitat characteristics | There were some mud and sand deposits present in the area. | There were some limited GSM deposits present in the area. | There were some sand and mud deposits present in the area. |
| IHAS general stream characteristics | A shallow stream consisting of slow flowing pools and glides. The water in the system was opaque at the time of assessment. Bankside cover is considered to be very good at the present time. | A narrow slow flowing stream consisting of slow flowing pools habitat with some areas of faster flowing riffles and glides. The water in the system was clear at the time of assessment. Bankside cover is considered adequate at the present time. | A shallow slow flowing stream consisting of pools. The water in the system was clear at the time of assessment. Bankside cover is considered very good at the present time. |

- Habitat diversity and structure at the CB2 point was considered adequate, while at the CB1 and CB3 points the habitat was considered inadequate for supporting a diversity of aquatic macro-invertebrate community structures.
- However, the abundant marginal and aquatic vegetation present at the CB2 and the CB3 points, is likely to aid in the diversity of the aquatic community at these points and as such, it is likely that higher SASS5 scores may be observed at these two points in relation to those at the CB1 assessment point.



4.1.4 *Aquatic Macro-invertebrates*

The results of the aquatic macro-invertebrate assessment according to the SASS5 index are summarised in the tables below. Table 13 indicates the results obtained at the site per biotope sampled. Table 14 summarises the findings of the SASS5 assessment based on the analyses of the data for the sites, as well as interpretation of the data for the sites.

Table 14: Biotope specific summary of the results obtained from the application of the SASS5 index to the S1 site.

| PARAMETER | SITE | STONES | VEGETATION | GRAVEL, SAND AND MUD | TOTAL |
|-------------|------|--------|------------|----------------------|-------|
| SASS5 Score | CB2 | 14 | 58 | 14 | 68 |
| Taxa | | 3 | 11 | 5 | 14 |
| ASPT | | 4.7 | 5.3 | 2.8 | 4.9 |
| SASS5 Score | CB1 | 15 | 40 | - | 46 |
| Taxa | | 4 | 9 | - | 9 |
| ASPT | | 3.8 | 4.4 | - | 5.1 |
| SASS5 Score | CB3 | - | 59 | - | 59 |
| Taxa | | - | 12 | - | 12 |
| ASPT | | - | 4.9 | - | 4.9 |



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

| Type of Result | CB2 | CB1 | CB3 |
|--|---|---|---|
| Biomes sampled | Stones and bedrock in and out of current, marginal vegetation in and out of current, sand and mud. | Stones and bedrock in and out of current, marginal vegetation in and out of current, sand and mud. | Marginal and aquatic vegetation and mud. |
| Sensitive taxa present | <i>Atyidae</i> ; <i>Caenidae</i> ; <i>Naucoridae</i> | None | <i>Hydracarina</i> ; <i>Caenidae</i> ; <i>Aeshnidae</i> |
| Sensitive taxa absent | <i>Chlorolestidae</i> ; <i>Athericidae</i> ; <i>Chlorocyphidae</i> ; <i>Gomphidae</i> ; <i>Hydracarina</i> ; <i>Aeshnidae</i> | <i>Chlorolestidae</i> ; <i>Chlorocyphidae</i> ; <i>Hydracarina</i> ; <i>Aeshnidae</i> ; <i>Elmidae</i> ; <i>Athericidae</i> | <i>Chlorolestidae</i> ; <i>Athericidae</i> ; <i>Naucoridae</i> ; <i>Chlorocyphidae</i> ; <i>Gomphidae</i> |
| Adjusted SASS5 score | 91 | 77 | 93 |
| SASS5 % of reference score | 48.6% | 32.9% | 42.1% |
| ASPT % of reference score | 81.7% | 85.0% | 81.7% |
| Dickens and Graham, 2001 SASS5 classification | Class D (Largely impaired) | Class E (Seriously impaired) | Class D (Largely impaired) |
| Dallas 2007 classification | Class E/F | Borderline Class E/F | Class E/F |

- The SASS5 data indicates that the aquatic macro-invertebrate communities in these tributaries of the Vaal River have suffered a serious loss in integrity when compared to the reference score for a pristine Highveld Ecoregion stream.
- At present, the CB2 and CB3 sites can be considered as being in a Class D (largely impaired) condition and the CB1 site in a Class E (seriously impaired) condition according to the Dickens & Graham (2001) classification system and all of the sites as a Class E/F condition according to the Dallas (2007) classification system thus falling below the DEMC for the catchment according to both the Dickens and Graham (2001) and the Dallas (2007) classification systems.
- Between the CB3 and the CB2 sites, the SASS5 score increased by 15.3%, while no change was observed in the ASPT score.
- Between the CB1 and CB2 sites, the SASS5 score increased significantly by 47.8% and the ASPT score decreased negligibly by 3.9%.



- The variation in the SASS5 scores observed may be attributed to variations in the habitat availability and suitability rather than as a result of impaired water quality.
- It is likely that impacts as a result of farming activities and erosion are likely to be affecting the aquatic ecological integrity at the CB1 point. No impacts as a result of the activities of the Camden Power Station were evident at the CB3 site.
- Further impacts as a result of the disturbance of the habitat due to any expansion activities, impoundments on the aquatic resources in the area as well as impacts on the water quality of these systems, are likely to lead to further degradation at each of these sites.
- Careful design and construction and mitigation measures will be required to limit the impact of the proposed development on the system.

4.1.5 ***Fish Community Integrity***

Table 16: A summary of the results obtained from the application of the FAIL index to the two sites.

| Type of Result | CB2 | CB1 | CB3 |
|--|-------------------------------|-------------------------------|-------------------------------|
| Species present and number of individuals obtained | <i>None</i> | <i>None</i> | <i>None</i> |
| Health and condition | Not applicable | Not applicable | Critical |
| Expected FAIL score | 49.8 | 49.8 | 49.8 |
| Observed FAIL score | 0 | 0 | 0 |
| Relative FAIL score | 0% | 0% | 0% |
| FAIL classification (Kleynhans, 1999) | Class F (Critically modified) | Class F (Critically modified) | Class F (Critically modified) |

- Many of the systems are non-perennial and are not ideal for supporting diverse and sensitive fish communities in the area.
- The FAIL data indicates that the fish communities in this area have suffered a critical loss in integrity, and when compared to the reference score for a pristine Highveld Ecoregion stream, falling into a Class F indicating critically modified conditions.
- The limited diversity of fish in the system is indicative of long term impacts on the system, with special mention of loss of spawning habitat, upstream and downstream migration barriers and poor water quality as a result of mining activities.



- Instream modifications and impacts from impoundments are considered to significantly impact on the indigenous fish community of the system and interfering with fish migrations along the rivers.
- It is thus considered unlikely that the proposed expansion activities will have a significant impact on fish communities in the area.

4.2 The Humanspruit (Sites CB4 and CB5)

4.2.1 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 are presented below together with a table summarising the observations for the various criteria made during the visual assessment undertaken at each site.



Figure 11: Local view of the CB5 site, indicating the abundant aquatic vegetation at this point.



Figure 12: Downstream view of the CB5 site.



Figure 13: Upstream view of the CB4 site, indicating the marginal vegetation and stones at this point.



Figure 14: Downstream view of the K2 site indicating the slow flowing shallow nature of the stream at this point.

Table 17: Description of the location of each assessment site on the Humanspruit

| SITE | CB5 | CB4 |
|---|---|--|
| Riparian zone characteristics | The riparian zone is considered to be slightly disturbed at this point and consists mainly of grasses at this point. | The riparian zone is considered to be in relatively good condition at this point with mainly natural vegetation occurring. The riparian zone consists mainly of grasses at this point. |
| Algal presence | No algal proliferation was observed at this point. | No algal proliferation was observed at this point. |
| Visual indication of impact on aquatic fauna | The construction of the bridge and the service road at this point has negatively impacted the flow of the stream at this point. | Some instream sedimentation was observed at this point. |
| Depth characteristics | The stream consisted of a shallow stream. | The stream consisted of both deeper and shallower pools with some shallow runs and riffles in areas. |
| Flow condition | The site consisted of very slow flowing runs at this point. | Flow was very slow at this point with some faster flowing runs and riffles present. |
| Water clarity | Water is clear | Water is clear. |
| Water odour | None | None |
| Erosion potential | There is limited potential for erosion in high flow conditions due to the abundant aquatic and bankside vegetation. | Potential for erosion is considered low at this point due to the low gradient of the banks at this point and the abundant bankside vegetation present. |



4.2.2 *Physico-Chemical Water Quality*

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

Table 18: Biota specific water quality data along the Humanspruit.

| SITE | COND mS/m | pH | TEMP °C |
|------|-----------|------|---------|
| CB5 | 74.7 | 6.38 | 24.4 |
| CB4 | 100.7 | 5.55 | 29.3 |

- General water quality at each of the sites may be considered poor.
- Dissolved salts present in the system are considered to be significantly elevated in relation to the natural conditions expected to occur in the study area.
- Spatially, between the two sites, a 34.8% increase in the EC levels took place. This increase exceeds the limits stipulated by the DWAF TWQR for aquatic ecosystems and some osmotic stress on the aquatic communities in this section of the Humanspruit is deemed likely.
- The data indicates that there has been some catchment wide impact from the current mining and agricultural activities on the dissolved salt concentrations within this system.
- The pH levels may be considered low. A negative effect on the aquatic communities at these points, with special mention of the CB4 site as a result of the low pH is likely to be occurring.
- These observations indicate that the current activities of the Camden Power Station are likely leading to the acidification of the aquatic resources in the area. The proposed expansion project will most likely lead to additional impacts on the water quality of these systems into the future.
- Temperatures can be regarded as normal for the time of year and time of assessment at each point.



