DIGBY WELLS ENVIRONMENTAL

Dagsoom Twyfelaar Coal Mining Project near Ermelo, Mpumalanga

Aquatic Biodiversity and Impact Assessment Report

Project Number:

DAG5603

Prepared for:

Dagsoom Coal Mining (Pty) Ltd

October 2019

Digby Wells and Associates (South Africa) (Pty) Ltd
Co. Reg. No. 2010/008577/07. Turnberry Office Park, 48 Grosvenor Road, Bryanston, 2191. Private Bag X10046, Randburg, 2125, South Africa
Tel: +27 11 789 9495, Fax: +27 11 069 6801, info@digbywells.com, www.digbywells.com

DIGBY WELLS ENVIRONMENTAL

This document has been prepared by Digby Wells Environmental.

Report Type:	**Aquatic Biodiversity and Impact Assessment Report**
Project Name:	**Dagsoom Twyfelaar Coal Mining Project near Ermelo, Mpumalanga**
Project Code:	**DAG5603**

Name	Responsibility	Signature	Date
Julia Ndou	Field and data collation assistant		06/09/2019
Nathan Cook Cand.Sci.Nat.	Lead specialist		08/10/2019
Byron Bester Pr.Sci.Nat.	Technical review		19/09/2019
Xanthe Taylor	Project Manager		08/10/2019

DECLARATION OF INDEPENDENCE

Digby Wells and Associates (South Africa) (Pty) Ltd

Contact person: Nathan Cook

Digby Wells House
Turnberry Office Park
48 Grosvenor Road
Bryanston
2191

Tel: 011 789 9495
Fax: 011 789 9498
E-mail: Nathan.cook@digbywells.com

I, Nathan Cook as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of Dagsoom Coal Mining (Pty) Ltd, other than fair remuneration for work performed.

N Cook

Full Name:	Nathan Cook
Title/ Position:	Aquatic Ecologist
Qualification(s):	BSc Hons Aquatic Ecosystem Health
Experience (Years):	3
Registration(s):	Cand.Sci.Nat (Reg. no. 119160)

EXECUTIVE SUMMARY

Digby Wells Environmental has been appointed by Dagsoom Coal Mining (Pty) Ltd to aid in the Mining Right Application and National Environmental Management Act, 1998 (Act No. 107 of 1998) Application Process for the proposed Twyfelaar Coal Mine situated approximately 6 km from the town of Sheepmoor in Mpumalanga, South Africa.

This document serves as the Aquatic Specialist Study for the proposed Project. The goal of the Aquatic Study was to describe the baseline conditions within the aquatic ecosystems associated with the Project and proposed surface infrastructure prior to the commencement of construction activities. Foreseeable aquatic related impacts were also identified and appropriate mitigation measures were provided for the preservation of the assessed aquatic ecosystems.

The main aquatic ecosystem of focus in the Aquatic Study is the Sandspruit (SQR W53A-01757). This watercourse drains along the southern most boundary of the MRA before passing the town of Sheepmoor and merging with the larger Ngwempisi River. The aquatic ecosystems within the MRA consist of smaller, non-perennial drainage lines and channeled wetland ecosystems, some of which are situated directly within the footprint of the proposed surface infrastructure. All of these considered "smaller" aquatic ecosystems drain into the Sandspruit SQR of concern. Sampling sites were selected based on the location of the infrastructure, the MRA and areas suspected to inhabit sensitive/conservational important aquatic species.

The timing of the aquatic survey coincided with the dry season for the Study Area which consists of all sampling sites and aquatic ecosystems, even those considered outside of the MRA. As a result, aquatic conditions were observed to be deteriorated in terms of connectivity and water levels. Aquatic habitat, as indicated by the determined IHAS scores, also appear to be severely influenced by the dry conditions of the assessed watercourses. The recorded aquatic biota within the MRA reflected the poor aquatic conditions by being present in low diversity and sensitivity. The ecological health indices utilised during the baseline determination also reflected modified/poor conditions for the aquatic ecosystems within the MRA.

However; some sensitive macroinvertebrate families were present within the MRA. This indicated that the associated aquatic ecosystems do have the capacity to support sensitive life and should be conserved irrespective of the modified ecological outcomes expressed in the Aquatic Study. Furthermore, highly sensitive aquatic species (i.e. both macroinvertebrates and fish) were present within the lower reaches of the Sandspruit which, as aforementioned, has several adjoining watercourses draining from the proposed MRA. The conservation important fish species *Chiloglanis emarginatus* (i.e. listed as Vulnerable according to the International Union for Conservation of Nature) was also present in fair abundance for the dry season in the lower Sandspruit confluence with the Ngwempisi River. Therefore, water emanating from the MRA needs to be of good quality and quantity as to not impact on the critically sensitive and important downstream aquatic life.

The surface related impacts associated with the Project were determined to be Minor for the larger downstream aquatic ecosystems. These findings could however be largely skewed due to the dry conditions during the Aquatic Study. This was seen to limit the amount of aquatic data available for collection which could also have provided false pretence during the Impact Assessment Phase.

Aquatic related mitigation measures have been provided for in the Aquatic Study which are expected to conserve the determined baseline conditions. It must be noted that conditions during the wet season have only been assumed for inclusion of the provided measures. An aquatic survey should be conducted during the wet season for the Study Area (i.e. November to March) in attempt to more accurately describe the aquatic conditions within the MRA and to account for expected increased water levels and flow within the associated aquatic ecosystems.

An Aquatic Biomonitoring Programme has also been developed for the duration of the Project. This programme is aimed at better determining the ecological health of the ecosystems as well as to act as an early detection tool for impacts that might severely affect the identified sensitive and conservation important species in the Study Area and especially in the lower reaches of the Sandspruit. The Project should not commence unless the Aquatic Biomonitoring Programme is adopted into the Environmental Management Plan for the Project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

ASPT	Average Score Per Taxa
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
FRAI	Fish Response Assessment Index
IHI	Index for Habitat Integrity
IHAS	Integrated Habitat Assessment System
MIRAI	Macroinvertebrate Response Assessment Index
MPRDA	Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)
MRA	Mining Rights Area
MTIS	Mineable tonnes in-situ
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NFEPA	National Freshwater Ecosystem Priority Area
PCD	Pollution Control Dam
PES	Present Ecological State
SASS5	South African Scoring System version 5
SQR	Sub-Quaternary Reach
WMA	Water Management Area

1 Introduction

Digby Wells Environmental (hereinafter Digby Wells) has been appointed by Dagsoom Coal Mining (Pty) Ltd (hereinafter Dagsoom) to aid in the Mining Right Application and National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) Application Process for the proposed Twyfelaar Coal Mine (hereinafter the Project) situated approximately 6 km from the town of Sheepmoor in Mpumalanga, South Africa.

To satisfy the above application processes, various Environmental Impact Assessment (EIA) studies were undertaken by Digby Wells. This document serves as the specialist assessment pertaining to the natural aquatic ecosystems associated with the Project (hereinafter the Aquatic Study).

1.1 Key Objectives

The main aim of the Aquatic Study is to describe the baseline conditions of the aquatic ecosystems/natural watercourses associated with the Project prior to commencement of any mine related activities or construction. Therefore, to enable an adequate description of the representative status of the aquatic biodiversity within the aquatic ecosystems associated with the Project, the following indicators were evaluated:

- Stressor Indicators:
  - *In situ* water quality.
- Habitat Indicators:
  - Instream and riparian habitat conditions; and
  - Instream biotope availability for aquatic macroinvertebrates.
- Response Indicators:
  - Aquatic macroinvertebrates assemblages; and
    - Ichthyofaunal assemblages.

The above indicators are assessed holistically using the EcoClassification method (Kleynhans and Louw, 2008) to determine the Present Ecological State (PES) of the associated aquatic ecosystems. This provides an indication of the health or integrity of the assessed watercourses as well as insight to the sources of deviation of the PES from natural conditions for each aquatic ecosystem. A detailed description of each index/approach utilised in the baseline description and EcoClassification has been outlined in Appendix A.

Furthermore, potential aquatic-related impacts were identified/predicted and rated utilising the Digby Wells Impact Assessment methodology (see Appendix A). Mitigation measures have also been provided were applicable together in attempt to preserve the associated aquatic ecosystems. An Aquatic Biomonitoring Programme has also been developed which will allow for early identification of impacts, if any, throughout the Project life, aiding in decisions making and conservation/preservation efforts.

2 Details of the Specialist

This Aquatic Specialist Report has been compiled by the following specialists.

Table 2-1: Details of the specialist(s) who prepared this report

Responsibility	**Lead Specialist and Report Compiler**
Full Name of Specialist	Nathan Gerard Cook
Highest Qualification	BSc Hons in Aquatic Ecosystem Health
Years of experience in specialist field	3
Registration	South African Council for Natural Scientific Professionals: *Candidate Natural Scientist* (Reg. No. 119160)
Responsibility	**Technical Reviewer**
Full Name of Specialist	Byron Mathew Bester
Highest Qualification	MSc in Aquatic Health
Years of experience in specialist field	8
Registration	South African Council for Natural Scientific Professionals: *Professional Natural Scientist* (Reg. No. 400662/15)

2.1 Declaration of the Specialist

I, Nathan Cook, as the appointed specialist hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent:
  - other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity; or
  - am not independent, but another specialist that meets the general requirements set out in Regulation 13 have been appointed to review my work (Note: a declaration by the review specialist must be submitted);
- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
- have disclosed/will disclose, to the applicant, the Department and interested and affected parties, all material information that have or may have the potential to influence the decision of the Department or the objectivity of any report, plan or document prepared or to be prepared as part of the application;

- have ensured/will ensure that information containing all relevant facts in respect of the application was/will be distributed or was/will be made available to interested and affected parties and the public and that participation by interested and affected parties was/will be facilitated in such a manner that all interested and affected parties were/will be provided with a reasonable opportunity to participate and to provide comments;
- have ensured/will ensure the inclusion of inputs and recommendations from the specialist reports in respect of the application, where relevant; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA/EIA Regulations.

Signature of the specialist

Nathan Gerard Cook

Full Name and Surname of the specialist

Digby Wells Environmental

Name of company

12/09/2019

Date

2.2 Conditions of this Report

Findings, recommendations and conclusions provided in this report are based on the best available scientific methods and the author's professional knowledge and information at the time of compilation. Digby Wells employees involved in the compilation of this report, however, accepts no liability for any actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, and by the use of the information contained in this document.

No form of this report may be amended or extended without the prior written consent of the author and/or a relevant reference to the report by the inclusion of an appropriately detailed citation.

Any recommendations, statements or conclusions drawn from or based on this report must clearly cite or make reference to this report. Whenever such recommendations, statements or conclusions form part of a main report relating to the current investigation, this report must be included in its entirety.

3 Project Description

Dagsoom was the holder of a Prospecting Right for coal on the Farm Twyfelaar 298IT which is situated on the eastern escarpment of the Mpumalanga Highveld in the Ermelo Coal field (Figure 3-1). Dagsoom has applied for a Mining Right in terms of the Minerals and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA).

The coal resource is sub-outcropping on the east and southern side of the hill intended for mining (i.e. Block A). There are numerous wetlands and hillside seepage areas around this hill and most of the potential opencast mineable resources are sterilised. The mine will therefore be an underground mine with all infrastructure around the mine access area on the eastern side of the Mining Rights Area (MRA) on the farm Twyfelaar 298IT. It is proposed that the impact of the underground mine on the environment will be limited and contained to the mine access area where all surface activities are concentrated. However, the potential of surface runoff from this area is still probable and could result in deterioration of the associated aquatic ecosystems.

The C-Seam and, in particular, the C-Lower seam, is the only seam that occurs at mineable thickness (>1.4 m for Continuous Miners) over the MRA. There is a sandstone and shale parting of more than 3 meters that separates the C-Upper and C-Lower seams and no opportunity exists for these seams to be mined together as per the case at other mines in the area. In addition, no faults or dykes were discovered during the exploration phase and bord and pillar mining with continuous miners as the preferred mining option.

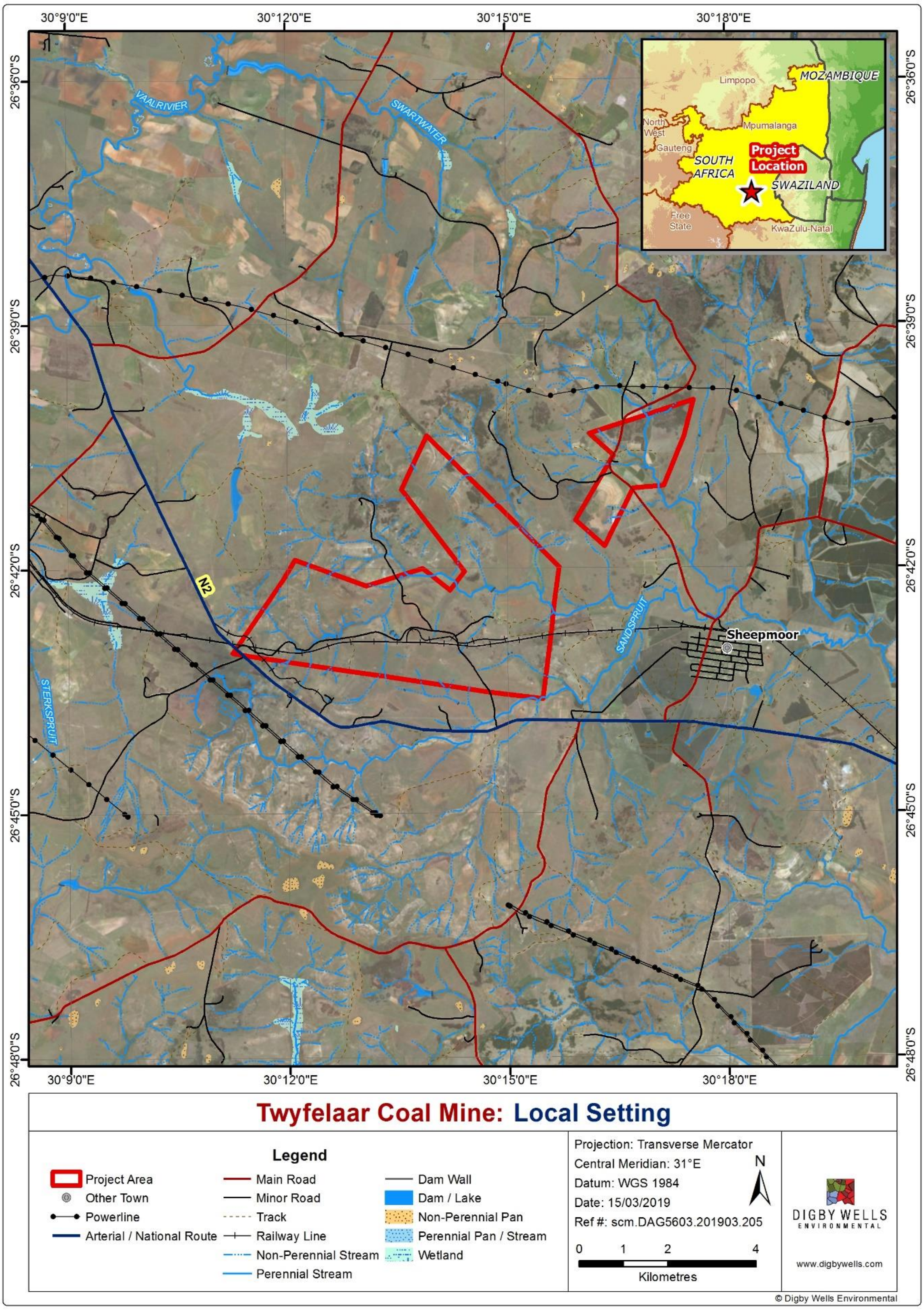

Figure 3-1: Local setting of the proposed Project

3.1 Proposed Infrastructure and Activities

A list of the proposed infrastructure associated with the Project is provided for below:

- Underground Mine accessed by adit. Boxcut will produce limited rock dump;
- Access and haulage road – Maximum 9.6m wide, maximum 6km long;
- Adit – Grassland no other vegetation;
- Two ventilation fans;
- Processing plant;
- Pollution Control Dam (PCD; volumetric capacity of approximately 5 500 m^3 and measures 40x35x4 m);
- Raw water pump station and process water pump station;
- Pipelines:
  - Both pipelines are 2 inch HPDE. Maximum requirement 22.1 m3/h;
  - Raw water pipeline = 1.49 km (traverses two watercourses and road);
  - Process water pipeline;
- Electricity supply – 22kV line 2.3 km long;
- Potable water treatment plant and associated tanks;
- Sewage treatment plant;
- Reverse Osmosis plant;
- 2 x change houses;
- Offices and ablutions;
- Workshops and cable workshop;
- Refuel bay;
- Weighbridge and weighbridge control room;
- Access control office.

