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Arnot South Environmental Authorisation and Water Use License Application

Aquatic Biodiversity and Impact Assessment

Prepared for:
Universal Coal PLC

Project Number:
UCD6802

July 2021

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Report Type:	Aquatic Biodiversity and Impact Assessment
Project Name:	Arnot South Environmental Authorisation and Water Use License Application
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Name	Responsibility	Signature	Date
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Tebogo Khoza *Cand.Sci.Nat.*	Field survey, data collation and report writer		July 2021
Byron Bester *Pr.Sci.Nat.*	Technical review		July 2021

DETAILS AND DECLARATION OF THE SPECIALIST

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Experience (years):	3
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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.

	August 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

Digby Wells Environmental was appointed by Universal Coal to undertake an Environmental Application Process for the mining of the No. 2 Seam which varies between 10 m to 100 m below the surface. This Aquatic Biodiversity and Impact Assessment study forms part of the required specialist studies to support this Environmental Application.

The proposed project falls under the jurisdiction of the Chief Albert Luthuli and Steve Tshwete Local Municipalities, located in the Gert Sibande and Nkangala District Municipalities respectively of the Mpumalanga Province. The mining right boundary falls within two Water Management Areas (WMA), i.e. Olifants and Inkomati-Usuthu, wherein lies six sub-quaternary reaches encompassed by three river systems. The Klein-Olifants, the Rietkuilspruit and the Vaalwaterspruit associated with the proposed underground mining. River systems of the Olifants WMA drain the West and systems of the Inkomati-Usuthu WMA drain the East.

The goal of the Aquatic Study was to describe the baseline conditions within the aquatic ecosystems associated with the proposed Project 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.

Baseline Ecological Conditions

The timing of the baseline aquatic survey coincided with the late wet season period (or high-flow; in April 2021) for the Project Area. Key findings from the data collected during the current aquatic survey are as follows:

Amongst the *in situ* water quality, temperature levels were recorded within the normal range for water bodies in South Africa and within the typical summer season temperatures, pH values largely exhibited close to neutral to slightly alkaline conditions, conductivity values were generally high at most assessed sites, and dissolved oxygen levels were low to moderate. Therefore the overall *in situ* water quality was interpreted as modified with potential impacts associated with the surrounding farming and mining activities, such as nutrient enrichment.

The habitat integrity for the assessed reaches were determined to be *Moderately Modified* for the instream components and *Largely Natural* for the riparian components. The overall major impacts of the habitat integrity were water quality deterioration, flow modification, inundation and exotic vegetation.

A wide variety of macroinvertebrate habitat availability was observed at the assessed watercourses, ranging from shallow to deep and still to moderately-flowing water; marginal and aquatic vegetation; and the SASS5 biotopes Gravel Sand and Mud (GSM) and stones. All assessed sites of the Klien-Olifants and Rietkuilspruit systems however exhibited *Poor* aquatic macroinvertebrate habitat availability, whilst the Vaalwaterspruit systems exhibited macroinvertebrate habitat availability ranging from *Poor* to *Good*. Throughout the sampled river systems, the aquatic macroinvertebrate assemblages were dominated by taxa that have a high tolerance to water quality modifications. The overall ecological condition of the aquatic

macroinvertebrate assemblages were *Largely Modified* (Ecological Category D) throughout the assessed river systems.

A total of six fish species were sampled throughout the assessed watercourses, one of which was an alien invasive *Micropterus salmoides*. A single species was sampled at the Klein-Olifants systems, two species were sampled at the Rietkuilspruit systems and five species were sampled at the Vaalwaterspruit systems. All five sampled indigenous fish species are known to be tolerant, to varying extends, to water quality and or flow modifications. The overall ecological condition of the fish communities were *Seriously Modified* (Ecological Category E) for the Klein-Olifants and Rietkuilspruit systems and *Largely Modified* (Ecological Category D) for the Vaalwaterspruit systems.

Following integration of the defined ecological conditions obtained for the instream biological integrity (i.e. Macroinvertebrate Response Assessment Index (MIRAI) from aquatic invertebrates and Fish Response Assessment Index (FRAI) from fish) and the riparian component (i.e. Index for Habitat Integrity (IHI) from riparian vegetation assessment), it was determined that the sampled Klien-Olifants, Rietkuilspruit and Vaalwaterspruit systems represented an integrated EcoStatus of *Moderately Modified* (Ecological Category C).

Impact Assessment and Mitigation Measures

Potential impacts on the aquatic ecosystems associated with the proposed Project were determined to be:

- ***Minor*** during construction of infrastructure and ***Negligible*** upon adequate implementation of mitigation measures;
- ***Minor*** during the operational phase and ***Negligible*** upon adequate implementation of mitigation measures; and
- ***Moderate*** during the Closure, Decommissioning and Rehabilitation Phase and ***Negligible*** upon adequate implementation of mitigation measures.

An aquatic biomonitoring programme has been provided for the monitoring and preservation of the aquatic ecosystems associated with the proposed 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 aquatic biota.

Reasoned Opinion Whether Project Should Proceed

In light of the nonperennial nature of the associated watercourses in the Project Area, it is the opinion of the ecologist that the proposed Project's footprint will result in minor impacts to the watercourses provided all mitigation measures are implemented sufficiently.

With regards to the activities associated with the proposed Infrastructure Footprint Area, no fatal flaws were identified during the current study. However, with regards to the proposed underground mining activities, the risk of land subsidence poses a fatal flaw for the watercourses underlain by the underground mine. Therefore, 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

Based on the results of the current study, the following recommendations are proposed:

- The developed Aquatic Biomonitoring Programme must be adopted on an annual basis, prior to the commencement of the Construction Phase of the proposed Project. This programme should continue for the life of the Project and for at least three years post the Decommissioning Phase;
- In light of the nonperennial nature of the watercourses associated with the proposed Project Area, diatom assessments should be conducted during the low-flow survey at atleast a single dam associated with each of the reaches assessed in the current study; and

The proposed Project should adopt a water and habitat quality preservation mindset throughout the life of the Project. In other words, the proposed activities should not result in the deterioration/degradation of aquatic habitat (i.e. riparian and instream habitat) and water quality within the associated aquatic ecosystem.

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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
IFA	Infrastructure Footprint Area
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
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 License
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 1.4
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Page III
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1
cA	And indication of the quality and age of the base data used for the specialist report;	Section 1
cB	A description of existing impacts on site, cumulative impacts of the proposed development and levels of acceptable change;	Section 7.5
(d)	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 6
(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 4.1
(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 1.4
(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;	Refer to Wetlands Impact Assessment Report
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.3

Legal Requirement		**Section in Report**
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 6
(k)	any mitigation measures for inclusion in the EMPr;	Section 8
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 9
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 9
(n)	a reasoned opinion (Environmental Impact Statement) -	Section 10
	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 10
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	N/A
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/A
(q)	any other information requested by the competent authority.	Section 10

1 Introduction

Freshwater ecosystems provide habitat for a significant number of animal and plant species which constitute a valuable natural resource, in economic, cultural, aesthetic, scientific and educational terms (Schmeller *et al*., 2018). In most parts of the world, these systems are experiencing declines in biodiversity and some of the well documented threats include: overexploitation; water pollution; flow modification; destruction or degradation of habitat; and invasion by exotic species (Dudgeon *et al.*, 2006; Skowno *et al.*, 2019). Mining is one of the major industrial sectors that alter and negatively impact the water quality of natural aquatic ecosystems (Dallas & Day, 2004). The conservation and management of these systems is thus essential for maintaining ecosystem diversity, functionality, and connectivity.

Digby Wells Environmental (hereafter Digby Wells) was appointed to undertake an Environmental Application Process for the mining of the No. 2 Seam, which varies between 10 m to 100 m below the surface. This Aquatic Biodiversity and Impact Assessment study undertaken in the month of April 2021 forms part of the required specialist studies to support this Environmental Authorisation application.

1.1 Project Description

The Arnot South Prospecting Area (hereafter Project Area) is approximately 10 km east of Hendrina, 25 km west of Carolina, and 50 km southeast of Middelburg. The Project is near two of Eskom's power stations, namely Hendrina and Arnot. There are five farm homesteads situated within the planned underground mining area, and several nonperennial streams occur within the Mining Right Area (MRA). The land is currently mainly used for agriculture. The target area for mining lies mainly on the farms Weltevreden 174 IS, Mooiplaats 165 IS, Vlakfontein 166 IS, and Schoonoord 164 IS.

A Mining Right Application and Mining Works Programme (MWP) for underground mining have been submitted to the Department of Mineral Resources and Energy (DMRE), Reference Number MP 30/5/1/2/2/1029 MR.

As stated in the MWP provided, the No. 2 Seam is the only economically viable seam to mine. The depth of the Seam varies between 10 m to 100 m below the surface. Figure 1-1 below, extracted from the MWP, shows the depth distribution. Based on this, Digby Wells has determined **high risk** areas, which correlate with the shallowest sections of the Seam (shown in green in the figure below).

1.2 Study Objective

The goal of the Aquatic Study was to describe the baseline conditions within the aquatic ecosystems associated with the proposed Project 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 standard River EcoStatus Monitoring Programme (REMP, previously the River Health

Programme) techniques were used.

1.3 Assumptions, Limitations and Exclusions

To obtain a comprehensive understanding of the dynamics of the biota present within a watercourse (e.g. migratory pathways, seasonal prevalence, etc.), studies should include investigations conducted during different seasons, over several years and through extensive sampling efforts. Given the time constraints of the present study, such long-term research could not be conducted. Instead, conclusions provided within this report are based on data collected during a single late wet season sampling event, a literature review, and professional experience.

In terms of constraints for the study, the associated watercourses predominantly flow through private property, thus sampling was mostly restricted to the nearest possible public road crosses as access to some of the properties could not be granted.

1.4 Details of the Specialist/s

The following specialists were involved in the compilation of this report.

Responsibility	**Field Survey and Data Collation**
Full Name of Specialist	Julia Ndou
Highest Qualification	MSc. Aquatic Health
Years of experience in specialist field	4
Registration(s):	*Candidate Natural Scientist* (Reg. No. 133433)
Responsibility	**Field Survey, Data Collation and Report Compilation**
Full Name of Specialist	Tebogo Khoza
Highest Qualification	MSc. Biodiversity & Conservation
Years of experience in specialist field	3
Registration(s):	South African Council for Natural Scientific Professionals: *Candidate Natural Scientist* (Reg. No. 119651)
Responsibility	**Technical Review**
Full Name of Specialist	Byron Bester
Highest Qualification	MSc Aquatic Health
Years of experience in specialist field	10
Registration(s):	South African Council for Natural Scientific Professionals: *Professional Natural Scientist* (Reg. No. 400662/15)

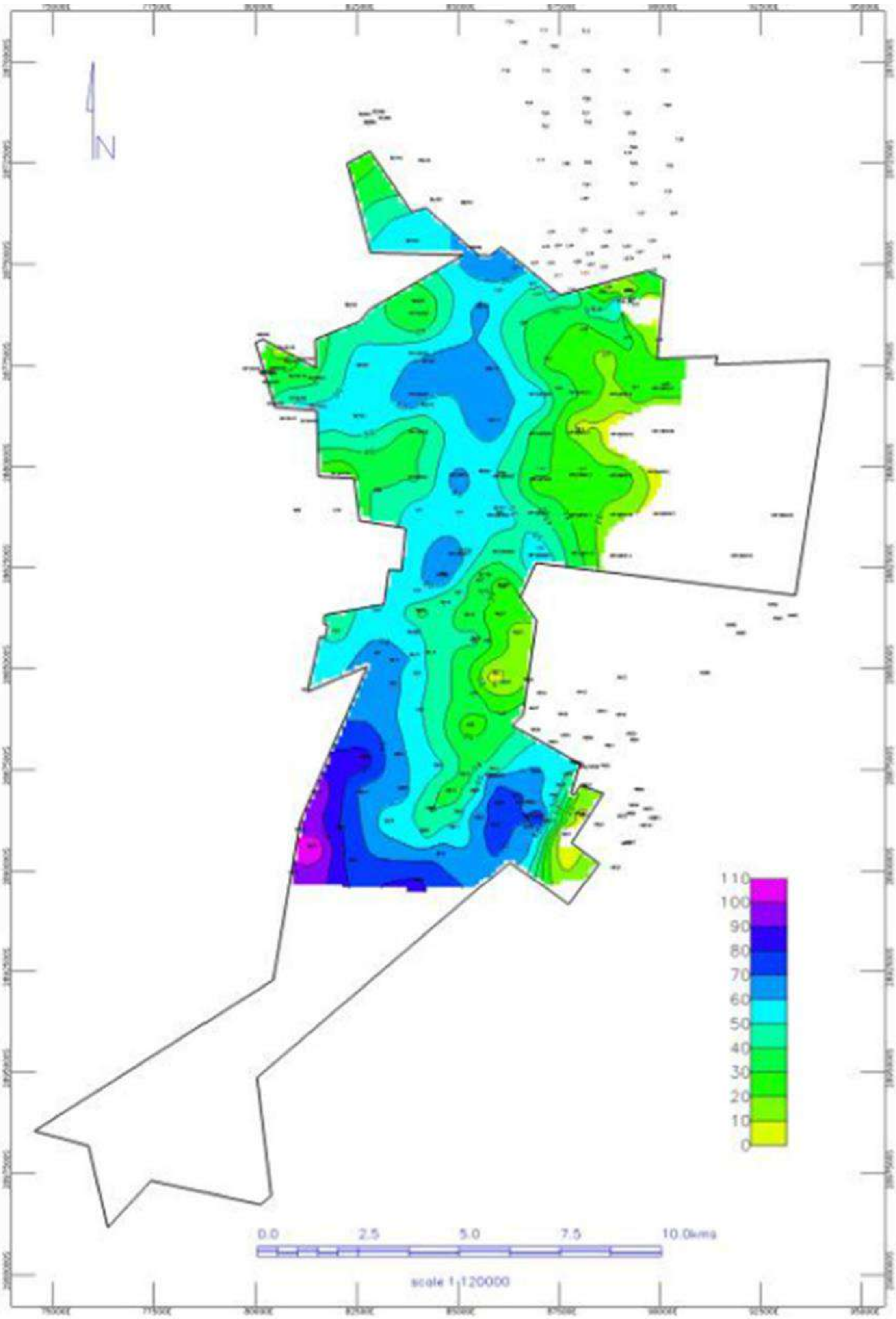

Figure 1-1: No. 2 Seam Elevation (Source: Arnot South MWP, 2020)

2 Relevant Legislation, Standards and Guidelines

Aquatic-related legislation, standards, and guidelines applicable to the Project are listed and briefly discussed below (Table 2-1).