4.2.3 **Habitat Assessment**

- According to the IHIA, there are some large impacts at each point with regard to the instream habitat as well as the riparian zone.
- At the upstream CB5 site, instream impacts included serious flow, bed and channel and modifications as well as inundation, with smaller impacts from water quality modifications, while riparian zone impacts included indigenous vegetation removal and flow and channel modifications.
- At the CB4 site, the most significant instream impact was from water quality modification.
- Overall, an IHIA rating of 45.2% and 83.9% was achieved at the CB5 and the CB4 sites, respectively, which indicates largely modified (class D conditions) at the CB5 site and natural (class A conditions) at the CB4 site. The CB5 site therefore falls below the DEMC for the quaternary catchment.
- Impacts on the aquatic resources in this area should be limited. Any impacts from further activities in the area should be managed in such a way as to limit the impact on habitat integrity and to limit impacts on aquatic habitat.

The table below is a summary of the results obtained from the application of the IHAS Index to each assessment site in the vicinity of the study area. This index determines habitat suitability, with particular reference to the requirements of aquatic macro-invertebrates. The results obtained from this assessment will aid in defining the habitat condition and thereby assist in the interpretation of the other biological data for the area.



Table 19: A summary of the results obtained from the application of the IHAS index to the assessment sites.

| SITE | CB5 | CB4 |
|--|--|--|
| IHAS score | 60 | 74 |
| IHAS Adjustment score (illustrative purposes only) | +26 | +18 |
| McMillan, 1998 IHAS description | Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community. | Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community. |
| Stones habitat characteristics | Rocky habitat was limited to bedrock. | Extensive rocky habitat was available at this point, which will increase the habitat available for colonization by aquatic communities at this point. |
| Vegetation habitat characteristics | Excellent marginal vegetation was present. | Some marginal vegetation was present at the time of the assessment. |
| Other habitat characteristics | There was extensive mud deposits present in the area. | GSM deposits were limited at the time of the assessment. |
| IHAS general stream characteristics | A moderately shallow slow flowing stream. The water in the system was clear at the time of assessment. Bankside cover is considered very good at the present time. | A small stream with a diversity of depth and flow profiles. The water in the system was clear at the time of assessment. Bankside cover is considered very good at the present time. |

- Habitat diversity and structure at the CB5 point was considered inadequate for supporting a diversity of aquatic macro-invertebrate community structures, while at the CB4 site, the habitat was considered adequate.
- The large difference in the habitat suitability between the two sites will influence and shape the community structure at each site.

4.2.4 Aquatic Macro-invertebrates

The results of the aquatic macro-invertebrate assessment according to the SASS5 index are summarised in the tables below. Table 13 indicates the results obtained at the site per biotope sampled. Table 14 summarises the findings of the SASS5 assessment based on the analyses of the data for the sites, as well as interpretation of the data for the sites.



Table 20: Biotope specific summary of the results obtained from the application of the SASS5 index to the sites on the Humanspruit.

| PARAMETER | SITE | STONES | VEGETATION | GRAVEL, SAND AND MUD | TOTAL |
|-------------|------|--------|------------|----------------------|-------|
| SASS5 Score | CB5 | 16 | 30 | 38 | 49 |
| Taxa | | 4 | 7 | 8 | 11 |
| ASPT | | 4.0 | 4.3 | 4.8 | 4.5 |
| SASS5 Score | CB4 | 13 | 29 | 17 | 40 |
| Taxa | | 4 | 8 | 5 | 11 |
| ASPT | | 3.3 | 3.6 | 3.4 | 3.6 |

Table 21: A summary of the results obtained from the application of the SASS5 and IHAS indices to the sites.

| Type of Result | CB5 | CB4 |
|--|--|--|
| Biotores sampled | Marginal and aquatic vegetation in and out of current, mud and bedrock. | Stones in and out of current, marginal vegetation out of current, gravel, sand and mud. |
| Sensitive taxa present | <i>Aeshnidae</i> | <i>None</i> |
| Sensitive taxa absent | <i>Hydracarina; Chlorolestidae; Athericidae; Naucoridae; Chlorocyphidae; Gomphidae</i> | <i>Aeshnidae; Naucoridae; Elmidae; Athericidae; Chlorolestidae; Chlorocyphidae; Hydracarina; Gomphidae</i> |
| Adjusted SASS5 score | 75 | 58 |
| SASS5 % of reference score | 35.0% | 28.6% |
| ASPT % of reference score | 75.0% | 60.0% |
| Dickens and Graham, 2001 SASS5 classification | Class E (Seriously impaired) | Class E (Seriously impaired) |
| Dallas 2007 classification | Class E/F | Class E/F |

- The SASS data indicates that the aquatic macro-invertebrate community at the CB5 and CB4 sites has suffered only a serious loss in integrity when compared to the reference score for a pristine Highveld Ecoregion stream.



- At present, both sites can be considered as being in a Class E (seriously impaired) condition according to the Dickens & Graham (2001) classification system and as a Class E/F according to the Dallas (2007) classification system.
- Both sites therefore fall below the DEMC for the catchment.
- The SASS5 score at the CB4 site is 18.4% lower than that of the upstream CB5 site and the ASPT score is 20.0% lower at the CB4 site. It is considered likely that the existing activities of the Camden Power Station may be impacting on the aquatic communities of the Humanspruit leading to an aquatic community of significantly lower sensitivity at the downstream point while community abundance remained unchanged.
- Further impacts as a result of the disturbance of the habitat due to the proposed expansion activities, impoundments on the aquatic resources in the area as well as impacts on the water quality of these systems, could lead to further degradation at each of these sites.
- Careful design and construction and mitigation measures will be required to limit the impact on the system.

4.2.5 *Fish Community Integrity*

Table 22: A summary of the results obtained from the application of the FAIL index to the two sites.

| Type of Result | CB5 | CB4 |
|--|-------------------------------|-------------------------------|
| Species present and number of individuals obtained | <i>None</i> | <i>None</i> |
| Health and condition | Not applicable | Not applicable |
| Expected FAIL score | 49.8 | 49.8 |
| Observed FAIL score | 0 | 0 |
| Relative FAIL score | 0% | 0% |
| FAIL classification (Kleynhans, 1999) | Class F (Critically modified) | Class F (Critically modified) |

- The FAIL data indicates that the fish communities in this area have suffered a critical loss in integrity, and when compared to the reference score for a pristine Highveld Ecoregion stream, falling into a Class F indicating critically modified conditions.



- The absence of fish in the system is indicative of long term impacts on the system, with special mention of loss of spawning habitat, upstream and downstream migration barriers and poor water quality as a result of mining and agricultural activities.
- Instream modifications and impacts from impoundments are considered to significantly impact on the indigenous fish community of the system and interfering with fish migrations along the rivers. In addition, many of the systems are non-perennial and are not ideal for supporting diverse and sensitive fish communities in the area.

4.3 Toxicological Assessment

4.3.1 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 are presented below.



Figure 15: Local view of the CT1 site.



Figure 16: General view of the CT1 site, indicating the proximity of the ash dump from the water body.





Figure 17: Local view of the CT2 site, indicating the abundant marginal vegetation at this point.



Figure 18: General view of the CT2 site indicating the prolific instream vegetation at this point.

4.3.2 *Physico-Chemical Water Quality*

The table below records the biota specific water quality of each toxicity sampling site.

Table 23: Biota specific water quality data along the Humanspruit.

| SITE | COND mS/m | pH | DO mg/L | TEMP °C |
|------|-----------|-------|---------|---------|
| CT1 | 190.7 | 11.47 | 7.54 | 24.2 |
| CT2 | 36.9 | 6.73 | 7.78 | 25.3 |

- General water quality at the CT1 site may be considered poor, with significantly elevated dissolved salt concentrations in relation to the natural conditions expected to occur in the study area.
- The pH observed at the CT1 site was also found to be alkaline and somewhat higher than the pH range of between 6 and 8.5 expected under natural conditions.
- Should this water reach the surrounding aquatic resources it is likely that the pH variation will significantly impact the integrity of the aquatic communities present.
- A fair impact as a result of osmotic stress is also deemed likely.
- Dissolved oxygen levels are adequate and unlikely to limit the sensitivity and diversity of the aquatic communities likely to occur in the area.