The various phases and associated activities for the Project are highlighted in Table 3-1.

Table 3-1: Project phases and associated activities

Project Phase	Project Activity
Construction Phase	Site/vegetation clearance
	Access and haul road construction
	Infrastructure construction
	Power line construction
	Diesel storage and explosives magazine
	Topsoil stockpiling
Operational Phase	Removal of rock (blasting)
	Stockpiling (rock dumps, soils, ROM, discard dump) establishment and operation
	Diesel storage and explosives magazine
	Operation of the underground workings
	Operating processing plant
	Operating sewage treatment plant
	Water use and storage on-site – during the operation water will be required for various domestic and industrial uses. Dams will be constructed that capture water from the mining area which will be stored and used accordingly
	Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste
	Maintenance activities – through the operations maintenance will need to be undertaken to ensure that all infrastructure in operating optimally and does not pose a threat to human or environmental health. Maintenance will include haul roads, pipelines, processing plant, machinery, water and stormwater management infrastructure, stockpile areas
Decommissioning Phase	Demolition and removal of infrastructure – once mining activities have been concluded infrastructure will be demolished in preparation of the final land rehabilitation.
	Rehabilitation – rehabilitation mainly consists of spreading of the preserved subsoil and topsoil, profiling of the land and re-vegetation
	Post-closure monitoring and rehabilitation

4 Desktop Aquatic Information

The proposed MRA is situated within the W53A quaternary catchment in the Inkomati-Usuthu Water Management Area 3 (WMA 3). According to the Department of Water and Sanitation (DWS, 2014), the major watercourse associated with the proposed Project and MRA appears to be the Sandspruit; (Sub-Quaternary Reach (SQR) W53A-01757). This watercourse is a first order stream, approximately 33.08 km in length, which drains from west to east along the southern boundary of the MRA. The MRA also consists of numerous non-perennial drainage lines, including a number located above the targeted coal footprint, which report to the Sandspruit before the town of Sheepmoor (Figure 4-1). Additionally, there is a large unclassified drainage line (DWS, 2014) which intersects the southern MRA, south of the proposed surface infrastructure location. This watercourse also reports to the Sandspruit further downstream. Therefore, aquatic-related data recorded in the Sandspruit is the focus for the desktop aquatic baseline findings.

4.1 Desktop Present Ecological Status, Importance and Sensitivity

Table 4-1 outlines the desktop aquatic related data obtained for the Sandspruit W53A-01757 SQR (DWS, 2014). Figure 4-1, below, displays the potentially affected watercourses and Sandspruit.

Table 4-1: Desktop aquatic data pertaining to the Sandspruit

SQR Code/Aquatic Component	W53A-01757
Ecological Category	B
Category Description	Largely natural
Ecological Importance	High
Ecological Sensitivity	Very high

According to the desktop data obtained for the Sandspruit W53A-01757 SQR (DWS, 2014), the reach appears to be in a largely natural state; (Ecological Category B. Limited land use is present in the upper reaches of the Sandspruit associated with the Project. However, impacts such as road crossings; instream dam construction; alien invasive plant species; urban encroachment; extensive forestry in the lower reaches; and the draining of wetlands are affecting the current aquatic ecology associated with the Sandspruit (DWS, 2014).

The Ecological Importance (EI) of the Sandspruit SQR has been classified as “High”. It is expected to contain a total of 61 macroinvertebrate taxa as well as a total of 11 indigenous fish species, two of which are of conservation importance (DWS, 2014). Additionally, the quaternary catchment is expected to inhabit the endemic and vulnerable plant species *Eugenia simii* (River Myrtle) which is mainly found in the KwaZulu-Natal Province of South Africa (Victor *et. al*., 2005). The Ecological Sensitivity (ES) for the SQR has been classified as “Very high”. This, from an instream perspective, is mainly due to the large number of highly sensitive macroinvertebrate and fish species expected in the Sandspruit.

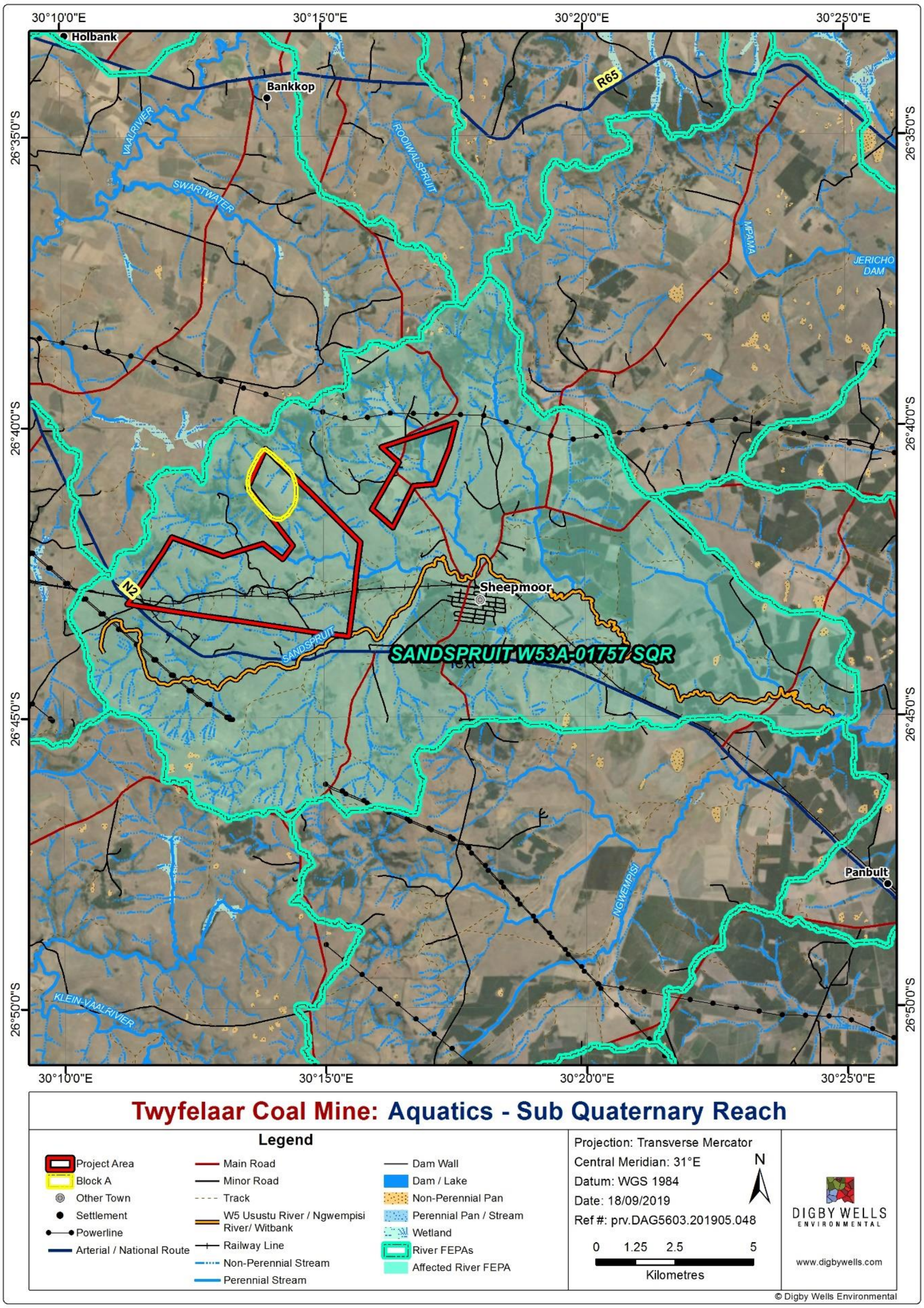

Figure 4-1: Potentially affected watercourses associated with the Project

4.1.1 Expected Macroinvertebrates

The expected macroinvertebrate taxa of concern for the Sandspruit SQR are presented in Table 4-2.

Table 4-2: Expected macroinvertebrate taxa in the Sandspruit

Family names		
Porifera	Belostomatidae	Hydrophilidae
Turbellaria	Corixidae	Psephenidae
Oligochaeta	Gerridae	Athericidae
Potamonautidae	Hydrometridae	Blephariceridae
Atyidae	Naucoridae	Ceratopogonidae
Hydracarina	Nepidae	Chironomidae
Baetidae	Notonectidae	Culicidae
Caenidae	Pleidae	Dixidae
Heptageniidae	Veliidae	Muscidae
Oligoneuridae	Ecnomidae	Simuliidae
Leptophlebiidae	Hydropsychidae	Tabanidae
Polymitarcyidae	Philopotamidae	Tipulidae
Prosopistomatidae	Polycentropodidae	Ancylidae
Tricorythidae	Hydroptilidae	Bulininae
Chlorocyphidae	Leptoceridae	Lymnaeidae
Ceonagrionidae	Dytiscidae	Planorbinae
Lestidae	Elmidae	Corbiculidae
Aeshnidae	Gyrinidae	Sphaeriidae
Gomphidae	Haliplidae	Unionidae
Libellulidae	Helodidae	
Crambidae	Hydraenidae	

Green: High physio-chemical sensitivity; **Blue**: Indicates high velocity dependence; **Orange**: Both high physio-chemical sensitivity and velocity dependence.

Of the 61 expected macroinvertebrate taxa, 13 have been classified as highly sensitive with regards to water quality and velocity/flow dependence (DWS, 2014). Of the 13 taxa, two are regarded as sensitive towards water quality changes, five to lack of flow sensitivity and six sensitive towards both physio-chemical changes and no flow conditions.

Based on the lack of land use in the adjacent land associated with the MRA, the water in the associated aquatic ecosystems is expected to be of natural/good quality (DWS, 2014;

Wolmarans, 2014). As a result, it is suspected that the watercourses associated with the Project will be able to inhabit macroinvertebrate taxa sensitive towards water quality, such as Helodidae and numerous Baetidae species. However, due to the number of non-perennial watercourses in the MRA, the flow dependant macroinvertebrate taxa are expected to be restricted to the Sandspruit alone and potentially limited in its adjoining tributaries when flow permits (see 6.3; Macroinvertebrate Assessment for in field findings/discussion).

4.1.2 Expected Fish Species

The fish species expected in the Sandspruit SQR have been provided for in Table 4-3 (DWS, 2014; IUCN, 2018; Skelton, 2001). Additionally, each species sensitivity ratings towards physio-chemical and no-flow conditions (DWS, 2014) have been provided for together with their conservation status according to the IUCN Red List of Threatened Species.

Table 4-3: Expected fish species in the Sandspruit

Fish Species	Common Name	Tolerance (1-2=tolerant; >4-5=intolerant)		Conservation Status
		Physio-chemical	No-flow	
Anguilla mossambica	African Longfin Eel	2.5	2.8	LC
Amphilius uranoscopus	Common Mountain Catfish	**4.8**	**4.8**	LC
Chiloglanis anoterus	Pennant-tailed Suckermouth	**4.7**	**4.8**	LC
Chiloglanis emarginatus	Phongolo Suckermouth	**5.0**	**5.0**	V
Clarias gariepinus	African Catfish	1.0	1.7	LC
Enteromius anoplus	Chubbyhead Barb	2.6	2.3	LC
Enteromius brevipinnis	Shortfin Barb	**4.1**	**4.1**	NT
Enteromius crocodilensis	Rosefin Barb	**4.1**	**4.6**	LC
Enteromius paludinosus	Straightfin Barb	1.8	2.3	LC
Labeobarbus maraquensis	Largescale Yellowfish	2.1	3.2	LC
Labeobarbus polylepis	Smallscale Yellowfish	2.9	3.3	LC
Pseudocrenilabrus philander	Southern Mouthbrooder	1.4	1.0	LC
Tilapia sparmanii	Banded Tilapia	1.4	0.9	NA
LC=Least Concern; NT=Near Threatened; V=Vulnerable; NA=Not Assessed				

Five of the 11 expected fish species are regarded as highly sensitive towards water quality and no-flow conditions. Three of these species are catfishes, one belonging to the Amphilidae family (i.e. *Amphilius uranoscopus*) and the other two to the Mochokidae family (i.e. *Chiloglanis anoterus* and *Chiloglanis emarginatus*). These small catfish species are rheophilic species which live in fast flowing streams and rivers with cobbles acting as the substrate. Satellite imagery of the MRA and its associated watercourses however do not reflect the availability of such habitat. Therefore, it is of low confidence that these species are present in the Sandspruit and more likely occur in the lower reaches. The remaining two sensitive fish species belong to the Cyprinidae family (i.e. *Enteromius argenteus* and *Enteromius brevipinnis*). Both these species also inhabit fast flowing waters where *E. brevipinnis* requires vegetation types such as undercut banks, root stocks and marginal vegetation rather than cobbles. According to DWS (2014), it is highly likely that these two species are present in the Sandspruit SQR..

4.1.2.1 Fish species of conservation importance

As mentioned, two of the expected fish species are of conservation importance. A summary of these species and major impacts associated with them have been outlined below.

***Chiloglanis emarginatus*:**

C. emarginatus has been listed as Vulnerable (IUCN, 2018). A major impact resulting in the decline of this species includes coal mining and associated pollution and increased sedimentation in aquatic ecosystems (Roux and Hoffman, 2018). Additionally, habitat degradation caused by over abstraction and sedimentation from agro-forestry activities are also contributing to this species decline (Roux and Hoffman, 2018).

***Enteromius brevipinnis*:**

E. brevipinnis has been listed as Near Threatened (IUCN, 2018). This species is on the decline mainly as a result of habitat deterioration, especially due to upstream activities such as sedimentation caused by forestry activities (Engelbrecht *et al*., 2017). Predation by alien fish species like trout and bass (i.e. Salmonidae spp. and *Micropterus* spp.) and the effects from dams and water abstraction are also contributing to the decline of the *E. brevipinnis* population in Southern Africa (Engelbrecht *et al*., 2017). It must however be noted that the MRA and Sandspruit SQR of concern do not fall within the IUCN distribution for this species. Although, the IUCN distribution of the similar looking species *E. viviparus* does align with the MRA. It is possible that misidentification could have occurred between the two species as well as between *E. anoplus*. Therefore, this species does not form part of the baseline assessment.

4.2 Assessed Aquatic Ecosystems

As mentioned, the Sandspruit is of focus for the Aquatic Study whereby preservation of this reach should be prioritised. There are two main unclassified tributaries draining from the MRA into the Sandspruit which, for the purpose of the Study, have been named as the Northern Tributary and the Southern Tributary. These watercourses were assessed in this Aquatic Study and are described below with their monitoring points described in Table 4-4 and presented in relation to the proposed infrastructure in Figure 4-2 (see Appendix B for Site Photographs).

