Aquatic Baseline & Risk Assessment for the proposed Tetra4 Cluster 2 Project

Virginia, Free State Province

April 2022

CLIENT

Prepared by:

The Biodiversity Company

Cell: +27 81 319 1225

Fax: +27 86 527 1965

info@thebiodiversitycompany.com

www.thebiodiversitycompany.com

Report Name	Aquatic Baseline & Risk Assessment for the proposed Tetra4 Cluster 2 Project
Submitted to	EIMS ENVIRONMENTAL IMPACT MANAGEMENT SERVICES
Report / Fieldwork and Writer	**Christian Fry**
	Christian Fry has obtained an MSc in Aquatic Health from the University of Johannesburg and is a registered Professional Scientist (Pr. Sci. Nat: 119082). Christian has 9 years of experience conducting basic assessments, biomonitoring and EIAs for various sectors.
Reviewer	**Andrew Husted**
	Andrew Husted is Pr Sci Nat registered (400213/11) in the following fields of practice: Ecological Science, Environmental Science and Aquatic Science. Andrew is an Aquatic, Wetland and Biodiversity Specialist with more than 12 years' experience in the environmental consulting field. Andrew has completed numerous wetland training courses, and is an accredited wetland practitioner, recognised by the DWS, and also the Mondi Wetlands programme as a competent wetland consultant.
Declaration	The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the Environmental Impact Assessment Regulations, 2014 (as amended). We have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. We have no vested interest in the project, other than to provide a professional service within the constraints of the project (timing, time and budget) based on the principles of science.

Declaration

I, Christian Fry 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 71 and is punishable in terms of Section 24F of the Act.

Christian Fry

Freshwater Ecologist

The Biodiversity Company

April 2022

Table of Contents

Tables

Figures

1 Introduction

The modification of land use within a river catchment has the potential to degrade local water resources (Wepener *et al*., 2005). Primary activities such as mining thus have the potential to negatively impact on local water resources and ecosystem services. In order to effectively manage the potential impacts to watercourses, the establishment of the baseline condition of a watercourse is required.

The Biodiversity Company was appointed by Environmental Impact Management Services (EIMS) to conduct an aquatic baseline and impact (risk) assessment for the proposed Tetra4 Cluster 2 gas exploration project in Virginia, Free State Province. A single wet season survey was conducted from the 14th of March 2022 to 18th of March 2022 by a freshwater ecologist.

1.1 Background

The following information was provided by EIMS:

In 2012, a Production Right (Ref: 12/4/1/07/2/2) was granted which spans approximately 187 000 hectares for the development of natural gas (Helium and Methane) production operations around the town of Virginia in the Free State Province. Within the approval of the Production Right, the 2010 Environmental Management Programme (EMPr) was approved which is applicable to a large portion of the Production Right area (Figure 1-1).

The activities in the Production Right include:

- Continued exploration activities;
- Drilling and establishment of further production wells throughout the entire production area (260 production wells);
- Installation of intra-field pipelines throughout the entire production area (~500km);
- Installation of boosters and main compressors; and
- Central gas processing plant (not approved in the original EIA and approved EMPr).

On 21 September 2017, the Department of Mineral Resources and Energy (DMRE) issued an integrated environmental authorisation (“Cluster 1 EA”) (reference: 12/04/07) to Tetra4 in terms of the NEMA. The Cluster 1 EA (as amended by Cluster 1 EA amendments dated 26 August 2019 and 1 September 2020) authorises the development of “Cluster 1” of the Project. In this EA approval, various new wells and pipelines, booster and compressor stations, a Helium and LNG Facility and associated infrastructure was approved which comprises the first gas field for development within the approved Production Right area. The Cluster 1 EA also authorises certain waste management activities as per the List of Waste Management Activities (Government Notice 921, as amended) published under the National Environmental Management: Waste Act 59 of 2008 (NEMWA).

Furthermore, the following licences have been issued to Tetra4 in respect of Cluster 1 of the Project:

- Provisional Atmospheric Emission Licence (PAEL) dated 4 August 2017 (reference: LDM/AEL/YMK/014) for the Storage and Handling of Petroleum Products [Category 2: Subcategory 2.4 of the Listed Activities (Government Notice 893, as amended) published under the National Environmental Management: Air Quality Act 39 of 2004 (NEMAQA)] by the Lejweleputswa District Municipality. A final atmospheric emission licence will be issued after operation of the plant which is currently under construction; and
- Water Use Licence (WUL) dated 22 January 2019 (reference: 08/C42K/CI/8861) for the construction of pipelines for the Project in terms of section 21(c&i) water uses of the National Water Act 36 of 1998 (NWA) by the Department of Water and Sanitation (DWS).

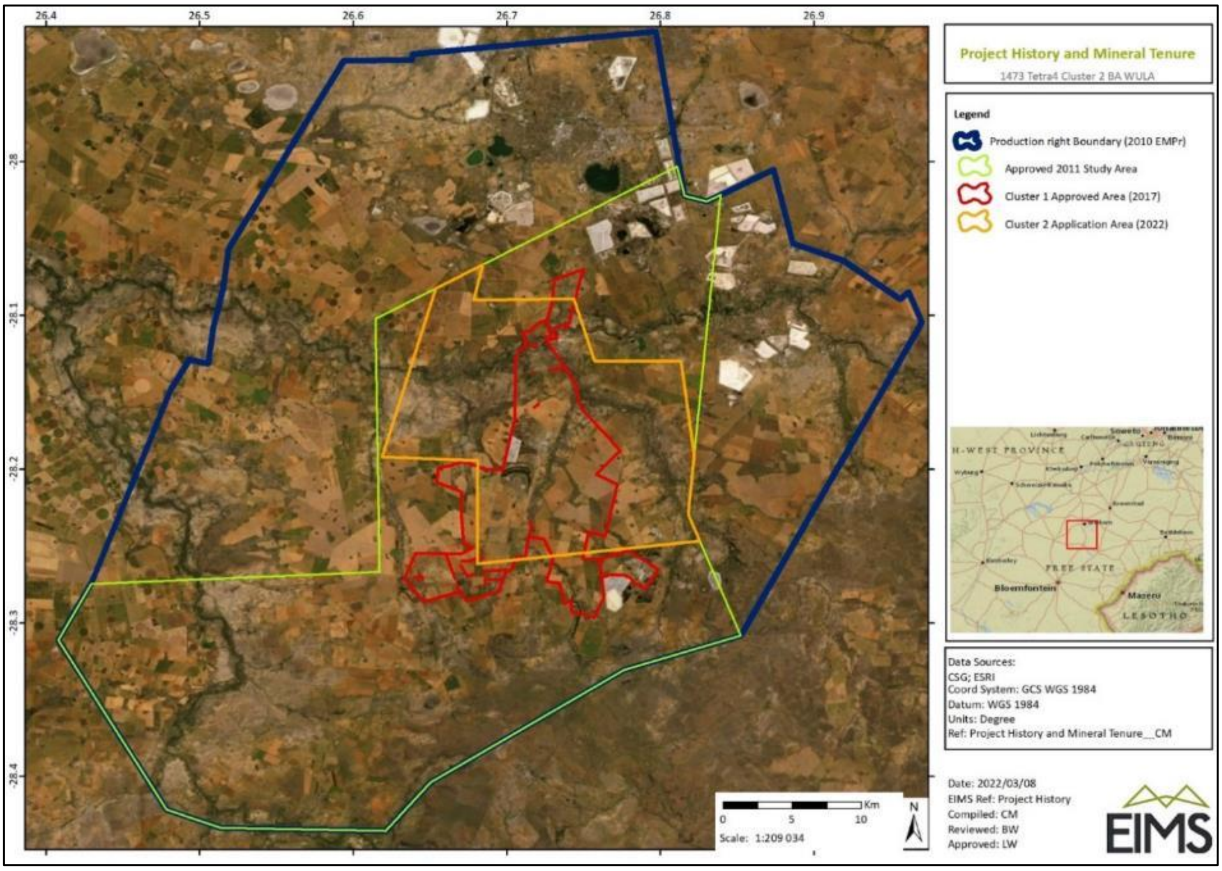

Figure 1-1 Project history and mineral tenure.

The following information is as provided by EIMS:

“Tetra 4 has a natural gas production right over a very large area in the Free State Province, near Virginia. They also have an existing environmental authorisation and associated water use licence for their current production activities (referred to as Cluster 1 above). Tetra 4 wishes to expand their current production operations onto other areas which still fall within the approved Production Right, but outside of the areas approved in the EA and WUL. The planned expansions will include the following (Figure 1-2):

- Expansions to the current LNG and Helium production plant located on the Farm Mond van Doorn Rivier. The planned expansions will be to increase the helium and LNG production capacities significantly (~30 fold increase) and increase the footprint of the existing approved plant by approximately 10ha.
- The drilling of new gas wells ~300 wells spread over a total study area (Cluster 2) of approximately 27500ha.
- The installation of trenched pipelines connecting the wells to localised booster compressors and then to in-field compressor stations (~3 sites) and subsequently the compressor stations to the main plant area.
- There will be a requirement to have short powerline and water connections to the compressor sites.”

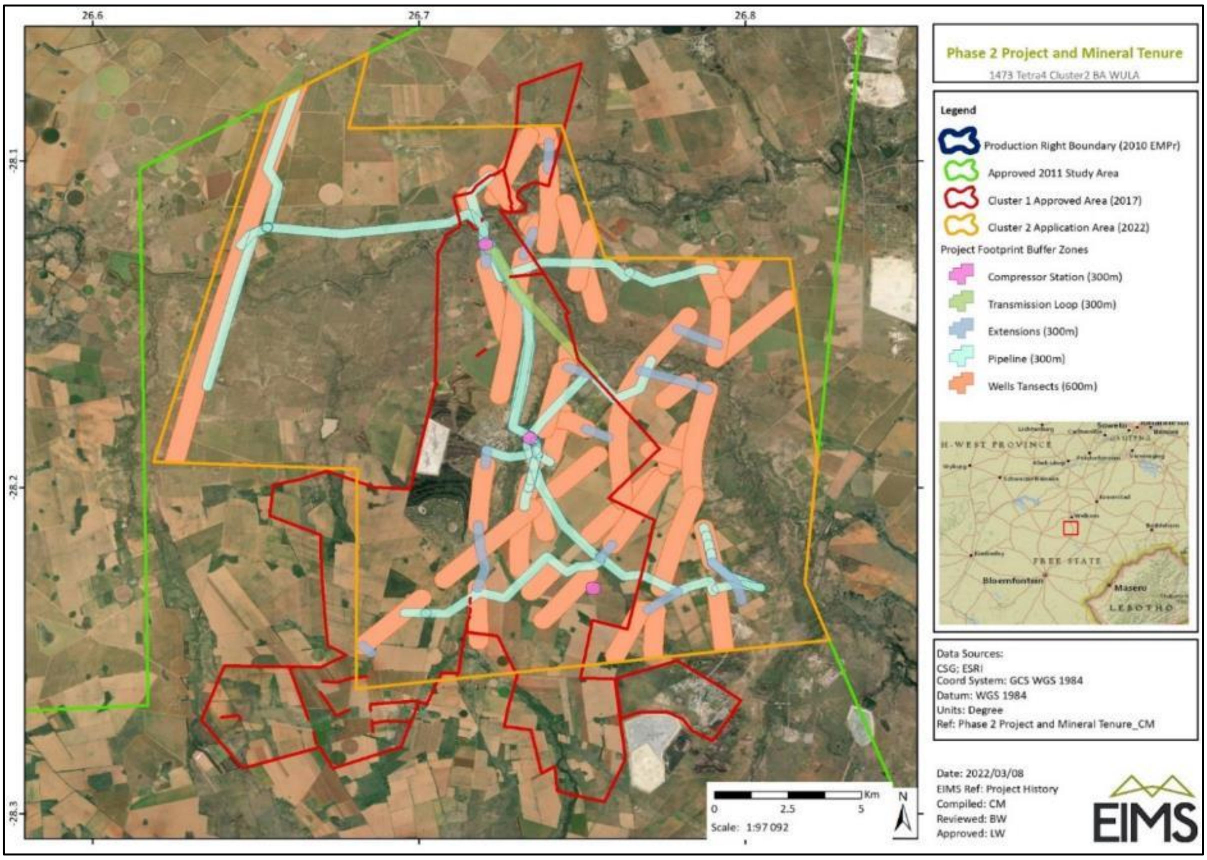

Figure 1-2 Cluster 2 study area and proposed infrastructure footprint buffer zones

This assessment was conducted in accordance with the amendments to the Environmental Impact Assessment Regulations. 2014 (GNR 326, 7 April 2017) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). The approach has taken cognisance of the recently published Government Notices (GN) 320 (20 March 2020): "Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation" (Reporting Criteria). The National Web based Environmental Screening Tool has characterised the aquatic sensitivity of the project area as "Very High" (Figure 1-3), and therefore an aquatic biodiversity specialist assessment was completed for the proposed project.

The purpose of the specialist study is to provide relevant input into the basic assessment process and provide a report for the proposed activities associated with the project. This report, after taking into consideration the findings and recommendations provided by the specialist herein, should inform and guide the Environmental Assessment Practitioner (EAP) and regulatory authorities, enabling informed decision making, as to the ecological viability of the proposed project.

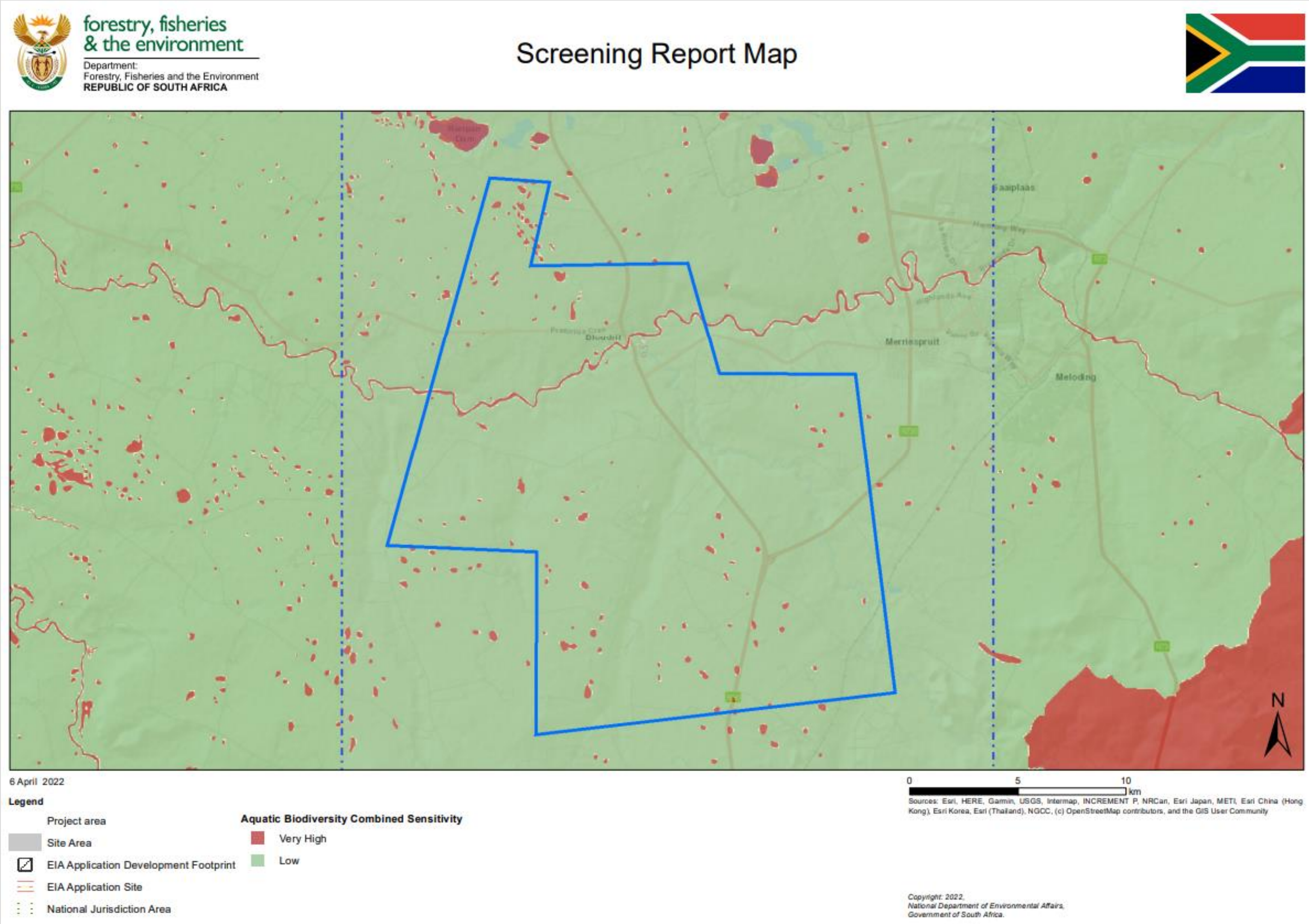

Figure 1-3 Sensitivity of aquatic biodiversity features for the project area

1.2 Terms of Reference

The following tasks were completed in fulfilment of the terms of reference for this assessment:

- Review of existing desktop information;
- The determination of the baseline Present Ecological Status (PES) of the associated watercourses, their instream and riparian condition – using appropriate survey methods;
- The delineation and identification of sensitive riverine areas;
- Conduct risk assessments relevant to the proposed activity;
- Recommendations relevant to associated impacts; and
- Report compilation detailing the baseline findings.

