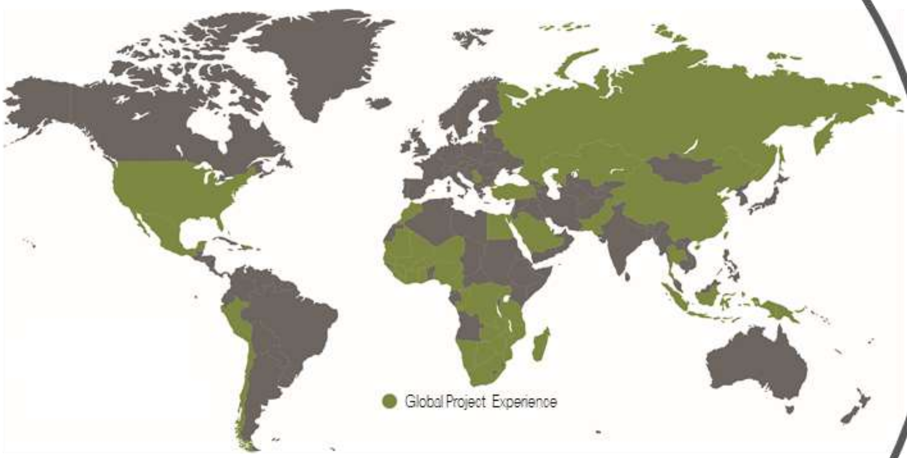

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Proposed Dalyshope Coal Mining Project, Situated in the Magisterial District of Lephalale, Limpopo Province

Aquatic Biodiversity and Impact Assessment Report

Prepared for: Anglo Operations Proprietary Limited	**Project Number:** UCD6170
DMR Ref. number: LP30/1/2/3/2/1(10183) MR	August 2020

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Report Type:	Aquatic Biodiversity and Impact Assessment Report
Project Name:	Proposed Dalyshope Coal Mining Project, Situated in the Magisterial District of Lephalale, Limpopo Province
Project Code:	UCD6170

Name	**Responsibility**	**Signature**	**Date**
Tebogo Khoza *Cand.Sci.Nat.*	Field survey, data collation and report writer		February 2021
Byron Bester *Pr.Sci.Nat.*	Field survey, and technical review		February 2021
Danie Otto *Pr.Sci.Nat.*	Senior Review		February 2021

DETAILS AND DECLARATION OF THE SPECIALIST

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

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Specialist Background

Tebogo Khoza is an Aquatic and Wetland Ecologist with a M.Sc. in Biodiversity and Conservation. He has recently joined the Digby Wells team as a Junior Ecologist, having over a years' worth of experience in the environmental consulting industry with focus on aquatic-related studies.

Full name:	Tebogo Khoza
Title/ Position:	Junior Aquatic Ecologist
Qualification(s):	MSc. Biodiversity & Conservation
Experience (years):	2
Registration(s):	South African Council for Natural Scientific Professionals: *Professional Natural Scientist* (Reg. No. 119651)

I, Tebogo Khoza , declare that: –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
  - I declare that there are no circumstances that may compromise my objectivity in performing such work;
  - I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

	February 2021
Signature of the Specialist	*Date*

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.

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EXECUTIVE SUMMARY

This study was commissioned by Universal Coal Development IV (Pty) Ltd on behalf of Anglo Operations Proprietary Limited to assess the baseline ecological state of the lotic aquatic ecosystems associated with the proposed Dalyshope Coal Mining Project. Digby Wells Environmental (hereafter Digby Wells) conducted an aquatic ecological state assessment in 2013/14 high and low-flow (dry and wet season) surveys for the proposed Dalyshope Coal Mine. The current survey therefore refers to the findings of the previous wet season assessment – wherein a flood was experienced – for comparison purposes.

The project is located in the Lephalale area, Limpopo Province, and entails the establishment of a contractor operated, truck and shovel opencast mine producing approximately 2.4 million tonnes per annum (Mtpa) of thermal coal product for approximately five years. After five years, the mine will ramp up production to approximately 12 Mtpa of product for approximately 25 years from a single open pit (OC1), giving a total life of mine of 30 years.

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 Limpopo River (SQR A41E-00126) wherein sampling was undertaken from the 12th to 14th February 2020. This watercourse drains from south-west along the north-western boundary of the Project Area. The Limpopo River is a transboundary resource shared with Botswana and Zimbabwe, flows in an easterly direction, into Mozambique and drains into the Indian Ocean. The Project Area lies in an endorheic region – an area that does not contribute to surface water flow to river systems – with several depression pans present within the Project's boundary. Water drainage into the Limpopo from the project area can be limited to diffuse overland flow.

The timing of the baseline aquatic survey coincided with the wet season for the Study Area. At the time of the survey, the Limpopo River system was in flood and had water levels exceeding the water table. Instream channels along the Limpopo system were too deep to sample without a boat, the presence of crocodiles and hippos presented a high risk as well. As such, these negatively affected the depth of sampling as suitable habitat for aquatic biota could not be accessed and sampling was limited to the marginal banks of the defined river channel where it was deemed safer to sample. This is reflected in the ecological health indices utilised during the baseline determination.

Baseline Ecological Conditions

Water quality results within the sampled Limpopo River reach were variable. The pH values recorded exhibited largely close to neutral, slightly alkaline conditions. Conductivity values and oxygen levels were predominantly low at all assessed sites. These were suspected to be attributed to the flooding event at the time of the survey, i.e. a dilution effect causing lower levels of the parameters. None of the parameters recorded extreme levels, therefore were not expected to deter indigenous aquatic biota from colonisation and/or inhabiting the associated extent of the watercourse to a notable degree. In comparison to the 2014 wet season survey, only conductivity and dissolved oxygen levels differ at a single upstream site, most notably the conductivity levels. The relatively higher conductivity and dissolved oxygen levels were probably a result of increased turbidity and aeration caused by the high flows.

Along the assessed Limpopo River reach, the ecological condition of the habitat was found to be in a moderately modified state (Ecological Category C) both for the instream and riparian components. The main modifications were those associated with game reserves and agricultural land uses such as water abstraction for irrigation, installation of weirs, small dams, alien invasive vegetation encroachment and sedimentation. The same Ecological Category (C) was obtained for the instream component during the 2013 surveys, whilst the Ecological Category for the riparian component declined from A to B (i.e. from natural state to largely natural state). This decline is attributed to the increase in alien vegetation encroachment along the sampled Limpopo River reach.

The availability and integrity of aquatic macroinvertebrate biotopes were poor across the sampled river reach, as sampling was largely limited to the marginal banks due to both flood conditions and, thus not the ideal natural habitat of the macroinvertebrates. Similarly, the results of the South African Scoring System version 5 (SASS5) and Macroinvertebrate Response Assessment Index (MIRAI) indicate that conditions at the sampled reach largely modified (Ecological Category D). The aquatic macroinvertebrate specimens collected are believed to have been flushed towards the floodplain margins or seeking refuge there. In the 2014 survey, the integrity of aquatic inverts' habitat was scored as poor due to lack of the stones and vegetation biotopes along the sampled Limpopo River reach, subsequently the invert community assemblage exhibited largely modified conditions (Ecological Category D).

Results of the fish community assessment showed that the sampled Limpopo River Reach was in a seriously modified condition (Ecological Category E). This was likely due to the fact that sampling was limited to the riverbanks and not across a variety of other fish habitats. The presence of species with moderate sensitivity to water quality modifications gives an indication that the aquatic ecosystems do have the capacity to support sensitive life and should be conserved irrespective of the modified ecological outcomes expressed in the baseline Aquatic Study. The conservation important fish species *Oreochromis mossambicus* (i.e. listed as Vulnerable according to the International Union for Conservation of Nature) was also present in the sampled Limpopo River reach. In terms of the fish community assemblage sampled in the 2013/14 surveys (both 2013 and 2014 surveys were considered in the determination of the PES), the Present Ecological State was determined to be largely natural as a result of collecting 15 out of the expected 16 species.

Following integration of the defined ecological conditions obtained for the instream biological integrity (i.e. combination of Macroinvertebrate Response Assessment Index (MIRAI) from aquatic invertebrates and Fish Response Assessment Index (FRAI) from fish) and the riparian component (i.e. surrogate Index of Habitat Integrity (IHI) from riparian vegetation assessment), it was determined that the habitat segments represented an integrated EcoStatus of largely modified (Ecological Category D) at the upstream sites and close to largely modified at the downstream site.

This was driven largely by the observed aquatic macroinvertebrate and fish assemblages, as a low confidence was associated with these biological response indicators. Furthermore, the Ecological Importance was likely to be regarded as High and the Ecological Sensitivity determined to be High during periods of '*normal*' flow and improved water quality conditions i.e., lower turbidity.

Similarly, an integrated EcoStatus of largely modified conditions (Ecological Category D) was attained during the 2013/14 surveys. The water quality was largely natural across the sampled sites whilst the habitat integrity and aquatic macroinvertebrates were seriously modified and largely modified respectively. The fish community assemblage was in a natural condition.

Impact Assessment and Mitigation Measures

The potential surface related impacts associated with the proposed open cast pit were determined to be minor for the associated Limpopo River reach which is approximately 780 m away at its closest point. The absence of watercourses draining into the Limpopo River means the extent of runoff is expected to be limited to the site and surrounding endorheic pans. However, the given mitigation measures are required to limit the magnitude of the potential impacts of the surrounding pans, thus ensuring reduced impact on the Limpopo River during periods of floods.

An aquatic biomonitoring programme has been provided for the monitoring and preservation of the aquatic ecosystems associated with 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 significantly affect the expected sensitive and conservation important species in the Limpopo River.

Reasoned Opinion Whether Project Should Proceed

In light of the lack of watercourses draining into the Limpopo River and a gentle slope between the project area and the Limpopo River, it is the opinion of the ecologist that the proposed Project's footprint will only result in minor impacts onto the Limpopo River provided all mitigation measures are implemented sufficiently. No notable fatal flaws were identified during the current study, thus the Project may proceed with an immediate implementation of the mitigation measures and the aquatic biomonitoring programme must be adhered to throughout the operation and decommissioning phases.

Recommendations

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

- In light of the 'unusual' nature of the high and low-flow cycles within the Limpopo River, toxicity testing (screening-level) should be implemented for a minimum of three biological groups (i.e. algae, invertebrates, and fish) at a quarterly basis during the construction phase and biannually during the operational phase of the project;

- Diatom assemblage assessments should be undertaken to further investigate the potential drivers of change and provide an indication of the Present Ecological State during periods of low flow where there is connectivity along the Limpopo River; 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.

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ACRONYMS, ABBREVIATIONS AND DEFINITION

ASPT	Average Score Per Taxa
CSIR	Council for Scientific and Industrial Research
DO	Dissolved Oxygen
DWS	Department of Water and Sanitation
EC	Ecological Category
FRAI	Fish Response Assessment Index
IHAS	Invertebrate Habitat Assessment System
IHI	Index for Habitat Integrity
MAP	Mean Annual Precipitation
MIRAI	Macro-Invertebrate Response Assessment Index
MRA	Mining Rights Area
NBA	National Biodiversity Assessment
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NFEPA	National Freshwater Ecosystem Priority Areas
PES	Present Ecological State
PCD	Pollution Control Dam
REMP	River EcoStatus Monitoring Programme
SAIAB	South African Institute of Aquatic Biodiversity
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SASS5	South African Scoring System version 5
SQR	Sub-Quaternary Reach
TWQR	Target Water Quality Range
WMA	Water Management Area
WRC	Water Research Commission
WUL	Water Use Licenses
WWF	Worldwide Fund for Nature

Legal Requirement		Section in Report
(1)	A specialist report prepared in terms of these Regulations must contain-	
(a)	details of- (i) the specialist who prepared the report; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Section 1.3 Appendix A
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Declaration of Independence
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1 & 1.2
cA	An indication of the quality and age of the base data used for the specialist report;	Section 4.1 & 6
cB	A description of existing impacts on site, cumulative impacts of the proposed development and levels of acceptable change;	Section 7
(d)	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 4.1
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of the equipment and modelling used;	Section 4 Appendix B
(f)	Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternatives;	Section 1.1
(g)	an identification of any areas to be avoided, including buffers;	Section 7
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 7 – 1
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.4
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 11.1
(k)	any mitigation measures for inclusion in the EMPr;	Section 8
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 11.2
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 8 & 9
(n)	a reasoned opinion (Environmental Impact Statement) - whether the proposed activity, activities or portions thereof should be authorised; and if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 11.1

Legal Requirement		Section in Report
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 10
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	
(q)	any other information requested by the competent authority.	No

1. Introduction

Anglo Operations (Pty) Ltd (hereafter Anglo or the Applicant) has partnered with Universal Coal Development IV (Pty) Ltd (hereinafter Universal) to undertake the relevant environmental authorisations required for the proposed Dalyshope Coal Mining Project near Lephalale in Limpopo Province, South Africa. Anglo is the holder of the two Prospecting Rights, but Universal is funding and managing the project development, including the Mining Right application. The farms Klaarwater 231LQ and Dalyshope 232LQ are directly affected farm portions with respect to mining and mining-related activities.

This application considers the establishment of a contractor operated truck and shovel opencast mine, producing approximately 2.4 million tonnes per annum (Mtpa) of thermal coal product for approximately five years. After five years, the mine will ramp up production to approximately 12 Mtpa of product for approximately 25 years from a single open pit, giving a total Life of Mine (LoM) of approximately 30 years.

To satisfy the above application processes, various baseline specialist studies were undertaken by Digby Wells, as Digby Wells previously undertook studies for AATC in 2013 on the same farm portions. This document serves as the specialist assessment pertaining to the natural aquatic ecosystems associated with the Project (hereinafter the Aquatic Study), which was undertaken on the 12th to 14th February 2020, in relation to the 2013/2014 studies have been considered in this report.

1.1. Project Description

Opencast strip mining using selective mining techniques is proposed for extracting the resource. The mine will be accessed via a boxcut and ramp arrangement located in the southern portion of the farm Dalyshope. Overburden material will be hauled to spoil until such time as sufficient void has been created within the pit to allow for in-pit tipping. Selective mining of the coal seams is not required due to the specification of the product required, but selective mining of the partings will be conducted.

Run of Mine (ROM) coal from the pit will be crushed in a primary crusher at the pit head. The crushed coal will be transported by conveyor belt from the pit head to stockpiles before the washing plant. Coal will be removed from the stockpile and fed into the plant. The coal will be screened to remove -50 mm coal. The oversize coal will be crushed in a secondary crusher before re-joining the -50 mm coal. The -50 mm coal is fed into the cyclone plant whereby it will be washed at a density of 1.80 to produce product and discard. The washing plant will be in modular format, with two modules each capable of a throughput of 1 000 tons per hour.

The discard will be taken by conveyor belt back to the pit head where it will be loaded into trucks to be deposited back into the bottom of the pit.

The product will be placed on stockpiles before being transported to market. The product will either be transported by road haulers on the district/provincial road or by means of a rail line, should the latter prove economically viable.

The main infrastructure associated with the mine includes, but is not limited to:

- Contractors laydown yard;
- Temporary stockpiles for construction;
- Temporary PCD for construction;
- Opencast 1 ("OC1") pit
- ROM stockpiles;
- Slew product stockpiles;
- Discard facility;
- Topsoil and subsoil stockpiles;
- Overburden (Hards/Softs) stockpiles
- Weighbridges;
- Conveyers belts;
- Workshop;
- Two PCDs;
- Washing plant;
- Crush and Screen plant;
- Offices;
- Change-house;
- Stores;
- Laboratory;
- Laundry facility
- Water tanks;
- Potable water Pipeline and distribution;
- Dirty water pipeline;
- Sewage Treatment Plant
- Water Treatment Plant;
- Brine Pond
- Diesel/wash bay and oil separator;
- Explosives magazine;
- Stormwater management infrastructure
- Powerline/s
- Substation
- Rail link and Rail loadout facility
- Brake-test ramp;
- LDV and light vehicle access road;
- Truck access road; and
- Road upgrade (Steenbokpan to site)

1.2. Terms of Reference and Purpose of this Report

The terms of reference for the current study were as follows:

- Update the baseline aquatic biodiversity assessment within the receiving watercourses associated with the proposed Dalyshope Coal Mining Project:
  - Determine the Present Ecological State (PES; or Ecological Category) of the associated watercourses, where possible; and
  - Assess the Ecological Importance and Sensitivity (EIS) associated with each of the selected watercourses.
- Assess the potential impacts upon the associated watercourses likely to originate from the proposed activity and associated infrastructure:
  - Identify potential impacts (incl. direct, indirect and cumulative) upon the associated watercourses implicated by the proposed infrastructure and mining operations to be undertaken within the study area;

- Provide a professional opinion and assessment of the potential impacts (including assessment of duration, extent, magnitude, nature, etc.) of each of the identified potential impacts; and
- Recommend appropriate mitigation measures, management objectives and interventions, as well as identify any potential fatal flaws associated with the proposed activities, if and when applicable.

1.3. Details of the Specialist/s

The following specialists were involved in the compilation of this report (CVs of the Project Team are included in Appendix A).

Responsibility	**Field Survey, Data Collation and Report Compilation**
Full Name of Specialist	Tebogo Khoza
Highest Qualification	Junior Aquatic Ecologist
Years of experience in specialist field	MSc. Biodiversity & Conservation
Registration(s):	2
Responsibility	**Field Survey, Data Collation, Report Compilation and Technical Review**
Full Name of Specialist	Byron Bester
Highest Qualification	MSc Aquatic Health
Years of experience in specialist field	9
Registration(s):	South African Council for Natural Scientific Professionals: *Professional Natural Scientist* (Reg. No. 400662/15)
Responsibility	**Senior Review**
Full Name of Specialist	Danie Otto
Highest Qualification	MSc (Geography & Environmental Management)
Years of experience in specialist field	20
Registration(s):	South African Council for Natural Scientific Professionals: *Professional Natural Scientist* (Reg. No. 400096/02)

1.4. Assumptions, Exclusions and Limitations

The following limitations were made by the author at the time of writing:

- The associated reach of the Limpopo River was in flood at the time of the survey, this however is deemed typical of the Limpopo River, where flood-drought cycles have been regularly observed in the past several years (see section 4.1.1). Thus, the application of the selected assessment indices should therefore be interpreted with caution, as each of the selected indices were primarily designed for application within typical riverine systems with a moderate hydrology and diverse habitat availability and not at the time of the flood;

- Local farmers warned of freely-roaming dangerous animals (hippopotami and crocodiles) along the Limpopo River, which was confirmed with the presence of two crocodiles at the time of the survey. Subsequently, this restricted sampling to the shallow marginal riverbanks, where it was deemed safer and accessible;
- Like-for-like comparisons of data between the current survey and the 2013 wet season survey could only be done for sites DAL 1 and DAL 3 since the positions of sites DAL 2 and DAL 4 were not the same between these surveys.
- At the time of writing this report, layout plans for linear infrastructure such as water supply pipelines and powerlines were not finalised yet, thus the impact assessment did not include these components. Should these be made available at a later stage, it is recommended that the assessment be updated to incorporate this ancillary infrastructure.