Table 2-1: Applicable legislation, regulations, and guidelines

Legislation, Regulation, Guideline or By-Law	Applicability
National Environmental Management Act (Act No. 107 of 1998) (NEMA): NEMA (as amended) was set in place under Section 24 of the Constitution. Certain environmental principles under NEMA must be adhered to, to inform decision making for issues affecting the environment. Section 24 (1)(a) and (b) of NEMA state that: *The potential impact on the environment and socio-economic conditions of activities that require authorisation or permission by law and which may significantly affect the environment must be considered, investigated and assessed before their implementation and reported to the organ of state charged by law with authorizing, permitting, or otherwise allowing the implementation of an activity.* The NEMA requires that pollution and degradation of the environment be avoided, or, where it cannot be avoided be minimised and treated.	• The listed activities of the Project have the potential to impact on the environment, specifically the associated aquatic ecology. Therefore, requiring environmental authorisation before commencement.
National Environmental Management Biodiversity Act (Act No. 10 of 2004) (NEM:BA) The NEM:BA regulates the management and conservation of the biodiversity of South Africa within the framework provided under NEMA. This Act regulates the protection of species and ecosystems that require national protection and considers the management of alien and invasive species. The following regulations which have been promulgated in terms of the NEM:BA are also of relevance.	• An Aquatic Impact Assessment has been undertaken to identify species protected under this Act as well as the impacts posed to biodiversity; and • Required mitigation measures will be included in the Environmental Management Plan (EMP) as part of Environmental Authorisation process.
National Water Act (Act No. 27 of 2014) (NWA): The NWA aims to protect, use, develop, conserve, manage and control water resources including rivers, dams, wetlands, the surrounding land, groundwater,	• An Aquatic Impact Assessment has been undertaken to identify water resources (particularly riverine ecosystems) associated with the

Legislation, Regulation, Guideline or By-Law	Applicability
as well as human activities that influence them. The NWA intends to protect these water resources against over exploitation and to ensure that there is water for social and economic development and water for the future.	proposed Project and the impacts thereof.
Mpumalanga Nature Conservation Act (Act No. 10 of 1998): This Act provides for the protection of wildlife, hunting, fisheries, protection of endangered fauna and flora as listed in the Convention on international Trade in Endangered Species of Wild Fauna and Flora, the control of harmful animals, freshwater pollution and enforcement within the Mpumalanga Province.	• An Aquatic Impact Assessment has been undertaken to identify potential occurrence of endangered aquatic species associated with the proposed Project.
The Mineral and Petroleum Resources Development Act (Act No.28 of 2002) (MPRDA) intends: • to make provision for equitable access to and sustainable development of the nation's mineral and petroleum resources; and • to provide for matters connected therewith.	• An aquatic ecology Impact Assessment was undertaken as part of the EIA Phase for the mining of Resources; • Environmental Management Plan and Monitoring Program is included in the EIA Phase; and • Recommendations to prevent, avoid, and rehabilitate possible impacts were assessed.
Protocol for the specialist assessment and minimum report content requirements for environmental impacts on terrestrial animal species This protocol provides the criteria for the specialist assessment and minimum report content requirements for impacts on terrestrial animal species for activities requiring environmental authorisation.	• The protocol was used in this Aquatic Study to comply with the minimum assessment and reporting requirements as set out by the Department of Environment, Forestry and Fisheries (2020).

3 Description of the Environment

The following sections briefly describe the locality, the biophysical attributes and provide a regional context for the proposed underground mine,.

3.1 Locality

The Project Area is in the Mpumalanga Province under the jurisdiction of the Emalahleni Local Municipality, which is in the Nkangala District Municipality (Figure 3-1). The site is located approximately 20 km north of Kriel and 27 km south-east from Ogies.

3.2 Associated Watercourses

The water resources of South Africa are divided into quaternary catchments, which are regarded as the principal water management units in the country (Department of Water Affairs and Forestry, 2011). These catchments represent the fourth order of the hierarchical classification system, the primary catchments are referred to as Water Management Areas (WMA). The Department of Water and Sanitation (DWS) has established nine WMAs as contained in the National Water Resource Strategy 2 (2013) in terms of Section 5 subsection 5 (1) of the NWA.

The MRA falls within two Water Management Areas (WMA), i.e. Olifants and Inkomati-Usuthu, wherein lies six Sub Quaternary Reaches (SQRs) encompassed by three river systems associated with the proposed underground mining (see Table 3-1). River systems of the Olifants WMA drain toward the west and systems of the Inkomati-Usuthu WMA drain toward the east (Figure 3-2).

Table 3-1: Watercourses Associated with the Proposed Underground Mining

WMA	Primary Drainage	Quaternary Catchment	SQR	Name
Olifants	Region B	B12A	B12A-01309	Klien-Olifants
		B12B	B12B-01256	
			B12B-01213	Rietkuilspruit
Inkomati-Usuthu	Region X	X11A	X11A-01300	Vaalwaterspruit tributary
			X11A-01295	Vaalwaterspruit
			X11A-01248	

WMA = Water Management Area; SQR = Sub-quaternary Reach

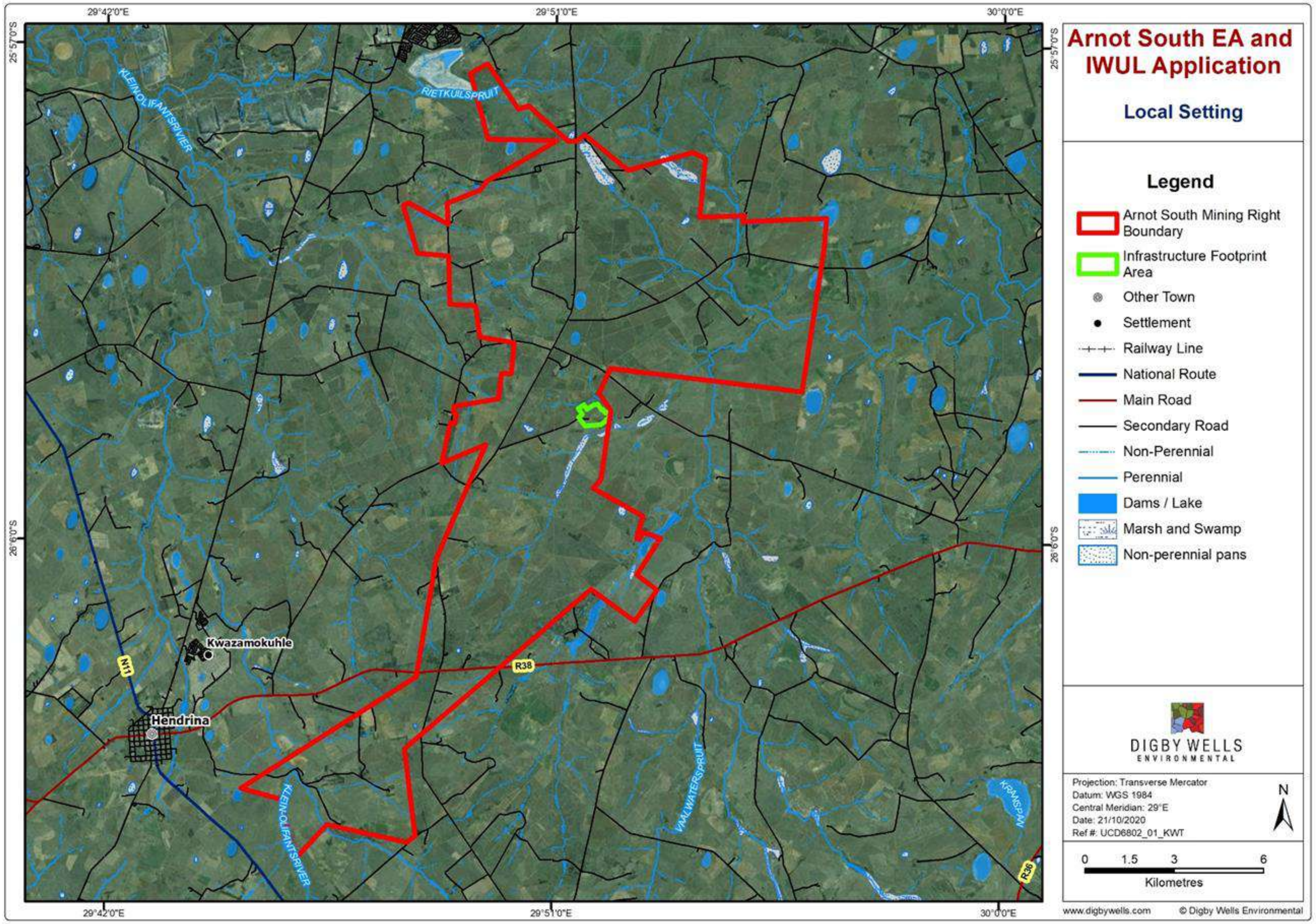

Figure 3-1: Locality Map

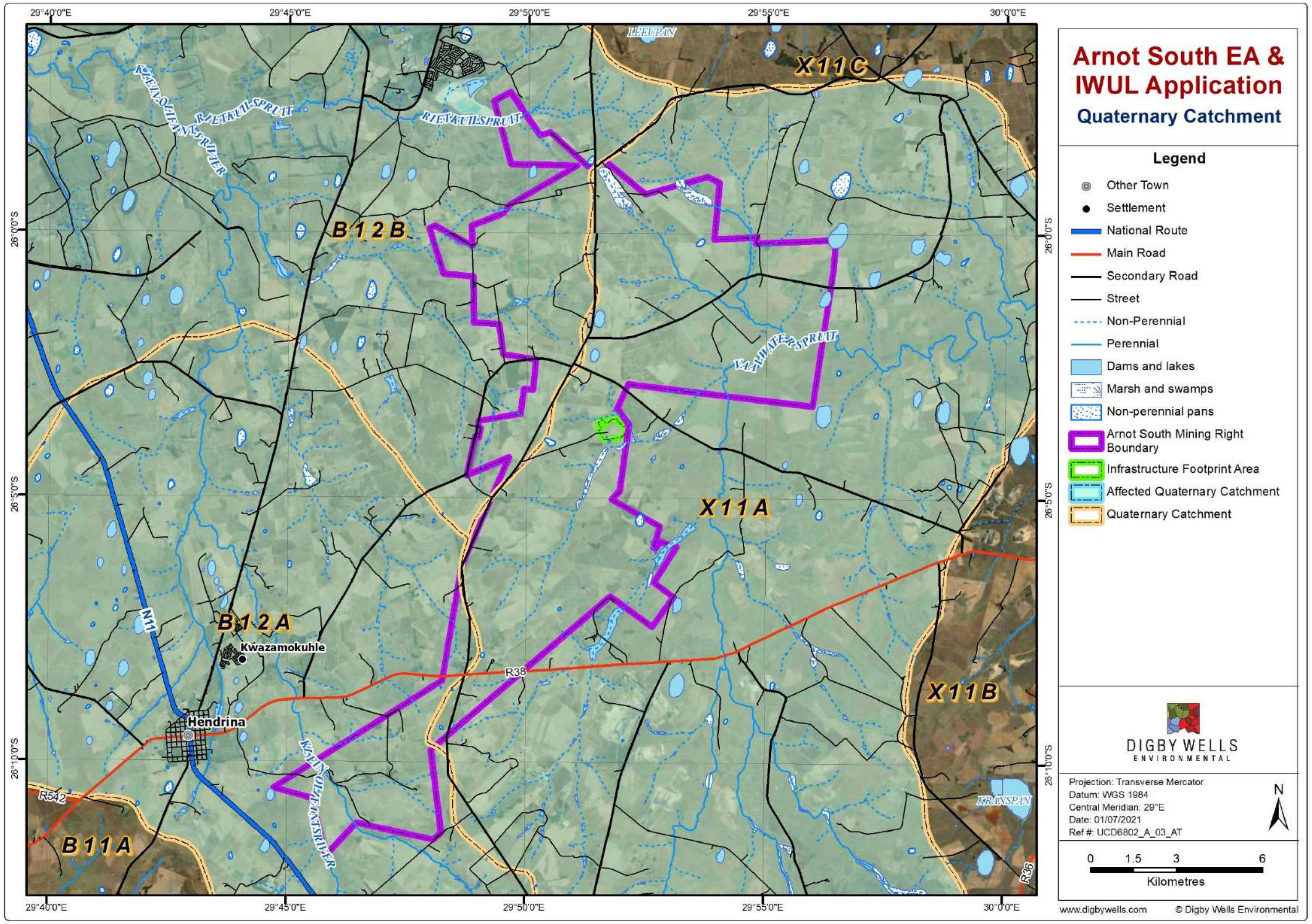

Figure 3-2: Quaternary Catchment of the Arnot South Project Area

3.3 Regional Biodiversity importance

3.3.1 Freshwater Ecoregions

Ecoregions are regions characterised by a relative similarity in the type of ecosystems and ecosystem components, i.e. biotic and abiotic. The proposed Project Area is located within the Southern Temperate Highveld freshwater ecoregion situated in the interior of South Africa, with the western boundary formed by the Magaliesberg, Pilanesberg and Waterberg mountain ranges, the northern boundary formed by the Soutpansberg, and the eastern boundary formed by the Drakensberg Mountains. This ecoregion combines headwaters of coastal basins that drain to the Indian Ocean with those of the Atlantic-draining Orange basin (Abell *et al*. 2008; Darwall *et al.* 2009).