- The general water quality at the CT2 site is good and unlikely to limit all but the most sensitive aquatic macro-invertebrate taxa.
- From the data it is evident that impacts from the existing Camden ash dam are not reaching this point
- Temperatures can be regarded as normal for the time of year and time of assessment at each point.

4.3.3 Toxicological Testing

The table below serves as an indication of the results of the toxicological testing of each site.

Table 24: A summary of the results obtained from the application of the toxicological tests to a sample from the three toxicological assessment sites

| SITE | WATERFLEA ACUTE TEST <i>DAPHNIA PULEX</i> | GUPPY ACUTE TEST <i>POECILIA RETICULATA</i> | BACTERIAL BIOLUMINESCENCE <i>VIBRIO FISCHERI</i> | ALGAL GROWTH <i>SELENASTRUM CAPRICORNUTUM</i> | CLASSIFICATION |
|------|--|--|---|--|------------------------------|
| | % mortality | % mortality | %inhibition/stimulation | %inhibition/stimulation | |
| CT1 | 100% | 40% | -99 | -92 | Class 4: High acute hazard |
| CT2 | 10% | 10% | -20 | +55 | Class 2: Slight acute hazard |
| CB3 | 0% | 30% | -47 | +40 | Class 2: Slight Acute hazard |

- A statistically significant level of toxicity was observed at all four sites in the more sensitive lower trophic levels, *Vibrio fischeri* and *Selenastrum capricornutum*.
- *Vibrio fischeri* indicated a statistically significant degree of inhibition in each of the samples, which indicates that a toxicological effect is expressed on a bacterial level.
- *Selenastrum capricornutum* indicated a significant degree of inhibition at the CT1 site, however, at each of the other sites (CT2 and CB3) the test indicated a significant degree of stimulation, which may indicate that farming activities in the area may be leading to eutrophication of the aquatic resources in the area.
- In the higher trophic levels, a statistically significant level of toxicity was observed for both the *Daphnia pulex* and *Poecilia reticulata* at the CT1 site,



while at the CB3 site, a statistically significant toxicological response was observed only in the *Poecilia reticulata* test.

- No response was observed in either of the higher trophic levels at the CT2 site, indicating that it is unlikely that seepage from the existing Camden Ash dump has reached this area to the degree that an acute toxicological response is observed.
- The toxicological effect observed at the CB3 site may be a combination of farming activities as well as a result of a pollution plume as a result of seepage from the existing ash dump at the Camden Power Station.
- In general, a slight toxicological impact (Class 2) is currently expressed on the tributaries of the Vaal River and its associated underground resources, which in turn may lead to a chronic impact on the aquatic community in this system. At the CT1 site, however, a high toxicological impact (Class 4) was observed, which will significantly impact on the surrounding aquatic resources with the degree of impact dependant on the volume of water reaching the receiving aquatic environment and the degree to which dilution of the impaired water quality occurs.
- It is considered essential that the toxicological monitoring of these points continue and that an additional point at the CB4 biomonitoring site be implemented so as to determine the extent of the pollution plume in the vicinity of the current ash dump and if toxicity levels are to decline further with the proposed expansion, immediate mitigatory action will be required.
- It may be necessary to select additional toxicological monitoring points based on the final placement of the proposed ash dam.

5. IMPACT ASSESSMENT

The table presented on the following pages serves to summarise the findings of the impact assessment undertaken as well as the required measures to mitigate the impacts. The table indicates the impacts considering that no mitigation will take place as well as considering that extensive impact mitigation will take place.



From the results of the impact assessment it is evident that prior to mitigation there are a number of high level impacts. If extensive impact mitigation takes place, it can be seen that all impacts can be reduced to low to moderate level impacts with two moderate level impacts occurring and three low level impacts occurring.

5.1 IMPACT ASSESSMENT AND IMPACT MINIMIZATION



Table 25: Impacts identified and the proposed mitigation measures

| POTENTIAL IMPACT | ACTIVITY | ENVI | | | | | | RECOMMENDED MITIGATION MEASURES/ | ENVI | | | | | |
|--|---|------|---|---|---|-------|----|---|------|---|---|---|-------|----|
| | | M | D | S | P | TOTAL | SP | | M | D | S | P | TOTAL | SP |
| POTENTIAL ENVIRONMENTAL IMPACTS | | | | | | | | | | | | | | |
| ISSUES RELATED TO AQUATIC ECOLOGY | | | | | | | | | | | | | | |
| Stream flow reduction | Separation of dirty areas from clean areas leading to reduced catchment yield. Specifically impacts from the footprint area of the proposed expansion. | 8 | 5 | 2 | 5 | 75 | H | Designated dirty water areas should remain as small as possible. Surface footprint areas of infrastructure and the proposed ash dam should remain as small as possible. All drainage lines should be diverted around infrastructure to ensure stream connectivity. Detailed investigation of the impact of the proposed expansion on the groundwater environment needs to take place. Dewatering boreholes should be placed downgradient of the proposed ash dam so as to prevent dirty water reaching the aquatic resources further downstream. A suitably sized buffer needs to be placed around the various aquatic resources, wherein no activities are to take place which could lead to impacts from poor quality on the system. | 4 | 2 | 1 | 2 | 14 | L |
| Alteration of stream morphology and instream habitat | Encroachment of the expansion activity footprint onto the aquatic resources may result in erosion, incision and lead to sedimentation of the aquatic ecosystems | 8 | 5 | 2 | 4 | 60 | H | The time in which soils are exposed during construction activities should remain as short as possible. Surface footprint areas of infrastructure and areas to be cleared should remain as small as possible. During construction, 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 during the construction phase of the development: <ul style="list-style-type: none"> Where the track has slope of less than 2%, berms every 50m should be installed. Where the track slopes between 2% and 10%, berms every 25m should be installed. Where the track slopes between 10%-15%, berms every 20m should be installed. Where the track has slope greater than 15%, berms every 10m should be installed. All areas affected by construction should be rehabilitated upon completion of the construction phase of the development and concurrent rehabilitation should take place. Areas should be reseeded with indigenous grasses as required. Ensure that all activities take the riverine boundaries and associated buffer zones into account. No activities are to infringe upon the riverine boundaries or associated buffer zones unless it is absolutely unavoidable. In this regard specific mention is made of the need to: <ul style="list-style-type: none"> Demarcate all wetland and riverine boundaries and associated buffer zones; No vehicles are to enter or drive through demarcated areas except at designated roadways; No dumping of waste or any other materials is allowed within these areas. No activities are to infringe upon the riverine boundaries or associated buffer zones. Should it be absolutely unavoidable that expansion activities occur within these areas, relevant authorisation should be obtained according to the National Environmental Management Act (NEMA) 107 of 1998 and Section 21 c and i of the National Water Act 36 of 1998. Ecological connectivity of wetland and riverine features should be maintained with special mention of bridge crossings over drainage features. Vehicles should be restricted to travelling only on designated roadways to limit the ecological footprint of the proposed development activities. | 4 | 2 | 1 | 2 | 14 | L |
| River bed siltation | Clearing of vegetation, earthworks and dust, erosion and runoff from the ash dam | 8 | 5 | 2 | 4 | 60 | H | The time in which soils are exposed during construction activities should remain as short as possible. Surface footprint areas of infrastructure and areas to be cleared should remain as small as possible. During construction, 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 during the construction phase of the development: <ul style="list-style-type: none"> Where the track has slope of less than 2%, berms every 50m should be installed. Where the track slopes between 2% and 10%, berms every 25m should be installed. Where the track slopes between 10%-15%, berms every 20m should be installed. Where the track has slope greater than 15%, berms every 10m should be installed. All areas affected by construction should be rehabilitated upon completion of the construction phase of the development and concurrent rehabilitation should take place. Areas should be reseeded with indigenous grasses as required. Measures to prevent erosion and dust control from the proposed ash dam should be put in place to prevent ash deposits reaching the aquatic resources in the vicinity of the proposed expansion project | 4 | 2 | 1 | 2 | 14 | L |