2. Relevant Legislation, Standards and Guidelines

The Aquatic Biodiversity and Impact Assessment aims to support the following regulations, regulatory procedures and guidelines:

- Section 24 of the Constitution of the Republic of South Africa ,1996 (Act No. 108 of 1996);
- The National Water Act, 1998 (Act No. 36 of 1998) (NWA);
- Section 5 of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA);
- National Environmental Management Biodiversity Act, 2004 (Act No. 10 of 2004) (NEM:BA); and
- National Freshwater Ecosystems Priority Areas (NFEPA, Nel *et al*., 2011).

3. Description of the Environment

The location of the proposed Project and biophysical features are described in the following sub-sections.

3.1. Locality

The proposed Dalyshope Coal Mine lies on the farms Klaarwater 231LQ and Dalyshope 232LQ which falls under the jurisdiction of the Lephalale Local Municipality, situated in the north-western part of the Waterberg District Municipality in Limpopo Province adjacent to the town of Lephalale.

Other closest towns include Steenbokpan, Thabazimbi and Modimolle.

3.2. Climate

The project area falls within a generally low lying, dry to arid, hot region with altitudes ranging from 300 – 1100 m above mean sea level (a.m.s.l). Relative to the country's average mean annual precipitation (MAP) of 490 mm, this ecoregion experiences low to arid rainfall within the range of 200 to 600 mm falling predominantly during early to mid-summer (Colvin *et al*., 2016).

The mean annual temperature is high to very high ranging from 18-22 °C (Kleynhans *et al.*, 2005).

3.3. Associated Watercourses

The proposed coal mine falls within primary drainage region A of the Limpopo WMA and the A41E quaternary catchment, Sub-Quaternary Reach (SQR) A41E-00126 (Limpopo River). The Limpopo River is a fifth order stream, approximately 293.35 km in length, which drains from south-west along the north-western boundary of the Project Area.

The Limpopo River is a transboundary resource shared with Botswana and Zimbabwe, flows in an easterly direction, into Mozambique and drains into the Indian Ocean.

Figure 3-1 indicates the Quaternary Catchment and freshwater resources associated with the study area.

A summary of general site information is presented in Table 3-1.

Table 3-1: Summary of general site information

Map Reference	2327CA 2327CB
Political Region	Limpopo
Level 1 Ecoregion	1. Limpopo Plain
Level 2 Ecoregion	1.02
Freshwater Ecoregion	Zambezian Lowveld
Geomorphic Province	Western Limpopo Flats
Vegetation Type	Limpopo Sweet Bushveld
Water Management Area	1. Limpopo
Secondary Catchment	A4
Quaternary Catchment	A41E
Watercourse/s	Limpopo River
Seasonality	Perennial

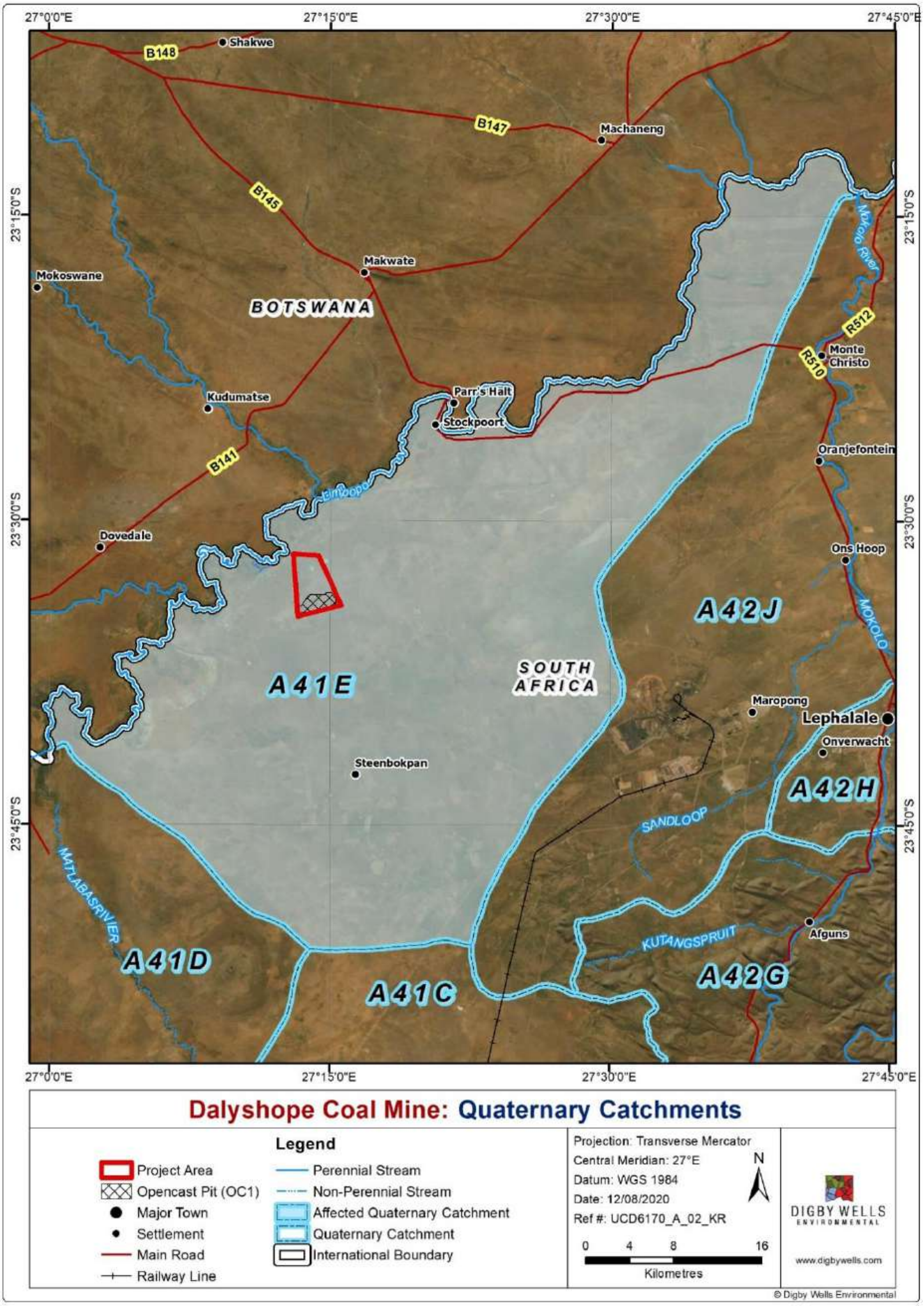

Figure 3-1: Quaternary Catchments

3.4. Regional Biodiversity Importance

The regional biodiversity characteristics of the project location are described in each of the following subsections.

3.4.1. Freshwater Ecoregion of the World

The study area occurs within the Zambezian Lowveld freshwater ecoregion, which is composed of perennial and seasonal rivers and associated floodplains, swamp forests, swamps, seasonally inundated pans and grasslands, and coastal lakes of this coastal plains ecoregion which support an extremely rich and diverse biota.

3.4.2. Limpopo Conservation Plan

In 2013, the Department of Economic Development, Environment and Tourism (LEDET) published their Limpopo Conservation Plan version 2. This revised version was developed from the existing Limpopo Conservation Plan version 1 by executing a quantitative systematic spatial biodiversity planning methodology that:

- Addresses the deficiencies of the original provincial plan (i.e. Version 1);
- Considers the most up-to-date spatial data and institutional and expert knowledge;
- Aligns the methods and terminology of the plan with the national guidelines for the development of bioregional plans (Government Gazette No.32006, 16 March 2009);
- Considers existing spatial biodiversity planning products; and
- Involves skills transfer through working with LEDET staff on the development of the CBA map and GAP assessment.

The Limpopo Conservation Plan develops the spatial component of a bioregional plan (one of the range of tools used to inform land-use planning, environmental assessment and authorisations and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity (Desmet *et al*., 2013). This is done by providing a map of biodiversity priority areas or Critical Biodiversity Areas (CBA) together with accompanying land-use planning and decision-making guidelines.

Critical Biodiversity Areas (CBAs) with a bioregion are the portfolio of areas (i.e. map of CBAs for Limpopo Province), which if maintained in the appropriate respective condition (i.e. Land-use Guidelines) would meet the pattern targets for all biodiversity features, as well as ensure that areas necessary for supporting critical ecological processes remain functional.

Based on these primary outputs, the northern portion of the proposed Dalyshope Coal Mine was predominantly classified as an Critical Biodiversity Area 1, while the two pans located in the southern portion of the study area are regarded as Ecological Support Areas 1 (Figure 3-2; Table 3-2). The purpose of compiling land-use guidelines is to provide direction for the types of activities that might be deemed to be compatible with the biodiversity management objectives of each of the relevant categories. While this does not detract from existing land-use rights or the statutory requirement for permits and/or environmental authorisations, it is recommended that any planned activity within an identified conservation area comply with the Duty of Care obligations of Section 28 of the National Environmental Management (Act No 107 of 1998).

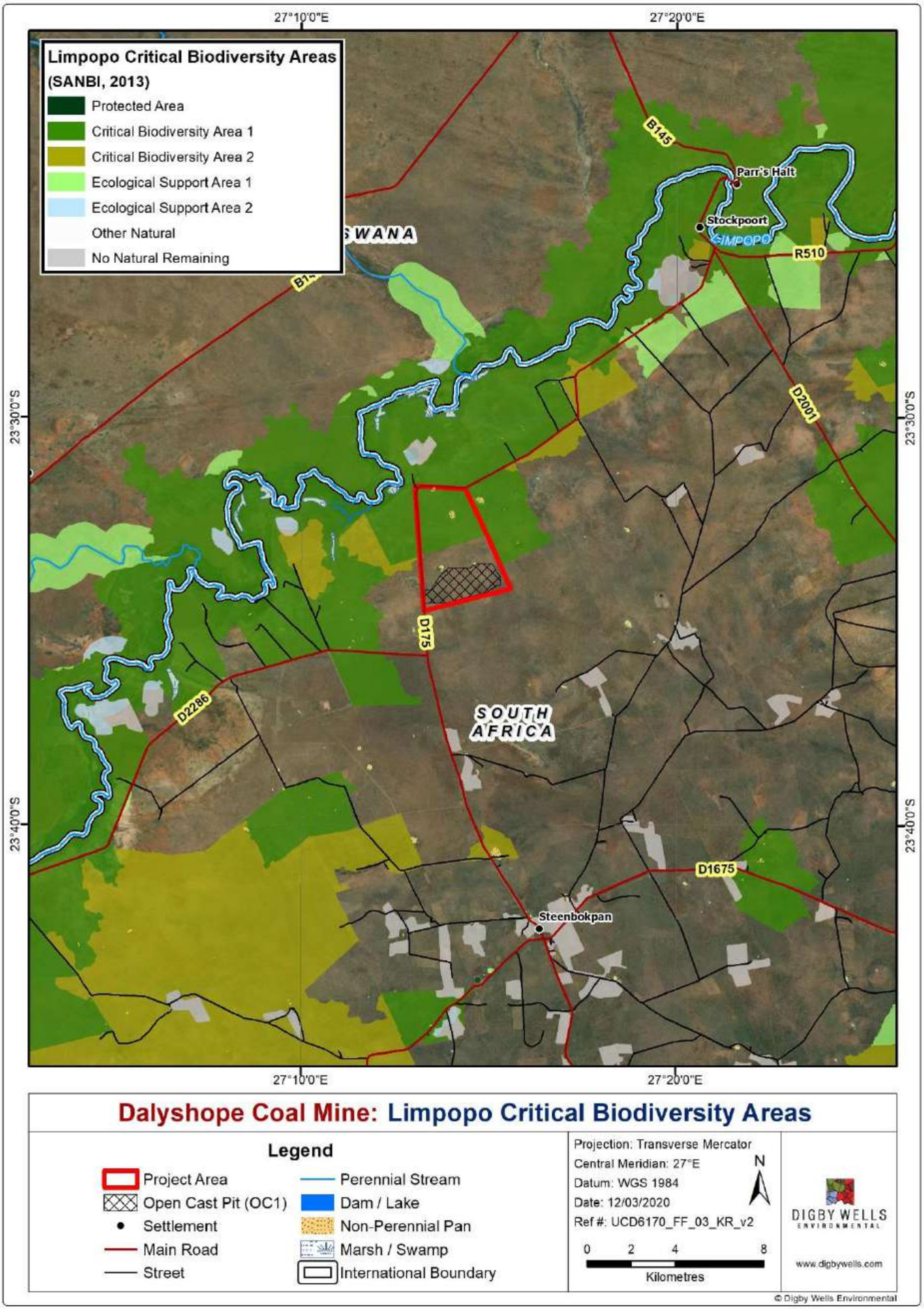

Figure 3-2: Limpopo Conservation Areas associated with the study site

Table 3-2: Limpopo Conservation Plan categories directly associated with the proposed Dalyshope Coal Mine, as well as recommended Land Management Objective (Desmet, 2013)

Category*	Description	Land Management Objective
CBA1	Areas required to meet biodiversity pattern and/or ecological process targets.	Maintain in a natural state with limited or no biodiversity loss; and
	Note: No alternative sites are available to meet targets.	Rehabilitate degraded areas to natural or near natural state and manage for no further degradation.
ESA1	Natural, near natural and degraded areas supporting CBAs by maintaining ecological processes	Maintain ecosystem functionality and connectivity allowing for limited loss of biodiversity pattern.
* **Conservation Plan Categories: CBA1** – Critical Biodiversity Area 1, **ESA1 –** Ecological Support Area 1		

3.4.3. National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA; now Department of Water and Sanitation, or DWS), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

- Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems;
  - This aim is to accomplish systematic biodiversity planning to identify priorities for conserving South Africa's freshwater biodiversity within the context of equitable social and economic development.
- Develop a basis for effective implementation of measures to protect FEPAs, including free-flowing rivers. This aim comprises of two separate components:
  - National component aimed to align DWA (or currently the DWS) and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems; while the
  - Sub-national component is aimed to use three case studies to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes.

- Maximize synergies and alignment with other national level initiatives, including the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation (Driver *et al*., 2011).

The project further aimed to maximize synergies and alignment with other national level initiatives, including the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation (Driver *et al*., 2011).

Based on the current outputs of the NFEPA project (Nel *et al*., 2011; Table 3-3), the Limpopo River reach associated with the Project is unclassified, but there are several FEPA wetlands occurring within the proposed Mining Right area. A Wetland Cluster occurs to the north portion of Klaarwater 231 (Figure 3-3). The sub-quaternary catchment (A41E) within which the proposed Project lies is not considered a NFEPA Water Management Area, however, River FEPA and Phase 2 River FEPA occur east of the project area within the A42J sub-quaternary catchment (Figure 3-4).

Table 3-3: Freshwater ecosystem types directly associated with the proposed Dalyshope Coal Mine, showing National Freshwater Ecosystem Priority Areas (NFEPA) categories (Nel *et al*., 2011; Nel & Driver, 2012)

Type of Watercourse	Freshwater Ecosystem Type
River	Limpopo Plain-Perennial/Seasonal-Lowland River **(1_P_F)**
Wetland	Central Bushveld Group 4 - Channelled Valley-bottom
	Central Bushveld Group 4 - Depression
	Central Bushveld Group 4 - Flat

