# AQUATIC ECOLOGICAL ASSESSMENT FOR THE PROPOSED ANGLO PLATINUM DER BROCHEN EXPANSION PROJECT, LIMPOPO PROVINCE

## Prepared for:

## SRK Consulting (Pty) Ltd

## April 2018

## Revised: August 2019

## SECTION B: AQUATIC ECOLOGICAL ASSESSMENT

| | |
|---|---|
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| **Report Reference:** | **SAS 217170** |
| **Conception Date:** | **21 March 2018** |
| **Submission Date:** | **13 April 2018** |
| **Revision Date:** | **January 2019** |
| **Second Revision:** | **August 2019** |

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# MANAGEMENT SUMMARY

## Background:

Scientific Aquatic Services (SAS) was appointed to conduct an aquatic ecological assessment as part of the Environmental Impact Assessment (EIA) and authorisation process for the proposed Anglo Platinum Der Brochen Expansion Project, Limpopo Province, hereafter referred to as the "focus area". The Anglo Platinum Der Brochen Mine is situated northeast of the R555 provincial road, and northwest of the R540 within the Limpopo Province approximately 24km south-west (40km by road) of the town of Steelpoort. Lydenburg is approximately 31km from the focus area in a southeast direction. The mine is located in the Greater Tubatse Local Municipality which forms part of the Greater Sekhukhune District Municipality.

The purpose of the ecological study, conducted in late February 2018 (with consideration of historical data from the existing biomonitoring program), was to define the Present Ecological State (PES) as well as the Ecological Importance and Sensitivity (EIS) of the Groot Dwars River and its unnamed tributary (known locally as the Mareesburg Spruit) associated with the Anglo Platinum Der Brochen Project.

An impact assessment on the aquatic resources of the proposed expansion was performed to determine the significance of the perceived impacts on the receiving environment. In addition, mitigatory measures were developed which aim to minimise the impacts, followed by an assessment of the significance of the impacts after mitigation, assuming that they are fully implemented. The results of this assessment are contained in Section C (*Freshwater Resource and Aquatic Ecological Assessment for the Proposed Anglo Platinum Der Brochen Project, Limpopo Province. Section C: Integrated Impact Assessment and Mitigation. (SAS, 2018))*.

In Government Gazette Number 39943 issued 22 April 2016, it is indicated that the Klein Dwars River at the confluence with the Groot Dwars River (quaternary catchment B41G), should be maintained in at Ecological Category D. For the overall Steelpoort River (quaternary catchment B41K), it is also stated that an Ecological Category D should be maintained. It is thus clear that catchment wide impacts have occurred, as the DWS RQIS database also indicate the PES to be in an Ecological Category D condition given the Resource Quality Objectives (RQO's) of the system. The system can also be seen as a "working river" where degradation is expected.

## Methodology:

During this aquatic ecological assessment, results from the existing biomonitoring program (biomonitoring data for the period November 2001 to December 2017) were considered, as the assessment sites were also applicable to the proposed expansion.

## Results:

The available biomonitoring data allowed adequate assessment of the PES and EIS of the system. Said results largely support the desktop study results, as will be discussed in more detail below.

Despite the current PES, the EIS is considered high to very high (Kleynhans 1999 and DWS RQIS database), with a very high EIS rating also achieved during the current assessment. The Groot Dwars River is considered to be unique on a national scale based on biodiversity, with biota and habitat sensitive to flow and habitat modifications.

**Result summary:**

The results of the aquatic ecological assessment based on biomonitoring program data, as well as relevant desktop data, is provided below:

| Biomonitoring assessment results summary: | | | | | | |
|---|---|---|---|---|---|---|
| Criteria | Ecological Category classification achieved for the following sites: | | | | | |
| | GD2 | GD3 | GD4 | GD5 | Overall for the Groot Dwars River | T1 unnamed tributary on Mareesburg farm* |
| SASS5 | C | E/F | D | E/F | D | E/F |
| MIRAI | C | D | D | D | D | D |
| Instream IHI | B | B | B/C | B | B | B |
| Riparian IHI | B | C | C | C | C | C |
| FRAI | - | - | - | - | D | NA |
| VEGRAI | - | - | - | - | C | |
| Ecological Integration Tool result | | | | | C | |
| Ecological Importance and Sensitivity Assessment | | | | | High | |

* The tributary will be referred to as "Mareesburg Spruit" for the purpose of this report

The results for relevant desktop data, is provided below:

| Desktop assessment result summary: | |
|---|---|
| Desktop EIS (Kleynhans 1999, DWS RQIS) | High to Very High |
| Desktop PEMC (Kleynhans 1999) | B |
| Desktop DEMC (Kleynhans 1999) | B |
| Desktop PES (DWS RQIS) | D |
| Desktop REC (DWS 2016) | C/D |

NA = Not applicable; EIS = Ecological Importance and Sensitivity; PEMC = Present Ecological Management Class; DEMC = Desired Ecological Management Class; PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors; EI = Ecological Importance; ES = Ecological Sensitivity; EC = Ecological Category; default based on median PES and highest of EI or ES means; REC = Recommended Ecological Category.

### Water Quality and Toxicological Hazard Considerations:

**Groot Dwars River:** As also defined in the existing biomonitoring program, site GD5 is used to indicate the level of aquatic ecological integrity after the cumulative effects, if any, of the existing Der Brochen project on the Groot Dwars River. Monitoring results (temporal and spatial comparisons of percentage change in values) at this site indicate a potential impact on water quality [increased Electrical Conductivity (EC) in a downstream direction] from existing mining activities. Specifically, potential impact from the existing Mototolo concentrator on salt load (compounded by potential impacts from upstream pollution sources and geological variation) was noted at site GD4. Data suggest that increased EC will also be a likely compounding risk with reference to the planned expansion activities. Process water systems associated with the existing Mototolo concentrator, based on available historical data, poses a significant toxicological hazard to the receiving environment. Results varied seasonally, but risk ranged between a no acute hazard (Class 1) to a high acute hazard (Class 4). Over the same period the conditions in the Groot Dwars River posed a slight acute (Class 2) to acute (Class 3) hazard. Although already impacted, any potential spills or overflow from dirty water areas are likely to have negative impact in terms of both water quality (notably elevated EC), as well as a toxicological hazard impact on aquatic biota in the Groot Dwars River. It is anticipated that process water systems associated with the planned concentrator, as well as any other dirty water areas associated with the proposed mining operation expansion, will pose a similar threat (i.e. potential cumulative impact).

**Mareesburg Spruit:** Slightly elevated EC was observed at site T1 (Mareesburg Spruit subjected to potential cumulative impacts from surrounding agricultural and mining activities, confluences with the

Dwars River just above the GD5 site), which could potentially also contribute to salt loading of the Groot Dwars River at site GD5. As was also stated for the Groot Dwars River above, the proposed expansion infrastructure will likely contribute to a cumulative salt loading risk in the system.

**Aquatic Biota Considerations:**

Available biomonitoring data indicate that the macro-invertebrate community diversity and sensitivity decreases in a downstream direction on the Groot Dwars River. The observed decrease is likely related to slight variation in water quality (notably EC) to which the existing Der Brochen operations, Mototolo Concentrator, as well as unknown point and diffuse sources of pollution. The proposed expansion will result in cumulative risk with reference to water quality impact (salt loading and toxicological hazard described above) and habitat impacts (risk of sedimentation in case of spillages described above), with potential direct and indirect negative impact on aquatic communities.

**PES/EIS status:**

The Ecostatus Categories for the Index of Habitat Integrity (IHI) and the Macro-Invertebrate Response Assessment Index (MIRAI) classifications for all of the Groot Dwars River sites are congruent with the Resource Quality Objectives (RQO's) of the Olifants River catchment (Ecological Category C/D, DWS, 2016). As mentioned previously, this is a "working river" and hence existing impact can be anticipated.

**Most important risks identified based on aquatic ecological assessment:**

Risk of impact on the Groot Dwars River thus pertains predominantly to potential spillages or overflow (from process water systems and other dirty water areas), leaching (from waste rock dumps or mining shafts), decant (from shafts following closure) and run-off (from disturbed surfaces, hard surfaces and other proposed mining infrastructure), depending on phase of proposed development. Potential impact pertains to changes in water quality, as well as impact from sedimentation and settling of fine tailings. With reference to water quality, the specific risk of elevated EC based on historical data has been highlighted, as has toxicological hazards posed by dirty water systems. With reference to sedimentation and tailing deposits, potential direct and indirect effects are applicable.

**Aquatic ecological assessment synopsis:**

Existing biomonitoring data shows that the existing mining infrastructure do have an impact on the system. Should the planned expansion proceed, addition of similar infrastructure will likely lead to similar impacts (or risks thereof), potentially resulting in a cumulative effect. Should the expansion project proceed, very good mitigation is required to avoid and minimise potential impacts on the receiving environment, in line with the requirements of the mitigation hierarchy (prevention, reduction, remediation and compensation) as advocated by the Department of Environmental Affairs.

## Impact Assessment:

Following the assessment of the freshwater resources, an impact assessment was undertaken in order to ascertain the significance of perceived impacts associated with the proposed activities on the receiving environment. The results of this assessment are contained in Section C (*Freshwater Resource and Aquatic Ecological Assessment for the Proposed Anglo Platinum Der Brochen Project, Limpopo Province. Section C: Integrated Impact Assessment and Mitigation.SAS, 2018)*.

Based on the findings of the ecological assessment and results of the impact assessment, it is the opinion of the ecologist that the proposed expansion project carries the potential to pose a significant risk to the Groot Dwars River, pertaining mostly water quality (notably elevated EC) and sedimentation impacts on both aquatic habitat and biota. Risks pertain mostly to altered flow patterns with associated run-off, erosion and sedimentation as well as spillage/leaching/decant. However, should careful planning of the positioning and layout of the proposed infrastructure take into account the locations of the drainage lines, with appropriate measures to prevent or manage spillage/leaching/decant and run-off, impact significance can be greatly reduced. Furthermore, the adherence to cogent, well-conceived mitigation measures as well as general good construction practice will aid in reducing the impact significance to acceptable levels.

However, it should be noted that the significance of some risks, such as possible decant from the open pit and shaft, leaching from stockpiles and loss of catchment yield could not be accurately assessed since the relevant specialist studies had not been completed at the time of this assessment.

Taking the above into account, it is therefore the opinion of the specialist that from an aquatic ecological perspective, the proposed expansion project be carefully considered, and that preferably, further development and refinement of the site layout plans takes place before the project is authorised.

# DOCUMENT GUIDE

The table below provides a guide of the contents of this report in line with the requirements for specialist studies as per Appendix 6 of the EIA regulations, as amended in 2017 (GN326).

| No. | Requirement | Section in report |
|---|---|---|
| a) | Details of - | - |
| (i) | The specialist who prepared the report | Appendix F |
| (ii) | The expertise of that specialist to compile a specialist report including a curriculum vitae | Appendix F |
| b) | A declaration that the specialist is independent | Appendix F |
| c) | An indication of the scope of, and the purpose for which, the report was prepared | Section 1.2 |
| cA) | An indication of the quality and age of base data used for the specialist report | Section 2.2 and 3 |
| cB) | A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change | Section 2.2, 4 and 5 |
| d) | The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment | Section 1.2, 4 and 5 |
| e) | A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used | Section 3 and Appendix C |
| f) | Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives | Section 4 and 5 |
| g) | An identification of any areas to be avoided, including buffers | Section A (Freshwater Resource Ecological Assessment) |
| h) | A map superimposing the activity including the associated structure and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers | Section A (Freshwater Resource Ecological Assessment) |
| i) | A description of any assumption made and any uncertainties or gaps in knowledge | Section 1.3 |
| j) | A description the findings and potential implication\s of such findings on the impact of the proposed activity, including identified alternatives on the environment or activities | Section 4 and 5, Section C |
| k) | Any mitigation measures for inclusion in the EMPr | Section C |
| l) | Any conditions for inclusion in the environmental authorisation | Section C |
| m) | Any monitoring requirements for inclusion in the EMPr or environmental authorisation | Section C |
| n) | A reasoned opinion - | |
| (i) | As to whether the proposed activity, activities or portions thereof should be authorised | Section 7, Section C |
| (iA) | Regarding the acceptability of the proposed activity or activities | Section 7, Section C |
| (ii) | If the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan | Section 7, Section C |
| o) | A description of any consultation process that was undertaken during the course of preparing the specialist report | N/A |
| p) | A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and | N/A |
| q) | Any other information requested by the competent authority | N/A |

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# ACRONYMS AND GLOSSARY OF TERMS

| Abbreviations and Acronyms | Full Form | Definition (Where Applicable) |
|---|---|---|
| ASPT | Average Score Per Taxon | The average sensitivity of the aquatic community obtained by determining the sum of the sensitivity scores for each aquatic macro-invertebrate family observed and then dividing by the number of families present. |
| DEEEP | Direct Estimation of Ecological Effect Potential | DEEEP proposes a battery of tests to directly assess effluent oxygen demand, lethal (acute) and sublethal (chronic) toxicity, bioaccumulation, mutagenicity and persistence potential of effluents, using test organisms from a range of trophic levels. |
| DO | Dissolved Oxygen | Dissolved Oxygen is the amount of oxygen that is present in the water. It is measured in milligrams per litre (mg/L). |
| % DO sat | Dissolved Oxygen Saturation | In aquatic environments, oxygen saturation is a ratio of the concentration of dissolved oxygen in the water to the maximum amount of oxygen that will dissolve in the water at that temperature and pressure under stable equilibrium. |
| DWAF | Department of Water Affairs and Forestry | |
| DWS | Department of Water and Sanitation (formerly known as DWAF, see above) | |
| DMS | Dense Medium Separation | |
| EC | Electrical Conductivity | Electrical conductivity (EC) is a measure of the ability of water to conduct an electrical current. This ability is a result of the presence in water of ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium, all of which carry an electrical charge. |
| EIS | Ecological Importance and Sensitivity | Ecological importance refers to the diversity, rarity or uniqueness of the habitats and biota. Ecological sensitivity refers to the ability of the ecosystem to tolerate disturbances and to recover from certain impacts. |
| EMP | Environmental Management Plan | An EMP is a site-specific plan developed to ensure that all necessary measures are identified and implemented in order to protect the environment and comply with environmental legislation. |
| EWR | Ecological Water Requirements | The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components. |
| IHAS | Invertebrate Habitat Assessment System | An assessment index to determine the suitability of the habitat at any assessment point for colonisation by aquatic macro-invertebrates. |
| IHIA | Intermediate Habitat Integrity Assessment | The habitat integrity assessment is based on two perspectives of the river, the riparian zone and the instream channel. Assessments are made separately for both aspects, but data for the riparian zone are primarily interpreted in terms of the potential impact on the instream component. |
| MIRAI | Macro-invertebrate Response Assessment Index | MIRAI integrates the ecological requirements of the invertebrate taxa in a community or assemblage to their response to modified habitat conditions. |
| NA | Not Applicable | |
| NEMA | National Environmental Management Act | |
| NWA | National Water Act | |

# ACRONYMS AND GLOSSARY OF TERMS (CONTINUED)

| Abbreviations and Acronyms | Full Form | Definition (Where Applicable) |
|---|---|---|
| OREWRA | Olifants River Ecological Water Requirement Assessment | A comprehensive determination of the Reserve was conducted with the aim of quantifying the environmental requirements of the resource in order to protect the aquatic ecosystem and secure ecologically sustainable development and use of the resource. The outcome of this determination was recommended flow and water quality objectives that should be achieved in order that the aquatic ecosystem can be afforded the level of protection as required by the Ecological Class. |
| PES | Present Ecological State | The current state or condition of a water resource in terms of its biophysical components (drivers) such as hydrology, geomorphology and water quality and biological responses viz. fish, invertebrates, riparian vegetation). The degree to which ecological conditions of an area have been modified from natural (reference) conditions. |
| Ref | Reference | |
| RQIS | Resource Quality Information Services | RQIS provides national water resource managers with aquatic resource data, technical information, guidelines and procedures that support the strategic and operational requirements for assessment and protection of water resource quality. |
| RQOs | Resource Quality Objectives | Classes and resource quality objectives of water resources for the Olifants catchment from Government Gazette number 39943, 22 April 2016, Department of Water and Sanitation (DWS 2016). |
| SA RHP | South African River Health Programme | The RHP serves as a source of information regarding the overall ecological status of river ecosystems in South Africa. For this reason, the RHP primarily makes use of in-stream and riparian biological communities (e.g. fish, invertebrates, vegetation) to characterise the response of the aquatic environment to multiple disturbances. |
| SASS5 | South African Scoring System | An index to determine the integrity of the aquatic macro-invertebrate community at any given assessment point. |
| SQR | Sub-quaternary Reach | A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments). |
| TWQR | Target Water Quality Requirement | *Guidelines set by the South African Department of Water and Sanitation (DWS), formerly the Department of Water Affairs and Forestry (DWAF), for various physico-chemical and biological parameters for various uses as well as ecosystem functioning. |
| Var | Variation | |
| WET | Whole Effluent Toxicity | Whole Effluent Toxicity refers to the aggregate toxic effect to aquatic organisms from all pollutants contained in a facility's wastewater (effluent). |
| WMS | Water Management System | WMS is a suite of computer programmes developed for the Department of Water and Sanitation to provide information for water resource monitoring and management in South Africa. |
| WUL | Water Use License | The National Water Act (Act 36 of 1998) gives the Department of Water and Sanitation the tools to gather the information that we need for the optimal management of our water resources. The registration of water use is one of these tools. |

***** South African water quality guidelines volume 7, Aquatic ecosystems (DWS 1996): This reference provides percentage change guidelines as follows:

- **Electrical conductivity (EC)/Total Dissolved Solids (TDS)** concentrations should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year, and the amplitude and frequency of natural cycles in EC/TDS concentrations should not be changed;

- **pH values** should not be allowed to vary from the range of the background pH values for a specific site and time of day, by > 0.5 of a pH unit, or by > 5 %, and should be assessed by whichever estimate is the more conservative.
- **Dissolved Oxygen (DO)** concentration should be 80% to 120% of saturation. In addition, for the purposes of this report, any spatial or temporal change exceeding 15% will be considered significant.

**Note that EC and pH comparisons refer to temporal comparisons. However, as no guidelines are available for spatial comparisons, the percentage change recommendations will also be applied to spatial comparisons.** For the purpose of this report, a temporal or spatial change of 15% will be considered significant with reference to DO.

**Two other water quality related guideline documents consulted during the aquatic assessments were:**

- Olifants River Ecological Water Requirements Assessment (OREWRA) (Palmer and Rossouw, 2001) for the Lower Olifants, Steelpoort River. Water quality parameter values were compared to guideline values from this reference, denoted as OREWRA (2001) in discussions that follow;
- Classes and resource quality objectives of water resources for the Olifants catchment from Government Gazette number 39943, 22 April 2016, Department of Water and Sanitation (DWS 2016). This publication provided updated classes and resource quality objectives of water resources for the Olifants River catchment. However, it does not specify water quality ranges for oxygen concentration, pH value and electrical conductivity concentration for quaternary catchment B41G (Upper reaches of Groot Dwars River or the Klein Dwars confluence with the Groot Dwars) or B41J (Steelpoort River, EWR Site 9). Details on ecological category, water quality in terms of nutrients and toxins, instream habitat and biota and riparian zone habitat are included in Section 2 of this report, and was used to aid in interpretation of biological monitoring data.

# 1. INTRODUCTION

## *1.1 Background Information*

Scientific Aquatic Services (SAS) was appointed to conduct a freshwater resource assessment as part of the amendment to the Anglo American Platinum (AAP)-Rustenburg Platinum Mines Limited (RPM) Der Brochen Mine's approved EMPr and associated Environmental Authorisation (EA), including an update of the existing Water Use Licence (WUL) to include various new activities. The proposed developments are summarised below and are collectively henceforth referred to as the 'focus area' (Figures 1 and 2). The Anglo Platinum Der Brochen Project is situated northeast of the R555 provincial road, and northwest of the R540, and approximately 24km south-west (40km by road) of the town of Steelpoort. Lydenburg is approximately 31km from the focus area in a southeast direction. The Anglo Platinum Der Brochen Mine is located in the Greater Tubatse Local Municipality which forms part of the Greater Sekhukhune District Municipality.

**Project Description**

The focus area comprises the following additional mining-related infrastructure as part of the mine's development strategy (as per the Memorandum for the Der Brochen Amendment Project developed and provided by SRK Consulting, 23 July 2019, Project Reference 533247):

- One new decline shaft (South Decline Shaft) with associated infrastructure including water management infrastructure;
- The previously approved North Opencast Pit area with associated infrastructure as previously approved in 2015, i.e. water management infrastructure and waste rock stockpiles;
- Three up-cast ventilation shafts required for the underground workings associated with the South Decline Shaft;
- A Dense Medium Separation (DMS) Plant to be located within the existing footprint area of the Mototolo Concentrator area;
- A DMS Stockpile with associated water management infrastructure;
- The conversion of the existing Mototolo chrome plant from a final tailings' arrangement to an inter-stage arrangement;
- Additional Run of Mine stockpiles and associated silos;
- Change houses and office complex to be located at the proposed South Decline Shaft area;

- An explosive destruction bay area to be located near the proposed South decline shaft;
- Staff accommodation facilities to be located near the Der Brochen Dam; and
- Additional linear infrastructure, i.e.:
  - **Two conveyor systems.** *One conveyor belt system will be constructed to connect the proposed South Decline Shaft with the proposed DMS Plant that will be located in the existing footprint area of the Mototolo Concentrator Plant, for the purpose of transporting ore from the South Decline Shaft to the plant area. Another conveyor belt system will be required to transport DMS material from the proposed DMS Plant to the proposed DMS Stockpile area. It is currently anticipated that the DMS conveyor system will run along the existing Mareesburg tailings pipeline system.*
  - **Access and haul roads**. *New access roads to the proposed ventilation shafts will be required for maintenance purposes. Certain existing roads will also be required to be upgraded to provide sufficient access roads to the project related infrastructure such as the North Opencast Pit area, the South Decline Shaft and offices. The mine is also considering including a haul road within the proposed corridor associated with the ore conveyor belt system to transport ore from the proposed South Decline Shaft to the Mototolo Concentrator Plant area as an interim measure, whilst the conveyor belt system is being constructed*.

It should be noted that although the scope of this study does not include the previously authorized North Open Pit and associated infrastructure, where necessary, reference is made to the potential cumulative impact that the proposed North Open Pit may have on freshwater resources identified within the focus area.

The focus area is within an undisturbed area which has an endemic floral and faunal community, and is therefore of considerable ecological importance (SRK, 2002). The Der Brochen mine is situated in the catchment of the Groot Dwars River (quaternary catchment B41G). This river confluences with the Klein Dwars River before it enters the Steelpoort River. The primary catchment of the system is the Olifants River system. In this area, the water resources are used for mining purposes, however, some subsistence fishing as well as domestic and agricultural use of water is likely to occur downstream of the project area.
Due to the “Good to Excellent” biotic conditions historically observed in the area, this region of the Steelpoort catchment has been regarded as having a high ecological importance. However, in Government Gazette Number 39943 issued 22 April 2016, it is indicated that the Klein Dwars River at the confluence with the Groot Dwars River (quaternary catchment B41G), should be maintained in at Ecological Category D. For the upper reaches of the Dwars River, prior to mining impacts (also quaternary catchment B41G), it is stated that an Ecological

Category C should be maintained. It is thus clear that catchment wide impact has occurred in this quaternary catchment.

SAS currently manages an ecological biomonitoring program pertaining to the existing Der Brochen activities. Historic data from this program were also used to help define the ecological state of aquatic resource characteristics, including defining the Present Ecological State (PES) and Ecological Integrity and Sensitivity (EIS) of the section of the Groot Dwars River associated with the mine expansion.

A pre-defined impact assessment method supplied by the Environmental Assessment Practitioner (EAP) was applied to determine the significance of the perceived impacts associated with the mining expansion activities. In addition, mitigatory measures were developed which aim to minimise the impacts, followed by an assessment of the significance of the impacts after mitigation, assuming that they are fully implemented. These results are contained in Section C (*Freshwater Resource and Aquatic Ecological Assessment for the Proposed Anglo Platinum Der Brochen Project, Limpopo Province. Section C: Integrated Impact Assessment and Mitigation.SAS, 2018)*. Please refer to Section 1.2 for the detailed scope of work encompassed by this study.

This study aims to provide detailed information to guide the proposed project activities in the vicinity of the aquatic resource (Groot Dwars River), to ensure the ongoing functioning of the ecosystems, such that local and regional conservation requirements and the provision of ecological services in the local area are supported while considering the need for sustainable economic development. This report, after consideration of the above, must guide the relevant authorities, by means of a reasoned opinion and recommendations, as to the viability of the proposed mining activities from an aquatic resource management perspective.