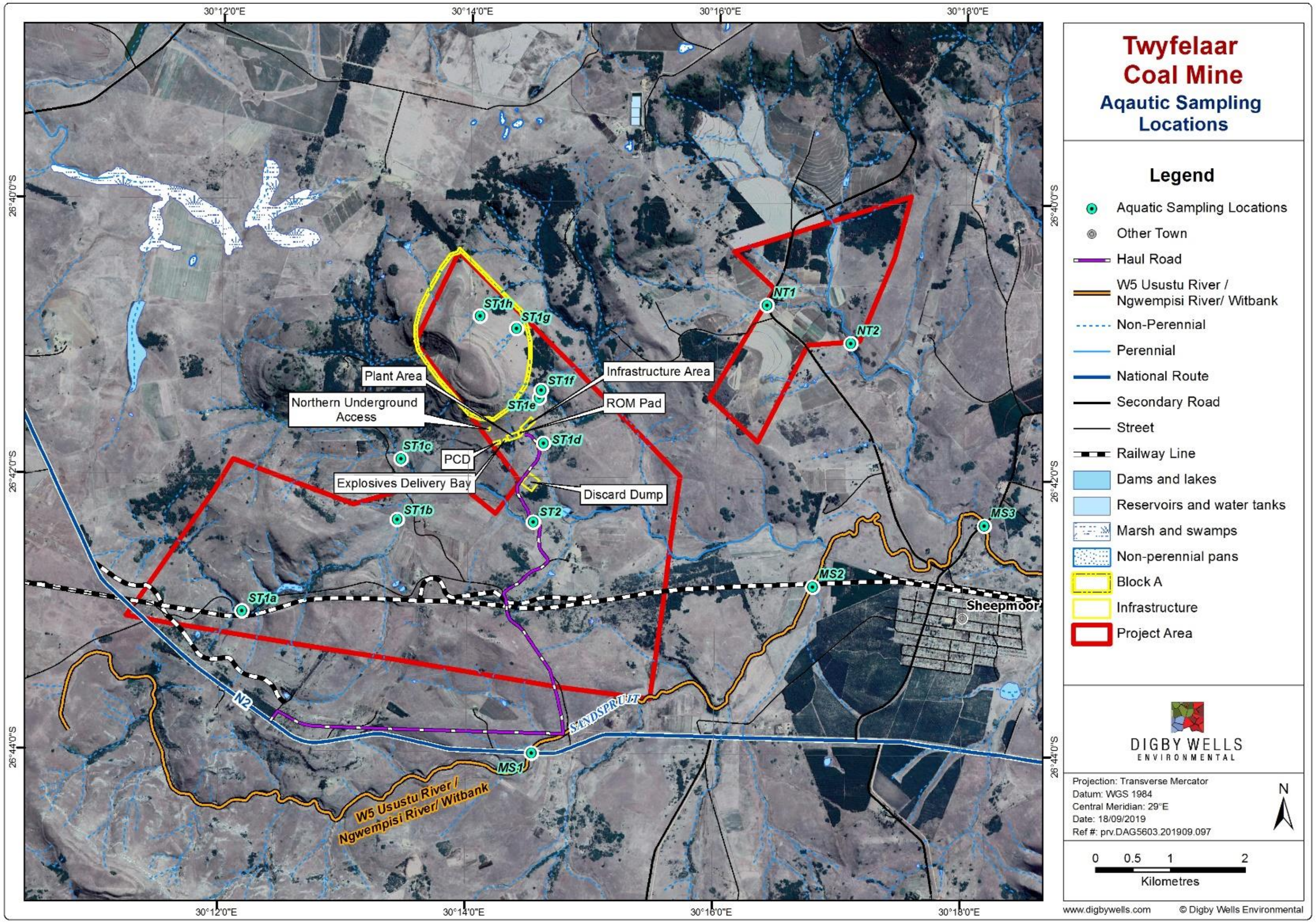

Figure 4-2: Sampling site localities in relation to the tributaries and infrastructure of concern

- **Northern Tributary**: This watercourse is located north east of the Southern Tributary and is associated with the northern portion of the Project. Currently, a large farm surrounds both sides of this tributary within the MRA as well as smaller farmlands to the south of the MRA before it merges with the Sandspruit.
- **Southern Tributary**: This watercourse is located to the north of the Sandspruit in the centre of the southern MRA portion. Numerous tributaries and drainage lines associated with the proposed Block A enter this tributary before it merges with the Sandspruit, east of the southern MRA portion. The upper reaches of this watercourse represent typical riverine conditions whereas the lower reaches, associated with the eastern portion of the MRA, represent typical channelled wetland ecosystems.
- **Sandspruit**: The Sandspruit River originates outside the MRA in proximity to its south western end. It flows for approximately 8.6 km before entering the south eastern corner of the MRA and then continues to flow past the town of Sheepmoor before merging with the larger Ngwempisi River.

Table 4-4: Coordinates and Descriptions of the Selected Monitoring Sites

Site Code	Coordinates	Description
Northern Tributary		
NT1	26°40'44.58"S 30°16'23.83"E	This site was selected as an upstream reference site for the Northern Tributary although the sampled area fell within the MRA during assessment. The sampled area is situated downstream from the associated road crossing and reflects more of a typical wetland site with a deep, muddy channel and grassy banks.
NT2	26°41'00.78"S 30°17'04.54"E	This site is located just outside of the north eastern portion of the MRA and consists of a shallow stream flowing through the current farm boundary. Large amounts of debris and gravel was available during sampling.
Southern Tributary		
ST1a	26°42'59.74"S 30°12'10.83"E	This site is in the south western corner of the MRA at a concrete bridge crossing. The river was flowing in a shallow channel upstream from the crossing into a deep pool after the crossing. Large amounts of algae were visible in the upper section with the lower section consisting mainly of cobbled and gravel substrate after the pool.
ST1b	26°42'19.22"S 30°13'25.68"E	This site is downstream from Site ST1a along a tributary of the main Southern Tributary stem. At the time of the survey, now flow was observed from the muddy pool which was sampled for the site.
ST1c	26°41'52.90"S 30°13'27.22"E	This site is situated outside of the MRA to the west of the proposed location of Block A. It is situated within a channelled bedrock drainage line which only had isolated pools available for sampling during the survey. The aim of this site was to serve as a reference site for the

Site Code	Coordinates	Description
		Southern Tributary but also can act as a detection source for impacts originating from the western end of Block A.
ST1d	26°41'45.51"S 30°14'36.18"E	These sites all consist of drainage lines from the proposed Block A area. Most of the sites were observed as dry during the survey except for small pools found at Site ST1e and ST1h. Not much land use was visible in this area, although signs of livestock was noted at most of the sites. The water draining from these sites is expected to be of good quality which was further supported by the results from the assessed pools. The riparian vegetation at these sites are dominated by alien invasive Wattle species (i.e. *Acacia mearnsii*). Additionally, these sites are only expected to contain water/flow during the rainy season for the Study Area.
ST1e	26°41'25.82"S 30°14'34.02"E	
ST1f	26°41'22.42"S 30°14'34.91"E	
ST1g	26°40'55.72"S 30°14'22.63"E	
ST1h	26°40'50.41"S 30°14'04.98"E	
ST2	26°42'19.78"S 30°14'31.55"E	This site was selected to gauge the conditions of the tributary within the mid-range of the reach. It was however observed dry during the survey with a large presence of cattle around the site.
Sandspruit		
MS1	26°44'00.42"S 30°14'31.88"E	This site was selected as a reference site for the Sandspruit, although it was dry during the survey. It is dominated by bedrock and what appears to be undercut banks should the water levels rise at the site.
MS2	26°42'46.94"S 30°16'47.23"E	Site MS1 was replaced with this site which is situated above the point where the Southern Tributary merges into the Sandspruit. It is located under a railway crossing and consists of a deep channelled watercourse, dominated by sandy substrate and was observed to be slowly flowing during the survey.
MS3	26°42'19.75"S 30°18'10.14"E	This site serves to act as an end point monitoring site for the Project as it is located downstream from where both the Northern and Southern Tributaries merge with the Sandspruit. It is located at a road crossing which is suspected to have contributed to the fair number of cobbles available for sampling at the site. It is also dominated by sandy substrate and had limited flow during the survey.
MS DWN	26°45'20.97"S 30°26'22.87"E	This site was selected to determine whether the identified fish species of concern were present within the lower reaches of the Sandspruit. It is located downstream from where the Sandspruit and the Ngwempisi River merge. It is dominated by cobbles and gravelled substrate within decent flowing sections for the dry season.

5 Limitations to Study

During the proposal phase of the Project, it was recommended that the Aquatic Study should take place during the wet season associated with the Study Area. However, due to the limited time allowed during the EIA application process, the survey was scheduled forward to take place during the month of August 2019. According to rainfall data gathered from World Weather Online, the town of Sheepmoor only received a total of 7.2 mm of rainfall during the three months leading up to August (i.e. May-July). Additionally, the months from December 2018 to March 2019 received the highest rainfall since 2010. This could have resulted in a "flushing like effect" of the associated aquatic ecosystems, which consequently, followed by the extreme low rainfall period prior to the August survey, could have negatively affected the aquatic ecology within the ecosystems. This should be considered when interpreting the ecological findings determined for the Study Area, as it is most likely that conditions are deteriorated/below the norm.

Figure 5-1 displays the rainfall trend for the province of Mpumalanga (DWS, 2019). This serves to outline the general dry conditions expected for the province and thus, Study Area. Reference conditions required by the various EcoClassification indices utilised in the Aquatic Study have been altered in attempt to align with the dry conditions of the aquatic ecosystems.

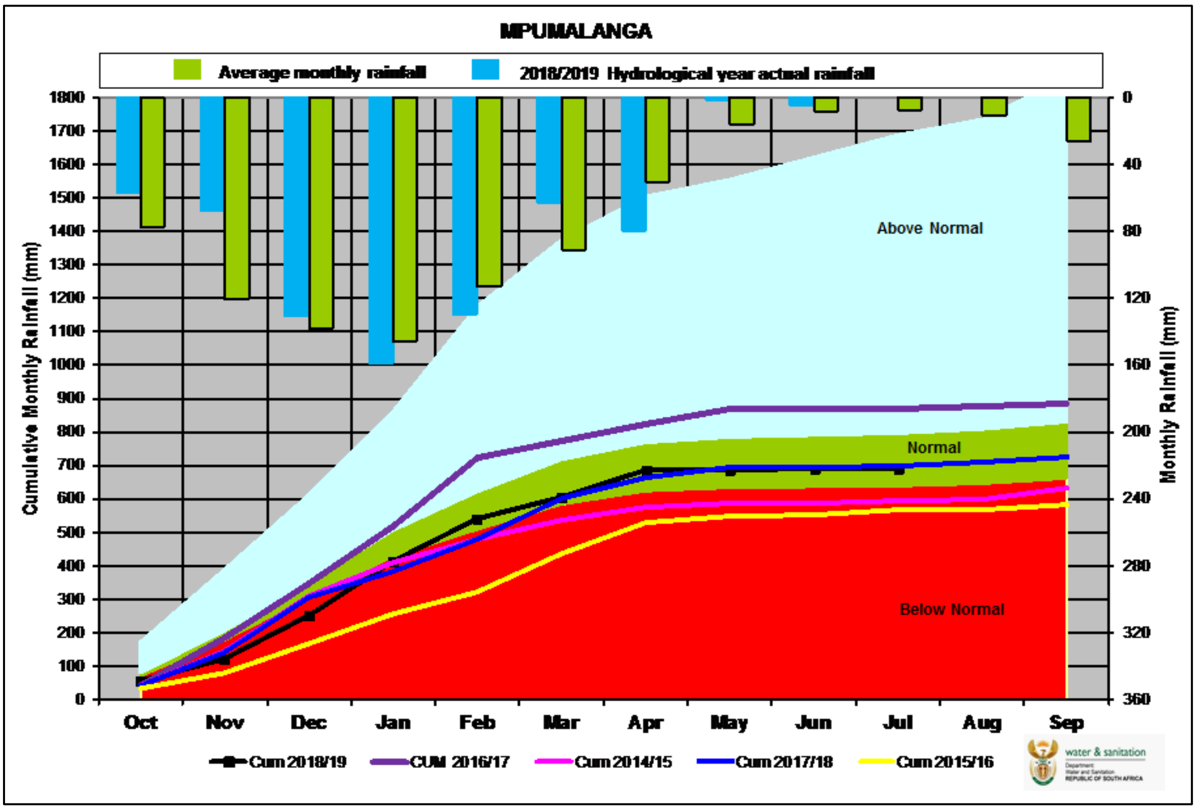

Figure 5-1: Annual Rainfall Trend for the Mpumalanga Province (DWS, 2019)

6 Findings and Discussion

The aquatic baseline findings for the August 2019 survey have been detailed in the respective subsections below.

6.1 *In-situ* Water Quality

The results of the in situ water quality assessment are provided in Table 6-1 for the Northern Tributary and Sandspruit and in Table 6-2 for the Southern Tributary.

Table 6-1: Water quality results recorded within the Northern Tributary and Sandspruit

Site	NT1	NT2	MS1	MS2	MS3	MS DWN	Guideline Values
Temperature (˚C)	21.7	22.1	DRY	21.3	17.3	22.5	-
pH	**8.43**	7.94		**8.03**	**8.54**	**8.55**	6-8
Conductivity (µS/cm)	65.7	144		167	183	143	<500
Red values indicate constituents exceeding recommended guidelines for aquatic life							

The overall *in-situ* findings recorded for the assessed Sandspruit and Northern Tributary reaches were fair despite the slightly elevated pH findings. It is suspected that agricultural influences (i.e. nutrient runoff from crops and livestock) might be altering the pH in the aquatic ecosystems. Farmlands and livestock were observed throughout the survey in proximity to most of the monitoring sites. On the contrary, the conductivity recorded in the assessed monitoring sites was low, indicating low dissolved solids content within the ecosystems. Dissolved solids concentration is one of the most influential water quality variables on aquatic biotic community structures (Dallas & Day, 2004). Therefore, the water quality within the Northern Tributary and Sandspruit appears suitable for the colonisation of sensitive aquatic biota.

Table 6-2: Water quality results recorded within the Southern Tributary

Site	ST1a	ST1b	ST1c	ST1d	ST1e	ST1f	ST1g	ST1h	ST2	Guideline Values
Temperature (˚C)	18.2	24.6	27.6	DRY	21.6	DRY	DRY	19.1	DRY	-
pH	**8.92**	**8.61**	**8.56**		7.82			7.98		6-8
Conductivity (µS/cm)	416	360	287		203			117		<500
Red values indicate constituents exceeding recommended guidelines for aquatic life										

The *in-situ* water quality determined within the Southern Tributary, especially in the western tributaries of the main stem (i.e. Sites ST1a to ST1c) appeared slightly deteriorated in comparison to the Northern Tributary and Sandspruit conditions. These sites exhibited slightly elevated pH levels and relatively high conductivity for the Study Area (i.e. > 250 µS/cm). Sensitive aquatic biota might not as be prevalent in this watercourse in comparison to the Sandspruit or Northern Tributary.

6.2 Index for Habitat Integrity

The Index for Habitat Integrity (IHI) was completed on a desktop level for each aquatic ecosystem considered in the Study and populated with observations recorded during the field survey.