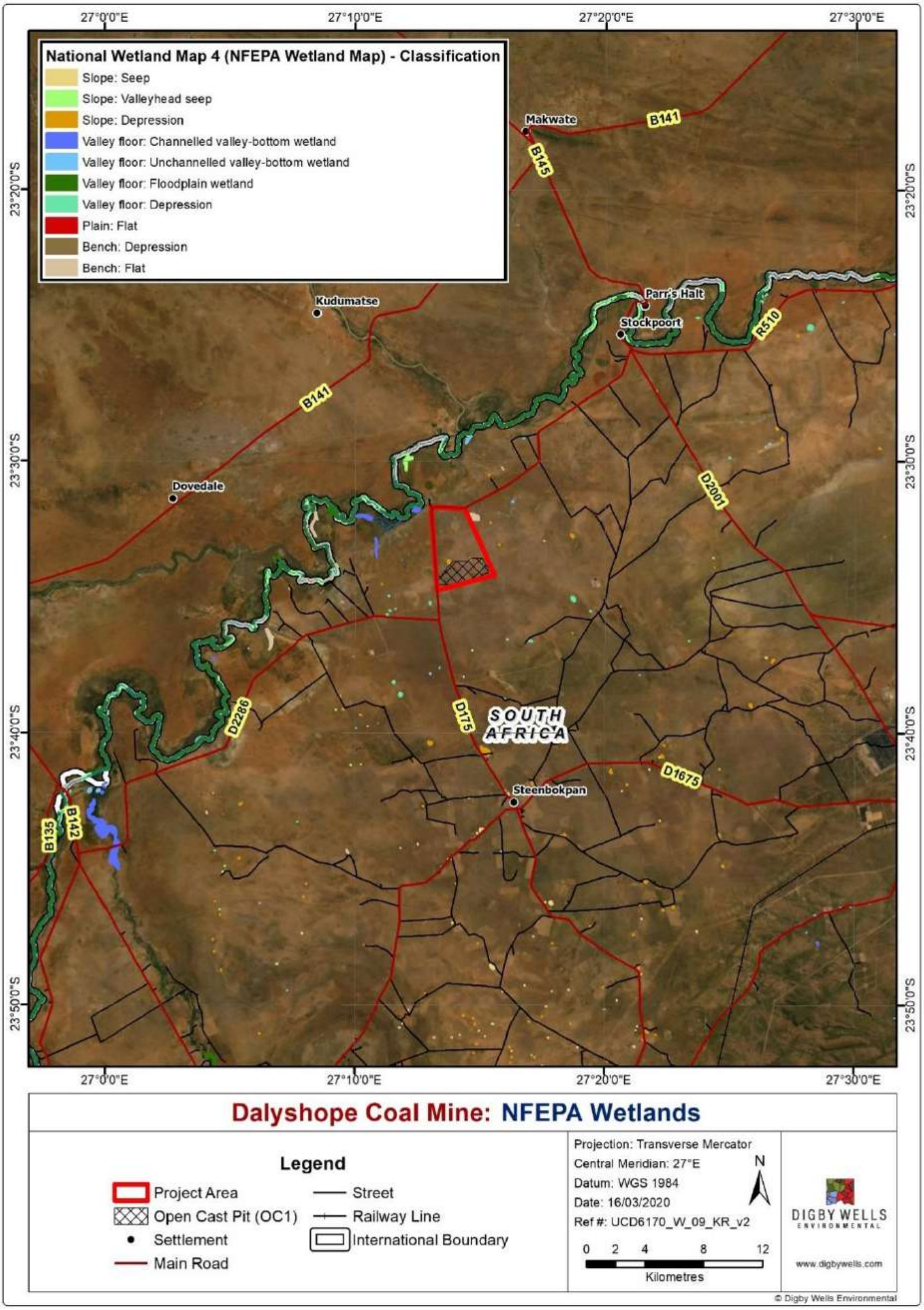

Figure 3-3: HGM units associated with proposed project area

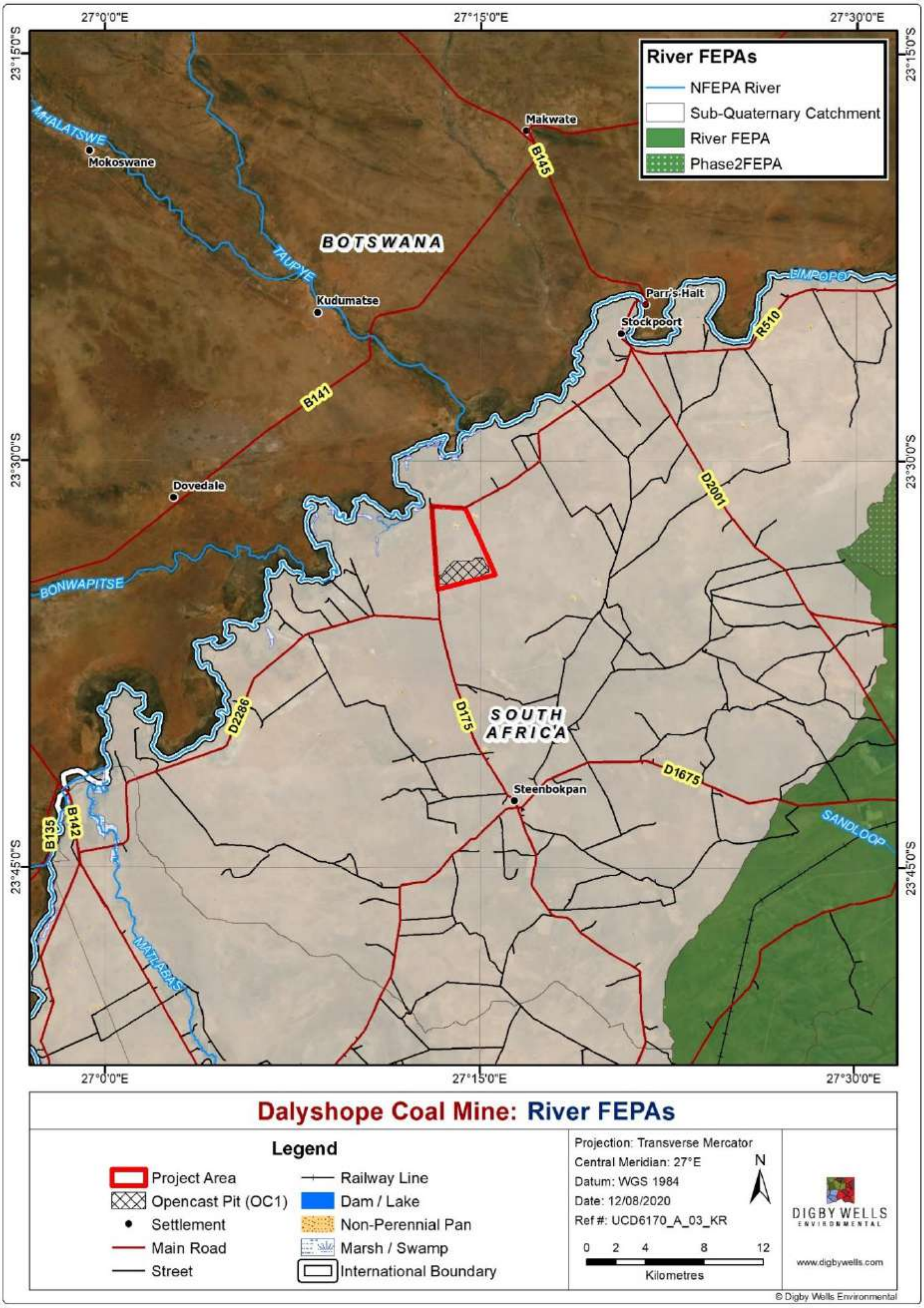

Figure 3-4: River FEPAs

4. Study Directive

This section provides a brief description of field observations at the time of the field survey, a summary of the proposed approach to the study, including each of the respective bioassessment indices to be utilised, as well as each of the selected monitoring sites.

4.1. Field Survey

This report presents the current aquatic biodiversity observed within the aquatic ecosystems associated with the proposed Dalyshope Coal Mining Project, the field survey for which was conducted between the 12th – 14th February 2020 (i.e. wet season).

Findings of the previous aquatic biomonitoring assessment undertaken in early March 2013 are used for comparative purposes.

4.1.1. Flow Regime of the Limpopo River

In the past five years, the Limpopo River catchment received the highest rainfall during the 2019/20 year, with a cumulative monthly rainfall of approximately 600 mm in February 2020 (~200 mm more than the previous year; Figure 4-1).

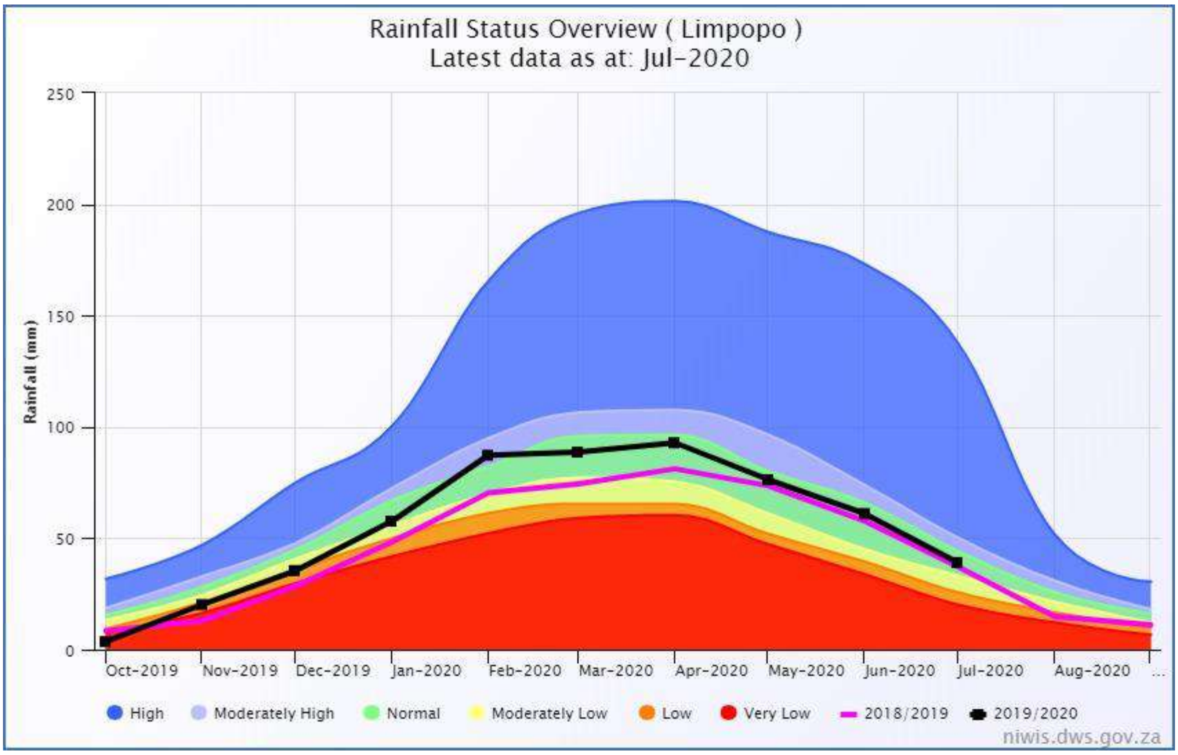

Figure 4-1: Monthly Rainfall data for the Limpopo Province

The Limpopo River was historically described as a strong perennial river system, however, due to anthropogenic activities such as water abstraction, irrigation, domestic and industrial water use and the creation of impoundments in the upper catchments, a cessation of flow occurs in the lower reaches during the dry season (DWE, 2014; FEOW, 2019). The Limpopo

River is now classified as a dryland river with surface flow ceasing entirely in the winter dry season (DWE, 2014).

Precipitation occurs in the summer months with 95 percent occurring between October and April. Rainfall varies significantly between years, with maximum monthly rainfall being as high as 340 mm compared with mean monthly rainfalls of 50–100 mm for January, February and March (FAO, 2004). Rainfall events are predominantly in the form of thunderstorms and therefore, consist of short duration, intense rainfall resulting in flooding. Droughts are frequent and floods occur regularly during intensive rain falls (DWE, 2014).

Floods occur when low-lying areas that are typically dry become temporarily inundated with water outside of their normal confines. The effects of flooding on aquatic ecosystems can be negative or positive since floods are not created equal and the causes and consequences are often unique – 65% of floods are caused by heavy precipitation. The large volumes of water moving rapidly downstream creates high shear stress on the stream bed and surrounding channel that abrades or moves substrates, suspends sediments in the water column, deposits logs and detritus, and can alter channel shape (Hughes *et al.*, 2008). Rivers need floods to create unique habitat and support biological productivity (i.e. nutrient transport, and sediment distribution) and biodiversity. However, floods may be disruptive for aquatic organisms by killing or displacing them and indirectly, by changing food resources and habitat availability (Talbot *et al*., 2018).

4.2. Approach to Study

To enable an adequate description of the aquatic environment and the determination of the present ecological state, the following stressor, habitat and response indicators were evaluated:

- **Stressor indicators:**
  - *In-situ* water quality assessment (Temperature, pH, Electrical Conductivity, and Dissolved Oxygen), including comparison to applicable guideline values (if any) and identification of parameters of potential concern; and
- **Habitat indicator:**
  - Instream and riparian habitat conditions, utilising the Index for Habitat Integrity (IHI, version 2); and
  - Aquatic macroinvertebrate biotope evaluation through the Adapted Invertebrate Habitat Assessment System (IHAS, Version 2.2).
- **Response indicators:**
  - Aquatic macroinvertebrate assessment, including the determination of ecological condition through Version 5 of the South African Scoring System (SASS5) and the Macro-Invertebrate Response Assessment Index (MIRAI);
  - Ichthyological assessment, including the evaluation of reference conditions and determination ecological condition through the Fish Response Assessment Index (FRAI); and
  - Determination of the integrated EcoStatus (EcoStatus 4, Version 1.02).

A detailed description of each index/approach utilised in the baseline determination has been outlined in Appendix B.

4.3. Selected Sampling Sites

Sampling sites were previously based on the 2013 studies, however some of the sites were amended due to the flooded nature observed at the time of the current survey, which presented accessibility difficulties (Table 4-1). Sites were selected based on the location of the infrastructure, the Mining Right area and areas suspected to support sensitive/conservational important aquatic species (refer to Appendix C for Site Photographs).

Table 4-1: Aquatic biomonitoring sampling sites within the study area

Site	Coordinates	Description
DAL 1 (Same as 2013 study)	23°31'24.58"S 27° 8'12.73"E	Located on the upper Limpopo River reach, below the confluence with the Bonwapitse River. Site lies upstream of the proposed project area.
DAL 2 (Added in present study)	23°29'40.10"S 27°12'9.45"E	Located on the middle Limpopo River reach, upstream of the confluence with the Mhalatswe River. Site lies adjacent to the project area.
DAL 3 (Same as **DAL 2** from 2013 study)	23°28'30.73"S 27°16'27.04"E	Located on the middle Limpopo River reach, below the confluence with the Mhalatswe River. Site lies downstream of the project area.
DAL 4 (Added in present study)	23°24'9.95"S 27°21'24.86"E	Located on the lower Limpopo River reach, at a river crossing of the South Africa – Botswana border, downstream of a non-perennial tributary of the Limpopo River. Site lies downstream of the project area.

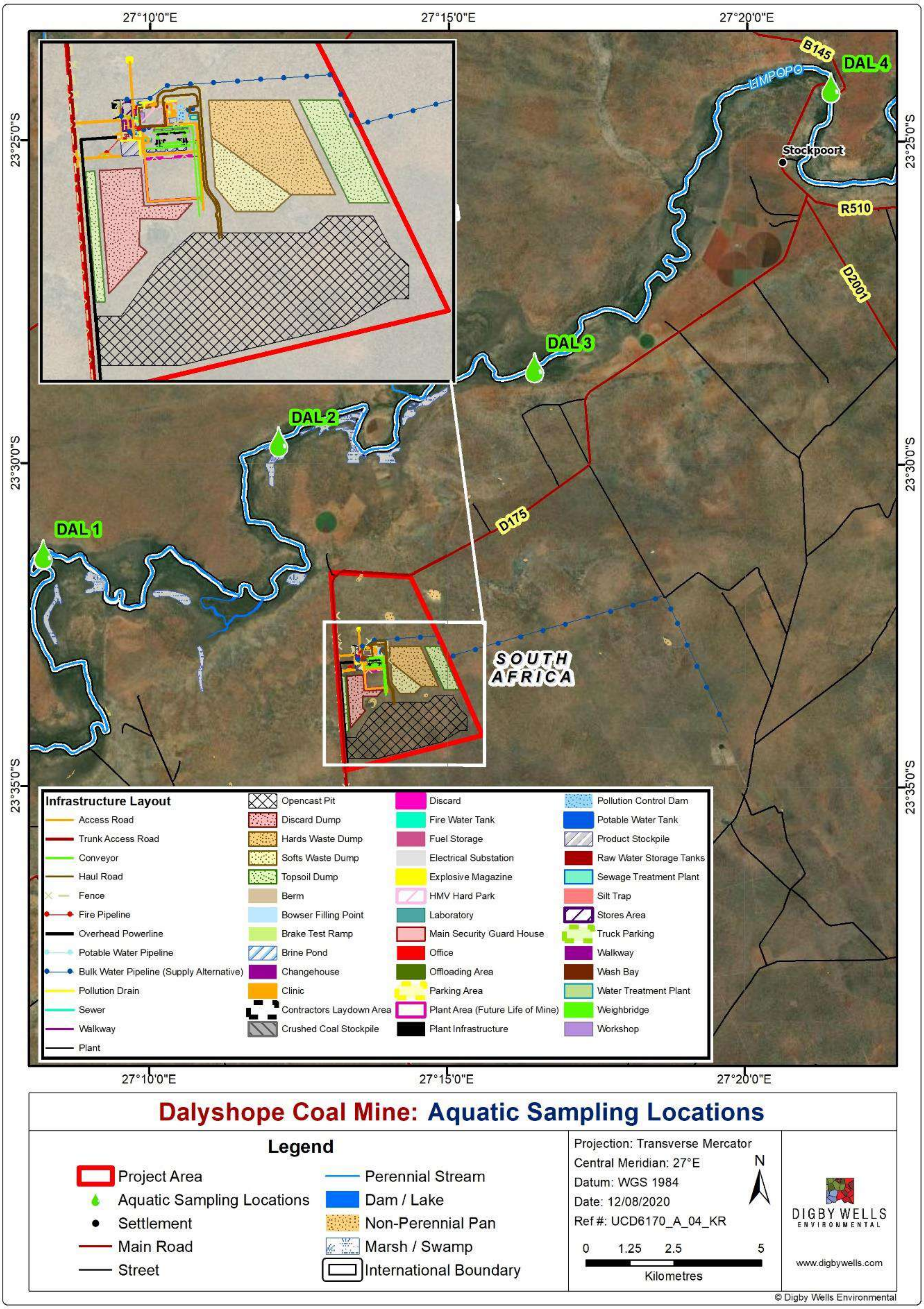

Figure 4-2: Selected aquatic sampling points and along the Limpopo River proposed and infrastructure layout

5. Desktop Information

The Present Ecological State, Ecological Importance and Sensitivity (PESEIS) information available for the considered aquatic ecosystems in the Department of Water and Sanitation 1:500 000 river layer (DWS, 2014) are discussed below.

Table 5-1 outlines the desktop aquatic-related data obtained for the Limpopo A41E-00126 SQR (DWS, 2014).

Table 5-1: Desktop aquatic data pertaining to the Limpopo River

SQR Code/Aquatic Component	A41E-00126
Ecological Category	**C**
Category Description	Moderately Modified
Ecological Importance (EI)	High
Ecological Sensitivity (ES)	High

According to the desktop data obtained for the Limpopo A41E-00126 SQR (DWS, 2014), the reach appears to be in a Moderately Modified state (i.e. Ecological Category C). Game reserves and agricultural land uses were observed to be present in the upper reaches of the Limpopo River associated with the Project Area. According to the DWS (2014), impacts associated with study area comprise of game reserves and agricultural activities, such as water abstraction; small dams; overgrazing and trampling; vegetation removal; increased fire frequency; soil erosion and compaction; sedimentation; irrigation as well as inundation and nature reserves appear to be affecting the current aquatic ecology associated with the Limpopo SQR (DWS, 2014).

The Ecological Importance of the Limpopo River SQR has been classified as “High”. A total of 41 macroinvertebrate taxa and 32 indigenous fish species are expected to occur within this SQR. Twenty eight fish species are listed as Least Concern (LC) in terms of their conservation status, whilst two are Near Threatened (NT), one is Vulnerable (VU) and there is limited data (Data Deficient; DD) for one species.

The Ecological Sensitivity for the SQR has been classified as “High”. This, from an instream perspective, is mainly due to the large number of highly sensitive macroinvertebrate and fish species expected.

5.1. Expected Macroinvertebrates

The expected macroinvertebrate taxa for the Limpopo River SQR of concern are presented in Table 5-2. Of the 41 expected macroinvertebrate taxa at the Limpopo SQR, seven have been classified as highly sensitive with regards to water quality and velocity/flow dependence (DWS, 2014). Of the seven taxa, two are regarded as sensitive towards both water quality changes and flow conditions, whilst the rest are regarded as sensitive to flow conditions only (i.e. high preference for fast-flowing water Table 5-2).

Table 5-2: Expected macroinvertebrate taxa in the Limpopo River

Family names		
Oligochaeta	Belostomatidae	Ceratopogonidae
Hirudinea	Corixidae	Chironomidae
Potamonautidae	Gerridae	Culicidae
Atyidae	Hydrometridae	Muscidae
Hydracarina	Naucoridae	Simuliidae
Baetidae > 2 sp	Nepidae	Tabanidae
Caenidae	Notonectidae	Lymnaeidae
Leptophlebiidae	Pleidae	Physidae
Tricorythidae	Veliidae / Mesoveliidae	Planorbinae
Coenagrionidae	Hydropsychidae 2 sp	Thiaridae
Aeshnidae	Leptoceridae	Corbiculidae
Corduliidae	Dytiscidae	Sphaeriidae
Gomphidae	Gyrinidae	Unionidae
Libellulidae	Hydrophilidae	
Blue shading indicates high-velocity dependence; **Orange** indicates high physio-chemical sensitivity and velocity dependence.		

Based on the absence of mining and sparse agricultural land use in the adjacent land areas associated with the Project Area, water quality in the associated aquatic ecosystems is expected to be of "small" modification (DWS, 2014). As a result of this deduction, it is suspected that the watercourses associated with the Project Area will inhabit macroinvertebrate taxa sensitive towards water quality, such as numerous Baetidae species.

5.2. Expected Fish Species

The fish species expected in the Limpopo River SQR (DWS, 2014) and those that were previously collected during the 2013 surveys have been provided for in Table 5-3. Additionally, each species' probability of occurrence (DWS, 2014) have been provided for, together with their conservation status according to the IUCN Red List of Threatened Species (2020).

A total of 33 fish species are expected to occur within the Limpopo River SQR A41E-00126. According to the IUCN, the conservation status of two of the species (*Anguilla bengalensis* and *Anguilla mossambica*) is near threatened (NT), whilst *Oreochromis mosambicus* is vulnerable (VU) and no data (DD) is reported for *Labeo ruddii.* The rest of the species are least concern (LC). (Table 5-3).