3.3.2 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.

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), the sub-quaternary catchments associated with the proposed Project Area was defined as a *River FEPA* toward the south-east; as an *Upstream management area* and *Fish Support Area* toward the eastern portions of the MRA (Figure 3-3). The associated unnamed tributary of the Vaalwaterspruit was considered to support biodiversity targets for river ecosystems and threatened/near threatened fish species. And as such, the stream therefore needs to be manged in a way that maintains the good condition. On the other hand, upstream management areas are sub-quaternary catchments in which human activities need to be managed to prevent degradation of downstream river FEPAs and Fish Support Areas.

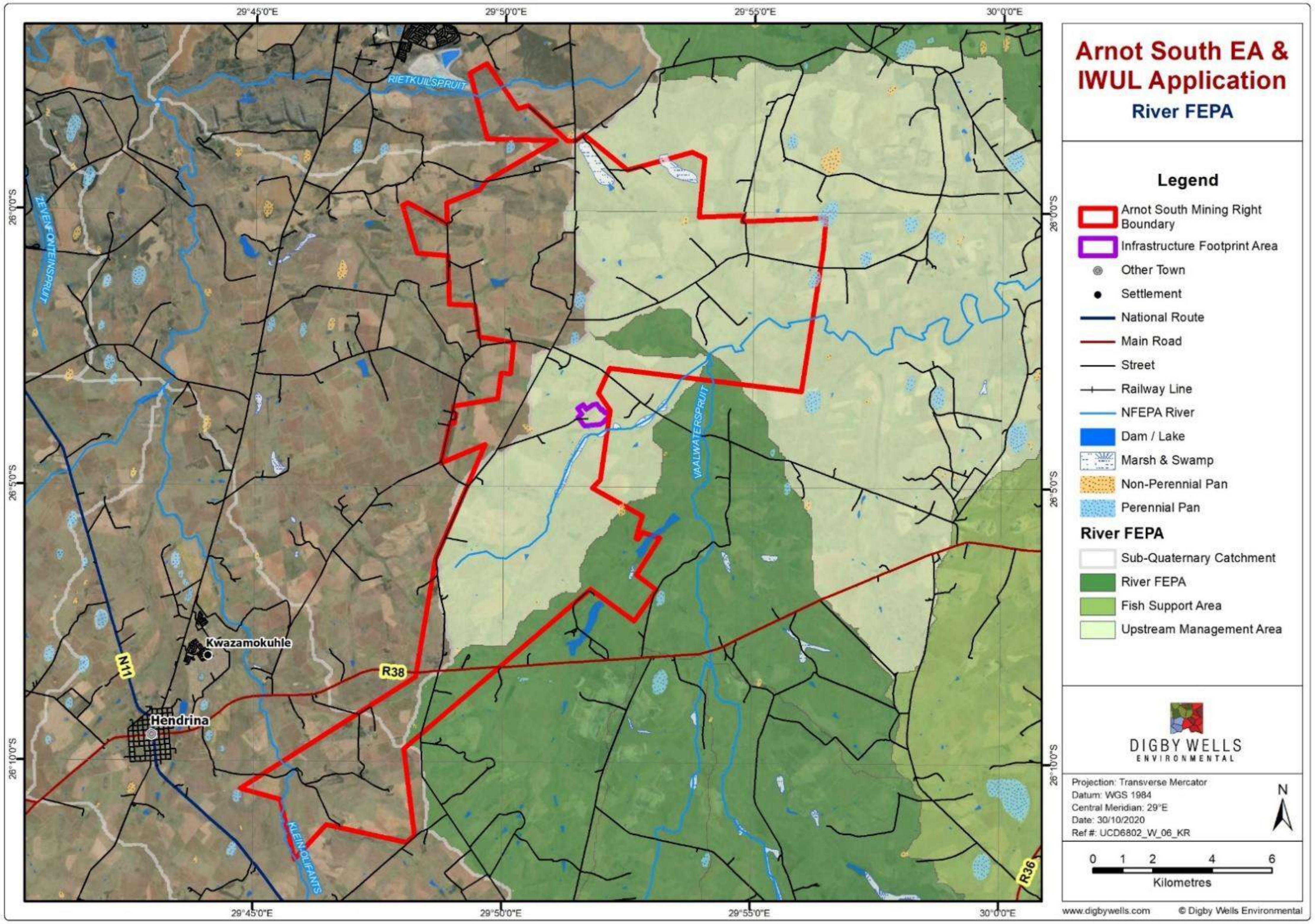

Figure 3-3: River FEPAs of the Arnot South Project Area

3.4 Mpumalanga Biodiversity Sector Plan

The Mpumalanga Biodiversity Sector Plan (MBSP) is a spatial tool that forms part of the national biodiversity planning tools and initiatives that are provided for national legislation and policy. The MBSP was published in 2014 by the Mpumalanga Tourism and Parks Agency (MTPA) and comprises a set of maps of biodiversity priority areas accompanied by contextual information and land-use guidelines for use in land-use and development planning, environmental assessment and regulation, and natural resource management. Strategically the MBSP enables the province to:

- Implement the NEM:BA, 2004 provincially, and comply with requirements of the National Biodiversity Framework, 2009 (NBF) and certain international conventions.
- Identify those areas of highest biodiversity that need to be considered in provincial planning initiatives; and
- Address threat of climate change (ecosystem-based adaptation).

The publication includes terrestrial and freshwater biodiversity areas that are mapped and classified in Protected Areas (PAs), Critical Biodiversity Areas (CBAs), Ecological Support Areas (ESAs) or Other Natural Areas (ONAs) (Figure 3-4).

Table 3-2: Mpumalanga Biodiversity Sector Plan Categories Associated with the proposed open-cast mine, as well as recommended Land Management Objectives

Category*	Description	Land Management Objective
ESA	Areas that are not essential for meeting biodiversity targets, but that play an important role in supporting the functioning of protected areas or CBAs and for delivering ecosystem services.	Maintain in a functional, near-natural state, but some habitat loss is acceptable. A greater range of land-uses over wider areas is appropriate, subject to an authorization process that ensures the underlying biodiversity objectives are not compromised.
ONAs	Areas that have not been identified as a priority in the current systematic biodiversity plan but retain most of their natural character and perform a range of biodiversity and ecological infrastructural functions. Although they have not been prioritized for biodiversity, they are still an important part of the natural ecosystem.	An overall management objective should be to minimise habitat and species loss and ensure ecosystem functionality through strategic landscape planning. These areas offer the greatest flexibility in terms of management objectives and permissible land-uses, but some authorisation may still be required for high-impact land-uses.
Heavily or Moderately Modified Areas	Areas that have been modified by human activity to the extent that they are no longer natural, and do not contribute to biodiversity targets. These areas may still provide limited biodiversity and ecological	Such areas offer the most flexibility regarding potential land-uses, but these should be managed in a biodiversity-sensitive manner, aiming to maximize ecological functionality and authorization

Category*	Description	Land Management Objective
	infrastructural functions, even if they are never prioritized for conservation action.	is still required for high-impact land-uses. Moderately modified areas (old lands) should be stabilized and restored where possible, especially for soil carbon and water-related functionality.

CBAs within a bioregion are the portfolio of areas (i.e. map of CBAs for Mpumalanga 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 proposed Infrastructure Footprint Area (IFA) is classified as **Other Natural Areas** and **Moderately Modified – Old Lands.** Portions within the remainder of the MRA are classified as **CBA Irreplaceable** (scattered to the north east and south), **CBA Optimal** (predominantly at the centre and south portions)**, Other Natural Areas** and **Moderately Modified – Old Lands** scattered throughout the MRA (Table 3-2), these are likely to be impacted if and when subsidence occurs.

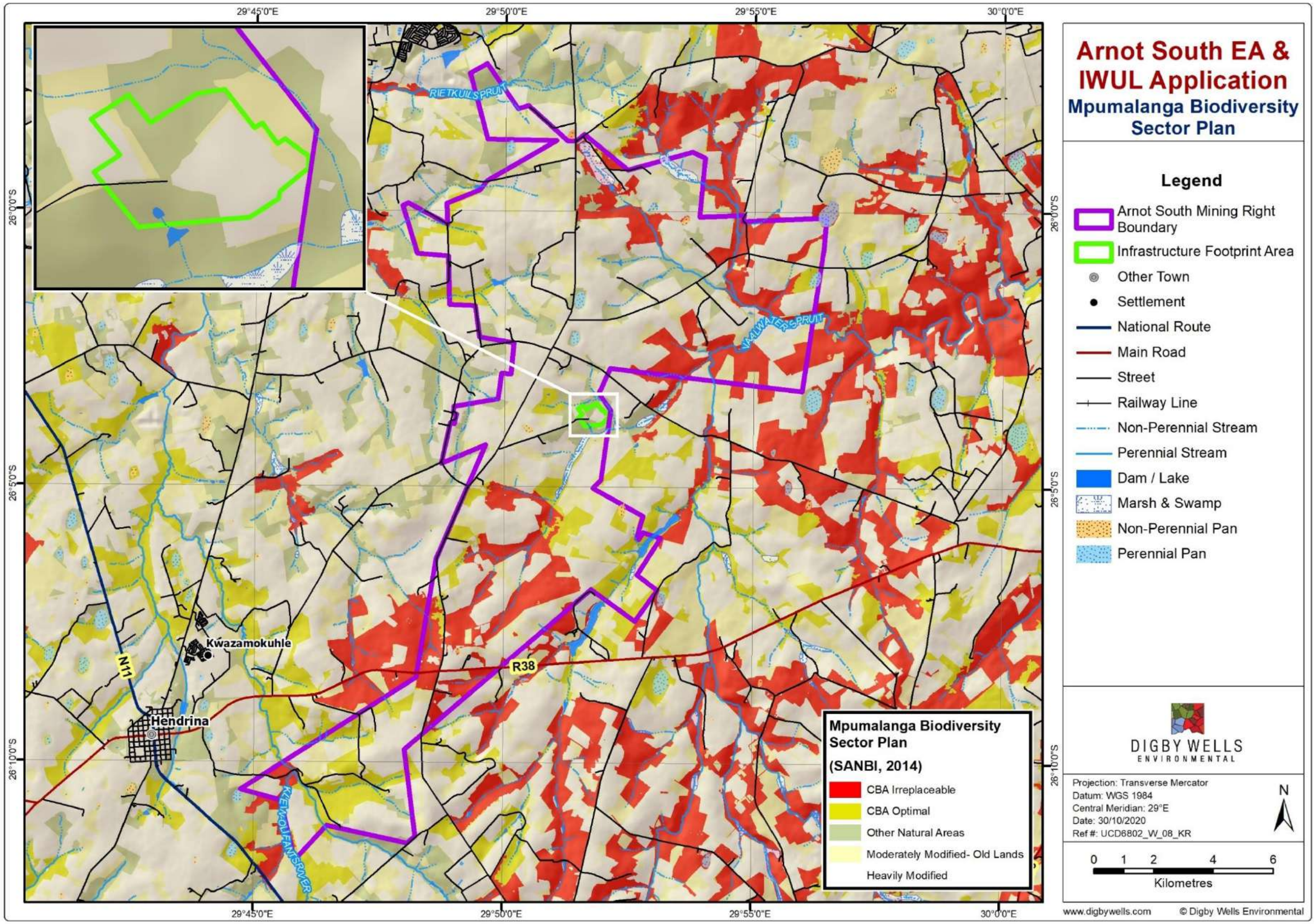

Figure 3-4: Mpumalanga Biodiversity Sector Plan (MBSP)

3.5 Mining and Biodiversity Guideline

The Mining and Biodiversity Guideline was developed collaboratively by SANBI, DFFE, the Department of Mineral Resources and Energy (DMRE), the Chamber of Mines and the South African Mining and Biodiversity Forum (2013). The purpose of the guideline was to provide the mining sector with a manual to integrate biodiversity into the planning process thereby encouraging informed decision-making around mining development and environmental authorizations. The aim of the guideline is to explain the value for mining companies to consider biodiversity management throughout the planning process.