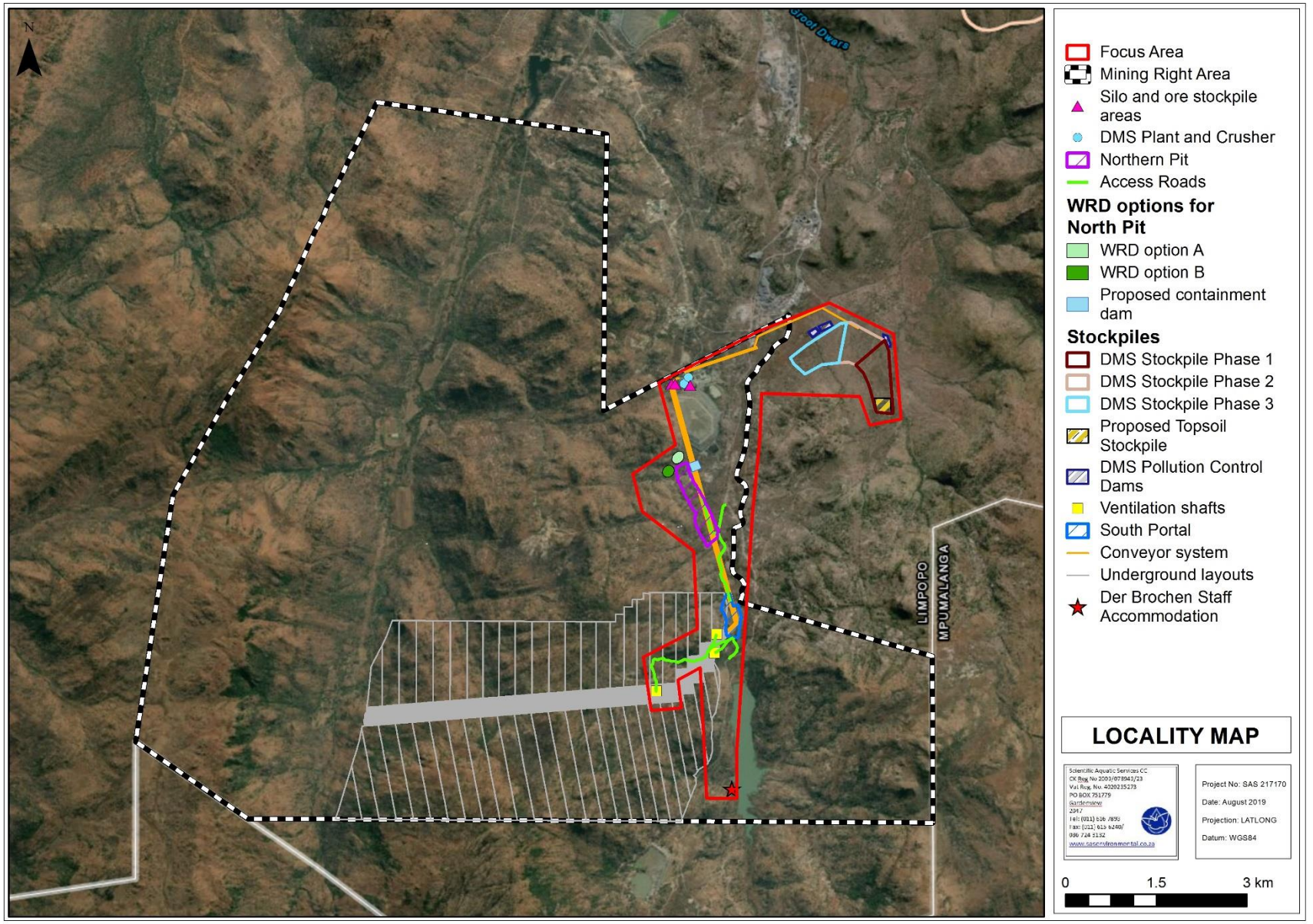



**Figure 1: A digital satellite image depicting the location of the proposed Der Brochen mine expansion in relation to the greater MRA.**

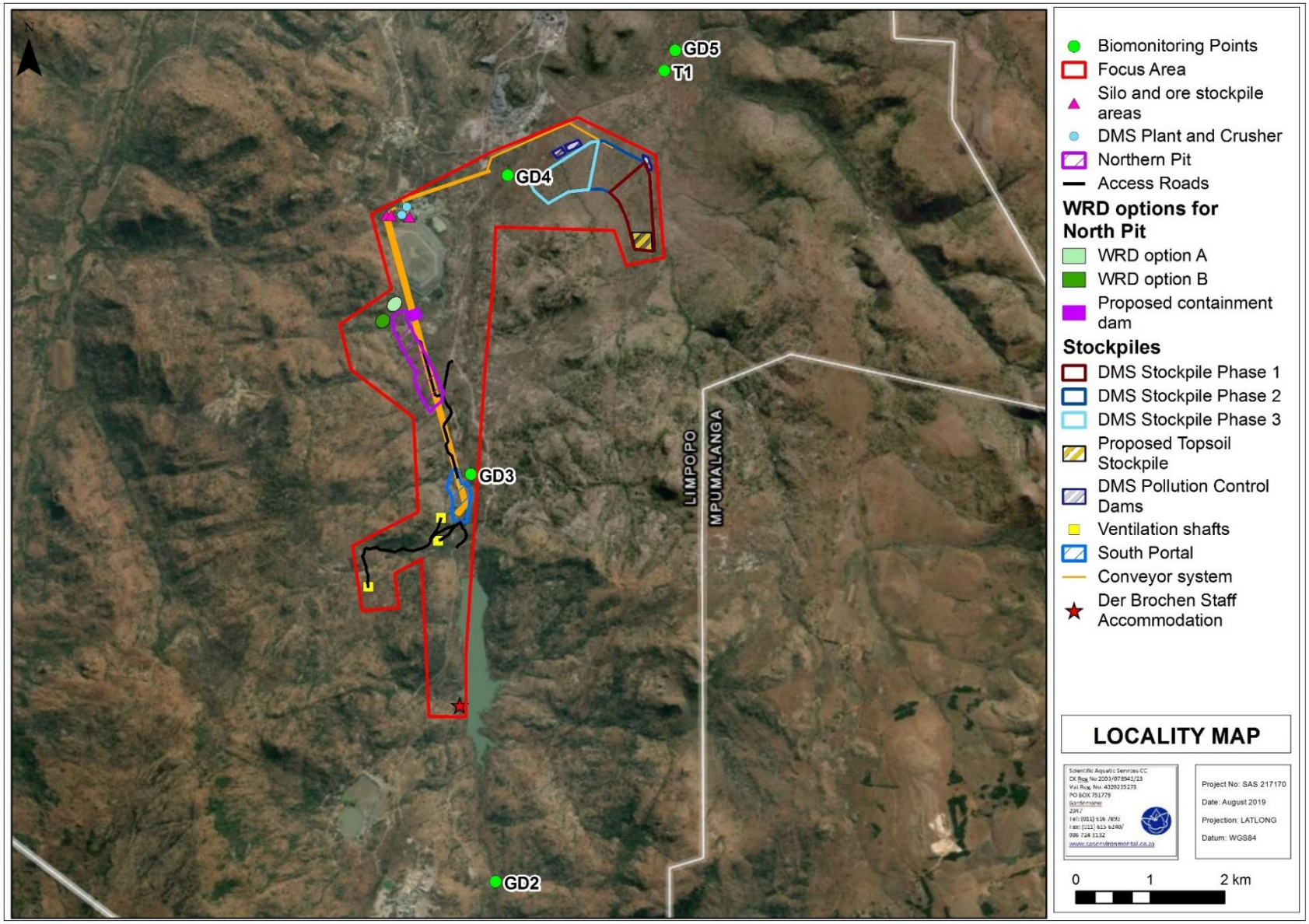



**Figure 2: A digital satellite image depicting the location of the proposed Der Brochen mine expansion and the biomonitoring points in relation to the surrounding area.**

## 1.2 Scope of Work

Specific outcomes in terms of the assessment of the aquatic resources within the Investigation Area were to:

- To define the Present Ecological State (PES) of the aquatic resources within the study areas;
- To define the Ecological Importance and Sensitivity (EIS) of the aquatic resources within the study area;
- To collect baseline data and present recommendations with the intention to:
  - Maintain the PES of the system in support of the EIS of the aquatic ecosystem;
  - Ensure that connectivity of the aquatic resources is maintained between the areas upstream and downstream of the proposed development areas;
  - Ensure that no further incision and erosion of the river system takes place as a result of the proposed development;
  - Ensure that no significant persistent impact on water quality will take place;
- To determine the impact that the proposed project might have on the aquatic ecology of the area as a result of the proposed mining activities, and to aim to quantify the significance thereof; and
- To present management and mitigation measures which should be implemented by the proponent to assist in minimising the impact on the receiving environment.

This report serves to report on an assessment of the PES and EIS of, as well as potential risk to, the Groot Dwars River and associated Mareesburg Spruit, with consideration of data obtained from the existing biomonitoring and toxicity testing program. Period of biomonitoring used for this purpose ranged from November 2001 to December 2017. Five biomonitoring sites pertaining to the Groot Dwars River have historically been identified for assessment. These same sites were employed for the purpose of this study, as they will also be applicable to the proposed expansion. The locations of the respective sites are presented in Figures 2 and 3. The upstream site (GD2) is used as a spatial reference site to indicate whether any change in aquatic ecological integrity takes place over the existing mine property. This upstream point is important, since changes which have already taken place in the system due to anthropogenic activities, prior to the effects of the existing Der Brochen project, can then be accounted for. Site GD3 is located upstream of the Helena/Der Brochen boundary fence. Site GD4 serves as an intermediate point which will aid in identifying impacts occurring within existing the mining area. This point also acts as a spatial reference point to which data from site GD5 can be compared. This will allow existing impacts in the lower mining sections to be quantified and will allow the existing impacts of the Mototolo Tailings Dam on the Groot Dwars

River to be determined. The downstream site (GD5) is used to indicate the level of aquatic ecological integrity after the existing cumulative effects, if any, of the Der Brochen project on the Groot Dwars River. Identifying impact of existing infrastructure will assist to identify potential risks and cumulative impacts that may be posed by addition of similar new infrastructure, should the proposed expansion proceed.

Site T1 is located on the Mareesburg Spruit which confluences with the Dwars River just above the GD5 site. In order to ensure that results are temporally comparable, the same sampling locations were used as those which were used during scheduled biomonitoring assessments of the existing mining operation.

**Table 1: Location of the biomonitoring points with co-ordinates and descriptions of the site in relation to surrounding features.**

| SITE | LATITUDE | LONGITUDE | DESCRIPTION |
|---|---|---|---|
| GD2 | 25° 05" 12.5 S | 30° 07" 29.9 E | Located on the Groot Dwars River downstream of the Booysendal boundary fence. Used as a spatial reference site to indicate whether any change in aquatic ecological integrity takes place over the mine property |
| GD3 | 25º 02" 26.6 S | 30º 07" 12.8 E | Located approximately 100 meters downstream of the existing low water crossing of the Groot Dwars River, which is upstream of the Helena/Der Brochen boundary fence. |
| GD4 | 25º 00" 21.6 S | 30º 07" 28.3 E | Groot Dwars River downstream of the Mototolo concentrator but upstream of the Helena mine. Located at a point where the road along the east bank of the river is near to the river downstream of a small waterfall. Assessment of this site will allow impacts in the lower mining sections to be quantified and will allow the impacts of the Mototolo Tailings Dam on the Groot Dwars River to be determined. |
| GD5 | 24º 59" 26.3 S | 30º 08" 42.5 E | Located within the Xstrata game farm grounds. The point is approximately 150 meters downstream of the confluence of the Mareesburg Spruit with the Groot Dwars River. The site (GD5) is used to indicate the level of aquatic ecological integrity after the cumulative effects, if any, of the Der Brochen project on the Groot Dwars River. |
| T1 | 24º 59" 35.3 S | 30º 08" 37.7 E | Located on the Mareesburg Spruit which confluences with the Dwars River just above the GD5 site. |

This report serves to report on an assessment of the PES and EIS of, as well as potential risk to, the Groot Dwars River and associated Mareesburg Spruit, with consideration of data obtained from the existing biomonitoring program (period of biomonitoring from November 2001 to December 2017, with the exception of the assessment of the riparian vegetation using the (VEGRAI Ecostatus tool) applied in February 2018). Factors investigated included the visual conditions of the site, together with an assessment of potential impacts on the stream at each point. General habitat integrity was assessed using the Index of Habitat Integrity (IHI) system.

Habitat suitability for aquatic macro-invertebrates was determined using the Invertebrate Habitat Assessment System (IHAS) method. The integrity of the aquatic macro-invertebrate

communities was assessed using the South African Scoring System version 5 (SASS5) and the Macro-Invertebrate Response Assessment Index (MIRAI). The integrity of the fish community was assessed using the Fish Response Assessment Index (FRAI), whilst that of riparian vegetation was assessed using Riparian Vegetation Response Assessment Index (VEGRAI).

Section 3 and Appendix C describes the methods used to assess the various aspects of the ecological integrity of the system, and the results obtained are discussed in Section 4. In Section 5 ecological importance and sensitivity are assessed. In Section 7 a synthesis of the findings is made.

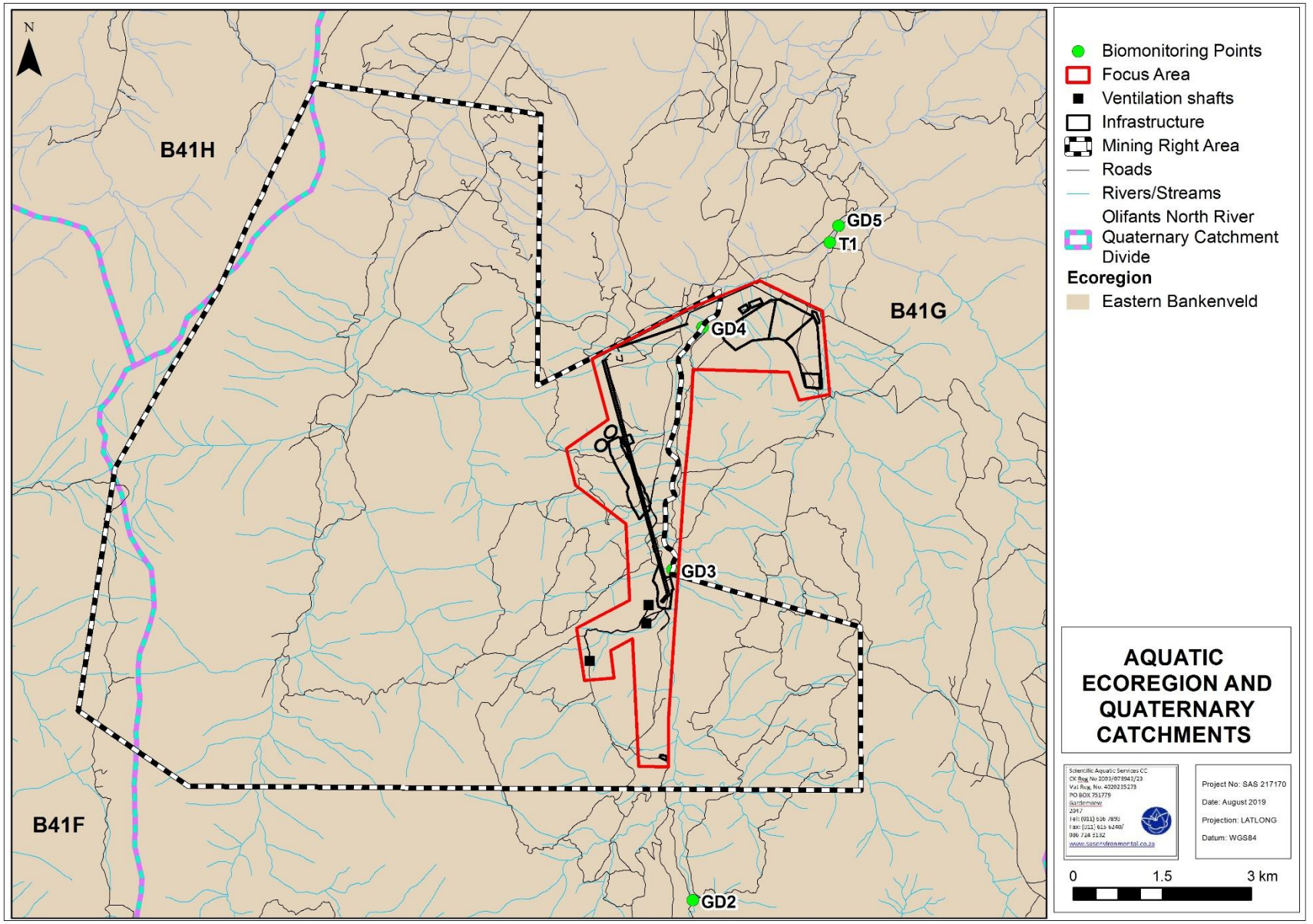



**Figure 3: Biomonitoring sites presented in relation to the Aquatic Ecoregion and relevant quaternary catchments, including the Dwars River Catchment.**

## 1.3 Assumptions and Limitations

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

- ***Area examined:*** The determination of the aquatic resource boundaries and the assessment thereof, is confined to the focus area. The general surroundings were, however, considered in the desktop assessment of the focus area as well as general knowledge of the consultants on the Greater Dwars River system;
- ***Reference conditions are unknown:*** Considering existing mining activities in the larger catchment, the composition of aquatic biota in the focus area, prior to disturbance, is largely unknown. For this reason, reference conditions are partly hypothetical, and are based on historical biomonitoring data in the area (dating back to April 2007), professional judgement and inferred from desktop data available such as the Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database, as discussed in Section 2. These sources indicate that the system is highly sensitive with a very high ecological importance and ecological sensitivity rating;
- ***Integrated Ecological Impact Assessment:*** The results of the integrated impact assessment undertaken for the aquatic and freshwater (riparian) resources are presented in Section C[1]. It is important to note however that at the time of the assessment, detailed layouts of some infrastructure areas (e.g. the auxiliary infrastructure associated with the South Decline Shaft) had not been finalized. The impact assessment is therefore based on general investigation areas provided by the proponent and the impact significance of some perceived impacts could change. The impact assessment was therefore based on a "worst case scenario".

## 1.4 Legislative Considerations

The following legislative requirements were taken into consideration during the assessment. A detailed description of these legislative requirements is presented in Appendix B:

- Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA)
- National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA)
- National Water Act, 1998 (Act 36 of 1998) (NWA);

[1] *Integrated Impact Assessment for the Der Brochen* 2018. Prepared by Scientific Aquatic Services for SRK Consulting (Pty) Ltd. Specialist report. Unpublished.

- General Notice (GN) 509 as published in the Government Gazette 40229 of 2016 as it relates to the NWA, 1998 (Act 36 of 1998); and
- Government Notice 704 as published in the Government Gazette 20119 of 1999 as it relates to the NWA, 1998 (Act 36 of 1998) regarding the use of water for mining and related activities aimed at the protection of water resources.

# 2. AQUATIC ECOLOGICAL DESCRIPTION (DESKTOP ANALYSIS)

## *2.1 Ecoregions*

When assessing the ecology of any area (aquatic or terrestrial), it is important to know which ecoregion the study areas are located within. This knowledge allows improved interpretation of data, since reference information and representative species lists are often available on this level of assessment, which aids in guiding the assessment. With reference to expected macro-invertebrate and fish taxa, refer to Section 2.2.2 [Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database].

The Der Brochen study areas fall within the Eastern Bankenveld Ecoregion and is located within the B41G quaternary catchment).

**Table 2: Key Attributes of the Eastern Bankenveld Ecoregion**

| **Dominant characteristics of the Eastern Bankenveld Ecoregion Level 2 (10.01) (Kleynhans *et al.,* 2005)** | |
|---|---|
| Dominant primary terrain morphology | Plains; Low Relief; (very limited)<br>Plains; Moderate Relief;<br>Lowlands; Hills and Mountains; Moderate and High Relief; (limited)<br>Open Hills; Lowlands; Mountains; Moderate to High Relief; (limited)<br>**Closed Hills; Mountains; Moderate and High Relief**; |
| Primary vegetation types **(dominant in bold text)** | Sour Lowveld Bushveld; **Mixed Bushveld**; Clay Thorn Bushveld (limited);<br>Rocky Highveld Grassland; Moist Sandy Highveld Grassland;<br>**North Eastern Mountain Grassland;**<br>Patches Afromontane Forest. |
| Altitude (m a.m.s.l) | 500 – 2300 |
| MAP (mm) | 300 – 1000 |
| Coefficient of Variation (% of MAP) | < 20 to 34 |
| Rainfall concentration index | 55 to >65 |
| Rainfall seasonality | Early to mid summer |
| Mean annual temp. (°C) | 10 to 22 |
| Winter temperature (July) | 0 – 24 C |
| Summer temperature (Feb) | 8 – 30 C |
| Median annual simulated runoff (mm) | 20 to 150; 200 to > 250 |

## 2.2 Ecostatus

### 2.2.1 Historical Quaternary Catchment Information from Kleynhans, 1999

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 in future field studies.

**Table 3: Classification of river health assessment classes in line with the RHP**

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

In addition, the Ecological Category (EC) classification will be employed using the eco-status A to F continuum approach (Kleynhans *et al.,* 2007a). This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 5.


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

Studies undertaken by the Institute for Water Quality Studies (IWQS) assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments the 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.

To define the EIS, PEMC and DEMC, a study undertaken by Kleynhans (1999) helped define the quaternary catchment of concern (B41G).

The findings by Kleynhans (1999) forms part of the project entitled: "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 4: Quaternary catchment information.**

| Catchment | Resource | EIS | PEMC | DEMC |
|---|---|---|---|---|
| B41G | Dwars River (Upper portion) | High | Class B: Largely Natural | B: Sensitive System |

According to the ecological importance classification for the quaternary catchment, the system can be classified as a highly sensitive system which, in its present state, can be considered to be a Class B (Largely natural) stream.

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

- The aquatic resources within this quaternary catchment have been highly affected by bed modification.
- Significant flow modifications and impacts from inundation have taken place, due to several small weirs and the Der Brochen Dam in the system.
- Riparian zones and stream bank conditions are considered to be impacted with some *Acacia* sp. invasion.
- An impact on water quality, from mining related activities, is deemed likely especially downstream of the upstream mining areas.

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

- The riverine systems in this catchment have a high diversity of habitat types, increasing their ecological sensitivity and importance. Gorges, rapids, riffles and waterfalls are all known to occur in the area.
- The site has a moderate importance in terms of conservation, with unique geological conditions.
- The riverine resources have a very high sensitivity to flow requirements, with the species *Amphilius uranoscopus* and *Chiloglanis pretoriae* being dependent on flow as part of their biological requirements. Flow in the system is also very important for invertebrate community conservation in the area.
- The area has a little importance in terms of migration of aquatic species, although the area forms an important eco-tone with a concomitant increase in species diversity.

- The area is considered likely to be very important in terms of rare and endemic species conservation. However, confidence in this regard is low.
- The area provides important refuge areas due to the very inaccessible nature of the upper reaches of the Groot Dwars River.
- The ecology of the area is considered to be moderately sensitive to changes in water quality.

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

The PES/EIS database, as developed by the DWS RQIS department, was utilised to obtain additional background information on the project area. The PES/EIS database has been made available to consultants since mid-August 2014. The information from this database is based on information at a sub-quaternary catchment reach (SQR) level. Descriptions of the aquatic ecology is based on information collated by the DWS RQIS department from available sources of reliable information, such as SA RHP sites, Ecological Water Requirements (EWR) sites and Hydro Water Management system (WMS) sites.

In this regard, information for the SQRs of rivers associated with the focus area were obtained. The applicable SQR points are as follows (see Figure 6):

- B41G – 00721 (Groot Dwars River);
- B41G – 00726 Mareesburg Spruit, tributary of Groot Dwars River); and
- B41G – 00674 (Groot Dwars River)

Key information on fish species, invertebrates and background conditions, as contained in this database and pertaining to the Present Ecological State (PES), ecological importance and ecological sensitivity for the Rivers, are tabulated in Tables 5 to 7 below.

**Table 5: Fish species previously collected from or expected in the various SQR monitoring points associated with the focus area**

| | B41G – 00721 (Groot Dwars River); | B41G – 00726 (Mareesburg Spruit, tributary of Groot Dwars River) | B41G – 00674 (Groot Dwars River) |
|---|---|---|---|
| *Amphilius uranoscopus* | X | X | X |
| *Barbus motebensis* | X | X | |
| *Barbus neefi* | X | | X |
| *Barbus trimaculatus* | | | X |
| *Barbus unitaeniatus* | | | X |
| *Clarias gariepinus* | X | X | X |
| *Chiloglanis pretoriae* | X | X | X |
| *Labeobarbus marequensis* | X | X | X |
| *Labeo cylindricus* | | | X |
| *Labeo molybdinus* | | | X |
| *Oreochromis mossambicus* | | | X |
| *Pseudocrenilabrus philander* | X | X | X |
| *Tilapia sparrmanii* | X | X | X |

**Table 6: Invertebrates previously collected from or expected at the various SQR monitoring points associated with the various assessment areas.**

| Taxa | B41G – 00721 (Groot Dwars River) | B41G – 00726 (Mareesburg Spruit, tributary of Groot Dwars River) | B41G – 00674 (Groot Dwars River) |
|---|---|---|---|
| Aeshnidae | X | X | |
| Ancylidae | | X | X |
| Athericidae | X | X | X |
| Baetidae > 2 Sp | X | X | X |
| Belostomatidae | X | X | X |
| Caenidae | X | X | X |
| Ceratopogonidae | X | X | X |
| Chironomidae | X | X | X |
| Chlorocyphidae | X | | X |
| Coenagrionidae | X | X | X |
| Corduliidae | | X | |
| Corixidae | X | X | X |
| Crambidae (Pyralidae) | | X | |
| Culicidae | X | X | X |
| Dixidae | X | X | |
| Dytiscidae | X | X | X |
| Ecnomidae | | X | |
| Elmidae/Dryopidae | X | X | X |
| Gerridae | X | X | X |
| Gomphidae | X | X | X |
| Gyrinidae | X | X | X |
| Helodidae | | X | |
| Heptageniidae | X | X | X |
| Hirudinea | X | X | |
| Hydracarina | X | X | X |
| Hydraenidae | | X | X |
| Hydrometridae | X | | X |
| Hydrophilidae | X | X | |
| Hydropsychidae 2 Sp | X | X | X |
| Hydroptilidae | | X | X |
| Lepidostomatidae | | X | |
| Leptoceridae | X | X | X |
| Leptophlebiidae | X | X | X |
| Libellulidae | X | X | X |
| Lymnaeidae | X | X | |
| Muscidae | X | X | |
| Naucoridae | X | X | X |

| Taxa | B41G – 00721 (Groot Dwars River) | B41G – 00726 (Mareesburg Spruit, tributary of Groot Dwars River) | B41G – 00674 (Groot Dwars River) |
|---|---|---|---|
| Nepidae | X | X | X |
| Notonectidae | X | X | X |
| Oligochaeta | X | X | X |
| Perlidae | X | | X |
| Philopotamidae | X | X | X |
| Physidae | X | | |
| Planorbinae | X | X | X |
| Pleidae | X | X | X |
| Potamonautidae | X | X | X |
| Prosopistomatidae | X | | |
| Psephenidae | X | X | X |
| Psychodidae | X | | |
| Simuliidae | X | X | X |
| Sphaeriidae | | X | |
| Tabanidae | X | X | X |
| Thiaridae | X | | |
| Tipulidae | X | X | X |
| Tricorythidae | X | X | X |
| Turbellaria | X | X | X |
| Veliidae/Mesoveliidae | X | X | X |

**Table 7: Summary of the ecological status of the sub-quaternary catchment (SQ) reaches associated with the focus area based on the DWS RQS PES/EIS database**

| Criteria | B41G – 00721 (Groot Dwars River) | B41G – 00726 (Mareesburg Spruit, tributary of Groot Dwars River) | B41G – 00674 (Groot Dwars River) |
|---|---|---|---|
| **Synopsis** | | | |
| **PES Category Median** | C (Moderately Modified) | B (Largely Natural) | D (Largely Modified) |
| **Mean EI class** | High | High | High |
| **Mean ES class** | Very High | Very High | Very High |
| **Length** | 32,04 | 18,71 | 11,84 |
| **Stream order** | 1 | 1 | 2 |
| **Default EC[4]** | A (Very High) | A (Very High) | A (Very High) |
| **PES Details** | | | |
| **Instream habitat continuity MOD** | Large | Small | Moderate |
| **RIP/wetland zone continuity MOD** | Small | Small | Moderate |
| **Potential instream habitat MOD activities** | Moderate | Moderate | Large |
| **Riparian/wetland zone MOD** | Small | Small | Moderate |
| **Potential flow MOD activities** | Moderate | Moderate | Large |
| **Potential physico-chemical MOD activities** | Moderate | Small | Large |
| **EI Details** | | | |
| **Fish spp/SQ** | 8 | 7 | 12 |
| **Fish average confidence** | 3,75 | 4,71 | 5 |
| **Fish representivity per secondary class** | Low | Low | Moderate |
| **Fish rarity per secondary class** | Moderate | Moderate | High |
| **Invertebrate taxa/SQ** | 48 | 51 | 41 |
| **Invertebrate average confidence** | 3,92 | 3,94 | 4,17 |
| **Invertebrate representivity per secondary class** | Very High | Very High | High |
| **Invertebrate rarity per secondary class** | Very High | Very High | High |
| **EI importance: riparian-wetland-instream vertebrates (excluding fish) rating** | Low | High | Very High |
| **Habitat diversity class** | Very High | High | Moderate |
| **Habitat size (length) class** | High | Low | Low |
| **Instream migration link class** | Moderate | Very High | High |
| **Riparian-wetland zone migration link** | Very High | Very High | High |
| **Riparian-wetland zone habitat integrity class** | Very High | Very High | High |
| **Instream habitat integrity class** | High | High | Moderate |
| **Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m** | Very High | Very High | Very High |
| **Riparian-wetland natural vegetation rating based on expert rating** | Low | Low | Low |
| **ES Details** | | | |
| **Fish physical-chemical sensitivity description** | Very High | Very High | Very High |
| **Fish no-flow sensitivity** | Very High | Very High | Very High |
| **Invertebrates physical-chemical sensitivity description** | Very High | Very High | Very High |
| **Invertebrates velocity sensitivity** | Very High | Very High | Very High |
| **Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description** | High | High | Very High |
| **Stream size sensitivity to modified flow/water level changes description** | Very High | Very High | High |
| **Riparian-wetland vegetation intolerance to water level changes description** | Low | Low | Low |

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

This information was used to compile the following expected fish species table, also including intolerance ratings and frequency of occurrence (FROC) scores.