2 Project Area

Tetra4 Cluster 2 is located approximately 17 km south of Welkom and 11 km west of Virginia in the Free State Province (Figure 2-1). The project area is approximately 28,000 ha and falls within the Matjhabeng Local Municipality. The project area is drained by several ephemeral and perennial watercourses, which fall within the C42J, C42L and C42K quaternary catchments, and Vaal Water Management Area (WMA5). The easter portion of the project area falls within the C42K quaternary catchment and ephemeral systems drain into the Boschluisspruit and Doring Rivers which eventuate into the Sand River at the catchment boundary. The eastern portion of the project area falls within the C42L quaternary catchment and consists of several small ephemeral systems which drain into the Sand River. The Sand River flows west into the Vet River, which has its confluence with the Vaal River 87 km west within the Bloemhof Dam. The elevation ranges between 1338 meters above sea level (masl) in the upper reaches of the Doring River to 1282 masl on the Sand River at the outlet of the project area. The spatial framework for the PES assessment of the watercourses falls within the Vaal WMA and includes the Boschluispruit, Doring River and Sand River, as well as several unnamed tributaries.

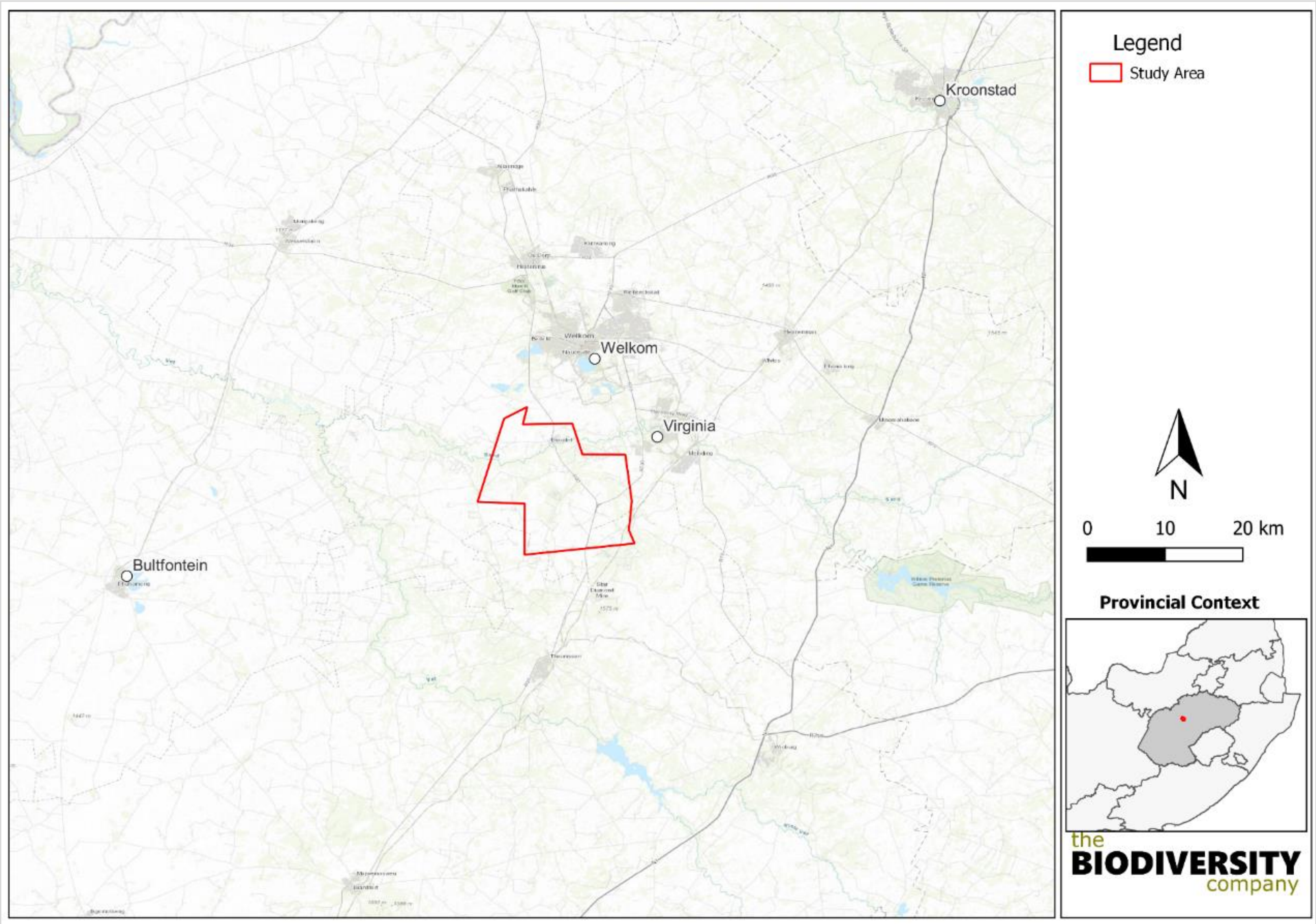

Figure 2-1 Locality of the project area

3 Key Legislative Requirements

3.1 National Water Act (NWA, 1998)

The Department Water and Sanitation (DWS) is the custodian of South Africa's water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers. The National Water Act (Act No. 36 of 1998) (NWA) allows for the protection of water resources, which includes:

- The maintenance of the quality of the water resource to the extent that the water resources may be used in an ecologically sustainable way;
- The prevention of the degradation of the water resource; and
- The rehabilitation of the water resource.

A watercourse is defined in the NWA as:

- A river or spring;
- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows; and
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

The NWA recognises that the entire ecosystem and not just the water in isolation, and any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the DWS. Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from the DWS in terms of Section 21 (c) and (i).

3.1.1 National Water Act, 1998 – General Notice 704 (1999)

Restrictions on locality; no person in control of a mine or activity may – except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 m from any watercourse or estuary, whichever is greatest.

3.1.2 National Water Act, 1998 – Section 21: (c) and (i) water uses for General Authorisation – GN 509 of 26 August 2016

The DWS, is of the view that any activity within the 500 m Regulated Area or radius from the boundary (temporary zone) of any wetland or pan, or within the outer edge of the 1 in 100 year flood line or riparian habitat measured from the middle of the watercourse from both banks, requires a risk assessment to determine whether a Water Use Licence (WUL) or General Authorisation (GA) for a section 21(c) and (i) water use is required (DWS, 2016a).

3.2 National Environmental Management Act (NEMA, 1998)

The National Environmental Management Act (NEMA) (Act 107 of 1998) and the associated EIA Regulations as amended in November 2017, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment Report (BAR) process or the Scoping and Environmental Impact Reporting (S&EIR) process depending on the scale of the impact.

4 Methodology

4.1 Approach and Methodology

A single aquatic sampling survey was conducted on the 14th of March 2022 to 18th of March 2022. The survey constituted a wet season/ high flow/ summer assessment. Standard methods were implemented to establish the baseline conditions of the considered river reaches. Details pertaining to the specific methodologies applied are provided in the relevant sections below.

A total of 11 sites were assessed during the study, with emphasis placed on the systems within the project area and a downstream receiving environment on the Sand River. Figure 4-1 illustrates the sampling points for the study, and Table 4-1 presents site photographs, Global Positioning System (GPS) coordinates. It should be noted that several sites were dry and access to two sites was limited.

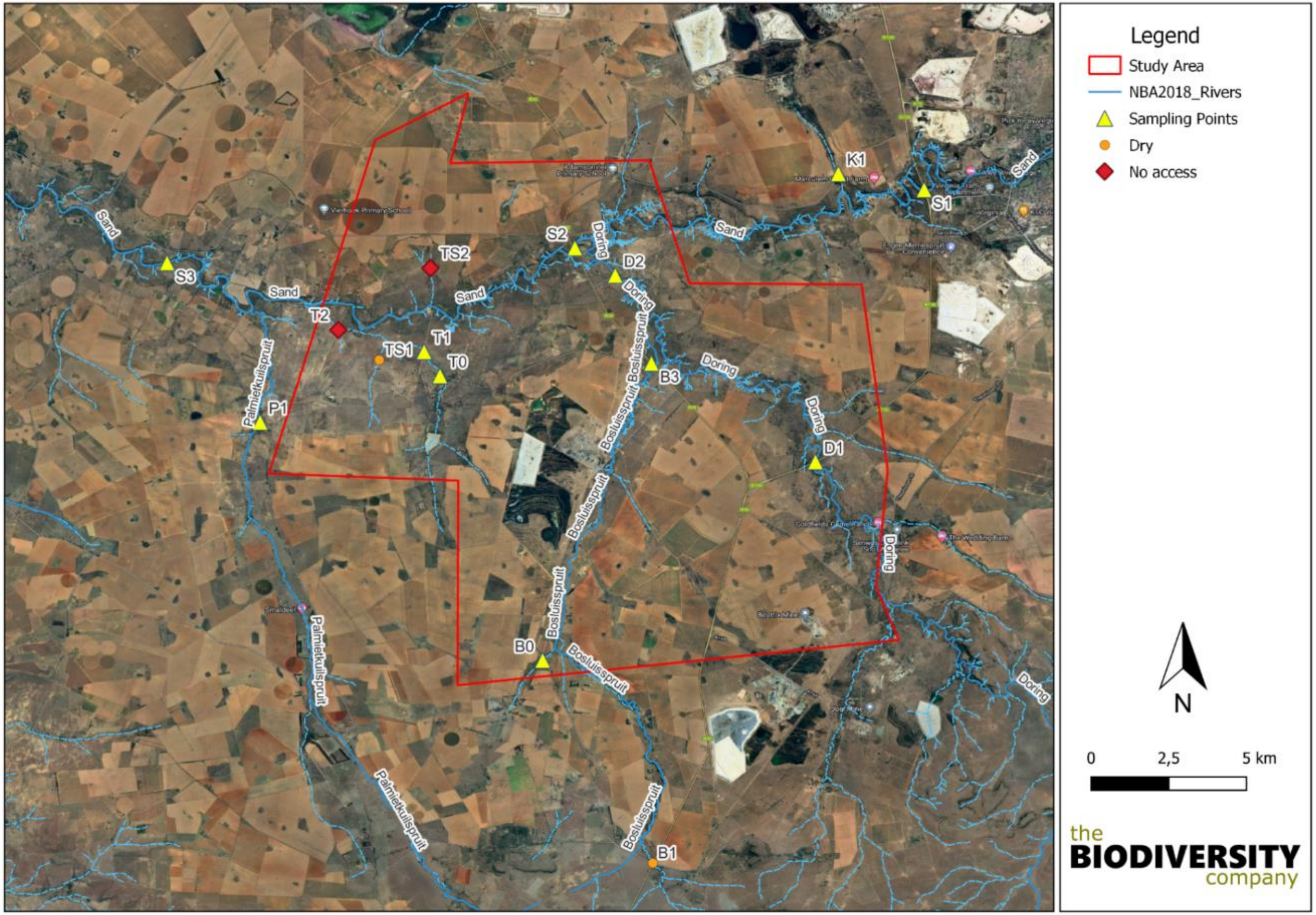

Figure 4-1 Study sampling points

Table 4-1 Investigation site photographs and coordinates (March 2022)

Site	Upstream	Downstream
Sand River		
S1		
Comments	Upstream Sand River site. Substrate dominated by sand and scattered stones of current. Debris within the channel provides cover features for aquatic biota. Flooding conditions during sampling.	
GPS-coordinates	28° 5'55.27"S 26°50'2.40"E	
S2		
Comments	Midstream Sand River site. Flooding conditions during sampling. Substrate dominated by sand and portions of bedrock.	
GPS-coordinates	28° 7'4.26"S 26°43'9.48"E	
S3		
Comments	Downstream Sand River site. Flooding conditions during sampling. Instream habitat limited, predominantly sand substrate.	
GPS-coordinates	28° 7'21.92"S 26°35'7.29"E	

Site	Upstream	Downstream
Doring River		
D1		
Comments	Upstream Doring River site. Limited instream habitat diversity and hydraulic biotopes.	
GPS-coordinates	28°11'17.45"S 26°47'53.81"E	
D2		
Comments	Downstream Doring River site. Limited instream habitat diversity and hydraulic biotopes.	
GPS-coordinates	28° 7'36.76"S 26°43'57.13"E	
Palmietkuilspruit		
P1		
Comments	Reference site on the Palmietkuilspruit. Diverse habitat including stones and marginal vegetation.	
GPS-coordinates	28°10'30.53"S 26°36'57.33"E	

Site	Upstream	Downstream
Boschluispruit		
B0		
Comments	Upstream site on Boschluispruit, characteristic of wetland system.	
GPS-coordinates	28°15'12.51"S 26°42'31.37"E	
B3		
Comments	Wetland system in downstream reaches of Boschluispruit	
GPS-coordinates	28° 9'20.92"S 26°44'39.94"E	
Ephemeral Tributaries		
K1		
Comments	Site downstream of mining activities, outside of project area. Flows into the Sand River upstream of project area.	
GPS-coordinates	28° 5'36.28"S 26°48'20.94"E	

Site	Upstream	Downstream
T0		
Comments	Ephemeral tributary. Site limited to a standing pool.	
GPS-coordinates	28° 9'35.66"S 26°40'29.93"E	
T1		
Comments	Ephemeral tributary with limited surface water	
GPS-coordinates	28° 9'6.98"S 26°40'11.16"E	

4.1.1 Water Quality

Water quality was measured in situ using a handheld calibrated Extech® DO700 multi-meter. The constituents considered that were measured included: pH, electrical conductivity (µS/cm), temperature (°C) and Dissolved Oxygen (DO) in mg/l.

4.1.2 Aquatic Habitat Integrity

The Intermediate Habitat Integrity Assessment (IHIA) as described in the Procedure for Rapid Determination of Resource Directed Measures for River Ecosystems (Section D), 1999 was used to define the ecological status of the considered river reaches. The method is based on Kleynhans (1996).