The guideline highlights the importance of biodiversity in managing the social, economic and environmental risk of the proposed mining Project. (Table 3-3). The country has been mapped into biodiversity priority areas including the four categories each with associated risks and implications (Department of Environmental Affairs, Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum, & South African National Biodiversity Institute, 2013).

Table 3-3: Mining and Biodiversity Guideline Categories (DEA *et al*., 2013)

Category	Risk and Implications for Mining
Legally Protected	Mining prohibited; unless authorised by ministers of both the DFFE and DMRE.
Highest Biodiversity Importance	Highest Risk for Mining: the EIA process must confirm significance of the biodiversity features that may be a fatal flaw to the proposed Project. Specialists must provide site-specific recommendations for the application of the mitigation hierarchy that informs the decision-making processes of mining licences, water use licences and environmental authorisations. If granted, authorisations should set limits on allowed activities and specify biodiversity related management outcomes.
High Biodiversity Importance	High Risk for Mining: the EIA process must confirm the significance of the biodiversity features for the conservation of biodiversity priority areas. Significance of impacts must be discussed as mining options are possible but must be limited. Authorisations may set limits and specify biodiversity related management outcomes.
Moderate Biodiversity Importance	Moderate Risk for Mining: the EIA process must confirm the significance of the biodiversity features and the potential impacts as mining options must be limited but are possible. Authorisations may set limits and specify biodiversity related management outcomes.

Two Mining and Biodiversity Guideline categories cover the proposed Infrastructure Footprint Area, **Highest Biodiversity Importance – Highest Risk for Mining** and **Moderate Biodiversity Importance – Moderate Risk for Mining** (Figure 3-5). These categories predominantly cover the rest of the MRA.

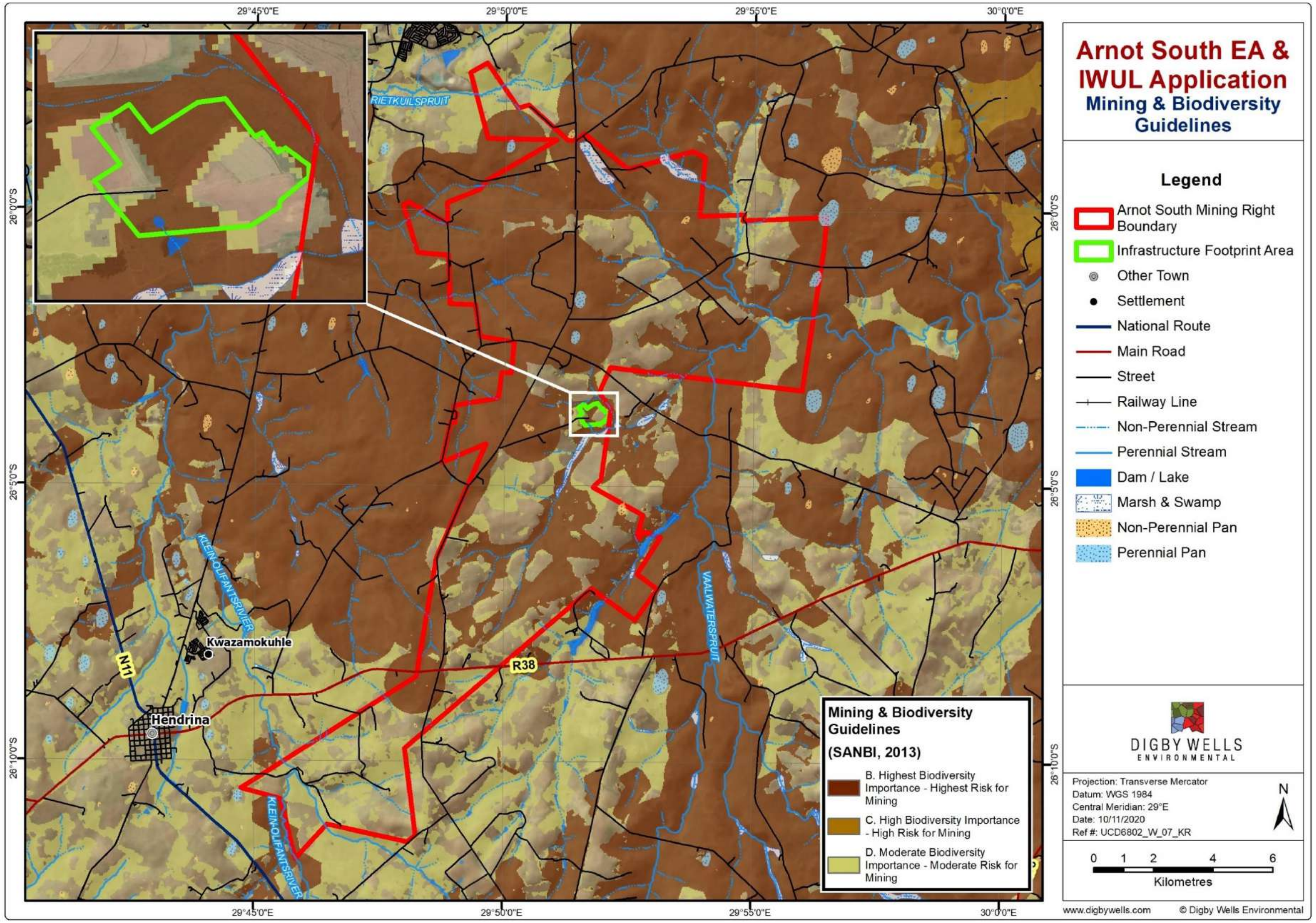

Figure 3-5: Mining and Biodiversity Guideline for Associated Project Area

4 Study Directive

This section provides a summary of the approach to the study, including each of the respective bioassessment indices utilised at each of the selected monitoring sites.

4.1 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 A.

4.2 Selected Monitoring Sites

Aquatic Ecology monitoring sites were selected based on the location of the proposed Project infrastructure, the MRA and ease of accessibility (Table 4-1; Figure 4-1). See Appendix B for Site Photographs.

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

Site/Point	Coordinates	Description
Klein-Olifants		
KO1	26° 3'1.04"S 29°49'16.32"E	Located at a road crossing, below a dam draining an unnamed tributary of the Klein-Olifants
KO2	26° 1'23.00"S	Located ~2 km north of Site KO1 at a road crossing, below a dam

Site/Point	Coordinates	Description
	29°49'49.10"E	draining an unnamed tributary of the Klein-Olifants.
KO3	26° 0'16.02"S 29°47'21.13"E	Located ~4 km northwest of Site KO2 above a dam draining an unnamed tributary of the Klein-Olifants.
Rietkuilspruit		
RK1	25°57'42.81"S 29°51'20.52"E	Located at a road crossing, within the headwaters of the Rietkuilspruit
RK2	25°57'54.77"S 29°49'21.90"E	Located ~3 km downstream of Site RK1 above the Eskom Mine dump
RK3	25°57'31.78"S 29°46'30.82"E	Located ~5 km downstream of Site RK2 at a road crossing, below a dam draining the Rietkuilspruit
Vaalwaterspruit		
VW1	26° 2'57.61"S 29°51'43.56"E	Located at a road crossing above a dam draining an unnamed tributary of the Vaalwaterspruit
VW2	26° 3'56.63"S 29°52'27.99"E	Located ~2 km south east of Site VW1 at a road crossing, of an unnamed tributary of the Vaalwaterspruit
VW3	26° 4'4.77"S 29°54'2.39"E	Located ~2 km east of Site VW2 at a Bridge, below a dam draining the Vaalwaterspruit tributary
VW4	26° 1'15.15"S 29°53'58.69"E	Located at a road crossing, on an unnamed tributary of the Vaalwaterspruit
VW5	26° 0'50.72"S 29°54'34.52"E	Located ~1 km northeast of Site VW4 at a road crossing, on an unnamed tributary of the Vaalwaterspruit

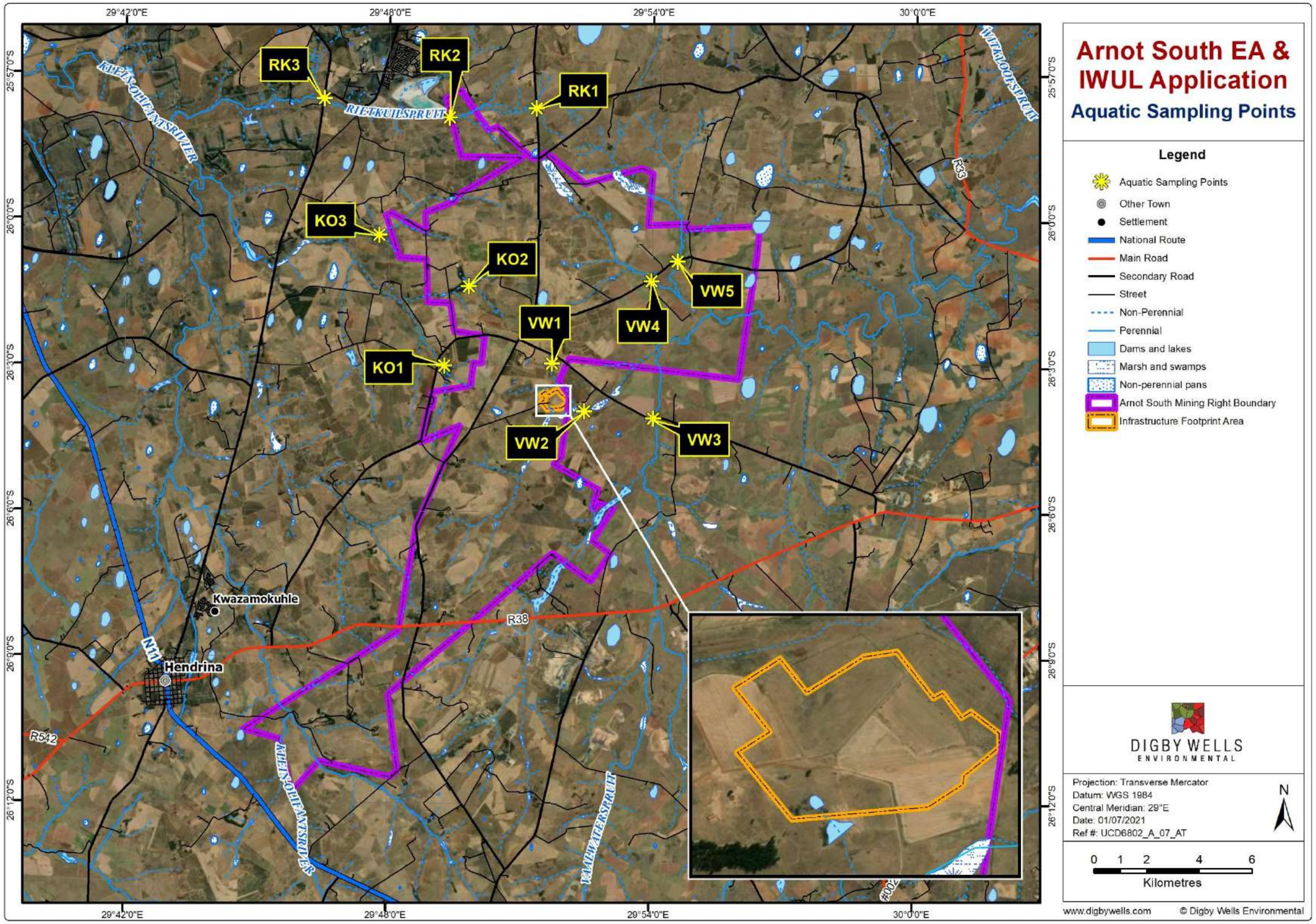

Figure 4-1: Selected Aquatic Sampling Points

5 Desktop Present Ecological State, Importance and Sensitivity

A few insights into the desktop-based ecological conditions and the expected aquatic biota (incl. aquatic macroinvertebrates and fish) likely to be present within the study area are described within this section.

Table 5-1 outlines the desktop aquatic-related data obtained for the potentially affected Quaternary Catchments (DWS, 2014).