**Table 8: Intolerance ratings as well as FROC (anticipated by Ecologist as none is provided for catchment B41G in Kleynhans *et al*., 2007) scores for naturally occurring fish species expected to occur in the Groot Dwars River and surrounding area [Department of Water and Sanitation (DWS) Resource Quality Services (RQS) PES/EIS database, sub-quaternary catchment (SQ) reach B41G-00674 (Groot Dwars River)].**

| SPECIES NAME | COMMON NAME | INTOLE-RANCE RATING | FROC score | COMMENTS |
|---|---|---|---|---|
| *Amphilius uranoscopus* | Stargazer (mountain catfish) | *4.8* | 1 | Okovango and Zambezi systems, east coast rivers south to Mkuze in northern Kwa-Zulu Natal. IUCD red data list status: **Least concern**. |
| *Enteromius motebensis* | Marico barb | 3.1 | 1 | The headwater tributaries of the Marico, Crocodile and Steelpoort branches of the Limpopo River System. IUCD red data list status: **Near threatened[1].** |
| *Enteromius neefi* | Sidespot barb | 3.4 | 1 | Tributaries of the Steelpoort-Limpopo system. IUCD red data list status: **Least concern**. |
| *Enteromius trimaculatus* | Threespot barb | 2.2 | 1 | Common in many river systems of southern Africa IUCD red data list status: **Least concern**. |
| *Enteromius unitaeniatus* | Longbeard barb | 1.7 | 1 | Widely distributed in southern Africa IUCD red data list status: **Least concern**. |
| *Chiloglanis pretoriae* | Shortspine Suckermouth or Rock catlet | 4.6 | 1 | Widespread (Incomati, Limpopo & Zambezi) IUCD red data list status: **Least concern**. |
| *Clarias gariepinus* | Sharptooth Catfish | 1.4 | 1 | Widespread throughout southern Africa. IUCD red data list status: **Least concern**. |
| *Labeo cylindricus* | Redeye labeo | 3.1 | 1 | Widespread East-African rivers down to Phongolo system in KwaZulu-Natal IUCD red data list status: **Least concern**. |
| *Labeo molybdinus* | Leaden labeo | 3.2 | 1 | Middle and lower Zambezi down to Tugela system in KwaZulu-Natal IUCD red data list status: **Least concern**. |
| *Labeobarbus marequensis* | Largescale yellowfish | 2.6 | 2 | Widely distributed from the middle and lower Zambezi south to the Phongolo system. IUCD red data list status: **Least concern**. |
| *Oreochromis mossambicus* | Mozambique Tilapia | 1.3 | 1 | East coastal rivers from the Lower Zambezi River south to the Bushman's system, Eastern Cape. IUCD red data list status: **Near threatened[2].** |

| SPECIES NAME | COMMON NAME | INTOLE-RANCE RATING | FROC score | COMMENTS |
|---|---|---|---|---|
| *Pseudocrenilabrus philander* | Southern mouthbrooder | 1.3 | 1 | From the Orange and southern KwaZulu-Natal northwards throughout the region. Extends to southern Congo tributaries and Lake Malawi. IUCD red data list status: **Not yet assessed for IUCN Red List.** |
| *Tilapia sparrmanii* | Banded Tilapia | 1.3 | 2 | Extensively translocated south of the Orange in the Cape. IUCD red data list status: **Least concern**. |

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

**1** The Marico Barb (*Barbus motebensis*) occurs in small streams and has a restricted distribution range with an extent of occurrence (EOO) of 12,552 km$^2$ and very small area of occupancy (AOO) of 132 km$^2$. It is known from approximately 20 locations, most of which are threatened by water abstraction associated with agriculture, with some also affected by urban water pollution. Other streams are impacted by seepage from mines via the dolomitic groundwater flow and also by competition from invasive alien fish. These impacts have been exacerbated by the severe recent droughts. The species qualifies as Near Threatened.

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

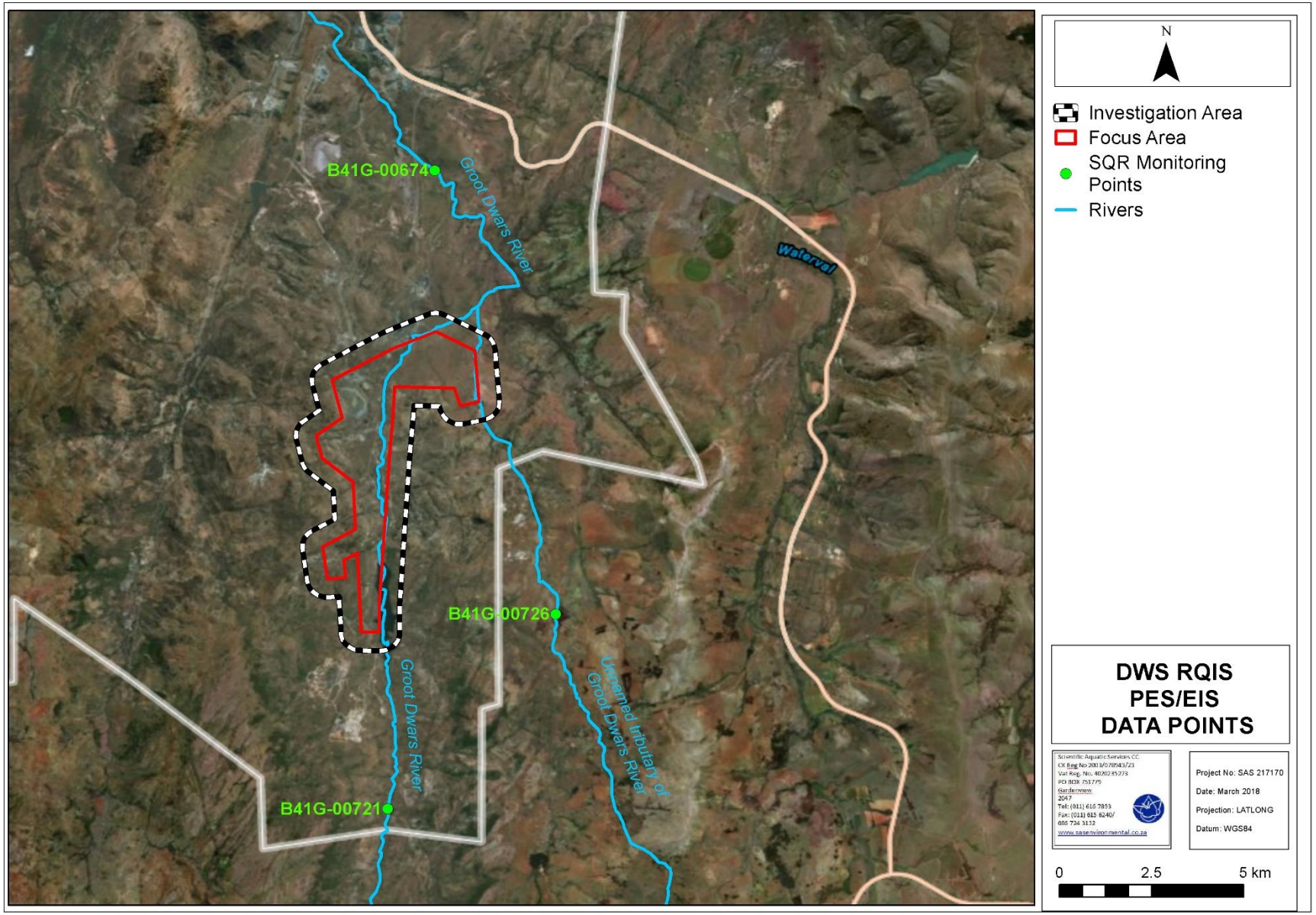



**Figure 5: Relevant Sub-Quaternary Catchment Reaches of the Groot Dwars River and associated Mareesburg Spruit in the vicinity of the Der Brochen Investigation Area.**

### 2.2.3 Classes and resource quality objectives of water resources for catchments of the Olifants River in terms of Section 13(1) (a) and (b) of the National Water Act (Act no.36 of 1998)

The classes and resource quality objectives are determined for all or part of every significant water resource within the catchments of the Olifants as set out below (DWS, 2016):

**Water Management Area:** Olifants

**Drainage Regions:** B primary drainage region

**Rivers:** Olifants River System

- A summary of the water resource classes for Integrated Units of Analysis (IUA) and ecological categories for the Olifants is set out in Table 6;
- Integrated Units of Analysis are classified in terms of their extent of permissible utilization and protection as either:
  - Class I: indicating high environmental protection and minimal utilization;
  - Class II indicating moderate protection and moderate utilization;
  - Class III indicating sustainable minimal protection and high utilization.
- Resource Quality Objectives (RQO) are defined for each prioritised Resource Unit (RU) for every IUA in terms of water quantity, quality, habitat and biota as shown in Table 7 to 9 respectively;
- Where specified, the ecological category or Recommended Ecological Category (REC) means the assigned ecological condition by the Minister to a water resource that reflects the ecological condition of that water resource in terms of the deviation of its biophysical components from a predevelopment condition;
- RQO are applicable upon the date of approval by the Minister, unless otherwise specified.

The tables below define the RQO for the Steelpoort River catchment area (DWS, 2016):

**Table 9: Water Resource Classes per Integrated Unit of Analysis (IUA) and Ecological Categories per Biophysical Node**

| IUA | Water Resource Class for IUA | Biophysical Node Name | Quaternary Catchment | River Name | EC to be maintained | Natural MAR (million m3/a) | EWR as % of natural MAR |
|---|---|---|---|---|---|---|---|
| Steelpoort River | III | HN62 | B41G | Upper reaches of Groot Dwars River (before mining impacts) | C | 24.5 | 13.33 |
| | | HN61 | B41G | Klein Dwars (Confluences with the Groot Dwars) | D | - | - |
| | | EWR Site 10 | B41K | Steelpoort (Confluence with Olifants River) | D | 336.6 | 7.43 |

**Table 10: Resource Quality Objectives (RQO) for River water quality in the Olifants catchment**

| IUA | Class | River | RU | Biophysical Node Name | REC | Component | Sub-component | RQO | Indicator/ Measure | Numerical Limits |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | III | Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6) | RU66 | 64 | D | Quality | Nutrients | Nutrients should be maintained to support the ecosystem. | Phosphate ($PO_4$) | ≤ 0.125 mg/L P |
| 6 | III | Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants -outlet of IUA6) | RU66 | 66 | D | Quality | Toxins | Toxics should be minimised to reduce the risk of human health and ecosystem impairment. | Al<br>As<br>Cd hard<br>Cr(VI)<br>Cu hard<br>Hg<br>Mn<br>Pb hard<br>Se<br>Zn<br>Chorine<br>Endosulfan<br>Atrazine | ≤ 0.063 mg/L<br>≤ 0.058 mg/L<br>≤ 1.6 µg/L<br>≤ 68 µg/L<br>≤ 4.9 µg/L<br>≤ 0.53 µg/L<br>≤ 0.680 mg/L<br>≤ 5.8 µg/L<br>≤ 0.013 mg/L<br>≤ 14.4 µg/L<br>≤ 1.8 µg/L free Cl<br>≤ 0.08 µg/L<br>≤ 48.8 µg/L |

**Table 11: Resource Quality Objectives for River Instream Habitat and Biota in the Olifants catchment**

| RIVER INSTREAM HABITAT AND BIOTA | | | | | | |
|---|---|---|---|---|---|---|
| **IUA** | **Class** | **River** | **RU** | **REC** | **RQO** | **Numerical Objectives** |
| 6. Steelpoort River catchment | III | Steelpoort | 64 & 66 | D | Instream habitat must be in a largely modified or better condition to support ecosystem processes. | Instream Habitat Integrity category: ≥ D (≥ 42) |
| | | | | | Instream biota must be in a largely modified or better condition. | Fish ecological category: ≥ D (≥ 42) |
| | | | | | Low and high flows must be suitable to maintain the river habitat and ecosystem condition. | Macro-invertebrate ecological category: ≥ D (≥ 42) |
| | | | | | Water quality: | Instream Ecostatus category: ≥ D (42) |
| | | | | | Toxics must be minimised to reduce the risk of human health and ecosystem impairment. | Hydrological category: ≥ D (≥ 42) |
| | | | | | | Water Quality category: ≥ D (≥ 42) |

**Table 12: Resource Quality Objectives for River Riparian Zone Habitat in Olifants catchment**

| IUA | Class | River | RU | REC | Component | RQO | Numerical Limits |
|---|---|---|---|---|---|---|---|
| 6 | III | Steelpoort | RU66 | D | Quality | ➢ The riparian zone must be in a largely modified or better condition.<br>➢ Riparian vegetation must be in a largely modified or better condition.<br>➢ Low and high flows must be in a largely modified or better condition. | ➢ Riparian Zone Habitat Integrity category ≥ D (≥ 42)<br>➢ Riparian ecostatus category: ≥ D (≥ 62)<br>➢ Hydrological category ≥ D (≥ 62) |
| 6 | III | Steelpoort | RU64 | C/D | Quality | ➢ The riparian zone must be improved to be in a better than largely modified condition.<br>➢ Riparian vegetation must be maintained in a largely modified or better condition<br>➢ Low and high flows must be in a largely modified or better condition. | ➢ Riparian Zone Habitat Integrity category ≥ C/D (≥ 58)<br>➢ Riparian ecostatus category: ≥ D (≥ 42)<br>➢ Hydrological category ≥ D (≥ 42) |

# 3. METHOD OF INVESTIGATION

Best practice methodologies (detailed methodologies to be provided on request but a more detailed summary of the methods employed are provided in Appendix 2) were used to assess the aquatic ecological integrity of the various sites, based on water quality, habitat suitability and biological impacts and integrity.

All work was undertaken by a South African River Health Program (SA RHP) accredited assessor. Note that data obtained were obtained from the existing biomonitoring program. Period of biomonitoring used for this purpose ranged from November 2001 to December 2017. The only exception is the assessment of the riparian vegetation through application of the VEGRAI Ecostatus tool, which was applied during February 2018.

Factors investigated included the following:

- Visual conditions of the site, including an assessment of impacts on the stream at each point;
- On-site testing of biota specific water quality parameters including pH, Electrical Conductivity (EC), Dissolved Oxygen concentration (DO) and temperature took place at the biomonitoring sites. The results aid in the interpretation of the data obtained by the biomonitoring;
- Water Quality – Guidelines Consulted (also see footnote in Glossary of Terms" section:
  - Olifants River Ecological Water Requirements Assessment (OREWRA) (Palmer and Rossouw, 2001) for the Lower Olifants, Steelpoort River [denoted as OREWRA (2001) in discussions that follow];
  - South African water quality guidelines volume 7, Aquatic ecosystems, by the Department of Water Affairs and Forestry (DWAF), now Department of Water and Sanitation (DWS) [denoted as DWAF (1996) in discussions that follow];
  - Classes and resource quality objectives of water resources for the Olifants catchment from Government Gazette number 39943, 22 April 2016, Department of Water and Sanitation (DWS 2016), with reference to ecological category, water quality in terms of nutrients and toxins, instream habitat and biota and riparian zone habitat (see Section 2, used to aid in interpretation of biological monitoring data).
- The general habitat integrity of the site was assessed based on the application of the Index of Habitat Integrity (IHI), based on the protocol of Kleynhans *et al.* (2008);
- Assessment of the riparian vegetation was performed using the Riparian Vegetation Response Assessment Index (VEGRAI), designed in such a way that qualitative ratings translate into quantitative and defensible results (Kleynhans *et al.*, 2007b);

- Habitat suitability for aquatic macro-invertebrates was determined using the IHAS (Invertebrate Habitat Assessment System) method, and was applied according to the protocol of McMillan (1998);
- The integrity of the aquatic macro-invertebrate community was assessed using the South African Scoring System version 5 (SASS5) as defined by Dickens & Graham (2002) as well as the application of the Macro-Invertebrate Response Assessment Index (MIRAI) Ecostatus tool as described by Thirion (2007);
- Interpretation of the results, in relation to reference scores, was made according to the SASS5 data interpretation guidelines (Dallas 2007). Aquatic macro-invertebrates expected within the system were derived from data obtained during previous assessments;
- Fish fauna were assessed employing the Fish Response Assessment Index (FRAI) also with consideration of historical and desktop data available;
- The Ecological Importance and Sensitivity of the aquatic resources was determined according to the protocols of DWAF (1999);
- The Environmental Impact Assessment method as supplied by the EAP was applied to identify the impacts that may affect the aquatic resources as a result of the proposed mining activities, and to aim to quantify the significance thereof (see Appendix 2).

# 4. RESULTS AND INTERPRETATION

The period of biomonitoring data used for the purpose of this report ranged from November 2001 to December 2017. VEGRAI was applied during February 2018. The sections below present the results of each of the sampling points applicable to the Groot Dwars River.

Results are presented as “dashboard style” reports. These dashboard reports aim to present concise summaries of the data on as few pages as possible, in order to allow for integration of results by the reader to take place. Where required further discussion and interpretation is provided.

**Table 13: Results of the assessment at site GD2 (Groot Dwars River downstream of the Booysendal boundary fence).**

**Site GD2**

**Figure 6: General view of the GD2 site at the time of the last assessment (December 2017).**

| | |
|---|---|
| **Algal proliferation** | Algae present on rocks. |
| **Depth profiles** | Shallow. Generally, > ½ - 1 m. |
| **Flow condition** | Slow flow. |
| **Riparian zone characteristics** | Mix of grass and shrubs, between 81% and 95% bank cover. |
| **Water clarity** | Water was discoloured. |

**SITE ECOSTATUS CATEGORY**

| **Biomonitoring data assessment result** | |
|---|---|
| **Dallas (2007)** | **Category C** |
| **MIRAI** | **Category C** |
| **Instream IHI** | **Category B** |
| **Riparian IHI** | **Category B** |
| **Desktop assessment result** | |
| **EIS (Kleynhans 1999, DWS RQIS)** | **High to very high** |
| **PEMC (Kleynhans 1999)** | **B** |
| **DEMC (Kleynhans 1999)** | **B** |
| **PES (DWS RQIS)** | **D** |
| **REC (DWS 2016, RQOs)** | **C/D** |

***In situ* physico-chemical water quality**

| Parameter | Value | % Variation (% Var) change from baseline (November 2001) |
|---|---|---|
| **pH** | 7.54 | -1.3 |
| **EC (mS/m)** | 26.0 | **+98.5** |
| **TDS (mg/L)** | 169.0 | NA |
| **DO (mg/L)** | 6.78 | -6.2 |
| **DO (% sat)** | 88.9 | NA |
| **Temp (℃)** | 22.1 | NA |

**Key**: Negative value = decrease; Positive value = increase.
Normal text = no significant change; **Bold text = significant change (compared to guideline).**
**Red text = significant deterioration;**
**Blue text = significant improvement.**

**Site specific spatial water quality variations (% var.)**

| Parameter | % Variation from upstream spatial reference |
|---|---|
| **pH**<br>**EC (mS/m)**<br>**DO (mg/L)****<br>**Temp** | NA (No upstream spatial reference) |

**Aquatic macro-invertebrate community and habitat integrity**

| Parameter | Score/Category | % Var. from ref ecoregion data (SASS5) | % Var change from baseline (July 2009) |
|---|---|---|---|
| **SASS5 score** | 142 | -30.7 | +4.4 |
| **Number of taxa** | 23 | NA | NA |
| **ASPT score** | 6.2 | -19.9 | 0.0 |
| **IHAS score** | 69 (Good) | NA | +1.5 |
| **MIRAI score** | 63.5 (Category C) | NA | NA |
| **Instream IHI** | 85.8 (Category B) | NA | NA |
| **Riparian IHI** | 83.2 (Category B) | NA | NA |

**Key:** Negative value = decrease; Positive value = increase.
**A temporal deterioration exceeding 15% was considered significant.**

**Site specific spatial aquatic invertebrate community variations (% var.)**

| Parameter | % Variation from upstream spatial reference |
|---|---|
| **SASS5**<br>**ASPT**<br>**IHAS** | NA (No upstream spatial reference) |

**Key Drivers of System Change**

- Lack of strong flowing water at this point and variability in system flow rate also limits habitat availability at this point, thus limiting the diversity and sensitivity of the aquatic community likely to occur at this point.

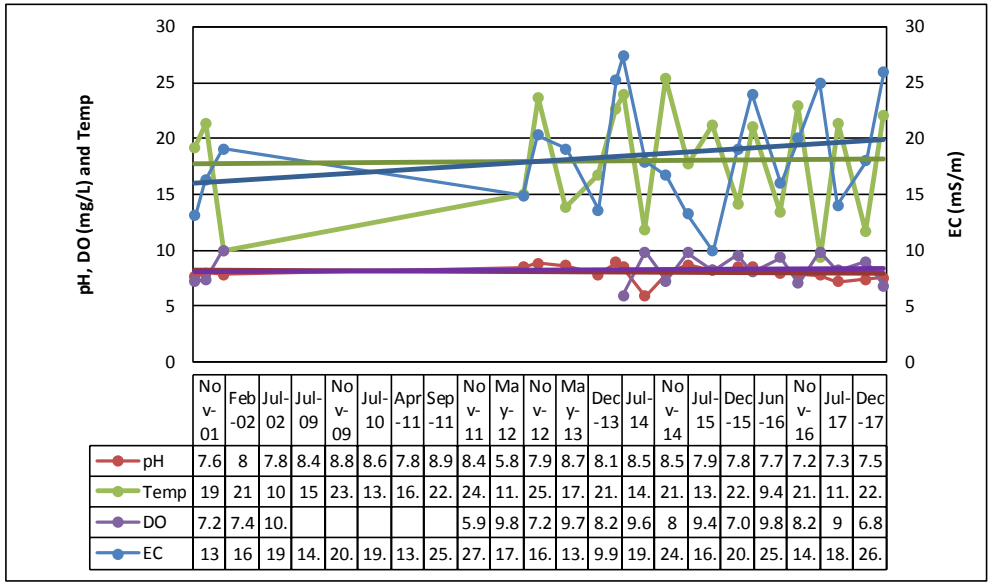
**Trends Compared to Baseline Applied to Proposed Expansion**

- Variation from ecoregion reference data shows that the system is already impacted upon prior to any potential impact from existing Der Brochen activities and infrastructure;
- Temporal water quality data shows decreasing pH and DO, and increasing EC compared to baseline. Although absolute values are still within expected ranges (see discussion in Table 14), temporal data shows catchment-wide impact, particularly with reference to salt load;
- Despite the temporal impact on water quality, SASS5, ASPT and IHAS scores did not decrease compared to baseline. However, as mentioned comparison to ecoregion reference data, negative impact on macro-invertebrate community is evident;
- Prior to any potential impact from existing Der Brochen activities the system is already impacted upon. Additional expansion may potentially result in increased risk of impact, with specific reference to risk of spillage from dirty water systems (elevated EC, risk of sedimentation).

**The Ecostatus Category for the IHI, Dallas (2007) and MIRAI classifications comply with the Resource Quality Objectives (RQO's) of the Olifants River catchment (DWS, 2016).**

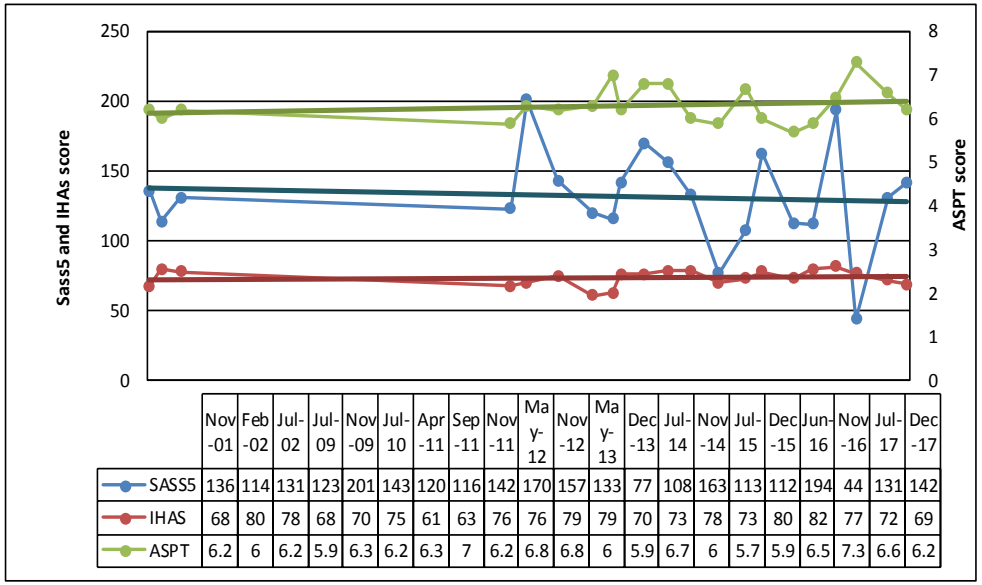
**NA = Not Applicable, SASS reference score = 205, ASPT reference score = 7.0**

**Table 14: Temporal variations observed at site GD2 since the baseline assessment in July 2009.**




| | Nov-01 | Feb-02 | Jul-02 | Jul-09 | Nov-09 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Dec-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7.6 | 8 | 7.8 | 8.4 | 8.8 | 8.6 | 7.8 | 8.9 | 8.4 | 5.8 | 7.9 | 8.7 | 8.1 | 8.5 | 8.5 | 7.9 | 7.8 | 7.7 | 7.2 | 7.3 | 7.5 |
| Temp | 19 | 21 | 10 | 15 | 23. | 13. | 16. | 22. | 24. | 11. | 25. | 17. | 21. | 14. | 21. | 13. | 22. | 9.4 | 21. | 11. | 22. |
| DO | 7.2 | 7.4 | 10. | | | | | | 5.9 | 9.8 | 7.2 | 9.7 | 8.2 | 9.6 | 8 | 9.4 | 7.0 | 9.8 | 8.2 | 9 | 6.8 |
| EC | 13 | 16 | 19 | 14. | 20. | 19. | 13. | 25. | 27. | 17. | 16. | 13. | 9.9 | 19. | 24. | 16. | 20. | 25. | 14. | 18. | 26. |

**Figure 7: Site-specific temporal water quality variation at site GD2**




| | Nov-01 | Feb-02 | Jul-02 | Jul-09 | Nov-09 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Dec-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SASS5 | 136 | 114 | 131 | 123 | 201 | 143 | 120 | 116 | 142 | 170 | 157 | 133 | 77 | 108 | 163 | 113 | 112 | 194 | 44 | 131 | 142 |
| IHAS | 68 | 80 | 78 | 68 | 70 | 75 | 61 | 63 | 76 | 76 | 79 | 79 | 70 | 73 | 78 | 73 | 80 | 82 | 77 | 72 | 69 |
| ASPT | 6.2 | 6 | 6.2 | 5.9 | 6.3 | 6.2 | 6.3 | 7 | 6.2 | 6.8 | 6.8 | 6 | 5.9 | 6.7 | 6 | 5.7 | 5.9 | 6.5 | 7.3 | 6.6 | 6.2 |

**Figure 8: Site-specific temporal macro-invertebrate community integrity variation at site GD2**

- With expected Electrical Conductivity (EC) ranging from 35 – 45 mS/m as stipulated in the Olifants River Ecological Water Requirements Assessment (OREWRA) (2001) for the Lower Olifants, Steelpoort River: Sections 1 to 9 for the month of December, the absolute EC values can be considered as largely natural over time;
- However, EC increased by 98.5% when compared to the baseline assessment (July 2009), suggesting catchment-wide impact prior to any potential impact from either the existing or proposed expansion developments. The change exceeds the DWS target water quality guideline recommendation (DWAF, 1996) (Table 13), which advocates that seasonal and temporal changes should not exceed 15%. Overall, the long-term trend line indicates a temporal increase in EC;
- When compared to the baseline assessment the pH decreased by 1.3%, and complies with the DWS target water quality guideline recommendation (DWAF, 1996) (Table 13), which advocates that seasonal and temporal changes should not exceed 5%. Also, the absolute value complies with the pH range of 7.0 to 8.5 recommended by OREWRA (2001) for a river in this section of the catchment. The long-term trend line indicates that pH remained stable;
- Dissolved oxygen (DO) saturation can be considered as adequate in supporting a diverse and sensitive aquatic community, as it complies with the 80% saturation recommendation (DWAF, 1996);
- DO concentrations are variable over time and largely dependent on seasonality, but the long-term trend line shows a stable trend;
- **Temporal trends show existing system water quality impact in terms of salt load. The proposed expansion infrastructure and operation will likely contribute to the risk, hence strict mitigation measures are required should development continue.**