Table 6-3: Index for Habitat Integrity for the Northern Tributary

Assessed Reach	Habitat Component	IHI Score	Ecological Category
Northern Tributary	Instream	61.73	C
	Riparian	52.42 (14+9)*	D
Southern Tributary	Instream	64.76	C
	Riparian	62.17 (6+14)*	C
Sandspruit	Instream	78.76	C/B
	Riparian	77.40 (5+8)*	C/B

*Values in brackets represent the ratings for vegetation removal and alien invasive vegetation encroachment respectively used in the riparian Ecological Category surrogate during EcoClassification

The findings from the IHI assessments conducted indicate that the habitat components ranged from largely modified/Ecological Category D to almost minimally modified conditions (i.e. Ecological Category B) within the Study Area. Findings for the habitat of each assessed aquatic ecosystem have been discussed separately below:

6.2.1 Northern Tributary

The instream habitat for the Northern Tributary has been classified as moderately modified/Ecological Category C. The main modifications to the assessed reach are of agricultural origin. Water abstraction, flow modification and inundation as a result of the farming practices in the upper reaches of this system appear to be the major impacts pertaining to the above categorisation. Surprisingly, flow was still visible downstream from the MRA, indicating some form of integrity/connectivity despite the farm dams and abstraction upstream.

The riparian habitat was categorised as largely modified/Ecological Category D due largely to vegetation removal and inundation impacts associated with the reach. Farmlands have replaced and encroached on pre-existing habitat, resulting in a loss of riparian species. Additionally, damming of the system has resulted in inundation of mainly the upper reaches. It appears that this has also resulted in a replacement of typical woody riparian plant species to more wetland suited grass species.

6.2.2 Southern Tributary

The instream and riparian habitat assessed for the Southern Tributary were both categorised as moderately modified/Ecological Category C. Like the impacts associated with the Northern Tributary, it appears that agricultural influence in the catchment has contributed largely to these categorisations. Farm dams along the Southern Tributary have inundated various sections of the reach and have also altered the natural flow of the system. No connectivity was visible downstream from the large farm dam present downstream from Site ST1a. A smaller dam located lower down in the tributary has also played a role in the above categorisation, contributing to flow, inundation and channel modifications in the associated reach.

The riparian habitat appears to be mainly modified by the encroachment of alien invasive plant species (i.e. *Acacia mearnsii*). This is further compounded by sections of the system which appear to have been modified by farm dams, resulting in the modifying of the riparian zone to typical wetland nature (i.e. unchanneled, inundated grasslands).

6.2.3 Sandspruit

The IHI findings for the Sandspruit were just below the categorisation score for Ecological Category B (i.e. indicating minimally modified conditions from natural state). According to the gathered desktop information, the Sandspruit is expected to be largely natural with “small” modifications to the instream and riparian habitat. However, the ratings allocated for both the instream and riparian components were sufficient to categorise them within the Ecological Category C score range (60-79).

Agricultural and forestry related impacts are prevalent along the reach. However, they are minimal in comparison to the impacts rated for both the Northern and Southern Tributaries. Farm dams and road crossings are slightly modifying the flow and channel of the Sandspruit. Alien vegetation encroachment and minor areas are riparian vegetation removal from farmlands and forestry have also contributed in the modified scores.

6.3 Macroinvertebrate Assessment

Various macroinvertebrate related assessments were conducted at sites applicable for sampling (i.e. sufficient water level and habitat). This excludes the water quality monitoring sites (i.e. Site ST1d to ST1h). The findings from these assessments are discussed respectively in the following subsections.

6.3.1 Integrated Habitat Assessment System

The results of the Integrated Habitat Assessment System (IHAS) are presented in Table 6-4. These scores indicate the availability and suitability of the sampled macroinvertebrate habitat at each of the assessed monitoring sites and the findings thereof are discussed separately in detail following Table 6-4.

Table 6-4: Integrated Habitat Assessment System findings for the Aquatic Study

Sampling Site	IHAS Score (%)	Interpretation
Northern Tributary		
NT1	43.6	Poor
NT2	43.6	Poor
Southern Tributary		
ST1a	69.1	Good
ST1b	32.7	Poor
ST1c	40.0	Poor
ST2	DRY	
Sandspruit		
MS1	DRY	
MS2	50.9	Poor
MS3	47.3	Poor
MS DWN	76.4	Excellent

Most of the results for the IHAS conducted for the sampling sites classified the available macroinvertebrate habitat as Poor. The Northern Tributary sites as well as the lower reaches of the Southern Tributary represented typical wetland ecosystems rather than riverine conditions (i.e. lacking sufficient flow and cobbles). The Northern Tributary sampling sites were dominated by muddy substrates and marginal vegetation whereas the Southern Tributary sites (i.e. Sites ST1b and ST1c) consisted of sections of pooled water with even less vegetation for sampling (Figure 6-1). The macroinvertebrate habitat at the upstream site along the Southern Tributary (i.e. Site ST1a) was however classified as Good. This site consisted of a variety of biotopes available for sampling, ranging from sections of cobbles and gravel in and out of current as well as a fair amount of marginal and aquatic vegetation. Sites with higher IHAS scores are expected to house a more diverse assemblage of macroinvertebrates with a variety of habitat preferences (discussed below).

Figure 6-1: Limited amounts of water available for sampling at Site ST1c

The sampled habitat at the sites along the Sandspruit (i.e. Sites MS2 and MS3) were classified as Poor with the habitat at the furthest downstream site, Site MS DWN, classified as Excellent. The low water levels observed within the Sandspruit appears to be a main cause for these classifications. Site MS2 consisted of pooled water with limited flow and it was highly sedimented, most likely due to the road and train crossing at the site. Site MS3 was also observed to have limited flow during the survey and was dominated by a diverse range of gravel and stone biotopes. However, the water levels were so low at the site that the marginal vegetation was not reaching the water thus, not available for sampling. Site MS DWN consisted of a variety of all macroinvertebrate biotopes included in the South African Scoring System version 5 (SASS5) assessment (i.e. stones, vegetation and gravel, sand and mud/GSM). Considering solely the habitat at the sites within the Study Area, it is assumed that macroinvertebrate assemblages would be of highest diversity and sensitivity at this site due to the abundance and diversity of the biotopes available for colonisation.

6.3.2 South African Scoring System Version 5

The SASS5 scores recorded within the MRA, with the exception of Site ST1a, were generally low in comparison to the findings along the Sandspruit and especially in comparison to Site DWN along the Ngwempisi River. These scores provide an indication of the overall aquatic conditions (i.e. water quality and habitat availability) at the sites. Higher SASS5 scores indicate an overall more sensitive macroinvertebrate assemblage, requiring “cleaner” water and habitat of better quality and diversity for survival. The findings from the SASS5 assessments conducted during the Aquatic Study are presented in Table 6-5.

Table 6-5: SASS5 scores recorded during the Aquatic Study

Sampling Site	SASS5 Score	No. of Taxa*	ASPT**
Northern Tributary			
NT1	54	13	4.15
NT2	51	11	4.64
Southern Tributary			
ST1a	94	16	5.88
ST1b	49	10	4.90
ST1c	55	12	4.58
ST2	DRY		
Sandspruit			
MS1	DRY		
MS2	91	20	4.55
MS3	88	15	5.87
MS DWN	183	27	6.78
*Number of individual macroinvertebrate families sampled; **Average Score per Taxon			

The differences in SASS5 scores between the MRA sampling sites and the Sandspruit sites were to be expected to some extent as the macroinvertebrate habitat within the Sandspruit was more favourable, according to the IHAS scores, than most of the habitat within the Northern and Southern tributaries. Additionally, water quality was generally “worse” within the Southern Tributary sampling sites which will also influence the overall SASS5 scores. However, it is important to consider that the *in-situ* water quality findings at Site ST1a was of the poorest quality (i.e. highest pH and conductivity) in comparison to all assessed sites. Based on this, it appears that habitat availability and quality, especially within the MRA, is driving the macroinvertebrate assemblages in comparison to water quality. The Macroinvertebrate Response Assessment Index (MIRAI) section below provides further details regarding the drivers behind the macroinvertebrate assemblages.

6.3.3 Macroinvertebrate Response Assessment Index

It is preferred to apply the MIRAI on a reach-based level by incorporating macroinvertebrate findings at several sites which have similar aquatic conditions along the same watercourse. Looking at the gathered habitat and water quality data, it was decided that this approach takes place for the assessed Northern Tributary and Sandspruit. The lack of connectivity compounded by the differences in habitat along the Southern Tributary (i.e. upper riverine nature associated with Site ST1a compared to the wetland nature of the lower reach/Sites ST1b and ST2) do not suit a reach based MIRAI approach. Therefore, a site-based approach has been adopted for Site ST1a which talks to the macroinvertebrate Ecological Category for the upper reach of the Southern Tributary. A site-based MIRAI has also been applied at Site ST1c in attempt to determine the PES of the watercourse draining into the Southern Tributary. It must however be noted that Site ST1c consisted of low water levels and small pools for sampling, as discussed in the IHAS section (see Figure 6-1). Therefore, the MIRAI findings are expected to be largely skewed as a result of the poor conditions.

The MIRAI findings for the various watercourses/sites considered in the Aquatic Study are outlined and discussed in the respective tables below:

Table 6-6: MIRAI findings for the Northern Tributary

Invertebrate Metric Group	**Score Calculated**
Flow modification	37.6
Habitat	44.0
Water Quality	45.8
Ecological Score	**42.4**
Invertebrate Ecological Category	**D**

The MIRAI findings for the Northern Tributary indicate that the macroinvertebrate assemblage within the assessed reach is in a largely modified state from reference/natural conditions for the tributary (i.e. Ecological Category D). It appears that modifications to flow is largely responsible for the determined score, resulting in a loss of flow dependent taxa from the reach. A large road has been constructed above the upstream sampling site as well as farm dams within the upper reaches of the Northern Tributary. These impacts appear to be severely altering the natural flow in the reach. Additionally, modifications to habitat and water quality also appear to be greatly driving the macroinvertebrate assemblage in the Northern Tributary. The low rainfall experienced prior to the survey should however be considered when interpreting these results as the findings may be negatively skewed as a result of the consequential poor aquatic conditions.

Therefore, habitat preservation within the MRA is key, although conservation of the water quality of the aquatic ecosystems should also be of priority in order to maintain the colonisation of sensitive taxa.

Table 6-7: MIRAI findings for Site ST1a

Invertebrate Metric Group	**Score Calculated**
Flow modification	45.8
Habitat	41.6
Water Quality	49.7
Ecological Score	**45.6**
Invertebrate Ecological Category	**D**

Before interpreting the MIRAI findings for Site ST1a, it should be noted that the determined scores were based solely on the presence or absence of macroinvertebrate families within the site. Not all families are expected to be frequent within the entirety of the reach. Therefore, the overall Ecological Category could be negatively skewed as "missed" taxa may be present within additional sites along the watercourse. None the less, the MIRAI scores for the relevant metric groups categorised the macroinvertebrate assemblage at Site ST1a as largely modified/Ecological Category D. The habitat metric scored the lowest for this assessment whereas the habitat score for the site was classified as Good according to the applied IHAS. Looking closer at the habitat metric, it appears that vegetation dependent taxa were mostly absent from this site where the Good IHAS classification was mainly due to the abundance of cobbles at the site. A sensitive vegetation dependent Odonata (i.e. dragonfly and damselfly) individual was sampled at the site (Figure 6-2).

Figure 6-2: Chlorolestidae individual sampled at Site ST1a

The presence of this small individual sensitive taxa could indicate early signs of colonisation. It is expected that vegetation dependent taxa will diversify come an increase in rainfall and water levels.

Table 6-8: MIRAI findings for Site ST1c

Invertebrate Metric Group	Score Calculated
Flow modification	16.5
Habitat	28.9
Water Quality	27.8
Ecological Score	**24.4**
Invertebrate Ecological Category	**E**

Based solely on the presence/absence findings, the MIRAI scores indicate that the macroinvertebrate assemblage at Site ST1c is in a seriously modified state/Ecological Category E. This to some extent could be accurate based solely on the severe dry conditions of the site (Figure 6-1). However, interpretations of the metrics will not truly be accurate as the SASS5 assessment is not applicable at the shallow, pooled site. It is clear though, that the flow modifications metric, which is suspected to reflecting the complete lack of flow observed at the site, has largely driven the sampled macroinvertebrate assemblage. The Chlorolestidae family (Figure 6-2) was also sampled at this site together with the moderately flow dependent Aeshnidae and Libellulidae Odonata larvae (Figure 6-3).

Figure 6-3: Aeshnidae (left) and Libellulidae (right) individuals sampled at Site ST1c

The presence of these taxa could also indicate the onset of early colonisation at the site which will only increase during the rainy season. Sampling later in the season is expected to observe better macroinvertebrate and overall aquatic health findings.

Table 6-9: MIRAI findings for the Sandspruit

Invertebrate Metric Group	Score Calculated
Flow modification	53.0
Habitat	56.2
Water Quality	57.0
Ecological Score	**55.4**
Invertebrate Ecological Category	**D**

The MIRAI findings for the Sandspruit indicate that the macroinvertebrates are in a largely modified state/Ecological Category D. The macroinvertebrates within the reach appear to be driven similarly by flow, habitat and water quality modifications according to the metric scores. Again, the dry conditions of the Study Area, especially in the upper reaches of the Sandspruit (i.e. dry Site MS1), are most likely negatively influencing the above findings. Improved water levels in the Sandspruit should support the colonisation of additional macroinvertebrate taxa which is expected to improve the above score to at least an Ecological Category C (i.e. >59).

6.4 Ichthyofaunal Assessment

Fish sampling took place at all sites with sufficient water level for the application of electroshocking techniques. This includes site ST1a, the Northern Tributary sites, the Sandspruit sites and Site MS DWN. Table 6-10 below presents the fish species collected during the survey.

Table 6-10: Sampled fish species within the Study Area

Fish Species	Conservation Status	Sampling Site	Abundance
Anguilla mossambica	LC	Not sampled	
Amphilius uranoscopus	LC	MS DWN	1
Chiloglanis anoterus	LC	MS DWN	1
Chiloglanis emarginatus	V	MS DWN	5
Clarias gariepinus	LC	MS DWN	1
Enteromius anoplus	LC	MS2	11
		MS3	7
		MS DWN	8
		NT1	5
Enteromius crocodilensis	LC	Not sampled	
Enteromius paludinosus	LC	MS DWN	11
Labeobarbus maraquensis	LC	MS DWN	4
Labeobarbus polylepis	LC	MS DWN	7
Pseudocrenilabrus philander	LC	MS DWN	23
Tilapia sparmanii	NA	MS2	3
		MS DWN	18
LC=Least Concern; NT=Near Threatened; V=Vulnerable; NA=Not Assessed			

A total of 13 fish species were sampled during the survey, although almost all of them were sampled at the furthest downstream site from the MRA (i.e. Site MS DWN). Fish sampling at the sites within the MRA was not greatly successful due to the low water levels within the sites.

Only the tolerant *Enteromius* cf. *anoplus* was sampled within the MRA and Sandspruit (Figure 6-4). In addition to this barb species, a potentially undescribed barb was sampled downstream from Site MS3 at a road crossing which was briefly assessed in passing when searching for the fish conservation species of importance in the reach (i.e. GPS coordinates: 26°44'38.01"S 30°23'48.02"E). According to a study done by Dr Albert Chakona (2015), this species of fish (suspected to be *Enteromius pallidus*;) shows species-level genetic divergence between two populations (i.e. northern and southern), which could represent the sampled species shown by the IUCN distributions to occur in the MRA and Study Area as a whole (Chakona, 2018).