Table 5-1: Desktop Aquatic Data pertaining to River Reaches Associated with the Project

SQR Code	EC	Category Description	EI	ES
Olifants Water Management Area				
B12A-01309	**C**	Moderately modified	High	High
B12B-01256	**C**	Moderately modified	High	High
B12B-01213	**E**	Seriously modified	Moderate	Moderate
Usutu-Komati Water Management Area				
X11A-01300	**B**	Largely natural	Moderate	Moderate
X11A-01295	**B**	Largely natural	Moderate	High
X11A-01248				
EC = Ecological Category; EI = Ecological Importance; ES = Ecologiacal Sensitivity				

Both river reaches of the Klien-Olifants (B12A-01309 and B12B-01256 SQRs) appear to be in a *Moderately modified* state (i.e. Ecological Category C; DWS, 2014). Surrounding these reaches are mining and agricultural land uses. Impacts associated with these activities include mining roads runoff, vegetation removal, erosion, alien vegetation, water abstraction, increased flows and small dams. The Ecological Importance and Ecological Sensitivity of both SQRs has been classified as “High” with a total of six fish species and 51 macroinvertebrate taxa expected.

The Rietkuilspruit B12B-01213 SQR is said to be in a *Seriously modified* state and impacted by activities associated with agricultural, mining and residential land uses, which include low water crossings, effluent discharge, canalisation, erosion, abstraction, increased flows (DWS, 2014). The Ecological Importance and Ecological Sensitivity of both SQRs has been classified as “Moderate” with only three fish species and 41 macroinvertebrate taxa expected.

The Vaalwaterspruit river reaches (X11A-01300, X11A-01295 and X11A-01248 SQRs) appear to be in a *Largely natural* state (i.e. Ecological Category B). Agricultural land uses are present in the upper reaches associated with the Project Area. Impacts associated with these agricultural activities include low-water crossings, erosion, vegetation removal, water abstraction, algal growth, dams, alien vegetation encroachment, overgrazing and trampling, irrigation, roads and sedimentation (DWS, 2014). The Ecological Importance of the

Vaalwaterspruit tributary SQR has been classified as "Moderate". It is expected to contain a total of seven fish species and 48 macroinvertebrate taxa.

5.1.1 Expected Aquatic Macroinvertebrate Taxa

The expected macroinvertebrate taxa for the associated watercourses are presented in Table 5-2.

Table 5-2: Expected Macroinvertebrate Taxa in Watercourses Associated with the proposed Underground Mining Area

Family Names		
Porifera	Belostomatidae	Hydraenidae
Coelenterata	Corixidae	Hydrophilidae
Turbellaria	Gerridae	Ceratopogonidae
Oligochaeta	Hydrometridae	Chironomidae
Hirudinea	Naucoridae	Culicidae
Potamonautidae	Nepidae	Dixidae
Atyidae	Notonectidae	Muscidae
Hydracarina	Pleidae	Psychodidae
Baetidae 1 sp	Veliidae/Mesoveliidae	Simuliidae
Caenidae	Ecnomidae	Tabanidae
Leptophlebiidae	Hydropsychidae 2 sp	Tipulidae
Tricorythidae	Hydrophilidae	Ancylidae
Coenagrionidae	Leptoceridae	Lymnaeidae
Aeshnidae	Dytiscidae	Physidae
Corduliidae	Elmidae	Planorbinae
Gomphidae	Gyrinidae	Corbiculidae
Libellulidae	Haliplidae	Sphaeriidae
Blue shading = high dependence for fast-flowing water; **Orange** shading = moderate water quality dependence; **Green** shading = dependence for both fast-flowing water and moderate water quality		

The expected aquatic macroinvertebrate assemblage is largely composed of taxa (or families) with preference for slow-flowing to moderately-flowing water and low water quality dependence, only seven of the expected 51 species have preference for fast-flowing water and only 10 taxa are sensitive to water quality modifications (DWS, 2014).

Based on distribution records, no macroinvertebrate species of conservation concern are likely to occur within the associated watercourses (Darwall et al., 2009) and no aquatic macroinvertebrate species of commercial or economic value were listed on the original NEM:BA Threatened and Protected Species (ToPS) Regulations.

5.1.2 Expected fish species

The fish species expected in the river reaches associated with the Project Area have been provided for in Table 5-3 (DWS, 2014). Additionally, each species' sensitivity ratings towards modified physio-chemical and no-flow conditions (DWS, 2014) have been provided for, together with their conservation status according to the IUCN Red List of Threatened Species (2018).

Table 5-3: Expected Fish Species in the Reaches Associated with the Project Area

Fish Species	Common Name	Tolerance/Preference		Conservation Status
		Modified Water Quality	No-flow	
Amphilius uranoscopus	Common Mountain Catfish	4.8	4.8	LC
Chiloglanis pretoriae	Shortspine Suckermouth	4.5	4.8	LC
Clarias gariepinus	Sharptooth Catfish	1	1.7	LC
Enteromius anoplus	Chubbyhead Barb	-	-	LC
Enteromius paludinosus	Straightfin Barb	1.8	-	LC
Labeobarbus polylepis	Bushveld Samllscale Yellowfish	-	-	LC
Pseudocrenilabrus philander	Southern Mouthbrooder	1.4	1	LC
Tilapia sparrmanii	Banded Tilapia	1.4	0.9	LC
Tolerance rated out of 5: **Red** Shading = intolerant, **Green** shading = tolerant, Conservation Status: LC=Least Concern				

Following a review of available collection records of fish species occurring within the watercourses associated with the study area (including records from the Freshwater Biodiversity Information System (FBIS)), a total of 8 fish species are expected to occur within the B12A, B12B and X11A catchments. Four of the species are tolerant to modified water quality, three of those are also tolerant to no-flow conditions (DWS, 2014).

6 Findings and Discussion

Each of the assessment indicators applied at the time of the present survey, on the 15th to 16th April 2021, representing a late wet season survey.

6.1 Water Quality

The *in situ* water quality results of the 2021 late wet season survey for the watercourses associated with the proposed Project are presented in Table 6-1 and further discussed in the below sections. For the purposes of the assessment, each of the values were compared against various water quality guidelines, including:

- Temperature, 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).

Table 6-1: *In situ* Water Quality Results for Watercourses Associated with the proposed Project

River System	Site	Time	Temperature (°C)	pH	Conductivity (µS/cm)	Dissolved oxygen (mg/l)	Dissolved oxygen (Saturation %)
Guideline	-	-	5 - 30	6 - 8	≤ 500	> 5	80 - 120
Klein-Olifants Tributary	**KO1**	11H35	20.2	**8.14**	**820.0**	5.53	**42.8**
	KO2	12H10	23.1	**8.19**	**699.0**	5.61	**66.1**
	KO3	10H20	18.7	**8.23**	157.4	7.64	80.4
Rietkuilspruit	**RK1**	10H32	20.1	**8.01**	**1230.0**	5.53	**62.5**
	RK2	09H56	18.3	7.91	**1287.0**	**4.34**	**45.6**
	RK3	09H00	15.8	**8.04**	**8880.0**	**4.63**	**34.2**
Vaalwaterspruit	**VW1**	13H01	24.0	**8.24**	**691.0**	5.42	**64.8**
	VW2	14h00	21.9	**8.23**	**905.0**	7.26	81.6
	VW3	11H38	20.1	**8.24**	409.0	7.11	88.1
	VW4	15H46	20.6	**8.19**	**863.0**	6.06	87.3
	VW5	16H33	19.3	**8.18**	**938.0**	6.86	84.3

***Red values indicate constituents exceeding recommended guideline values**

6.1.1 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 (DWAF, 1996). 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).

Temperature values recorded at monitoring sites associated with the proposed Project ranged from 15.8 ^{o}C to 24.0 ^{o}C, typical of the summer season temperatures in South Africa. Therefore, all recordings were within the normal temperature ranges for inland waters, thus all sites were expected to support temperature-sensitive aquatic biota.

6.1.2 pH

The pH value is a measure of hydrogen (H^+), hydroxyl (OH^-), bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions in water (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 carbon dioxide from the water, thus elevated pH levels may be a characteristic of eutrophic systems where algal blooms are in abundance (DWAF, 1996).

The pH values recorded exhibited close to neutral to slightly alkaline conditions, ranging from 7.91 pH units to 8.24 pH units during the present study. The DWAF (1996) guideline upper limit of 8 pH units was exceeded at all sampled sites except at the Site RK2 along the Rietkuilspruit, which was one of two sites (the other site being KO2) with no obvious signs of abundant algae being present at the time of the survey. The recorded pH levels were likely influenced by natural processes such as photosynthesis and to some extent to a state of eutrophication as was evidenced by the presence of algae at some of the sites (Figure 6-1 for example).

6.1.3 Electrical Conductivity

Electrical conductivity (or conductivity) is a measure of the ability of water to conduct an electrical current. This ability is a result of the presence 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. On the other hand, anthropogenic sources of increased dissolved salts include domestic and industrial effluent discharges and surface runoff from urban, industrial and cultivated areas (DWAF, 1996).

Conductivity values recorded during the present study were predominantly high and recorded above the recommended guideline of 500 µS/cm (USEPA, 2010) at all the sites, except at Sites KO3 and VW3 (157.4 µS/cm and 409.0 µS/cm). These sites supported moderately fast flows in relation to other sampled sites, thus potential pollutants were likely flushed downstream and not allowed to settle or accumulate within the reach. The conductivity levels at the other sampled sites were likely attributed to nutrients stemming from the surrounding farming activities. Most notably, Site RK3 recorded a drastically elevated conductivity level (8880.0 µS/cm), which in consideration of its location below an ash dump, potential contamination may be implicating these values.

Figure 6-1: Algae suggesting a potential state of eutrophication at Site VW3 along the Vaalwaterspruit

6.1.4 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 (DO) 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 DO concentration provides a useful measure of the health of an aquatic ecosystem.

Dissolved oxygen levels were predominantly low throughout the sampled sites, however only recorded below the recommended guideline of 5 mg/l (Nebeker *et al*., 1996) at sites RK2 and RK3. The flow of water at the assessed watercourses was predominantly low with no bubbling water at rapids, except at Site VW3, thus aeration was limited and the low dissolved oxygen levels were expected. Some sites however recorded dissolved oxygen levels above 7 mg/l, all these sites were observed to have some aquatic vegetation (Figure 6-2). Similarly, dissolved oxygen saturation levels were predominantly low and exceeded the recommended guideline levels of 80 – 120 % at most of the sites (Department Of Water Affairs And Forestry, 1996).

The relatively low dissolved oxygen levels were considered a potential concern for sensitive aquatic biota.

Figure 6-2: Photo Showing Filamentous Algae at Site VW3 (Left), Water Lilies and Reeds at Site KO3 (Middle) and Oxygen Weed at Site VW2 (Right)

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). While the IHI is a rapid, field-based, visual assessment of modifications to a few 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 Index for Habitat Integrity (IHI) was completed on a desktop level for each aquatic ecosystem considered in the present survey and populated with observations recorded during the field survey (Table 6-2).

Table 6-2: IHI Findings for the Watercourses Associated with the Proposed Project

Habitat Component	IHI Score	Ecological Category	Major Impacts
Klein-Olifants			
Instream	71.3	C	Water quality deterioration and flow modification
Riparian	80.5	B	Inundation and flow modification due to presence of dams
Rietkuilspruit			
Instream	78.3	C	Water quality deterioration due to high prevalence of farm lands and mining activities
Riparian	86.1	B	Inundation and water quality deterioration
Vaalwaterspruit			
Instream	79.8	C	Water quality deterioration due to high prevalence of farm lands
Riparian	80.1	B	Isolated infestations of alien-invasive Blue Gum trees observed along the channel

The findings from the IHI assessments conducted during the current survey indicate that the habitat integrity along each of the assessed tributaries were *Moderately Modified* (Ecological Category C) for the instream components and *Largely Natural* (Ecological Category B) for the riparian component. At the Klein-Olifants reach, major impacts of the instream habitat were water quality deterioration and flow modification, whilst major impacts of the riparian habitat include inundation and flow modification. At the Rietkuilspruit reach, major impacts were water quality deterioration and inundation. At the Vaalwaterspruit reaches, major impacts of the instream habitat were water quality deterioration and flow modification, whilst major impacts of the riparian habitat include inundation, flow modification and exotic vegetation.

The assessed watercourses were predominantly flanked by farmlands with a significant number of dams. These result in apparent water quality deterioration due to fertilisers/nutrients entering the watercourses and dam/weirs acting as barriers which cause flow and channel modifications.

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 6-3 shows the adapted IHAS scores at the sites assessed during the current survey.

Table 6-3: IHAS Values and Interpretation for the Sampled Sites

Site	IHAS Score (%)	Interpretation
Klein-Olifants		
KO1	30.1	**Poor**
KO2	36.4	**Poor**
KO3	54.1	**Poor**
Rietspruit		
RK1	45.5	**Poor**
RK2	34.5	**Poor**
RK3	52.7	**Poor**
Vaalwaterspruit		
VW1	41.8	**Poor**
VW2	49.1	**Poor**
VW3	60.0	**Adequate / Fair**
VW4	72.7	**Good**
VW5	61.8	**Adequate / Fair**

During the survey, the sampled Klein-Olifants and Rietkuilspruit systems varied between shallow to deep, slow to moderately-flowing water. Gravel, sand, mud (GSM) and marginal vegetation were the dominant biotopes whilst the lack of the stones biotope was a common feature throughout the sites. Consequently, all assessed sites exhibited *Poor* aquatic macroinvertebrate habitat availability. A relatively wider diversity in habitat biotope availability were observed at the assessed Vaalwaterspruit sites, from shallow to deep, still to be moderately-flowing water and all SASS5 biotopes (stones, GSM and Vegetation) were available. The macroinvertebrate habitat availability therefore ranged between *Poor* to *Good*.