- When compared to the baseline assessment (July 2009) the SASS5 score has increased by 4.4% and the IHAS score by 1.5%. ASPT score remained unchanged (Table 13);
- The macro-invertebrate community diversity and sensitivity is highly variable over time and indicative of seasonal trends (such as change in flow patterns following heavy rainfall). However, the stable trend-line for the IHAS score suggests that habitat changes are likely not responsible for the variations in ASPT and SASS5 scores, with variations in water quality likely an important driver of the trends observed. The long-term trend line for ASPT shows a very slight increasing trend, whilst that for the SASS5 score shows a slightly more pronounced decreasing trend;
- Macro-invertebrate habitat suitability can be considered as adequate or highly suited and stable over time;
- **Comparison of SASS5 and ASPT scores to ecoregion reference data, shows that the macro-invertebrate community is already impacted upon prior to any potential impacts from the existing or proposed Der Brochen activities and infrastructure. Driver of change appears to be water quality, with SASS5 score showing a long-term decreasing trend. The proposed developments, if approved, could potentially contribute further to potential impact, notably with reference to spillage, seepage or decant from dirty water areas, resulting in decreased water quality, toxicological hazard and sedimentation/deposition of fine tailings. Strict mitigation measures are required should development continue.**

**Table 15: Results of the assessment at site GD3 (Approximately 100 m downstream of the existing low water crossing of the Groot Dwars River, upstream of the Helena/der Brochen boundary fence).**

**Site GD3**

**Figure 9: General view of the GD3 site at the time of the last assessment (December 2017).**

| | |
|---|---|
| **Algal proliferation** | Algal proliferation on rocks. |
| **Depth profiles** | Shallow. Generally, > ½ - 1 m. |
| **Flow condition** | Slow flow. |
| **Riparian zone characteristics** | Mix of grass and shrubs, between 51% and 80% bank cover. |
| **Water clarity** | Slightly discoloured. |

**SITE ECOSTATUS CATEGORY**

**Biomonitoring data assessment result**

| | |
|---|---|
| **Dallas (2007)** | **Category E/F** |
| **MIRAI** | **Category D** |
| **Instream IHI** | **Category B** |
| **Riparian IHI** | **Category C** |

**Desktop assessment result**

| | |
|---|---|
| **EIS (Kleynhans 1999, DWS RQIS)** | **High to very high** |
| **PEMC (Kleynhans 1999)** | **B** |
| **DEMC (Kleynhans 1999)** | **B** |
| **PES (DWS RQIS)** | **D** |
| **REC (DWS 2016, RQOs))** | **C/D** |

**The Ecostatus Category for the IHI and MIRAI classifications are congruent with the RQO's of the Olifants River catchment (DWS, 2016).**

***In situ* physico-chemical water quality**

| Parameter | Value | % Variation (% Var) change from baseline (July 2009) |
|---|---|---|
| **pH** | 7.39 | **+7.7** |
| **EC (mS/m)** | 22.0 | **+22.2** |
| **TDS (mg/L)** | 143.0 | NA |
| **DO (mg/L)** | 6.98 | **-15.4** |
| **DO (% sat)** | 87.3 | NA |
| **Temp (℃)** | 20.1 | NA |

**Key**: Negative value = decrease; Positive value = increase.
Normal text = no significant change; **Bold text = significant change (compared to guideline).**
**Red text = significant deterioration;**
**Blue text = significant improvement.**

**Site specific spatial water quality variations (% var.)**

| Parameter | % Var from upstream spatial reference GD2 |
|---|---|
| **pH** | -2.0 |
| **EC (mS/m)** | **-15.4** |
| **DO (mg/L)**** | +2.9 |

**Aquatic macro-invertebrate community and habitat integrity**

| Parameter | Score/Category | % Var. from ref ecoregion data (SASS5) | % Var change from baseline (July 2009) |
|---|---|---|---|
| **SASS5 score** | 77 | -62.4 | **-49.3** |
| **Number of taxa** | 14 | NA | NA |
| **ASPT score** | 5.3 | -24.3 | -10.2 |
| **IHAS score** | 68 (Good) | NA | -8.1 |
| **MIRAI score** | 50.6 (Category D) | NA | NA |
| **Instream IHI** | 84.6 (Category B) | NA | NA |
| **Riparian IHI** | 65.8 (Category C) | NA | NA |

**Key:** Negative value = decrease; Positive value = increase.
**A temporal deterioration exceeding 15% was considered significant.**

**Site specific spatial aquatic invertebrate community variations (% var.)**

| Parameter | % Var from upstream spatial reference GD2 |
|---|---|
| **SASS5** | **-45.8** |
| **ASPT** | -14.5 |
| **IHAS** | -1.4 |

**Key Drivers of System Change**

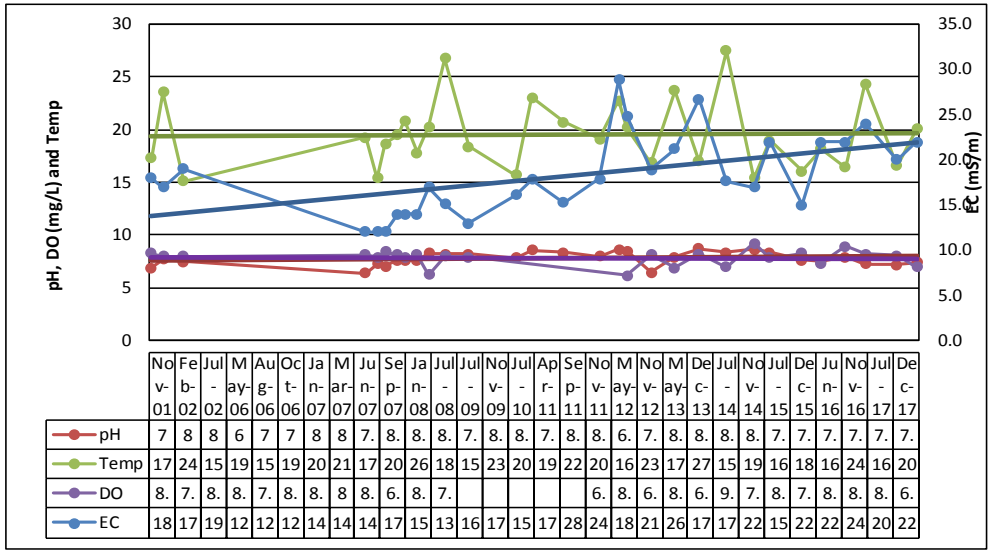
- Lack of strong flowing water at this point and variability in system flow rate also limits habitat availability at this point, thus limiting the diversity and sensitivity of the aquatic community likely to occur at this point.
- Potential water quality impacts from surrounding upstream activities

**Trends Compared to Baseline Applied to Proposed Expansion**

- Temporal water quality data shows decreasing DO, but increasing pH and EC compared to baseline. Temporal data shows potential impact from existing Der Brochen activities, particularly with reference to salt load;
- SASS5, ASPT and IHAS scores also decreased compared to baseline. Temporal data shows values are variable but with a generally decreasing trend evident for SASS5 score, indicating existing impact on the macro-invertebrate community in the system;
- Biomonitoring data suggest that the Der Brochen dam as well as other upstream impacting mining operations and existing Der Brochen exploration activity has an impact on the Groot Dwars River. Additional expansion may potentially result in increased risk of impact, with specific reference to risk of spillage from dirty water systems (elevated EC, risk of sedimentation).

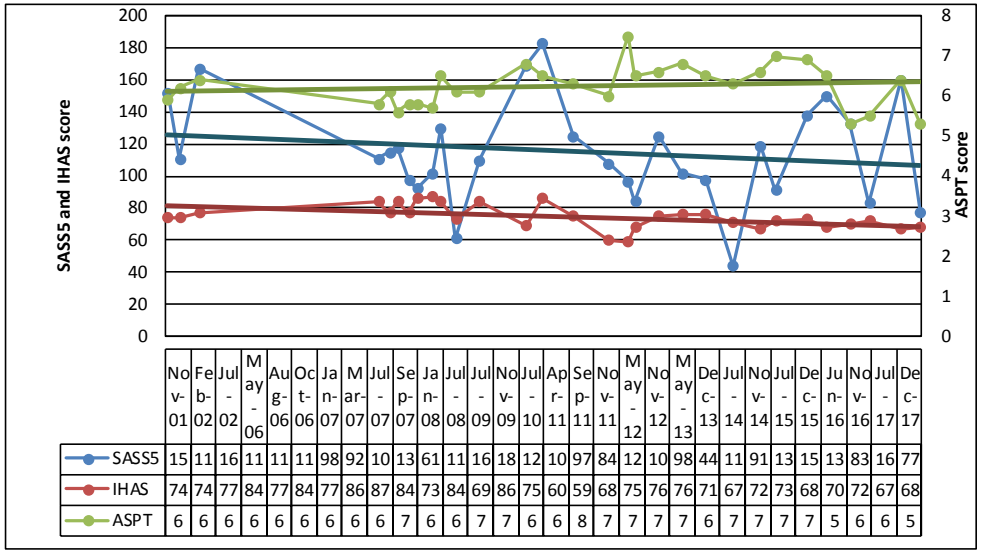
**NA = Not Applicable, SASS reference score = 205, ASPT reference score = 7.0**

**Table 16: Temporal variations observed at site GD3 since the baseline assessment in April 2007.**




| | Nov-01 | Feb-02 | Jul-02 | May-06 | Aug-06 | Oct-06 | Jan-07 | Mar-07 | Jun-07 | Sep-07 | Jan-08 | Jul-08 | Jul-09 | Nov-09 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Dec-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7 | 8 | 8 | 6 | 7 | 7 | 8 | 8 | 7. | 8. | 8. | 8. | 7. | 8. | 8. | 7. | 8. | 8. | 6. | 7. | 8. | 8. | 8. | 8. | 7. | 7. | 7. | 7. | 7. | 7. |
| Temp | 17 | 24 | 15 | 19 | 15 | 19 | 20 | 21 | 17 | 20 | 26 | 18 | 15 | 23 | 20 | 19 | 22 | 20 | 16 | 23 | 17 | 27 | 15 | 19 | 16 | 18 | 16 | 24 | 16 | 20 |
| DO | 8. | 7. | 8. | 8. | 7. | 8. | 8. | 8 | 8. | 6. | 8. | 7. | | | | | | 6. | 8. | 6. | 8. | 6. | 9. | 7. | 8. | 7. | 8. | 8. | 8. | 6. |
| EC | 18 | 17 | 19 | 12 | 12 | 12 | 14 | 14 | 14 | 17 | 15 | 13 | 16 | 17 | 15 | 17 | 28 | 24 | 18 | 21 | 26 | 17 | 17 | 22 | 15 | 22 | 22 | 24 | 20 | 22 |

**Figure 10: Site-specific temporal water quality variation at site GD3**




| | Nov-01 | Feb-02 | Jul-02 | May-06 | Aug-06 | Oct-06 | Jan-07 | Mar-07 | Jul-07 | Sep-07 | Jan-08 | Jul-08 | Jul-09 | Nov-09 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Dec-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SASS5 | 15 | 11 | 16 | 11 | 11 | 11 | 98 | 92 | 10 | 13 | 61 | 11 | 16 | 18 | 12 | 10 | 97 | 84 | 12 | 10 | 98 | 44 | 11 | 91 | 13 | 15 | 13 | 83 | 16 | 77 |
| IHAS | 74 | 74 | 77 | 84 | 77 | 84 | 77 | 86 | 87 | 84 | 73 | 84 | 69 | 86 | 75 | 60 | 59 | 68 | 75 | 76 | 76 | 71 | 67 | 72 | 73 | 68 | 70 | 72 | 67 | 68 |
| ASPT | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 6 | 6 | 7 | 7 | 6 | 6 | 8 | 7 | 7 | 7 | 7 | 6 | 7 | 7 | 7 | 7 | 5 | 6 | 6 | 5 |

**Figure 11: Site-specific temporal macro-invertebrate community integrity variation at site GD3**

- With expected Electrical Conductivity (EC) ranging from 35 – 45 mS/m as stipulated in the Olifants River Ecological Water Requirements Assessment (OREWRA) (2001) for the Lower Olifants, Steelpoort River: Sections 1 to 9 for the month of December, the absolute EC values can be considered as largely natural over time.;
- EC increased by 22.2% when compared to the baseline assessment (April 2007). The temporal change from baseline data exceeds the DWS target water quality guideline recommendation (DWAF, 1996) (Table 15), which advocates that seasonal and temporal changes should not exceed 15%. The long-term trend line for EC shows a clear increasing trend;
- When compared to the baseline assessment, the pH increased by 7.7%, and exceeds the DWS target water quality guideline (DWAF, 1996) (Table 15), which advocates that seasonal and temporal changes should not exceed 5%. However, the absolute value complies with the pH range of 7.0 to 8.5 recommended by OREWRA (2001) for a river in this section of the catchment. The long-term trend line suggests that pH remained stable;
- Dissolved oxygen (DO) saturation can be considered as adequate in supporting a diverse and sensitive aquatic community, as it complies with the 80% saturation recommendation (DWAF, 1996).;
- DO concentrations are variable over time and largely dependent on seasonality However, the long-term trend line suggests that DO remained largely stable at site GD3;
- Refer to Table 10 for a discussion on spatial trends;
- **Temporal trends show existing system water quality impact in terms of salt load. The proposed expansion infrastructure and operation will like contribute to the risk, hence strict mitigation measures are required should development continue.**

- When compared to the baseline assessment (April 2007) the SASS5 score has decreased by 49.3% and the ASPT score by 8.1%, along with a 8.1% decrease in habitat suitability (Table 4);
- The macro-invertebrate community diversity (of which SASS score is representative) and sensitivity (of which ASPT score is representative) is highly variable over time and indicative of seasonal trends;
- The long-term trend lines show a slight increasing trend for ASPT, and a decreasing trend for both SASS5 and IHAS;
- The temporal decrease in macro-invertebrate community diversity and sensitivity is likely related to the slight changes in the water quality of the system (as was observed at site GD2). This is supported by the fact that temporal trends for SASS and ASPT score does not correlate with trends in changes in the IHAS score, indicating that factors other than habitat suitability affects macro-invertebrate community integrity to a greater degree. However, the long term decreasing trend in IHAS score may contribute to the long-term decreasing trend observed for SASS5;
- Macro-invertebrate habitat suitability can be considered as adequate or highly suited and stable over time
- **Comparison of SASS5 and ASPT scores to ecoregion reference data, as well as the long-term decreasing trend observed for the SASS5 score, shows that the macro-invertebrate community is already impacted upon. The proposed expansion developments, if approved, could potentially contribute further to potential impact, notably with reference to spillage, seepage or decant from dirty water areas, resulting in decreased water quality, toxicological hazard and sedimentation/deposition of fine tailings. Strict mitigation measures are required should development continue.**Refer to Table 11 for a discussion on spatial trends

**Table 17: Results of the assessment at site GD4 (Groot Dwars River downstream of Mototolo concentrator but upstream from other mining activities).**

**Site GD4**

**Figure 12: General view of the GD4 site at the time of the last assessment (December 2017).**

| | |
|---|---|
| **Algal proliferation** | Algal proliferation on rocks. |
| **Depth profiles** | Shallow. Generally, > ½ - 1 m. |
| **Flow condition** | Slow flow. |
| **Riparian zone characteristics** | Mix of grass and shrubs, between 81% and 95% bank cover. |
| **Water clarity** | Slightly discoloured. |

***In situ* physico-chemical water quality**

| Parameter | Value | % Variation (% Var) change from baseline (July 2009) |
|---|---|---|
| **pH** | 6.97 | **-9.4** |
| **EC (mS/m)** | 38.0 | **+111.1** |
| **TDS (mg/L)** | 247.0 | NA |
| **DO (mg/L)** | 8.24 | +10.2 |
| **DO (% sat)** | 99.1 | NA |
| **Temp (℃)** | 18.5 | NA |

**Key**: Negative value = decrease; Positive value = increase.
Normal text = no significant change; **Bold text = significant change (compared to guideline).**
**Red text = significant deterioration;**
**Blue text = significant improvement.**

**Aquatic macro-invertebrate community and habitat integrity**

| Parameter | Score/Category | % Var. from ref ecoregion data (SASS5) | % Var change from baseline (July 2009) |
|---|---|---|---|
| **SASS5 score** | 90 | -56.1 | **-51.6** |
| **Number of taxa** | 15 | NA | NA |
| **ASPT score** | 6.0 | -14.3 | -9.1 |
| **IHAS score** | 73 (Good) | NA | -11.0 |
| **MIRAI score** | 50.8 (Category D) | NA | NA |
| **Instream IHI** | 81.5 (Category B/C) | NA | NA |
| **Riparian IHI** | 74.3 (Category C) | NA | NA |

**Key:** Negative value = decrease; Positive value = increase.
**A temporal deterioration exceeding 15% was considered significant.**

**Site specific spatial water quality variations (% var.)**

| Parameter | % Variation from upstream spatial reference GD2 | % Variation from upstream spatial reference GD3 |
|---|---|---|
| **pH*** | **-7.6** | **-5.7** |
| **EC (mS/m)** | **+46.2** | **+72.7** |
| **DO (mg/L)**** | **+21.5** | **+18.1** |

**Site specific spatial aquatic invertebrate community variations (% var.)**

| Parameter | % Variation from upstream spatial reference GD2 | % Variation from upstream spatial reference GD3 |
|---|---|---|
| **SASS5** | **-36.6** | +16.9 |
| **ASPT** | -3.2 | +13.2 |
| **IHAS** | +5.8 | +7.4 |

**SITE ECOSTATUS CATEGORY**

**Biomonitoring data assessment result**

| | |
|---|---|
| **Dallas (2007)** | **Category D** |
| **MIRAI** | **Category D** |
| **Instream IHI** | **Category B/C** |
| **Riparian IHI** | **Category C** |

**Desktop assessment result**

| | |
|---|---|
| **EIS (Kleynhans 1999, DWS RQIS)** | **High to very high** |
| **PEMC (Kleynhans 1999)** | **B** |
| **DEMC (Kleynhans 1999)** | **B** |
| **PES (DWS RQIS)** | **D** |
| **REC (DWS 2016, RQOs)** | **C/D** |

**Key Drivers of System Change**

- Lack of strong flowing water at this point and variability in system flow rate also limits habitat availability at this point, thus limiting the diversity and sensitivity of the aquatic community likely to occur at this point.
- Potential impact from Mototolo concentrator on salt load compounded by potential impacts from upstream pollution sources and geological variation at the time of the assessment.

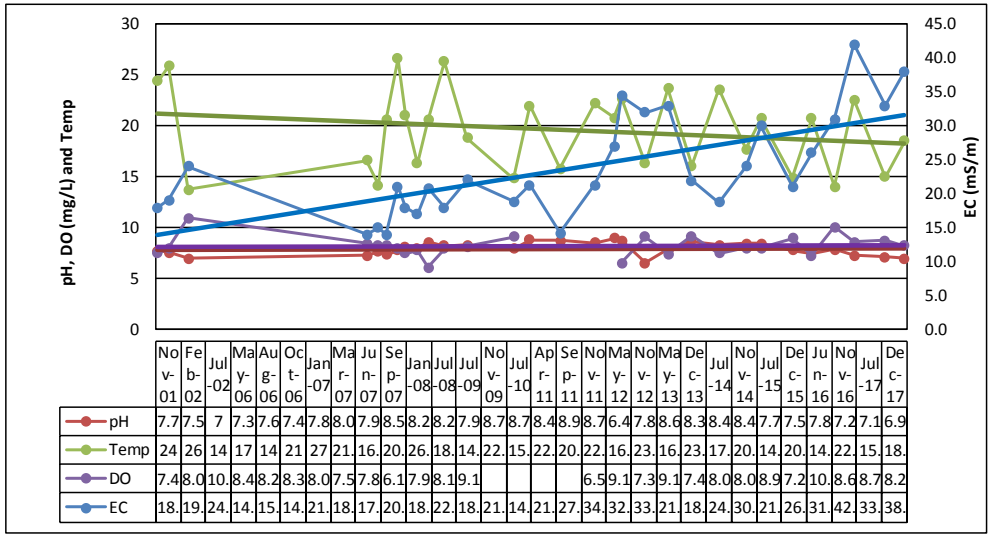
**Trends Compared to Baseline Applied to Proposed Expansion**

- Temporal water quality data shows increased EC and decreased pH compared to baseline. Temporal data shows potential impact from existing Der Brochen activities (salt load) along with the effects of other upstream mining activities;
- SASS5, ASPT and IHAS scores are variable over time, and in December 2017 lower compared to conditions at baseline;
- However, process water systems associated with the existing Mototolo concentrator, based on available historical data, poses a significant toxicological hazard to the receiving environment [high acute hazard (Class 4) in some instances]. Although the Groot Dwars River is already impacted upon, any potential spills or overflow from dirty water areas are likely to have negative impact. It is anticipated that process water systems associated with the proposed expansion will pose a similar risk (i.e. potential cumulative impact).

**The Ecostatus Category for the IHI, Dallas (2007) and MIRAI classifications comply with the Resource Quality Objectives (RQO's) of the Olifants River catchment (DWS, 2016).**

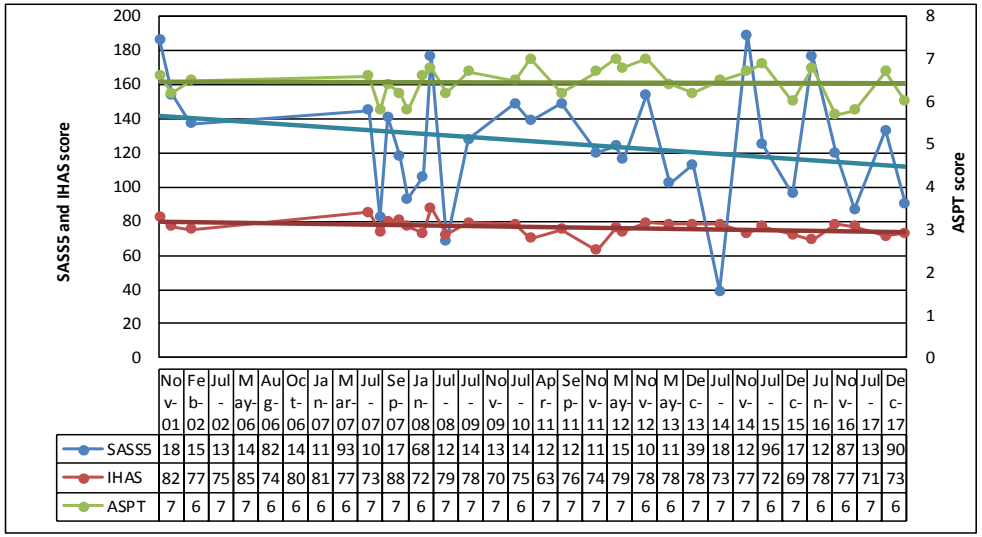
**NA = Not Applicable, SASS reference score = 205, ASPT reference score = 7.0**

**Table 18: Temporal variations observed at site GD4 since the baseline assessment in April 2007.**




| | Nov-01 | Feb-02 | Jul-02 | May-06 | Aug-06 | Oct-06 | Jan-07 | Mar-07 | Jun-07 | Sep-07 | Jan-08 | Jul-08 | Jul-09 | Nov-09 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Dec-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7.7 | 7.5 | 7 | 7.3 | 7.6 | 7.4 | 7.8 | 8.0 | 7.9 | 8.5 | 8.2 | 8.2 | 7.9 | 8.7 | 8.7 | 8.4 | 8.9 | 8.7 | 6.4 | 7.8 | 8.6 | 8.3 | 8.4 | 8.4 | 7.7 | 7.5 | 7.8 | 7.2 | 7.1 | 6.9 |
| Temp | 24 | 26 | 14 | 17 | 14 | 21 | 27 | 21 | 16. | 20. | 26. | 18. | 14. | 22. | 15. | 22. | 20. | 22. | 16. | 23. | 16. | 23. | 17. | 20. | 14. | 20. | 14. | 22. | 15. | 18. |
| DO | 7.4 | 8.0 | 10. | 8.4 | 8.2 | 8.3 | 8.0 | 7.5 | 7.8 | 6.1 | 7.9 | 8.1 | 9.1 | | | | | 6.5 | 9.1 | 7.3 | 9.1 | 7.4 | 8.0 | 8.0 | 8.9 | 7.2 | 10. | 8.6 | 8.7 | 8.2 |
| EC | 18. | 19. | 24. | 14. | 15. | 14. | 21. | 18. | 17. | 20. | 18. | 22. | 18. | 21. | 14. | 21. | 27. | 34. | 32. | 33. | 21. | 18. | 24. | 30. | 21. | 26. | 31. | 42. | 33. | 38. |

**Figure 13: Site-specific temporal water quality variation at site GD4**




| | Nov-01 | Feb-02 | Jul-02 | May-06 | Aug-06 | Oct-06 | Jan-07 | Mar-07 | Jul-07 | Sep-07 | Jan-08 | Jul-08 | Jul-09 | Nov-09 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Dec-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SASS5 | 18 | 15 | 13 | 14 | 82 | 14 | 11 | 93 | 10 | 17 | 68 | 12 | 14 | 13 | 14 | 12 | 12 | 11 | 15 | 10 | 11 | 39 | 18 | 12 | 96 | 17 | 12 | 87 | 13 | 90 |
| IHAS | 82 | 77 | 75 | 85 | 74 | 80 | 81 | 77 | 73 | 88 | 72 | 79 | 78 | 70 | 75 | 63 | 76 | 74 | 79 | 78 | 78 | 78 | 73 | 77 | 72 | 69 | 78 | 77 | 71 | 73 |
| ASPT | 7 | 6 | 7 | 7 | 6 | 6 | 6 | 6 | 7 | 7 | 6 | 7 | 7 | 7 | 6 | 7 | 7 | 7 | 7 | 6 | 6 | 7 | 7 | 7 | 6 | 7 | 6 | 6 | 7 | 6 |

**Figure 14: Site-specific temporal macro-invertebrate community integrity variation at site GD4**

- With expected Electrical Conductivity (EC) ranging from 35 – 45 mS/m as stipulated in the Olifants River Ecological Water Requirements Assessment (OREWRA) (2001) for the Lower Olifants, Steelpoort River: Sections 1 to 9 for the month of December, the absolute EC values can be considered as largely natural over time;
- EC increased by 111.1% when compared to the baseline assessment (April 2007). The temporal change from baseline data exceeds the DWS target water quality guideline (DWAF, 1996) (Table 17), which advocates that seasonal and temporal changes should not exceed 15%. The long-term trend line for EC also shows a clear increasing trend;
- When compared to the baseline assessment, the pH decreased by 9.4%, and exceeds the DWS target water quality guideline (DWAF, 1996) (Table 17), which advocates that seasonal and temporal changes should not exceed 5%. The absolute value does not comply with the pH range of 7.0 to 8.5 recommended by OREWRA (2001) for a river in this section of the catchment, however, absolute pH is very close to neutral. The long term trend line indicates that pH remained stable;
- Dissolved oxygen (DO) saturation can be considered as adequate in supporting a diverse and sensitive aquatic community, as it complies with the 80% saturation recommendation (DWAF, 1996);
- DO concentrations are variable over time and largely dependent on seasonality. However, the long-term trend line indicates;
- **Temporal trends show existing system water quality impact in terms of salt load. The proposed expansion infrastructure and operation will like contribute to the risk, hence strict mitigation measures are required should development continue.**

- When compared to the baseline assessment (April 2007) the SASS5 score has decreased by 51.6%, the ASPT score by %, and the IHAS score by 9.1% (Table 17);
- Long-term trend lines indicate a stable trend for ASPT, a decreasing trend for SASS5, and a slight decreasing trend for IHAS;
- The variability in macro-invertebrate community diversity and sensitivity is likely related to the slight changes in the water quality of the system. This is supported by the fact that temporal trends for SASS and ASPT score does not correlate with trends in changes in the IHAS score, indicating that factors other than habitat suitability affects macro-invertebrate community integrity to a greater degree. However, over the long term the slight decreasing IHAS trend may contribute to the decreasing trend for the SASS5 score;
- Historical data show that the process water systems associated with the existing Mototolo concentrator poses a toxicological hazard to the receiving environment, should spillage or overflow occur. Similar dirty water systems associated with the planned expansion, is likely to pose a similar risk (potential compounding impact);
- **Comparison of SASS5 and ASPT scores to ecoregion reference data, as well as the long-term decreasing trend observed for the SASS5 score, shows that the macro-invertebrate community is already impacted upon. The proposed expansion developments, if approved, could potentially contribute further to potential impact, notably with reference to spillage, seepage or decant from dirty water areas, resulting in decreased water quality, toxicological hazard and sedimentation/deposition of fine tailings. Strict mitigation measures are required should development continue.**
- Refer to Table 22 for a discussion on spatial trends.