Table 5-3: Expected fish species in the reaches associated with the project area

Fish Species	Common Name	Probability of Occurrence	Status
Anguilla bengalensis	Indian Mottled Eel	Low	NT
Anguilla marmorata	Marbled Eel	Low	LC
Anguilla mossambica	African Longfin Eel	Low	NT
Brycinus imberi	Imberi	Moderate	LC
Chetia flaviventris	Canary Kurper	High	LC
Chiloglanis paratus	Sawfin Suckermouth	Low	LC
Clarias gariepinus	Sharptooth Catfish	High	LC
Coptodon rendalli	Redbreast Tilapia	High	LC
Enteromius afrohamiltoni	Hamilton's barb	Moderate	LC
Enteromius annectens	Broadstriped Barb	Low	LC
Enteromius bifrenatus	Hyphen Barb	Moderate	LC
Enteromius mattozi	Papermouth	Low	LC
Enteromius paludinosus	Straighfin Barb	High	LC
Enteromius radiatus	Redeye Barb	Moderate	LC
Enteromius trimaculatus	Threespot Barb	High	LC
Enteromius unitaeniatus	Longbeard barb	High	LC
Enteromius viviparus	Bowstripe barb	Low	LC
Labeo cylindricus	African Carp	High	LC
Labeo molybdinus	Leaden Labeo	High	LC
Labeo rosae	Rednose Labeo	High	LC
Labeo ruddii	Silver Labeo	High	DD
Labeobarbus marequensis	Lowveld Largescale Yellowfish	High	LC
Engraulicypris brevianalis	River Sardine	Low	LC
Micralestes acutidens	Silver Robber	Moderate	LC
Micropanchax johnstoni	Johnston's Topminnow	Moderate	LC
Marcusenius macrolepidotus	Bulldog	High	LC
Oreochromis mossambicus	Mozambique Tilapia	High	VU
Petrocephalus wesselsi	Southern Churchill	Moderate	LC
Pseudocrenilabrus philander	Southern Mouthbrooder	High	LC

Fish Species	Common Name	Probability of Occurrence	Status
Schilbe intermedius	Butter Catfish	High	LC
Synodontis zambezensis	Brown Squeaker	High	LC
Tilapia sparrmanii	Banded Tilapia	High	LC
Conservation Status: LC=Least Concern, NT=Near Threatened, DD=Data Deficient			

5.2.1. Species of Conservation Concern

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

***Anguilla bengalensis* and *Anguilla mossambica*:**

A. bengalensis and *A. mossambica* have been listed as Near Threatened by the IUCN. These species are susceptible to, primarily anthropogenic, threats including, but not limited to; barriers to migration, climate change, habitat degradation, invasive species, parasitism, pollution, predation and unsustainable exploitation. In South Africa, poor water quality is suggested to have caused eel species to become rare in some localities. The predatory bass (*Micropterus spp.)* and catfish (*Clarias spp*.), may also have contributed to the decline. Conservation actions should focus on a holistic approach and not on a single threat in isolation because all anguillids migrate to the ocean to breed, therefore barriers – such as dam walls – between continental waters and the ocean together with threats associated with both freshwater and marine environments increase the impact of threats (Pike *et al*., 2019).

***Oreochromis mossambicus*:**

O. mossambicus (Mozambique Tilapia) has been listed as Vulnerable by the IUCN. According to (Bills, 2019), The Nile Tilapia (*Oreochromis niloticus*), is invading this species' natural range in the Zambezi and Limpopo rivers systems. Hybridisation is occurring in the Limpopo River System and pure Mozambique Tilapia are likely to become extirpated in those systems through competition and hybridisation. Conservation actions that should be taken to protect the genetic integrity of Mozambique Tilapia include prevention of deliberate and accidental introductions of the Nile Tilapia and other non-native *Oreochromis* species in river systems that have not yet been invaded.

6. Results and Discussion

Each of the assessment indicators applied at the time of the February 2020 survey are discussed below and where possible, trend analyses are undertaken for spatial and temporal comparison to previous studies undertaken.

6.1. Water Quality

Water quality testing is an important part of environmental monitoring in rivers. When water quality is poor, it affects not only aquatic life, but the surrounding ecosystem as well. The maintenance of adequate dissolved oxygen (DO) concentrations is critical for the survival and functioning of the aquatic biota because it is required for the respiration of all aerobic organisms (DWAF, 1996).

For the purposes of the current aquatic biomonitoring and impact assessment report, each of the values recorded at the time of the surveys were compared against various water quality guidelines originating from the following sources:

- pH and saturation percentage guidelines obtained from Department of Water Affairs and Forestry (1996a);
- Conductivity guideline value of 500 µS/cm stipulated in U.S. Environmental Protection Agency (2010); and
- Dissolved oxygen concentration guideline for macroinvertebrates from Nebeker *et al*. (1996). And dissolved oxygen saturation for aquatic biota from Department of Water Affairs and Forestry (1996).

The water quality results of the 2020 wet season survey for the Limpopo River are presented in Table 6-1 and are further discussed in this section. Results comparing the current survey to the 2014 wet season survey are shown in Table 6-2. It should be noted that the *in-situ* results are not deemed to represent the typical wet season characteristics due to the occurrence of floods at the time of the survey.

Table 6-1: *In-situ* water quality results obtained along the Limpopo River system at the time of the current survey

Monitoring Site	DAL 1	DAL 2	DAL 3	DAL 4	Guideline
Time	9h30	10h30	13h40	16h20	-
Temperature (°C)	26.2	27.1	27.4	29.1	-
pH	7.67	7.69	7.57	7.55	6-8
Conductivity (µS/cm)	62	59	64	64	≤500
Dissolved oxygen (mg/l)	6.31	6.47	5.43	5.87	>5
Dissolved oxygen (Saturation %)	74.3	89.9	66.5	71.6	80-120
***Red values indicate constituents exceeding recommended guideline values**					

Temperature

Water temperature is an important abiotic factor in aquatic ecosystems, it influences organisms' growth, feeding and metabolic rates, emergence, fecundity and behaviour. Thus all organisms have an optimum temperature range within which they survive. The temperatures of inland waters in South Africa generally range from 5-30 ^{o}C which is the range within which most aquatic invertebrates in southern Africa thrive (Dallas & Rivers-Moore, 2012). Human-induced changes in temperature include (amongst others), water abstraction, heated return-flows of irrigation water; and discharge of water from impoundments (Department Of Water Affairs And Forestry, 1996).

pH

The pH value is a measure of hydrogen (H^+), hydroxyl (OH^-), bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions in water (H.F. Dallas & Day, 2004). The pH of natural water is determined by geological and atmospheric influences and may also vary both diurnally and seasonally. Diurnal fluctuations occur in productive systems where the relative rates of photosynthesis and respiration vary over a 24-hour period because photosynthesis alters the carbonate/bicarbonate equilibrium by removing CO from the water, thus elevated pH levels may be a characteristic of eutrophic systems where biological activity is increased. The toxicity of many elements in water is determined by pH, aluminium for example, is mobilized in acidic waters (DWAF, 1996).

The pH values recorded exhibited largely close to neutral, slightly alkaline conditions during the present study. pH values ranged from 7.55 at Site DAL 4 to 7.69 at DAL 2 and were recorded within the TWQR of 6-8 at all the sites.

Electrical Conductivity

Electrical conductivity (conductivity) is a measure of the ability of water to conduct an electrical current. This ability is a result of the presence in water of total dissolved salts or dissolved compounds that carry an electrical charge. Conductivity in natural waters varies in part on the characteristics of geological formations which the water has been in contact with and the dissolution of minerals in soils and plant matter. Anthropogenic sources of increased dissolved salts include domestic and industrial effluent discharges and surface runoff from urban, industrial and cultivated areas.

Conductivity values recorded during the present study were predominantly low and recorded below the recommended guideline of 500 µS/cm at all the sites. Values ranged from 59 µS/cm at DAL 2 to 64 µS/cm at Site DAL 3 and DAL 4 respectively. The low conductivity values recorded are likely attributed to the unusually high water levels observed at the time of the survey, which likely flushed the system to an extent, thus diluting the system.

Dissolved Oxygen

Gaseous oxygen (O_2) from the atmosphere dissolves in water and is also produced in water by aquatic plants and phytoplankton. The maintenance of adequate dissolved oxygen concentrations is critical for the survival and functioning of the aquatic biota because it is required for the respiration of all aerobic organisms. Therefore, the dissolved oxygen concentration provides a useful measure of the health of an aquatic ecosystem.

Dissolved oxygen levels were predominantly low along the sampled Limpopo River reach, ranging from 5.4 mg/l at Site DAL 3 to 6.5 mg/l at DAL 2. Sites DAL 3 and DAL 4 recorded levels below the recommended guideline of 5 mg/l. According to the Department Of Water Affairs And Forestry (1996) TWQR for oxygen saturation, all the sites, except DAL 2, recorded levels below the lower limit of 80 %. Sampling was restricted to the marginal areas of the floodplain where the water was mostly stagnant, as such, biota escaping predation and avoiding the instream heavy flows are suspected to have been consuming the available oxygen through biological respiration, thus causing low oxygen levels.

Table 6-2: *In-situ* water quality results between the current survey and the 2014 wet season survey

Monitoring Site	DAL 1		DAL 3		Guideline
Year	2014	2020	2014	2020	-
Temperature (°C)	26	26.2	25	27.4	-
pH	7.7	7.67	7.8	7.57	6-8
Conductivity (µS/cm)	447	62	400	64	≤500
Dissolved oxygen (mg/l)	7.29	6.31	6.48	5.43	>5
Dissolved oxygen (Saturation %)	114	74.3	94	66.5	80-120
Exceedances in Target Water Quality Range (TWQR; Department of Water Affairs and Forestry, 1996; Government notice 562, 2019) are indicated in red					

Amongst the water quality results obtained between the current survey and the 2014 wet season survey, only conductivity was observed to differ significantly. In the 2014 survey, high conductivity levels – seven and six times higher than the current survey at sites DAL 1 and DAL 3 – were recorded. The river was reported to be in flood during the 2014 survey. Unlike the 2020 survey, the DWE (2014) report does not report on inaccessibility to sample instream despite the flooded state. It is therefore assumed that the relatively higher conductivity and dissolved oxygen levels were a result of increased turbidity and aeration caused by the flows.

6.2. Aquatic and Riparian Habitat

Assessment of aquatic habitat within the study area was based largely on the application of recognised assessment indices at each of the selected sampling points, as well as associated reach) within the assessed watercourses, namely the Index for Habitat Integrity (IHI) and the Invertebrate Habitat Assessment System (IHAS). While the IHI is a rapid, field-based, visual assessment of modifications to a number of pre-selected biophysical drivers (i.e. semi-quantitative) used to determine the Present Ecological State (PES, or Ecological Category) of associated instream and riparian habitats.

6.2.1. Index for Habitat Integrity

The IHI was completed on a desktop level for each aquatic ecosystem considered in the Study and populated with observations recorded during the field survey. IHI scores from the previous survey are included. Both low and high-flow 2013 surveys were considered in determining the scores (Table 6-3).

Table 6-3: Index for Habitat Integrity for the study area during the current survey and 2013 surveys

Habitat Component	IHI Score	Ecological Category
2020 survey		
Instream	69	**C**
Riparian	80	**B**
2013 survey		
Instream	62	**C**
Riparian	92	**A**

The findings from the IHI assessments conducted during the current survey indicate that the habitat integrity was moderately modified (Ecological Category C) for the instream component and largely natural (Ecological Category B) for the riparian component throughout the study area. In comparison to the 2013 surveys, the IHI score for the instream component remained as moderately modified, whilst the Ecological Category moved from A (natural) to B (largely natural) for the riparian component which is probably attributed to an increase in alien vegetation encroachment over the years.

The main modifications to the assessed Limpopo reach were observed to be associated with game reserves and agricultural land uses such as water abstraction; small dams; overgrazing and trampling; vegetation removal; sedimentation; irrigation as well as inundation.

6.3. Aquatic Macroinvertebrate Assessment

The following sections provides insights into the available habitat that was sampled at each respective monitoring sites at the time of the current survey, as well as the South African Scoring System (SASS, Version 5) metrics obtained and the subsequent determination of the ecological condition of the observed assemblages in relation to reference conditions.

6.3.1. Invertebrate Habitat Assessment System

The Invertebrate Habitat Assessment System (IHAS, Version 2.2), developed by McMillan (1998), has routinely been used in conjunction with the SASS approach as a measure of variability in the quantity and quality of representative aquatic macroinvertebrate biotopes available during sampling. However, according to a study conducted within the Mpumalanga and Western Cape regions, the IHAS method does not produce reliable scores at assessed sampling sites, as its performance appears to vary between geomorphologic zones and biotope groups (Ollis *et al*., 2006). While no conclusion can be made regarding the accuracy of the index until further testing has been conducted, these potential limitations and/or shortfalls should be noted. Nevertheless, due to the value of basic instream habitat assessment data and its suitability for comparison of available macroinvertebrate habitats between various sampling sites, an adapted IHAS approach was maintained during the interim period, excluding assessment of the '*surrounding physical stream condition*.'

Table 6-4 shows the adapted IHAS scores at the sites assessed during the current survey and the IHAS scores obtained during the 2014 wet-season survey.

Table 6-4: IHAS values obtained throughout the study area

Site	2020		2014	
	IHAS Score (%)	Interpretation	IHAS Score (%)	Interpretation
DAL 1	43.6	Poor	37	Poor
DAL 2	29.1	Poor	N/A	
DAL 3	32.7	Poor	39	Poor
DAL 4	36.4	Poor	N/A	
*N/A not assessed				

Due to the flood conditions within the study area during the current survey, accessibility of representative aquatic macroinvertebrate biotopes was largely limited, and sampling of aquatic macroinvertebrates was limited to the inundated marginal and riparian zones, as such, the stones biotope was largely absent. The system was dominated by shallow to deep, still and/or slow-flowing water at the banks. Consequently, each of the assessed sampling sites exhibited largely poor habitat availability with varying degrees of fringing vegetation, sand and mud being the dominant biotopes. By comparison, the dominant feature amongst invertebrate habitat was reported to be sandy substrate with the stones and vegetation biotopes lacking (DWE, 2014).

6.3.2. Benthic Communities and Composition

Due to the differential sensitivities of aquatic macroinvertebrates, the composition of the aquatic macroinvertebrate community can provide an indication of changes in water quality and other ecological conditions within a watercourse. The use of the SASS has undergone numerous advances, culminating in Version 5 presently being utilised in river health studies along with the application of the MIRAI. However, it should be noted that the application of the SASS5 and MIRAI indices within heavily flooded systems should be interpreted with caution because the sample collected will not be a true reflection of the biota at the site.

Table 6-5 presents the SASS5 results for the assessed monitoring sites within the Limpopo River system. Comparisons in SASS5 results between the current survey and the 2014 wet-season survey are presented in Table 6-6.

Table 6-5: SASS5 data obtained for the 2020 high-flow assessment

Monitoring Site	DAL 1	DAL 2	DAL 3	DAL 4
SASS5 Score	19	15	7	22
Taxa	6	5	3	4
ASPT	3.2	3	2.3	5.5

A total of only 10 families (out of the expected 41) were collected along the Limpopo River reach during the present study. Ranging from three at Site DAL 3 to six at Site DAL 1. Five of the taxa are generally regarded as having a high preference for very slow-flowing water, whilst the rest are regarded as having preference for either slow or moderate-flowing water. These thus took refuge at the marginal areas of the floodplain where flows were slower.

Site DAL 4 recorded the highest SASS score, as well as the highest Average Score Per Taxon (ASPT) value, whilst Site DAL 3 recorded the lowest SASS score and ASPT. The highest number of taxa was collected at Site DAL 1 (site in the upper reaches of the Limpopo River) whilst the lowest number of taxa was collected at Site DAL 3 (site in the middle reaches of the Limpopo River). Only macroinvertebrate families highly tolerant to water quality impairment were collected at all sites. The high ASPT at Site DAL 4 is a result of collecting taxa with relatively high sensitivity scores (i.e., 5 and 6) which skewed the results.

Table 6-6: SASS5 data for the 2020 vs 2014 high-flow assessments

Survey	2014	2020	2014	2020
Monitoring Site	**DAL 1**		**DAL 3**	
SASS5 Score	25	19	36	15
Taxa	7	6	10	5
ASPT	3.4	3.2	3.6	3

Similar SASS5 results were obtained for the two surveys which were both conducted during periods of floods along the Limpopo River. The low number of invertebrate families collected is therefore attributed to the state of floods which limited sampling accessibility and limited the availability of aquatic macroinvertebrate biotopes.

6.3.3. Ecological Condition of the Aquatic Macroinvertebrate Assemblages

Although Chutter (1998) originally developed the SASS protocol as an indicator of water quality, it has since become clear that the SASS approach gives an indication of more than mere water quality, but also a general indication of the current state of the macroinvertebrate community. While SASS does not have a particularly strong cause-effect basis for interpretation, as it was developed for application in the broad synoptic assessment required for the old River Health Programme (RHP), the aim of the Macro-Invertebrate Response Assessment Index (MIRAI) is to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic macroinvertebrate community (assemblage) from the reference condition (C. Thirion, 2008). This does not preclude the calculation of SASS scores, but encourages the application of MIRAI assessment, even for River Health Programme purposes, as the preferred approach. Accordingly, the SASS5 data obtained was used in the MIRAI (Thirion, 2008) to determine the Present Ecological State (PES, or Ecological Category) of the associated macroinvertebrate assemblage.

Results for the MIRAI at the Limpopo River reach are shown in Table 6-7. The PES was determined on a reach-basis for purposes of comparing to the 2013 survey.

Table 6-7: Macroinvertebrate Response Assessment Index (MIRAI) at the Limpopo River monitoring sites during baseline aquatic assessment

Component	2020	2014
MIRAI (%)	52.85	50.31
EC: MIRAI	D	D
Category	Largely modified	Largely modified

The macroinvertebrate assemblages along the sampled Limpopo River reach exhibited largely modified conditions (Ecological Category D) for both the current and previous 2013 surveys. These findings are however of low confidence and not regarded to represent the 'natural' state of macroinvertebrate assemblage at the Limpopo River reach as the sampling was conducted during periods of floods which are known to cause disturbances in aquatic invertebrate communities (Hughes *et al*., 2008). All the aquatic macroinvertebrate samples collected are believed to have been flushed onto the riverbanks or carried along with substrates.

6.4. Fish Communities

Using fish as a means to determine ecological disturbance has many advantages (Zhou *et al*., 2008). Fish are long living, respond to environmental modification, continuously exposed to aquatic conditions, often migratory and fulfil higher niches in the aquatic food web. Therefore, fish can effectively give an indication into the degree of modification of the aquatic environment. The River EcoStatus Monitoring Programme (REMP) uses the FRAI which is based on the preferences of various fish species as well as the frequency of occurrence. The techniques applied to sample the available fish species within the project area included cast nets and electroshocking which were applied at all sites where possible and a variety of fish species were captured.

Thirty-two fish species were expected to occur within the study area, with three species deemed a conservation concern (see section 5.2;Table 5-3).

The fish species collected during the present study are discussed in the below sub-sections.

6.4.1. Catch Record

It should be noted that only floodplain benches were sampled whilst other (instream) habitat was inaccessible due to the flood conditions at the time of the survey. Consequently, the lower abundance of collected specimens throughout the Limpopo River reach was expected.