Figure 6-4: *Enteromius* cf. *anoplus* sampled at Site MS2

Figure 6-5: *Enteromius* cf. *pallidus* sampled within the Sandspruit

No sensitive fish species or species of conservation importance were sampled within the MRA or associated Sandspruit sites. However, all the expected sensitive catfish species were sampled at Site MS DWN. This includes the Vulnerable species *Chiloglanis emarginatus* (Roux and Hoffman, 2018), *Chiloglanis anoterus* and *Amphilius uranoscopus*. These species of catfish are highly sensitive to lack of flow/flow modifications as well as water quality deterioration/modifications (DWS, 2014). It is important to note that these species were sampled in very low abundances at the site, only occupying a small gravel bed with limited flow at the site, approximately 4 m in length. It appears that these fish are holding out in the larger sections of the Sandspruit, awaiting the rainy season and consequential increase in water levels before moving into the upper reaches. Therefore, it should be of utmost importance to preserve the quality and quantity of water entering the Sandspruit from the MRA.

Photographs of the *Chiloglanis* species are presented in the following figures. It is worth discussing the distinguishable teeth characteristics between the sampled fish. It is possible that a third/undescribed species is present at the site (labelled C in Figure 6-6 and Figure 6-7 below) as three of the specimens were more representative of *C. emarginatus* from a lateral view, although they keyed out to *C. anoterus* except for the elongate barbels (Skelton, 2001). For this study they have been referred to as *Chiloglanis* cf. *emarginatus*, needing confirmation.

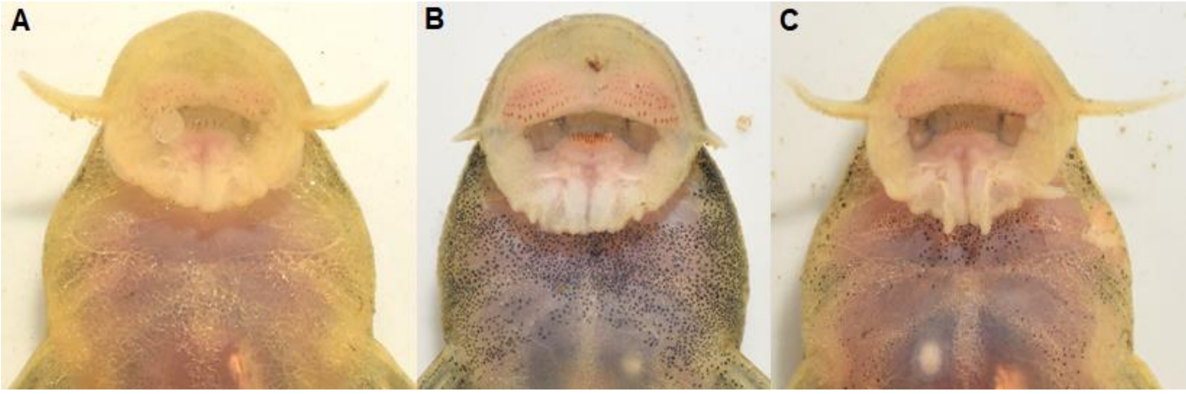

Figure 6-6: Photographs of the sampled *Chiloglanis* species mouth parts (A: *C. emarginatus*; B: *C. anoterus*; C: *C.* cf. *emarginatus*)

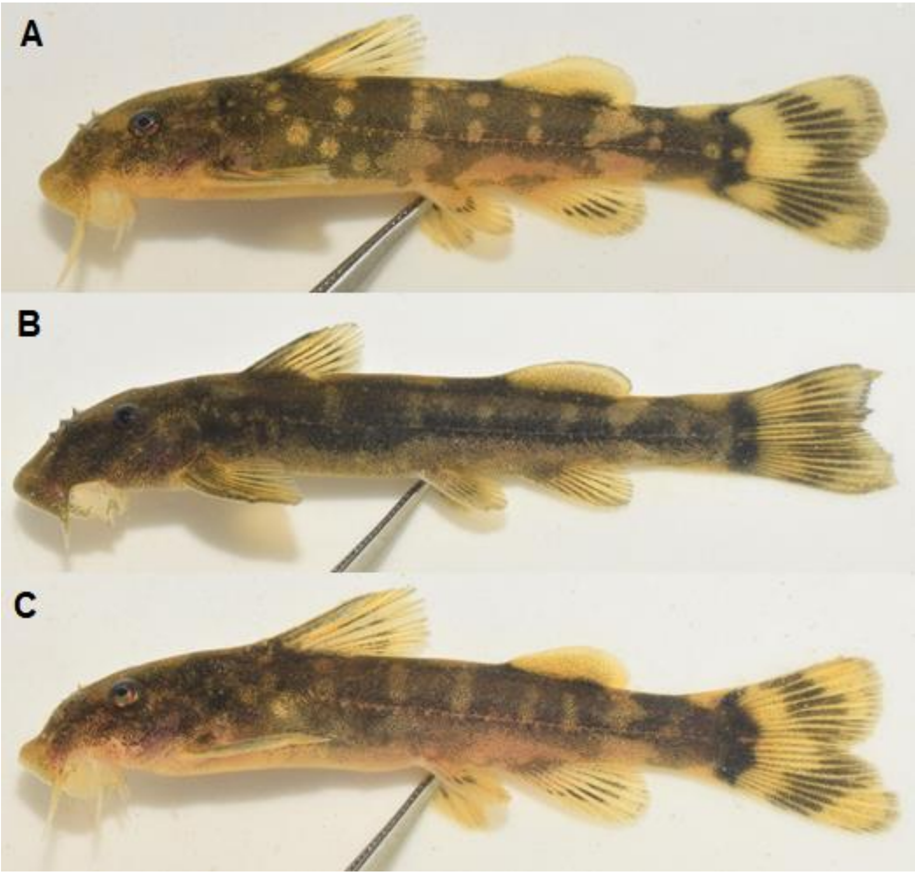

Figure 6-7: Lateral photographs of the sampled *Chiloglanis* species (A: *C. emarginatus*; B: *C. anoterus*; C: *C.* cf. *emarginatus*)

6.4.1 Fish Response Assessment Index

As mentioned, the gathered desktop information pertains to the Sandspruit SQR which appears in South Africa's 1:500 000 river network. Its tributaries (i.e. Northern Tributary and Southern Tributary) do not match the same habitat conditions as the Sandspruit. Additionally, the sampling sites associated with the MRA were not suitable for fish occupancy. They consisted mainly of pooled or little water for sampling. Therefore, the application of a reach-based Fish Response Assessment Index (FRAI) for the respective tributaries within the MRA is not applicable. As a result, the FRAI was conducted solely for the Sandspruit whereby sampled fish within the MRA can in the meantime be utilised as "dry season" baseline conditions. It is however expected that more species/individuals will be present during the wet season.

The FRAI findings for the assessed Sandspruit reach are presented below. These findings only incorporate the sampled fish from Sites MS2 and MS3 which subsequentially talks accurately to the ecological integrity of the upper Sandspruit reach and not the entire SQR. It is also important to note that the frequency of occurrence of each species has been lowered to account for the poor conditions experienced during the survey within the dry season.

Table 6-11: Sandspruit FRAI findings

Species	**Expected Frequency of Occurrence rating**	**Recorded Frequency of Occurrence rating**
Anguilla mossambica	2	0
Amphilius uranoscopus	1	0
Chiloglanis anoterus	1	0
Chiloglanis emarginatus	1	0
Clarias gariepinus	2	0
Enteromius anoplus	5	5
Enteromius crocodilensis	1	0
Enteromius paludinosus	3	0
Labeobarbus maraquensis	1	0
Labeobarbus polylepis	1	0
Pseudocrenilabrus philander	3	3
Tilapia sparmanii	3	3
Adjusted FRAI %	**38.7**	
Ecological Category	E	

According to the FRAI results, the fish assemblage with the upper reaches of the Sandspruit is in a seriously modified state/Ecological Category E. It appears that flow/water level constraints within the reach has greatly contributed to this modified category. These findings are also of low confidence as the species are more likely present within the lower reaches. An assessment during the wet season of the Study Area will be required to truly determine the ichthyofaunal integrity of the upper Sandspruit.

7 Present Ecological Status

The findings of the EcoClassification for the three assessed watercourses are presented in the tables below and discussed respectively.

Table 7-1: The PES of the Northern Tributary

Ecological Category	Score	Ecological category
Riparian Habitat	54.0	D
Macroinvertebrate assemblage	42.4	D
Ecostatus	**48.2**	**D**

According to the EcoClassification results, the assessed Northern Tributary reach appears to be in a largely modified state/Ecological Category D. Equal confidence was allocated to both the determined riparian and macroinvertebrate categories for the tributary. Therefore, both components are contributing proportionally to overall PES for the Northern Tributary.

Table 7-2: The PES of the Southern Tributary

Ecological Category	Score	Ecological category
Riparian Habitat	60.0	C
Macroinvertebrate assemblage	45.6	D
Ecostatus	**56.4**	**D**

According to the EcoClassification results for the assessed Southern Tributary, the reach also appears to be in a largely modified state/Ecological Category D. It is important to note that the macroinvertebrate Ecological Category sued in this assessment comes solely from the findings for Site ST1a. Therefore, a lower proportion and confidence was allocated to the macroinvertebrate score during the EcoClassification determination process.

Table 7-3: The Present Ecological Status of the Sandspruit

Ecological Category	Score	Ecological category
Riparian Habitat	74.0	C
Macroinvertebrate assemblage	55.4	D
Fish assemblage	38.7	E
Ecostatus	**62.62**	**C**

Lastly, the EcoClassification results for the upper Sandspruit indicate that the ecosystem is in a moderately modified state/Ecological Category C. It is important that equal proportions and confidence ratings were allocated to both the riparian and macroinvertebrate Ecological Categories in the Classification determination tool. However, the confidence and proportional contribution of the fish findings were reduced as it is felt that conditions were not favourable for fish assessments within the upper reach and during the dry period. Nonetheless, the sampled fish assemblage still provides some indication to the ecological health of the reach.

8 Impact Assessment

The proposed infrastructure in relation to the aquatic ecosystems and sampling sites is presented in Figure 8-1. Focus of the impact assessment has been solely on the proposed infrastructure and associated activities with Block A/Northern Underground Access. The identified potential impacts that will negatively affect aquatic ecology are discussed below for the various phases of the Project (i.e. Construction Phase, Operational Phase and Decommissioning Phase).

8.1 Construction Phase

Land manipulation and vegetation clearing associated with the proposed infrastructure establishment and is the main foreseeable aquatic-related impact associated with the Construction Phase of the Project. There is also a risk of contaminants associated with construction activities and machinery entering the aquatic systems from the Project workings and storage sites.

8.1.1 Impact Description: Water and habitat quality deterioration associated with vegetation manipulation/clearing

Land manipulation and vegetation clearance for infrastructure will most likely increase surface runoff, erosion and subsequently the amount of suspended and dissolved solids as well as pollutants (i.e. hazardous substances from the actual construction areas such as hydrocarbons, organic waste from lack of ablutions and domestic litter) entering the associated watercourses. This has the potential to negatively affect the water and habitat quality within the associated watercourses.

Erosion of land in association with natural aquatic ecosystems will not only modify the morphology of the systems (e.g. channel and bank modifications) but also has the potential to impact on aquatic-related habitat which, in turn, has the potential to alter biological community structure. Erosion and runoff into the associated aquatic ecosystems can result in the sedimentation of habitat and overall increase in suspended solids content. This can directly alter aquatic habitats after deposition (Wood & Armitage, 1997) which in turn will negatively impact biotic community structure by displacing biota that favour the affected habitat. Suspended solids can also directly impact aquatic biota through the accumulation of silt on respiratory organs (i.e. gills) and by decreasing visibility (i.e. increasing turbidity) which will affect feeding habits of specific taxa (e.g. *Labeobarbus* fish species)

Erosion and runoff from cleared land can also alter water quality by increasing turbidity, as aforementioned, and by increasing the number of contaminants entering the watercourses from the surrounding landscapes, such as fertilisers/nutrients and unearthed metals. This is expected to alter the physio-chemistry of water and deter water quality sensitive biota.

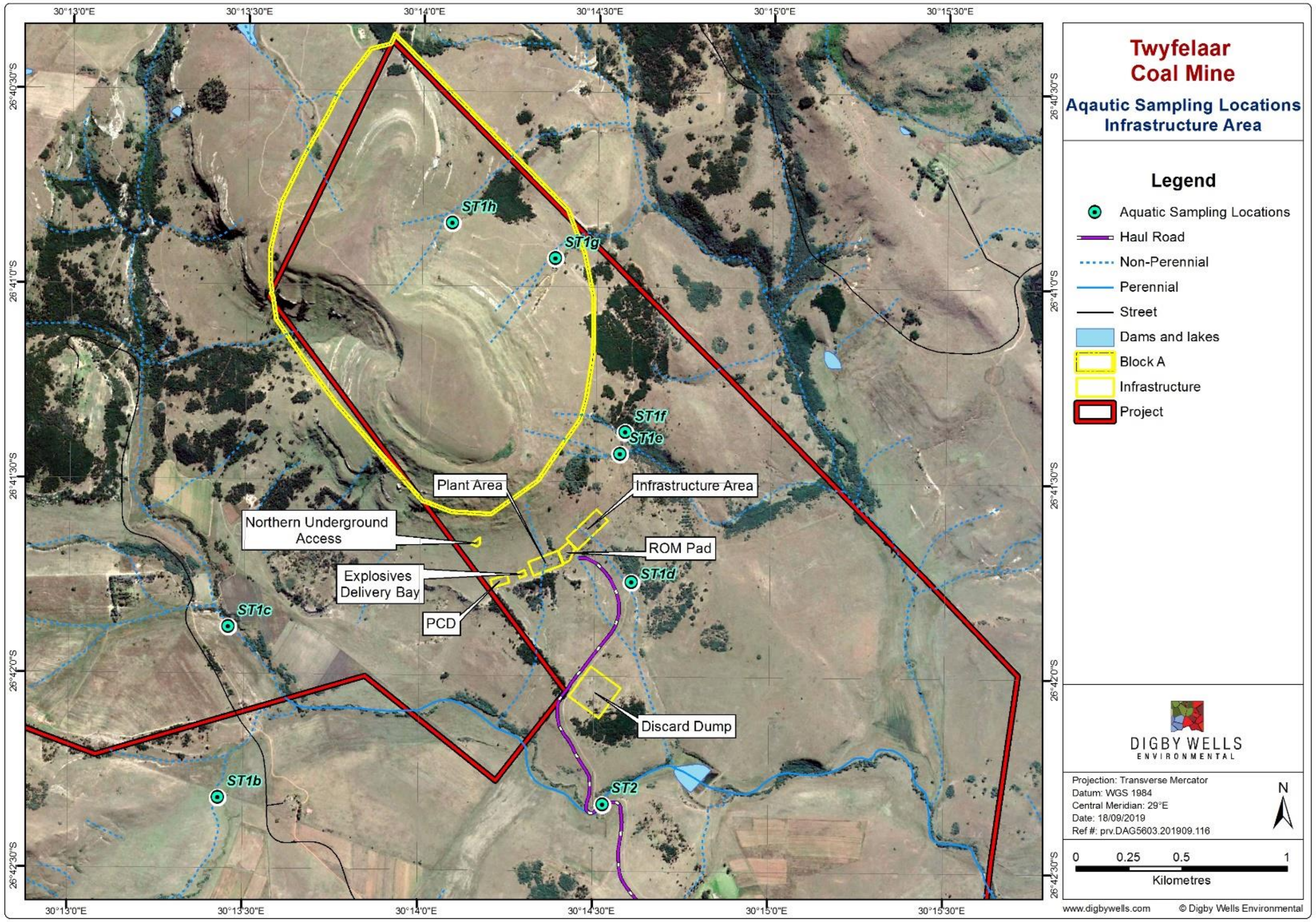

Figure 8-1: Proposed infrastructure in relation to the watercourses of concern

8.1.1.1 Management Objectives

The main objective for mitigation would be to limit the areas proposed for disturbance/vegetation clearance combined with remaining as far as possible from the banks of associated watercourses by creating buffer zones. Construction activities should be restricted to the immediate footprint associated with the proposed infrastructure.