**Table 19: Results of the assessment at site GD5 (Groot Dwars River in Xstrata game farm downstream from tributary confluence and also downstream from other mining activities).**

**Site GD5**

**Figure 15: General view of the GD5 site at the time of the last assessment (December 2017).**

| | |
|---|---|
| **Algal proliferation** | Algal proliferation observed on rocks. |
| **Depth profiles** | Shallow. Generally, > ½ - 1 m. |
| **Flow condition** | Slow flow. |
| **Riparian zone characteristics** | Mix of grass and shrubs, between 81% and 95% bank cover. |
| **Water clarity** | Clear. |

| **SITE ECOSTATUS CATEGORY** | |
|---|---|
| **Biomonitoring data assessment result** | |
| **Dallas (2007)** | **Category E/F** |
| **MIRAI** | **Category D** |
| **Instream IHI** | **Category B** |
| **Riparian IHI** | **Category C** |
| **Desktop assessment result** | |
| **EIS (Kleynhans 1999, DWS RQIS)** | **High to very high** |
| **PEMC (Kleynhans 1999)** | **B** |
| **DEMC (Kleynhans 1999)** | **B** |
| **PES (DWS RQIS)** | **D** |
| **REC (DWS 2016, RQOs)** | **C/D** |

***In situ* physico-chemical water quality**

| Parameter | Value | % Variation (% Var) change from baseline (July 2009) |
|---|---|---|
| **pH** | 7.92 | **+5.2** |
| **EC (mS/m)** | 33.0 | **+73.7** |
| **TDS (mg/L)** | 214.5 | NA |
| **DO (mg/L)** | 7.56 | -6.1 |
| **DO (% sat)** | 100.7 | NA |
| **Temp (℃)** | 23.7 | NA |

**Key**: Negative value = decrease; Positive value = increase.
Normal text = no significant change; **Bold text = significant change (compared to guideline).**
**Red text = significant deterioration;**
**Blue text = significant improvement.**

**Site specific spatial water quality variations (% var.)**

| Parameter | % Var. from site GD2 | % Var. from site GD3 | % Var. from site GD4 |
|---|---|---|---|
| **pH*** | +0.3 | **+26.9** | **+16.8** |
| **EC (mS/m)** | +2.3 | **+50** | +13.5 |
| **DO (mg/L)**** | +8.5 | -13.2 | -3.9 |

**Aquatic macro-invertebrate community and habitat integrity**

| Parameter | Score/Category | % Var. from ref ecoregion data (SASS5) | % Var change from baseline (July 2009) |
|---|---|---|---|
| **SASS5 score** | 85 | -58.5 | **-40.1** |
| **Number of taxa** | 17 | NA | NA |
| **ASPT score** | 5.0 | -28.6 | -5.7 |
| **IHAS score** | 71 (Good) | NA | -6.6 |
| **MIRAI score** | 59.0 (Category D) | NA | NA |
| **Instream IHI** | 87.0 (Category B) | NA | NA |
| **Riparian IHI** | 74.1 (Category C) | NA | NA |

**Key:** Negative value = decrease; Positive value = increase.
**A temporal deterioration exceeding 15% was considered significant.**

**Site specific spatial aquatic invertebrate community variations (% var.)**

| Parameter | % Var. from site GD2 | % Var. from site GD3 | % Var. from site GD4 |
|---|---|---|---|
| **SASS5** | **-40.1** | +10.4 | -5.6 |
| **ASPT** | **-19.3** | -5.7 | **-16.7** |
| **IHAS** | +2.9 | +4.4 | -2.7 |

**Key Drivers of System Change**

- Lack of strong flowing water at this point and variability in system flow rate also limits habitat availability at this point, thus limiting the diversity and sensitivity of the aquatic community likely to occur at this point.
- Potential impact from Mototolo concentrator on salt load compounded by potential impacts from upstream pollution sources and geological variation at the time of the assessment.

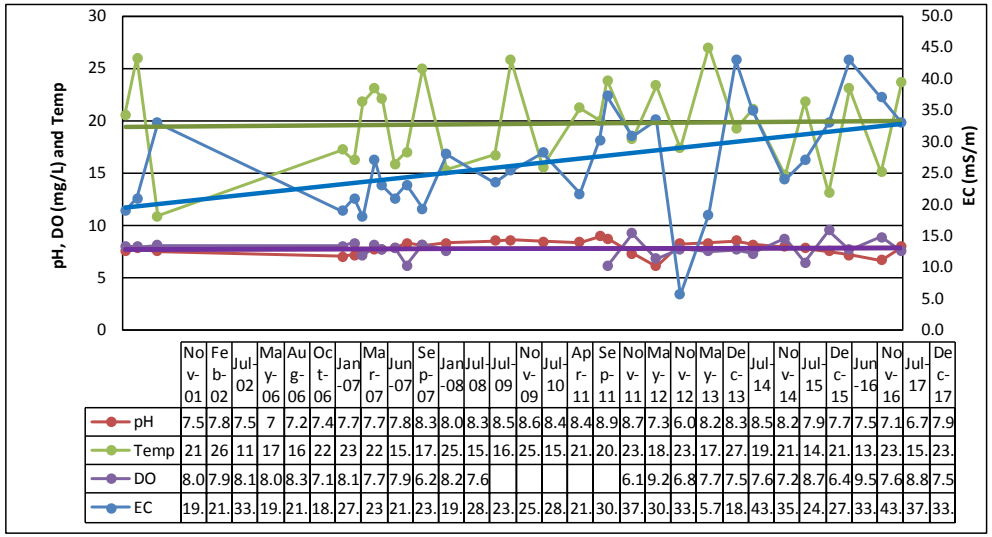
**Trends Compared to Baseline Applied to Proposed Expansion**

- Temporal water quality data shows increased EC compared to baseline. Although still within expected/acceptable ranges (Table 20), temporal data shows potential impact from existing Der Brochen activities (salt load);
- SASS5, ASPT and IHAS scores are variable over time, and in December 2017 lower compared to conditions at baseline;
- Potential impact from the existing Mototolo concentrator has been described for site GD4. The same impact applies to site GD5. Although the Groot Dwars River is already impacted upon, any potential spills or overflow from dirty water areas are likely to have negative impact. It is anticipated that process water systems associated with the proposed expansion will pose a similar risk (i.e. potential cumulative impact).

**The Ecostatus Category for the IHI and MIRAI classifications comply with the Resource Quality Objectives (RQO's) of the Olifants River catchment (DWS, 2016).**

**NA = Not Applicable, SASS reference score = 205, ASPT reference score = 7.0**

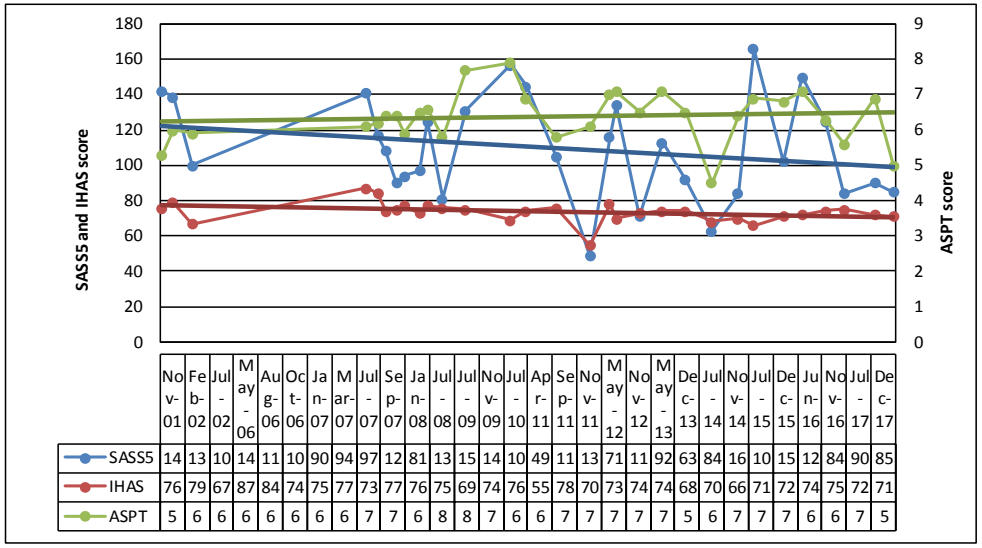
**Table 20: Temporal variations observed at site GD5 since the baseline assessment in April 2007.**




| | Nov-01 | Feb-02 | Jul-02 | May-06 | Aug-06 | Oct-06 | Jan-07 | Mar-07 | Jun-07 | Sep-07 | Jan-08 | Jul-08 | Jul-09 | Nov-09 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Dec-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7.5 | 7.8 | 7.5 | 7 | 7.2 | 7.4 | 7.7 | 7.7 | 7.8 | 8.3 | 8.0 | 8.3 | 8.5 | 8.6 | 8.4 | 8.4 | 8.9 | 8.7 | 7.3 | 6.0 | 8.2 | 8.3 | 8.5 | 8.2 | 7.9 | 7.7 | 7.5 | 7.1 | 6.7 | 7.9 |
| Temp | 21 | 26 | 11 | 17 | 16 | 22 | 23 | 22 | 15. | 17. | 25. | 15. | 16. | 25. | 15. | 21 | 20. | 23. | 18. | 23. | 17. | 27. | 19. | 21. | 14. | 21. | 13. | 23. | 15. | 23. |
| DO | 8.0 | 7.9 | 8.1 | 8.0 | 8.3 | 7.1 | 8.1 | 7.7 | 7.9 | 6.2 | 8.2 | 7.6 | | | | | | 6.1 | 9.2 | 6.8 | 7.7 | 7.5 | 7.6 | 7.2 | 8.7 | 6.4 | 9.5 | 7.6 | 8.8 | 7.5 |
| EC | 19. | 21. | 33. | 19. | 21. | 18. | 27. | 23 | 21. | 23. | 19. | 28. | 23. | 25. | 28. | 21. | 30. | 37. | 30. | 33. | 5.7 | 18. | 43. | 35. | 24. | 27. | 33. | 43. | 37. | 33. |

**Figure 16: Site-specific temporal water quality variation at site GD5**

- With expected Electrical Conductivity (EC) ranging from 35 – 45 mS/m as stipulated in the Olifants River Ecological Water Requirements Assessment (OREWRA) (2001) for the Lower Olifants, Steelpoort River: Sections 1 to 9 for the month of December, the absolute EC values can be considered as largely natural over time;
- However, EC increased by 73.7% when compared to the baseline assessment (April 2007), and exceeds the DWS target water quality guideline recommendation (DWAF, 1996) (Table 19), which advocates that seasonal and temporal changes should not exceed 15%. As for the other sites, the long-term trend line shows a clear increasing trend for EC;
- With this point used to measure cumulative impact of the existing Der Brochen operation, it can be concluded that current mining operations potentially contribute to salt load in the system. With additional, similar infrastructure commissioned during the proposed expansion, cumulative impact is possible;
- When compared to the baseline assessment, the pH increased by 5.2%. The change exceeds the DWS target water quality guideline recommendation (DWAF, 1996) (Table 19). However, the absolute value complies with the pH range of 7.0 to 8.5 recommended by OREWRA (2001) for a river in this section of the catchment, and long-term trend line shows a stable trend;
- Dissolved oxygen (DO) saturation can be considered as adequate in supporting a diverse and sensitive aquatic community as it complies with the 80% saturation recommendation (DWAF, 1996);
- DO concentrations are variable over time and largely dependent on seasonality, but the long-term trend line shows a stable trend;
- **Temporal trends show existing system water quality impact in terms of salt load. The proposed expansion infrastructure and operation will likely contribute to the risk, hence strict mitigation measures are required should development continue.**



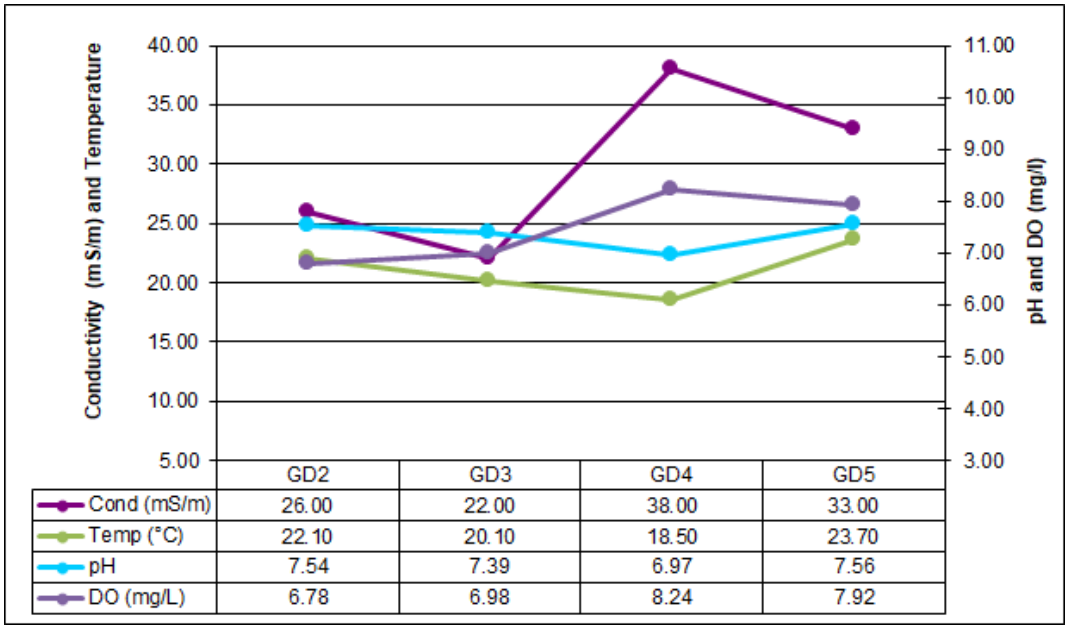

| | Nov-01 | Feb-02 | Jul-02 | May-06 | Aug-06 | Oct-06 | Jan-07 | Mar-07 | Jul-07 | Sep-07 | Jan-08 | Jul-08 | Jul-09 | Nov-09 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Dec-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SASS5 | 14 | 13 | 10 | 14 | 11 | 10 | 90 | 94 | 97 | 12 | 81 | 13 | 15 | 14 | 10 | 49 | 11 | 13 | 71 | 11 | 92 | 63 | 84 | 16 | 10 | 15 | 12 | 84 | 90 | 85 |
| IHAS | 76 | 79 | 67 | 87 | 84 | 74 | 75 | 77 | 73 | 77 | 76 | 75 | 69 | 74 | 76 | 55 | 78 | 70 | 73 | 74 | 74 | 68 | 70 | 66 | 71 | 72 | 74 | 75 | 72 | 71 |
| ASPT | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 6 | 8 | 8 | 7 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 5 | 6 | 7 | 7 | 7 | 6 | 6 | 7 | 5 |

**Figure 17: Site-specific temporal macro-invertebrate community integrity variation at site GD5**

- When compared to the baseline assessment, the SASS5 score has decreased by 40.1% and the ASPT score by 5.7%, along with a 6.6% decrease in habitat suitability (Table 19);
- Long-term trend lines indicate an increasing trend for ASPT, a decreasing trend for SASS5, and a slight decreasing trend for IHAS;
- The variability in macro-invertebrate community diversity and sensitivity is likely related to the slight changes in the water quality of the system, notably variation in EC. This is supported by the fact that temporal trends for SASS and ASPT score does not correlate with trends in changes in the IHAS score, indicating that factors other than habitat suitability affects macro-invertebrate community integrity to a greater degree. However, over the long term the slight decreasing IHAS trend may contribute to the decreasing trend for the SASS5 score;
- **Comparison of SASS5 and ASPT scores to ecoregion reference data, as well as the long-term decreasing trend in SASS5 score, show that the macro-invertebrate community is already impacted upon. The proposed expansion developments, if approved, could potentially contribute further to potential impact, notably with reference to spillage, seepage or decant from dirty water areas, resulting in decreased water quality, toxicological hazard and sedimentation/deposition of fine tailings. Strict mitigation measures are required should development continue.**

**Table 21: Spatial trends in water quality at sites GD2 to GD5 (Groot Dwars River)**

**Water quality (Groot Dwars River)**



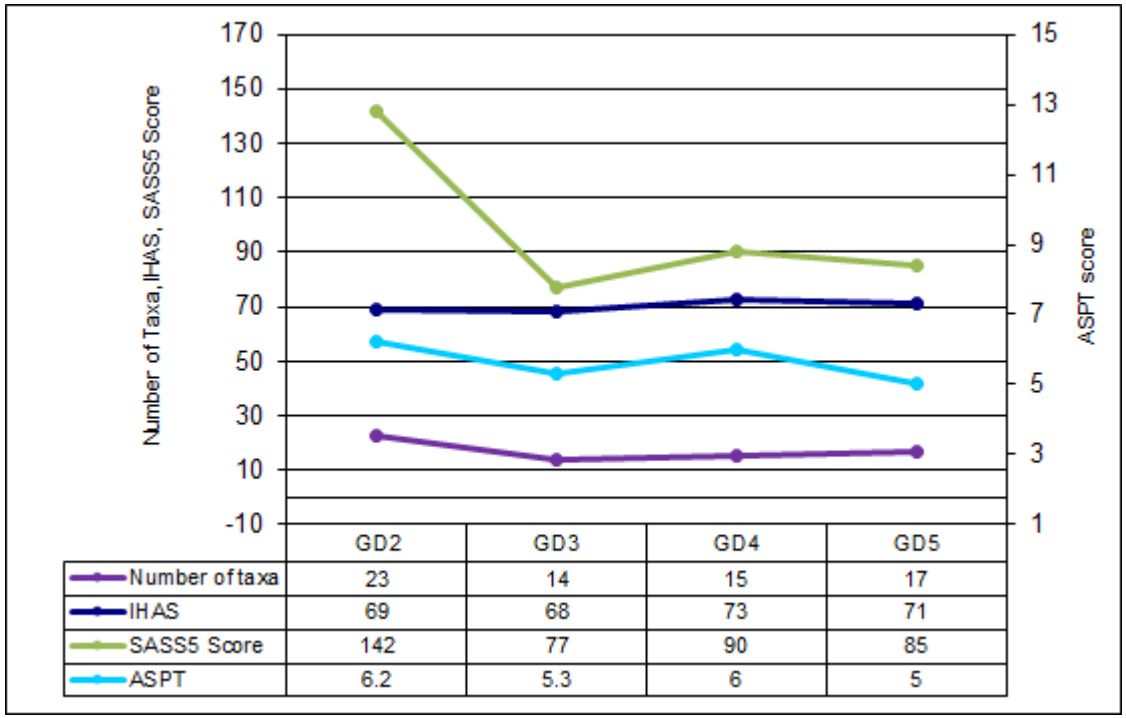

| | GD2 | GD3 | GD4 | GD5 |
|---|---|---|---|---|
| Cond (mS/m) | 26.00 | 22.00 | 38.00 | 33.00 |
| Temp (°C) | 22.10 | 20.10 | 18.50 | 23.70 |
| pH | 7.54 | 7.39 | 6.97 | 7.56 |
| DO (mg/L) | 6.78 | 6.98 | 8.24 | 7.92 |

**Figure 18: Spatial trends in water quality between sites GD2 up to GD5.**

- EC concentration increases in a downstream direction, and spatial changes from site GD3 and GD4 exceed the Department of Water and Sanitation (DWS), previously Department of Water Affairs and Forestry (DWAF), guideline recommendation (>15% spatial change) for aquatic ecosystems (DWAF 1996);
- The geology of the area leads to elevated amounts of dissolved salts in the system under natural conditions. The EC values of all four sites still comply with the target levels of 35 -45 mS/m as stipulated in the OREWRA (2001);
- However, increasing trend suggests possible salt loading in the system, with the most significant increase between sites GD3 and GD4. This suggest potential impact from the existing Mototolo concentrator. Likewise, the overall increase in a downstream direction may indicate cumulative impacts from other mining activities;
- The pH values remained largely stable in a downstream direction, with the exception of a slight decrease at site GD4 that exceeds the DWS guidelines (<5%, DWAF 1996), and also falls below the target pH range of 7.0 to 8.5 as recommended by the OREWRA (2001). This suggests a potential impact from the existing Mototolo concentrator on the pH;
- DO concentration increased in a downstream direction between sites and 80% saturation was reached at all sites. No impact from the existing Der Brochen mining project footprint on DO at time of assessment is anticipated;
- Temperature variation between sites is normal considering seasonal and diurnal cycles.
- **Spatial trends show existing system water quality impact in terms of salt load, and to a lesser degree pH, with specific reference to the existing Mototolo concentrator. The long-term increasing trend in EC is also evident at all sites when considering temporal data. The proposed expansion infrastructure and operation will likely contribute to the risk, hence strict mitigation measures are required should development continue.**

**Table 22: Spatial trends in SASS5, ASPT and IHAS scores at sites GD2 to GD5 (Groot Dwars River)**

**SASS5, ASPT and IHAS scores**




| | GD2 | GD3 | GD4 | GD5 |
|---|---|---|---|---|
| Number of taxa | 23 | 14 | 15 | 17 |
| IHAS | 69 | 68 | 73 | 71 |
| SASS5 Score | 142 | 77 | 90 | 85 |
| ASPT | 6.2 | 5.3 | 6 | 5 |

**Figure 19: Spatial trends in SASS5, ASPT and IHAS scores between sites GD2 up to GD5.**

- Macro-invertebrate community diversity decreased in a downstream direction when compared to the upstream reference site GD2. Overall, the SASS5 score decreased by 45.8% at site GD3, by 36.6% at site GD4, and by 40.1% at site GD5;
- Similarly, the macro-invertebrate community sensitivity decreased in a downstream direction. Overall, the ASPT scores decreased by 14.5% at site GD3, by 3.2% at site GD4 and by 19.3% at site GD5;
- Macro-invertebrate habitat suitability can be considered as adequate at all of the sites during the assessment;
- The significant decrease in macro-invertebrate community integrity in a downstream direction is likely related to the slight variation in water quality of the system (notably salt load with possible impacts from existing Der Brochen operations, existing Mototolo Concentrator, as well as point and diffuse sources of pollution from further upstream in the catchment);
- **Spatial comparison of SASS5 and ASPT between sites indicate a decrease in a downstream direction, with potential impact from existing Der Brochen operations, compounded by catchment-wide impacts upstream of site GD2. The macro-invertebrate community is already impacted upon prior to implementation of the proposed expansion, with specific reference to long-term decreasing trends in SASS5 score observed during temporal comparisons. The proposed expansion developments, if approved, could potentially contribute further to potential impact, notably with reference to spillage, seepage or decant from dirty water areas, resulting in decreased water quality, toxicological hazard and sedimentation/deposition of fine tailings. Strict mitigation measures are required should development continue.**

**Table 23: Results of the assessment at site T1 (Mareesburg Spruit that confluences with the Groot Dwars River just above GD5).**

**Site T1**

**Figure 20: General view of the T1 site at the time of the last assessment (December 2017).**

| | |
|---|---|
| **Algal proliferation** | None observed. |
| **Depth profiles** | Shallow. Generally, < ½ m. |
| **Flow condition** | Slow flow. |
| **Riparian zone characteristics** | Mix of grass and shrubs, between 81% and 95% bank cover. |
| **Water clarity** | Discoloured. |

**SITE ECOSTATUS CATEGORY**

| **Biomonitoring data assessment result** | |
|---|---|
| **Dallas (2007)** | **Category E/F** |
| **MIRAI** | **Category D** |
| **Instream IHI** | **Category B** |
| **Riparian IHI** | **Category C** |
| **Desktop assessment result** | |
| **EIS (Kleynhans 1999, DWS RQIS)** | **High to very high** |
| **PEMC (Kleynhans 1999)** | **B** |
| **DEMC (Kleynhans 1999)** | **B** |
| **PES (DWS RQIS)** | **D** |
| **REC (DWS 2016, RQOs)** | **C/D** |

***In situ* physico-chemical water quality**

| Parameter | Value | % Variation (% Var) change from baseline (July 2009) |
|---|---|---|
| **pH** | 7.90 | **+6.6** |
| **EC (mS/m)** | 46.0 | **+155.6** |
| **TDS (mg/L)** | 299.0 | NA |
| **DO (mg/L)** | 6.73 | **-19.6** |
| **DO (% sat)** | 96.1 | NA |
| **Temp (℃)** | 27.2 | NA |

**Key**: Negative value = decrease; Positive value = increase.
Normal text = no significant change; **Bold text = significant change (compared to guideline).**
**Red text = significant deterioration;**
**Blue text = significant improvement.**

**Site specific spatial water quality variations (% var.)**

| Parameter | % Var. from upstream spatial reference GD2 | % Var. from downstream spatial reference GD5 |
|---|---|---|
| **pH*** | +4.8 | +4.5 |
| **EC (mS/m)** | **+76.9** | **+39.4** |
| **DO (mg/L)**** | -0.8 | **-15.0** |

**Aquatic macro-invertebrate community and habitat integrity**

| Parameter | Score/Category | % Var. from ref ecoregion data (SASS5) | % Var change from baseline (July 2009) |
|---|---|---|---|
| **SASS5 score** | 95 | -53.7 | -5.0 |
| **Number of taxa** | 19 | NA | NA |
| **ASPT score** | 5.0 | -28.6 | **-15.3** |
| **IHAS score** | 65 (Good) | NA | -1.5 |
| **MIRAI score** | 52.3 (Category D) | NA | NA |
| **Instream IHI** | 83.4 (Category B) | NA | NA |
| **Riparian IHI** | 70.5 (Category C) | NA | NA |

**Key:** Negative value = decrease; Positive value = increase.
**A temporal deterioration exceeding 15% was considered significant.**

**Site specific spatial aquatic invertebrate community variations (% var.)**

| Parameter | % Var. from upstream spatial reference GD2 | % Var. from upstream spatial reference GD5 |
|---|---|---|
| **SASS5** | **-33.1** | +11.8 |
| **ASPT** | **-19.4** | 0 |
| **IHAS** | -5.8 | -8.5 |

**Key Drivers of System Change**

- Potential cumulative impacts from surrounding agricultural and mining activities on salt load.
- Lack of strong flowing water at this point and variability in system flow rate also limits habitat availability at this point, thus limiting the diversity and sensitivity of the aquatic community likely to occur at this point.