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.

Table 6-4 presents the SASS5 results for the assessed monitoring sites within the proposed Project area.

Table 6-4: SASS5 Data Obtained for the Assessed Sites

Site	SASS5 Score	Taxa/Family	ASPT
Klein-Olifants Tributary			
KO1	55	13	4.30
KO2	54	16	3.40
KO3	62	15	4.10
Rietkuilspruit			
RK1	61	14	4.36
RK2	79	19	4.16
RK3	78	18	4.33
Vaalwaterspruit			
VW1	81	17	4.76
VW2	78	18	4.33
VW3	68	15	4.53
VW4	59	14	4.21
VW5	59	16	3.69
ASPT = Average Score Per Taxon			

A total of 29 macroinvertebrate taxa or families (out of the expected 51) were sampled throughout the three sampled sites along the Klein-Olifants tributaries. The aquatic macroinvertebrate community assemblages were predominantly composed of taxa that have *"Low"* water quality requirements (i.e. SASS sensitivity score of 1-7). Only two families with a *Moderate* water quality requirement (i.e. SASS sensitivity score of 8-12) were sampled, namely Hydracarina and Elmidae. At the Rietkuilspruit, a total of 25 macroinvertebrate families (out of the expected 41) were sampled throughout the three sampled sites. The aquatic macroinvertebrate community assemblages were predominantly composed of taxa that have *"Low"* water quality requirements. Only three families with a *Moderate* water quality requirement were sampled, namely Hydracarina, Lestidae and Aeshnidae. At the Vaalwaterspruit, a total of 30 macroinvertebrate families (out of the expected 45) were sampled throughout the three sampled sites. The aquatic macroinvertebrate community assemblages were predominantly composed of taxa that have *"Low"* water quality requirements. Four families with a *Moderate* water quality requirement were sampled (Hydracarina, Lestidae, Aeshnidae and Dixidae).

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 (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 assessed sites are shown in Table 6-5 and discussed below.

Table 6-5: MIRAI data for the Assessed Sites

		Klein-Olifants	Rietkuilspruit	Vaalwaterspruit
Flow	Overall % Change	52	52	49
Habitat		33	41	35
Water Quality		58	38	48
MIRAI Value		**52.7**	**56.1**	**55.7**
Ecological Category		**D**	**D**	**D**
Description		Largely Modified	Largely Modified	Largely Modified

The macroinvertebrate assemblage at all assessed watercourses around the Study Area exhibited *Largely Modified* conditions (Ecological Category D). At the assessed Klein-Olifants tributaries, the water quality metric constituted the highest overall % change in macroinvertebrate assemblage. This suggests that of the three assessed metrices, water quality was the main contributor to the state of macroinvertebrate assemblages at these sites. At both assessed Rietkuilspruit and Vaalwaterspruit sites, the flow metric constituted the highest overall percentage change in macroinvertebrate assemblage. This suggests that flow modifications at these sites were the main contributor to the state of macroinvertebrate assemblages.

6.4 Fish Communities

Using fish 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 electro-narcosis technique was applied to sample the available fish species within watercourses associated with the proposed Project Area. The sampled species and subsequent ecological condition of the fish communities is discussed in the below sub-sections.

6.4.1 Catch Record

Eight indigenous fish species were expected to occur within the associated watercourses, with none of the species deemed a potential conservation concern (see Table 5-3).

A total of 6 fish species were sampled, one of which was regarded as alien invasive species (*Micropterus salmoides* or Largemouth Bass). The number of fish sampled per site sampled is shown in Table 6-6.

Table 6-6: Fish sampled within the sampled reaches

Site	*Amphilius uranoscopus*	*Chiloglanis pretoriae*	*Clarias gariepinus*	*Enteromius anoplus*	*Enteromius paludinosus*	*Labeobarbus polylepis*	*Pseudocrenilabrus philander*	*Tilapia sparrmanii*	*Micropterus salmoides*
Klein-Olifants									
KO1	-	-	-	-	-	-	-	-	-
KO2	-	-	-	-	-	-	-	-	-
KO3	-	-	-	-	-	-	-	7	
Rietkuilspruit									
RK1	-	-	-	-	-	-	-	-	-
RK2	-	-	-	1	3	-	-	-	-
RK3	-	-	-	-	-	-	-	-	-
Vaalwaterspruit									
VW1	-	-	-	-	-	-	-	-	-
VW2	-	-	-	-	-	-	-	-	-
VW3	-	-	1	-	7	-	1	-	1
VW4	-	-	-	-	10	-	9	7	-
VW5	-	-	-	-	16	-	11	7	-

*** Alien species; Values in parenthesis indicated observed specimens**

Along the assessed Klein-Olifants tributaries, a single fish species was sampled at Site KO3. At the Rietkuilspruit sites, only 2 species were sampled, whilst the most number of fish species were sampled at the Vaalwaterspruit (a total of 5 species). All 5 sampled indigenous fish species are known to be tolerant, to varying extents, only *Amphilius uranoscopus* and *Chiloglanis pretoriae* are known to be sensitive towards water quality and flow modifications, thus the absence of these two species from the sampled fish assemblages may suggest that there were water quality and or flow modifications at the sampled watercourses at the time of the survey.

The *Enteromius paludinosus* (Straightfin Barb) was the most abundant and prevalent species and was sampled at 4 sites, at the Rietkuilspruit Site KR2 and Vaalwaterspruit sites VW3, VW4 and VW5 (Figure 6-3).

Figure 6-3: *Enteromius paludinosus* (Straightfin Barb) specimen sampled at sites RK2, VW3, VW4 and VW5

A single specimen of the alien invasive *Micropterus salmoides* (Largemouth Bass; Figure 6-4) was sampled at Site VW3. The specimen was observed to be in an unhealthy state with skin lesions possibly caused by copepods, bacteria or fungi (NOGA, 1986). The Largemouth Bass is a popular, freshwater gamefish species which favours clear, standing or slow-flowing waters with submerged or floating vegetation (Skelton, 2001).

Figure 6-4: *Micropterus salmoides* (Largemouth Bass) specimen sampled at Site VW3

6.4.2 Ecological Category of Fish Assemblages

The REMP uses the FRAI which is based on the preferences of various fish species as well as the frequency of occurrence. The FRAI results for the sampled river reaches are shown in Table 6-7 and discussed below.

Table 6-7: FRAI Results for the current aquatic assessment

River System	FRAI Score	Ecological Category	Description
Klein-Olifants	24.0	**E**	Seriously Modified
Rietkuilspruit	34.6	**E**	Seriously Modified
Vaalwaterspruit	49.5	**D**	Largely Modified

A single fish species was sampled at the assessed Klein-Olifants tributaries, and two species were sampled at the assessed Rietspruit reaches. Consequently, both river systems were representative of *Seriously Modified* (Ecological Category E) condition. The greatest number of species (four) and total number of specimens (80) were sampled at the Vaalwaterspruit reaches, thus, the assessed Vaalwaterspruit reaches were representative of *Largely Modified* (Ecological Category D) condition at the time of the survey.

These findings could be attributed to a number of factors including the no-flow conditions observed at most of the sites during the survey; potential water quality modifications such as excessive nutrients within the watercourses which was evidenced by mild eutrophication at some of the sites and or the effectiveness of the electro-narcosis technique. The effectiveness of this technique has been shown to be hampered in high-conductivity water (Hill & Willis, 1994). Site KO3 recorded the lowest conductivity and was the only site along the assessed Klein-Olifants tributaries where fish were sampled. Site VW3 recorded the second lowest conductivity and the most number fish species. At the other sites which recorded elevated conductivity, the voltage setting on the electro-narcosis devise had to be reduced to a minimum during sampling, this resulted in a very weak current being transmitted in the water and inability to shock any fish.

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 associated with the Project Area were determined below (Table 6-8).

Following integration of the defined ecological conditions obtained for the instream biological integrity (i.e. 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 Klien-

Olifants tributaries, the Rietkuilspruit and Vaalwaterspruit reaches represented an integrated EcoStatus of *Moderately Modified* (Ecological Category C).

In relation to the Recommended Ecological Category (REC), the assessed sections of the Upper Olifants River Catchment i.e. the Klein-Olifants and Rietkuilspruit systems were determined to attain to the Recommended Ecological Category (REC) of a C, as gazetted in April 2016 (*Classes and Resource Quality Objectives of Water Resources for The Olifants Catchment of Section 13(1)(A) and (B) of the National Water Act, 1998 (Act No.36 of 1998)*, 2016). Similarly, the assessed sections of the Inkomati River Catchment i.e. the Vaalwaterspruit systems (X11A-01295 and X11A-01248; excluding the X11A-01300 SQR) were determined to attain to the REC of a C, as gazetted in April 2016 (*Classes and Resource Quality Objectives of Water Resources for The Catchments of The Inkomati of Section 13(1)(A) and (B) of the National Water Act, 1998 (Act No.36 of 1998)*, 2016).

Table 6-8: The PES of the reaches under study at the time of the November 2020 field survey through the use of the ECOSTATUS4 (Version 1.02; Kleynhans & Louw, 2008)

River System	Response Indices			EcoStatus		
	MIRAI EC	FRAI EC	Instream EC	Riparian Vegetation EC (IHI)	Score	Category
Klein-Olifants	D	E	D	B	64.1	C
Rietkuilspruit	D	E	D	B	69.8	C
Vaalwaterspruit	D	D	D	B	68.4	C

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 on the proposed No. 2 Seam underground mining and the IFA. Above the No. 2 Seam lies a watershed which drains a network of nonperennial streams, some drain eastward whilst others drain westward. The nonperennial streams predominantly flow over areas where the Seam depth ranges between 10 – 30 m (Figure 7-1), thus are likely to be impacted by subsidence and or mining activities. The proposed IFA drains into the unnamed network of tributaries adjoining the Vaalwaterspruit.

. The identified potential impacts that will negatively affect aquatic ecosystems are discussed below for the various phases of the Project (i.e. Construction Phase, Operational Phase, as well as Closure and Decommissioning Phase).

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

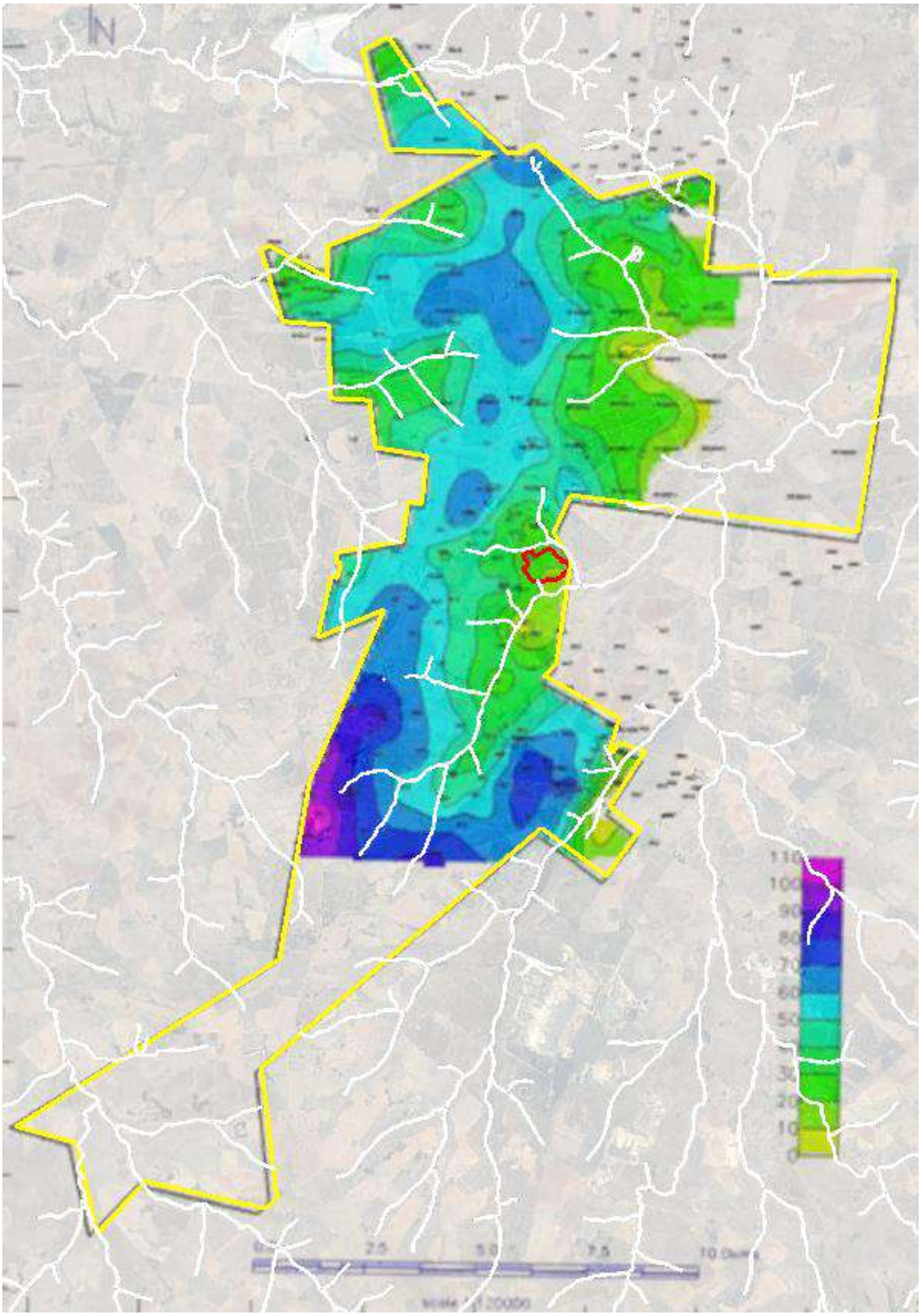

Figure 7-1: No. 2 Seam Elevation Layout Overlain with Associated Watercourses

7.1 Proposed Activities

The construction, operation and decommissioning phases of the proposed Project shall comprise of the activities in Table 7-1.