| | | | | | | | | | | | | | | |
|---|--|----|---|---|---|----|---|---|---|---|---|---|----|---|
| Increased turbidity | Clearing of vegetation, earthworks, erosion and dust | 8 | 5 | 2 | 4 | 60 | H | <p>The time in which soils are exposed during construction activities should remain as short as possible. Surface footprint areas of mining infrastructure and areas to be cleared should remain as small as possible. During construction erosion berms should be installed to prevent gully formation and siltation of the aquatic resources.</p> <p>The following points should serve to guide the placement of erosion berms during the construction phase of the development:</p> <ul style="list-style-type: none"> • Where the track has slope of less than 2%, berms every 50m should be installed. • Where the track slopes between 2% and 10%, berms every 25m should be installed. • Where the track slopes between 10%-15%, berms every 20m should be installed. • Where the track has slope greater than 15%, berms every 10m should be installed. <p>All areas affected by construction or open pit development should be rehabilitated upon completion of the construction phase of the development and concurrent rehabilitation of open pits should take place. Areas should be reseeded with indigenous grasses as required. Measures to prevent erosion and dust control from the proposed ash dam should be put in place to prevent ash deposits reaching the aquatic resources in the vicinity of the proposed expansion project</p> | 4 | 2 | 1 | 2 | 14 | L |
| Altered water quality of the receiving environment | Seepage from the proposed ash dam will affect the conductivity and the pH of the water resources in the receiving environment. Heavy metals typically present in coal ash may leach into soil and groundwater resources. | 10 | 5 | 3 | 5 | 90 | H | <p>The footprint of the proposed ashdam must be kept as small as possible.</p> <p>Detailed investigation of the impact of the proposed expansion on the groundwater environment needs to take place. Dewatering boreholes should be placed downgradient of the proposed ash dam so as to prevent dirty water reaching the aquatic resources further downstream. The coal ash should be appropriately treated before being introduced to the ash dam. Ongoing treatment of coal ash must take place in order to ensure that water quality is sufficiently improved in order to prevent ongoing degradation of the aquatic ecosystems in the area</p> | 6 | 5 | 2 | 4 | 52 | M |
| Loss of aquatic biodiversity and sensitive aquatic taxa | Impacts of sedimentation, impaired water quality, introduction of toxicants and increased turbidity may lead to the loss of sensitive aquatic community members | 10 | 5 | 3 | 5 | 90 | H | <p>Good housekeeping and implementation of all the mitigatory measures presented in this document will limit the impact on the aquatic community of the system.</p> <p>Ongoing monitoring of the trends in ecological integrity of the aquatic resources in the vicinity of the proposed mining area need to be included both upstream and downstream of the proposed mining activities to allow for comparison.</p> <p>The monitoring program should be carried out with the following indices and tests being undertaken on a six monthly basis:</p> <ul style="list-style-type: none"> • Biota Specific water quality • IHAS • SASSS. • Toxicological testing of aquatic resources in the vicinity of the existing ash dam as well as the proposed expansion area. <p>The monitoring program should be carried out with the following indices and tests being undertaken on an annual basis:</p> <ul style="list-style-type: none"> • IHIA • FAII | 6 | 5 | 2 | 3 | 39 | M |
| Loss of refuge areas in the low flow season | Encroachment of the expansion activity footprint onto the aquatic resources may result in loss of stream continuity, erosion, incision and lead to sedimentation of the aquatic ecosystems. Runoff from exposed soils and dust and erosion from the ash dam may lead to sedimentation and silting up of the aquatic resources. | 8 | 5 | 2 | 4 | 60 | H | <p>The time in which soils are exposed during construction activities should remain as short as possible. Surface footprint areas of infrastructure and areas to be cleared should remain as small as possible. During construction, erosion berms should be installed to prevent gully formation and siltation of the aquatic resources.</p> <p>The following points should serve to guide the placement of erosion berms during the construction phase of the development:</p> <ul style="list-style-type: none"> • Where the track has slope of less than 2%, berms every 50m should be installed. • Where the track slopes between 2% and 10%, berms every 25m should be installed. • Where the track slopes between 10%-15%, berms every 20m should be installed. • Where the track has slope greater than 15%, berms every 10m should be installed. <p>All areas affected by construction should be rehabilitated upon completion of the construction phase of the development and concurrent rehabilitation should take place. Areas should be reseeded with indigenous grasses as required. Ensure that all activities take the riverine boundaries and associated buffer zones into account. No activities are to infringe upon the riverine boundaries or associated buffer zones unless it is absolutely unavoidable. In this regard specific mention is made of the need to:</p> <ul style="list-style-type: none"> • Demarcate all wetland and riverine boundaries and associated buffer zones; • No vehicles are to enter or drive through demarcated areas except at designated roadways; • No dumping of waste or any other materials is allowed within these areas. <p>No activities are to infringe upon the riverine boundaries or associated buffer zones. Should it be absolutely unavoidable that expansion activities occur within these areas, relevant authorisation should be obtained according to the National Environmental Management Act (NEMA) 107 of 1998 and Section 21 c and i of the National Water Act 36 of 1998.</p> <p>Ecological connectivity of wetland and riverine features should be maintained with special mention of bridge crossings over drainage features.</p> <p>Vehicles should be restricted to travelling only on designated roadways to limit the ecological footprint of the proposed development activities.</p> | 4 | 2 | 1 | 2 | 14 | L |



5.2 IMPACT ASSESSMENT CONCLUSION

The aquatic resources in the vicinity of the study area have already been significantly disturbed by mining and agricultural activities in the area, as well as some impacts as a result of the existing ash dam at the Camden Power Station. Many of the impacts which occur will affect the local area permanently and are likely to increase the existing impacts on the receiving environment. If mitigation measures are implemented, the likelihood of further impacts occurring and the consequence of the impacts are significantly reduced to moderate and low levels.

The points below serve to summarise the measures deemed necessary in order to ensure protection of the riparian and aquatic resources, and to ensure environmental protection in the vicinity of the proposed expansion:

- No surface structures or construction should occur in the vicinity of any riverine systems in the study area and it must be ensured that downstream impacts on the ecology of the system do not occur. Special mention is made of the following:
 - Stream flow continuity needs to be maintained downstream of any disturbed areas in order to ensure the ongoing viability of the instream aquatic communities in these areas.
 - Water quality with special mention of pH, dissolved salts and specific problem substances like sulphate need to be managed, and monitored in order to ensure that reasonable water quality occurs downstream of the proposed expansion area in order to allow for the ongoing survival of an aquatic community of some diversity and reasonable sensitivity.
- The ash dam should not be placed within an aquatic resource in the study area or within the 1:100 year floodline in compliance of the requirements of regulation GN 704 of the National Water Act (Act 26 of 1998).
- Ensure that all activities take the wetland and riverine boundaries into account. No activities are to infringe upon the wetland and riverine boundaries unless it is absolutely unavoidable. In this regard specific mention is made of the following:



- Wherever , no activities should take place within 100m of the aquatic resources;
 - As an absolute minimum no infrastructure should be placed within 32m of any aquatic resources except for bridge crossings;
 - Roadways and crossings should cross any features encountered at a 90 degree angle to minimise the footprint of the impact on these resources;
 - Demarcate all wetland and riverine boundaries;
 - No vehicles are to enter or drive through demarcated areas except at designated roadways;
 - Vehicles should be restricted to travelling only on designated roadways to limit the ecological footprint of the proposed development activities.
 - No dumping of waste or any other materials is allowed within these areas. If any spills occur, they should be immediately cleaned up;
 - No activities are to infringe upon the riverine boundaries. Should this be absolutely unavoidable that activities occur within these areas, relevant authorisation should be obtained according to the National Environmental Management Act (NEMA) 107 of 1998 and Section 21 c and i of the National Water Act 36 of 1998.
- No dirty water runoff from the ash dam must be permitted to reach the drainage features in the study area and the requirements of regulation GN 704 of the National Water Act (Act 36 of 1998) need to be strictly adhered to.
 - Regularly inspect all vehicles for leaks. Re-fuelling of vehicles must take place on a sealed surface area surrounded by berms to prevent ingress of hydrocarbons into topsoil.
 - Close monitoring of water quality must take place and adequate pH treatment and desalination of coal ash should take place.
 - Ongoing monitoring of the groundwater resources in the vicinity of the proposed resources should take place on an ongoing basis.
 - Dewatering boreholes should be situated down-gradient of the proposed ash dam so as to prevent any contaminated water from reaching the receiving environment further down-gradient.



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- Adequate stormwater management must be incorporated into the design of the proposed development in order to prevent erosion and the associated sedimentation of the riparian and instream areas, as these systems have aquatic communities which rely on stream substrates clear of sediment and on clear, fast flowing water.
 - Sheet runoff from cleared areas, paved surfaces and access roads needs to be curtailed.
 - Runoff from paved surfaces should be slowed down by the strategic placement of berms.
 - During the construction and operational phases of the proposed expansion, erosion berms should be installed to prevent gully formation and siltation of the riparian resources. The following points should serve to guide the placement of erosion berms:
 - Where the track has slope of less than 2%, berms every 50m should be installed.
 - Where the track slopes between 2% and 10%, berms every 25m should be installed.
 - Where the track slopes between 10%-15%, berms every 20m should be installed.
 - Where the track has slope greater than 15%, berms every 10m should be installed.
 - Any river crossings must ensure that the creation of turbulent flow in the system is minimised, in order to prevent downstream erosion. No support pillars should be constructed within the active channel.
 - The duration of impacts on any drainage feature should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised.
 - All areas affected by any river crossing should be rehabilitated upon completion of the construction phase of the development. Areas should be reseeded with indigenous grasses as required.
 - During the construction phase, no vehicles should be allowed to indiscriminately drive through any riparian areas.