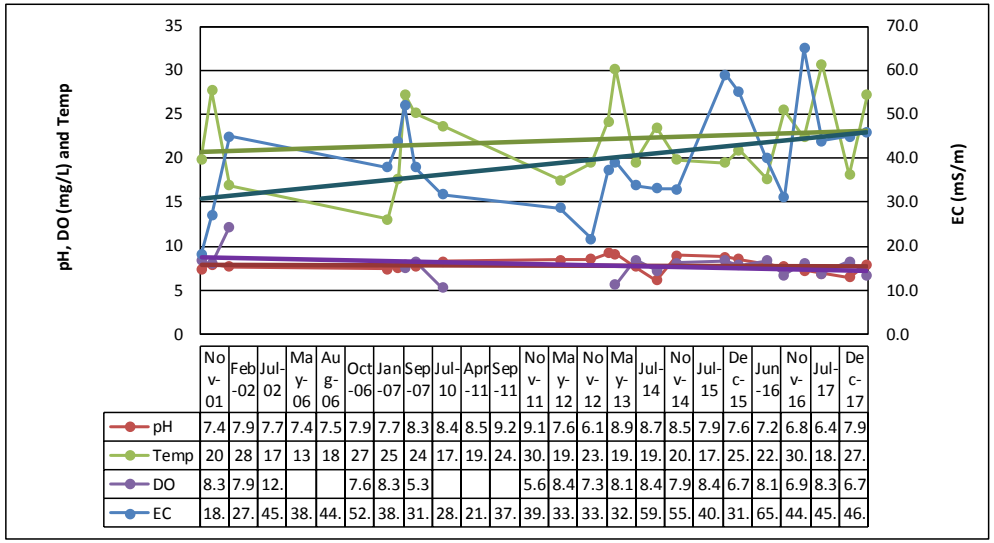
**Trends Compared to Baseline Applied to Proposed Expansion**

- Temporal water quality data shows decreasing DO and increasing pH and EC compared to baseline. Although absolute values are borderline with expected ranges for EC (see discussion in Table 24), temporal data shows potential impact from existing mining and surrounding agricultural activities, particularly with reference to salt load;
- SASS5, ASPT and IHAS scores also decreased compared to baseline. Temporal data shows values are variable but with a generally decreasing trend evident, indicating existing impact on the macro-invertebrate community in the system;
- Biomonitoring data suggest existing impact on the Groot Dwars River. Additional expansion may potentially result in increased risk of impact, with specific reference to risk of spills from dirty water systems (elevated EC, risk of sedimentation).

**The Ecostatus Category for the IHI, Dallas (2007) and MIRAI classifications comply with the Resource Quality Objectives (RQO's) of the Olifants River catchment (DWS, 2016).**

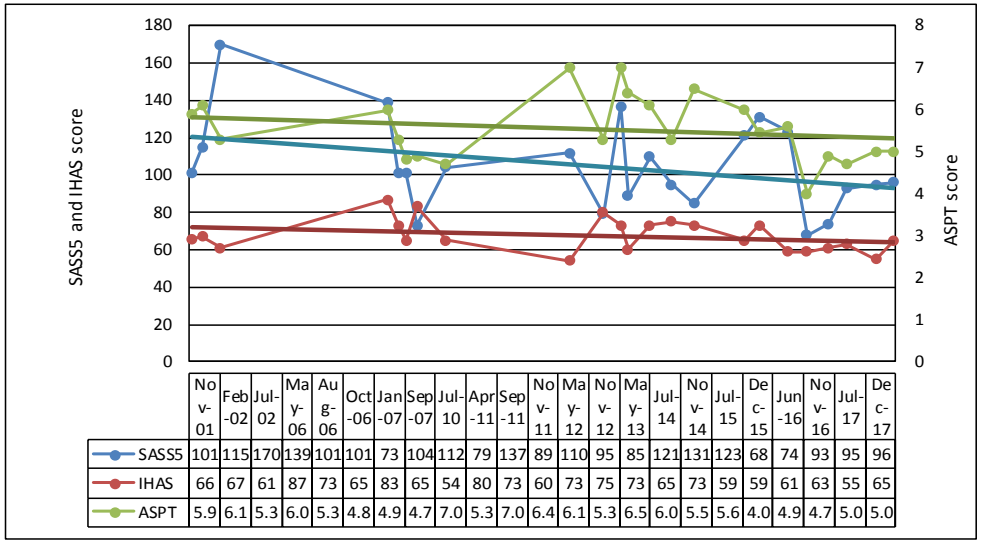
**NA = Not Applicable, SASS reference score = 205, ASPT reference score = 7.0**

**Table 24: Temporal variations observed at site T1 since the baseline assessment in July 2010.**




| | Nov-01 | Feb-02 | Jul-02 | May-06 | Aug-06 | Oct-06 | Jan-07 | Sep-07 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7.4 | 7.9 | 7.7 | 7.4 | 7.5 | 7.9 | 7.7 | 8.3 | 8.4 | 8.5 | 9.2 | 9.1 | 7.6 | 6.1 | 8.9 | 8.7 | 8.5 | 7.9 | 7.6 | 7.2 | 6.8 | 6.4 | 7.9 |
| Temp | 20 | 28 | 17 | 13 | 18 | 27 | 25 | 24 | 17. | 19. | 24. | 30. | 19. | 23. | 19. | 19. | 20. | 17. | 25. | 22. | 30. | 18. | 27. |
| DO | 8.3 | 7.9 | 12. | | | 7.6 | 8.3 | 5.3 | | | | 5.6 | 8.4 | 7.3 | 8.1 | 8.4 | 7.9 | 8.4 | 6.7 | 8.1 | 6.9 | 8.3 | 6.7 |
| EC | 18. | 27. | 45. | 38. | 44. | 52. | 38. | 31. | 28. | 21. | 37. | 39. | 33. | 33. | 32. | 59. | 55. | 40. | 31. | 65. | 44. | 45. | 46. |

**Figure 21: Site-specific temporal water quality variation at site T1**




| | Nov-01 | Feb-02 | Jul-02 | May-06 | Aug-06 | Oct-06 | Jan-07 | Sep-07 | Jul-10 | Apr-11 | Sep-11 | Nov-11 | May-12 | Nov-12 | May-13 | Jul-14 | Nov-14 | Jul-15 | Dec-15 | Jun-16 | Nov-16 | Jul-17 | Dec-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SASS5 | 101 | 115 | 170 | 139 | 101 | 101 | 73 | 104 | 112 | 79 | 137 | 89 | 110 | 95 | 85 | 121 | 131 | 123 | 68 | 74 | 93 | 95 | 96 |
| IHAS | 66 | 67 | 61 | 87 | 73 | 65 | 83 | 65 | 54 | 80 | 73 | 60 | 73 | 75 | 73 | 65 | 73 | 59 | 59 | 61 | 63 | 55 | 65 |
| ASPT | 5.9 | 6.1 | 5.3 | 6.0 | 5.3 | 4.8 | 4.9 | 4.7 | 7.0 | 5.3 | 7.0 | 6.4 | 6.1 | 5.3 | 6.5 | 6.0 | 5.5 | 5.6 | 4.0 | 4.9 | 4.7 | 5.0 | 5.0 |

**Figure 22: Site-specific temporal macro-invertebrate community integrity variation at site T1**

- With expected Electrical Conductivity (EC) ranging from 35 – 45 mS/m as stipulated in the Olifants River Ecological Water Requirements Assessment (OREWRA) (2001) for the Lower Olifants, Steelpoort River: Sections 1 to 9 for the month of December. The absolute EC value just exceeds the recommended range by 2.2%;
- EC increased by 155.6% when compared to the baseline assessment (July 2010), and exceeds the DWS target water quality guideline (DWAF, 1996) (Table 12), which advocates that seasonal and temporal changes should not exceed 15%. The long-term trend line shows an increasing trend for EC;
- When compared to the Groot Dwars River, the EC is 76.9% higher when compared to the upstream site GD2 and 39.4% higher when compared to the downstream site GD5. It is thus possible that the tributary has contributed slightly to the salt load in the Groot Dwars River at site GD5;
- When compared to the baseline assessment, the pH increased by 6.6%, and exceeds the DWS target water quality guideline recommendation (DWAF, 1996) (Table 23). The absolute pH value can be considered largely natural and complies with the pH range of 7.0 to 8.5 recommended by OREWRA (2001) for a river in this section of the catchment. Also, the long-term trend line shows a stable trend;
- When compared to the Groot Dwars River, the pH is 4.8% higher when compared to the upstream site GD2 and 4.5% higher when compared to the downstream site GD5. It is thus unlikely that the tributary will have a negative impact on the Groot Dwars River at site GD5;
- Dissolved oxygen (DO) saturation can be considered as adequate in supporting a diverse and sensitive aquatic community as it complies with the 80% saturation recommendation (DWAF, 1996). The long-term trend line shows largely stable conditions, but with a slight decreasing trend;
- **Temporal trends show existing system water quality impact in terms of salt load. The proposed expansion infrastructure and operation will like contribute to the risk, hence strict mitigation measures are required should development continue.**

- When compared to the baseline assessment, the SASS5 score has decreased by 5.0% and the ASPT score by 15.3%, and the IHAS score by 1.5% (Table 23);
- The long-term trend lines for all three parameters show a decreasing trend;
- The temporal impact on macro-invertebrate diversity and sensitivity, when compared to baseline data, can likely be attributed to a combination of decreasing habitat suitability and long-term changes in water quality over time (catchment wide impact from general agricultural and mining activities as well as other unknown point and diffuse sources of pollution). Elevated EC is considered to be a major driver of change in the system;
- Spatial comparison indicates that any impact from altered water quality is unlikely to have a negative effect on the macro-invertebrate community at site GD5;
- **Comparison of SASS5 and ASPT scores to ecoregion reference data, as well as the long-term decreasing trends in both ASPT and SASS5 scores, shows that the macro-invertebrate community is already impacted upon. The proposed expansion developments, if approved, could potentially contribute further to potential impact, notably with reference to spillage, seepage or decant from dirty water areas, resulting in decreased water quality, toxicological hazard and sedimentation/deposition of fine tailings. Strict mitigation measures are required should development continue.**

**Table 25: Riparian Vegetation Response Assessment Index (VEGRAI) and Fish Response Assessment Index (FRAI) results**

**VEGRAI**

Application of the VEGRAI tool yielded the following result:

**LEVEL 3 ASSESSMENT**

| METRIC GROUP | CALCULATED RATING | WEIGHTED RATING | CONFIDENCE | RANK | % WEIGHT |
|---|---|---|---|---|---|
| MARGINAL | 73.3 | 40.7 | 3.3 | 1.0 | 100.0 |
| NON MARGINAL | 73.3 | 32.6 | 3.3 | 2.0 | 80.0 |
| | 2.0 | | | | 180.0 |
| LEVEL 3 VEGRAI (%) | | | | 73.3 | |
| **VEGRAI EC** | | | | **C** | |
| AVERAGE CONFIDENCE | | | | 3.3 | |

**FRAI**

Fish species expected to occur in the system were presented in Section 2.2.2. Specific mention must be made of the potential presence of two near threatened fish taxa in this section of the Groot Dwars River: *Enteromius motebensis*, and *Oreochromis mossambicus*. Details on justification of the IUCN red data list status was provided in a footnote in Section 2.2.2.

The following fish species were collected or observed during the biomonitoring assessment performed:

*Enteromius trimaculatus*
*Enteromius unitaeniatus*
*Chiloglanis pretoriae*
*Labeobarbus marequensis*
*Tilapia sparmani*

Application of the FRAI tool yielded the following result:

| | |
|---|---|
| FRAI (%) | 49.3 |
| **FRAI EC** | **D** |

The Ecostatus Category for the FRAI classification complies with the Resource Quality Objectives (RQO's) of the Olifants River catchment (DWS, 2016). See Section 2.2.3.

**Table 26: Summary data table for assessment of the Groot Dwars River with available ecostatus data comparisons**

| Ecostatus desktop assessment data summary | | | | Biomonitoring assessment results summary | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Criteria | Kleynhans 1999 | DWS RQIS database | Olifants Resource Quality Objectives (DWS 2016) | Criteria | Ecological Category classification achieved for the following sites as well as overall rating for the Groot Dwars River: | | | | |
| | | | | | GD2 | GD3 | GD4 | GD5 | Overall |
| Applicable catchment/sub-quaternary catchment | B41G | B418-00674 | B41G<br>B41K | SASS5 | C | E/F | D | E/F | D |
| EIS | High | - | - | MIRAI | C | D | D | D | D |
| Mean EI class | - | High | - | | | | | | |
| Mean ES class | - | Very High | - | Instream IHI | B | B | B/C | B | B |
| PEMC | Class B: Largely natural | - | - | | | | | | |
| PES | - | D (Largely modified) | - | Riparian IHI | B | C | C | C | C |
| DEMC | Class B: Sensitive system | - | - | | | | | | |
| Default EC | - | A | - | FRAI | - | - | - | - | D |
| REC | - | | C*<br>D** | VEGRAI | - | - | - | - | C |
| Ecological Integration Tool result*** | | | | | | | | 65.15 | C |

EIS = Ecological Importance and Sensitivity; PEMC = Present Ecological Management Class; DEMC = Desired Ecological Management Class; PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors; EI = Ecological Importance; ES = Ecological Sensitivity; EC = Ecological Category; default based on median PES and highest of EI or ES means; REC = Recommended Ecological Category

* Upper reaches of Groot Dwars River before mining impact;

** Klein Dwars River at the confluence with the Groot Dwars River, also the REC for the Steelpoort River in this catchment of the Olifants River. Corresponds with PES of the Groot Dwars as per DWS RQIS database.

*** The mean MIRAI score for sites GD2 to GD5 (56.0), as well as the FRAI (49.3) and VEGRAI (73.3) scores calculated for the Groot Dwars River, was employed in this calculation.

**Table 27: Summary data table for assessment of the Mareesburg Spruit that confluences with the Groot Dwars River just above GD5**

| Site | SASS5 | MIRAI | Instream IHI | Riparian IHI |
|---|---|---|---|---|
| T1 | E/F | D | B | C |

# 5. ECOLOGICAL IMPORTANCE AND SENSITIVITY ASSESSMENT

The Ecological Importance and Sensitivity (EIS) method (DWAF, 1999) was applied to the Groot Dwars River in order to ascertain the current sensitivity and importance of the system. The results of the assessment are presented in the table below:

**Table 28: Results of the EIS assessment for the Groot Dwars River within the study area.**

| Biotic Determinants | Score |
|---|---|
| Rare and endangered biota | 3 |
| Unique biota | 3 |
| Intolerant biota | 3 |
| Species/taxon richness | 3 |
| **Aquatic Habitat Determinants** | - |
| Diversity of aquatic habitat types or features | 4 |
| Refuge value of habitat type | 3 |
| Sensitivity of habitat to flow changes | 3 |
| Sensitivity of flow-related water quality changes | 3 |
| Migration route/corridor for instream and riparian biota | 2 |
| Nature Reserves, Natural Heritage sites, Natural areas, PNEs | 1 |
| **RATINGS** | **2.8** |
| **EIS CATEGORY** | **High** |

The Ecological Importance and Sensitivity Assessment analysis of the Groot Dwars River provided a score of 2.8 which is regarded as **important and sensitive**. Quaternaries/delineations that obtain this score are considered to be unique on a national scale based on their biodiversity. These rivers (in terms of biota and habitat) may be sensitive to flow modifications.

The high importance and sensitivity of the river is mainly as a result of the presence of the unique biota known to occur in the area based on available databases (DWS RQIS PES/EIS database). Fish taxa known to be sensitive (high water quality and pristine habitat requirements) include *Amphilius uranoscopus, Labeobarbus marequensis* and *Chiloglanis pretoriae.* In addition, two near threatened red data list fish species, according to the IUCN occur in the area based on desktop assessments, namely *Enteromius motebensis* and *Oreochromis mossambicus* (see Sections 2.2.2 and Section 4, Table 25).

Sensitive (intolerant) invertebrate taxa that may potentially occur in the area based on desktop assessment include Athericidae, Chlorocyphidae, Heptageniidae, Perlidae, Philopotamidae and Psephenidae. The presence of sensitive/intolerant biota, diversity of aquatic habitat types as well as the sensitivity of the habitat to flow changes, added to the high importance and sensitivity rating.

# 6. IMPACT ASSESSMENT

Please refer to Section C for the results of the integrated impact assessment undertaken for both the aquatic and freshwater (riparian) resources associated with the proposed Der Brochen expansion project. Section C also indicates the required mitigatory measures needed to minimise the perceived impacts of the proposed development on these resources and presents an assessment of the significance of the impacts taking into consideration the available mitigatory measures and assuming that they are fully implemented.

# 7. CONCLUSION

During this aquatic ecological assessment, results from the existing biomonitoring program (biomonitoring data for the period April 2007 to December 2017) were considered, as the assessment sites were also applicable to the proposed expansion. The available biomonitoring data allowed adequate assessment of the PES and EIS of the system. Said results largely support the desktop study results. Despite the current PES, the EIS is considered high to very high (Kleynhans 1999 and DWS RQIS database), with a very high EIS rating also achieved during the current assessment. The Groot Dwars River is considered to be unique on a national scale based on biodiversity, with biota and habitat sensitive to flow and habitat modifications.

The results of the aquatic ecological assessment based on biomonitoring program data as described previously, as well as relevant desktop data, is provided below:

| **Biomonitoring assessment results summary:** | | | | | | |
|---|---|---|---|---|---|---|
| **Criteria** | **Ecological Category classification achieved for the following sites:** | | | | | |
| | **GD2** | **GD3** | **GD4** | **GD5** | **Overall for the Groot Dwars River** | **T1 unnamed tributary on Mareesburg farm*** |
| **SASS5** | **C** | **E/F** | **D** | **E/F** | **D** | **E/F** |
| **MIRAI** | **C** | **D** | **D** | **D** | **D** | **D** |
| **Instream IHI** | **B** | **B** | **B/C** | **B** | **B** | **B** |
| **Riparian IHI** | **B** | **C** | **C** | **C** | **C** | **C** |
| **FRAI** | **-** | **-** | **-** | **-** | **D** | **NA** |
| **VEGRAI** | **-** | **-** | **-** | **-** | **C** | |
| **Ecological Integration Tool result** | | | | | **C** | |
| **Ecological Importance and Sensitivity Assessment** | | | | | **High** | |

* The tributary will be referred to as "Mareesburg Spruit" for the purpose of this report

The results for relevant desktop data, is provided below:

| Desktop assessment result summary: | |
|---|---|
| Desktop EIS (Kleynhans 1999, DWS RQIS) | High to Very High |
| Desktop PEMC (Kleynhans 1999) | B |
| Desktop DEMC (Kleynhans 1999) | B |
| Desktop PES (DWS RQIS) | D |
| Desktop REC (DWS 2016) | C/D |

NA = Not applicable; EIS = Ecological Importance and Sensitivity; PEMC = Present Ecological Management Class; DEMC = Desired Ecological Management Class; PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors; EI = Ecological Importance; ES = Ecological Sensitivity; EC = Ecological Category; default based on median PES and highest of EI or ES means; REC = Recommended Ecological Category.

**Water Quality and Toxicological Hazard Considerations:**

**Groot Dwars River:** As also defined in the existing biomonitoring program, site GD5 is used to indicate the level of aquatic ecological integrity after the cumulative effects, if any, of the existing Der Brochen project on the Groot Dwars River as well as other mining activities and the effects of the Der Brochen dam further upstream. Monitoring results (temporal and spatial comparisons of percentage change in values) at this site indicate a potential impact on water quality [increased Electrical Conductivity (EC) in a downstream direction] from existing mining activities. Specifically, potential impact from the existing Mototolo concentrator on salt load (compounded by potential impacts from upstream pollution sources and geological variation) was noted at site GD4. Although all absolute values complied with expected/natural water quality ranges during the most recent aquatic biomonitoring assessment, data suggest that increased EC will also be a likely compounding risk with reference to the planned expansion activities and changes from the baseline conditions will continue to occur. Process water systems associated with the existing Mototolo concentrator, based on available historical data, poses a significant toxicological hazard to the receiving environment. Results varied seasonally, but risk ranged between a no acute hazards (Class 1) to a high acute hazard (Class 4). Over the same period the conditions in the Groot Dwars River posed a slight acute (Class 2) to acute (Class 3) hazard. Although already impacted, any potential spills or overflow from dirty water areas are likely to have negative impact in terms of both water quality (notably elevated EC), as well as a toxicological hazard impact on aquatic biota in the Groot Dwars River. It is anticipated that process water systems associated with the planned concentrator, as well as any other dirty water areas associated with the proposed mining operation expansion, will pose a similar threat (i.e. potential cumulative impact).

**Mareesburg Spruit:** Slightly elevated EC was observed at site T1 (Mareesburg Spruit subjected to potential cumulative impacts from surrounding agricultural and mining activities, confluences with the Dwars River just above the GD5 site), which could potentially also



contribute to salt loading of the Groot Dwars River at site GD5. As was also stated for the Groot Dwars River above, the proposed expansion infrastructure will likely contribute to a cumulative salt loading risk in the system.

**Aquatic Biota Considerations:**

Available biomonitoring data indicate that the macro-invertebrate community diversity and sensitivity decreases in a downstream direction on the Groot Dwars River. The observed decrease is likely related to slight variation in water quality (notably EC) to which the existing Der Brochen operations, Mototolo Concentrator, as well as other mining activities further upstream. The proposed expansion will result in cumulative risk with reference to water quality impact (salt loading and toxicological hazard described above) and habitat impacts (risk of sedimentation in case of spillages described above), with potential direct and indirect negative impact on aquatic communities.

**PES/EIS status:**

The Ecostatus Categories for the Index of Habitat Integrity (IHI) and the Macro-Invertebrate Response Assessment Index (MIRAI) classifications for all of the Groot Dwars River sites are congruent with the Resource Quality Objectives (RQO's) of the Olifants River catchment (Ecological Category C/D, DWS, 2016). As mentioned previously, this is a "working river" and hence existing impact can be anticipated.

**Most important risks identified based on aquatic ecological assessment:**

Risk of impact on the Groot Dwars River thus pertains predominantly to potential spillages or overflow (from process water systems and other dirty water areas), leaching (from waste rock dumps or mining shaft complexes), decant (from shafts following closure) and run-off (from disturbed surfaces, hard surfaces and other proposed mining infrastructure), depending on phase of proposed development. Potential impact pertains to changes in water quality, as well as impact from sedimentation and settling of fine tailings. With reference to water quality, the specific risk of elevated EC based on historical data has been highlighted, as has toxicological hazards posed by dirty water systems. With reference to sedimentation and tailing deposits, potential direct and indirect effects are applicable.

**Aquatic ecological assessment synopsis:**

Existing biomonitoring data shows that the existing mining infrastructure do have an impact on the system. Should the planned expansion proceed, addition of similar infrastructure will likely lead to similar impacts (or risks thereof), potentially resulting in a cumulative effect. Should the expansion project proceed, very good mitigation is required to prevent and

minimise potential impacts on the receiving environment, in line with the requirements of the mitigation hierarchy (prevention, reduction, remediation and compensation) as advocated by the Department of Environmental Affairs.

**Impact Assessment:**

Following the assessment of the freshwater resources, an impact assessment was undertaken in order to ascertain the significance of perceived impacts associated with the proposed activities on the receiving environment. The results of this assessment are contained in Section C (*Freshwater Resource and Aquatic Ecological Assessment for the Proposed Anglo Platinum Der Brochen Project, Limpopo Province. Section C: Integrated Impact Assessment and Mitigation. SAS, 2018)*.

Based on the findings of the ecological assessment and results of the impact assessment, it is the opinion of the ecologist that the proposed expansion project carries the potential to pose a significant risk to the Groot Dwars River, pertaining mostly water quality (notably elevated EC) and sedimentation impacts on both aquatic habitat and biota. Risks pertain mostly to altered flow patterns with associated run-off, erosion and sedimentation as well as spillage/leaching/decant. However, should careful planning of the positioning and layout of the proposed infrastructure take into account the locations of the drainage lines, with appropriate measures to prevent or manage spillage/leaching/decant and run-off, impact significance can be greatly reduced. Furthermore, the adherence to cogent, well-conceived mitigation measures as well as general good construction practice will aid in reducing the impact significance to acceptable levels.

However, it should be noted that the significance of some risks, such as possible decant from the shafts, leaching from various stockpiles and loss of catchment yield could not be accurately assessed since the relevant specialist studies had not been completed at the time of this assessment, and accurate layout diagrams are currently not available.

Taking the above into account, it is therefore the opinion of the specialist that from an aquatic ecological perspective, the proposed expansion project be carefully considered, and that preferably, further development and refinement of the site layout plans takes place before the project is authorised.

# 8. RECOMMENDATIONS

To avoid repetition, recommended mitigation measures were provided as part of the Environmental Impact Assessment. The reader is thus referred to Section C.

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# APPENDIX A - Terms of Use and Indemnity

## INDEMNITY AND TERMS OF USE OF THIS REPORT

The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge as well as available information. The report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken and SAS CC and its staff reserve the right to modify aspects of the report including the recommendations if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.
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# APPENDIX B - Legislation

| | |
|---|---|
| **Mineral and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002)** | The obtaining of a New Order Mining Right (NOMR) is governed by the MPRDA. The MPRDA requires the applicant to apply to the DMR for a NOMR which triggers a process of compliance with the various applicable sections of the MPRDA. The NOMR process requires environmental authorisation in terms of the MPRDA Regulations and specifically requires the preparation of a Scoping Report, an Environmental Impact Assessment (EIA) and Environmental Management Programme (EMP), and a Public Participation Process (PPP). |
| **National Environmental Management Act (NEMA) (Act No. 107 of 1998)** | The National Environmental Management Act (NEMA) (Act 107 of 1998) and the associated Regulations as amended in 2017, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment Report (BAR) process or the Environmental Impact Assessment (EIA) process depending on the scale of the impact. Provincial regulations must also be considered. |
| **National Water Act (NWA) (Act No. 36 of 1998)** | The National Water Act (NWA) (Act 36 of 1998) recognises that the entire ecosystem and not just the water itself in any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the Department of Water and Sanitation (DWS). Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from the DWS in terms of Section 21 (c) & (i). |
| **General Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the NWA (Act 36 of 1998)** | In accordance with Regulation GN509 of 2016, a regulated area of a watercourse for section 21c and 21i of the NWA, 1998 is defined as:<br>a) The outer edge of the 1 in 100 year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam;<br>b) In the absence of a determined 1 in 100 year flood line or riparian area the area within 100 m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench; or<br>c) A 500 m radius from the delineated boundary (extent) of any wetland or pan.<br>This notice **replaces GN1199** and may be exercised as follows:<br>i) Exercise the water use activities in terms of Section 21(c) and (i) of the Act as set out in the table below, subject to the conditions of this authorisation;<br>ii) Use water in terms of section 21(c) or (i) of the Act if it has a low risk class as determines through the Risk Matrix;<br>iii) Do maintenance with their existing lawful water use in terms of section 21(c) or (i) of the Act that has a LOW risk class as determined through the Risk Matrix;<br>iv) Conduct river and stormwater management activities as contained in a river management plan;<br>v) Conduct rehabilitation of wetlands or rivers where such rehabilitation activities has a LOW risk class as determined through the Risk Matrix; and<br>vi) Conduct emergency work arising from an emergency situation or incident associated with the persons' existing lawful water use, provided that all work is executed and reported in the manner prescribed in the Emergency protocol.<br>A General Authorisation (GA) issued as per this notice will require the proponent to adhere with specific conditions, rehabilitation criteria and |

| | |
|---|---|
| | monitoring and reporting programme. Furthermore, the water user must ensure that there is a sufficient budget to complete, rehabilitate and maintain the water use as set out in this GA.<br><br>Upon completion of the registration, the responsible authority will provide a certificate of registration to the water user within 30 working days of the submission. On written receipt of a registration certificate from the Department, the person will be regarded as a registered water user and can commence within the water use as contemplated in the GA. |
| **GN 704 – Regulations on use of water for mining and related activities aimed at the protection of water resources, 1999** | These regulations, forming part of the National Water Act, were put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining.<br><br>It is recommended that the project complies with Regulation GN 704 of the NWA, 1998 (Act no. 36 of 1998) which contains regulations on use of water for mining and related activities aimed at the protection of water resources. GN 704 states that:<br>*No person in control of a mine or activity may:*<br>*(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year floodline or within a horizontal distance of 100 metres (m) from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on waterlogged ground, or on ground likely to become waterlogged, undermined, unstable or cracked;*<br>According to the above, the activity footprint must fall outside of the 1:100 year floodline of the drainage feature or 100m from the edge of the feature, whichever distance is the greatest, unless authorised by DWS. |

# APPENDIX C - Method of Assessment

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

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 the study area.