8.1.1.2 Management Actions

General mitigation actions provided in the wetlands and surface water studies conducted by Digby Wells should be used to guide the effective management of aquatic resources potentially affected by the Project. However, more specific management actions for the Construction Phase are listed below.

Clearly marked buffer zones must be established, which are defined as regions of natural vegetation between watercourses/wetlands and developments or activities (WRC, 2015). This is a key management action that should take place. However, this is not possible as the proposed infrastructure is already intercepting drainage lines/watercourses, although non-perennial, which flow into the Southern Tributary. This is mainly noticeable for the drainage lines between and at the proposed infrastructure associated with the Northern Underground Access area which enters the Southern Tributary above and below Site ST2 (i.e. also draining from the proposed infrastructure area through Site ST1d; Figure 8-1).

- Limit vegetation removal to the infrastructure footprint area only where removed or damaged vegetation areas (riparian or aquatic related) should be revegetated as soon as possible;
- Bare land surfaces downstream of construction activities must be vegetated to limit erosion from the expected increase in surface runoff from infrastructure;
- Environmentally friendly barrier systems, such as silt nets or, in severe cases, use trenches downstream from construction sites to limit erosion and possibly trap contaminated runoff from construction;
- Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow;
- Water used at construction sites should be utilised in such a manner that it is kept on site and not allowed to run freely into nearby watercourses (i.e. use of a PCD);
- Construction chemicals, such as paints and hydrocarbons, should be used in an environmentally safe manner with correct storage as per each chemical's specific storage descriptions;
- Construction chemicals, such as paints and hydrocarbons, should be used in an environmentally safe manner with correct storage as per each chemical's specific storage descriptions; and

- High rainfall periods (usually November to March) should be avoided during construction to possibly avoid increased surface runoff in attempt to limit erosion and the entering of external material (i.e. contaminants and/or dissolved solids) into associated aquatic systems.

8.1.1.3 Impact Ratings

Table 8-1 presents the impact ratings associated with land and vegetation clearing impacts predicted for the Construction Phase of the Project. It must be noted that the ratings have been determined based on the observations during the survey and are related largely to impacts on the Southern Tributary rather than the immediately affected non-perennial systems/drainage lines. Therefore, the drainages lines associated with the proposed infrastructure have been perceived to have limited flow or only flow during rainfall periods (e.g. Site ST1b; Figure 8-2). This is a limitation to the ratings, as the true hydrology or high flow of the watercourses could not be determined during the survey in August 2019.

Figure 8-2: Site photograph of a dry muddy bed associated with Site ST1d

From the figure above, it is visible that the depth of water draining from the site is not great. However, based on the width of the channel, there could be a fair amount of water present during the rainy season.

Elevation profiles were also developed for the drainage line associated with Site ST1d (i.e. Eastern Drainage Line) and for the drainage line flowing directly through the proposed infrastructure footprint area (i.e. Western Drainage Line). This was done from the upper most visible sections of the drainage lines from a desktop level to where the watercourses merge with the Southern Tributary. Both assessments were approximately 1.2 km in length. The elevation profiles are displayed in Figure 8-3.

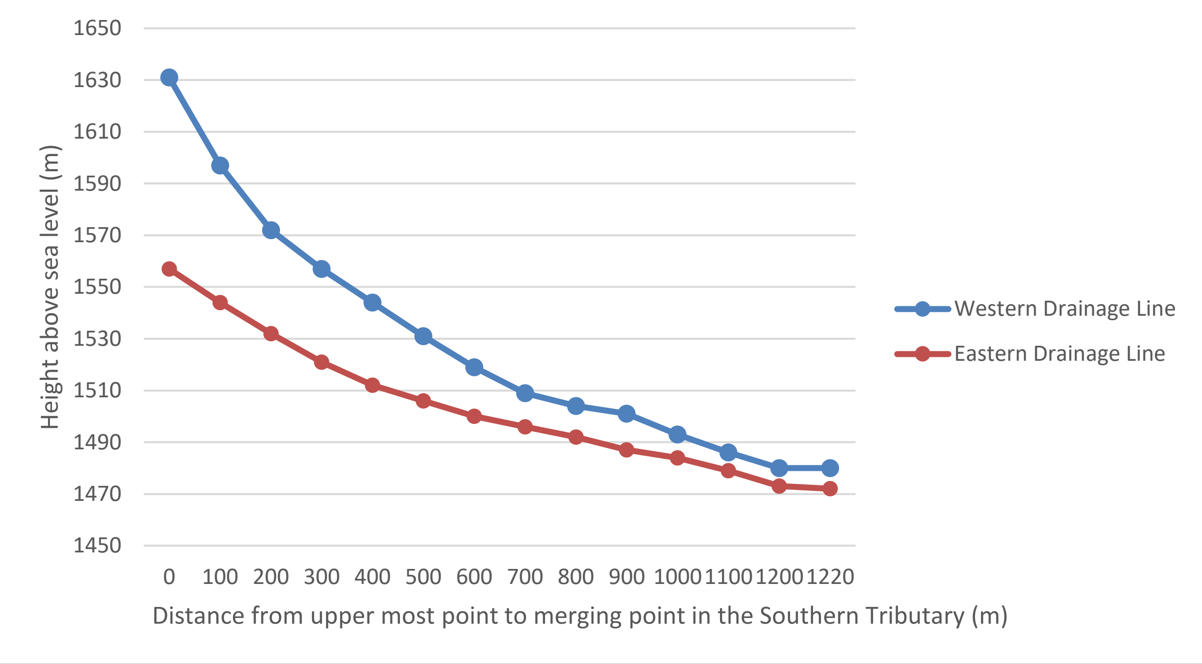

Figure 8-3: Elevation profile of the drainage lines associated with the proposed infrastructure associated with Block A

The upper sections of the drainage lines vary in gradient. The slope of the Western Drainage Line (i.e. for the first 500 m of the assessment) equates to 20 % with the slope of the Eastern Drainage Line (i.e. also for the first 500 m) as 10.2 %. A steep slope is regarded as a gradient of ≥ 15 %. Therefore, runoff or flow in these systems in proximity to the proposed infrastructure is expected to be high during heavy rainfall periods, especially in the Western Drainage Line. This could make storm management a difficult task. Again, this deduction is limited as the MRA was assessed during the dry season.

Table 8-1: Potential land and vegetation clearing for infrastructure construction

Dimension	Rating	Motivation	Significance
Activity and Interaction: Site clearance and construction of proposed infrastructure			
Impact Description: Land and vegetation manipulation/clearing for infrastructure in proximity to the Southern Tributary and within non-perennial drainage lines			
Prior to Mitigation/Management			

Dimension	Rating	Motivation	Significance
Duration	Project life (5)	Once vegetation is cleared for infrastructure, no revegetation will occur until project closure.	Minor (negative) – 52
Extent	Local (3)	Based on the dry nature observed during the survey and of the lower Southern Tributary reach (i.e. near Site ST2), the extent of runoff is expected to be limited to the Southern Tributary.	
Intensity x type of impact	Moderate - Negative (-5)	Due to the dry nature of the observed immediate drainage lines, impacts associated with an increase in runoff are expected to be limited. However, this is increased based on the elevation profiles of the associated drainage lines and based on the sensitive taxa sampled within the Sandspruit and lower reaches.	
Probability	Probable (4)	The impact is likely to occur more than once during construction but limited due to periodic rainfall events. Erosion in the reach is also currently present.	
Nature	Negative		
Post-Mitigation			
Duration	Project Life (5)	Once vegetation is cleared for infrastructure, no revegetation will occur until the closure phase of the Project or removal of the infrastructure.	Negligible (negative) – 20
Extent	Limited (2)	Runoff will most likely be restricted or captured after mitigation actions and if high rainfall periods are avoided for construction.	
Intensity x type of impact	Minor - Negative (-3)	If mitigation measures are all incorporated for the Construction Phase, the intensity of the impact should decrease significantly, especially due to the dry nature observed during the survey.	

Dimension	Rating	Motivation	Significance
Probability	Improbable (2)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme cases or unexpected rainfall events.	
Nature	Negative		

8.1.2 Impact Description: Infrastructure construction over watercourses

Construction of the proposed access and haul roads as well as the construction of any pipelines have been assessed separately for the Construction Phase. The proposed road and pipeline construction will directly affect watercourses (e.g. the Southern Tributary) as the infrastructure needs to be constructed over the watercourse. Similar to the aforementioned impact, roads or pipeline construction over watercourses will also result in cleared vegetation, increased runoff at the site and an increase in erosion resulting in possible sedimentation of the immediate site area and associated watercourse. Depending on the design for each watercourse crossing, impacts will vary. Infrastructure construction over watercourses and associated culverts have the potential to interfere with the natural flow pathway of the aquatic ecosystem which, in turn, can also impact on the migration and movement of biota.

8.1.2.1 Management Objectives

Key objectives for management must be to maintain the natural flow and connectivity as well as to limit direct construction activities within the watercourses of concern (i.e. in direct contact with instream habitat and substrate).

8.1.2.2 Management Actions

Mitigation measures detailed for the site and vegetation clearing impact should be applied to areas leading up to the watercourse crossing points. However, the infrastructure construction over a watercourse needs additional attention due to the proximity of the activity to aquatic ecosystems. Essentially, the watercourse is going to be directly affected unless a “suspension” approach is adopted (e.g. suspending the infrastructure, allowing only contact with the banks of the watercourse of concern). This is recommended where applicable but will most likely only be a viable option for pipelines that cross watercourses, if any. Larger constructions over watercourses, more specifically the proposed road constructions and associated culverts (if any), are of focus. The design as well as the physical construction of roads should not alter the natural hydrology and connectivity of the watercourses in any way (i.e. damming or creating barriers). Any infrastructure proposed to be in contact with the substrate/channel bottom should allow for the free flow of water and material. If hard surfaces are going to be used as foundation or if culverts are going to be installed, their base should not be noticeable above the natural channel bottom to maintain connectivity. Monitoring of the crossing points should also form part of the management actions to ensure correct flow occurs through the crossing point, especially during the wet season.

8.1.2.3 Impact Ratings

Table 8-2 presents the impact ratings associated with infrastructure construction over watercourses during the Construction Phase of the Project.

Table 8-2: Predicted impact ratings for the proposed construction over watercourse

Dimension	Rating	Motivation	Significance
Activity and Interaction: Physical construction of infrastructure over natural aquatic ecosystems			
Impact Description: Vegetation removal for site access and potential hydrological disturbance of associated watercourses			
Prior to Mitigation/Management			
Duration	Beyond project life (6)	Pipelines may be decommissioned after closure. However, it is likely that road crossings will remain after the life of the Project.	Minor (negative) – 52
Extent	Local (3)	Due to the typical wetland nature of the lower Southern Tributary reaches and dry conditions experienced during the survey, the impact of runoff, erosion and sedimentation is likely to be limited to only the Southern Tributary.	
Intensity x type of impact	Moderate - Negative (-4)	No migratory taxa were sampled during the survey within the MRA. However, aquatic ecosystems are regarded as sensitive. Therefore, construction within the immediate pathway of associated watercourses can be regarded as serious.	
Probability	Probable (4)	Poor infrastructure crossing developments are currently present within the MRA where the impacts with the proposed construction are probable.	
Nature	Negative		
Post-Mitigation			

Dimension	Rating	Motivation	Significance
Duration	Medium Term (6)	If no decommissioning is proposed for the road crossings, the impact will persist beyond the life of the Project.	Negligible (negative) – 20
Extent	Limited (2)	Cleared vegetation associated with the riverbanks/riparian zones will be revegetated if not within the immediate footprint of the infrastructure, flow and connectivity will be maintained within the watercourses. Therefore, the impact after construction is likely to be restricted to the immediate site area.	
Intensity x type of impact	Minor - Negative (-2)	If mitigation measures and environmentally friendly culverts are used followed by biannual monitoring of the crossing points for interreferences, the intensity of the impact should minor.	
Probability	Improbable (2)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme cases or unexpected significant rainfall/flooding events.	
Nature	Negative		

8.2 Operational Phase

A major foreseeable impact associated with the Operational Phase of the Project is increased runoff possibly resulting in erosion and sedimentation because of constructed impermeable surfaces. The use of chemicals on site and runoff containing contaminants from unearthing activities (e.g. trace metals from overburden or topsoil stockpiles) also has the potential to enter nearby watercourses throughout the Operational Phase.

8.2.1 Impact Description: Water quality and habitat deterioration associated with an increase in runoff from the operational areas of the Project

Like the impacts described for the Construction Phase, the predicted increased runoff has the potential to increase flow rates, sediment input, erosion and contaminants in the associated watercourses. These influences will directly impact on water quality and aquatic habitat which in turn will negatively affect the aquatic biota. Stormwater and water used on site (e.g. Sewage Treatment Plant and dust suppression water) has the potential to directly alter habitat and the morphology of the receiving aquatic ecosystems if allowed to flow freely from the MRA (e.g.

through sedimentation). Uncontrolled runoff also has the potential to alter water chemistry and degrade water quality of the affected systems by collecting contaminants as it drains across the associated landscapes. This will consequently affect the aquatic ecology and water quality sensitive aquatic biota.

8.2.2 Management Objectives

Water should not be allowed to flow freely from the mining activities and associated infrastructure (including stockpiles of any type). As proposed, dirty water or water runoff from mine related infrastructure should be stored in PCD's and utilised as intended. Additionally, the proposed plan is to use mine-affected water for dust suppression on site. Again, this water should be controlled and not allowed to freely flow from the area of use. This may be a challenging task during dust suppression.

8.2.3 Management Actions

The following management actions are recommended to guide the effective management of stormwater and water generated on site:

- During the Operational Phase of the Project a Storm Water Management Plan (SWMP) should already be implemented. This should consider all drainage lines associated with the new developments/infrastructure which should divert storm water away from the surface infrastructure and back into natural watercourses. The SWMP should also convey storm water to silt traps where needed in order to limit erosion and an increase of suspended solids in downstream watercourses;
- Channelled water should not be dispersed in a concentrated manner. Baffles should be incorporated into artificial drainage lines/channels around the surface infrastructure to decrease the kinetic energy of water as it flows into the natural environment;
- Bare surfaces downstream from the developments where silt traps are not an option should be vegetated in order to attempt to limit erosion and runoff that might be carrying contaminants;
- Careful monitoring of the areas where dust suppression is proposed should be undertaken regularly. Areas concentrating water runoff should be addressed and not allowed to flow freely into associated watercourses; and
- Monitoring of infrastructure over watercourses should be done by an aquatic specialist in order to determine localities of areas subjected to erosion and increased runoff where after new mitigation actions should be implemented as per the specialist's recommendations.

8.2.4 Impact Ratings

Table 8-3 presents the impact ratings determined for the potential runoff from the proposed infrastructure and associated activities.