Table 7-1: Project Activities

Phase	Activity
Construction	Site/vegetation clearance (52.281385 ha)
	Diesel storage and explosives magazine
	Establishment of infrastructure (Infrastructure footprint - 13.2849 ha; linear infrastructure - 51 501 m) Ventilation fans, change houses, offices, ablutions, workshops, cable workshop, weighbridge, weighbridge control room and access control office
	Construction of access and haulage road (19 113 meters), Power line construction 22kV line, 2.3 km long
	Construction of Pollution control dam (PCD) (1.6078 ha), Raw water pipeline, Process water, Sewage treatment plant (STP)
	Stockpiling of soils, rock dump and discard dump establishment.
Operational	Operating STP (18.3168 m (combination of two delineations)), PCD, raw water pipeline, process water, washing plant
	Mining of coal by underground mining (underground) (5 050.83 ha) Removal of rock (blasting). Rock/discard dumps, soils, ROM, discard dump (discard dump 2946 ha and Overburden stockpile 13716 ha)
	Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste
	Maintenance of haul roads, pipelines, machinery, water, effluent and stormwater management infrastructure and stockpile areas.
	Continue with exploration activities
Decommissioning	Demolition and removal of infrastructure.
	Post-closure monitoring and rehabilitation.
	Closure of the underground mine.

7.2 Construction Phase

Land manipulation and vegetation clearing associated with the proposed surface infrastructure is the main foreseeable aquatic-related impact associated with the Construction Phase of the Project (See Figure 7-2 for IFA). There is also a risk of contaminants associated with construction activities and machinery entering the aquatic systems from the Project workings and storage sites.

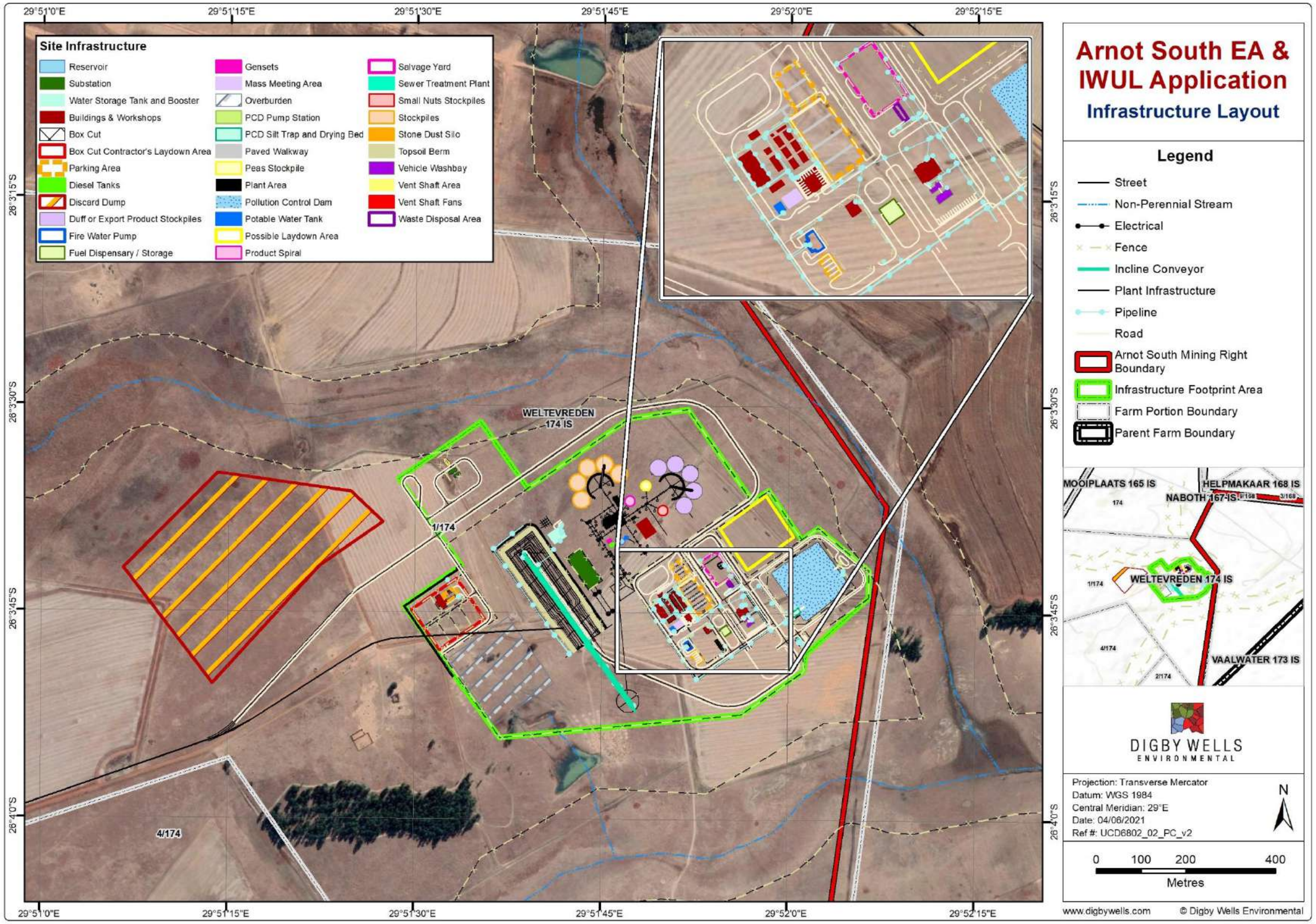

Figure 7-2: Infrastructure Layout Plan (or IFA) for the Proposed Project

7.2.1 Impact Description: Water and Habitat Quality Deterioration Associated with Vegetation Manipulation/Clearing

The proposed IFA drains the unnamed tributaries of the Vaalwaterspruit. Each of the tributaries lie less than 500 m from the IFA boundaries, however impacts to these tributaries and watercourses lying further downstream are reduced by the 100 m during the Construction phase through to the Closure and Decommissioning Phase.

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.

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 proposed Project. However, more specific management actions for the Construction Phase are listed below:

- Limit vegetation removal to the IFA 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;
- 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 project;
- All waste must be removed and transported to appropriate waste facilities; and
- High rainfall periods (usually November to March) should be avoided during construction to possibly avoid increased surface runoff in attempt to limit erosion and the entering of external material (i.e. contaminants and/or dissolved solids) into associated aquatic systems.

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 proposed Project. It must be noted that the ratings have been determined based on the observations during the survey.

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 in proximity to the watercourses.			
Prior to Mitigation/Management			
Duration	Project life (5)	Once vegetation is cleared for infrastructure, no revegetation will occur until project closure.	Minor (negative) – 60

Dimension	Rating	Motivation	Significance
Extent	Local (3)	Based on the proximity of the proposed IFA to the Vaalwaterspruit tributaries and nonperennial nature of the tributaries, the extent of runoff is expected to be localised to within the tributaries and only reaching the Vaalwaterspruit during the high-flow seasons.	
Intensity x type of impact	Moderately High - Negative (-5)	Effects to biological or physical resources expected to occur within close proximity and potentially impact on downstream reaches.	
Probability	Likely (5)	Due to the nonperennial nature of the tributaries, the impact is likely to be significant during high-flow season only. However, direct modifications to the watercourses during the dry periods will have a negative impact	
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) – 18
Extent	Limited (2)	Following mitigation actions and if high rainfall periods are avoided for construction, impacts will be limited to immediate surroundings.	
Intensity x type of impact	Minor - Negative (-2)	If mitigation measures are all incorporated for the Construction Phase, the intensity of the impact should be low.	
Probability	Improbable (2)	The likelihood of the impact occurring at the surrounding watercourses is reduced by the mitigation actions and should only result in extreme cases or unexpected rainfall events.	
Nature	Negative		

7.3 Operational Phase

A major foreseeable impact associated with the Operational Phase of the Project is seepage and leaks stemming from the Pollution Control Dam (PCD) and discard dump potentially contaminating the nearby watercourses as well as subsidence due to collapse and failure of underground mining excavations.

7.3.1 Impact Description: Water Quality and Habitat Deterioration Associated with Runoff, Seepage and Leaks from the Operational Areas of the Project

Like the impacts described for the Construction Phase uncontrolled runoff of stormwater and water used on site (e.g. dirty water treatment and process water) 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. Subsidence depressions have the potential to disrupt and divert the flow of surface water altering the geomorphology of the watercourses.

7.3.1.1 Management Objectives

Water should not be allowed to flow freely from the operational areas. As proposed, dirty water or water runoff from mine related infrastructure should be stored in PCD's and utilised as storage facilities.

Additionally, the proposed plan is to use mine-affected water for dust suppression on dirt roads.

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 nearby watercourses, unless DWS discharge authorisation and compliance with relevant discharge standards are adhered to;
- If discharge of water occurs, 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;
- The Dynamic Subsidence Reclamation or DSR techniques, similar to concurrent mining and reclamation concepts used in surface mining should be applied (reader is referred to Hu et al. (2016)); and

- Monitoring of the associated water courses should be done by an aquatic specialist 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, seepage and leaks from the proposed infrastructure.

Table 7-3: Impact Assessment Ratings for the Operational Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Uncontrolled runoff of stormwater or process water from or through the surface infrastructure			
Impact Description: Water quality 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) – 70
Extent	Local (3)	Based on the proximity of the proposed infrastructure to watercourses, and largely disconnected nature of the watercourses, the extent of runoff is expected to be localised to within the respective catchment.	
Intensity x type of impact	Very High - Negative (-6)	Runoff, seepage and/or leakage into watercourses is expected to impact functioning the aquatic ecosystems.	
Probability	Likely (5)	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
Extent	Very limited (1)	Runoff will most likely be largely restricted and captured within the efficiently-lined PCD.	

Dimension	Rating	Motivation	Significance
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 Post Closure 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: Decommissioning, Closure, and Post-closure water quality deterioration as a result of decant resulting in Acid Mine Drainage

The demolition and removal of infrastructure is expected to impact on the aquatic ecosystems due to the close proximity between the watercourses and the proposed IFA. Contamination of aquatic ecosystems through decant resulting in Acid Mine Drainage (AMD) is expected from the underground mining areas. This will consequently affect the aquatic ecology and aquatic biota.

7.4.1.1 *Management Objectives*

The main objective during the Decommissioning and Post Closure Phase should be focused on preventing contaminated water from entering the associated aquatic environment.

7.4.1.2 *Management Actions*

The goal of mitigation should be to prevent and or limit the decant of contaminated water into associated aquatic ecosystems. The following measures may be utilised in attempt to reduce the Decommissioning and Post Closure impacts:

- The demolition of infrastructure should occur during the dry season to avoid increase runoff of contaminated water into associated watercourses;

- Best practise rehabilitation should be utilised to trap and contain the deep sediments that contain the acid forming rock responsible for acid water formation;
- Subsidence and decant should be monitored to prevent changes to the geomorphology of the water courses and potential contamination with AMD; and
- If decant occurs post-closure, passive treatment with lime or other alkaline compounds can be applied to neutralise AMD at the decant points.

Aquatic biomonitoring is also recommended to monitor any changes in the aquatic ecosystems and to provide solutions for identified, additional/unforeseen impacts for at least three years after rehabilitation.

7.4.1.3 Impact Ratings

The impact ratings associated with the Post Closure Phase on associated aquatic ecosystems are predicted in Table 7-4 below.