A total of 11 fish species were collected (or observed), one of which was regarded as alien invasive species (*Gambusia affinis* or Mosquitofish). Among the species of conservation concern, only *O. mossambicus* was collected. The number of fish collected per site sampled (Figure 4-2) is shown in Table 6-8.

Table 6-8: Fish collected (or observed) within the reaches of the Limpopo River

Scientific Name	DAL 1	DAL 2	DAL 3	DAL 4
Brycinus imberi	2	-	-	1
Enteromius paludinosus	1		-	-
Enteromius trimaculatus	-	2	-	-
*Gambusia affinis**	-	-	(1)	-
Labeo cylindricus	1	-	-	-
Labeo ruddi	-	-	-	2
Labeo molybdinus	1	-	-	-
Labeo rosae	2	3	-	-
Engraulicypris brevianalis	6	-	-	-
Oreochromis mossambicus	1	4	-	-
Pseudocrenilabrus philander	-	2	-	-
Number of Species	7	4	1	2
Total Catch	13	11	1	3
Catch per Unit Effort (per minute/throw)	1.6	1.1	-	0.3
*** Alien species. Values in parenthesis indicated observed specimens.**				

A single individual of the alien Mosquitofish was observed at Site DAL 3. The Mosquitofish – introduced in South Africa as a mosquito control agent and forage for bass – has proved to be an aggressive invader species capable of restricting other fish populations by preying on fish larvae (Skelton, 2001).

The highest number of species were collected at the upper reaches (Site DAL 1 and DAL 2; nine species in total) whilst only one and two species were collected at the lower reaches (DAL 3 and DAL 4 respectively). *Labeo rosae* (Rednose Labeo) and *Oreochromis mossambicus* (Mozambique Tilapia) were the only species collected at more than one site. The Rednose Labeo prefers sandy stretches of larger perennial and intermittent rivers whilst the Mozambique Tilapia prefers waters (Skelton, 2001). Both these species prefer slow deep waters and are moderately tolerant and tolerant (respectively) to water quality modifications (DWS, 2016). Dominance of these species during the current survey is therefore suspected to be a result of the above mentioned biological traits, i.e. individuals were spending more time along the banks where the flow velocity was slower and the water was clearer as sediments were allowed to settle making it easier to feed.

6.4.2. Ecological Condition of the Fish Assemblages

The assemblage of fish in the current study featured both tolerant (*Enteromius paludinosus* for example) and intolerant species (*Brycinus imberi* for example) to water quality modifications. FRAI results are presented in Table 6-9. A reach-based FRAI was implemented for purposes of comparing to the 2014 results.

Table 6-9: FRAI results for the baseline aquatic assessment

Survey	FRAI Score (%)	Ecological Category	Description
2020	32.2	**E**	Seriously modified
2014	83.1	**B/C**	Largely natural/moderately modified

Based on the results obtained, the fish assemblage collected within the assessed portion of the Limpopo River was representative of seriously modified conditions (Ecological Category E). The determined ecological condition is suspected to be attributed to the high water levels and floods experienced at the time of survey which limited the ability to sample in a diversity of potential fish habitat and across the water column. The collected assemblage was dominated by species that have a high preference for *slow-deep* and *slow-shallow* habitat (where sampling was mostly limited to). In terms of preferences to modified water quality, fish tolerances ranged from moderately intolerant to tolerant.

In the DWE (2014) report, FRAI results were determined based on 2013 and 2014 surveys wherein a total of 15 of the expected 19 species were captured, resulting in PES of largely natural conditions (Ecological Category B; with a FRAI % score of 83.1). At the time of the surveys, the water levels allowed for sampling over a wider variety of fish habitat thereby capturing ten species which were not collected in the present survey. Only *Brycinus imberi* and the alien *Gambusia affinis* were captured in the present study and not in the previous studies. *B. imberi* is moderately intolerant to no flow conditions and water quality modifications (DWS, 2014).

6.5. Integrated EcoStatus Determination

The EcoStatus is defined as: "*The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services*" (Iversen *et al*., 2000). In essence, the EcoStatus represents an integrated ecological state representing the drivers (hydrology, geomorphology, physico-chemical) and responses (fish, aquatic invertebrates and riparian vegetation; Kleynhans & Louw, 2008). The Instream Biological Integrity, as well as the integrated EcoStatus, for the sampled river reaches within the project area were determined below (Table 6-10).

Table 6-10: The Present Ecological Status of the reaches under study at the time of the February 2020 field survey through the use of the ECOSTATUS4 (Version 1.02; Kleynhans & Louw, 2008)

Survey	Response Indices					
	Aquatic Macroinvertebrate EC (MIRAI)	Fish EC (FRAI)	INSTREAM EC	Riparian Vegetation EC (IHI)	ECOSTATUS	
					Score (%)	Category
2020	D	E	D	C/B	61.35	C/D

Following integration of the defined ecological conditions obtained for the instream biological integrity (i.e. combination of MIRAI from aquatic invertebrates and FRAI from fish) and the riparian component (i.e. IHI from riparian vegetation assessment), it was determined that the sampled Limpopo River represented an integrated EcoStatus of close to moderately modified (Ecological Category C/D). It is important to note that a low confidence rating was given to the scoring of instream and riparian vegetation ecological categories due to inaccessibility to sample a wide range of aquatic biota as a result of the flood at the time of the survey.

An integrated EcoStatus of largely modified conditions (Ecological Category D) was attained during the 2013 survey. The water quality was largely natural across the sampled sites whilst the habitat integrity and aquatic macroinvertebrates were seriously modified and largely modified respectively. The fish community assemblage was in a natural condition.

7. Impact Assessment

Any development in a natural (or modified) system will impact on the surrounding environment, potentially in a negative way. The purpose of this section of the report is to identify and assess the significance of the impacts likely to arise during the proposed activity and provide a short description of the mitigation required to limit the magnitude of the potential impact of the proposed activity on the natural environment.

Focus of the impact assessment has been solely on the proposed open cast pit and associated activities (see section 1; Figure 7-1). The identified potential impacts that will negatively affect aquatic ecology, particularly the riverine system (Limpopo River) are discussed below for the various phases of the Project (i.e. Construction Phase, Operational Phase, as well as Closure and Decommissioning Phase). An impact assessment

For a detailed description of the Impact Assessment Criteria and Calculations used during the assessment below, the reader is referred to Appendix B.

7.1. Impact Activities

The below provides the project activities to be considered as part of the impact assessment:

Table 7-1: Project phases and associated activities

Project Phase	Project Activity
Construction Phase	Site/vegetation clearance
	Temporary PCD
	Contractors laydown yard
	Access and haul road construction
	Infrastructure construction
	Diesel storage and explosives magazine
	Topsoil stockpiling
Operational Phase	Open pit establishment
	Removal of rock (blasting)
	Stockpiling (rock dumps, soft dumps, soils, ROM, product, discard dump) establishment and operation
	Diesel storage and explosives magazine
	Operation of the open pit workings
	Operating crush and screen and coal washing plant
	Operating sewage treatment plant and water treatment plant
	Water use and storage on-site – during the operation water will be required for various domestic and industrial uses. Water Management infrastructure including Two Pollution Control Dams (PCDs) will be constructed that capture water from the mining area, which will be stored and used accordingly. Workshop and storage of chemicals; Laundry and Laboratory services; Backfilling and concurrent rehabilitation; Weighing of coal trucks; Coal transportation through trucking, rail and conveyer belts; Washing of mine vehicles; and Fuelling of diesel on site.
	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 is operating optimally and does not pose a threat to human or environmental health. Maintenance will include haul roads, crushing and washing plant, machinery, water and stormwater management infrastructure, stockpile areas, dumps, etc.

Project Phase	Project Activity
Closure and Decommissioning Phase	Demolition and removal of infrastructure – once mining activities have been concluded infrastructure will be demolished in preparation of the disturbed land rehabilitated
	Rehabilitation – rehabilitation mainly consists of spreading of the preserved subsoil and topsoil, profiling of the land and re-vegetation
	Post-closure monitoring and rehabilitation

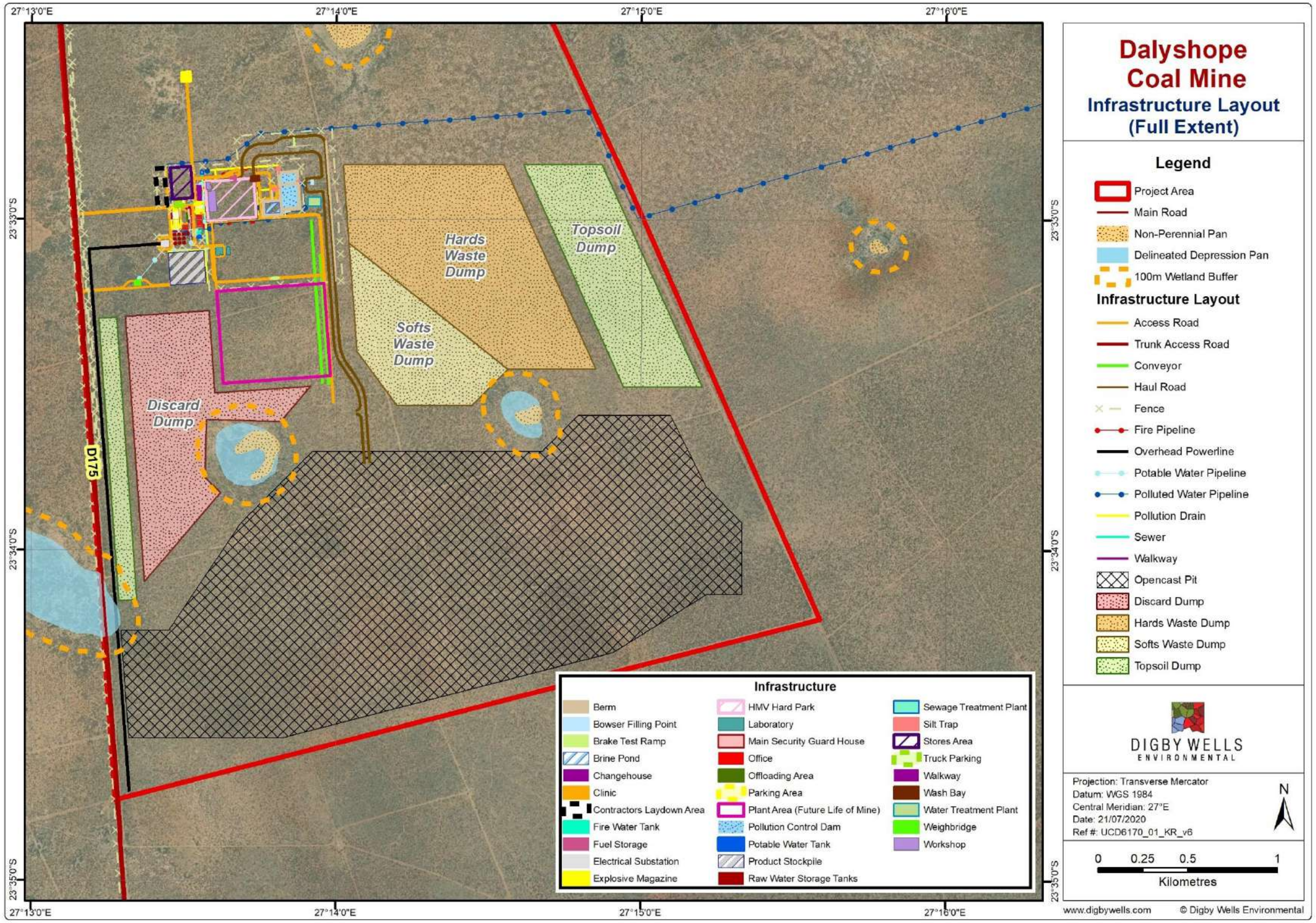

Figure 7-1: Proposed Infrastructure layout, excluding the water augmentation

7.2. Construction Phase

Land manipulation and vegetation clearing associated with the proposed open cast pit 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.

7.2.1. 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.

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.

7.2.1.1. Management Objectives

The main objective for mitigation would be to limit the areas proposed for disturbance/vegetation clearance combined with keeping 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.

7.2.1.2. 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:

- No buffer zones were proposed due to distance between the Limpopo River and the proposed Dalyshope Coal Mine operations;
- 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;
- All vehicles must be frequently inspected for leaks;
- No material may be dumped or stockpiled within any rivers, drainage lines in the vicinity of the proposed Coal Mine;
- All waste must be removed and transported to appropriate waste facilities;
- 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; and
- Monitoring of the associated Limpopo River reach should be implemented upon commissioning of the construction phase.

7.2.1.3. Impact Ratings

Table 7-2 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 Limpopo River.

Table 7-2: Impact assessment ratings for the Construction Phase

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 watercourses potentially draining into the Limpopo River via diffuse overland flow.			
Prior to Mitigation/Management			
Duration	Project life (5)	Once vegetation is cleared for infrastructure, no revegetation will occur until project closure.	Negligible (negative) – 24
Extent	Very limited (1)	Based on the absence of watercourses draining into the Limpopo River, the extent of runoff is expected to be limited to the site and its immediate surroundings.	
Intensity x type of impact	low - Negative (-2)	Effects to biological or physical resources limited to endorheic water bodies, thus not expected to affect ecosystem functioning of the Limpopo River.	
Probability	Unlikely (3)	The impact is unlikely to occur due to the dry nature of the area and impacts are limited due to periodic rainfall events.	
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) – 14
Extent	Very limited (1)	Runoff will be limited to specific isolated parts of the site following mitigation actions and if high rainfall periods are avoided for construction.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Minor - Negative (-1)	If mitigation measures are all incorporated for the Construction Phase, the intensity of the impact should decrease significantly, especially due to the segregated nature of water bodies observed during the survey.	
Probability	Highly unlikely (2)	The likelihood of the impact occurring at the surrounding endorheic pans is reduced by the mitigation actions and should only result in extreme cases or unexpected rainfall events.	
Nature	Negative		

7.2.2. Impact Description: Infrastructure construction over watercourses

Impacts associated with linear infrastructure will be addressed in the Wetland's Impact Assessment Report since non riverine resources occur within the proposed footprint for the construction of haul roads, conveyer systems and pipelines (Portable water and dirty water pipelines). The construction of these linear infrastructure is therefore not expected to notably impact on the Limpopo River.

Impacts associated with the construction of water supply pipelines and powerlines will be assessed once the layout plan is finalised.

7.2.2.1. Management Objective and action

Key objectives for management must be to avoid hydrocarbon spillages and leaks (including coal) from mine vehicles through routine vehicle inspections.

7.3. 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.

7.3.1. 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.

7.3.1.1. 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.

7.3.1.2. Management Actions

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

- Runoff from dirty areas should be directed to the storm water management infrastructure (drains and PCDs) and should not be allowed to flow into the surrounding pans, unless DWS discharge authorisation and compliance with relevant discharge standards as stipulated in the NWA is obtained as suggested in DWE Surface Water Impact Assessment Report (2020);
- 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 the associated Limpopo River reach should be done by an aquatic specialist in order to determine potential impacts where after new mitigation actions should be implemented as per the specialist's recommendations.

7.3.1.3. Impact Ratings

Table 7-3 presents the impact ratings determined for the potential runoff from the proposed infrastructure and associated activities.

Table 7-3: Impact assessment ratings for 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) – 36
Extent	Limited (2)	Due to the segregate nature of the watercourses in the MRA, surface runoff is expected to be limited which should result in limited contaminant input. It is unlikely that areas downstream of the Limpopo River system will be affected when rainfall events lead to contaminant input.	
Intensity x type of impact	Minor loss - Negative (-2)	Effects to biological or physical resources limited to endorheic water bodies, thus not expected to affect ecosystem functioning of the Limpopo River.	
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) – 21

Dimension	Rating	Motivation	Significance
Extent	Very limited (1)	Runoff will most likely be largely restricted and captured after mitigation.	
Intensity x type of impact	Minimal to no loss - Negative (-1)	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 may 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		

7.4. Closure and Decommissioning Phase

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

7.4.1. Impact Description: Physical decommissioning and removal of infrastructure in proximity to endorheic pans

Disturbance of aquatic ecosystems, using heavy machinery, will most likely result in erosion and increased runoff in the areas near or in the highlighted endorheic pans. 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.

7.4.1.1. *Management Objectives*

It is predicted that the natural morphology of the endorheic pans associated with the proposed surface infrastructure would have changed 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.

7.4.1.2. 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;
- 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 endorheic pans prior to rainfall/flow events; and
- Ensure the revegetation activities use appropriate indigenous plant species.

7.4.1.3. 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 7-4 below.

Table 7-4: Impact assessment ratings for 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) – 28
Extent	Limited (2)	Due to the segregate nature of the endorheic pans, impacts are expected to be limited to the immediate watercourses.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Minor loss - Negative (-2)	Effects to biological or physical resources limited to endorheic water bodies, thus not expected to affect ecosystem functioning of the Limpopo River.	
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) – 15
Extent	Very limited (1)	If mitigation measures are adhered to, especially working in the dry season, runoff is expected to be restricted to the mitigation structures.	
Intensity x type of impact	Minimal to no loss - Negative (-1)	If mitigation measures are all incorporated for the Project, the intensity of the impact should decrease notably especially after rehabilitation.	
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		

7.5. Cumulative Impacts

Most of the Limpopo River basin sub-catchments are either *Stressed* or *Very Stressed* with low Mean Annual Precipitation (MAP) and high evaporation rates and as such, water supply surpasses demand (Figure 4-2). Presently, the main cumulative impact identified for the aquatic ecosystems within the Limpopo River basin appears to be the influence of several game farming and, to a lesser extent, agricultural fields and mining operations (including the Grootegeluk, Biokarabelo, Temo and other mines in the area). The former are known to abstract water for animal consumption and for irrigation (Ginster *et al.*, 2010), whilst the latter uses significant amounts of water for mineral processing, dust suppression, slurry transport and domestic uses. The establishment of the Dalyshope Coal mine might result in the establishment of other economic activities, such as residential, retail and other mining developments in the area, which will further add on to the water demand pressures.