The IHIA model will be used to assess the integrity of the habitats from a riparian and in-stream perspective. The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale which are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). This model compares current conditions with reference conditions that are expected to have been present. Specification of the reference condition follows an impact based approach where the intensity and extent of anthropogenic changes are used to interpret the impact on the habitat integrity of the system. To accomplish this, information on abiotic changes that can potentially influence river habitat integrity are obtained from surveys or available data sources. These changes are all related and interpreted in terms of modification of the drivers of the system, namely hydrology, geomorphology and physico-chemical conditions and how these changes would impact on the natural riverine habitats. The criteria and ratings utilised in the assessment of habitat integrity in the current study are presented in Table 4-2 and Table 4-3 respectively.

Table 4-2 Criteria used in the assessment of habitat integrity (Kleynhans, 1996)

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated 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 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 point sources. Measured directly or alternatively 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.
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
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.
Indigenous 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.

Table 4-3 Descriptions used for the ratings of the various habitat criteria

Impact Category	Description	Impact Score
None	No discernible impact or the modification 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 very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are 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

Impact Category	Description	Impact Score
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area 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 influenced detrimentally.	21-25

4.1.3 Aquatic Macroinvertebrate Assessment

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

4.1.3.1 Macroinvertebrate Habitat

The invertebrate habitat at the site was assessed using the South African Scoring System version 5 (SASS5) biotope rating assessment. A rating system of 0 to 5 was applied, 0 being not available or absent, while 5 was abundant and diverse. The weightings for lowland rivers (slope class F) were used to categorize biotope ratings (Rowntree *et al.,* 2000; Rowntree & Ziervogel, 1999).

4.1.3.2 South African Scoring System

The South African Scoring System version 5 (SASS5) is the current index being used to assess the status of riverine macroinvertebrates in South Africa. According to Dickens and Graham (2002), the index is based on the presence of aquatic invertebrate families and the perceived sensitivity to water quality changes of these families. Different families exhibit different sensitivities to pollution, these sensitivities range from highly tolerant families (e.g. Chironomidae) to highly sensitive families (e.g. Perlidae). SASS results are expressed both as an index score (SASS score) and the Average Score Per recorded Taxon (ASPT value).

Sampled invertebrates were identified using the “Aquatic Invertebrates of South African Rivers” Illustrations book, by Gerber and Gabriel (2002). Identification of organisms was made to family level (Fry, 2022; Thirion *et al.,* 1995; Dickens and Graham, 2002; Gerber and Gabriel, 2002).

All SASS5 and ASPT scores are compared with the SASS5 Data Interpretation Guidelines (Dallas, 2007) for the Highveld Lower - Ecoregion (Figure 4-2). This method seeks to develop biological bands depicting the various ecological states and is derived from data contained within the Rivers Database and supplemented with other data not yet in the database.

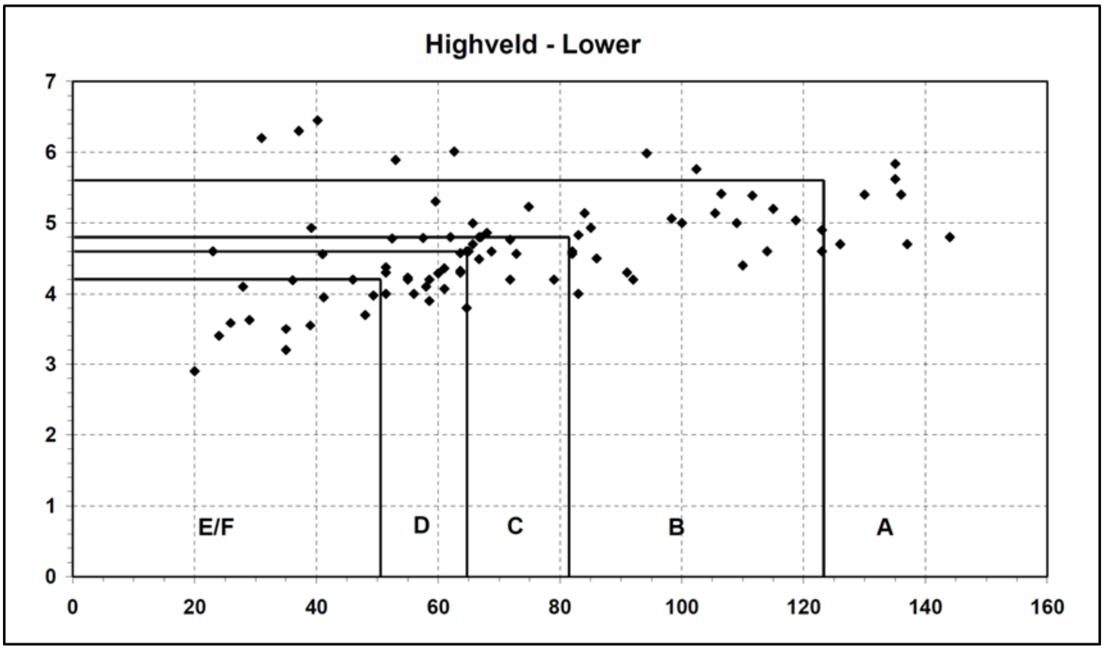

Figure 4-2 Biological Bands for the Highveld Lower - Ecoregion, calculated using percentiles

4.2 Macroinvertebrate Response Assessment Index

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

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

The results of the MIRAI will provide an indication of the current ecological category and therefore assist in the determination of the PES. This was conducted for the Doring, Boschluispruit and Sand River.

4.3 Fish Presence

Fish were sampled through electroshocking (Figure 4-3). All fish were identified in the field and released at the point of capture, in order not to cross fish populations. Fish species were identified using the guide Freshwater Fishes of Southern Africa (Skelton, 2001). The identified fish species were compared to those expected to be present for the quaternary catchment. The expected fish species list for the project area was developed from a literature survey to compare to the sampled species at site. Different fish species represent different sensitivities to water chemistry, habitat and flow which considered as part of the Fish Response Assessment Index (FRAI) (Kleynhans *et al*., 2007 and Skelton 2001).

Figure 4-3 Example of methodology used to catch fish species (KZN, 2019).

4.4 Present Ecology Status Classification

Ecological classification refers to the determination and categorisation of the integrity of the various selected biophysical attributes of ecosystems compared to the natural or close to natural reference conditions (Kleynhans and Louw, 2007). For the purpose of this study, ecological classifications have been determined for biophysical attributes for the associated watercourses. This was completed using the river ecoclassification manual by Kleynhans and Louw (2007). The areas considered in the PES assessment are outlined in the description of the project area section.

4.5 Determining Buffer Requirements

The "Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries" (Macfarlane *et al.*, 2014) was used to determine the appropriate buffer zone for the proposed activity.

4.6 Limitations

The following limitations are applicable:

- Results for the study are based on a single high flow survey and therefore no ecological trends are included in this report;
- Standard rapid assessment protocols were applied during the study, and therefore a low confidence is provided in the assessment of the biotic community and a snapshot of water quality conditions. As the survey protocols are rapid, it is likely that the biotic community is underestimated, and that additional studies would yield additional species. Despite the rapid nature of the survey, the results do provide informative data of the general biotic community;
- Flooding conditions within the Sand River reduced the efficacy of sampling instream habitat for aquatic biota. Additionally, water quality results do not reflect stable conditions within the region; and
- Access to several sites was limited during the survey, and therefore no sampling was conducted at sites T2, TS2, and limited access to S3. Additionally, several ephemeral systems were dry. These sites remain critical to ecosystem services and are regarded as highly sensitive.

5 Desktop Baseline Assessment

5.1 Hydrological Setting

The spatial framework for the PES assessment of the watercourses falls within the Vaal WMA and includes the perennial systems Boschluispruit, Doring River and Sand River, as well as several unnamed ephemeral tributaries. The Sand River is classified as a lowland river, with a low gradient alluvial fine bed and meandering channel. A distinctive macro-channel is visible with sand and silt deposits occurring throughout the reach. Riparia zone is well developed. The upper reaches of the Boschluispruit are characteristic of upper foothills geoclass, and develop into lower foothills. The riparian zone is poorly defined and wetland delineations provide a more robust delineation of the watercourse. The Doring River is classed as lower foothills, with incised channels, limiting the lateral movement of water.

The Sand River is represented by two Sub-Quaternary Reaches (SQRs), namely the C42J-2716 and C42L-2690. The Doring is represented by the C42K-2754 and C42K-2744 SQRs. The Boschluispruit is represented by a single SQR, C42K- 2764. The Present Ecological State (PES) of the rivers range from largely natural (class B) to moderately modified (class C) within the region. Impacts to the watercourses are attributed to runoff from mining, agricultural activities, urban areas (Virginia) and flow modifications. The activities have contributions to water quality perturbations and impacts to instream habitat, erosion of channel and banks, and proliferation of alien vegetation.

A summary of the PES, stream orders, and Ecological Importance (EI) and Ecological Sensitivity (ES) for the relevant SQRs are presented in Table 5-1 and the PES are illustrated in Figure 5-1. The freshwater features within the region are presented in Figure 5-2 and additional water source points are in Figure 5-3.

Table 5-1 Desktop Ecological summary for the relevant quaternary catchments

SQR	Stream order	Length (km)	PES (DWS, 2014)	ES	EI	Default Ecological Category
Sand River						
C42J-2578	3	27	E	High	Moderate	C
PES-EIS Justification		Large impacts to instream habitat and connectivity. Serious water quality perturbations and large flow modifications. Low to moderate instream and wetland integrity class. Moderate to high sensitivity of aquatic biota to changes in flow and physicochemical modifications. Impacts include urban runoff from Virginia, mining, roads and instream dams, Waste Water Treatment Works (WWTW), and slimes dams.				
C42L-2690	3	16	C	Moderate	High	B
PES-EIS Justification		Moderate to large impacts to instream habitat and connectivity. Serious water quality perturbations and moderate flow modifications. Moderate instream and wetland integrity class. High sensitivity of aquatic biota to changes in flow and physicochemical modifications. Impacts include urban runoff from agriculture, instream weirs and low water crossings.				
Doring River						
C42K-2754	2	32	B	Moderate	High	B
PES-EIS Justification		Minor impacts to instream habitat and connectivity, water quality and flow modifications are small. Very high instream and wetland integrity class and connectivity. Moderate to High sensitivity of aquatic biota to changes in flow and physicochemical modifications. Impacts within the reach are attributed to mining, slimes dams, agriculture, small dams, and roads.				
C42K-2744	2	6	C	Moderate	Moderate	C
PES-EIS Justification		Small to moderate impacts to the ecological state of the system, with moderate impacts to water quality and instream habitat. High instream migration link class, and very high instream habitat integrity. Moderate to high intolerance of aquatic biota to flow and water quality modifications. Roads and weirs contribute to modifications to ecological state.				
Boschluispruit						
C42K- 2764	1	28	C	Moderate	Moderate	C
PES-EIS Justification		.Small to moderate modifications to instream and riparian habitat and moderate impacts to water quality. Very high migration class, and high riparian habitat integrity class. Moderate to high sensitivity of aquatic biota to changes in flow and water quality. Impacts within the reach include mining, chicken farm, agriculture and roads.				

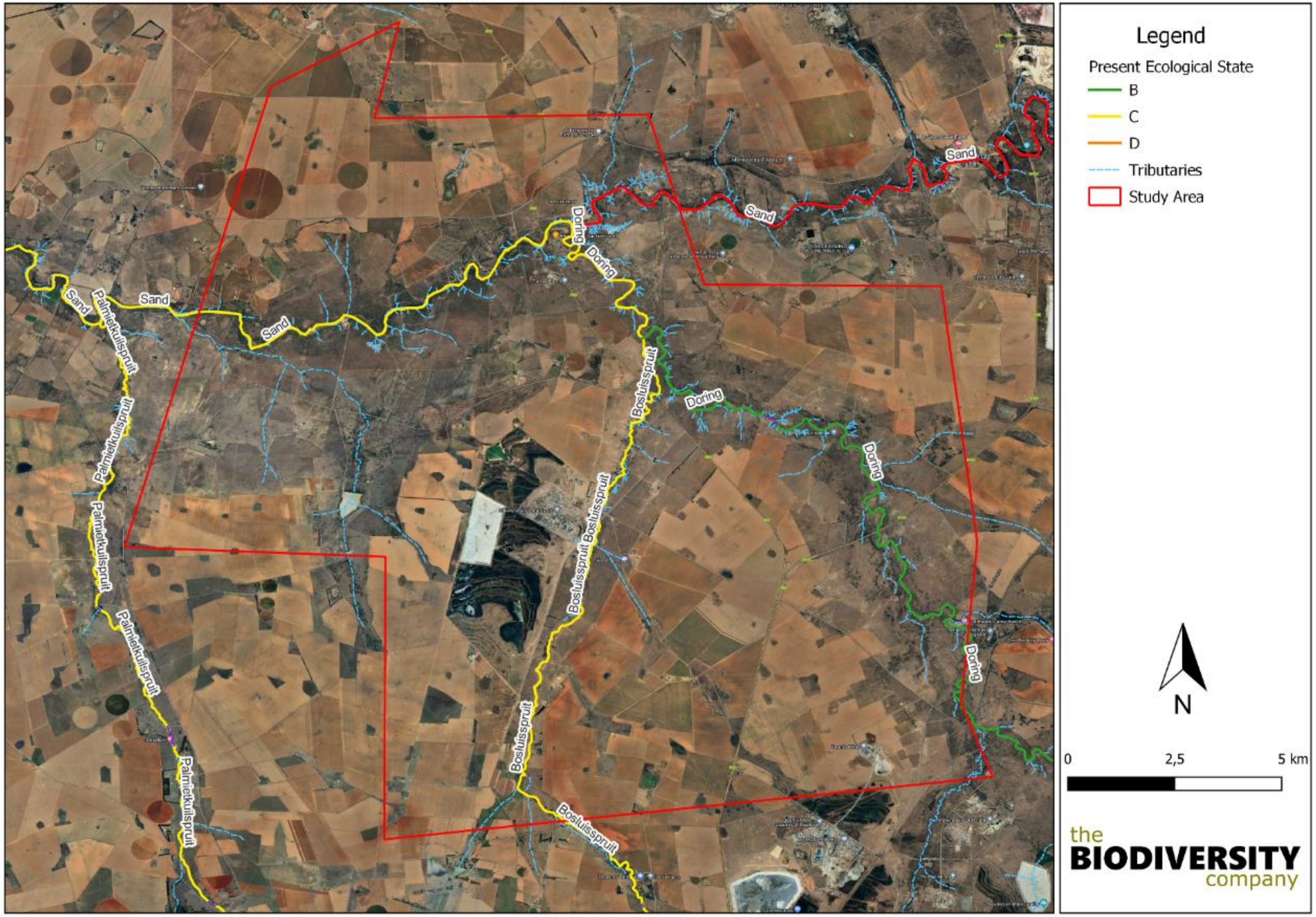

Figure 5-1 Illustration of the Present Ecological State within the relevant catchments (DWS, 2014)