Table 7-4: Impact assessment ratings for the Post Closure Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Decant and runoff of contaminated water entering aquatic ecosystems			
Impact Description: Water quality deterioration of watercourses in contact with contaminated water resulting in AMD			
Prior to Mitigation/Management			
Duration	Permanent (7)	AMD will continue to contaminate the associated watercourses beyond the life of Project.	Moderate (negative) – 108
Extent	Local (3)	Based on the proximity of the proposed IFA to the Vaalwaterspruit tributaries and nonperennial nature of the tributaries, the extent of contamination is expected to be localised to within the tributaries and only reaching the Vaalwaterspruit during the high-flow seasons.	
Intensity x type of impact	Very High – Negative (-6)	High significant impact on the environment. With potential loss of aquatic biota.	
Probability	Highly probable (6)	AMD is a common problem related to coal mining.	
Nature	Negative		
Post-Mitigation			

Dimension	Rating	Motivation	Significance
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 incorporated, impacts will be limited.	
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

Presently, the main cumulative impact identified for the aquatic ecosystems within the Project Area appears to be the influence of agricultural fields and mining operations (including Eskom's Hendrina and Arnot power stations, the Mbuyelo Coal Mavungwani Colliery and other mines in the area).

Agricultural fields and game farms are known to abstract water for animal consumption and for irrigation (Ginster *et al.*, 2010), and mines use significant amounts of water for mineral processing, dust suppression, slurry transport and domestic uses. The establishment of the proposed mine might result in synergistic effects which will potentially impact on the biotic and abiotic environment.

7.6 Unplanned and Low Risk Events

There is a risk that watercourses associated with the proposed Project and 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, as well as 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 the proposed Project, 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); • Conduct routine inspections for potential leaks and spills • 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 Environmental Management Plan (EMP).

Table 8-1: Environmental Management Plan

Activity/ies	Potential Impacts	Aspects Affected	Phase	Mitigation Measure	Mitigation Type	Time period for implementation
Site clearing and infrastructure construction.	• 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 access roads	• Water quality impairment	Aquatic Biodiversity	Construction	• Spillage management kits or controls should be taken seriously and put in place in order 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 Project	• 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 PCD); • The aquatic biomonitoring 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 associated watercourses.	Aquatic Biodiversity	Decommissioning	• Restore the topography to pre-mining conditions as much as is practically possible; • 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; • Ensure that the infrastructure (pipelines, fuel storage areas, pumps) are first emptied of all residual material before decommissioning; and • Capping, reprofiling and revegetation of TSF post-closure to limit the potential for future oxidation of stored tailings, and enable clean runoff to be discharged to the surrounding environment.	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 proposed 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 aquatic biota in the associated riverine systems.

Table 9-1 outlines the aquatic monitoring methods undertaken at the monitoring points set out above (see section 4.2) on an biannual basis by a suitably-qualified, SASS-accredited aquatic ecologist. The annual programme comprises of a single survey during the autumn season (or low flow season) for the Study Area and a single survey during the spring season (or high flow). 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. The following stressor, habitat and response indicators should be evaluated:

- **Stressor indicators**
  - *In situ* water quality
- **Habitat indicator:**
  - Instream and riparian habitat conditions (IHI, version 2)
  - Aquatic macroinvertebrate biotope evaluation (IHAS, Version 2.2).
- **Response indicators:**
  - Aquatic macroinvertebrate assessment (SASS5 and MIRAI)
  - Ichthyological assessment (FRAI)
  - Determination of the integrated EcoStatus (EcoStatus 4, Version 1.02).

Table 9-1: Biomonitoring Programme

Monitoring Element	Comment	Frequency	Responsibility
Water Quality: *In situ* water testing focusing on temperature, pH, conductivity and oxygen content.	No noticeable change from determined baseline water quality for each respective season. Salt Concentrations must be maintained at levels where they do not render the ecosystem unsustainable.	Water quality should be tested on a biannual basis at each monitoring site to determine the extent of change from baseline results.	Aquatic Ecologist (SASS-accredited)
Habitat Quality: Instream and riparian habitat integrity; and Availability/suitability of macroinvertebrate	The application of the IHI should be done for the associated aquatic systems.	Habitat quality should be assessed on a biannual basis	

Monitoring Element	Comment	Frequency	Responsibility
habitat at each monitoring site.	The IHAS must be applied at each monitoring site prior to sampling. The Ecological Category determined for each assessed site must be in a largely modified or better conditions to support the ecosystem.		
Aquatic Macroinvertebrates: Aquatic Macroinvertebrate assemblages must be assessed biannually.	This must be done through the application of the latest SASS, incorporated with the application of the MIRAI as outlined in this Aquatic Study. Baseline Ecological Categories should not be allowed to drop in category for each assessed site.	The latest version of the SASS should be conducted on a biannual basis.	
Fish: Fish assemblages must be assessed biannually	Sampling of fish must be undertaken by utilising various methods such as cast nets in addition to the standard electro-narcosis technique to compensate for its ineffectiveness in elevated conductivity waters. Baseline Ecological Categories should not be allowed to drop in category for each assessed site.	Sampling of fish communities should be undertaken on a biannual basis	
Integrated EcoStatus Determination	The Ecological Category for each assessed river reach should not deteriorate from the Resource Quality Objectives of the Olifants Catchment and the Inkomati Catchment.	The Integrated EcoStatus should be determined upon completion of the biannual aquatic surveys.	
***REC = Recommended Ecological Category**			

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

10 Recommendations

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

- The developed Aquatic Biomonitoring Programme must be adopted on a biannual basis, prior to the commencement of the Construction Phase of the proposed Project. This programme should continue for the life of the Project and for at least three years post the Decommissioning Phase;
- In light of the nonperennial nature of the watercourses associated with the proposed Project Area, diatom assessments should be conducted during the low-flow survey at atleast at a single site associated with each of the reaches assessed in the current study. Diatoms are highly representative of water quality and can be used to pinpoint specific changes related to water quality, such as organic pollution, eutrophication, acidification, metal pollution and changes in pH; and
- The proposed Project should adopt a water and habitat quality preservation mindset throughout the life of the Project. In other words, the proposed activities should not result in the deterioration/degradation of aquatic habitat (i.e. riparian and instream habitat) and water quality within the associated aquatic ecosystem. At least 100 m buffer zone of regulation must be implemented as a no-go zone between the aquatic systems and mining activities.

11 Reasoned Opinion Whether Project Should Proceed

In light of the nonperennial nature of the associated watercourses in the Project Area, it is the opinion of the ecologist that the proposed Project's footprint will result in minor impacts to the watercourses despite the close proximity between the proposed IFA and the nonperennial tributaries of the Vaalwaterspruit – provided all mitigation measures are implemented sufficiently.

With regards to the activities associated with the proposed Infrastructure Footprint Area, no fatal flaws were identified during the current study. However, with regards to the proposed underground mining activities, the risk of land subsidence poses a fatal flaw for the watercourses underlain by the underground mine as the inhabiting aquatic biota will be impacted. Therefore, 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.

12 Conclusions

Based on the data collected from the current Aquatic Biodiversity Impact Assessment, the following key findings should be noted:

- ***In situ* water quality:**
  - Temperature levels were recorded within the normal range for water bodies in South Africa and within the typical summer season temperatures;
  - pH values largely exhibited close to neutral to slightly alkaline conditions;
  - Conductivity values were generally high at most assessed sites; and
  - Dissolved oxygen levels were moderate.

The overall *in situ* water quality was interpreted as mildly modified with potential impacts associated with the surrounding farming and mining activities, such as nutrient enrichment and potential eutrophication.

- **Aquatic and Riparian Habitat:**
  - The habitat integrity for the assessed reaches were determined to be *Moderately Modified* for the instream components and *Largely Natural* for the riparian components; and
  - Generally, major impacts of the habitat integrity were water quality deterioration, flow modification, inundation and exotic vegetation.
- **Aquatic Macroinvertebrate Assessment**
  - The macroinvertebrate habitat availability at the assessed watercourses was observed to range from shallow to deep and still to moderately-flowing water; marginal and aquatic vegetation; and the SASS5 biotopes GSM and stones;
  - All assessed sites of the Klien-Olifants and Rietkuilspruit systems however exhibited *Poor* aquatic macroinvertebrate habitat availability, whilst the Vaalwaterspruit systems exhibited macroinvertebrate habitat availability ranging from *Poor* to *Good*;
  - Throughout the sampled river systems, the aquatic macroinvertebrate assemblages were dominated by taxa that have a high tolerance to water quality modifications; and
  - The overall ecological condition of the aquatic macroinvertebrate assemblages were *Largely Modified* throughout the assessed river systems.
- **Fish communities:**
  - A total of 6 fish species were sampled throughout the assessed watercourses, one of which was an alien invasive *Micropterus salmoides*;
  - A single species was sampled at the Klein-Olifants systems, two species were sampled at the Rietkuilspruit systems and 5 species were sampled at the Vaalwaterspruit systems;
  - All 5 sampled indigenous fish species are known to be tolerant, to varying extends, to water quality and or flow modifications;

- The overall ecological condition of the fish communities were *Seriously Modified* for the Klein-Olifants and Rietkuilspruit systems and *Largely Modified* for the Vaalwaterspruit systems.

Following integration of the defined ecological conditions obtained for the instream biological integrity (i.e. 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 Klien-Olifants, Rietkuilspruit and Vaalwaterspruit systems represented an integrated EcoStatus of *Moderately Modified* (Ecological Category C).

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Appendix A: Methodology

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 (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 13-1).

As per the original IHI approach (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 13-1: 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 13-2). 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.

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.

Table 13-2: 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

Each of the allocated scores was then moderated by a weighting system (Table 13-3), 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 13-3: 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 12-4).

Table 13-4: 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 13-5.

Table 13-5: 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

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 13-5. Consequently, the assessment index describes the quantity, quality and diversity of available macroinvertebrate habitat relative to an "ideal" diversity of available habitat.

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 sampled macroinvertebrate assemblages (Dallas & Day, 2004).

SASS5 is essentially a biological assessment index which determines the health of a river based on the aquatic macroinvertebrates sampled on-site, whereby each taxon is allocated a score based on its perceived sensitivity/tolerance to environmental perturbations (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 sampled, 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; Dallas, 1997).

Macroinvertebrate Response Assessment Index (MIRAI)

In order to determine the Present Ecological State (PES; or Ecological Category) of the aquatic macroinvertebrates sampled/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 sampled 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) 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 13-6).

Table 13-6: 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 sampled 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 sampled 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 (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 (Kleynhans, 2008).

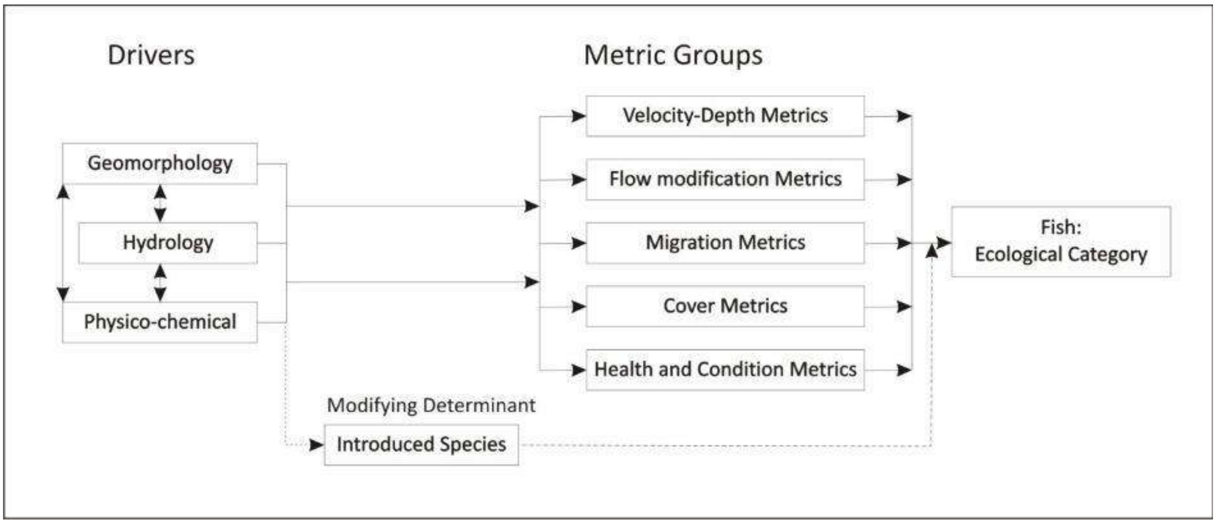

Figure 13-1: Relationship between drivers and fish metric groups

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 13-1. Table 13-7 provides the steps and procedures required for the calculation of the FRAI.

Table 13-7: 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 (Kleynhans, 1999). Each category describes the generally expected conditions for a specific range of FRAI scores (Table 13-8).

Table 13-8: 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 13-11. 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 13-10, which is extracted from Table 13-9. The description of the significance ratings is discussed in Table 13-11.

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 13-9: 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	Great improvement to the overall conditions of	National	Beyond project life: The impact will remain for some time after the life of the	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)**			
	moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	a large percentage of the baseline.	Will affect the entire country.	project and is potentially irreversible even with management.	

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.	<u>Province/ Region</u> 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.	<u>Municipal Area</u> 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.	<u>Local</u> 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.	<u>Limited</u> 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.

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Table 13-10: Probability/Consequence Matrix

	Significance																																					
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
Probability 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 13-11: 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 B: Site Photographs

Klein-Olifants Systems

KO1

KO2

KO3

Rietkuilspruit System

RK1

RK2

RK3

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Vaalwaterspruit Systems

VW1

VW2

VW3

VW4

VW5