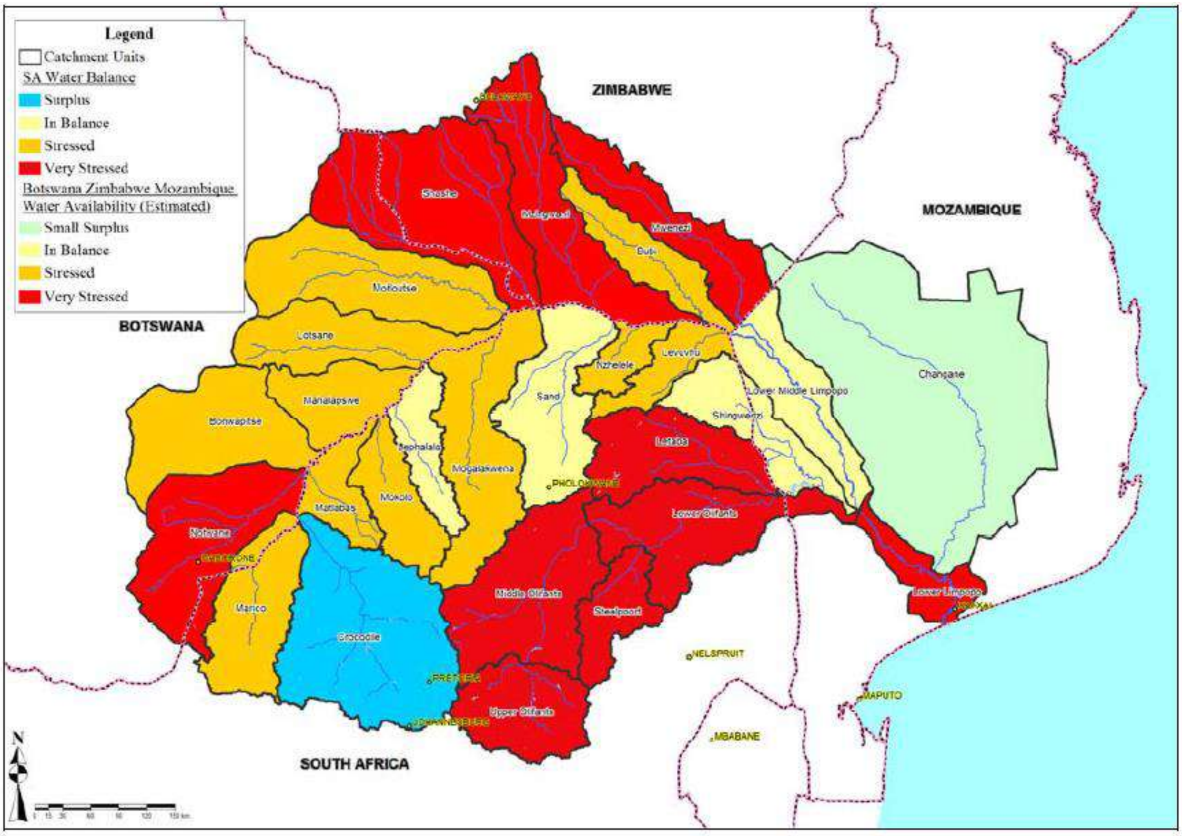

Figure 7-2: General water balances in the Limpopo River basin illustrated as the ratio between natural runoff and water use per sub-catchment (LBPTC, 2010).

7.6. 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, might affect the habitat and water quality of associated aquatic ecosystems.

Therefore, Table 7-5 outlines mitigation measures that must be adopted in the event of unplanned impacts throughout the life of the Project.

Table 7-5: 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.

8. Environmental Management Plan

Table 8-1 provides a summary of the proposed project activities, environmental aspects and impacts on the receiving environment. Information on the frequency of mitigation, relevant legal requirements, recommended management plans, timing of implementation, and roles / responsibilities of persons implementing the EMP.

Table 8-1: Environmental Management Plan

Activity/ies	Potential Impacts	Aspects Affected	Phase	Mitigation Measure	Mitigation Type	Time period for implementation
Site clearing, access and haul road construction, and topsoil stockpiling; and	• Erosion and sedimentation • Altered hydrology.	Aquatic Biodiversity	Construction	• Limit the footprint area of the construction activities to what is essential in order to minimise impacts as a result of vegetation clearing and potential erosion areas; • If possible, construction activities must be prioritised to the dry months of the year to limit mobilisation of sediments, dust generation and hazardous substances from construction vehicles used during site clearing; • Ensure soil management programme is implemented and maintained to minimise erosion and sedimentation; and • An efficient drainage system (e.g. diversion trenches > settling area (or sump) > baffled discharge outlets) should be implemented prior to construction.	*Modify* through construction site planning *Control* through stormwater management and sediment containment infrastructure.	Prior to construction activities are initiated
Construction activities, including vehicular activities and maintenance of haul roads	• Water quality impairment	Aquatic Biodiversity	Construction	• Spillage management kits or controls should be taken seriously and put in place to reduce oil or fuel run offs to enter nearby river systems. • All vehicles must be frequently inspected for leaks; and • All waste must be removed and transported to appropriate waste facilities.	*Control* through driving access permits and permit areas and ongoing maintenance.	Ongoing throughout the Construction and Operational phases

Activity/ies	Potential Impacts	Aspects Affected	Phase	Mitigation Measure	Mitigation Type	Time period for implementation
Operational aspects of proposed Coal Mine	• Erosion and sedimentation • Water quality improvement/impairment	Aquatic Biodiversity	Operational	• Runoff from dirty areas should be directed to the storm water management infrastructure (drains and PCDs); • The water quality monitoring program provided in this report should be adhered to for monitoring water resources within and in close proximity to the Project Area to allow detection of any contamination arising from operational activities; • The overall housekeeping and storm water system management (including the maintenance of berms, de-silting of dams and conveyance channels and clean-up of leaks) must be maintained throughout the life of mine; and • The hydrocarbon and chemical storage areas and facilities must be located on hard-standing area (paved or concrete surface that is impermeable), roofed and bunded in accordance with SANS1200 specifications. This will prevent mobilisation of leaked hazardous substances; • Training of mine personnel and contractors in proper hydrocarbon and chemical waste handling procedures is recommended; • Vehicles must only be serviced within designated service bays; • Wash bay and workshop runoff should flow through an oil separator as indicated on the infrastructure plan prior to discharge into the PCD	*Control* through inspection and monitoring, as well as stormwater management and sediment containment infrastructure.	Ongoing

Activity/ies	Potential Impacts	Aspects Affected	Phase	Mitigation Measure	Mitigation Type	Time period for implementation
Demolition and removal of infrastructure; Rehabilitation and closure.	• Erosion and sedimentation; • Altered hydrology; and • Restoration of the pre-mining streamflow regime in the Limpopo River	Aquatic Biodiversity	Decommissioning	• Restore the topography to pre-mining conditions as much as is practically possible by backfilling, removing stockpiles and restore the slope gradient and angle of the site; • Clearing of vegetation should be limited to the decommissioning footprint area and immediate revegetation of cleared areas; • Decommissioning activities should be prioritized during dry months of the year where practical; • Disturbance of soils during infrastructure demolition should be restricted to relevant footprint areas; • Movement of demolition machinery and vehicles should be restricted to designated access roads to minimise the extent of soil disturbance; • Use of accredited contractors for removal or demolition of infrastructure during decommissioning is recommended; this will reduce the risk of waste generation and accidental spillages; and • Ensure that the infrastructure (pipelines, fuel storage areas, pumps) are first emptied of all residual material before decommissioning.	Storm water management: Control contamination of receiving waterbodies by consideration of potential contamination sources and strategic decommissioning to minimize on potential environmental impacts	During the decommissioning phase And post-decommissioning phase

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 expected sensitive and conservation important species in the Limpopo River.

Table 9-1 outlines the aquatic monitoring methods to be undertaken at the monitoring points set out above (Figure 4-2) 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 at the monitoring points indicated. However, due to the characteristic nature of the Study Area (i.e., dry nature of the Limpopo River during the dry season), the biannual surveys should be undertaken during early wet season – for the low-flow assessment – and during late wet season – for the high-flow assessment. 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 site basis for the Limpopo River; The IHAS must be applied at each monitoring site prior to sampling.	• The Ecological Category determined for each assessed site must be maintained; and • The baseline IHAS scores should improve.
Aquatic Macroinvertebrates: Aquatic 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 site.
Fish:	Sampling must be done utilising standard electro-	Baseline Ecological Categories should not be allowed to drop

Method and Aquatic Component of Focus	Details	Goal/Target
Fish assemblages must be assessed biannually	narcosis techniques followed by the application of FRAI for applicable reaches.	in category for each assessed site. The main goal for the Project must be to conserve the expected sensitive and conservation important species.

The Project should not commence without inclusion of the above Aquatic Biomonitoring Programme.

10. Stakeholder Engagement Comments Received

The Public Participation (PP) Process is currently underway, but only two comments applicable to the state of the Limpopo River were received at the time of the writing, including:

- Proximity to the Limpopo River was raised as a potential feature of concern by Dr Llew Taylor from the Wildlife and Environment Society of South Africa (WESSA).
    - As demonstrated by the assessment, the amended boundary of the study area occurs approximately 780 m away from the Limpopo River at its closest point. In addition, the landscape and topography are relatively flat with a number of isolated pans within the vicinity of the Project Area, so drainage into the Limpopo is believed to be limited, especially if the water utilised on-site is contained within the relevant Storm Water Management infrastructure.
- The conservation importance of the Limpopo River and surrounding areas within the vicinity of the Project area was queried in terms of the Limpopo Conservation Plan by Dr Llew Taylor from WESSA.
    - As per Section 3.4.1, the northern portion of the Project Area is classified as a Critical Biodiversity Area 1, while two of the pans within the southern portions are regarded as Ecological Support Areas. In each of these cases, the intention is to strive to achieve the Land Management Objectives for each respective category with the implementation of the Mitigation Hierarchy. However, it is recommended the Terrestrial Biodiversity and the Wetland Functionality studies also be referenced in terms of the appropriate considerations and the validity of these desktop-based classifications.

Should any other Interested and Affected Parties (I&APs) raise specific queries regarding aquatic ecosystem, the comments will be addressed in the CRR and updated submission to authorities.

11. Conclusion and Way Forward

In-situ water quality findings within the Limpopo River reach were variable. pH levels exhibited largely close to neutral, slightly alkaline, conditions. Conductivity and dissolved oxygen levels were predominantly low. The low conductivity and dissolved oxygen levels are suspected to be attributed to the flooding event at the time of the survey.

The availability and integrity of aquatic macroinvertebrate biotopes were poor across the sampled reaches as sampling was largely limited to the banks, thus not the natural habitat of the macroinvertebrates. The collected macroinvertebrate assemblages indicate that conditions at the sampled reaches ranged from seriously modified to critically modified. However, the aquatic macroinvertebrate specimens collected are believed to have been flushed onto the riverbanks or the floodplain margins served as refugia.

Results of the fish community assessment indicate that the systems were all in a seriously modified condition. However, the presence of species sensitive to water quality modifications gives an indication that the aquatic ecosystems do have the capacity to support sensitive life and should be conserved irrespective of the modified ecological outcomes expressed in the baseline Aquatic Study. The conservation important fish species *Oreochromis mossambicus* was also present in the upper reaches of the Limpopo River.

The findings in the current aquatic study are of low confidence due to the fact that the depth of sampling was affected by the flooding event. The drought/flood cycles are characteristic of the Limpopo River, and as such, future monitoring should take place during late wet season and early wet season. It is assumed that sampling during optimum water levels and flows will result in improved Ecological Categories for the indices applied.

11.1. Reasoned Opinion Whether Project Should Proceed

In light of the lack of watercourses draining into the Limpopo River and a gentle slope (0° to 2°) between the project area and the Limpopo River (Digby Wells, 2013), it is the opinion of the ecologist that the proposed Project’s footprint will result in minor impacts onto the Limpopo River provided all mitigation measures are implemented sufficiently.

No notable fatal flaws were identified during the current study, thus the Project may proceed with an immediate implementation of the mitigation measures and the aquatic biomonitoring programme must be adhered to throughout the operation and decommissioning phases to ensure that the ecological category of ‘C’ for the Limpopo River reach is maintained and or improved.

11.2. Recommendations

Based on the results of the current study, the following actions have been recommended to allow for commencement of the proposed Project:

- The ‘unusual’ nature of the high and low-flow cycles within the Limpopo River presents challenges in employing the preferred REMP indices, therefore toxicity testing (screening-level) should be implemented for a minimum of three biological groups (i.e. algae, invertebrates, and fish) on a quarterly basis during the construction phase and biannually during the operational phase of the project;

- Diatom assemblage assessments should be undertaken to further investigate the potential drivers of change and provide an indication of the Present Ecological State during periods of low flow where there is connectivity along the Limpopo River; 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.

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Appendix A: CV's of Specialist/s

DIGBY WELLS
ENVIRONMENTAL

Mr Tebogo Khoza

Ecology & Atmospheric Sciences

Digby Wells Environmental

1 Education

- 2018: MSc Biodiversity & Conservation (University of Johannesburg)
- 2015: BSc Hons. Zoology (University of Johannesburg)
- 2014: BSc Biochemistry & Zoology (University of Johannesburg)

2 Language Skills

- Sesotho (1st Language)
- English (2nd language)
- isiZulu
- Setswana
- Xitsonga
- Sepedi

3 Employment

- 11/2019 – Present: Junior Aquatic and Wetlands Ecologist at *Digby Wells Environmental*
- 03/2019 – 011/2019: Junior Ecologist at *GCS Water & Environmental (Pty) Ltd.*
- 09/2018 – 03/2019: Junior Natural Scientist (Aquatic Ecology) at *The Biodiversity Company (Pty) Ltd.*
- 03/2018 – 09/2018: Biodiversity Unit Intern at *Gauteng Department of Agriculture & Rural Development.*

4 Experience

The following specific skills applied in the projects are highlighted below:

- Baseline aquatic ecology assessments;
- Biological monitoring using aquatic ecology;
- Water and sediment sample analysis/interpretation; and
- Sampling and identification of aquatic macroinvertebrates and fish species.

5 Project Experience

Tebogo is a SASS5-accredited practitioner and has conducted site visits, undertaken data collection and compiled Aquatic Reports. Tebogo's project experience is summarised below:

- Sasol Mining (Pty) Ltd. Aquatic Biomonitoring for the proposed Ash Backfilling Project at Defunct Sigma Colliery, Sasolburg, Free State 2019/2020;
- Dalyshope Coal Mine (Pty). Aquatic Biomonitoring and Impact Assessment for the Proposed Dalyshope Coal Mine, Limpopo 2020;
- Ledjadja coal (Pty) Ltd. Aquatic Biomonitoring for the Boikarabelo Coal Mine 2018;
- HCL Coal (Pty) Ltd. Aquatic Biomonitoring for the Mbali Coal Mine 2018/2019;
- EIMS (Pty) Ltd. Aquatic Assessment – Kalabasfontein Coal Mining Project Extension
- Manyabe Consultancy (Pty) Ltd. Gibela, Dunnottar site Environmental Monitoring;
- Cabanga (Pty) Ltd. Droogvallei Siding Bi-annual Biomonitoring 2018;
- EnviroPro (Pty) Ltd. Proposed Libode Bulk Water Supply Scheme Ecological Assessment;
- Arcelor Mittal (Pty) Ltd. Aquatic Biomonitoring for ArcelorMittal Newcastle;
- Northam Booysendal (Pty) Ltd. Booysendal Contractors Camp Biomonitoring;
- Letšeng Diamonds Mine (Pty) Ltd. Letšeng Diamonds Mine_Surface Water Quality Biannual Monitoring; and
- WSP (Pty) Ltd. Biodiversity Baseline & Impact Assessment Report for the proposed Nondvo Dam Project.

6 Professional Affiliations

- South African Council for Natural Scientific Professions: Candidate Natural Scientist. (Reg. No. 119651).

DIGBY WELLS ENVIRONMENTAL

Mr. Byron Bester

Manager: Aquatic & Wetland Ecology

Ecology and Atmospheric Sciences

Digby Wells Environmental

Summary

Byron attained his Master's degree in Aquatic Health from the University of Johannesburg in South Africa by assessing the health status and edibility of selected fish species within various impoundments within the North West Province of South Africa. In addition to various aspects of aquatic ecosystem assessment (e.g. water quality assessment, sediment composition, fish biometric indices determination, etc.), he has specific experience and knowledge in the application of histopathological fish health assessments and human health risk assessments via the consumptive pathway. His passion for further research and exposure to water-related aspects of the natural system afforded him the opportunity to spend a few months at the renowned UNESCO-IHE Institute for Water Education in Delft, The Netherlands for a Special Programme in Environmental Science at a Master of Science level, for which he attained European Credit Transfer System points for the modules completed.

He has established himself as an aquatic ecologist (or scientist) through the completion of a number of specialist aquatic biodiversity assessments (or biomonitoring studies) in a wide range of sectors, including mining (e.g. coal, gold, lithium, platinum, titanium, etc.), industrial (e.g. smelters, brick-making projects, special economic zones, etc.), transport infrastructure upgrades (e.g. roads, airports, rapid transport systems, etc.), public utility services infrastructure (e.g. powerline installations, bulk water pipelines, etc.), as well as mixed-use, residential and commercial developments. He has been involved at various levels of Specialist Input required for the nationally legislated environmental processes throughout South Africa and abroad, especially in the form of Environmental Impact Assessments (EIA's) or Environmental and Social Impact Assessments (ESIA's), Mining Right Applications, Water Use License Applications (WULA's), as well as in fulfilment of Biodiversity Action Plans (BAP's) and/or Biodiversity Management Plans (BMP's).

In his current role, he is responsible for planning, managing and facilitating the execution of various aquatic ecology and wetland assessments (including biodiversity studies) within suitable timeframes and budget provisions. He strives to conduct scientifically-defensible assessments and present high quality, fit-for-purpose reports through ongoing literature and peer review processes. He manages and mentors a team of aquatic and/or wetland ecologists through regular one-on-one engagement/s and internal quality review processes to promote a logical thought process and provide guidance on interpretation of data and findings.

1 Education

Key qualifications include:

- Nationally registered as a Professional Natural Scientist with the South African Council for Natural Scientific Professions (Reg. No. 400662/15) and is a member of the South African Society of Aquatic Scientists.
- Accredited as a SASS5 River Eco-Status Monitoring Programme (REMP) practitioner with the Department of Water and Sanitation (previously Department of Water Affairs) of South Africa and competent the application of the latest bioassessment tools in Present Ecological State (or Ecological Category) determination.
- Familiarity with the Equator Principles, the Environmental and Social Performance Standards of the World Bank: International Finance Corporation, specifically the Biodiversity Conservation and Sustainable Management of Living Resources (i.e. Performance Standard 6), as well as the High Conservation Value (HCV) approach for financial industry benchmarking and certification programmes.
- Exposure to international philosophy and approaches during a Special Programme in Environmental Science at the renowned UNESCO-IHE Institute for Water Education in Delft, The Netherlands.

Table 1-1: Educational History

Dates	Institution	Degree(s) or Diploma(s) obtained
2013	University of Johannesburg, South Africa	MSc (Aquatic Health)
2010	University of Johannesburg, South Africa	BSc Hons (Zoology)
2009	University of Johannesburg, South Africa	BSc (Biochemistry and Zoology)

Other Qualifications/Skills

- South African Scoring System: Version 5 (SASS5) Field Assessment Accreditation in terms of the River Eco-Status Monitoring Programme, Department of Water Affairs and Sanitation (March 2012 – Present);
- Special Programme (Module 3 & 4): MSc Environmental Science at UNESCO-IHE Institute for Water Education in The Netherlands (December 2012 – February 2013)
- Skipper Ticket (Category R Vessel (< 9metres)

Other Training / Courses / Workshops:

- **HCV Assessor Training** *presented by* Mr Liviu Amariei (Training Facilitator and FSC Auditor) at AstraAcademy, 2019.