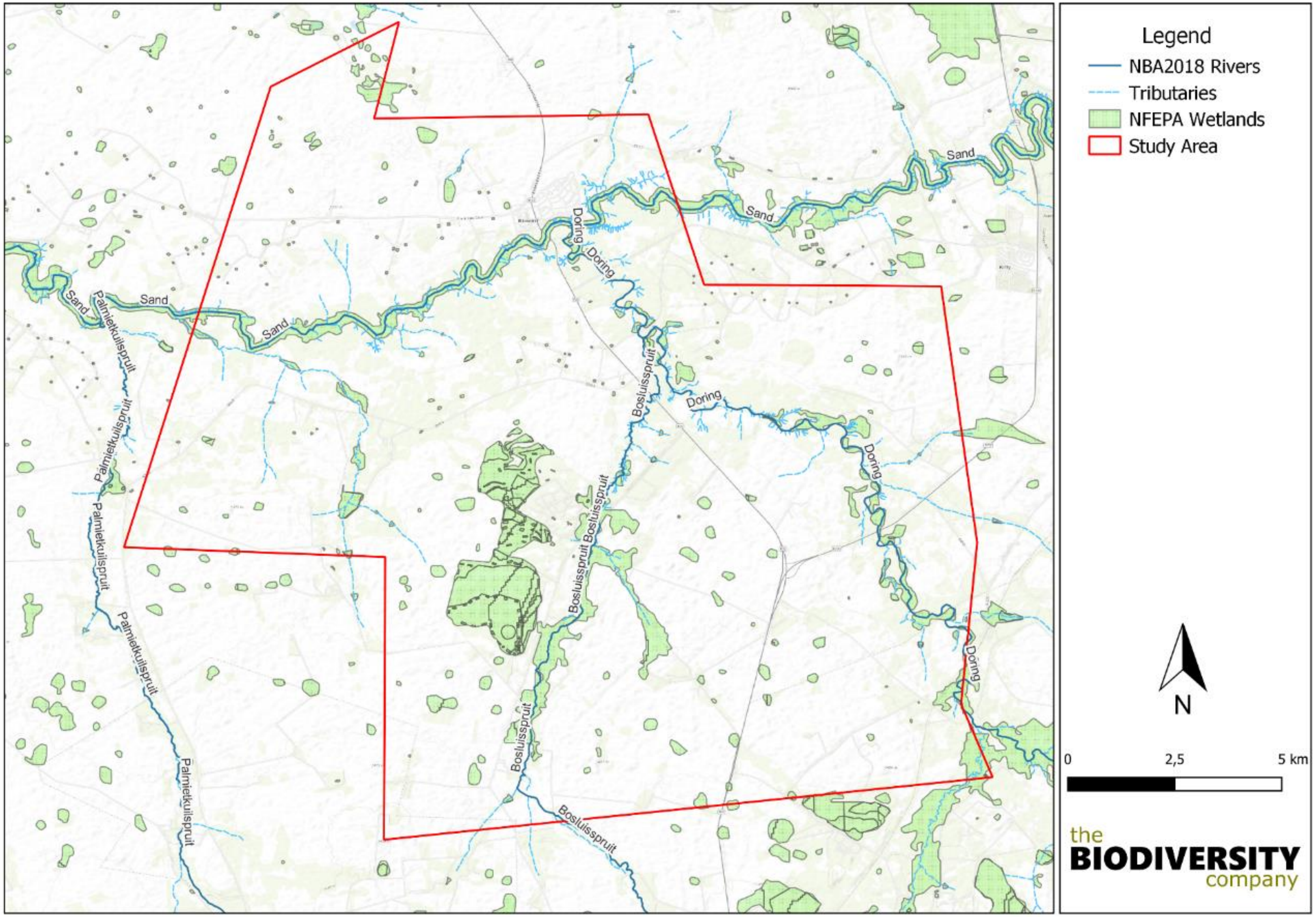

Figure 5-2 Illustration of the water resources associated with the project area

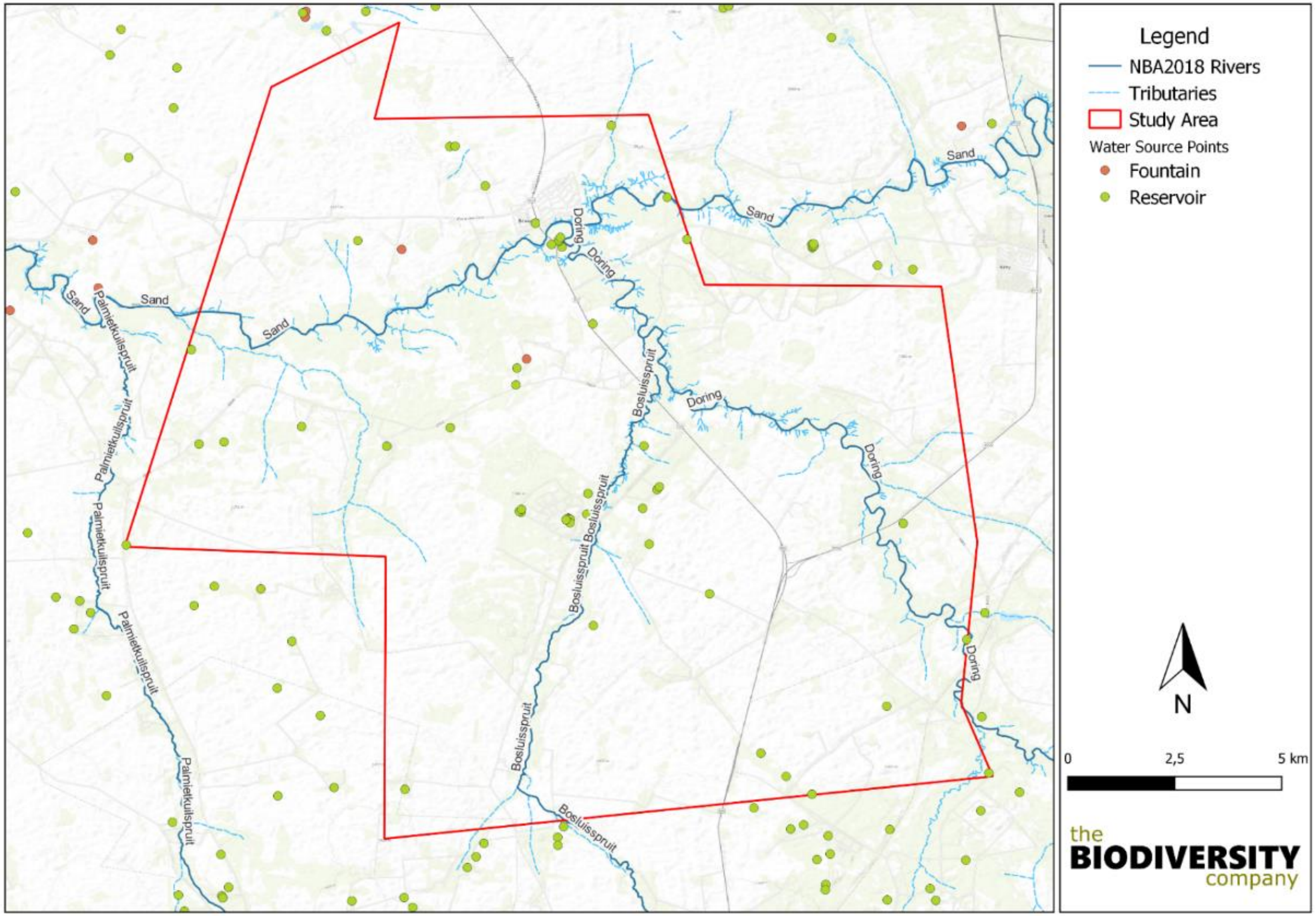

Figure 5-3 *Illustration of the water source points associated with the project area*

5.2 Climate

The region has seasonal rains, with rainfall occurring during the summer months of October to April (Figure 5-4) and Mean annual precipitation (MAP) of 530 mm (Mucina & Rutherford, 2006). High summer temperatures are common for this region with severe frost occurring throughout the winter (on average 37 days per year).

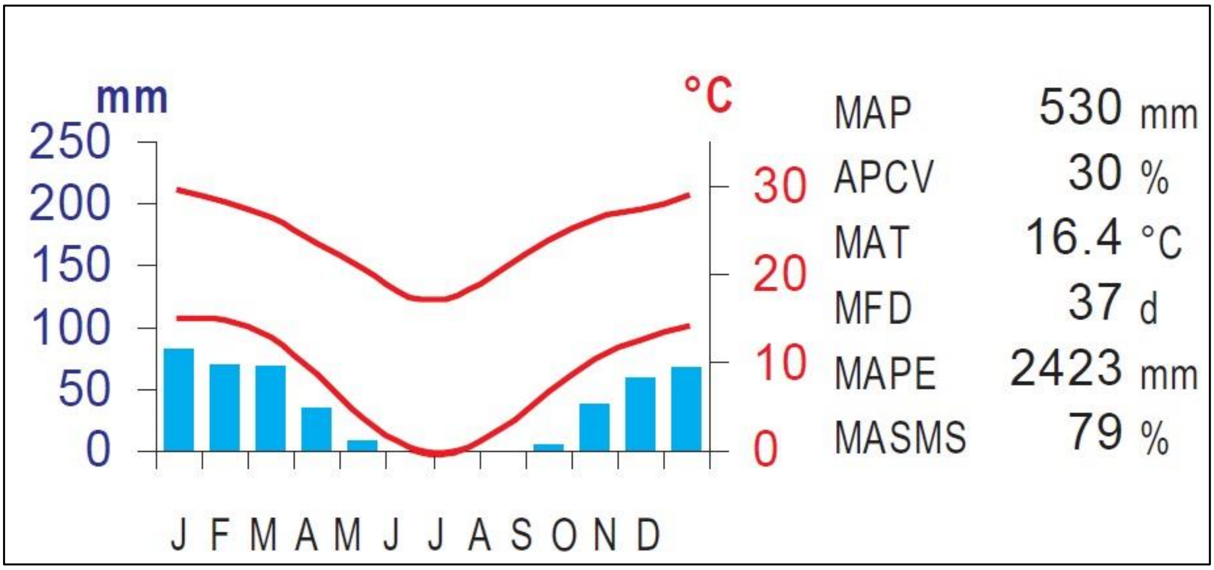

Figure 5-4 Climate for the Vaal-Vet Sandy Grassland (Mucina & Rutherford, 2006).

5.3 Land Use

The land use in the catchment area associated with the project consisted largely of commercial annuals crops rain-fed / dryland / non-irrigated (Table 5-2 and Figure 5-5). Natural grasslands predominantly occur along the various watercourses, particularly along the middle to lower reaches of the Boschluispruit, Doring River and Sand River.

Table 5-2 Major land uses within the catchment

Land Use	Hectares
Commercial Annuals Crops Rain-Fed / Dryland / Non-Irrigated	3409
Natural Grassland	385
Commercial Annuals Pivot Irrigated	410
Fallow Land & Old Fields (Grass)	229

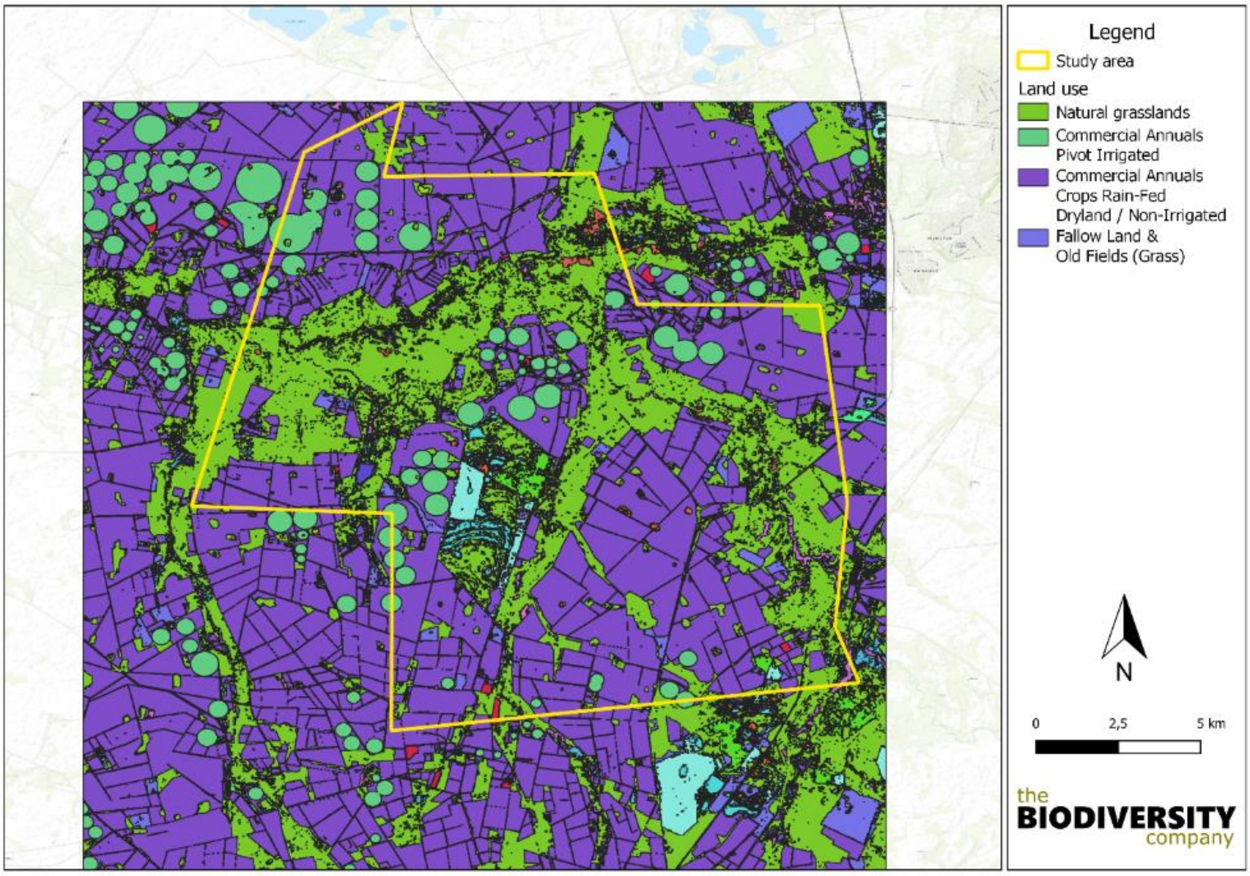

Figure 5-5 Land use within the catchment associated with the project area

5.4 Ecological Setting

The study area is located across a single Freshwater Ecoregion, the Southern Temperate Highveld (Figure 5-6), with the rivers eventuating into the Vaal River. The aquatic fauna of the Southern Temperate Highveld Freshwater Ecoregion, in comparison to northern African river systems is “lacking in diversity” with (Abel *et al.,* 2008). The ecoregion is known to have increased flow rates during the spring and summer seasons (September to March) and the indigenous fish species breed during this period. Notable aquatic ecology in these basins include the several endemic Cyprinid species. According to the expected fish species list, a total of 9 indigenous species are expected within the system. The species assemblage expected within the study area are typically widely distributed over a large geographic range.

The study area predominantly falls within the Highveld ecoregion [Kleynhans, Thirion and Moolman (2005)]. The ecoregion is characterised by plains with moderate to low relief and dry sandy grasslands and limited mixed bushveld.