- All riparian areas of disturbed and compacted soils need to be ripped, reprofiled and reseeded with indigenous grasses.
- All riparian areas affected by construction should be rehabilitated upon completion of the expansion project. Areas should be reseeded with indigenous grasses as required. All rehabilitated areas should be rehabilitated to a point where natural processes will allow the pre-development ecological functioning and biodiversity of the area to be reinstated.
- Ongoing alien vegetation removal should take place in any riparian areas where disturbance of the soil takes place.
- Ongoing biomonitoring of the aquatic resources in the vicinity of the proposed development must take place. Biomonitoring should take place at points located upstream and downstream of the activities. Biomonitoring should take place on a six monthly basis in the autumn and spring of each year. Biomonitoring should take place using the SASS5 and IHAS indices. Biomonitoring should be undertaken by a South African River Health Program (SARHP) accredited practitioner and extended contracts should be set up for this monitoring in order to ensure that good interpretation of complex biological data takes place.
- Toxicity testing of any features which contain water which may come into contact with the receiving environment as well as key areas indicating a pollution plume as a result of the proposed expansion project should be tested on a 6 monthly basis in conjunction with the biomonitoring surveys. Toxicity tests should be run on four trophic levels including *Poecilia reticulata*, *Daphnia pulex*, *Selenastrum capricornutum* and *Vibrio fischeri*.
- The results of the biomonitoring surveys should be compared to this baseline data in order to determine if any impacts on the aquatic ecosystems on the subject property are occurring. In addition if any impacting trends are observed, measures to prevent the impacts from occurring should be immediately sought.
- Four alternative sites for the placement of the proposed ash dam and its associated infrastructure have been previously selected. With regard to the protection of the aquatic resources in the vicinity of the proposed project, it is



recommended that either alternatives 2 or 3 are given preference rather than either alternative 1 or 4 as these are situated well away from any of the aquatic resources of the area. Additional biomonitoring or toxicological assessment sites may need to be selected, or existing assessment sites adjusted based on the final alternative chosen for future monitoring purposes.



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Appendix 1: IHI score sheet January 2012



In stream Habitat Integrity

| Weights | 14 | 13 | 13 | 13 | 14 | 10 | 9 | 8 | 6 | | |
|---------|-------------------|-------------------|------------------|----------------------|---------------|------------|---------------------|--------------|----------------------|-----------------|-----------------------|
| REACH | Water abstraction | Flow modification | Bed modification | Channel modification | Water quality | Inundation | Exotic macrobenthos | Exotic fauna | Solid waste disposal | Total Score (%) | Classification |
| CB1 | 0 | 9 | 6 | 14 | 10 | 0 | 0 | 0 | 0 | 76.1 | C Moderately modified |
| CB2 | 0 | 8 | 8 | 4 | 12 | 14 | 0 | 0 | 0 | 71.9 | C Moderately modified |
| CB3 | 0 | 0 | 0 | 0 | 8 | 2 | 0 | 0 | 0 | 94.1 | A Unmodified |
| CB4 | 0 | 8 | 6 | 2 | 18 | 4 | 0 | 0 | 0 | 71.0 | C Moderately modified |
| CB5 | 0 | 18 | 18 | 18 | 8 | 16 | 0 | 0 | 0 | 37.6 | E Seriously modified |

| | | | | | |
|------|-------|----------|-------|---------|----------|
| None | Small | Moderate | Large | Serious | Critical |
|------|-------|----------|-------|---------|----------|

Riparian Zone Habitat Integrity

| Weights | 13 | 12 | 14 | 12 | 13 | 11 | 12 | 13 | | |
|---------|--------------------|--------------------|--------------|-------------------|-------------------|----------------------|---------------|------------|-----------------|-----------------------|
| REACH | Vegetation removal | Alien encroachment | Bank erosion | Water abstraction | Flow modification | Channel modification | Water quality | Inundation | Total Score (%) | Classification |
| CB1 | 0 | 0 | 16 | 0 | 0 | 12 | 0 | 0 | 78.1 | C Moderately modified |
| CB2 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 4 | 94.7 | A Unmodified |
| CB3 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 3 | 95.1 | A Unmodified |
| CB4 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 96.9 | A Unmodified |
| CB5 | 18 | 2 | 2 | 0 | 16 | 16 | 0 | 8 | 52.7 | D Largely modified |

| | | | | | |
|------|-------|----------|-------|---------|----------|
| None | small | Moderate | Large | Serious | Critical |
|------|-------|----------|-------|---------|----------|

| REACH | INSTREAM HABITAT | RIPARIAN ZONE | IHI SCORE | CLASS |
|-------|------------------|---------------|-----------|-----------------------|
| CB1 | 76.1 | 78.1 | 77.1 | C Moderately modified |
| CB2 | 71.9 | 94.7 | 83.3 | B Minimally modified |
| CB3 | 94.1 | 95.1 | 94.6 | A Unmodified |
| CB4 | 71.0 | 96.9 | 83.9 | B Minimally modified |
| CB5 | 37.6 | 52.7 | 45.2 | D Largely modified |



Appendix 2: IHAS score sheets January 2012



| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|---|------------------|--------|---|--------|-------|-------|
| River Name: | | | | | | |
| Site Name: CB1 | Date: 20/01/2012 | | | | | |
| 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) (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| | | | SIC Score (max 20): 12 | | | |
| VEGETATION | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | | 1-25 | 26-50 | 51-75 | >75 |
| | | | Vegetation Score (max 15): 0 | | | |
| OTHER HABITAT/GENERAL | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'cor' = correct time) (** NOTE: you must still fill in the SIC section) | | under | | corr | | over |
| | | | Other Habitat Score (max 20): 12 | | | |
| | | | HABITAT TOTAL (MAX 55): 24 | | | |
| STREAM CONDITION | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| PHYSICAL | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >1 | 1 | >½-1 | ½ | <½-¼ | <¼ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | fl/dr | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) (** NOTE: if more than one option, choose the lowest) | 0-50 | 50-80 | 81-95 | >95 | | |
| | | | STREAM CONDITIONS TOTAL (MAX 36) | | | |
| | | | TOTAL IHAS SCORE (%): 60 | | | |



| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|--|-------------------|--------|--------|--------|-------|-------|
| River Name : | | | | | | |
| Site Name : CB2 | Date : 20/01/2012 | | | | | |
| SAMPLING HABITAT | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| STONES IN CURRENT (SIC) | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| SIC Score (max 20): | | | | | | 10 |
| VEGETATION | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | | 1-25 | 26-50 | 51-75 | >75 |
| Vegetation Score (max 15): | | | | | | 10 |
| 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: 'corr' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| Other Habitat Score (max 20): | | | | | | 12 |
| HABITAT TOTAL (MAX 55): | | | | | | 32 |
| STREAM CONDITION | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| PHYSICAL | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >1 | 1 | >½-1 | ½ | <½-¼ | <¼ |
| Approximate velocity of stream: ('slow' = <¼m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | fl/dr | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 50-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| STREAM CONDITIONS TOTAL (MAX 33) | | | | | | |
| TOTAL IHAS SCORE (%): | | | | | | 65 |



| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|--|-------------------|--------|--------|--------|-------|-------|
| River Name : | | | | | | |
| Site Name : CB3 | Date : 20/01/2012 | | | | | |
| 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 | | 1-25 | 26-50 | 51-75 | >75 |
| Vegetation Score (max 15): 12 | | | | | | |
| 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: 'corr' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| Other Habitat Score (max 20): 9 | | | | | | |
| HABITAT TOTAL (MAX 55): 21 | | | | | | |
| STREAM CONDITION | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| PHYSICAL | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >1 | 1 | >½-1 | ½ | <½-¼ | <¼ |
| Approximate velocity of stream: ('slow' = <¼m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | fl/dr | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 50-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| STREAM CONDITIONS TOTAL (MAX 28) | | | | | | |
| TOTAL IHAS SCORE (%): 49 | | | | | | |



| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|--|--------------------------|--------|--------|--------|-------|-------|
| River Name : | | | | | | |
| Site Name : CB4 | Date : 20/01/2012 | | | | | |
| SAMPLING HABITAT | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| STONES IN CURRENT (SIC) | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| SIC Score (max 20): 17 | | | | | | |
| VEGETATION | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | | 1-25 | 26-50 | 51-75 | >75 |
| Vegetation Score (max 15): 9 | | | | | | |
| OTHER HABITAT/GENERAL | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'corr' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| Other Habitat Score (max 20): 11 | | | | | | |
| HABITAT TOTAL (MAX 55): 37 | | | | | | |
| STREAM CONDITION | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| PHYSICAL | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >1 | 1 | >½-1 | ½ | <½-¼ | <¼ |
| Approximate velocity of stream: ('slow' = <¼m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | fl/dr | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 50-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| STREAM CONDITIONS TOTAL (MAX 37) | | | | | | |
| TOTAL IHAS SCORE (%): 74 | | | | | | |



| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|---|--------------------------|--------|--------|--------|-------|-------|
| River Name : | | | | | | |
| Site Name : CB5 | Date : 20/01/2012 | | | | | |
| 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) (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| SIC Score (max 20): | | | | | | 7 |
| VEGETATION | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | | 1-25 | 26-50 | 51-75 | >75 |
| Vegetation Score (max 15): | | | | | | 10 |
| 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: 'corr' = correct time) (** NOTE: you must still fill in the SIC section) | | under | | corr | | over |
| Other Habitat Score (max 20): | | | | | | 12 |
| HABITAT TOTAL (MAX 55): | | | | | | 29 |
| STREAM CONDITION | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| PHYSICAL | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >1 | 1 | >½-1 | ½ | <½-¼ | <¼ |
| Approximate velocity of stream: ('slow' = <¼m/s; 'fast' = >¼m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | fl/dr | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 50-80 | 81-95 | >95 | | |
| STREAM CONDITIONS TOTAL (MAX 31) | | | | | | |
| TOTAL IHAS SCORE (%): | | | | | | 60 |



Appendix 3: SASS5 score sheets January 2012



| RIVER HEALTH PROGRAMME - SASS5 SCORE SHEET | | | | | | | | | | | | | | | | | | |
|--|----------------------|----|---|----|-----|-----|------------------------|----|---|----|-----|-----|--|----|-----|-----|-----|-----|
| DATE: 20/01/2012 | 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 | | B | | B | Athericidae | 10 | | | | |
| E:° | TURBELLARIA | 3 | | | | | Corixidae* | 3 | | | | | Blepharoceridae | 15 | | | | |
| SITE CODE: CB1 | ANNELIDA: | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | | 1 | | 1 |
| RIVER: | Oligochaeta | 1 | | | | | Hydrometridae* | 6 | | | | | Chironomidae | 2 | A | B | | B |
| SITE DESCRIPTION: U/S Trib | Leeches | 3 | | | | | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | CRUSTACEA: | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 28.3 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | 1 | | 1 | Empididae | 6 | | | | |
| Ph: 8.72 | Potamonautidae* | 3 | | | | | Pléidae* | 4 | | | | | Ephydriidae | 3 | | | | |
| DO: mg/l | Atyidae | 8 | | | | | Veliidae/M...veliidae* | 5 | | | | | Muscidae | 1 | | | | |
| Cond: 33.6 mS/m | Palaemonidae | 10 | | | | | MEGALOPTERA: | | | | | | Psychoptidae | 1 | | | | |
| BIOTOPES SAMPLED: | HYDRACARINA | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | B | B | | B |
| SIC: TIME: minutes | PLECOPTERA: | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | TRICHOPTERA | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | 1 | | 1 |
| AQUATIC VEG: DOM SP: | EPHEMEROPTERA | | | | | | Ecnomidae | 8 | | | | | GASTROPODA | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | 1 | | | | Hydropsychidae 1sp | 4 | 1 | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | 1 | | | Hydropsychidae 2 sp | 6 | | 1 | | A | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | | | A | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | | | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychoptidae/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 | | | | | |
| | Prosoptomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricothyridae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| DISTURBANCE IN RIVER: | ODONATA: | | | | | | Lepidostomatidae | 10 | | | | | SASS SCORE: | | 15 | 40 | 0 | 46 |
| | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | NO OF TAXA: | | 4 | 9 | 0 | 9 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | ASPT: | | 3.8 | 4.4 | 0 | 5.1 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | IHAS: | | 60% | | | |
| | Coenagrionidae | 4 | | | | | Sericostomatidae SWC | 13 | | | | | OTHER BIOTA: | | | | | |
| | Lestidae | 8 | | | | | COLEOPTERA: | | | | | | COMMENTS: | | | | | |
| SIGNS OF POLLUTION: | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | 1 | | 1 | * = airbreathers | | | | | |
| | Protonuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | SWC = South Western Cape | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | | | | T = Tropical | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | ST = Sub-tropical | | | | | |
| | Coruliidae | 8 | | | | | Helodidae | 12 | | | | | S = Stone & rock | | | | | |
| OTHER OBSERVATIONS: | Gomphidae | 6 | | | | | Hydraenidae* | 8 | | | | | VG = all vegetation | | | | | |
| | Libellulidae | 4 | | | | | Hydrophilidae* | 5 | | | | | GSM = gravel, sand & mud | | | | | |
| | LEPIDOPTERA: | | | | | | Limnichidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | | | | | | |



| RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET | | | | | | | | | | | | | | | | |
|---|----------------------|----|----|-----|-----|--------------------------|----|----|-----|-----|--|----|-----|-----|-----|-----|
| DATE: 20/01/2012 | TAXON | S | VG | GSM | TOT | TAXON | S | VG | GSM | TOT | TAXON | S | VG | GSM | TOT | |
| GRID REFERENCE: | PORIFERA | 5 | | | | HEMIPTERA: | | | | | DIPTERA: | | | | | |
| S:° | COELENTERATA | 1 | | | | Belostomatidae* | 3 | | | | Athericidae | 10 | | | | |
| E:° | TURBELLARIA | 3 | | | | Corixidae* | 3 | 1 | B | B | Blepharoceridae | 15 | | | | |
| SITE CODE: CB2 | ANNELIDA: | | | | | Gerridae* | 5 | 1 | | 1 | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | | | 1 | Hydrometridae* | 6 | | | | Chironomidae | 2 | B | 1 | 1 | B |
| SITE DESCRIPTION: D/S TRIBS | Leeches | 3 | | | | Naucoridae* | 7 | 1 | | 1 | Culicidae* | 1 | | | | |
| WEATHER CONDITION: hot & clear | CRUSTACEA: | | | | | Nepidae* | 3 | | | | Dixidae* | 10 | | | | |
| TEMP: 26.3 °C | Amphipoda | 13 | | | | Notonectidae* | 3 | 1 | | 1 | Empididae | 6 | | | | |
| Ph: 8.80 | Potamonautidae* | 3 | | | 1 | Pleidae* | 4 | 1 | | 1 | Ephydriidae | 3 | | | | |
| DO: mg/l | Atyidae | 8 | | | 1 | Veliidae/M...velliidae* | 5 | 1 | | 1 | Muscidae | 1 | | | | |
| Cond: 37 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 | B | | | Hydropsychidae 2 sp | 6 | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | | A | Hydropsychidae >2 sp | 12 | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | A | | | Philopotamidae | 10 | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | Polycentropodidae | 12 | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | Psychoomyiidae/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 | | | | |
| | Tricothyridae | 9 | | | | Hydrosalpingidae SWC | 15 | | | | Unionidae | 6 | | | | |
| | ODONATA: | | | | | Lepidostomatidae | 10 | | | | SASS SCORE: | | 14 | 58 | 14 | 68 |
| DISTURBANCE IN RIVER: | Calopterygidae ST,T | 10 | | | | Leptoceridae | 6 | | | | NO OF TAXA: | | 3 | 11 | 5 | 14 |
| | Chlorocyphidae | 10 | | | | Petrothrincidae SWC | 11 | | | | ASPT: | | 4.7 | 5.3 | 2.8 | 4.9 |
| | Chlorolestidae | 8 | | | | Pisuliidae | 10 | | | | IHAS: | | 65% | | | |
| | Coenagrionidae | 4 | | | 1 | Sericostomatidae SWC | 13 | | | | OTHER BIOTA: | | | | | |
| | Lestidae | 8 | | | | COLEOPTERA: | | | | | COMMENTS: | | | | | |
| SIGNS OF POLLUTION: | Platycnemidae | 10 | | | | Dytiscidae* | 5 | 1 | 1 | A | * = airbreathers | | | | | |
| | Protoneuridae | 8 | | | | Elmidae/Dryopidae* | 8 | | | | SWC = South Western Cape | | | | | |
| | Zygoptera juvs. | 6 | | | | Gyrinidae* | 5 | | | | T = Tropical | | | | | |
| | Aeshnidae | 8 | | | | Halipidae* | 5 | | | | ST = Sub-tropical | | | | | |
| | Coruliidae | 8 | | | | Helodidae | 12 | | | | S = Stone & rock | | | | | |
| OTHER OBSERVATIONS: | Gomphidae | 6 | | | | Hydraenidae* | 8 | | | | VG = all vegetation | | | | | |
| | Libellulidae | 4 | | | | Hydrophilidae* | 5 | | | | GSM = gravel, sand & mud | | | | | |
| | LEPIDOPTERA: | | | | | Limnichidae | 10 | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |
| | Pyralidae | 12 | | | | Psephenidae | 10 | | | | | | | | | |



| RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET | | | | | | | | | | | | | | | |
|---|----------------------|----|----|-----|-----|--------------------------|----|----|-----|-----|--|-----|-----|-----|-----|
| DATE: | TAXON | S | VG | GSM | TOT | TAXON | S | VG | GSM | TOT | TAXON | S | VG | GSM | TOT |
| DATE: 20/01/2012 | PORIFERA | 5 | | | | HEMIPTERA: | | | | | DIPTERA: | | | | |
| GRID REFERENCE: | COELENTERATA | 1 | | | | Belostomatidae* | 3 | | | | Athericidae | 10 | | | |
| S:° | TURBELLARIA | 3 | | | | Corixidae* | 3 | | | | Blepharoceridae | 15 | | | |
| E:° | ANNELIDA: | | | | | Gerridae* | 5 | | | | Ceratopogonidae | 5 | | | |
| SITE CODE: CB3 | Oligochaeta | 1 | 1 | | 1 | Hydrometridae* | 6 | | | | Chironomidae | 2 | 1 | | 1 |
| RIVER: | Leeches | 3 | | | | Naucoridae* | 7 | | | | Culicidae* | 1 | | | |
| SITE DESCRIPTION: U/S TRIBS | CRUSTACEA: | | | | | Nepidae* | 3 | 1 | | 1 | Dixidae* | 10 | | | |
| WEATHER CONDITION: | Amphipoda | 13 | | | | Notosectidae* | 3 | 1 | | 1 | Empididae | 6 | | | |
| TEMP: 31.5 °C | Potamonautidae* | 3 | 1 | | 1 | Pleidae* | 4 | A | | A | Ephydriidae | 3 | | | |
| Ph: 9.99 | Atyidae | 8 | | | | Veliidae/M...velliidae* | 5 | | | | Muscidae | 1 | | | |
| DO: mg/l | Palaemonidae | 10 | | | | MEGALOPTERA: | | | | | Psychodidae | 1 | | | |
| Cond: 34.4 mS/m | HYDRACARINA | 8 | B | | B | Cordalidae | 8 | | | | Simuliidae | 5 | | | |
| BIOTOPES SAMPLED: | PLECOPTERA: | | | | | Sialidae | 6 | | | | Syrphidae* | 1 | | | |
| SIC: TIME: minutes | Notoemouridae | 14 | | | | TRICHOPTERA | | | | | Tabanidae | 5 | | | |
| SOOC: | Perlidae | 12 | | | | Dipseudopsidae | 10 | | | | Tipulidae | 5 | | | |
| BEDROCK: | EPHEMEROPTERA | | | | | Ecnomidae | 8 | | | | GASTROPODA | | | | |
| AQUATIC VEG: DOM SP: | Baetidae 1sp | 4 | | | | Hydropsychidae 1sp | 4 | | | | Ancylidae | 6 | | | |
| M VEG IC: DOM SP: | Baetidae 2 sp | 6 | | | | Hydropsychidae 2 sp | 6 | | | | Bulininae* | 3 | | | |
| M VEG OOC: DOM SP: | Baetidae >2 sp | 12 | 1 | | 1 | Hydropsychidae >2 sp | 12 | | | | Hydrobiidae* | 3 | | | |
| GRAVEL: | Caenidae | 6 | 1 | | 1 | Philopotamidae | 10 | | | | Lymnaeidae* | 3 | | | |
| SAND: | Ephemeraeidae | 15 | | | | Polycentropodidae | 12 | | | | Physidae* | 3 | | | |
| MUD: | Heptageniidae | 13 | | | | Psychoomyiidae/Xiphocen. | 8 | | | | Planorbidae* | 3 | | | |
| HAND PICKING/VISUAL OBS: | Leptophlebiidae | 9 | | | | CASED CADDIS: | | | | | Thiaridae* | 3 | | | |
| FLOW: | Oligoneuridae | 15 | | | | Barbarochthonidae SWC | 13 | | | | Viviparidae* ST | 5 | | | |
| TURBIDITY: | Polymitarcyidae | 10 | | | | Calamoceratidae ST | 11 | | | | PELECYPODA | | | | |
| RIPARIAN LAND USE: | Prosopistomatidae | 15 | | | | Glossosomatidae SWC | 11 | | | | Corbiculidae | 5 | | | |
| | Teloganodidae SWC | 12 | | | | Hydroptilidae | 6 | | | | Sphaeriidae | 3 | | | |
| | Tricothyridae | 9 | | | | Hydrosalpingidae SWC | 15 | | | | Unionidae | 6 | | | |
| | ODONATA: | | | | | Lepidostomatidae | 10 | | | | SASS SCORE: | 0 | 59 | 0 | 59 |
| DISTURBANCE IN RIVER: | Calopterygidae ST,T | 10 | | | | Leptoceridae | 6 | | | | NO OF TAXA: | 0 | 12 | 0 | 12 |
| | Chlorocyphidae | 10 | | | | Petrothrincidae SWC | 11 | | | | ASPT: | 0 | 4.9 | 0 | 4.9 |
| | Chlorolestidae | 8 | | | | Pisuliidae | 10 | | | | IHAS: | 49% | | | |
| | Coenagrionidae | 4 | 1 | | 1 | Sericostomatidae SWC | 13 | | | | OTHER BIOTA: | | | | |
| | Lestidae | 8 | | | | COLEOPTERA: | | | | | COMMENTS: | | | | |
| SIGNS OF POLLUTION: | Platycnemidae | 10 | | | | Dytiscidae* | 5 | 1 | | 1 | * = airbreathers | | | | |
| | Proto neuridae | 8 | | | | Elmidae/Dryopidae* | 8 | | | | SWC = South Western Cape | | | | |
| | Zygoptera juvs. | 6 | | | | Gyrinidae* | 5 | | | | T = Tropical | | | | |
| | Aeshnidae | 8 | B | | B | Halipidae* | 5 | | | | ST = Sub-tropical | | | | |
| | Coruliidae | 8 | | | | Helo didae | 12 | | | | S = Stone & rock | | | | |
| OTHER OBSERVATIONS: | Gomphidae | 6 | | | | Hydraenidae* | 8 | | | | VG = all vegetation | | | | |
| | Libellulidae | 4 | | | | Hydrophilidae* | 5 | | | | GSM = gravel, sand & mud | | | | |
| | LEPIDOPTERA: | | | | | Limnichidae | 10 | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | |
| | Pyralidae | 12 | | | | Psephenidae | 10 | | | | | | | | |



| RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET | | | | | | | | | | | | | | | | |
|---|----------------------|----|----|-----|-----|--------------------------|----|----|-----|-----|---------------------|--|-----|-----|-----|---|
| DATE: 20/01/2012 | TAXON | S | VG | GSM | TOT | TAXON | S | VG | GSM | TOT | TAXON | S | VG | GSM | TOT | |
| GRID REFERENCE: | PORIFERA | 5 | | | | HEMIPTERA: | | | | | DIPTERA: | | | | | |
| S:° | COELENTERATA | 1 | | | | Belostomatidae* | 3 | 1 | 1 | A | Athericidae | 10 | | | | |
| E:° | TURBELLARIA | 3 | | | | Corixidae* | 3 | 1 | 1 | A | Blepharoceridae | 15 | | | | |
| SITE CODE: CB4 | ANNELIDA: | | | | | Gerridae* | 5 | 1 | | 1 | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | | | | Hydrometridae* | 6 | | | | Chironomidae | 2 | B | 1 | B | B |
| SITE DESCRIPTION: D/W | Leeches | 3 | | | | Naucoridae* | 7 | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: Hot & clear | CRUSTACEA: | | | | | Nepidae* | 3 | | | | Dixidae* | 10 | | | | |
| TEMP: 29.3 °C | Amphipoda | 13 | | | | Notosectidae* | 3 | | | | Empididae | 6 | | | | |
| Ph: 5.55 | Potamonautidae* | 3 | | | | Pleidae* | 4 | 1 | | 1 | Ephyridae | 3 | | | | |
| DO: mg/l | Atyidae | 8 | | | | Veliidae/M...velliidae* | 5 | | | | Muscidae | 1 | 1 | | | 1 |
| Cond: 100.7 mS/m | Palaemonidae | 10 | | | | MEGALOPTERA: | | | | | Psychodidae | 1 | | | | |
| BIOTOPES SAMPLED: | HYDRACARINA | 8 | | | | Cordalidae | 8 | | | | Simuliidae | 5 | | | | |
| SIC: TIME: minutes | PLECOPTERA: | | | | | Sialidae | 6 | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notoemouridae | 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 | 1 | 1 | 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 | | | | Psychoomyiidae/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 | | | | |
| | Tricothyridae | 9 | | | | Hydrosalpingidae SWC | 15 | | | | Unionidae | 6 | | | | |
| | ODONATA: | | | | | Lepidostomatidae | 10 | | | | SASS SCORE: | 13 | 29 | 17 | 40 | |
| DISTURBANCE IN RIVER: | Calopterygidae ST,T | 10 | | | | Leptoceridae | 6 | | | | NO OF TAXA: | 4 | 8 | 5 | 11 | |
| | Chlorocyphidae | 10 | | | | Petrothrincidae SWC | 11 | | | | ASPT: | 3.3 | 3.6 | 3.4 | 3.6 | |
| | Chlorolestidae | 8 | | | | Pisuliidae | 10 | | | | IHAS: | 74% | | | | |
| | Coenagrionidae | 4 | 1 | | 1 | Sericostomatidae SWC | 13 | | | | OTHER BIOTA: | | | | | |
| | Lestidae | 8 | | | | COLEOPTERA: | | | | | COMMENTS: | | | | | |
| SIGNS OF POLLUTION: | Platycnemidae | 10 | | | | Dytiscidae* | 5 | 1 | | 1 | A | * = airbreathers | | | | |
| | Proto neuridae | 8 | | | | Elmidae/Dryopidae* | 8 | | | | | SWC = South Western Cape | | | | |
| | Zygoptera juvs. | 6 | | | | Gyrinidae* | 5 | 1 | | 1 | | T = Tropical | | | | |
| | Aeshnidae | 8 | | | | Halipidae* | 5 | | | | | ST = Sub-tropical | | | | |
| | Coruliidae | 8 | | | | Helo didae | 12 | | | | | S = Stone & rock | | | | |
| OTHER OBSERVATIONS: | Gomphidae | 6 | | | | Hydraenidae* | 8 | | | | | VG = all vegetation | | | | |
| | Libellulidae | 4 | 1 | | 1 | Hydrophilidae* | 5 | | | | | GSM = gravel, sand & mud | | | | |
| | LEPIDOPTERA: | | | | | Limnichidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | |
| | Pyralidae | 12 | | | | Psephenidae | 10 | | | | | | | | | |



| RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET | | | | | | | | | | | | | | | | |
|---|----------------------|----|----|-----|-----|--------------------------|----|----|-----|-----|---------------------|----|-----|-----|-----|-----|
| DATE: | TAXON | S | VG | GSM | TOT | TAXON | S | VG | GSM | TOT | TAXON | S | VG | GSM | TOT | |
| DATE: 20/01/2012 | PORIFERA | 5 | | | | HEMIPTERA: | | | | | DIPTERA: | | | | | |
| GRID REFERENCE: | COELENTERATA | 1 | | | | Belostomatidae* | 3 | | | | Athericidae | 10 | | | | |
| S:° | TURBELLARIA | 3 | | | | Corixidae* | 3 | 1 | | 1 | Blepharoceridae | 15 | | | | |
| E:° | ANNELIDA: | | | | | Gerridae* | 5 | | | | Ceratopogonidae | 5 | | | | |
| SITE CODE: CB5 | Oligochaeta | 1 | | | | Hydrometridae* | 6 | | | | Chironomidae | 2 | 1 | B | B | |
| RIVER: | Leeches | 3 | | | | Naucoridae* | 7 | | | | Culicidae* | 1 | | | | |
| SITE DESCRIPTION: U/S | CRUSTACEA: | | | | | Nepidae* | 3 | | | | Dixidae* | 10 | | | | |
| WEATHER CONDITION: Hot & clear | Amphipoda | 13 | | | | Notosectidae* | 3 | | | | Empididae | 6 | | | | |
| TEMP: 24.4 °C | Potamonautidae* | 3 | | | | Pleidae* | 4 | 1 | | 1 | Ephydriidae | 3 | | | | |
| Ph: 6.38 | Atyidae | 8 | | | | Veliidae/M...velliidae* | 5 | B | 1 | B | Muscidae | 1 | | | | |
| DO: mg/l | Palaemonidae | 10 | | | | MEGALOPTERA: | | | | | Psychodidae | 1 | | | | |
| Cond: 74.7 mS/m | HYDRACARINA | 8 | | | | Cordalidae | 8 | | | | Simuliidae | 5 | 1 | | B | |
| BIOTOPES SAMPLED: | PLECOPTERA: | | | | | Sialidae | 6 | | | | Syrphidae* | 1 | | | | |
| SIC: TIME: minutes | Notoemouridae | 14 | | | | TRICHOPTERA | | | | | Tabanidae | 5 | | | | |
| SOOC: | Perlidae | 12 | | | | Dipseudopsidae | 10 | | | | Tipulidae | 5 | | | | |
| BEDROCK: | EPHEMEROPTERA | | | | | Ecnomidae | 8 | | | | GASTROPODA | | | | | |
| AQUATIC VEG: DOM SP: | Baetidae 1sp | 4 | 1 | | 1 | Hydropsychidae 1sp | 4 | | | | Ancylidae | 6 | | | | |
| M VEG IC: DOM SP: | Baetidae 2 sp | 6 | | | | Hydropsychidae 2 sp | 6 | | | | Bulininae* | 3 | | | | |
| M VEG OOC: DOM SP: | Baetidae >2 sp | 12 | | | | Hydropsychidae >2 sp | 12 | | | | Hydrobiidae* | 3 | | | | |
| GRAVEL: | Caenidae | 6 | | | | Philopotamidae | 10 | | | | Lymnaeidae* | 3 | | | | |
| SAND: | Ephemeridae | 15 | | | | Polycentropodidae | 12 | | | | Physidae* | 3 | | | | |
| MUD: | Heptageniidae | 13 | | | | Psychoomyiidae/Xiphocen. | 8 | | | | Planorbidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Leptophlebiidae | 9 | | | | CASED CADDIS: | | | | | Thiaridae* | 3 | | | | |
| FLOW: | Oligoneuridae | 15 | | | | Barbarochthonidae SWC | 13 | | | | Viviparidae* ST | 5 | | | | |
| TURBIDITY: | Polymitarcyidae | 10 | | | | Calamoceratidae ST | 11 | | | | PELECYPODA | | | | | |
| RIPARIAN LAND USE: | Prosopistomatidae | 15 | | | | Glossosomatidae SWC | 11 | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | Hydroptilidae | 6 | | | | Sphaeriidae | 3 | | | | |
| | Tricothyridae | 9 | | | | Hydrosalpingidae SWC | 15 | | | | Unionidae | 6 | | | | |
| | ODONATA: | | | | | Lepidostomatidae | 10 | | | | SASS SCORE: | | 16 | 30 | 38 | 49 |
| DISTURBANCE IN RIVER: | Calopterygidae ST,T | 10 | | | | Leptoceridae | 6 | | | | NO OF TAXA: | | 4 | 7 | 8 | 11 |
| | Chlorocyphidae | 10 | | | | Petrothrincidae SWC | 11 | | | | ASPT: | | 4.0 | 4.3 | 4.8 | 4.5 |
| | Chlorolestidae | 8 | | | | Pisuliidae | 10 | | | | IHAS: | | 60% | | | |
| | Coenagrionidae | 4 | 1 | B | 1 | Sericostomatidae SWC | 13 | | | | OTHER BIOTA: | | | | | |
| | Lestidae | 8 | | | | COLEOPTERA: | | | | | COMMENTS: | | | | | |
| SIGNS OF POLLUTION: | Platycnemidae | 10 | | | | Dytiscidae* | 5 | 1 | | 1 | A | | | | | |
| | Proto neuridae | 8 | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | Gyrinidae* | 5 | | | 1 | 1 | | | | | |
| | Aeshnidae | 8 | 1 | 1 | A | Halipidae* | 5 | | | | | | | | | |
| | Coruliidae | 8 | | | | Helo didae | 12 | | | | | | | | | |
| OTHER OBSERVATIONS: | Gomphidae | 6 | | | | Hydraenidae* | 8 | | | | | | | | | |
| | Libellulidae | 4 | | 1 | 1 | Hydrophilidae* | 5 | | | | | | | | | |
| | LEPIDOPTERA: | | | | | Limnichidae | 10 | | | | | | | | | |
| | Pyralidae | 12 | | | | Psephenidae | 10 | | | | | | | | | |