- **Freshwater Fish Identification Course** *presented by* Roger Bills (Collections Manager) from South African Institute for Aquatic Biodiversity (SAIAB) near the Skukuza Camp in Kruger National Park, August 2018.
- **Riparian Vegetation Response Assessment Index (VEGRAI) training** *presented by* Mr James MacKenzie (Owner and Ecologist) at MacKenzie Ecological and Development Services, 2018.
- **Fish Invertebrate Flow Habitat Assessment (FIFHA) - Short Course** and **Rapid Habitat Assessment Model (RHAM) training** *presented by* Dr Neels Kleynhans (Fish Scientist) & Christa Thirion (Macroinvertebrate Scientist) at Department of Water and Sanitation: Resource Quality Information Services, 2015.
- **National Training and Development Buffer Zone Tool – Gauteng Workshop** *presented by* Ian Bredin (Senior Scientist) at Institute of Natural Resources and Doug Macfarlane (Director and Principal Scientist) at Eco-Pulse Consulting, 2015.
- **Quantum GIS (QGIS) training** *presented by* Michael Breetzke (UAV & LiDAR Technician) at Southern Mapping Geospatial, 2015.
- **New River Health Programme training** *presented by* Dr Neels Kleynhans (Fish Scientist) & Christa Thirion (Macroinvertebrate Scientist) at Department of Water Affairs: Resource Quality Services, 2014.
- **Atlas of Freshwater Ecosystem Priority Areas (FEPAs) in South Africa – Maps to support sustainable development of water resources** *presented by* Dr Jeanne Nel (Project Leader of the NFEPA Project and Principal Scientist) at Council for Scientific and Industrial Research (CSIR), 2012.
- **SASS5 Aquatic Biomonitoring Training Course** *presented by* Dr Mark Graham (Director and Regional KwaZulu-Natal SASS5 Auditor) at GroundTruth: Water, Wetlands, Biodiversity and Environmental Engineering, 2012.
- **Health Risk Assessment of Contaminants in Fish Training** *presented by* Ms Bettina Genthe (Group Leader of Water and Human Health Research Group) at Council for Scientific and Industrial Research (CSIR), 2011.

2 Language Skills

Table 2-1: Language competencies

Language	Speaking	Reading	Writing
English	Mother tongue	Excellent	Excellent
isiZulu	Conservational	Moderately Proficient	Proficient
Afrikaans	Conservational	None	None

3 Employment

Table 3-1: Employment history

Period	Employing organization	Title/position (highest held)
2017 – Present	Digby Wells Environmental	Unit Manager: Aquatic Ecology
2015 – 2017 (Acquisition/Merger)	GIBB Engineering and Architecture	Project Manager and Aquatic Ecologist
2011 – 2015	Strategic Environmental Focus	Junior Natural Scientist

4 Services Experiences

Byron's involvement in numerous biodiversity-related studies and health-risk assessments has culminated in the delivery of the following services and/or deliverables:

- **Desktop analysis** of aquatic ecology functionality and associated catchment level importance and sensitivity;
- **Aquatic biological monitoring** (or biomonitoring) through the application of various biological response assessment indices (incl. aquatic macroinvertebrate, fish and diatoms assemblages), as well as development of subsequent biomonitoring programmes;
- **Baseline aquatic biodiversity assessments** (including defining a list of expected freshwater species of conservation concern and alien invasive species);
- **Impact assessments** on aquatic ecology, as well as determination of recommended buffer zone surrounding affected watercourses;
- **Fish health assessments** through the application of a number of fish biomarkers (e.g. conditions factors, organosomatic indices, haematological assessment, necropsy-based evaluation, histopathology, and ageing of fish; and
- Experience in the application of **human health risk assessment models** through oral consumption of bioaccumulated pollutants sequestered within the muscle tissue of selected fish (or freshwater) species.

5 Countries of Experience

During various tenures at large multidisciplinary environmental and engineering consulting companies, Byron has established himself as an aquatic ecologist (or scientist) with experience throughout South Africa and abroad, including:

- Botswana, Cote d'Ivoire, Democratic Republic of Congo, Ghana, Mali, Namibia, Senegal, Tanzania and Zambia.

6 Project Experience

A few recent projects are listed below for further information:

Table 6-1: Selected project experience

Name of assignment	Bougouni Lithium Project
Year	Current
Location	Sikasso Region, Mali
Client	Kodal Minerals Limited
Main project features	Aquatic Biodiversity and Impact Assessment
Position	Lead Aquatic Ecologist
Activities	*In situ* water quality, sediment quality, instream and riparian habitat assessment, collection and identification of aquatic macroinvertebrate and fish assemblages.

Name of assignment	Massawa Gold Project
Year	2018
Location	Kédougou Region, Senegal
Client	Randgold Resources Limited
Main project features	Aquatic Biodiversity and Impact Assessment
Position	Aquatic Ecologist
Activities	Instream habitat mapping (i.e. depth-flow classes) for potential migratory fish species within the study area.

Name of assignment	Kibali Gold Mine | Tongon Gold Mine | Loulo & Gounkoto Gold Mining Complex
Year	2018

Location	Watsa Territory, Democratic Republic of Congo Savanes District, Cote d'Ivoire Kayes Region, Mali
Client	Randgold Resources Limited
Main project features	Aquatic Biomonitoring Assessment
Position	Lead Aquatic Ecologist
Activities	*In situ* water quality, sediment quality, instream habitat assessment, collection and identification of aquatic macroinvertebrate and fish assemblages.

Name of assignment	Environmental Monitoring for the Kazungula Bridge Project
Year	2017 - Present
Location	Chobe Region, Botswana | Kazungula Area, Zambia | Impalila Island, Namibia
Client	KBC Joint Venture (incl. Nippon Koei Co. Limited, Chodi Co. Ltd, Arcus GIBB (Pty) Limited, Bothakga Burrow Botswana (Pty), CPP Botswana (Pty) and Zulu Burrow Development Consultants Ltd)
Main project features	Aquatic Biomonitoring Assessment
Position	Lead Aquatic Ecologist
Activities	*In situ* water quality, instream and riparian habitat assessment, collection and identification of aquatic macroinvertebrate and fish assemblages.

Name of assignment	Matla Coal Annual Aquatic and Wetland Monitoring
Year	2017 - Present
Location	Mpumalanga, South Africa
Client	Exxaro Resources (Pty) Ltd.

Main project features	Aquatic, Ecological (i.e. Fauna & flora), Remote Sensing, and Wetland Monitoring Assessments.
Position	Project Manager and Technical Reviewer
Activities	Coordination and management of respective monitoring activities, as well as technical review.

Name of assignment	Richard Bay Minerals: Smelter and Processing Site
Year	2017 - Present
Location	KwaZulu-Natal, South Africa
Client	Richards Bay Minerals, a subsidiary of Rio Tinto
Main project features	Aquatic Biomonitoring Assessment
Position	Lead Aquatic Ecologist
Activities	*In situ* and *ex-situ* water quality, aquatic habitat assessment, collection and identification of aquatic macroinvertebrate and diatom assemblages.

Name of assignment	Tubatse Special Economic Zone
Year	2017
Location	Limpopo, South Africa
Client	Limpopo Economic Development Agency
Main project features	Aquatic Biodiversity and Impact Assessment
Position	Aquatic Ecologist
Activities	*In situ* water quality, instream and riparian habitat assessment, collection and identification of aquatic macroinvertebrate and fish assemblages, as well as buffer zone determination (or sensitivity analysis).

7 Professional Affiliations

Table 7-1: Professional affiliations

Position	Professional Body/Affiliation	Registration Number
Professional Natural Scientist	South African Council for Natural Scientific Professions: Aquatic Science & Zoological Science	400662/15
Member	South African Society of Aquatic Scientists, South Africa	N/R

8 Professional Registration

- South African Council for Natural Scientific Professions (SACNASP): Professional Natural Scientist (Registration. No. 400662/15)
  - Aquatic Science
  - Zoological Science

9 Publications/Conference Proceedings

- Bester, B. M. & Diarra, H. A lucrative livelihood or an invisible epidemic? Evidence of elevated mercury levels within fish populations in Bambouk area, Mali. Oral presentation. SASAqS Conference – Aquatic ecosystem health in a changing environment. Bela Bela, South Africa.
- Wagenaar, G. M., Bester, B. M. & Van Dyk, J. C. (2015) Are fish from polluted hyper-eutrophic impoundments healthy and safe for human consumption? Oral presentation. SETAC Europe 25th Annual Meeting – Environmental protection in a multi-stressed world: challenges for science, industry and regulators. Barcelona, South Africa.
- Bester, B. M., Wagenaar, G. M. & Van Dyk, J. C. (2013) An assessment of the histology and edibility of *Clarias gariepinus* and *Cyprinus carpio* from two impoundments in the North West Province, South Africa. Poster presentation. SASAqS Conference – Catchments, Coastal interfaces and Communities. Arniston, South Africa.
- Bester, B. M., Wagenaar, G. M. & Van Dyk, J. C. (2012) Is there a human health risk from consumption of freshwater fish in the North West Province? Oral presentation. SASAqS Conference – Aquatic ecosystems; conservation & connectivity. Cape St Francis, South Africa.
- Bester, B. M., Wagenaar, G. M. & Van Dyk, J. C. (2011) Histology-based fish health assessment and edibility of fish from two impoundments in the North West Province,

South Africa. Poster/PPT presentation. Suid-Afrikaanse Akademie Vir Wetenskap en Kuns (SAWEK). Pretoria, South Africa.

- Bester, B. M. & De Lange-Jacobs, P. C. (2010) Histological assessment of the main visceral organs of *Sternophysinx filaris* and *S. calceola* (Crustacea: Amphipoda). Oral presentation. Suid-Afrikaanse Akademie Vir Wetenskap en Kuns (SAWEK). Pretoria, South Africa.

Mr. Danie Otto

Director: Technical Services

Technical Services

Digby Wells Environmental

1 Education

- M.Sc (Geography & Environmental Management), University of Johannesburg (UJ), South Africa, 1997
- B.Sc (Hons) (Geography/Botany), UJ, 1992: Environmental Management and Geomorphology
- Water Management (Limnology) and GIS
- B.Sc (Geography & Botany): UJ, South Africa, 1991

2 Training

- ISO14001 International Auditors course
- University of Pretoria Wetland Identification and Rehabilitation Course
- Carrying capacity and grass identification course
- GIS Arc
- Management Skills Development
- GolderU – Finance for Non-Financial Managers Course
- Global Leadership Development
- Golder Project Management courses
- CS Project Management Course – Private Sector Training Course on Project Management
- Legal Liability Training
- ISO14001 auditor and update course (UNW)
- Leadership Development Course (DWE 2 day course)
- Client Centricity Course (Gibb School of Business)

3 Language Skills

- English
- Afrikaans
- Zulu (very limited)

4 Employment

2011 – Current Digby Wells & Associates Director

- Executive – Southern African Operations and Technical Services
- Bio-geomorphologist: Wetland and Rehabilitation Scientist managing the multi-disciplinary specialist teams for environmental permitting processes, environmental and compliance audits, rehabilitation and specialist studies.
- Divisions, Departments and Units managed:
  - Water Division:
    - Surface & Hydrology Unit;
    - Groundwater and Geochemistry Units.
  - Rehabilitation and Mine Closure Division:
    - Rehabilitation Unit, (including Remote Sensing);
    - Soil Unit;
    - Mine Closure Unit;
  - Ecology and Atmospheric Sciences
    - Biodiversity, Fauna & Flora Unit;
    - Aquatic Sciences Unit;
    - Wetland Unit; and
    - Atmospheric Sciences Unit (including Air Quality & Noise Modelling).
  - Environmental & Legal Services Division:
    - Environmental (EIA) Unit;
    - Auditing;
    - Legal Services; and
    - GIS Department.

- Social Sciences
    - Social Unit; and
    - Heritage & Archaeology Unit.
- Digby Wells Botswana Management
- Water, Soil, Auditing and Biodiversity specialists.

2005 – 2011 Golder Associates Africa (Pty) Ltd Associate

- Energy - Market Sector Leader for Africa
- Divisional Leader - Ecology.
- Manager: Florida Ecology Office and Lydenburg Office - Bio-geomorphologist: Wetland and Rehabilitation Scientist.
- Undertaking Environmental Assessments and compiling Environmental, Water & Waste Management Plans focussing on the mining industry.
- Integrated Pollution Control development via phytoremediation and wetland assessments. Construction of wetlands for passive water treatment purposes. Underlying this is the goal and function of river and wetland rehabilitation with the emphasis on geomorphological aspects. Manager of Ecology Division and office of 20 staff.

2003 - 2005 GCS (Pty) Ltd Director

- Managed personnel, budget and projects of the Environmental, Water Use and GIS Units undertaking environmental assessments, water licence applications etc.

1998 - 2003 Digby Wells & Associates (Pty) Ltd Director

- Managed projects, budgets and teams of various multidisciplinary projects.

1995 – 1998 Pulles Howard & De Lange (PHD) Inc.

Environmental Scientist

- Managed projects, budgets and teams of various multidisciplinary environmental and water projects and assisted in research such as passive treatment wetland projects and A Manual on Mine Water Management and Treatment Practices in South Africa.

1994 Vista University

Junior Lecturer

- Lectured Geomorphology and Environmental Management and undertook research on desert vegetation cover.

1993 - 1994 CSIR

Contract Researcher

- Undertook research on A manual to Assess and Manage the Impact of Gold Mining Operations on the Surface Water Environment – on CSIR contract.

1991 - 1992 RAU (University of Johannesburg)

Technical Assistant

- General laboratory assistant and soil laboratory assistant for research on tailings sediment and dune sand dynamics.

5 Experience

Daniel Otto is a biogeomorphologist that specialises in ecology of wetlands and rehabilitation. He has been a registered Professional Natural Scientist since 2002.

Daniel has 23 years of experience in the mining industry in environmental and specialist assessments, management plans, audits, rehabilitation, and research.

He has experience in various countries and his experience is in the environmental sector of coal, gold, platinum (PGMs), diamonds, asbestos, rock, clay & sand quarries, copper, phosphate, andalusite, lithium, base metals, heavy minerals (titanium), uranium, pyrophyllite, chrome, nickel, vanadium etc.

He has wetland and geomorphology working experience across Africa including specialist environmental input into various water resource related studies. These vary from studies of the wetlands of the Kruger National Park to swamp forests in central Africa to alpine systems in Lesotho.

He has been involved in various large environmental assessments and due diligences. His specific speciality lies in design and construction of wetlands and water treatment systems to address water quality challenges. He has a good water quality, limnology and aquatic biology background combined with practical constructed wetland and rehabilitation and ecological restoration experience.

Countries worked in:

Zimbabwe, Zambia, Botswana, South Africa, Lesotho, Mozambique, Mali, Central African Republic, Sierra Leone.

6 Project Experience

ENVIRONMENTAL IMPACT ASSESSMENTS AND MANAGEMENT PLANS

- Rio Tinto – Mali Green Gold Mine, Kwekwe, Zimbabwe: EIA to World Bank Standards
- Lithium Exploration, Gamoep, South Africa: Preliminary Pegamatite Investigation
- Kazungula Bridge & Quarries, Kasane, Botswana/Zambia: Environmental monitoring
- Mahambo Bridge, Shakawe, Botswana, Environmental monitoring
- Thuni Dam, Selebi Pikwe, Botswana: EIA scoping report
- Tanguma Diamond Mine, Sierra Leone: Baseline studies, Project Management
- Hazardous Waste Site, Lobatse area, Botswana: Environmental Audit and EIA input
- Nevsun-Tabakoto Gold Mine, Mali: Ecological survey to IFC/World Bank standards
- Kao Diamond Mine and Road, Lesotho: EMP & EMPR, Ecological Aspects
- Bakouma Uranium Mine, Central African Republic: Ecological aspects of EIA
- Benga Coal Mine EIA, Mozambique: Ecology and wetland aspects
- Moatize Biomonitoring, Mozambique: Project Manager
- Impala Platinum: 16, 17 and 20 Shaft EMPRs
- De Beers Finsch Diamond Mine: Fines Residue Deposit EMPR
- Anglo Coal - Mafube Coal Mine: EMPR and project team member
- Samancor: Eastern Chrome Mines: Project Manager - EIAs, Closure Plans
- Highveld Steel and Vanadium: Transalloys Tiaco process EIA
- Anglo Platinum Process Plant (ACP): Waterval Smelter EIA including river diversion
- TEM: Wild Coast Heavy Minerals Mining – Environmental Scan of Ecological Aspects
- South Eastern District Council Landfill, Gaborone, Botswana: Landfill and Hazardous Waste Site EMP
- Eskom/Amplats, Polokwane: Powerline to platinum processing plant – Ecology
- Strategic Fuel Fund-Tavistock: Wetland and pan assessments
- Anglovaal-Dorstfontein Coal Plant: Vegetation, wetland and land assessment

- Total Coal Holdings: Springbok siding scoping report specialist input
- Kriel TLC: Kriel powerline and pipeline to Dorstfontein – EIA
- Paulpietersburg siding: Scoping report specialist input (Paulpietersburg)
- Consolidated Modderfontein Mines Environmental: Johannesburg - South Africa Liability assessment review
- Foskor phosphate mine: EMP for re-mining tailings and new tailings dam facility
- Palabora Mining Company: Water Management Plan, IWULA, EIAs, Closure Plan
- Xstrata – Spitzkop Mine and Plant: Coal mine EMP amendments
- Xstrata Coal: Tselentis waste disposal facility EMP amendments
- Xstrata Coal: Beesting mine vegetation and wetland survey
- JCI Coal: Caroline opencast mine, plant and waste facilities
- Pafuri Metals on Zimbabwe Limpopo border: Vegetation survey for Madimbu corridor
- Bushveld Mines: Klipwal gold mine, plant and waste facilities
- Crown Gold Recoveries:
    - Meretsel Silts – Wetland alteration and rehabilitation EMP
    - Fleurhof Dam – Wetland alteration and rehabilitation for dredge mining EMP
- Anker/Gholfview: Ermelo Coal Rail Siding EIA
- Gibb Africa/Dept. of Transport: Mojadji development – road and quarries EMP
- Etruscan Diamonds: Scoping vegetation survey for diamond mining
- Dullstroom water purification plant: Ecological survey
- Xstrata Coal –Tavistock: Water Management Plan specialist input
- Kalgold (Harmony): Rock dump EMPR
- Metorex - Bankfontein Colliery: EMPR Ecological Aspects
- Metorex - Kleinfontein Colliery: EMPR Ecological Aspects
- Samancor - Western Chrome: Mooinooi Operations – Project Manager & EMPR Ecological. Aspects. Millsell Operations – Project manager & EMPR Ecological Aspects
- Matla: River diversion EIA, WULA, Audits, long term monitoring, Wetland Management Plan. Project Manager
- Protea Hotels (African Pride): EIA for Jackalberry Camp to Lodge and Concession in the Kruger National Park. Jakkalsbessie/Tinga KNP Concession Area – EIA & EMP

- Glenburn Lodge: Specialist ecology studies for EIA for expansion
- Bronberg Nature Reserve: Scoping ecological report – property sub-division
- Rand Uranium: EIA/EMP for Cooke Plant optimisation, tailings dam, pipelines and pit deposition (Project Sponsor)
- Matla Brine Ponds Design and Construction, Matla, South Africa – Project Manager