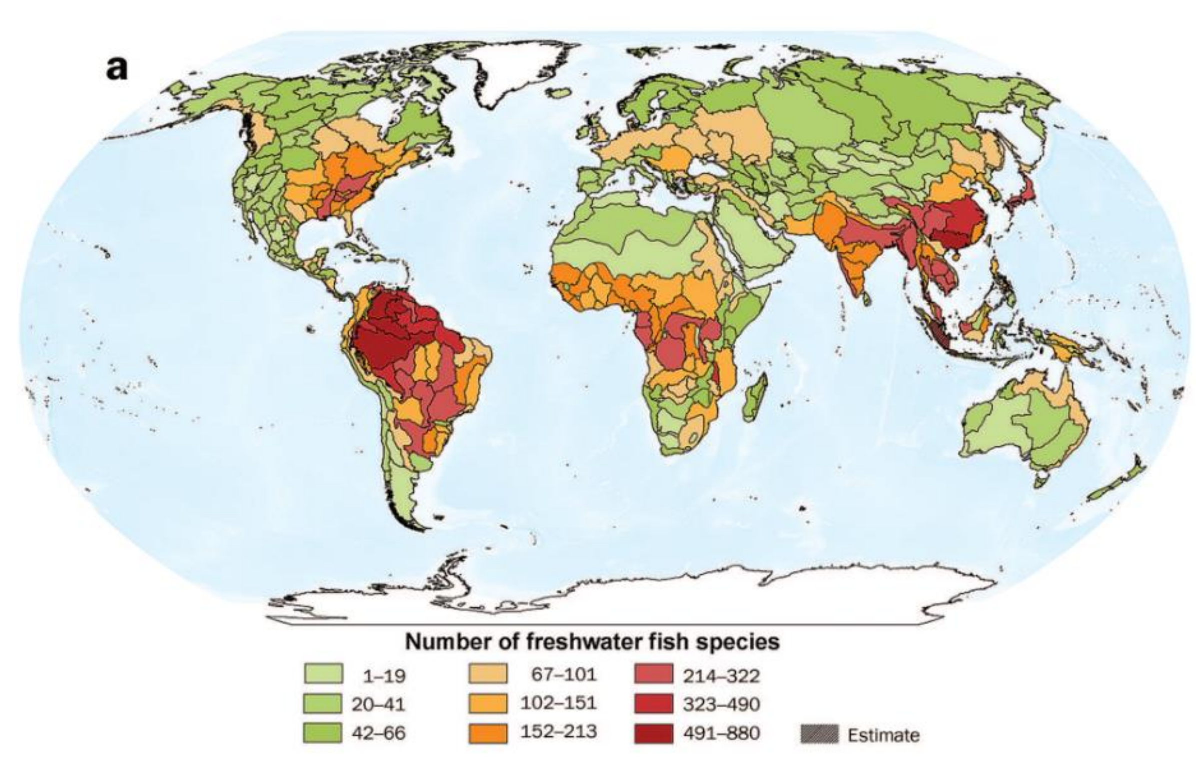

Figure 5-6 Freshwater Ecoregions of the World (Abell et al., 2008)

5.5 National Freshwater Ecosystem Priority Areas (NFEPA)

The National Freshwater Ecosystem Priority Areas (NFEPA) database forms part of a comprehensive approach to the sustainable and equitable development of South Africa's scarce water resources. This database provides guidance on how many rivers, wetlands and estuaries, and which ones, should remain in a natural or near-natural condition to support the water resource protection goals of the National Water Act (Act 36 of 1998). This directly applies to the National Water Act, which feeds into Catchment Management Strategies, water resource classification, reserve determination, and the setting and monitoring of resource quality objectives (Nel *et al.,* 2011). The NFEPAs are intended to be conservation support tools and envisioned to guide the effective implementation of measures to achieve the National Environment Management Biodiversity Act's biodiversity goals (NEM:BA) (Act 10 of 2004), informing both the listing of threatened freshwater ecosystems and the process of bioregional planning provided for by this Act (Nel *et al*., 2011).

The project area falls across five SQRs with several NFEPAs listed within the project area (Table 5-3). These FEPAs are associated with wetland type ecosystems and no aquatic biodiversity FEPAs are designated to the watercourses within the project area (Figure 5-7 and Figure 5-8).

Conserving the water quality, riverine and wetland habitat and associated ecological functioning within the project area and associated SQRs, will aid in the protection of riverine habitat supporting fish species occurring within the entire catchment and water quality for the aquatic and terrestrial biota downstream of the project area. The SQR's in which human activities occur need to be managed to maintain water quality and prevent further degradation of downstream water resources in order to contribute to national biodiversity goals and support sustainable use of water resources.

Table 5-3 NFEPAs listed for the project area

Type of FEPA map category	Biodiversity features
Doring River C42K-2754	

Type of FEPA map category	Biodiversity features
Wetland ecosystem type	3 WetCluster FEPAs
Wetland ecosystem type	Dry Highveld Grassland Group 3_Channelled valley-bottom wetland
Wetland ecosystem type	Dry Highveld Grassland Group 3_Depression
Wetland ecosystem type	Dry Highveld Grassland Group 3_Flat
Wetland ecosystem type	Dry Highveld Grassland Group 3_Seep
Wetland ecosystem type	Dry Highveld Grassland Group 3_Unchannelled valley-bottom wetland
Wetland ecosystem type	Dry Highveld Grassland Group 4_Channelled valley-bottom wetland
Wetland ecosystem type	Dry Highveld Grassland Group 4_Flat
Wetland ecosystem type	Dry Highveld Grassland Group 4_Seep
Wetland ecosystem type	Dry Highveld Grassland Group 4_Unchannelled valley-bottom wetland
Wetland ecosystem type	Dry Highveld Grassland Group 4_Valleyhead seep
Boschluispruit C42K- 2764	
Wetland ecosystem type	Dry Highveld Grassland Group 3_Channelled valley-bottom wetland
Wetland ecosystem type	Dry Highveld Grassland Group 3_Depression
Wetland ecosystem type	Dry Highveld Grassland Group 3_Flat
Wetland ecosystem type	Dry Highveld Grassland Group 3_Seep

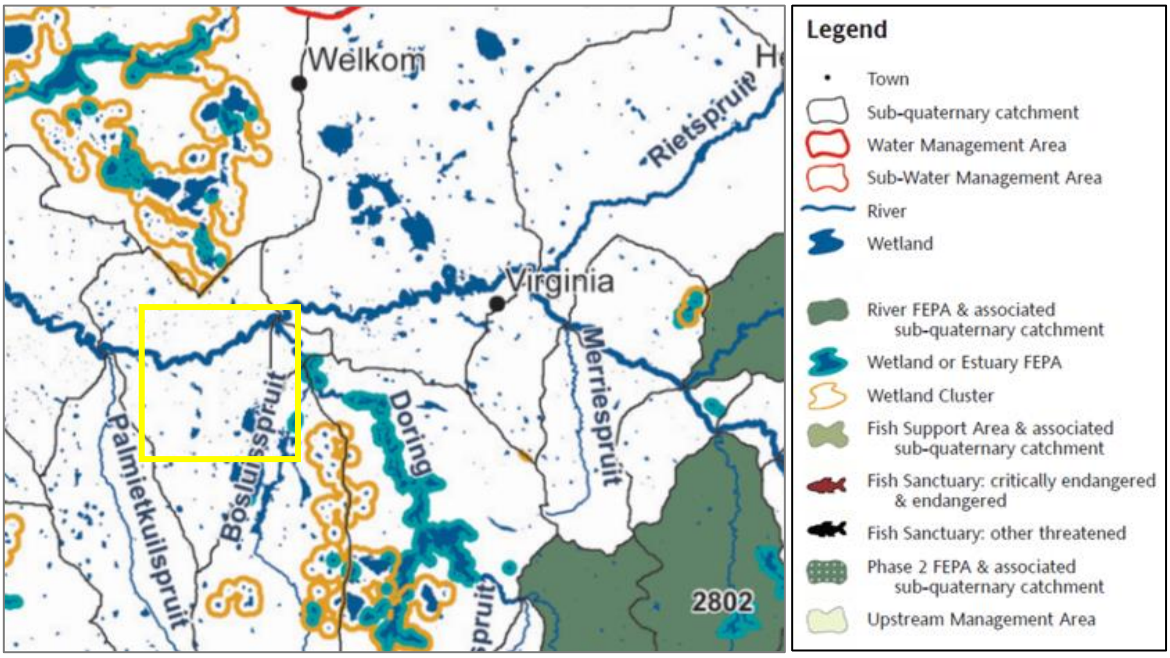

Figure 5-7 Map illustrating fish and river FEPAs for the project area, the project area is represented by the yellow square (Nel et al., 2011)

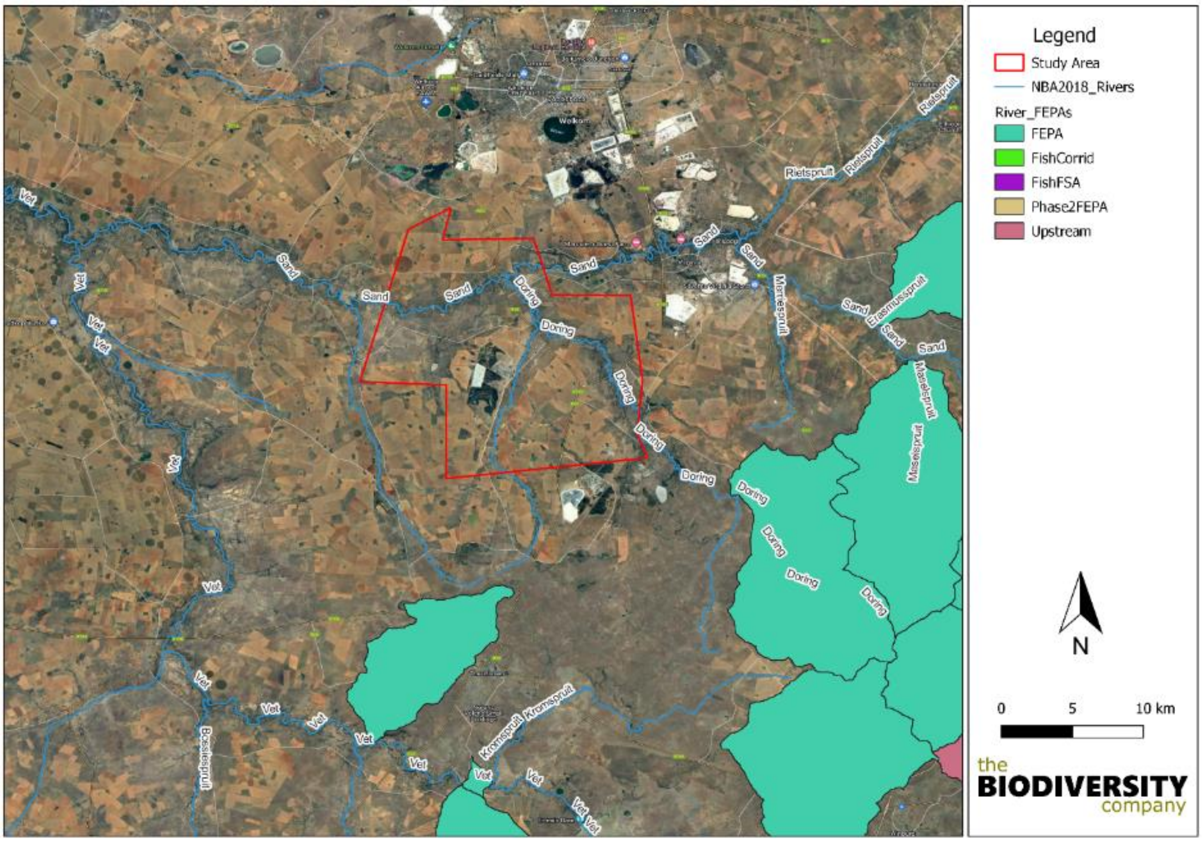

Figure 5-8 Aquatic FEPAs associated with the project area

5.6 Strategic Water Source Areas

Strategic Water Source Areas are areas that supply a disproportionate amount of mean annual runoff to a geographical region of interest. The areas supplying ≥ 50% of South Africa's water supply (which were represented by areas with a mean annual runoff of ≥ 135 mm/year) represent national Strategic Water Source Areas (SANBI, 2013). According to the Strategic Water Source Areas (SWSAs) of South Africa, Lesotho and Swaziland, the project area is not located within the SWSAs with all SWSA aligned along the coast. The project area is considered warm and temperate climate that receives limited rainfall (annual 530 mm) with an average annual temperature in the region of 16.4°C and does not fall within a SWSA.

5.7 Freshwater Critical Biodiversity Area

Critical Biodiversity Areas (CBAs) are terrestrial and aquatic areas of the landscape that need to be maintained in a natural or near-natural state to ensure the continued existence and functioning of species and ecosystems and the delivery of ecosystem services. CBAs are areas of high biodiversity value and need to be kept in a natural state, with no further loss of habitat or species (MTPA, 2014). Thus, if these areas are not maintained in a natural or near natural state then biodiversity targets cannot be met. Maintaining an area in a natural state can include a variety of biodiversity compatible land uses and resource uses (SANBI, 2017).

According to Collins (2016), no aquatic CBA have been designated for the Free State Province, however, terrestrial CBAs are provided in Figure 5-9. These should be taken into consideration with the freshwater systems due to ecosystem services provided by the watercourses in the region. Additionally, it was recommended by Collins (2016) to treat all NFEPA wetlands as Ecological Support Areas (ESA) within the region.

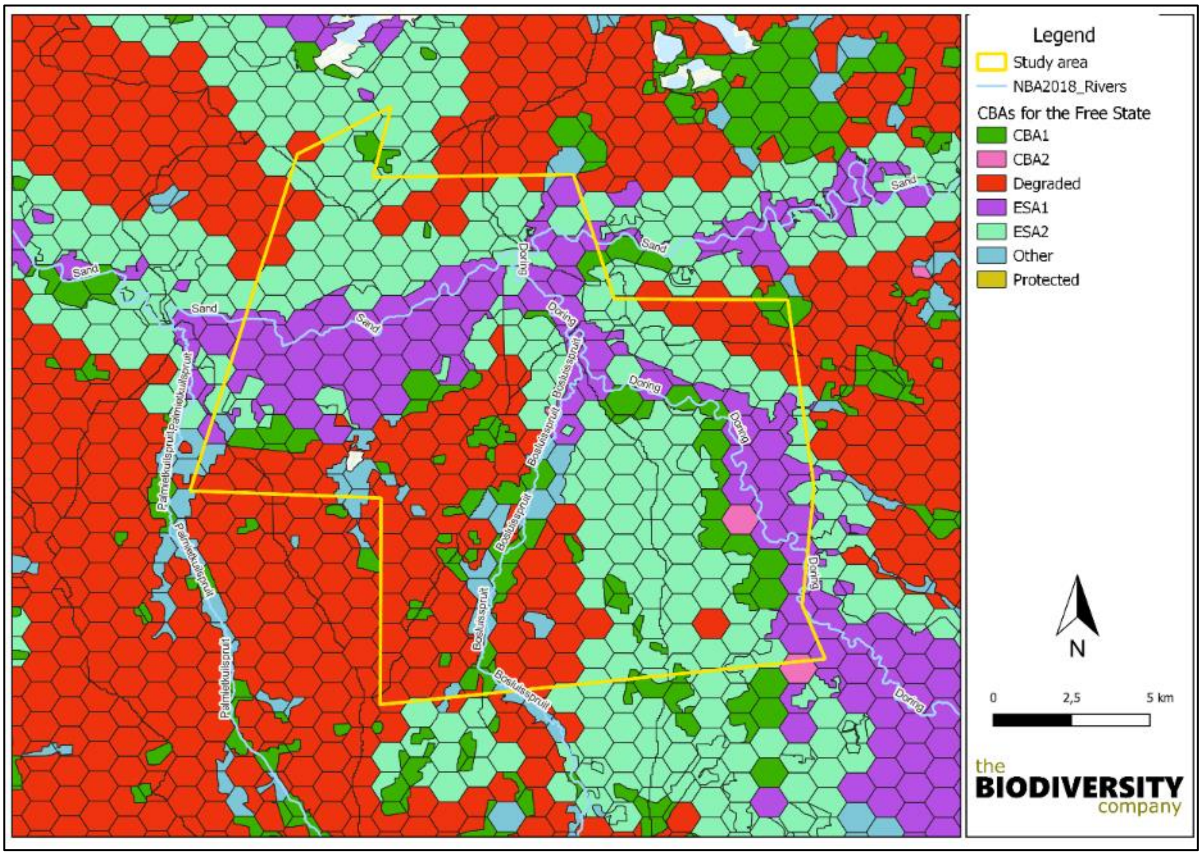

Figure 5-9 Illustration of the Terrestrial Critical Biodiversity Areas within the project area (Collins, 2016)

5.8 Ecosystem Threat Status

Ecosystem threat status outlines the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends (Skowno *et al*., 2019).