Table 8-3: Potential runoff related impacts associated with the Operational Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Uncontrolled runoff of stormwater or water generated from the mining operations from or through the surface infrastructure			
Impact Description: Water quality and habitat deterioration of watercourses receiving unnatural/contaminated runoff			
Prior to Mitigation/Management			
Duration	Project Life (5)	It is predicted that contaminant input will continue throughout the life of the Project whenever rainfall events occur.	Minor (negative) – 56
Extent	Municipal (4)	Due to the dry nature of the watercourses in the MRA, runoff is already expected to be limited which should result in limited contaminant input. However, downstream sections of the associated systems will most likely be affected when rainfall events lead to contaminant input and as a precautionary measure for the sensitive biota observed downstream, the extent rating has been increased.	
Intensity x type of impact	Serious - Negative (-5)	Due to the dry nature of the watercourses in the MRA, the intensity of runoff is already expected to be limited. However, aquatic systems are regarded as sensitive and the entry of contaminants will result in serious aquatic related impacts especially if water reaches the Sandspruit reach.	
Probability	Probable (4)	The impact is likely to occur throughout the life of the Project but limited due to periodic rainfall events.	
Nature	Negative		
Post-Mitigation			
Duration	Project Life (5)	Runoff will continue throughout the Project life.	Negligible (negative) – 30

Dimension	Rating	Motivation	Significance
Extent	Limited (2)	Runoff will most likely be largely restricted and captured after mitigation.	
Intensity x type of impact	Moderate - Negative (-3)	If mitigation measures are all incorporated for the Project, the intensity of the impact should decrease. However, contaminants are more difficult to manage compared to solid particles and are predicted to enter associated aquatic systems resulting in water quality deterioration.	
Probability	Unlikely (3)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme rainfall events or if mitigation structures aren't maintained.	
Nature	Negative		

8.3 Decommissioning Phase

This phase entails removal of mine related infrastructure as well as rehabilitation of potentially affected areas and aquatic ecosystems.

8.3.1 Impact Description: Physical decommissioning and removal of infrastructure in proximity to natural drainage lines

Disturbance of aquatic ecosystems, using heavy machinery, will most likely result in erosion and increased runoff in the areas near or in the highlighted drainage lines. Water runoff during these activities may also be of poor quality which will also result in the deterioration of the quality of the affected ecosystems. Dirty water entering natural aquatic ecosystems from the decommissioning activities and associated areas have the potential to alter water chemistry and degrade water quality of the affected systems. This will consequently affect the aquatic ecology and aquatic biota.

8.3.1.1 Management Objectives

It is predicted that the natural morphology of the drainage lines associated with the proposed surface infrastructure (i.e. Western Drainage Line and Eastern Drainage Line) would have change after the life of the Project. Therefore, the main management objective would be to restore the affected areas to natural/reference conditions without resulting in additional downstream impacts throughout the process.

8.3.1.2 Management Actions

The goal of mitigation should be to limit erosion and runoff from the footprint of the areas/infrastructure during decommissioning as well as during rehabilitation. The following measures may be utilised in attempt to reduce the decommissioning impacts:

- High rainfall periods should be avoided during decommissioning;
- Removed or damaged vegetation areas should be revegetated;
- Storm water must be diverted from decommissioning activities;
- Water used during decommissioning should be kept onsite and not be allowed to freely flow into nearby watercourses; and
- Stored mine-affected water should be treated before decommissioning of any mine-related water retention areas, such as PCDs;
- Land reprofiling should be done during the dry season to allow for attempts to restore the morphology of the drainage lines prior to rainfall/flow events; and
- Ensure the revegetation activities use appropriate indigenous plant species.

8.3.1.3 Impact Ratings

The impact rating associated with activities related to the removal of surface infrastructure and rehabilitation of potentially affected areas have been predicted in Table 8-4 below.

Table 8-4: Potential disturbance/runoff related impacts during the Decommissioning/Rehabilitation Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Physical removal of surface infrastructure and rehabilitation activities near and within drainage lines			
Impact Description: Water quality and habitat deterioration of watercourses in contact with heavy machinery and receiving runoff from surface workings			
Prior to Mitigation/Management			
Duration	Medium term (3)	The impact will only occur during decommissioning and until rehabilitation is complete.	Minor (negative) – 44

Dimension	Rating	Motivation	Significance
Extent	Municipal (4)	Due to the dry nature of the non-perennial drainage lines, impacts are expected to be limited to the immediate watercourses and potentially the lower reaches of the Southern Tributary. Discharging of stored mine water may however increase the extent of the impact downstream.	
Intensity x type of impact	Serious - Negative (-4)	Due to the dry nature of the watercourses within the MRA, the intensity of runoff is already expected to be limited. However, aquatic systems are regarded as sensitive and the entry of contaminants will result in serious aquatic related impacts, especially if contaminated water enters the ecosystems.	
Probability	Probable (4)	The impact is likely to occur throughout the Decommissioning Phase but limited due to periodic rainfall events.	
Nature	Negative		
Post-Mitigation			
Duration	Medium Term (3)	Impacts will persist throughout the Decommissioning Phase until rehabilitation activities are complete.	Negligible (negative) – 28
Extent	Limited (2)	If mitigation measures are adhered to, especially working in the dry season, runoff is expected to be restricted to the drainage lines or mitigation structures.	
Intensity x type of impact	Minor - Negative (-2)	If mitigation measures are all incorporated for the Project, the intensity of the impact should decrease notably especially after rehabilitation.	

Dimension	Rating	Motivation	Significance
Probability	Probable (4)	The impact is expected to at some point occur as workings will be within the direct flow pathway of the drainage lines.	
Nature	Negative		

8.4 Cumulative Impacts

The main cumulative impact identified for the aquatic ecosystems within the MRA appears to be the influence of agriculture. Areas of elevated conductivity and algal presence were identified during the survey (e.g. Site ST1a). In addition, almost all sampling sites associated with the Southern Tributary showed signs of livestock utilising the reach as a water source (e.g. trampling of vegetation and substrate disturbance). Growing areas of agriculture within the MRA will certainly add to the existing aquatic related impacts such as increased conductivity, nutrient content and associated algal growth. This, in turn, will place additional stress on the aquatic biota within the MRA and potentially those within the receiving Sandspruit SQR. This will ultimately result in further degradation of the assessed aquatic ecosystems and reflect in greater modification scores as indicated by the determined PES.

Forestry associated with and downstream from the town of Sheepmoor is also worth mentioning as a cumulative impact. Although not associated with the MRA, forestry has the potential to increase runoff into the associated aquatic ecosystems which could erode/sediment the ecosystem and be of poor water quality. Continuation and potential expansion of this industry in the area could result in additional stress on the lower Sandspruit reach as well as the Ngwempisi River which could displace the sensitive biota and species of conservation importance identified during the Aquatic Study.

8.5 Unplanned and Low Risk Events

There is a risk that watercourses associated with the mining operations/infrastructure throughout the Project life might be affected by the entry of hazardous substances, such as hydrocarbons, in the event of a spillage or unseen seepage from storage facilities; and

Accidents or deterioration of structures along the roadways and river crossings, including pipelines, might affect the habitat and water quality of associated aquatic ecosystems.

Table 8-5Therefore, Table 8-5 outlines mitigation measures that must be adopted in the event of unplanned impacts throughout the life of the Project.

Table 8-5: Unplanned events and associated mitigation measures

Unplanned Risk	Mitigation Measures
Chemical and (or) contaminant spills from mining operation, infrastructure and associated activities.	▪ Ensure correct storage of all chemicals at operations as per each chemical's specific storage requirements (e.g. sealed containers for hydrocarbons); ▪ Ensure staff involved at the proposed developments have been trained to correctly work with chemicals at the sites; and ▪ Ensure spill kits (e.g. Drizit) are readily available at areas where chemicals are known to be used. Staff must also receive appropriate training in the event of a spill, especially near watercourses/drainage lines.
Unplanned structural deterioration or accidents along the roadways and pipelines associated with aquatic ecosystems.	▪ Install safety valves and emergency switches that can be used to seal off leakages from pipelines when noticed or triggered; ▪ Ensure that spill kits and trained staff capable of using the kits are available on site in case of accidental spillages; ▪ Maintenance of roadways, river crossings and pipelines should be considered an ongoing process where leakages or issues with the pipe should be reporting to acting Environmental Coordinator of the Project immediately after notice; and ▪ Biannual aquatic monitoring should take place all infrastructure river crossing points. Additional mitigation or rehabilitation measure recommended but the appointed specialist must be incorporated.

9 Aquatic Biomonitoring Programme

An aquatic biomonitoring programme has been developed for the monitoring and preservation of the aquatic ecosystems assessed for the Project. This programme is aimed at better determining the ecological health of the ecosystems as well as to act as an early detection tool for impacts that might severely affect the identified sensitive and conservation important species in the lower reaches of the Sandspruit.

Table 9-1 outlines the aquatic monitoring methods to be undertaken on an annual basis by a qualified aquatic ecologist. The annual programme comprises of a single survey during the dry season for the Study Area and a single survey during the wet season (refer to Figure 5-1) at the monitoring points indicated in Southern Tributary and Sandspruit sampling points as indicated in Table 4-4. It is important to also include an additional monitoring point downstream from Site ST2 at an area along the Southern Tributary before it merges with the larger Sandspruit (SQR W53A-01757). This will determine the PES for the assessed aquatic ecosystems which will further determine whether the proposed Project is impacting the associated aquatic ecology and to what extent.

Table 9-1: Biomonitoring Programme

Method and Aquatic Component of Focus	Details	Goal/Target
Water Quality: ▪ In-situ water testing focusing on temperature, pH, conductivity and oxygen content.	Water quality should be tested on a biannual basis at each monitoring site to determine the extent of change from baseline results.	No noticeable change from determined baseline water quality for each respective season
Habitat Quality: ▪ Instream and riparian habitat integrity; and ▪ Availability/suitability of macroinvertebrate habitat at each monitoring site.	▪ The application of the IHI should be done on a reach basis for the Southern Tributary and larger Sandspruit reach; ▪ The IHAS must be applied at each monitoring site prior to sampling.	▪ The Ecological Category determined for each assessed reach must be maintained; and ▪ The IHAS scores determined within this report should improve especially during wet season monitoring.
Macroinvertebrates: ▪ Macroinvertebrate assemblages must be assessed biannually.	This must be done through the application of the latest SASS5, incorporated with the application of the MIRAI as outlined in this Aquatic Study.	▪ The baseline SASS5 scores should not noticeably deteriorate; and ▪ Baseline Ecological Categories should not be allowed to drop in category for each assessed reach/site.
Fish: ▪ Fish assemblages must be assessed biannually	Sampling must be done utilising standard electroshocking techniques followed by the application of FRAI for applicable reaches.	The presence of the species *Enteromius anoplus* at all sites within the MRA. However, the main goal for the Project must be to conserve the identified sensitive and conservation important species in the lower reaches of the Sandspruit: ▪ C. emarginatus; ▪ C. anoterus; and ▪ A. uranoscopus.

The Project should not commence without inclusion of the above Aquatic Biomonitoring Programme. An additional aquatic survey during the wet season for the Study Area must also be undertaken due to the limitations highlighted throughout this Aquatic Study.

10 Recommendations

The following actions have been recommended to allow for commencement of the proposed Project:

- A wet season aquatic survey must be undertaken prior to commencement of the Project;
- The Project should adopt a water and habitat quality preservation mindset throughout the life of the Project. In other words, the proposed Project activities should not result in the deterioration/degradation of aquatic habitat (i.e. riparian and instream habitat) and water quality within the associated aquatic ecosystems, especially where the drainage line associated with the surface infrastructure (Figure 8-1); and
- The developed Aquatic Biomonitoring Programme must be adopted on an annual basis after commencement of the Construction Phase of the Project. This programme should continue for the life of the Project and for at least three years post the Decommissioning Phase.

11 Conclusion

The timing of the aquatic survey coincided with the dry season for the Study Area. As a result, aquatic conditions were observed to be deteriorated in terms of connectivity and water levels. Aquatic habitat, as indicated by the determined IHAS scores, also appear to be severely influenced by the dry conditions of the assessed watercourses. Consequently, the recorded aquatic biota within the MRA reflected the poor aquatic conditions by being present in low diversity and sensitivity. The ecological health indices utilised during the baseline determination also reflected modified conditions for the aquatic ecosystems within the MRA.

On the contrary, some sensitive macroinvertebrate families were present within the MRA. This indicated that the associated aquatic ecosystems do have the capacity to support sensitive life and should be conserved irrespective of the modified ecological outcomes expressed in the Aquatic Study. Furthermore, highly sensitive aquatic species, both macroinvertebrates and fish, were present within the lower reaches of the Sandspruit which has several adjoining tributaries draining from the proposed MRA. The conservation important fish species *Chiloglanis emarginatus,* listed as Vulnerable, was also present in fair abundance for the dry season in the lower Sandspruit confluence with the Ngwempisi. Therefore, water emanating from the MRA needs to be of good quality and quantity so as not to impact on the critically sensitive and important downstream aquatic life.

The surface related impacts associated with the Project were determined to be Minor for the larger downstream aquatic ecosystems. These findings could however be largely skewed due to the dry conditions during the aquatic on-site assessment. This was seen to limit the amount of aquatic data available for collection which has lowered the overall confidence of the outcomes determined during the impact assessment phase.

Aquatic related mitigation measures provided are expected to conserve the determined baseline conditions. It must be noted that conditions during the wet season have only been assumed for inclusion of the provided measures. An aquatic survey should be conducted during the wet season for the Study Area (from November to March) to more accurately describe the aquatic conditions and to account for expected increased water levels and flow within the associated aquatic ecosystems.

An Aquatic Biomonitoring Programme has also been developed for the duration of the Project. This programme is aimed at better determining the ecological health of the ecosystems as well as to act as an early detection tool for impacts that might severely affect the identified sensitive and conservation important species in the Study Area and especially in the lower reaches of the Sandspruit. The Project should not commence unless the Aquatic Biomonitoring Programme is adopted into the environmental management plans for the Project.

12 Reference List

Bills r, Engelbrecht J and Marshall BE (2018) *Enteromius viviparus* (amended version of 2007 assessment). *The IUCN Red List of Threatened Species* 2018: e.T63383A126214827. http://dx.doi.org/10.2305/IUCN.UK.2018-1.RLTS.T63383A126214827.en. Downloaded on 08 September 2019.

Barbour MT, Gerritsen J, Snyder BD and Stribling JB (1998) Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers.

Chakona A (2018) *Enteromius pallidus*. *The IUCN Red List of Threatened Species* 2018: e.T63269A126755813. http://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T63269A126755813.en. Downloaded on 08 September 2019.

Dallas HF (2005) River Health Programme : Site Characterisation Field-Manual and Field-Data Sheets (March) 28.

Dallas HF and Day JA (2004) The effect of water quality variables on aquatic ecosystems: A Review. WRC Report. Water Research Commission, Pretoria, South Africa. 222 pp.

Darwall WRT, Smith KG, Tweddle D and Skelton P (2009) The status and distribution of freshwater biodiversity in southern Africa. Gland, Switzerland: IUCN and Grahamstown, South Africa: SAIAB. 131 pp.

Department of Water Affairs and Forestry (1996) South African Water Quality Guidelines. Aquatic Ecosystems. Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry (2004) National Water Resource Strategy. First Edition. Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water and Sanitation (2014) A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa.

Dickens CWS and Graham PM (2002) The South African Scoring System (SASS) Version 5 rapid bioassessment method for rivers. African Journal of Aquatic Science 27 1–10.

Dudgeon D, Arthington AH, Gessner MO, Kawabata Z-IZ-I, Knowler DJ, Lévêque C, Naiman RJ, Prieur-Richard A-HA-H, Soto D, Stiassny MLJ, and co-authors (2006) Freshwater biodiversity: importance, threats, status and conservation challenges. Biological Reviews of the Cambridge Philosophical Society 81 (2) 163–82. https://doi.org/10.1017/S1464793105006950.

Engelbrecht J, Bills R, Cambray J, Roux F and Hoffman A (2017) *Enteromius brevipinnis*. The IUCN Red List of Threatened Species 2017: e.T2574A100119351. http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T2574A100119351.en. Downloaded on 12 March 2019.

Gerber A and Gabriel MJM (2002) Aquatic Invertebrates of South African Rivers: Field Guide. Institute for Water Quality Studies. Department of Water Affairs and Forestry, Pretoria, South Africa. 150 pp.