ENVIRONMENTAL REHABILITATION

- Pomfret Asbestos Mine: Input into management plan and impact assessment from sources, pathways and rehabilitation point of view
- Iscor Steel Works (Vanderbijlpark): Management plan for waste discard and slag pollution control measures, rehabilitation and vegetation programme
- Peiring Lead Mine – BHP-Billliton: Closure plan. Rehabilitation aspects
- ERPM Gold Mine: Tailings facility rehabilitation management and vegetation survey (Germiston)
- Foskor Phosphate Mine: Rehabilitation consultation, EIA, EMP, Integrated Water Licence application
- Durnacol Coal Mine: Durnacol rehabilitation and closure risk assessment plan inputs
- Northern Metropolitan Local Council Randburg: Rehabilitation Plan input - Pipeline and watercourses for Cosmo City, co-manage implementation of EMP review and Audits
- Highveld Technopark Wetland: Review wetland and waste facility rehabilitation and environmental management plans of Centurion Council
- Hartebeesfontein: Tailings facility rehabilitation plan and on site implementation review
- CMR Golfcourse wetland: Concept design team for wetland for seepage treatment (Maraisburg)
- WAGM Arnot Colliery and VCC Colliery wetlands: Input into concept design and construction consultation on pilot scale passive treatment wetland systems
- Pidwa Game Ranch: Vegetation rehabilitation
- Kangala Cola Mine, Universal Coal: Rehabilitation plan
- Loulo Constructed Wetland Design and Construction: Project Sponsor. Nutrient removal
- New Liberty Gold Mine: Constructed wetland design for arsenic and cyanide removal
- Sasol Sigma Discard Dump Rehabilitation: Rehab plan and implementation with contractor supervision. (Project Manager - Ongoing)

AUDITS, CLOSURES PLANING, LIABILITY ASSESSMENTS AND ENVIRONMENTAL MANAGEMENT PLAN IMPLEMENTATIONS

- Hewlett Packard – Techink: Due diligence on digital ink manufacturing and milling facilities
- Target Gold Mine: SHE Audit, sustainability reporting, Performance Assessment audit
- Assmang Chrome Smelter: SHE Audit, sustainability reporting
- Assmang Manganese Smelter: SHE Audit, sustainability reporting
- Black Rock Manganese Mines: SHE Audit, sustainability reporting, Performance Assessment audit
- Beeshoek Iron Ore Mine: SHE Audit, sustainability reporting, Performance Assessment audit
- Dwarsrivier Chrome Mine: SHE Audit, sustainability reporting, Performance Assessment audit
- Nkomati Base Metals Mine: SHE Audit, sustainability reporting, Performance Assessment audit
- Crown Mines: Environmental audits for C-Dump, C-west, 3/L/13, Rosherville Dam, Valley Silts operations
- Bushveld Mines: Klipwal gold mine, water management plan for plant and waste facilities inputs
- Xstrata Coal: Spitzkop Mine and Plant specialist input
- Lepele Water: Phalaborwa Pipeline construction EMP audit
- Rand Water: Kroondal Pipeline construction EMP audit
- Total Coal Holdings: Forzando field condition audit
- Crocodile River Platinum Mine: State of Environment and investigation into potential effects on tree species
- Black Rock Manganese: Detailed closure costing
- Chemwes Gold Mine: Quarterly Environmental Audits 2000-2005
- Mamre Gold Mine: Closure Cost and Liability Assessment
- Wonderstone: Pyrophyllite mine, Environmental Audit
- Rustenburg Minerals Development: Environmental Audit of Chrome Mine

- Simmer & Jack, DRD: NW Operation (Buffelsfontein & Hartbeesfontein) liability assessment
- Simmer & Jack Management Committee, TGME: Pilgrims Rest Mines, EMP audits (part of Management Committee)
- Vanchem: Water Use Licence Audit (Vanadium Plant and Tailings Facility)
- Palabora Mining Company: Compliance Audit (Technical input)

DUE DILIGENCES AND ENVIRONMENTAL RISK ASSESSMENT AUDITS

- Iscor Vanderbijlpark: Flat Steel Plant, Environmental Risk Assessment and SHE audit. Galvanising, Hot Mills, Cold Mills, Continuous casting, Arc Furnaces, Blast furnaces
- Iscor Vereeninging: Specialist Steel Plant, Environmental Risk Assessment and SHE audit
- Iscor Newcastle: Profile Steel Plant, Environmental Risk Assessment and SHE audit
- National Metals: Scrap Steel processing facilities, Environmental Risk Assessment and SHE audit
- Dunswart Direct Iron Ore Reduction: Direct Iron Ore Kiln and Reduction Plant, Environmental Risk Assessment and SHE audit
- Vantin: Flat Steel Processing and packaging Plant, Environmental Risk Assessment and SHE audit
- Suprachem: Coking oven gas plant, BTEX Plant, Environmental Risk Assessment and SHE audit
- Vanchem: WULA Audit
- Sigma Coal Mine: Environmental Legal Compliance Audit

7 Professional Affiliations

- Kusile Power Station: Environmental Monitoring Committee for +10 years (Chairperson).
- Fellow: Water Institute of South Africa.
- Botanical Society of South Africa.

8 Professional Registration

- Registered Natural Scientist S.A (Reg. No. 400096/02)

9 Publications

- Howie, D.R. and Otto. D. (1996). The Impact of Gold Mining Activities on the Water Quality and Users in the Upper Klip River Catchment. WISA Conference Proceedings 1996.
- Pulles, W., Howie, D., Otto, D., and Easton, J. (1996) A Manual on Mine Water Management And Treatment Practices in South Africa. WRC Report TT 80/96.
- Contributing Author. A manual to Assess and Manage the Impact of Gold Mining Operations on the Surface Water Environment. WRC Report No. TT79/96.
- Matla's successful wetland undertaking, SA Mining, March 2009.
- Grundling, A.T; Price, J.S; Linstrom, A; Grundling, P; Van den Berg, H.M.; Riddel, E and Otto, D.J. (2010) The South African National Wetland Classification System: Relevance to the wetlands in the Kruger National Park. 8th Savanna Science Network Conference. Skukuza, South Africa.
- SA Development and World Bank Offsetting Seminar (2015): Panel representative
- SA Wetland Society Workshop Panel - Blue Crane Treatment Wetlands in association with ARM Reedbeds and the University of Pretoria Workshop on Constructed Wetlands.
- SACEPA conference (2018) Use of constructed wetlands for water treatment with case studies.
- Sustainability Week, Pretoria (2019). Constructed wetlands for water treatment

Appendix B: Baseline and EIA Methodology

Bioassessment Methodology

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

Water Quality

Selected *in-situ* water quality variables were measured at each of the sampling sites using water quality meters manufactured by Extech Instruments, namely an ExStik EC500 Combination Meter and an ExStik DO600 Dissolved Oxygen Meter. Temperature, pH, electrical conductivity and dissolved oxygen were recorded prior to sampling, while the time of day at which the measurements were assessed was also noted for interpretation purposes.

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.

Index for Habitat Integrity

The IHI (Version 2, Kleynhans, C.J., pers. comm., 2015) aims to assess the number and severity of anthropogenic perturbations along a river/stream/wetland and the potential inflictions of damage toward the habitat integrity of the system (H F Dallas, 2005). Various abiotic (e.g. water abstraction, weirs, dams, pollution, dumping of rubble, etc.) and biotic (e.g. presence of alien plants and animals, etc.) factors are assessed, which represent some of the most important and easily quantifiable, anthropogenic impacts upon the system (Table 12-1).

As per the original IHI approach (C. J. Kleynhans, 1996), the instream and riparian components were each 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.* (2008a) 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 a relatively few numbers of river 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 12-1: Descriptions of criteria used to assess habitat integrity (Kleynhans, 1996; cited in Dallas, 2005)

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 criterion, 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 12-2). 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 12-2: 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; see Appendix A), the most recent version of the IHI application (Kleynhans *et al.,* 2008) and the Model Photo Guides (Graham & Louw, 2008) were used to calibrate the severity of the scoring system. It should be noted that the assessment was 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.) were confirmed, potential impacts within relevant sections were considered and accounted for within the application of the method.

Each of the allocated scores was then moderated by a weighting system (Table 12-3), 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 12-3: 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 were 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 15-4).

Table 12-4

Table 12-4: 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

Aquatic Invertebrate Assessment

Integrated Habitat Assessment System

Assessment of the available habitat for aquatic macroinvertebrate colonization at each of the sampling sites 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 the South African Scoring System, Version 5 (SASS5) 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 categorized according to the values in Table 12-5.

According to a study conducted within the Mpumalanga and Western Cape regions, the IHAS method does not produce reliable scores at assessed sampling sites, as its performance appears to vary between biotopes. 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 was adapted by excluding the assessment of the aforementioned '*general stream characteristics*,' which resulted in the calculation of a percentage score out of 55 that was then categorised by the aforementioned Table 12-5. Consequently, the assessment index describes the quantity, quality and diversity of available macroinvertebrate habitat relative to an "ideal" diversity of available habitat.

Table 12-5: Adapted IHAS Scores and associated description of available aquatic macroinvertebrate habitat

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

South African Scoring System Version 5 (SASS5)

While there are a number of indicator organisms that are used within these assessment indices, there is a general consensus that benthic macroinvertebrates are amongst the most sensitive components of the aquatic ecosystem. This was further supported by their largely non-mobile (or limited mobility) within reaches of associated watercourses, which also allows for the spatial analysis of disturbances potentially present within the adjacent catchment area. However, it should also be noted that their heterogeneous distribution within the water resource is a major limitation, as this results in spatial and temporal variability within the collected macroinvertebrate assemblages (H.F. Dallas & Day, 2004).

SASS5 is essentially a biological assessment index which determines the health of a river based on the aquatic macroinvertebrates collected on-site, whereby each taxon is allocated a score based on its perceived sensitivity/tolerance to environmental perturbations (H F Dallas, 1997). However, the method relies on a standardised sampling technique using a handheld net (300 mm x 300 mm, 1000 micron mesh size) within each of the various habitats available for standardised sampling times and/or areas. Niche habitats (or biotopes) sampled during SASS5 application include:

- Stones (both in-current and out-of-current);
- Vegetation (both aquatic and marginal); and
- Gravel, sand and mud.

Once collection is complete, aquatic macroinvertebrates are identified to family level and a number of assemblage-specific parameters are calculated including the total SASS5 score, the number of taxa collected, and the Average Score per Taxa i.e. SASS5 score divided by the total number of taxa identified (Thirion *et al*., 1995); Davies and Day, 1998; (Dickens and Graham, 2002; Gerber and Gabriel, 2002). The SASS5 bio-assessment index has been proven to be an effective and efficient means to assess water quality impairment and general river health (Chutter, 1998; H F Dallas, 1997).

Macroinvertebrate Response Assessment Index (MIRAI)

In order to determine the Present Ecological State (PES; or Ecological Category) of the aquatic macroinvertebrates collected/observed, the SASS5 data was used as a basic input (i.e.

prevalence and abundance) into the recently improved MIRAI (Version 2, Thirion. C., *pers. comm.*, 2015). This biological index integrates the ecological requirements of the macroinvertebrate taxa in a community (or assemblage) and their respective responses to flow modification, habitat change, water quality impairment and/or seasonality (C. Thirion, 2008). The presence and abundance of the aquatic macroinvertebrates collected are compared to a derived reference list of families/taxa that are expected to be present under natural, un-impacted conditions (i.e. prior to the effect of anthropogenic activities). Consequently, the three (or four) aforementioned metric groups utilised during the application were combined within the model to derive the ecological condition of the site in terms of aquatic macroinvertebrates (Table 12-6).

Table 12-6: Allocation protocol for the determination of the Present Ecological State 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.

Ichthyofaunal Assessment

Fish were collected by means of electro-narcosis (or electro-fishing), whereby an anode and a cathode are immersed in the water to temporarily stun fish in the near vicinity. Each of the collected fish specimens were identified in the field – using the “Complete Guide to the Freshwater Fishes of Southern Africa” (Skelton, 2001) – and released back into the river.

Fish Response Assessment Index

Assessment of the Present Ecological State (PES; or Ecological Category) of the fish assemblage of the watercourses associated with the study area was conducted by means of the FRAI (Kleynhans, 2008). This procedure is an integration of ecological requirements of fish species in an assemblage and their derived (or observed) responses to modified habitat conditions. In the case of the present assessment, the observed response was determined by means of fish sampling, as well as a consideration of species requirements and driver changes (Kleynhans, 2008). The expected fish species assemblage within the study area was derived from (C. J. Kleynhans *et al*., 2008) and aquatic habitat sampled.

Although the FRAI uses essentially the same information as the Fish Assemblage Integrity Index (FAII), it does not follow the same procedure. The FAII was developed for application in the broad synoptic assessment required for the River Health Programme, and subsequently does not offer a particularly strong cause-and-effect basis. The purpose of the FRAI, on the other hand, is to provide a habitat-based cause-and-effect underpinning to interpret the deviation of the fish assemblage from the perceived reference condition (C. J. Kleynhans, 2008).

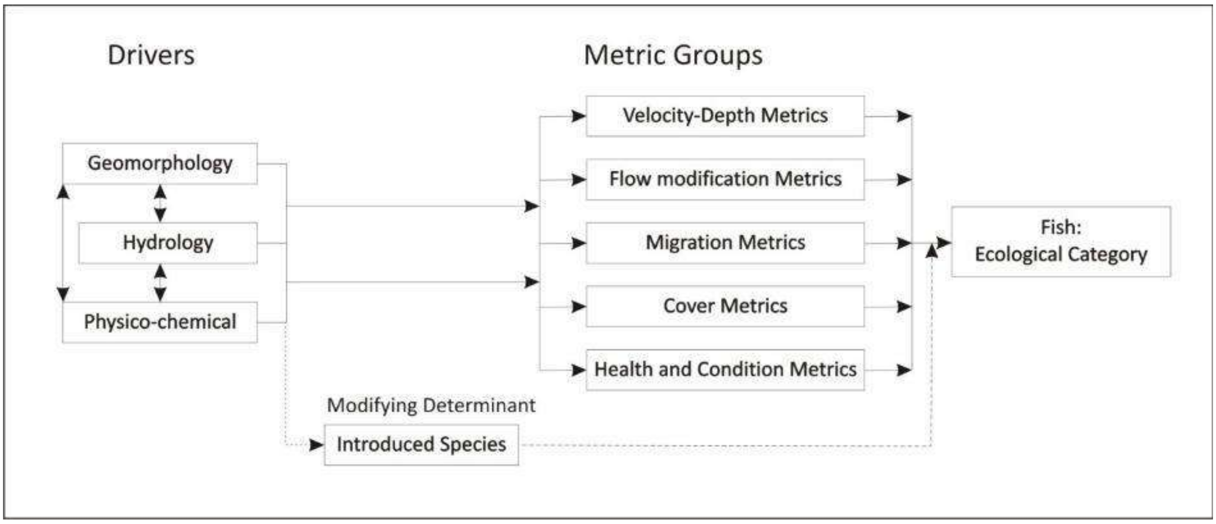

Figure 12-1: Relationship between drivers and fish metric groups

The FRAI is based on the assessment of selected metrics within metric groups, which are assessed in terms of:

- Habitat changes that are observed or derived;
- The impact of such habitat changes on species with particular preferences and tolerances; and
- The relationship between the drivers used in the FRAI and the various fish response metric groups, as are indicated in Figure 12-1. Table 12-7 provides the steps and procedures required for the calculation of the FRAI.

Table 12-7: Main steps and procedures followed in calculating the Fish Response Assessment Index

STEP	PROCEDURE
River section earmarked for assessment	As for study requirements and design
Determine reference fish assemblage: species and frequency of occurrence	• Use historical data & expert knowledge • Model: use ecoregional and other environmental information • Use expert fish reference frequency of occurrence database if available
Determine present state for drivers	• Hydrology • Physico-chemical • Geomorphology; or • Index of habitat integrity
Select representative sampling sites	Field survey in combination with other survey activities
Determine fish habitat condition at site	• Assess fish habitat potential Assess fish habitat condition
Representative fish sampling at site or in river section	• Sample all velocity depth classes per site if feasible • Sample at least three stream sections per site
Collate and analyse fish sampling data per site	Transform fish sampling data to frequency of occurrence ratings
Execute FRAI model	• Rate the FRAI metrics in each metric group • Enter species reference frequency of occurrence data • Enter species observed frequency of occurrence data • Determine weights for the metric groups • Obtain FRAI value and category • Present both modelled FRAI & adjusted FRAI.

Interpretation of the FRAI score follows a descriptive procedure in which the FRAI score is classified into a particular PES (or Ecological Category) based on the aforementioned integrity classes (C. J. Kleynhans, 1999). Each category describes the generally expected conditions for a specific range of FRAI scores (Table 12-8).

Table 12-8: Allocation protocol for the determination of the Present Ecological State (or Ecological Category) of the sampled/observed fish assemblage following application of the FRAI

FRAI (%)	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.

EcoStatus4 1.02 Model

For the purpose of the present assessment, the latest ECOSTATUS4 1.02 model was used, which is an upgraded and refined version of the original ECOSTATUS4 model (Kleynhans & Louw,2008). The results obtained from the fish and aquatic macroinvertebrate response indices (i.e. FRAI and MIRAI) are to be integrated within the model to determine an Instream Ecological Category, whereas the riparian elements from the IHI-96-2 model can be used as a surrogate for the Riparian Ecological Category in the following manner (Dr. C.J. Kleynhans, *pers. comm.*, 2015):

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

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 12-11. 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 12-10, which is extracted from Table 12-9. The description of the significance ratings is discussed in Table 12-11.

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 12-9: Impact Assessment Parameter Ratings

Rating	Intensity/Replaceability		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/Replaceability		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/Replaceability		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/Replaceability		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.

Table 12-10: 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
	-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

Table 12-11: 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 C: Site Photographs

DAL 1


DAL 2


DAL 3


DAL 4


Appendix D: Aquatic Macroinvertebrate Data

February 2020 Survey (late wet season)

Taxon	Reference Abundance	Reference Frequency	Sensitivity Score	DAL 1	DAL 2	DAL 3	DAL 4
ANNELIDA							
Oligochaeta (Earthworms)	B	5	1	A	A	A	
Hirudinea (Leeches)	A	3	3				
EPHEMEROPTERA (Mayflies)							
Baetidae 1sp			4		1		
Caenidae (Squaregills/Cainflies)	B	5	6				1
ODONATA (Dragonflies & Damselflies)							
Gomphidae (Clubtails)	B	5	6				1
Libellulidae (Darters/Skimmers)	A	5	4	1	1		
HEMIPTERA (Bugs)							
Belostomatidae (Giant Water Bugs)	A	5	3	1	A		
Corixidae (Water Boatmen)	B	5	3	A	A	1	
Gerridae (Pond Skaters/Water Striders)	B	5	5	A			1
Veliidae (Ripple Bugs)	A	4	5				A
GASTROPODA (Snails)							
Ancylidae (Limpets)	A	3	6				
Bulininae	A	3	3				
Lymnaeidae (Pond Snails)	A	3	3	1		1	
SASS5 Score				19	15	7	22
Number of Taxa				6	5	3	4
Average Score Per Taxon (ASPT)				3.17	3	2.33	5.5

*** Abundances:** 1 = 1 individual, A = 2 – 10 individuals, B = 11 – 100 individuals, C = 101 – 1000 individuals, D = >1000 individuals, **Frequency of Occurrence (FROC):** 1 = low, 2 = low-to-moderate, 3 = moderate, 4 = moderate-to-high, 5 = high., **Sensitivity Scores**: 1 – 3 = very low, 4 – 7 = low, 8 – 11 = moderate, 12-15 = high