Ecosystem types are categorised as Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Least Threatened (LT), based on the proportion of each ecosystem type that remains in good ecological condition (Skowno *et al*., 2019). The Ecosystem Threat Status (ETS) of each river assessed was based on the extent to which the system had been modified from its natural condition (SANBI, 2022). According to the South African Inventory of Inland Aquatic Ecosystems (SAIIAE) released with the National Biodiversity Assessment (NBA) of rivers, the rivers which were superimposed on the aquatic ecosystem threat status indicate that the project area falls across an interconnected CR ecosystem (Figure 5-10).

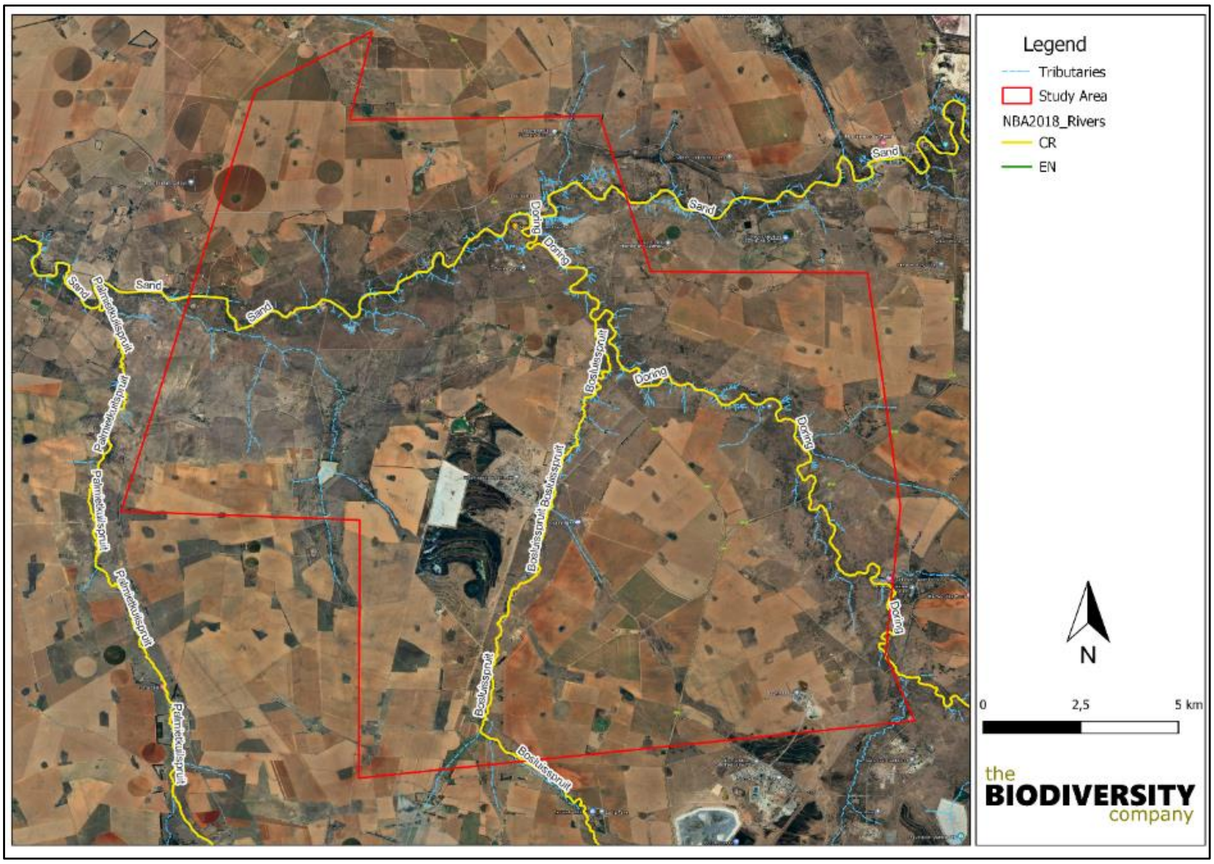

Figure 5-10 Illustration of the Ecosystem Threat Status of the project area (SANBI, 2022)

5.9 Ecosystem Protection Level

Ecosystem protection level tells us whether ecosystems are adequately protected or under-protected. Ecosystem types are categorised as not protected, poorly protected, moderately protected or well protected, based on the proportion of each ecosystem type that occurs within a protected area recognised in the Protected Areas Act (Skowno *et al*., 2019). The Ecosystem Protection Level (EPL) of each river assessed was based on the extent (expressed as a percentage) to which the system has their biodiversity target located within protected areas and are in a natural or near-natural ecological condition. Rivers in protected areas need to be in good condition (A or B ecological category) to be considered as protected. Well protected rivers have 100% located within protected areas, while moderately protected and poorly protected river ecosystem types have at least 50% and 5% of their biodiversity target in protected areas, respectively. Not protected rivers form less than 5% (SANBI, 2022).

The project area was superimposed on the ecosystem protection level map to assess the protection status of aquatic ecosystems associated with the development (Figure 5-11). This indicates that the aquatic ecosystems associated with the project area are predominantly rated as *poorly protected* with portions of the Boschluisspruit rated as *not protected*.

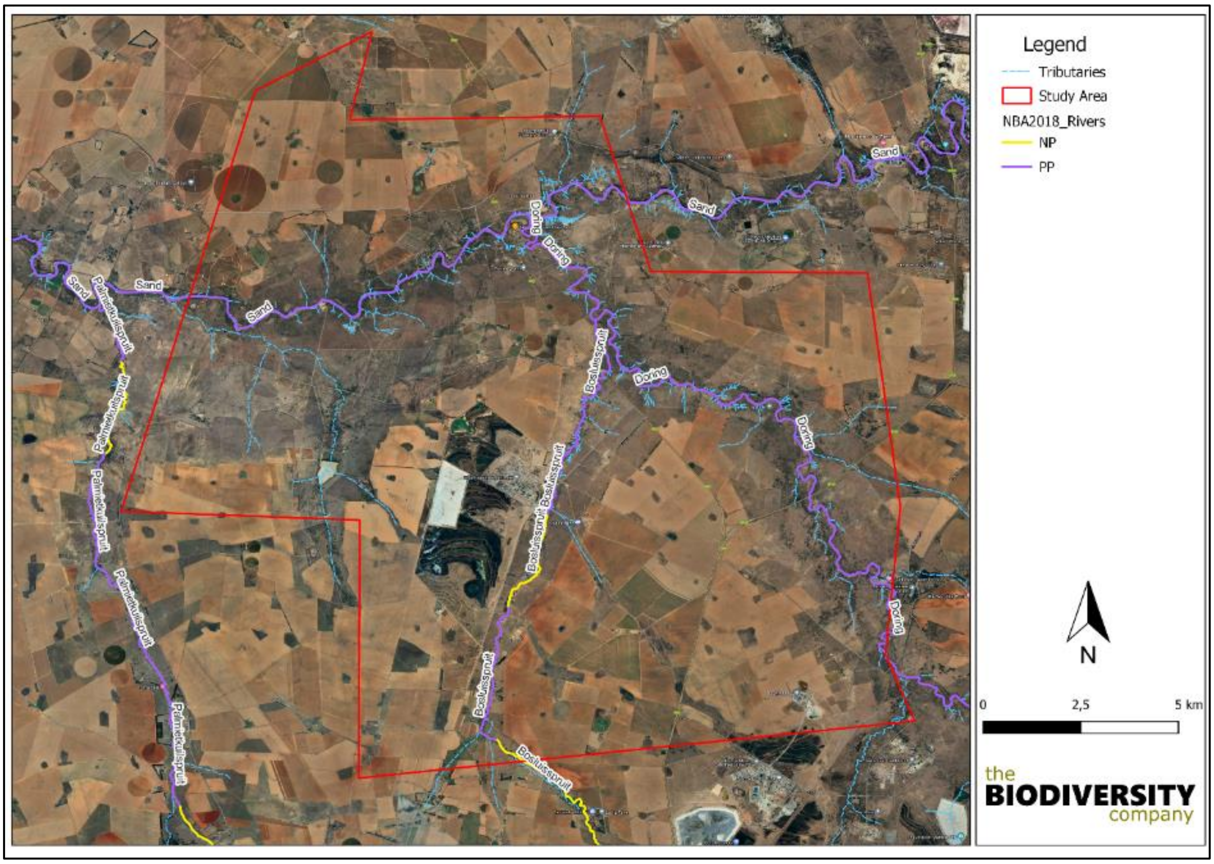

Figure 5-11 Illustration of the Ecosystem Protection Level of the project area (NBA, 2022)

5.10 Spatially Sensitive Mapping

This approach has also taken cognisance of the recently published Government Notice 320 in terms of NEMA dated March 2020: "Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation" (DWS, 2020). The National Web Based Environmental Screening Tool (NWBEST) has characterised the aquatic sensitivity of the project area as "very high" - requiring an assessment (Figure 5 1). The freshwater ecology of the immediate project area and further downstream areas are considered sensitive to disturbance from a hydrological and biological perspective. This will include all watercourses within the project area which are considered sensitive due to their relatively small spatial scale when compared to terrestrial habitat with a large demand for the ecosystem services which they provide. Construction and operation activities must take cognizance of this, and avoid any unnecessary disturbance of the watercourses and adjacent habitat.

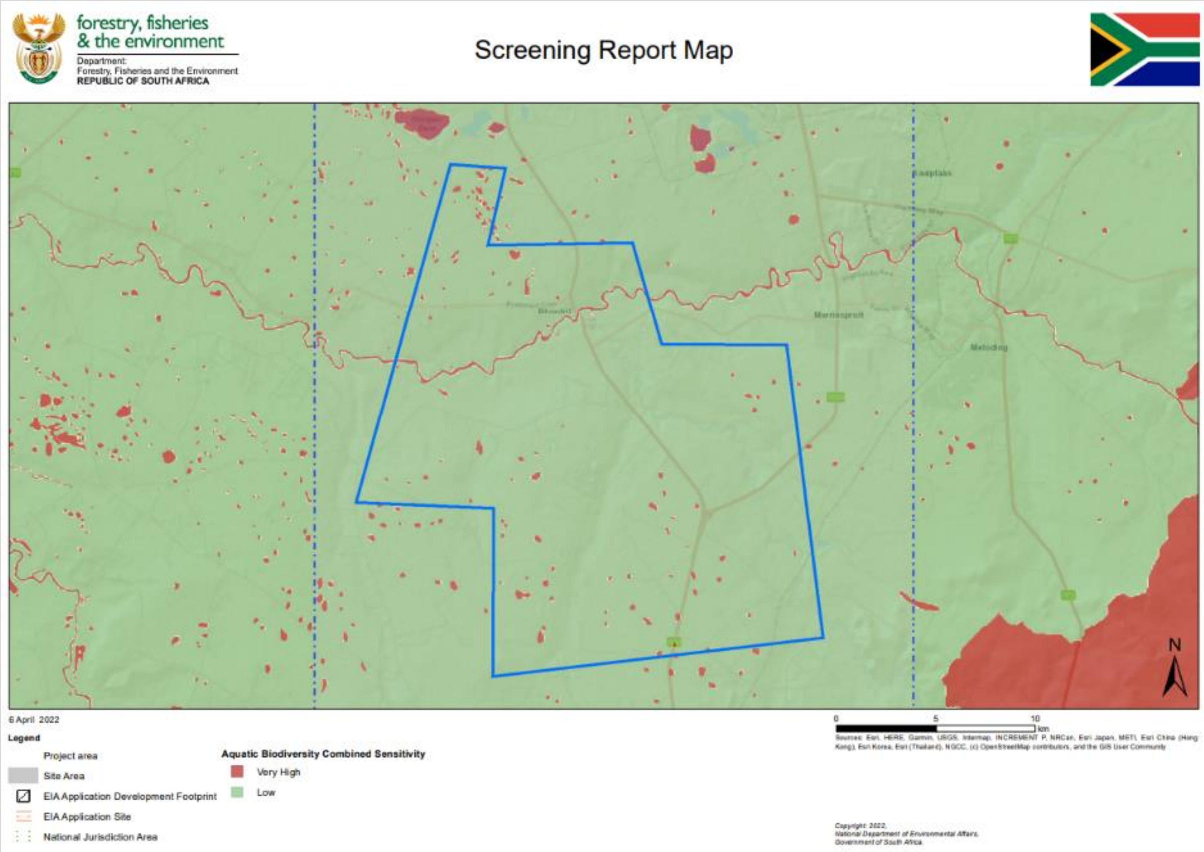

Figure 5-12 Aquatic Biodiversity Combined Sensitivity (National Web based Environmental Screening Tool)

5.11 Expected Fish Species

An expected species list was generated from DWS (2014), and Skelton (2011) for the C23H-01653 SQR's. A total of 10 fish species are expected to occur in the Sand River region which are presented in Table 5-4. The conservational status of fish species was assessed against the latest IUCN database (IUCN, 2022).

The expected species are generated on a reach basis, and the occurrence of all species in the system is unlikely as different species are specialists of different habitats which are present along a reach. The Sand River reach does however have limited habitat diversity and cover features which would likely limit the diversity of the fish community. A single species of conservational concern is expected within the reach and downstream systems, *Labeobarbus kimberleyensis* (Largemouth yellowfish) which is listed as Near Threatened (NT). The species is on decreasing population trend and is threatened by deterioration in water quality including eutrophication (nutrient enrichment through poor farming practices and inefficient wastewater treatment), loss of habitat and habitat fragmentation due to weirs and dams, loss of spawning grounds due to instream sedimentation (related to erosion), flow modifications due to drought and dam releases, and threats from exotic species, namely Common Carp (*Cyprinus carpio*) and Grass Carp (*Ctenopharyngodon idella*) (IUCN, 2022).

Table 5-4 Expected fish species for the SQRs sampled for the project

Species	Common Name	IUCN (2022)	C42L-2690 (Sand)	C42K-2754 (Doring)	C42K- 2764 (Boschluispruit)
Austroglanis sclateri	Rock-catfish	LC	1	1	
Clarias gariepinus	Sharptooth catfish	LC	1	1	
Enteromius anoplus	Chubby head barb	LC	1	1	1
Enteromius paludinosus	Straightfin barb	LC	1	1	1
Labeo capensis	Mudfish	LC	1	1	1
Labeo umbratus	Moggel	LC	1	1	1
Labeobarbus aeneus	Smallmouth yellowfish	LC	1	1	1
Labeobarbus kimberleyensis	Largemouth yellowfish	NT	1	1	
Pseudocrenilabrus philander	Southern mouthbrooder	LC	1	1	
Tilapia sparrmanii	Banded tilapia	LC	1	1	
Total expected species	**10**		**10**	**10**	**5**

LC - Least concern
NT - Near Threatened
NA - Not assessed

5.12 Resource Quality Objectives

Results from the aquatic assessment are compared to the Resource Quality Objectives (RQOs) for the Vaal WMA, Integrated Unit of Analysis MD2 Lower Sand, Resource Unit LS3 (DWS, 2016). The Resource Units (RU) are presented in Table 5-5 and the RQOs for the units are presented in Table 5-6. The stipulated RQOs should be considered for the Environmental Management Plan and monitoring protocols should EA be granted for this project. Each aspect of the aquatic assessment will be presented along with relevant RQOs.