Graham M and Louw MD (2008) River Ecoclassification: Manual for Ecostatus Determination (Version 2). Module G: Index of Habitat Integrity. Section 2: Model Photo Guide. WRC Report No. TT 378/08. Water Research Commission, Pretoria, South Africa.

Kleynhans CJ (1996) A qualitative procedure for the assessment of the habitat integrity status of Luvuvhu River (Limpopo system, South Africa). Journal of Aquatic Health 5 (1) 41–54. https://doi.org/10.1007/BF00691728.

Kleynhans CJ (1999) The development of a fish index to assess the biological integrity of South African rivers. Water SA 25 (3) 265–278.

Kleynhans CJ and Louw MD (2008) River EcoClassification Manual for EcoStatus Determination (Version 2) - Module A: EcoClassification and EcoStatus Determination. WRC Report No. TT 329/08. Water Research Commission, Pretoria, South Africa.

Kleynhans CJ, Louw MD and Graham M (2008) River Ecoclassification: Manual for Ecostatus Determination (Version 2). Module G: Index of Habitat Integrity. Section 1: Technical Manual. WRC Report No. TT 377/08. Water Research Commission, Pretoria, South Africa.

Kleynhans CJ, Thirion CA, Moolman J and Gaulana L (2007) A Level II River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Department of Water Affairs and Forestry - Resource Quality Services, Pretoria, South Africa.

McMillan PH (1998) An Integrated Habitat Assessment System (IHAS v2) for the Rapid Biological Assessment of Rivers and Streams. CSIR Research Report No. ENV-P-I 98132. Water Resources Management Programme, Council for Scientific and Industrial Research, Pretoria, South Africa, South Africa.

Ollis DJ, Boucher C, Dallas HF and Esler KJ (2006) Preliminary testing of the Integrated Habitat Assessment System (IHAS) for aquatic macroinvertebrates. African Journal of Aquatic Science 31 (1) 1–14.

Roux F and Hoffman A (2018) *Chiloglanis emarginatus*. The IUCN Red List of Threatened Species 2018: e.T63366A100194297. http://dx.doi.org/10.2305/IUCN.UK.2018-1.RLTS.T63366A100194297.en. Downloaded on 12 March 2019.

Skelton PH (2001) A Complete Guide to the Freshwater Fishes of southern Africa. Struik Publishers, Halfway House, South Africa. I-xiv + 1-395 p.

Thirion CA, Mocke A and Woest R (1995) Biological monitoring of streams and rivers using SASS4 - A User's Manual. Internal Report No. N 000/00REQ/1195. Department of Water Affairs and Forestry - Resource Quality Services, Pretoria, South Africa.

U.S. EPA (2010) A Field-Based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams (External Review Draft). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-10/023A, 2010.

Victor JE, Scott-Shaw CR and Van Wyk AE (2005) *Eugenia simii* Dummer. National Assessment: Red List of South African Plants version 2017.1. Downloaded on 11 March 2019.

World Weather Online (2019) Sheepmoor Monthly Climate Averages. https://www.worldweatheronline.com/sheepmoor-weather-averages/mpumalanga/za.aspx. Downloaded on 08 September 2019.

Appendix A: Baseline and EIA Methodology

1 Baseline Methodology

Descriptions of the various approaches for the determination of the aquatic ecology baseline are detailed in the respective sections below.

1.1 Water Quality

Selected *in situ* water quality variables will be measured using water quality meters manufactured by Extech Instruments, namely an ExStik EC500 Combination Meter. Temperature, pH and electrical conductivity was recorded prior to additional biological sampling.

1.2 Habitat Quality

The availability and diversity of aquatic habitat is important to consider in assessments due to the reliance and adaptations of aquatic biota to specific habitats types (Barbour *et. al*., 1996). Habitat quality and availability assessments are usually conducted alongside biological assessments that utilise fish and macroinvertebrates. Aquatic habitat will be assessed through visual observations on each river system considered.

1.2.1 Index for Habitat Integrity

The Index for Habitat integrity (IHI) (Version 2, Kleynhans, C.J., *pers. comm.*, 2015) aims to assess the number and severity of anthropogenic perturbations along a river/stream and the potential inflictions of damage toward the habitat integrity of the system (Dallas, 2005). Various abiotic (e.g. water abstraction, weirs, dams, pollution, dumping of rubble, etc.) and biotic (e.g. presence of alien plants and aquatic animals, etc.) factors are assessed, which represent some of the most important and easily quantifiable, anthropogenic impacts upon the system (Table 1-1).

As per the original IHI approach (Kleynhans, 1996), the instream and riparian components will each be analysed separately to yield two separate ecological conditions (i.e. Instream and Riparian components). However, it should be noted that the data for the riparian area is primarily interpreted in terms of the potential impact upon the instream component and as a result, may be skewed by a potentially deteriorated instream condition.

While the recently upgraded index (i.e. IHI-96-2; Dr. C. J. Kleynhans, *pers. comm.*, 2015) replaces the aforementioned comprehensive and expensive IHI assessment model developed by Kleynhans (1996), it is important to note that the IHI-96-2 does not replace the IHI model developed by Kleynhans et al. (2008), which is recommended in instances where an abundance of data is available (e.g. intermediate and comprehensive Reserve Determinations). Accordingly, the IHI-96-2 model is typically applied in cases where relatively few reaches need to be assessed, the budget and time provisions are limited, and/or any detailed available information is lacking (i.e. rapid Reserve Determinations and for REMP/RHP purposes).

Table 1-1: Descriptions of criteria used to assess habitat integrity

Factors	Relevance
Water abstraction	Direct impact upon habitat type, abundance and size. Also impacted in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in the temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included
Water quality modification	Originates from point and diffuse sources. Measured directly, or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments.
Alien/Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Alien/Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the riverbank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

In accordance with the magnitude of the impact created by the abovementioned criteria, the assessment of the severity of the modifications was based on six descriptive categories ranging between a rating of 0 (no impact), 1 to 5 (small impact), 6 to 10 (moderate impact), 11 to 15 (large impact), 16 to 20 (serious impact) and 21 to 25 (critical impact; Table 1-2). Based on available knowledge of the site and/or adjacent catchment, a confidence level (high, medium, low) was assigned to each of the scored metrics.

Table 1-2: Descriptive of scoring guidelines for the assessment of modifications to habitat integrity

Impact Category	Description	Score
None	No discernible impact or the factor is located in such a way that it has no impact on habitat quality diversity, size and variability.	0
Small	The modification is limited to a very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1 - 5
Moderate	The modification is present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6 - 10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced	11 - 15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability of almost the whole of the defined section are affected. Only small areas are not influenced.	16 - 20
Critical	The modification is present overall with a high intensity; the habitat quality, diversity, size and variability in almost the whole of the defined section are detrimentally influenced.	21 - 25

Given the subjective nature of the scoring procedure utilised within the general approach to habitat integrity assessment (including IHI-96-2), the most recent version of the IHI application (Kleynhans *et al*., 2008) and the Model Photo Guides (Graham and Louw, 2008) were used to calibrate the severity of the scoring system. It should be noted that the assessment will be limited to observed and/or suspected impacts present within the immediate vicinity of the delineated assessment units, as determined through the use of aerial photography (e.g. Google Earth) and observations made at each of the assessed sampling points during the field survey. However, in cases where major upstream impacts (e.g. construction of a dam, major water abstraction, etc.) are confirmed, potential impacts within relevant sections will be considered and accounted for within the application of the method.

Each of the allocated scores will then moderated by a weighting system (Table 1-3), which is based on the relative threat of the impact to the habitat integrity of the riverine system. The total score for each impact is equal to the assigned score multiplied by the weight of that impact. The estimated impacts (assigned score / maximum score [25] X allocated weighting) of all criteria are then summed together, expressed as a percentage and then subtracted from 100 to determine the Present Ecological State score (PES; or Ecological Category) for the instream and riparian components, respectively.

Table 1-3: Criteria and weightings used to assess habitat integrity

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality modification	14	Water abstraction	13
Inundation	10	Inundation	11
Alien/Exotic macrophytes	9	Flow modification	12
Alien/Exotic aquatic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	100	TOTAL	100

However, in cases where selected instream component criteria (i.e. water abstraction, flow, bed and channel modification, water quality and inundation) and/or any of the riparian component criteria exceeded ratings of large, serious or critical, an additional negative weight was applied. The aim of this is to accommodate the possible cumulative effect (and integrated) negative effects of such impacts (Kemper, 1999). The following rules were applied in this respect:

- Impact = Large, lower the integrity status by 33% of the weight for each criterion with such a rating.
- Impact = Serious, lower the integrity status by 67% of the weight for each criterion with such a rating.
- Impact = Critical, lower the integrity status by 100% of the weight for each criterion with such a rating.

Subsequently, the negative weights will be added for both facets of the assessment and the total additional negative weight subtracted from the provisionally determined integrity to arrive at a final habitat integrity estimate (Kemper, 1999). The eventual total scores for the instream and riparian zone components are then used to place the habitat integrity in a specific habitat integrity ecological category (

Table 1-4).

Table 1-4: Ecological Categories for the habitat integrity scores

Ecological Category	Description	Score (% of Total)
A	Unmodified, natural.	90 - 100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80 - 89
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and there has been 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

1.3 Aquatic Invertebrate Assessment

Macroinvertebrate assemblages are good indicators of localised conditions because many benthic macroinvertebrates have limited migration patterns or a sessile mode of life. They are particularly well-suited for assessing site-specific impacts (upstream and downstream studies) (Barbour et al. 1999). Benthic macroinvertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects (Barbour et al. 1999). The assessment and monitoring of benthic macroinvertebrate communities forms an integral part of the monitoring of the health of an aquatic ecosystem.

1.3.1 Integrated Habitat Assessment System

Due to the reliance and adaptations of aquatic biota to specific habitats, the availability and diversity of habitats is important to consider in aquatic assessments (Barbour et al., 1998). Assessment of the available habitat for aquatic macroinvertebrate colonisation at each sampling site is vital for the correct interpretation of results obtained following biological assessments. It should be noted that the available methods for determining habitat quality are not specific to rapid biomonitoring assessments and are inherently too variable in their approach to achieve consistency amongst users.

Nevertheless, the Invertebrate Habitat Assessment System (IHAS) has routinely been used in conjunction with SASS as a measure of the variability of aquatic macroinvertebrate biotopes available at the time of the survey (McMillan, 1998). The scoring system was traditionally split into two sections, namely the sampling habitat (comprising 55% of the total score) and the general stream characteristics (comprising 45% of the total score), which were summed together to provide a percentage and then categorised according to the values in Table 1-5.

Table 1-5: Description of IHAS scores with the Respective Percentage Category

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

However, the lack of reliability and evidence of notable variability within the application of the IHAS method has prompted further field validation and testing, which implies a cautious interpretation of results obtained until these studies have been conducted (Ollis et al., 2006). In the interim and for the purpose of this assessment, the IHAS method will be adapted by excluding the assessment of the general stream characteristics, which resulted in the calculation of a percentage score out of 55 that was then categorised by the aforementioned Table 1-5. Consequently, the assessment index describes the quantity, quality and diversity of available macroinvertebrate habitat relative to an "ideal" diversity of available habitat.

1.3.2 South African Scoring System Version 5 (SASS5)

The SASS5 is the current index being used to assess the status of riverine macroinvertebrates in South Africa. According to Dickens and Graham (2002), the index is based on the presence of aquatic invertebrate families and the perceived sensitivity to water quality changes of these families. Different families exhibit different sensitivities to pollution, these sensitivities range from highly tolerant families (e.g. Chironomidae) to highly sensitive families (e.g. Perlidae). SASS results are expressed both as an index score (SASS score) and the Average Score Per recorded Taxon (ASPT value).

Sampled invertebrates will be identified using the "Aquatic Invertebrates of South African Rivers" (Gerber and Gabriel, 2002). Identification of organisms will be made to family level (Thirion *et. al*., 1995; Dickens & Graham, 2002; Gerber & Gabriel, 2002).

1.3.3 Macroinvertebrate Response Assessment Index (MIRAI)

The Macroinvertebrate Response Assessment Index (MIRAI) is used to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic invertebrate community from the calculated reference conditions. This does not preclude the calculation of SASS5 scores if required (Thirion, 2007). The four major components of a stream system that determine productivity for aquatic macroinvertebrates are as follows:

- Flow regime;
- Physical habitat structure;
- Water quality; and
- Energy inputs from the watershed riparian vegetation assessment.

The results of the MIRAI will provide an indication of the current ecological category and therefore assist in the determination of the PES as outlined in Table 1-6 below.

Table 1-6: Present Ecological State (or Ecological Categories) for aquatic macroinvertebrates following application of the MIRAI

MIRAI (%)	Ecological Category	Description
90-100	A	Unmodified and natural. Community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
80-89	B	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
60-79	C	Moderately modified. Community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
40-59	D	Largely modified. Fewer species present then expected due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
20-39	E	Seriously modified. Few species present due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
0-19	F	Critically modified. Few species present. Only tolerant species present, if any.

1.4 Ichthyofaunal Assessment

Fish is a very important river health indicator whereby their responses to environmental change can be measured utilising the Fish Response Assessment Index (Kleynhans 1999; Kleynhans *et al*. 2005).

1.4.1 Fish Sampling

Fish sampling was conducted by means of at applicable sites with sufficient water depth. All fish captured will be identified and counted in the field and released alive at the point of capture. Fish species will be identified using the “Complete Guide to the Freshwater Fishes of Southern Africa” (Skelton, 2001).

1.5 Fish Response Assessment Index

The number of recorded fish species from sampling and their Frequency of Occurrence (FROC) will be used to supplement data in the Fish Response Assessment Index (FRAI). The information gained using the FRAI provides an indication of the PES of the river based on the fish assemblage structures observed. It allows for the determination of potential driver/changes to the aquatic ecosystem of concern based on fish species expected in the system in comparison to actual species present.

1.6 Present Ecological State (EcoClassification)

Ecological classification refers to the determination and categorisation of the integrity of the various selected biophysical attributes of ecosystems compared to the natural or close to natural, reference conditions (Kleynhans and Louw, 2008). Thus, the Present Ecological State (PES) or EcoStatus reflects the ecologically integrated state of a river representing the drivers (i.e. hydrology, geomorphology and physio-chemistry) and responses (i.e. riparian vegetation, macroinvertebrates and fish).

For the purpose of this study, ecological classifications were determined for the aforementioned biophysical components of the watercourses of concern (i.e. riparian vegetation, macroinvertebrates and fish) utilising the river EcoClassification manual by Kleynhans and Louw (2007). The metrics of each determined component were further integrated by combining the overall instream response Ecological Category (i.e. macroinvertebrates and fish) with the riparian vegetation Ecological Category following the Level 4 EcoStatus calculation (Kleynhans and Louw, 2008). It is, however, important to note that an adapted version of the Riparian Ecological Category surrogate (Dr. C.J. Kleynhans, pers. comm., 2015) will be used in this assessment as follows:

Riparian Vegetation EC = 100-(((IHIA 'Natural vegetation removal')+(IHIA 'Exotic Vegetation Encroachment'))/50*100)

2 Impact Assessment Methodology

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts.

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 2-3. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 2-2, which is extracted from Table 2-1. The description of the significance ratings is discussed in Table 2-3.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 2-1: Impact Assessment Parameter Ratings

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor loss and/or effects to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

DIGBY WELLS ENVIRONMENTAL

Table 2-2: Probability/Consequence Matrix

Significance

Probability																																						
7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Consequence	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Table 2-3: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

Appendix B: Site Photographs

Site NT1

Site NT1

Site ST1a

Site ST1b

Site ST1c

Site ST1d

Site ST1e

Site ST1f

Site ST1h

No photograph taken during the survey

Site ST2

Site MS1

Site MS2

Site MS3

Site MS DWN