**Table 2A: Classification of river health assessment classes in line with the RHP (Kleynhans, 1999).**

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

In addition, the ecological category (EC) classification will be employed using the eco-status A to F continuum approach (Kleynhans and Louw 2007). This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 2A.


**Figure 2A: Ecological categories (EC) eco-status A to F continuum approach employed (Kleynhans and Louw 2007).**

## Visual Assessment

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

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

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

## Physico Chemical Water Quality Data

On-site testing of biota specific water quality variables took place at the biomonitoring sites. Parameters measured include pH, Electrical Conductivity (EC), Dissolved Oxygen (DO) concentration and temperature. The results of on-site biota specific water quality analyses were used to aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values for aquatic ecosystems as defined by the Department of Water and Sanitation (DWS) formerly known as the Department of Water and Forestry (DWAF 1996 vol. 7), the Olifants River Ecological Water Requirement Assessment (OREWRA, 2001) and the Resource Quality Objectives (RQO) for the Olifants Catchment (DWS, 2016).

## General Habitat Integrity

The general habitat integrity of each site was discussed based on the application of the Index of Habitat Integrity (Kleynhans *et al.* 2008). It is important to assess the habitat at 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. This method describes the Present Ecological State (PES) of both the in-stream and riparian habitat at each site. The method classifies habitat integrity into one of six classes, ranging from unmodified/natural (Class A) to critically modified (Class F), as indicated in Table 2B below.

**Table 2B: Classification of Present State Classes in terms of Habitat Integrity [Kleynhans *et al.* 2008].**

| Class | Description | Score (% of total) |
|---|---|---|
| **A** | Unmodified, natural. | 90 - 100 |
| **B** | Largely natural with few modifications. The flow regime has been only slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. | 80 - 89 |
| **C** | Moderately modified. 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** | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. | 20 – 39 |
| **F** | Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible. | 0 - 19 |

### The Riparian Vegetation Response Assessment Index (VEGRAI)

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

Riparian vegetation is described in the National Water Act (NWA; Act 36 of 1998) as follows: 'riparian habitat' includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

**Table C2: Descriptions of the A-F ecological categories.**

| Ecological category | Description | Score (% of total) |
|---|---|---|
| A | Unmodified, natural. | 90-100 |
| B | Largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged. | 80-89 |
| C | Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged. | 60-79 |
| D | Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. | 40-59 |
| E | Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive. | 20-39 |
| F | Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible | 0-19 |

## Habitat for aquatic macro-invertebrates

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. However, according to a study conducted within the Mpumalanga and Western Cape regions, the IHAS method does not produce reliable scores with regard to the suitability of habitat at sampling sites for aquatic macroinvertebrates (Ollis *et al*., 2006). Furthermore, the performance of the IHAS seems to vary between geomorphologic zones and between biotope groups (Ollis *et al*., 2006). It has, however; become clear that IHAS requires further validation and testing, although the basic data remains of value (Thirion, 2007).

**Table 2C: IHAS Scores and their corresponding description of overall condition (quality and quantity) of available aquatic macroinvertebrate habitat (McMillan, 1998)**

| IHAS Score (%) | Description |
|---|---|
| >75 | Excellent |
| 65 – 74 | Good |
| 55 – 64 | Adequate / Fair |
| <55 | Poor |

## Aquatic Macro-Invertebrate Integrity: The South African Scoring System version 5 (SASS5)

Aquatic macro-invertebrate communities of the selected sites were investigated according to the method, which is specifically designed to comply with international accreditation protocols. This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter (1998).
The assessment was undertaken according to the protocol as defined by Dickens & Graham (2002). All work was undertaken by an accredited SASS5 practitioner.

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

high SASS5 score in conjunction with a low habitat score can be regarded as better than a high SASS5 score in conjunction with a high habitat score. A low SASS5 score together with a high habitat score would be indicative of poor conditions. The IHAS Index is valuable in helping to interpret SASS5 scores and the effects of habitat variation on aquatic macro-invertebrate community integrity.

The perceived reference state for the local streams was determined as a SASS5 score of 205 and an ASPT of 7, based on general conditions of streams in the Eastern Bankenveld Ecoregion and local habitat conditions.

Interpretation off SASS5 results was also carried out based on the South African Scoring System (SASS) data interpretation guidelines (Dallas, 2007). Data from the Eastern Bankenveld Ecoregion was used to aid in interpretation (Figure 2B).

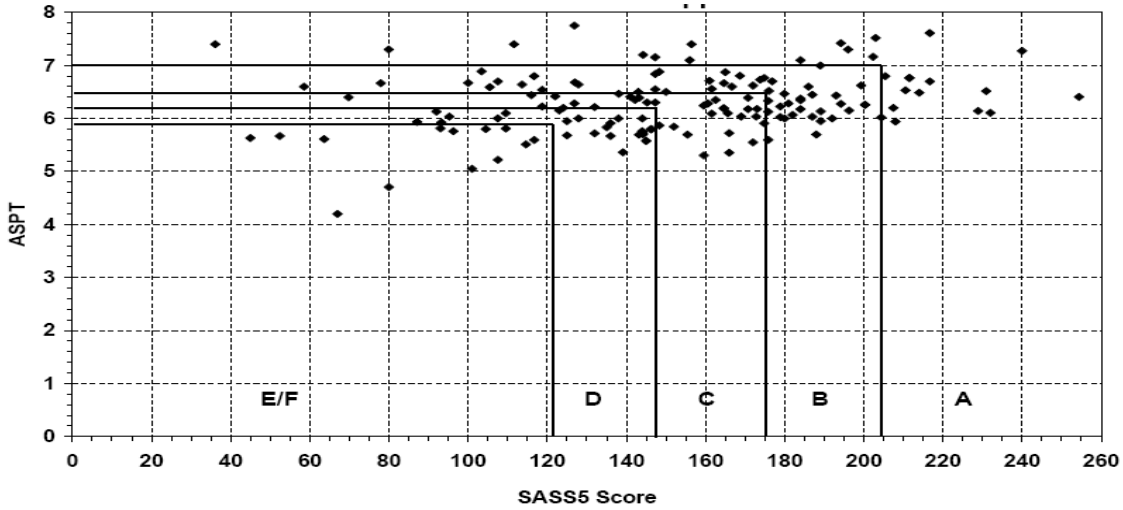


**Figure 2B: SASS5 Classification using biological bands calculated from percentiles for the Eastern Banenveld Ecoregion (Upper zones).**

## Aquatic Macro-Invertebrate Integrity: The Macro-invertebrate Response Assessment Index (MIRAI)

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

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

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

## Fish biota: Fish Response Assessment Index (FRAI)

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

The fish community of each site was sampled for a period of twenty minutes by means of a battery operated electro-fishing device. Fish species identified were compared to those expected to be present at the sites, which were compiled from a literature survey from Skelton (2001) and the Reference Frequency of Occurrence of Fish Species in South Africa (Kleynhans, et al., 2007c). Fish expected to occur in the system is summarised in Section 2.2.3. Comparisons between upstream and downstream points were made where applicable.

## Ecological Importance and Sensitivity (EIS) Method of assessment

The EIS method considers a number of biotic and habitat determinants surmised to indicate either importance or sensitivity. The determinants are rated according to a four-point scale (Table C4). The median of the resultant score is calculated to derive the EIS category (Table C5).

**Table C5: Definition of the four-point scale used to assess biotic and habitat determinants presumed to indicate either importance or sensitivity**

| Four point scale | Definition |
|---|---|
| 1 | One species/taxon judged as rare or endangered at a local scale. |
| 2 | More than one species/taxon judged to be rare or endangered on a local scale. |
| 3 | One or more species/taxon judged to be rare or endangered on a Provincial/regional scale. |
| 4 | One or more species/taxon judged as rare or endangered on a National scale (i.e. SA Red Data Books) |

**Table C6: Ecological importance and sensitivity categories (DWAF, 1999)**

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

# APPENDIX D – Results of Field Investigation (Scoresheets)

Site GD2

| INSTREAM IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Floods | 1.0 |
| **HYDROLOGY RATING** | **0.5** |
| pH | 0.0 |
| Salts | 0.0 |
| Nutrients | -2.0 |
| Water Temperature | 0.0 |
| Water clarity | 0.0 |
| Oxygen | 0.0 |
| Toxics | 0.0 |
| **PC RATING** | **0.5** |
| Sediment | 0.0 |
| Benthic Growth | -2.0 |
| **BED RATING** | **0.8** |
| Marginal | -1.5 |
| Non-marginal | -0.5 |
| **BANK RATING** | **1.0** |
| Longitudinal Connectivity | -1.0 |
| Lateral Connectivity | 1.0 |
| **CONNECTIVITY RATING** | **1.0** |
| | |
| **INSTREAM IHI %** | **85.8** |
| **INSTREAM IHI EC** | **B** |
| **INSTREAM CONFIDENCE** | **3.0** |

| RIPARIAN IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Moderate Floods | 1.5 |
| Large Floods | 1.5 |
| **HYDROLOGY RATING** | **0.9** |
| Substrate Exposure (marginal) | 1.0 |
| Substrate Exposure (non-marginal) | 1.0 |
| Invasive Alien Vegetation (marginal) | 0.5 |
| Invasive Alien Vegetation (non-marginal) | 0.5 |
| Erosion (marginal) | 1.0 |
| Erosion (non-marginal) | 1.0 |
| Physico-Chemical (marginal) | 1.0 |
| Physico-Chemical (non-marginal) | 1.0 |
| **Marginal** | 1.0 |
| **Non-marginal** | 1.0 |
| **BANK STRUCTURE RATING** | **1.0** |
| Longitudinal Connectivity | 0.5 |
| Lateral Connectivity | 0.5 |
| **CONNECTIVITY RATING** | **0.5** |
| | |
| **RIPARIAN IHI %** | **83.2** |
| **RIPARIAN IHI EC** | **B** |
| **RIPARIAN CONFIDENCE** | **3.0** |

Site GD3

| INSTREAM IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Floods | 1.0 |
| **HYDROLOGY RATING** | **0.5** |
| pH | 0.0 |
| Salts | 0.0 |
| Nutrients | -2.0 |
| Water Temperature | 0.0 |
| Water clarity | 1.0 |
| Oxygen | 0.0 |
| Toxics | 0.0 |
| **PC RATING** | **0.5** |
| Sediment | 0.0 |
| Benthic Growth | -2.0 |
| **BED RATING** | **0.8** |
| Marginal | -2.0 |
| Non-marginal | -1.0 |
| **BANK RATING** | **1.5** |
| Longitudinal Connectivity | -1.0 |
| Lateral Connectivity | 1.0 |
| **CONNECTIVITY RATING** | **1.0** |
| | |
| **INSTREAM IHI %** | **84.6** |
| **INSTREAM IHI EC** | **B** |
| **INSTREAM CONFIDENCE** | **3.0** |

| RIPARIAN IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Moderate Floods | 1.5 |
| Large Floods | 1.5 |
| **HYDROLOGY RATING** | **0.9** |
| Substrate Exposure (marginal) | 1.0 |
| Substrate Exposure (non-marginal) | 1.0 |
| Invasive Alien Vegetation (marginal) | 0.5 |
| Invasive Alien Vegetation (non-marginal) | 0.5 |
| Erosion (marginal) | 2.5 |
| Erosion (non-marginal) | 2.5 |
| Physico-Chemical (marginal) | 0.5 |
| Physico-Chemical (non-marginal) | 1.0 |
| **Marginal** | 2.5 |
| **Non-marginal** | 2.5 |
| **BANK STRUCTURE RATING** | **2.5** |
| Longitudinal Connectivity | 1.5 |
| Lateral Connectivity | 0.5 |
| **CONNECTIVITY RATING** | **1.4** |
| | |
| **RIPARIAN IHI %** | **65.8** |
| **RIPARIAN IHI EC** | **C** |
| **RIPARIAN CONFIDENCE** | **3.0** |

Site GD4

| INSTREAM IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Floods | 1.0 |
| **HYDROLOGY RATING** | **0.5** |
| pH | -0.5 |
| Salts | 0.0 |
| Nutrients | -2.0 |
| Water Temperature | 0.0 |
| Water clarity | 1.0 |
| Oxygen | 0.0 |
| Toxics | 0.0 |
| **PC RATING** | **1.5** |
| Sediment | 0.0 |
| Benthic Growth | -2.0 |
| **BED RATING** | **0.8** |
| Marginal | -1.5 |
| Non-marginal | -0.5 |
| **BANK RATING** | **1.0** |
| Longitudinal Connectivity | -1.0 |
| Lateral Connectivity | -0.5 |
| **CONNECTIVITY RATING** | **1.0** |
| | |
| **INSTREAM IHI %** | **81.5** |
| **INSTREAM IHI EC** | **B/C** |
| **INSTREAM CONFIDENCE** | **3.0** |

| RIPARIAN IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Moderate Floods | 1.5 |
| Large Floods | 1.5 |
| **HYDROLOGY RATING** | **0.9** |
| Substrate Exposure (marginal) | 1.5 |
| Substrate Exposure (non-marginal) | 1.5 |
| Invasive Alien Vegetation (marginal) | 0.5 |
| Invasive Alien Vegetation (non-marginal) | 0.5 |
| Erosion (marginal) | 2.0 |
| Erosion (non-marginal) | 2.0 |
| Physico-Chemical (marginal) | 1.5 |
| Physico-Chemical (non-marginal) | 1.0 |
| **Marginal** | 2.0 |
| **Non-marginal** | 2.0 |
| **BANK STRUCTURE RATING** | **2.0** |
| Longitudinal Connectivity | 0.5 |
| Lateral Connectivity | 0.5 |
| **CONNECTIVITY RATING** | **0.5** |
| | |
| **RIPARIAN IHI %** | **74.3** |
| **RIPARIAN IHI EC** | **C** |
| **RIPARIAN CONFIDENCE** | **3.0** |

Site GD5

| INSTREAM IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Floods | 1.0 |
| **HYDROLOGY RATING** | **0.5** |
| pH | 0.0 |
| Salts | 0.0 |
| Nutrients | 1.0 |
| Water Temperature | 0.0 |
| Water clarity | 1.0 |
| Oxygen | 0.0 |
| Toxics | 0.0 |
| **PC RATING** | **1.0** |
| Sediment | 0.0 |
| Benthic Growth | 1.0 |
| **BED RATING** | **0.4** |
| Marginal | -0.5 |
| Non-marginal | -1.5 |
| **BANK RATING** | **1.0** |
| Longitudinal Connectivity | -0.5 |
| Lateral Connectivity | -0.5 |
| **CONNECTIVITY RATING** | **0.5** |
| | |
| **INSTREAM IHI %** | **87.0** |
| **INSTREAM IHI EC** | **B** |
| **INSTREAM CONFIDENCE** | **3.0** |

| RIPARIAN IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Moderate Floods | 1.5 |
| Large Floods | 1.5 |
| **HYDROLOGY RATING** | **0.9** |
| Substrate Exposure (marginal) | 1.5 |
| Substrate Exposure (non-marginal) | 1.5 |
| Invasive Alien Vegetation (marginal) | 0.5 |
| Invasive Alien Vegetation (non-marginal) | 0.5 |
| Erosion (marginal) | 2.0 |
| Erosion (non-marginal) | 2.0 |
| Physico-Chemical (marginal) | 0.5 |
| Physico-Chemical (non-marginal) | 0.5 |
| **Marginal** | 2.0 |
| **Non-marginal** | 2.0 |
| **BANK STRUCTURE RATING** | **2.0** |
| Longitudinal Connectivity | 0.5 |
| Lateral Connectivity | 1.0 |
| **CONNECTIVITY RATING** | **0.5** |
| | |
| **RIPARIAN IHI %** | **74.1** |
| **RIPARIAN IHI EC** | **C** |
| **RIPARIAN CONFIDENCE** | **3.0** |

Site T1

| INSTREAM IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Floods | 1.0 |
| **HYDROLOGY RATING** | **0.5** |
| pH | 0.0 |
| Salts | -1.0 |
| Nutrients | 0.0 |
| Water Temperature | 0.0 |
| Water clarity | 0.0 |
| Oxygen | 0.0 |
| Toxics | 0.0 |
| **PC RATING** | **1.0** |
| Sediment | -1.0 |
| Benthic Growth | 0.0 |
| **BED RATING** | **0.6** |
| Marginal | -2.0 |
| Non-marginal | -0.5 |
| **BANK RATING** | **1.4** |
| Longitudinal Connectivity | -1.0 |
| Lateral Connectivity | 1.0 |
| **CONNECTIVITY RATING** | **1.0** |
| | |
| **INSTREAM IHI %** | **83.4** |
| **INSTREAM IHI EC** | **B** |
| **INSTREAM CONFIDENCE** | **3.0** |

| RIPARIAN IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Moderate Floods | 1.5 |
| Large Floods | 1.5 |
| **HYDROLOGY RATING** | **0.9** |
| Substrate Exposure (marginal) | 1.5 |
| Substrate Exposure (non-marginal) | 1.5 |
| Invasive Alien Vegetation (marginal) | 0.5 |
| Invasive Alien Vegetation (non-marginal) | 0.5 |
| Erosion (marginal) | 2.0 |
| Erosion (non-marginal) | 2.0 |
| Physico-Chemical (marginal) | 0.5 |
| Physico-Chemical (non-marginal) | 1.0 |
| **Marginal** | 2.0 |
| **Non-marginal** | 2.0 |
| **BANK STRUCTURE RATING** | **2.0** |
| Longitudinal Connectivity | 1.5 |
| Lateral Connectivity | 1.0 |
| **CONNECTIVITY RATING** | **1.3** |
| | |
| **RIPARIAN IHI %** | **70.5** |
| **RIPARIAN IHI EC** | **C** |
| **RIPARIAN CONFIDENCE** | **3.0** |

Site KD1

| INSTREAM IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Floods | 1.0 |
| **HYDROLOGY RATING** | **0.5** |
| pH | 0.0 |
| Salts | 0.0 |
| Nutrients | 0.0 |
| Water Temperature | 0.0 |
| Water clarity | 0.0 |
| Oxygen | 0.0 |
| Toxics | 0.0 |
| **PC RATING** | **0.0** |
| Sediment | -1.0 |
| Benthic Growth | 0.0 |
| **BED RATING** | **0.6** |
| Marginal | -1.5 |
| Non-marginal | -1.0 |
| **BANK RATING** | **1.3** |
| Longitudinal Connectivity | -1.5 |
| Lateral Connectivity | -1.0 |
| **CONNECTIVITY RATING** | **1.5** |
| | |
| **INSTREAM IHI %** | **86.7** |
| **INSTREAM IHI EC** | **B** |
| **INSTREAM CONFIDENCE** | **3.0** |

| RIPARIAN IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Moderate Floods | 1.5 |
| Large Floods | 1.5 |
| **HYDROLOGY RATING** | **0.9** |
| Substrate Exposure (marginal) | 1.5 |
| Substrate Exposure (non-marginal) | 1.5 |
| Invasive Alien Vegetation (marginal) | 0.5 |
| Invasive Alien Vegetation (non-marginal) | 0.5 |
| Erosion (marginal) | 2.0 |
| Erosion (non-marginal) | 2.0 |
| Physico-Chemical (marginal) | 0.5 |
| Physico-Chemical (non-marginal) | 1.0 |
| **Marginal** | 2.0 |
| **Non-marginal** | 2.0 |
| **BANK STRUCTURE RATING** | **2.0** |
| Longitudinal Connectivity | 0.5 |
| Lateral Connectivity | 0.5 |
| **CONNECTIVITY RATING** | **0.5** |
| | |
| **RIPARIAN IHI %** | **74.3** |
| **RIPARIAN IHI EC** | **C** |
| **RIPARIAN CONFIDENCE** | **3.0** |

Site KD2

| INSTREAM IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Floods | 1.0 |
| **HYDROLOGY RATING** | **0.5** |
| pH | 0.0 |
| Salts | 0.0 |
| Nutrients | 0.0 |
| Water Temperature | 0.0 |
| Water clarity | 0.0 |
| Oxygen | -0.5 |
| Toxics | 0.0 |
| **PC RATING** | **0.5** |
| Sediment | -1.0 |
| Benthic Growth | -0.5 |
| **BED RATING** | **0.8** |
| Marginal | -1.0 |
| Non-marginal | -1.0 |
| **BANK RATING** | **1.0** |
| Longitudinal Connectivity | -1.5 |
| Lateral Connectivity | -1.0 |
| **CONNECTIVITY RATING** | **1.5** |
| | |
| **INSTREAM IHI %** | **84.2** |
| **INSTREAM IHI EC** | **B** |
| **INSTREAM CONFIDENCE** | **3.0** |

| RIPARIAN IHI | |
|---|---|
| Base Flows | -1.0 |
| Zero Flows | 0.0 |
| Moderate Floods | 1.5 |
| Large Floods | 1.5 |
| **HYDROLOGY RATING** | **0.9** |
| Substrate Exposure (marginal) | 1.5 |
| Substrate Exposure (non-marginal) | 1.5 |
| Invasive Alien Vegetation (marginal) | 0.5 |
| Invasive Alien Vegetation (non-marginal) | 0.5 |
| Erosion (marginal) | 2.0 |
| Erosion (non-marginal) | 2.0 |
| Physico-Chemical (marginal) | 1.0 |
| Physico-Chemical (non-marginal) | 1.0 |
| **Marginal** | 2.0 |
| **Non-marginal** | 2.0 |
| **BANK STRUCTURE RATING** | **2.0** |
| Longitudinal Connectivity | 1.0 |
| Lateral Connectivity | 1.0 |
| **CONNECTIVITY RATING** | **1.0** |
| | |
| **RIPARIAN IHI %** | **72.1** |
| **RIPARIAN IHI EC** | **C** |
| **RIPARIAN CONFIDENCE** | **3.0** |

| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|---|---|---|---|---|---|---|
| **River Name**: | | | | | | |
| **Site Name**: GD2 | **06-12-2017** | | | | | |
| | | | | | | |
| ***SAMPLING HABITAT*** | **0** | **1** | **2** | **3** | **4** | **5** |
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | **16** | | |
| **VEGETATION** | **0** | **1** | **2** | **3** | **4** | **5** |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | **11** | |
| **OTHER HABITAT/GENERAL** | **0** | **1** | **2** | **3** | **4** | **5** |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | **10** | |
| | **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) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX 32** | | | | | |
| | **TOTAL IHAS SCORE (%):** | | | | **69** | |

**INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)**

**River Name**:
**Site Name**: GD3 **Date**: 06-12-2017

| ***SAMPLING HABITAT*** | **0** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | **16** | | |
| **VEGETATION** | **0** | **1** | **2** | **3** | **4** | **5** |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | **9** | |
| **OTHER HABITAT/GENERAL** | **0** | **1** | **2** | **3** | **4** | **5** |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | **11** | |
| | **HABITAT TOTAL (MAX 55):** | | | | **36** | |
| ***STREAM CONDITION*** | **0** | **1** | **2** | **3** | **4** | **5** |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX** | | | | **32** | |
| | **TOTAL IHAS SCORE (%):** | | | | **68** | |

**INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)**

**River Name**:
**Site Name**: GD4 **Date**: 27-11-2017

| *SAMPLING HABITAT* | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| **SIC Score (max 20):** | | | | **16** | | |
| **VEGETATION** | **0** | **1** | **2** | **3** | **4** | **5** |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| **Vegetation Score (max 15):** | | | | | **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: 'coor' = 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) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| **STREAM CONDITIONS TOTAL (MAX** | | | | | | **36** |
| **TOTAL IHAS SCORE (%):** | | | | | **73** | |

| INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS) | | | | | | |
|---|---|---|---|---|---|---|
| **River Name**: | | | | | | |
| **Site Name**: GD5 | **Date**: 06-12-2017 | | | | | |
| ***SAMPLING HABITAT*** | **0** | **1** | **2** | **3** | **4** | **5** |
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | **16** | | |
| **VEGETATION** | **0** | **1** | **2** | **3** | **4** | **5** |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | **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: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | **10** | |
| | **HABITAT TOTAL (MAX 55):** | | | | **36** | |
| ***STREAM CONDITION*** | **0** | **1** | **2** | **3** | **4** | **5** |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX 35** | | | | | |
| | **TOTAL IHAS SCORE (%):** | | | | **71** | |

**INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)**

**River Name**:
**Site Name**: T1 **Date**: 05-12-2017

| *SAMPLING HABITAT* | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | | | | **SIC Score (max 20):** | **14** | |
| **VEGETATION** | **0** | **1** | **2** | **3** | **4** | **5** |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | | | | **Vegetation Score (max 15):** | **9** | |
| **OTHER HABITAT/GENERAL** | **0** | **1** | **2** | **3** | **4** | **5** |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | | | | **Other Habitat Score (max 20):** | **14** | |
| | | | | **HABITAT TOTAL (MAX 55):** | **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) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | | | | **STREAM CONDITIONS TOTAL (MAX** | **28** | |
| | | | | **TOTAL IHAS SCORE (%):** | **65** | |

**INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)**

**River Name**:
**Site Name**: KD **Date**: 05-12-2017

| *SAMPLING HABITAT* | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| | **SIC Score (max 20):** | | | **0** | | |
| **VEGETATION** | **0** | **1** | **2** | **3** | **4** | **5** |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| | **Vegetation Score (max 15):** | | | | **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: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| | **Other Habitat Score (max 20):** | | | | **13** | |
| | **HABITAT TOTAL (MAX 55):** | | | | **23** | |
| ***STREAM CONDITION*** | **0** | **1** | **2** | **3** | **4** | **5** |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| | **STREAM CONDITIONS TOTAL (MAX 28** | | | | | |
| | **TOTAL IHAS SCORE (%):** | | | | **51** | |

**INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)**

**River Name**:
**Site Name**: KD2 **Date**: 05-12-2017

| ***SAMPLING HABITAT*** | **0** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|---|
| **STONES IN CURRENT (SIC)** | | | | | | |
| Total length of white water rapids (i.e.: bubbling water) (in meters) | none | 0-1 | >1-2 | >2-3 | >3-5 | >5 |
| Total length of submerged stones in current (run) (in meters) | none | 0-2 | >2-5 | >5-10 | >10 | |
| Number of separate SIC area's kicked (not individual stones) | 0 | 1 | 2-3 | 4-5 | 6+ | |
| Average stone size's kicked (cm's) (gravel is <2, bedrock is >20) | none | <2>20 | 2-10 | 11-20 | 2-20 | |
| Amount of stone surface clear (of algae, sediment, etc) (in %)* | n/a | 0-25 | 26-50 | 51-75 | >75 | |
| PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) | 0 | <1 | >1-2 | 2 | >2-3 | >3 |
| (* NOTE: up to 25% of stone is usually embedded in the stream bottom) | | | | | | |
| **SIC Score (max 20):** | | | | **16** | | |
| **VEGETATION** | **0** | **1** | **2** | **3** | **4** | **5** |
| Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters) | none | 0-½ | >½-1 | >1-2 | 2 | >2 |
| Amount of aquatic vegetation sampled (underwater) (in square meters) | none | 0-½ | >½-1 | >1 | | |
| Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only) | none | | run | pool | | mix |
| Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%) | none | 0 | 1-25 | 26-50 | 51-75 | >75 |
| **Vegetation Score (max 15):** | | | | | **11** | |
| **OTHER HABITAT/GENERAL** | **0** | **1** | **2** | **3** | **4** | **5** |
| Stones out of current (SOOC) sampled: (PROTOCOL - in square meters) | none | 0-½ | >½-1 | 1 | >1 | |
| Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | >½-1 | 1 | >1 |
| Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones) | none | under | 0-½ | ½ | >½ | |
| Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)** | none | 0-½ | ½ | >½** | | |
| Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)** | none | some | | | all** | |
| Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)*** | >2m² | rocks | 1-2m² | <1m² | isol | none |
| Tray identification: (PROTOCOL - using time: 'coor' = correct time) | | under | | corr | | over |
| (** NOTE: you must still fill in the SIC section) | | | | | | |
| **Other Habitat Score (max 20):** | | | | | **14** | |
| **HABITAT TOTAL (MAX 55):** | | | | | **41** | |
| ***STREAM CONDITION*** | **0** | **1** | **2** | **3** | **4** | **5** |
| **PHYSICAL** | | | | | | |
| River make up: ('pool' = pool/still/dam only; 'run' only; etc) | pool | | run | rapid | 2mix | 3mix |
| Average width of stream: (in meters) | | >10 | >5-10 | <1 | 1-2 | >2-5 |
| Average depth of stream: (in meters) | >2 | >1-2 | 1 | >½-1 | ½ | <½ |
| Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test) | still | slow | fast | med | | mix |
| Water colour: ('disc' = discoloured with visible colour but still transparent) | silty | opaque | | disc | | clear |
| Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)*** | flood | fire | constr | other | | none |
| Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees) | none | | grass | shrubs | mix | |
| Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)*** | erosn | farm | trees | other | | open |
| Left bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| Right bank cover: (rocks and vegetation) (in %) | 0-50 | 51-80 | 81-95 | >95 | | |
| (*** NOTE: if more than one option, choose the lowest) | | | | | | |
| **STREAM CONDITIONS TOTAL (MAX** | | | | | | **32** |
| **TOTAL IHAS SCORE (%):** | | | | | **73** | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 06-12-2017 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | **A** | | **A** | Athericidae | 10 | **1** | | | **1** |
| E: ° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | | **A** | | **A** | Blepharoceridae | 15 | | | | |
| SITE CODE: GD2 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | **A** | | **A** | Ceratopogonidae | 5 | **1** | | | **1** |
| RIVER: | Oligochaeta | 1 | | | **A** | **A** | Hydrometridae* | 6 | | | | | Chironomidae | 2 | **A** | | **A** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | | **1** | **1** | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 22.1 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph: 7.54 | Potamonautidae* | 3 | | | **1** | **1** | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 06.78 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | **A** | | **A** | Muscidae | 1 | | | | |
| Cond: 26.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | **A** | | | **A** | Cordalidae | 8 | | | | | Simuliidae | 5 | | | | |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | **A** | | | **A** |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | **A** | | | **A** | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | **A** | **B** | | **B** | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | **A** | | | **A** | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | **B** | | **1** | **B** | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 84 | 55 | 47 | 142 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | **1** | **1** | Leptoceridae | 6 | **1** | **B** | | **B** | **NO OF TAXA:** | | 12 | 9 | 8 | 23 |
| | Chlorocyphidae | 10 | **A** | | **1** | **A** | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 7.00 | 6.11 | 5.88 | 6.17 |
| | Chlorolestidae | 8 | | **A** | | **A** | Pisuliidae | 10 | | | | | **IHAS**: | | | | | |
| | Coenagrionidae | 4 | | | | | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | **1** | | | **1** | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | **1** | | **1** | Algal | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | **1** | **A** | **A** | | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | | | | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | | | | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 06-12-2017 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | **1** | | **1** | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | | **A** | **A** | **B** | Blepharoceridae | 15 | | | | |
| SITE CODE:GD3 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | **A** | | **A** | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | | | | | Hydrometridae* | 6 | | | | | Chironomidae | 2 | **B** | | **B** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP:20.1 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph: 7.39 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| 69.8/ 87.3% | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | **A** | | **A** | Muscidae | 1 | | | | |
| Cond: 22.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | **B** | **A** | | **B** | Cordalidae | 8 | | | | | Simuliidae | 5 | | **A** | | **A** |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | **B** | **B** | **B** | **B** | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | **B** | **B** | **B** | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | **B** | **B** | **B** | **B** | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 31 | 81 | 32 | 83 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | **1** | | **1** | **NO OF TAXA:** | | 4 | 14 | 5 | 15 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 7.75 | 5.79 | 6.40 | 5.53 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | | 68% | | | |
| | Coenagrionidae | 4 | | **B** | | **B** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | ALGAL PROLIF | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | | | | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | **A** | | **A** | | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | **A** | | **A** | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | **1** | | **1** | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 06-12-2017 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | | | | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | | **1** | | **1** | Corixidae* | 3 | **A** | **A** | | **B** | Blepharoceridae | 15 | | | | |
| SITE CODE:GD4 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | **1** | **A** | **A** | **B** |
| RIVER: | Oligochaeta | 1 | | | | | Hydrometridae* | 6 | | | | | Chironomidae | 2 | **A** | | **A** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | | | | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 18.5 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph: 6.97 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 8.24/99.1%mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | **A** | **A** | **A** | Muscidae | 1 | | | | |
| Cond: 38.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | **A** | | **A** | Cordalidae | 8 | | | | | Simuliidae | 5 | | | | |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | **A** | | | **A** | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | **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 | | **B** | | **B** | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | **A** | **A** | **A** | **B** | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | **1** | | **A** | **A** | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 46 | 56 | 37 | 90 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | **1** | | **1** | **NO OF TAXA:** | | 8 | 10 | 7 | 15 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 5.75 | 5.60 | 5.29 | 6.00 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | | 73% | | | |
| | Coenagrionidae | 4 | | **1** | | **1** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | | | | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | ALAGAL PROLIF | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | **1** | | | **1** | JUV fish x2 | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | | **A** | **A** | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | **1** | **1** | **A** | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 06-12-2017 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | | | | Athericidae | 10 | | | | |
| E:° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | | **A** | | **A** | Blepharoceridae | 15 | | | | |
| SITE CODE: GD5 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | | **1** | **A** | **A** |
| RIVER: | Oligochaeta | 1 | **1** | | **1** | **A** | Hydrometridae* | 6 | | | | | Chironomidae | 2 | | **A** | **A** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | **A** | | **A** | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | **1** | | **1** | Dixidae* | 10 | | | | |
| TEMP: 23.7 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph:7.92(100.7%) | Potamonautidae* | 3 | | **A** | **A** | **A** | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 7.56 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | | | | Muscidae | 1 | | | | |
| Cond: 33.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | | | | |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | **1** | | | **1** |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | | | | Ancylidae | 6 | | **A** | | **A** |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | **B** | **B** | **A** | **B** | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | **A** | **A** | **A** | **B** | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | **A** | | **A** |
| **FLOW**: | Leptophlebiidae | 9 | | | | | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 48 | 68 | 58 | 85 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 8 | 13 | 11 | 17 |
| | Chlorocyphidae | 10 | **1** | **1** | **1** | **A** | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 6.00 | 5.23 | 5.27 | 5.00 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | | 71% | | | |
| | Coenagrionidae | 4 | **A** | **A** | **A** | **B** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | | **A** | **A** | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | LIM VEG+GSM | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | | | | | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | **A** | | **A** | **A** | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | **1** | **A** | **A** | **A** | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 05-12-2017 | **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 | | | **1** | **1** |
| E:° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | | **1** | **A** | **A** | Blepharoceridae | 15 | | | | |
| SITE CODE: T1 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | | | | |
| RIVER: | Oligochaeta | 1 | | | | | Hydrometridae* | 6 | | | | | Chironomidae | 2 | | **A** | | **A** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | **A** | **A** | **A** | **B** | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 27.2 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | **1** | | **1** | Empididae | 6 | | | | |
| Ph: 7.90 | Potamonautidae* | 3 | | **A** | | **A** | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 6.73 mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | | | | Muscidae | 1 | | | | |
| Cond: 46.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | | | | |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | **A** | | **A** | **A** | Hydropsychidae 1sp | 4 | **1** | | | **1** | 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 | **A** | **A** | **A** | **B** | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | **A** | | **A** |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | **A** | | **A** |
| **FLOW**: | Leptophlebiidae | 9 | **A** | | **A** | **B** | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | **A** | | | **A** | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 50 | 57 | 58 | 95 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 9 | 13 | 10 | 19 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 5.56 | 4.38 | 5.80 | 5.00 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | | 65% | | | |
| | Coenagrionidae | 4 | **A** | **B** | **A** | **B** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | **A** | | **A** | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | | **A** | **A** | | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | **A** | **1** | **A** | **A** | Hydraenidae* | 8 | | **1** | | **1** | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | **1** | **A** | **A** | **A** | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 05-12-2017 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | | | | Athericidae | 10 | | | | |
| E:° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | | | **A** | **A** | Blepharoceridae | 15 | | | | |
| SITE CODE: KD1 | **ANNELIDA:** | | | | | | Gerridae* | 5 | | | | | Ceratopogonidae | 5 | | **A** | | **A** |
| RIVER: | Oligochaeta | 1 | | | | | Hydrometridae* | 6 | | | | | Chironomidae | 2 | | **A** | **A** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | **1** | **1** | **A** | Culicidae* | 1 | | | | |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | | | | Dixidae* | 10 | | | | |
| TEMP: 27.9 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | | | | Empididae | 6 | | | | |
| Ph: 7.90 | Potamonautidae* | 3 | | | | | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO: 7.08/100.2% mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | **A** | | **A** | Muscidae | 1 | | | | |
| Cond: 35.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | **A** | | **A** | Cordalidae | 8 | | | | | Simuliidae | 5 | | **A** | **A** | **B** |
| 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** | | | | | |
| MVEGIC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | **1** | | **1** | Ancylidae | 6 | | **1** | | **1** |
| MVEGOOC: DOM SP: | Baetidae 2 sp | 6 | | | **A** | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | | **B** | | **B** | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | | | **A** | **A** | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | **1** | | **1** | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbidae* | 3 | | | | |
| **FLOW**: | Leptophlebiidae | 9 | | **1** | | **1** | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | | | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 0 | 117 | 45 | 130 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | **1** | | **1** | Leptoceridae | 6 | | **A** | **1** | **A** | **NO OF TAXA:** | | 0 | 17 | 9 | 20 |
| | Chlorocyphidae | 10 | | **1** | | **1** | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 0.00 | 6.88 | 5.00 | 6.50 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | | 51% | | | |
| | Coenagrionidae | 4 | | **A** | | **A** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | | | | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | | **1** | | **1** | | | | | | |
| | Aeshnidae | 8 | | | | | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | | **A** | **B** | **B** | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | | | **A** | **A** | Hydrophilidae* | 5 | | | | | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

| **DATE**: 05-12-2017 | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** | **TAXON** | | **S** | **VG** | **GSM** | **TOT** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GRID REFERENCE**: | **PORIFERA** | 5 | | | | | **HEMIPTERA:** | | | | | | **DIPTERA:** | | | | | |
| S:° | **COELENTERATA** | 1 | | | | | Belostomatidae* | 3 | | | | | Athericidae | 10 | | | | |
| E: ° | **TURBELLARIA** | 3 | | | | | Corixidae* | 3 | **1** | | **A** | **A** | Blepharoceridae | 15 | | | | |
| SITE CODE: KD2 | **ANNELIDA:** | | | | **A** | **A** | Gerridae* | 5 | | **A** | | **A** | Ceratopogonidae | 5 | **A** | **A** | **A** | **B** |
| RIVER: | Oligochaeta | 1 | | | | | Hydrometridae* | 6 | | | | | Chironomidae | 2 | **A** | **A** | **A** | **B** |
| SITE DESCRIPTION: | Leeches | 3 | | | | | Naucoridae* | 7 | | | | | Culicidae* | 1 | | **1** | | **1** |
| WEATHER CONDITION: | **CRUSTACEA:** | | | | | | Nepidae* | 3 | | **A** | | **A** | Dixidae* | 10 | | | | |
| TEMP: 25.9 °C | Amphipoda | 13 | | | | | Notonectidae* | 3 | | **1** | **1** | **A** | Empididae | 6 | | | | |
| Ph: 7.79 | Potamonautidae* | 3 | **A** | | | **A** | Pleidae* | 4 | | | | | Ephydridae | 3 | | | | |
| DO:5.75 /79.6% mg/l | Atyidae | 8 | | | | | Veliidae/M..veliidae* | 5 | | **A** | | **A** | Muscidae | 1 | | | | |
| Cond: 35.0 mS/m | Palaemonidae | 10 | | | | | **MEGALOPTERA:** | | | | | | Psychodidae | 1 | | | | |
| **BIOTOPES SAMPLED:** | **HYDRACARINA** | 8 | | | | | Cordalidae | 8 | | | | | Simuliidae | 5 | | **A** | | **A** |
| SIC: TIME: minutes | **PLECOPTERA:** | | | | | | Sialidae | 6 | | | | | Syrphidae* | 1 | | | | |
| SOOC: | Notonemouridae | 14 | | | | | **TRICHOPTERA** | | | | | | Tabanidae | 5 | | | | |
| BEDROCK: | Perlidae | 12 | | | | | Dipseudopsidae | 10 | | | | | Tipulidae | 5 | | | | |
| AQUATIC VEG: DOM SP: | **EPHEMEROPTERA** | | | | | | Ecnomidae | 8 | | | | | **GASTROPODA** | | | | | |
| M VEG IC: DOM SP: | Baetidae 1sp | 4 | | | | | Hydropsychidae 1sp | 4 | | **1** | | **1** | Ancylidae | 6 | | | | |
| M VEG OOC: DOM SP: | Baetidae 2 sp | 6 | | | | | Hydropsychidae 2 sp | 6 | | | | | Bulininae* | 3 | | | | |
| GRAVEL: | Baetidae >2 sp | 12 | **B** | **B** | **B** | **B** | Hydropsychidae >2 sp | 12 | | | | | Hydrobiidae* | 3 | | | | |
| SAND: | Caenidae | 6 | **A** | **A** | | **B** | Philopotamidae | 10 | | | | | Lymnaeidae* | 3 | | | | |
| MUD: | Ephemeridae | 15 | | | | | Polycentropodidae | 12 | | | | | Physidae* | 3 | | | | |
| HAND PICKING/VISUAL OBS: | Heptageniidae | 13 | | | | | Psychomyiidae/Xiphocen. | 8 | | | | | Planorbinae* | 3 | **A** | **1** | | **A** |
| **FLOW**: | Leptophlebiidae | 9 | **A** | | | **A** | **CASED CADDIS:** | | | | | | Thiaridae* | 3 | | | | |
| **TURBIDITY**: | Oligoneuridae | 15 | | | | | Barbarochthonidae SWC | 13 | | | | | Viviparidae* ST | 5 | | | | |
| **RIPARIAN LAND USE:** | Polymitarcyidae | 10 | | | | | Calamoceratidae ST | 11 | | | | | **PELECYPODA** | | | | | |
| | Prosopistomatidae | 15 | | | | | Glossosomatidae SWC | 11 | | | | | Corbiculidae | 5 | | | | |
| | Teloganodidae SWC | 12 | | | | | Hydroptilidae | 6 | | | **1** | **1** | Sphaeriidae | 3 | | | | |
| | Tricorythidae | 9 | | | | | Hydrosalpingidae SWC | 15 | | | | | Unionidae | 6 | | | | |
| | **ODONATA:** | | | | | | Lepidostomatidae | 10 | | | | | **SASS SCORE:** | | 62 | 85 | 41 | 112 |
| **DISTURBANCE IN RIVER:** | Calopterygidae ST,T | 10 | | | | | Leptoceridae | 6 | | | | | **NO OF TAXA:** | | 12 | 18 | 9 | 24 |
| | Chlorocyphidae | 10 | | | | | Petrothrincidae SWC | 11 | | | | | **ASPT:** | | 5.17 | 4.72 | 4.56 | 4.67 |
| | Chlorolestidae | 8 | | | | | Pisuliidae | 10 | | | | | **IHAS**: | | 73% | | | |
| | Coenagrionidae | 4 | **1** | **A** | | **A** | Sericostomatidae SWC | 13 | | | | | **OTHER BIOTA**: | | | | | |
| | Lestidae | 8 | | | | | **COLEOPTERA:** | | | | | | | | | | | |
| **SIGNS OF POLLUTION:** | Platycnemidae | 10 | | | | | Dytiscidae* | 5 | | **A** | | **A** | **COMMENTS**: | | | | | |
| | Protoneuridae | 8 | | | | | Elmidae/Dryopidae* | 8 | | | | | | | | | | |
| | Zygoptera juvs. | 6 | | | | | Gyrinidae* | 5 | **B** | **A** | | **B** | | | | | | |
| | Aeshnidae | 8 | | **A** | | **A** | Halipidae* | 5 | | | | | | | | | | |
| | Corduliidae | 8 | | | | | Helodidae | 12 | | | | | * = airbreathers | | | | | |
| **OTHER OBSERVATIONS:** | Gomphidae | 6 | **A** | | **A** | **B** | Hydraenidae* | 8 | | | | | SWC = South Western Cape T = Tropical | | | | | |
| | Libellulidae | 4 | **A** | **1** | **A** | **B** | Hydrophilidae* | 5 | | **1** | | **1** | VG = all vegetation ST = Sub-tropical | | | | | |
| | **LEPIDOPTERA:** | | | | | | Limnichidae | 10 | | | | | GSM = gravel, sand & mud S = Stone & rock | | | | | |
| | Pyralidae | 12 | | | | | Psephenidae | 10 | | | | | 1=1, A=2-10, B=10-100, C=100-1000, D=>1000 | | | | | |

# APPENDIX E - Specialist information

## DETAILS, EXPERTISE AND CURRICULUM VITAE OF SPECIALISTS

### 1. (a) (i) Details of the specialist who prepared the report

Stephen van Staden MSc (Environmental Management) (University of Johannesburg)

### 1. (a). (ii) The expertise of that specialist to compile a specialist report including a curriculum vitae

| | | | |
|---|---|---|---|
| Company of Specialist: | Scientific Aquatic Services | | |
| Name / Contact person: | Stephen van Staden | | |
| Postal address: | 29 Arterial Road West, Oriel, Bedfordview | | |
| Postal code: | 2007 | Cell: | 083 415 2356 |
| Telephone: | 011 616 7893 | Fax: | 011 615 6240/ 086 724 3132 |
| E-mail: | stephen@sasenvgroup.co.za | | |
| Qualifications | MSc (Environmental Management) (University of Johannesburg)<br>BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg)<br>BSc (Zoology, Geography and Environmental Management) (University of Johannesburg) | | |
| Registration / Associations | Registered Natural Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)<br>Accredited River Health Practitioner by the South African River Health Program (RHP)<br>Member of the South African Soil Surveyors Association (SASSO)<br>Member of the Gauteng Wetland Forum | | |

**SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION**

**CURRICULUM VITAE OF STEPHEN VAN STADEN**

## PERSONAL DETAILS

| | |
|---|---|
| Position in Company | Managing member, Ecologist, Aquatic Ecologist |
| Date of Birth | 13 July 1979 |
| Nationality | South African |
| Languages | English, Afrikaans |
| Joined SAS | 2003 (year of establishment) |

## MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)

Accredited River Health practitioner by the South African River Health Program (RHP)

Member of the South African Soil Surveyors Association (SASSO)

Member of the Gauteng Wetland Forum

## EDUCATION

**Qualifications**

| | |
|---|---|
| MSc (Environmental Management) (University of Johannesburg) | 2002 |
| BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg) | 2000 |
| BSc (Zoology, Geography and Environmental Management) (University of Johannesburg) | 1999 |

## COUNTRIES OF WORK EXPERIENCE

South Africa – All Provinces

Southern Africa – Lesotho, Botswana, Mozambique, Zimbabwe

Eastern Africa – Tanzania

West Africa – Ghana, Liberia, Angola, Guinea Bissau

Central Africa – Democratic Republic of the Congo

## SELECTED PROJECT EXAMPLES

**Development compliance studies**

- Project co-leader for the development of the EMP for the use of the Wanderers stadium for the Ubuntu village for the World Summit on Sustainable Development (WSSD).
- Environmental Control Officer for Eskom for the construction of an 86Km 400KV power line in the Rustenburg Region.
- Numerous Environmental Impact Assessment (EIA) and EIA exemption applications for township developments and as part of the Development Facilitation Act requirements.
- EIA for the extension of mining rights for a Platinum mine in the Rustenburg area by Lonmin Platinum.
- EIA Exemption application for a proposed biodiesel refinery in Chamdor.
- Compilation of an EIA as part of the Bankable Feasibility Study process for proposed mining of a gold deposit in the Lofa province, Liberia.
- EIA for the development of a Chrome Recovery Plant at the Two Rivers Platinum Mine in the Limpopo province, South Africa.
- Compilation of an EIA as part of the Bankable Feasibility Study process for the Mooihoek Chrome Mine in the Limpopo province, South Africa.
- Mine Closure Plan for the Vlakfontein Nickel Mine in the North West Province.

**Specialist studies and project management**

- Development of a zero discharge strategy and associated risk, gap and cost benefit analyses for the Lonmin Platinum group.
- Development of a computerised water balance monitoring and management tool for the management of Lonmin Platinum process and purchased water.
- The compilation of the annual water monitoring and management program for the Lonmin Platinum group of mines.
- Analyses of ground water for potable use on a small diamond mine in the North West Province.
- Project management and overview of various soil and land capability studies for residential, industrial and mining developments.
- The design of a stream diversion of a tributary of the Olifants River for a proposed opencast coal mine.
- Waste rock dump design for a gold mine in the North West province.
- Numerous wetland delineation and function studies in the North West, Gauteng and Mpumalanga Kwa-Zulu Natal provinces, South Africa.
- Hartebeespoort Dam Littoral and Shoreline PES and rehabilitation plan.
- Development of rehabilitation principles and guidelines for the Crocodile West Marico Catchment, DWAF North West.

**Aquatic and water quality monitoring and compliance reporting**

- Development of the Resource quality Objective framework for Water Use licensing in the Crocodile West Marico Water management Area.
- Development of the Resource Quality Objectives for the Local Authorities in the Upper Crocodile West Marico Water management Area.
- Development of the 2010 State of the Rivers Report for the City of Johannesburg.
- Development of an annual report detailing the results of the Lonmin Platinum groups water monitoring program.
- Development of an annual report detailing the results of the Everest Platinum Mine water monitoring program.
- Initiation and management of a physical, chemical and biological monitoring program, President Steyn Gold Mine Welkom.
- Aquatic biomonitoring programs for several Xstrata Alloys Mines and Smelters.
- Aquatic biomonitoring programs for several Anglo Platinum Mines.
- Aquatic biomonitoring programs for African Rainbow Minerals Mines.
- Aquatic biomonitoring programs for several Assmang Chrome Operations.
- Aquatic biomonitoring programs for Petra Diamonds.
- Aquatic biomonitoring programs for several coal mining operations.
- Aquatic biomonitoring programs for several Gold mining operations.
- Aquatic biomonitoring programs for several mining operations for various minerals including iron ore, and small platinum and chrome mining operations.
- Aquatic biomonitoring program for the Valpre bottled water plant (Coca Cola South Africa).
- Aquatic biomonitoring program for industrial clients in the paper production and energy generation industries.
- Aquatic biomonitoring programs for the City of Tshwane for all their Waste Water Treatment Works.

- Baseline aquatic ecological assessments for numerous mining developments.
- Baseline aquatic ecological assessments for numerous residential commercial and industrial developments.
- Baseline aquatic ecological assessments in southern, central and west Africa.
- Lalini Dam assessment with focus on aquatic fish community analysis.
- Musami Dam assessment with focus on the FRAI and MIRAI aquatic community assessment indices.

**Wetland delineation and wetland function assessment**

- Wetland biodiversity studies for three copper mines on the copper belt in the Democratic Republic of the Congo.
- Wetland biodiversity studies for proposed mining projects in Guinea Bissau, Liberia and Angola in West Africa.
- Terrestrial and wetland biodiversity studies for developments in the mining industry.
- Terrestrial and wetland biodiversity studies for developments in the residential commercial and industrial sectors.
- Development of wetland riparian resource protection measures for the Hartbeespoort Dam as part of the Harties Metsi A Me integrated biological remediation program.
- Priority wetland mammal species studies for numerous residential, commercial, industrial and mining developments throughout South Africa.

**Terrestrial ecological studies and biodiversity studies**

- Development of a biodiversity offset plan for Xstrata Alloys Rustenburg Operations.
- Biodiversity Action plans for numerous mining operations of Anglo Platinum throughout South Africa in line with the NEMBA requirements.
- Biodiversity Action plans for numerous mining operations of Assmang Chrome throughout South Africa in line with the NEMBA requirements.
- Biodiversity Action plans for numerous mining operations of Xstrata Alloys and Mining throughout South Africa in line with the NEMBA requirements.
- Biodiversity Action plan for the Nkomati Nickel and Chrome Mine Joint Venture.
- Terrestrial and wetland biodiversity studies for three copper mines on the copperbelt in the Democratic Republic of the Congo.
- Terrestrial and wetland biodiversity studies for proposed mining projects in Guinea Bissau, Liberia and Angola in West Africa.
- Numerous terrestrial ecological assessments for proposed platinum and coal mining projects.
- Numerous terrestrial ecological assessments for proposed residential and commercial property developments throughout most of South Africa.
- Specialist Giant bullfrog (*Pyxicephalus adspersus*) studies for several proposed residential and commercial development projects in Gauteng, South Africa.
- Specialist Marsh sylph (*Metisella meninx*) studies for several proposed residential and commercial development projects in Gauteng, South Africa.
- Project management of several Red Data Listed (RDL) bird studies with special mention of African grass owl (*Tyto capensis*).
- Project management of several studies for RDL Scorpions, spiders and beetles for proposed residential and commercial development projects in Gauteng, South Africa.
- Specialist assessments of terrestrial ecosystems for the potential occurrence of RDL spiders and owls.
- Project management and site specific assessment on numerous terrestrial ecological surveys including numerous studies in the Johannesburg-Pretoria area, Witbank area, and the Vredefort dome complex.
- Biodiversity assessments of estuarine areas in the Kwa-Zulu Natal and Eastern Cape provinces.
- Impact assessment of a spill event on a commercial maize farm including soil impact assessments.

**Fisheries management studies**

- Tamryn Manor (Pty.) Ltd. still water fishery initiation, enhancement and management.
- Verlorenkloof Estate fishery management strategising, fishery enhancement, financial planning and stocking strategy.
- Mooifontein fishery management strategising, fishery enhancement and stocking programs.
- Wickams retreat management strategising.
- Gregg Brackenridge management strategising and stream recalibration design and stocking strategy.
- Eljira Farm baseline fishery study compared against DWAF 1996 aquaculture and aquatic ecosystem guidelines.

## SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

# CURRICULUM VITAE OF DIONNE CRAFFORD

### PERSONAL DETAILS

| | |
|---|---|
| Position in Company | Managing member, Ecologist, Aquatic Ecologist |
| Date of Birth | 17 October 1975 |
| Nationality | South African |
| Languages | English, Afrikaans |
| Joined SAS | 2003 (year of establishment) |

### MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)

### EDUCATION

**Qualifications**

| | |
|---|---|
| PhD Zoology (University of Johannesburg) | 2013 |
| M.Sc. Zoology Cum Laude (University of Johannesburg) | 2000 |
| B.Sc. (Hons) Zoology Cum Laude (University of Pretoria) | 1997 |
| B.Sc. Ecology (University of Pretoria) | 1996 |

### COUNTRIES OF WORK EXPERIENCE

South Africa – All Provinces

Southern Africa – Caprivi Strip (fish collections)

### SELECTED PROJECT EXAMPLES

**Aquatic and water quality monitoring and compliance reporting**

- Aquatic biomonitoring programs for several Xstrata Alloys Mines and Smelters.
- Aquatic biomonitoring programs for several Anglo Platinum Mines.
- Aquatic biomonitoring programs for African Rainbow Minerals Mines.
- Aquatic biomonitoring programs for several Assmang Chrome Operations.
- Aquatic biomonitoring programs for Petra Diamonds.
- Aquatic biomonitoring programs for several coal mining operations.
- Aquatic biomonitoring programs for several Gold mining operations.
- Aquatic biomonitoring programs for several mining operations for various minerals including iron ore, and small platinum and chrome mining operations.
- Aquatic biomonitoring programs for the City of Tshwane for all their Waste Water Treatment Works.
- Baseline aquatic ecological assessments for numerous mining developments.
- Musami Dam assessment with focus on the FRAI and MIRAI aquatic community assessment indices.