Table 5-5 Summary of resources assigned RQOs for the relevant Sand River region

Integrated Unit of Analysis (IUA)	RU	Water Resource Class for IUA	Quaternary Catchment	Mean Annual Runoff (MAR)	Present Ecological State	Recommended Ecological Category
Lower Sand River (MD2)	LS3	III	C42L	180.27	C	C

Table 5-6 Resource Quality Objectives for the sand River Resource Unit (RU) LS3

<table>
<tr><th>RU</th><th>Quaternary Catchment</th><th>Component</th><th>Component Sub-</th><th>Resource Quality Objective</th><th>Indicator/measure</th><th>Numerical limit</th></tr>
<tr><td rowspan="13">LS3</td><td rowspan="13">C42K, C42L, C43B</td><td>Quantity</td><td>Low flows</td><td>The maintenance low flows and drought flows must be attained to support a healthy condition for the ecosystem and users.</td><td>Total Ecological Water Requirement (node MD 2.3) = 43.933 million cubic metres/annum (24.37% of the Virgin Mean Annual Runoff) Maintenance flows (percentage value of naturalised flow distribution) Drought flows (percentage value of naturalised flow distribution)</td><td>
<table>
<tr><th>Month</th><th colspan="2">Maintenance Low Flows</th><th colspan="2">Drought Flows</th></tr>
<tr><th></th><th>cubic metres/ second</th><th>Per cen tile</th><th>cubic metres/ second</th><th>Per cen tile</th></tr>
<tr><td>Oct</td><td>0.4014</td><td>70</td><td>0.0523</td><td>99</td></tr>
<tr><td>Nov</td><td>0.7481</td><td>80</td><td>0.0270</td><td>99</td></tr>
<tr><td>Dec</td><td>0.8658</td><td>80</td><td>0.0187</td><td>99</td></tr>
<tr><td>Jan</td><td>1.2769</td><td>80</td><td>0.1792</td><td>99</td></tr>
<tr><td>Feb</td><td>1.5828</td><td>80</td><td>0.1819</td><td>99</td></tr>
<tr><td>Mar</td><td>1.5177</td><td>80</td><td>0.1120</td><td>99</td></tr>
<tr><td>Apr</td><td>1.0849</td><td>70</td><td>0.0849</td><td>99</td></tr>
<tr><td>May</td><td>0.6440</td><td>40</td><td>0.0933</td><td>99</td></tr>
<tr><td>Jun</td><td>0.3306</td><td>50</td><td>0.0849</td><td>99</td></tr>
<tr><td>Jul</td><td>0.1404</td><td>80</td><td>0.0448</td><td>99</td></tr>
<tr><td>Aug</td><td>0.1493</td><td>90</td><td>0.0493</td><td>99</td></tr>
<tr><td>Sep</td><td>0.2986</td><td>60</td><td>0.0876</td><td>99</td></tr>
</table>
</td></tr>
<tr><td rowspan="12">Quality</td><td rowspan="3">Nutrients</td><td rowspan="3">Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.</td><td>Dissolved Inorganic Nitrogen as Nitrogen</td><td>≤ 1.5 milligrams/litre (50th percentile)</td></tr>
<tr><td>Nitrate & Nitrite as Nitrogen</td><td>≤ 1.0 milligrams/litre (50th percentile)
≤ 6 milligrams/litre (95th percentile)</td></tr>
<tr><td>Orthophosphate as Phosphorus</td><td>≤ 0.058 milligrams/litre (50th percentile)</td></tr>
<tr><td>Salts</td><td>Salinity levels are significantly high. Instream salinity must be improved to support the aquatic ecosystem and the water quality requirements of the water users.</td><td>Electrical conductivity</td><td>≤ 85 milliSiemens/metre (95th percentile)</td></tr>
<tr><td rowspan="7">Toxics</td><td rowspan="7">The concentrations of toxins should not be at a level that is toxic to aquatic organisms and a threat to human health.</td><td>Cyanide (free)</td><td>≤ 0.045 milligrams/litre (95th percentile)</td></tr>
<tr><td>Aluminium</td><td>≤ 0.1 milligrams/litre (95th percentile)</td></tr>
<tr><td>Manganese</td><td>≤ 0.25 milligrams/litre (95th percentile)</td></tr>
<tr><td>Iron</td><td>≤ 0.3 milligrams/litre (95th percentile)</td></tr>
<tr><td>Uranium</td><td>≤ 0.03 milligrams/litre (95th percentile)</td></tr>
<tr><td>Ammonia as Nitrogen</td><td>≤ 0.072 milligrams/litre (95th percentile)</td></tr>
<tr><td colspan="2">A screening level whole effluent toxicity test should be conducted at four trophic levels and should the results show toxicity greater than 1 (limited to not acutely toxic) further definitive tests are required</td></tr>
</table>

LS3	Lower Sand (C42J) (Downstream Rietspruit tributary to confluence with the Vet River)	Quality	Pathogens	The presence of pathogens should pose a low risk to human health.	Escherichia coli	≤ 130 counts/100 millilitres (95th percentile)
			System variables	pH must be maintained at present state.	pH range	6.5 (5 percentile) th percentile) and 9.2 (95th)
				A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.
		Habitat	Instream Habitat	Instream and Riparian habitat must be in a moderately modified condition or better.	The Rapid Habitat Assessment Method must be implemented.	Instream and Riparian habitat Integrity category ≥ C (≥ 62)
		Biota	Fish	Instream biota must be in moderately modified condition or better through maintenance of habitat, flows, water quality.	A baseline assessment to determine the integrity and health of the fish community should be conducted to determine the current state and potential impacts to the population. Fish Response Assessment Index (FRAI) must be utilized.	Fish ecological category: ≥ C (≥ 62) Macro-invertebrate ecological category:≥ C (≥ 62) Instream Ecostatus category ≥ C (≥ 62) Hydrological category ≥ C (≥ 62) With monthly flow requirements as specified. Water Quality category: ≥ C (≥ 62)
			Aquatic Invertebrates	The integrity of the macroinvertebrate community within the system must be maintained.	The integrity of the invertebrate community should be determined using the Macroinvertebrate Response Assessment Index. Conduct aquatic biomonitoring annually using the South African scoring System 5 methodology.	Maintain the D ecological category by ensuring that the Average Score Per Taxon is >5 4.0.

6 Results

6.1 *In situ* Water Quality

In situ water quality analysis was conducted during the study at multiple points along the watercourses in the project area which contained water. Results have been compared to limits stipulated in the Target Water Quality Range (TWQR) for aquatic ecosystems (DWAF, 1996). The results of the March 2022 assessment are presented in Table 6-1.

Table 6-1 In situ surface water quality results (March 2022)

Site	pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)
RQOs* TWQR**	6.5-9.2*	850*	>5.00 mg/l**	5-30**
Palmietkuilspruit				
P1	7,0	1305	9,1	20.0
Sand River				
S1	6,6	342	5,3	20,6
S2	6,4	736	6,3	22,5
S3	6,6	735	5,4	23,8
Boschluispruit				
BO	6,9	833	4,3	19,3
B1	Dry			
B3	7,02	411	6,7	19,5
Doring River				
D1	7,1	1495	7,2	21,1
D2	6,8	1845	6,5	22,8
Ephemeral Tributaries				
K1	6,9	313	4,5	20,6
TS1	Dry			
T2	No access			
TS2	No access			
T1	6,0	346	4,8	19,3
TO	6,3	434	7,7	19,4

*TWQR – Target Water Quality Range (DWAF, 2006); ** Resource Quality Objective (DWS, 2016); Levels exceeding guideline levels are indicated in red

Water quality results indicate pH levels within the catchment fall largely into RQOs and the TWQR, and range from 6.0 at site T1 to 7.1 at site D1. Sites in the Sand River were acidic, ranging from 6.4 to 6.6 within the assessed reach. Additionally, acidic pH levels were recorded at sites on the unnamed tributary (T0 and T1). The low pH levels recorded at several sites would contribute to adverse conditions for local aquatic biota. Marked changes in pH levels within the catchment would further contribute to adverse conditions, limiting the abundances and diversity of sensitive aquatic biota.

The concentrations of dissolved solids as measured in Electrical Conductivity (EC) were found to range from 313 µS/cm at site K1 to 1845 µS/cm. The elevated EC levels within the Doring and Palmietkuilspruit would limit the diversity of local aquatic biota. The contributions of dissolved solids from the Doring into the Sand River increase EC levels by 46%. This marked increase would contribute to adverse conditions, interfering with osmotic balances in metabolism and respiration. Mining activities within the Doring River, and agricultural runoff contribute to the elevated levels.

Low Dissolved Oxygen (DO) levels were recorded within the tributaries (K1 and T1), and the upper reaches of the Boschluispruit. Sites T1 and B0 presented limited surface water and flow, reducing oxygen replenishment into the system. Chronically low DO levels would limit the diversity and abundances of sensitive aquatic biota. Water temperatures fell within expected ranges for the highveld ecoregion during the summer rainfall period.

6.2 Habitat Integrity Assessment

The IHIA was completed for the Sand River, Doring River and Boschluispruit as described in the IHIA methodology component of this study. The spatial framework of which constitutes a 5 km reach of the each of the systems was used to complete the IHIA and represented in Table 6-2.

Table 6-2 The Intermediate Habitat Integrity Assessment results for the various perennial watercourses

Instream	Sand River	Boschluispruit	Doring River
Water abstraction	8	10	10
Flow modification	10	15	19
Bed modification	11	16	19
Channel modification	14	15	15
Water quality	10	10	17
Inundation	10	12	10
Exotic macrophytes	10	5	5
Exotic fauna	5	5	5
Solid waste disposal	5	5	5
Total Instream	**61**	**55**	**48**
Category	**C**	**D**	**D**
Riparian	**Sand River**	**Boschluispruit**	**Doring River**
Indigenous vegetation removal	10	16	15
Exotic vegetation encroachment	10	8	10
Bank erosion	15	12	16
Channel modification	12	16	15
Water abstraction	10	10	10
Inundation	5	12	10
Flow modification	8	16	15
Water quality	5	15	17
Total Riparian	**62**	**47**	**45**
Category	**C**	**D**	**D**

The results of the instream and riparian habitat assessments in the Boschluispruit and Doring River indicated class D or largely modified habitat condition in all watercourses. The lowered ecological condition of the watercourses was derived to be below the recommended class C (moderately modified) or >62 condition of the RQOs for the C42K catchment. While these RQOs are not specific for these two rivers, the deterioration of these catchments below class C contributes to the deterioration of the downstream Sand River. The Sand River instream and riparian ecological integrity was rated as class

C, falling within the RQOs. The relatively low intensity of anthropogenic activities within the reach contributes to moderate modifications to the riparian and instream habitat integrity.

The watersheds considered in this study have modified land use, which is dominated by dryland agriculture and livestock land uses. Groundwater abstraction (boreholes) is anticipated to have impacted on the baseflow of the watercourses, whilst altered landcover has resulted in the increased flood-peaks of low duration. Direct discharges to surface water in the study area are also known to occur, whereby discharge or treated sewage water from upstream urban areas on the Sand River and Doring River and is considered a key source of water in the catchments with associated water quality issues (dissolved salt loads and eutrophication). Additionally, discharge of water from mines on the Doring catchment contribute to flow and water quality modifications, increasing dissolved solid concentration.

Instream habitat modifications within the catchment was noted at all sites, and particularly increased sediment deposits within the Doring and Sand Rivers. The source of the increased sediment yield can be attributed to the erosion of channel edges within the Doring and Sand River catchments, compounded by dryland agricultural activities (Figure 6-1 and Figure 6-2). The soils observed within the river banks was noted to be composed of highly erodible soils which is further contributing towards the erosion and sedimentation in the watercourses. The erosion of bed and banks results in channelisation and reduced lateral movement of water into the riparian zone. The reduced lateral flow of water and physical disturbance of the riparian zone due to erosion has compromised the riparian zone integrity within the catchment.

Figure 6-1 Erosion within the Doring River catchment (Google Earth, 2021)

Figure 6-2 Erosion within the Sand River catchment (Google Earth, 2021)

Similar aspects covered in the instream habitat assessment indicated above, the observation of woody invasive species (*Tamarix* sp.) were also observed in the bank-top vegetation which further contributed to the deteriorated ecological state (Figure 6-3). Additionally, anthropogenic activities within the riparian zone have contributed to a deteriorated ecological state, including residential areas and mining activities (Figure 6-4).

Figure 6-3 Illustration of Tamarix sp. in the bank-top vegetation of the Doring River

Figure 6-4 Illustration of mining activities along the Sand River bank (Google Earth, 2021)

6.3 Aquatic Macroinvertebrate Assessment

6.3.1 Macroinvertebrate Habitat

Biological SASS5 assessments were completed at representative sites in the considered river reaches. The results of the biotope assessment are provided in Table 6-3.

Table 6-3 Biotope availability at the sites in 2022 (Rating 0-5)

Biotope	Weighting (Lowland River)	P1	S2	B3	D1
Stones in current	18	3,5	3	0	3
Stones out of current	12	4	3	0	3
Bedrock	3	2	2,5	0	1
Aquatic Vegetation	1	1	1	1	0
Marginal Vegetation In Current	2	1	2	2	1
Marginal Vegetation Out Of Current	2	2	1,5	2	2
Gravel	4	3	3	1	1
Sand	2	3	4	1	2
Mud	1	3	1	2	3
Biotope Score		**22,5**	**21**	**9**	**16**
Weighted Biotope Score (%)		**64**	**56**	**8**	**49**
Biotope Category (Tate and Husted, 2015)		**B**	**C**	**F**	**D**

The biotope rating assessment indicated diverse habitat at sites P1, with diverse instream substrate including stones in and out of current, gravel, sand and mud substrate. Limited marginal and aquatic vegetation were recorded at all sites, reducing the expected macroinvertebrate orders from Odonata, Hemiptera and Coleoptera. Site S2 on the Sand River presented moderate biotope diversity, with substrate dominated by sand substrate with patches of stones in and out of current (Figure 6-5). Sedimentation and erosion have reduced the availability of stones in and out of current biotopes due to instream smothering. Poor habitat diversity was sampled at site B3, however, the site was naturally low in biotope diversity due to wetland nature of the system (Figure 6-6 and Figure 6-7). The low habitat diversity would limit the diversity and abundances of macroinvertebrate taxa with preferences to flow and stones biotopes. Moderate biotope diversity was sampled at site D1 on the Doring River, with substrate dominated by stones in and out of current, and mud substrate. No aquatic vegetation was sampled.

All sites bar B3 are considered to have habitat types capable of supporting a moderate diversity of macroinvertebrates and is therefore considered a hindrance on a highly diverse assemblage.

Figure 6-5 Habitat sampled at site S2 on the Sand River (March 2022)

Figure 6-6 Illustration of the reach type within the Boschluispruit (B3, March 2022)

Figure 6-7 Typical marginal vegetation within the Boschluispruit (B3, March 2022)

6.3.2 South African Scoring System

The SASS5 score and SASS5 ecological classes obtained for each site sampled during the surveys are presented in Table 6-4. According to RQOs, the ASPT for the Sand River must above 5 for the Sand River.

Table 6-4 Macroinvertebrate assessment results recorded during the survey (March 2022)

Site	SASS5	Taxa	ASPT*	**Class (Dallas, 2007)
		Sand River		
S2	96	16	6.0	B
		Palmietkuilspruit		
P1	72	16	4.5	C
		Doring River		
D1	94	14	6.7	B
		Boschluispruit		
B3	42	11	3.8	E/F

*ASPT: Average score per taxon; ** Highveld Lower - Ecoregion

The results of the high flow 2022 SASS5 assessment indicated total sensitivity scores ranging from 42 at B3 to 96 at S2. The diversity of taxa observed ranged from 11 at B3 to 16 at P1 and S2. The derived ASPT value (average sensitivity score) for the sites ranged from 3.8 at B3 to 6.7 at D1. The ecological classes obtained ranged from class E/F at B3 to class B at sites S2 and D1. The ASPT at site B3 indicated largely tolerant taxa were collected within the reach. Moderately tolerant taxa collected include Gerridae, Ceratopogonidae, and Dytiscidae. A total of 5 of the 11 taxa were air breathers at site B3 which allow these taxa to survive within the low DO waters at the site.

Moderately tolerant taxa were collected within the Palmietkuilspruit during the survey as indicated by the ASPT of 4.5. Flow sensitive taxa were collected within the system, including Hydropsychidae and more than 2 spp. of Baetidae. Moderately sensitive taxa collected include Ancylidae and Atyidae.

Site S2 presented a moderately diverse macroinvertebrate community and the biotic integrity was rated as largely natural. The ASPT score indicated a moderately tolerant community collected (ASPT of 6.0). Sensitive taxa collected include Elmidae, Atyidae, and Ecnomidae. The ASPT recorded was above the stipulated ASPT value within the RQOs of 5.

The ASPT recorded within the Doring River indicated moderately intolerant taxa collected within the reach (ASPT of 6.7). The biotic integrity of the site was rated at largely natural. Modifications to instream habitat and water quality contributed to the modifications to the macroinvertebrate community.

An illustration of selected macroinvertebrates is illustrated in Figure 6-8.

Figure 6-8 Examples of Atyidae on the left and Aeshnidae on the right

6.4 Macroinvertebrate Response Assessment Index

The MIRAI methodology was conducted according to Thirion (2007). Data collected from the SASS5 method was applied to the MIRAI model. The MIRAI model provides a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic macroinvertebrate community (assemblage) from the reference condition (unmodified river). The MIRAI results provide a more robust interpretation of the macroinvertebrate community structure compared to the SASS5 biological bands. It should be noted that the MIRAI score for Sand River should be interpreted with caution due to flooding conditions during the survey. Additionally, due to access limitations, MIRAI scores were determined from single sites on the reach, reducing the confidence of the scores. The reference condition for the study sites was selected based on the geomorphological setting and longitudinal zonation of the watercourses considered in the study. As derived from the SASS5 results the aquatic macroinvertebrate community observed in the study sites consisted of tolerant taxa, with highly sensitive species being absent from the samples. The results of the MIRAI are presented in Table 6-5.

Table 6-5 MIRAI Score for the various watercourses

Invertebrate Metric Group	Doring River	Sand River	Boschluispruit
Flow Modifications	52,2	37,0	47,0
Habitat	44,1	42,0	47,4
Water Quality	48,6	43,7	41,2
Ecological Score	**48**	**41**	**45**
Category	**D**	**D/E**	**D**
RQOs	**-**	**C**	**-**

The results of the MIRAI completed in the watercourses for the study period indicates largely modified conditions within the Doring and Boschluispruit systems. Modifications to habitat and water quality drivers were the largest contributors to modified macroinvertebrate communities within the Doring River, with flow modifications further contributing to the modified community.

The invertebrate community was largely dominated by species adapted to the vegetation biotopes where diverse groups of Hemiptera, Diptera and Coleoptera were observed. Several sensitive taxa observed included Scirtidae (previously Helodidae), Dixidae, and Elmidae. Several taxa were absent, including tolerant and water quality sensitive taxa such as Heptageniidae and Leptophlebiidae. The absence of the water quality sensitive taxa was anticipated due to the eutrophic nature of the watercourses compounded by the elevated salinity. The absence of the tolerant taxa could be attributed to instream habitat modification in the Doring River, whilst biotopes were found to be smothered in the Boschluispruit.

The results of the MIRAI confirm the ecological condition of the watercourses and effectively depict the current level of instream habitat modification. The ecological classification of the Sand River (class D/E) was below the stipulated RQOs of class C. As previously mentioned, due to flooding, these results should be interpreted with caution.

6.5 Fish Communities

Sampling for fish was conducted at sites S2, P1, B3 and D1 during the study. A total of nine of the eleven native species were observed during the survey, with the highest representation of the fish community observed at sites S2, with 73% of the expected community, and 50% at sites P1 and D1 of the expected fish community were collected. A summary of expected species and fish collected is presented in Table 6-6 and illustrated in Table 6-8. No fish were collected within the Boschluispruit.

It should be noted that *Enteromius trimaculatus* was collected within the Sand River at site S2, which is not expected in the reach according to DWS (2014), Skelton (2011) or IUCN (2022), and likely represents a new distribution record for the species. The species is listed as Least Concern (LC) and is not a species of conservational concern.

Habitat sampled within the Sand River was considered moderately diverse, however, the presence of a weir artificially increased habitat diversity. The fish community largely consisted of cyprinids from the genera *Enteromius* sp., *Labeo* sp., and *Labeobarbus* sp. which are moderately intolerant to moderately tolerant to flow modifications, and moderately tolerant to modified to physico-chemical parameters (Table 6-9).

Cover features sampled within the Doring and Palmietkuilspruit were limited and would contribute to the absence of several species. The presence of instream impoundments within the Boschluispruit would limit migration and the presence of several species in the upper reaches. Additional surveys are required to improve the confidence of the fish community assessment. No species of conservational concern were collected within the sampled sites.

The results of the Fish Response Assessment Index (FRAI) are presented in Table 6-7. Results indicate the fish community within the Sand River is moderately modified, which is attributed o the presence of 73% of the expected fish community. The absence of *Labeobarbus kimberleyensis* and *Austroglanis sclateri* contribute to the lowered ecological state, however, the results of this survey do not discount the presence of these species within the reach. The FRAI score indicated the stipulated RQOs of class C for the fish community were met within the Sand River.

The Palmietkuilspruit and Doring were classed as moderately to largely modified. The diversity of hydraulic biotopes and cover features were limited within both systems and were a limiting factor to the fish community. Water quality perturbations within the Doring further reduced the biotic integrity.

Table 6-6 Presence/absence of fish species for the sampled sites

Species	IUCN (2022)	S2	P1	B3	D1
Austroglanis sclateri	LC	0	0	0	0
Clarias gariepinus	LC	1	1	0	1
Enteromius anoplus	LC	0	1	0	1
Enteromius paludinosus	LC	1	1	0	0

Species	IUCN (2022)	S2	P1	B3	D1
Enteromius trimaculatus (not expected within the catchment)	LC	1	0	0	0
Labeo capensis	LC	1	0	0	0
Labeo umbratus	LC	1	0	0	0
Labeobarbus aeneus	LC	1	0	0	0
Labeobarbus kimberleyensis	NT	0	0	0	0
Pseudocrenilabrus philander	LC	1	1	0	1
Tilapia sparrmanii	LC	1	1	0	1
Expected		**11**	**10**	**5**	**10**
Total		**8**	**5**	**0**	**5**

Table 6-7 FRAI results for the various watercourses

FRAI	Doring River	Sand River	Boschluispruit	Palmietkuilspruit
Adjusted Score	61,75	76.86	23.0	59,32
Category	C/D	C	E/F	C/D
RQOs	-	C	-	

Table 6-8 Illustration of fish species observed

Species/Site	Photograph
Clarias gariepinus	
Enteromius anoplus	
Enteromius paludinosus	
Enteromius trimaculatus	

Species/Site	Photograph
Pseudocrenilabrus philander	
Tilapia sparrmanii	

Table 6-9 Hydraulic biotope preferences and water quality intolerances for expected and collected species

	Velocity-depth preference				Flow intolerance				Cover preference					Tolerance: modified physico-chem			
Scientific Names	**Fast deep**	**Fast shallow**	**Slow deep**	**Slow shallow**	**Intolerant: no-flow (>4)**	**Moderately intolerant: no flow(>3-4)**	**Moderately tolerant: no flow (>2-3)**	**tolerant: no flow (1-2)**	**Overhanging vegetation: high->very high (>3)**	**Bank undercut: high->very high (>3)**	**Substrate: high->very high (>3)**	**Aquatic macrophytes: high->very high (>3)**	**Water column: high->very high (>3)**	**Intolerant: modified wq (>4)**	**Moderately intolerant: modified wq (>3-4)**	**Moderately tolerant (>2-3): modified wq**	**Tolerant: modified wq (1-2)**
Austroglanis sclateri	0	3,80	3,40	0	0	3,20	0	0	0	3,50	4,40	0	0	0	0	2,60	0
Clarias gariepinus	0	0	4,30	3,40	0	0	0	1,70	0	0	0	0	0	0	0	0	1,00
Enteromius anoplus	0	0	4,10	4,30	0	0	2,30	0	4,00	0	0	3,20	0	0	0	2,60	0
Enteromius paludinosus	0	0	3,90	3,90	0	0	2,30	0	4,20	0	0	3,60	3,50	0	0	0	1,80
Enteromius trimaculatus	0	0	3,90	3,20	0	0	2,70	0	3,90	0	0	0	0	0	0	0	1,80
Labeo capensis	3,30	0	4,20	0	0	3,50	0	0	0	0	4,20	0	3,20	0	0	2,80	0
Labeo umbratus	0	0	4,50	0	0	0	2,70	0	0	0	4,20	0	0	0	0	0	1,60
Labeobarbus aeneus	3,50	4,00	3,50	0	0	3,30	0	0	0	0	4,00	0	4,00	0	0	2,50	0
Labeobarbus kimberleyensis	4,30	3,80	3,70	0	0	3,80	0	0	0	0	0	0	3,30	0	3,60	0	0
Pseudocrenilabrus philander	0	0	0	4,30	0	0	0	1,00	4,50	3,20	0	0	0	0	0	0	1,40
Tilapia sparrmanii	0	0	0	4,30	0	0	0	0,90	4,50	0	0	3,60	0	0	0	0	1,40

6.6 Present Ecological Status

The PES assessment for the Sand River, Doring River, and Boschluispruit are based on the collective data collected based on the March 2022 survey. The spatial, temporal, and flooding limitations experienced during the field survey. The results are provided in Table 6-10 and Table 6-11, respectively.

Table 6-10 Present Ecological Status of the Sand River (March 2022)

Aspect Assessed	Survey Results	RQOs
Instream Ecological Category	C	C
Riparian Ecological Category	C	C
Aquatic Invertebrate Ecological Category	D/E	C
Fish Community	C	
Ecostatus	C	C

The results of the PES assessment in the Sand River derived a moderately modified status in 2022. The anthropogenic activities within the reach have resulted in moderate modifications to the riparian and instream habitat integrity of the reach. However, upstream activities have contributed to erosion of the Sand River banks and riparian zones resulting in instream sedimentation, increased water quality perturbations from urban, agricultural and mining activities, reducing the biotic integrity of the reach. Despite upstream activities and deterioration to the system, the Sand River has achieved the RQOs of class C within the project area. Any proposed activities within the catchment should not further contribute to the deterioration of the instream and riparian zones as this will compromise the ecological integrity of the reach and RQOs may not be achieved.

Table 6-11 Present Ecological Status of the Doring River (March 2022)

Aspect Assessed	Score
Instream Ecological Category	48
Riparian Ecological Category	45
Aquatic Invertebrate Ecological Category	48
Fish Community	62
Ecostatus	class D

The ecological status of the Doring River during the 2022 survey was determined to be largely modified (class D). The modified nature of the watercourse was driven by diffuse agricultural runoff, discharges and runoff from mining activities, which have resulted in water quality perturbations that reduce the biotic integrity of the system. The erosion of banks and riparian zone have resulted in largely modified riparian and instream habitat integrity. The high erodibility of soils within the catchment have high risks to additional activities within the reach.

Table 6-12 Present Ecological Status of the Boschluispruit River (March 2022)

Aspect Assessed	Score
Instream Ecological Category	55
Riparian Ecological Category	47
Aquatic Invertebrate Ecological Category	45
Ecostatus	class D

The results of the Boschluispruit indicated largely modified ecological conditions within the reach. Modifications to the reach were attributed to erosion, instream impoundments within the upper reaches and influxes of poor water quality from agricultural and mining activities.

The baseline assessment indicated catchment wide impacts to the watercourses associated with the project area. Impacts have resulted in deterioration of drivers, namely water quality, habitat, and flow. The modification of these drivers have resulted in a modified biotic communities within the various watercourses. Despite direct modifications to the Sand River, and contributions of sediments and poor water quality from the Doring and Boschluispruit, the RQOs for the reach have been achieved. However, due to the sensitivity of soils to erosion within the reach, an increase in anthropogenic activities poses a risk to the ecological integrity of the watercourses. Given the findings of this assessment, no pristine or natural waterbodies were observed or expected in any of the project right areas.

6.7 Sensitivity Assessment

As noted in the geomorphological description of the project area, the watercourses considered in this assessment represented characteristic source zone waterbodies with wetlands. As can be observed in Figure 6-9, riparian vegetation was limited to features characteristic of wetlands. Given the wetland nature of the riparian vegetation, and relationships between wetland integrity within catchments and stable riverine conditions, the delineated wetlands as identified in TBC (2022) were used to derive the sensitive habitats. Riparian zones within the lower foothills of the Doring and Sand River were well defined and comprised of woody species Figure 6-10.

Figure 6-9 Typical headwater zone in the upper reaches of the Boschluispruit

Figure 6-10 Typical lower foothills zone and well defined riparian zone within the Sand River

The ecological sensitivity of the watercourses was determined to be largely uniform across the project area. Limited presence sensitive riverine biota was noted during the assessment, which is attributed to water quality and habitat degradation. Overall, the macroinvertebrate communities were made up of tolerant taxa with limited sensitivities. Taxa such as Atyidae (Freshwater shrimp), Hydropsychidae, Elmidae (Riffle beetles), and Ecnomidae (caddis fly) were determined to be the most sensitive aquatic invertebrates observed during the baseline assessment. Ichthyofauna communities were also found to be dominated by tolerant/adaptable taxa and largely consisted of cyprinids from the genera *Enteromius* sp., *Labeo* sp., and *Labeobarbus* sp. which are moderately intolerant to moderately tolerant to flow modifications, and moderately tolerant to modified to physico-chemical parameters.

Given the assessments that have been conducted in the region, the above taxa are likely to occur only in isolated populations. Considering the presence of such taxa, the watercourses in the project area are regarded as sensitive environments in relation to changes in flow and water quality.

In-line with GN704, the delineated floodline of 1:50 year or within a horizontal distance of 100 m from a watercourse, whichever is greatest should be considered a no-go area. According to the National Water Act, Section 21 (c) and (i), the term “wetland” is included in the legal definition of a watercourse. The legal definition of the extent of a watercourse is defined in the amendment of the General Authorisation for section 21 (c) and (i) water uses in terms of GN509 of 2016 (DWS, 2016a). The extent of the watercourse is defined as:

- A river, spring or natural channel in which water flows regularly or intermittently “within the outer edge of the 1 in 100 year floodline or riparian habitat measures from the middle of the watercourse from both banks” and for:
- Wetlands and pans: the delineated boundary (outer temporary zone) of any wetland or pan.

Given the varied geomorphological features of the watercourses, the delineated areas proposed in the wetland assessment for this project (TBC, 2022) are utilised to define the watercourse extent within the headwaters of the Boschluispruit, unchanneled valley bottoms and depressions, and the lower foothill riparian zones were delineated by identifying vegetation features on aerial imagery. An example of the proposed watercourse extent as well as where appropriate buffer areas are provided in Figure 6-11 and Figure 6-12. The various layouts and their respective delineated sensitive areas are depicted in Figure 6-13.

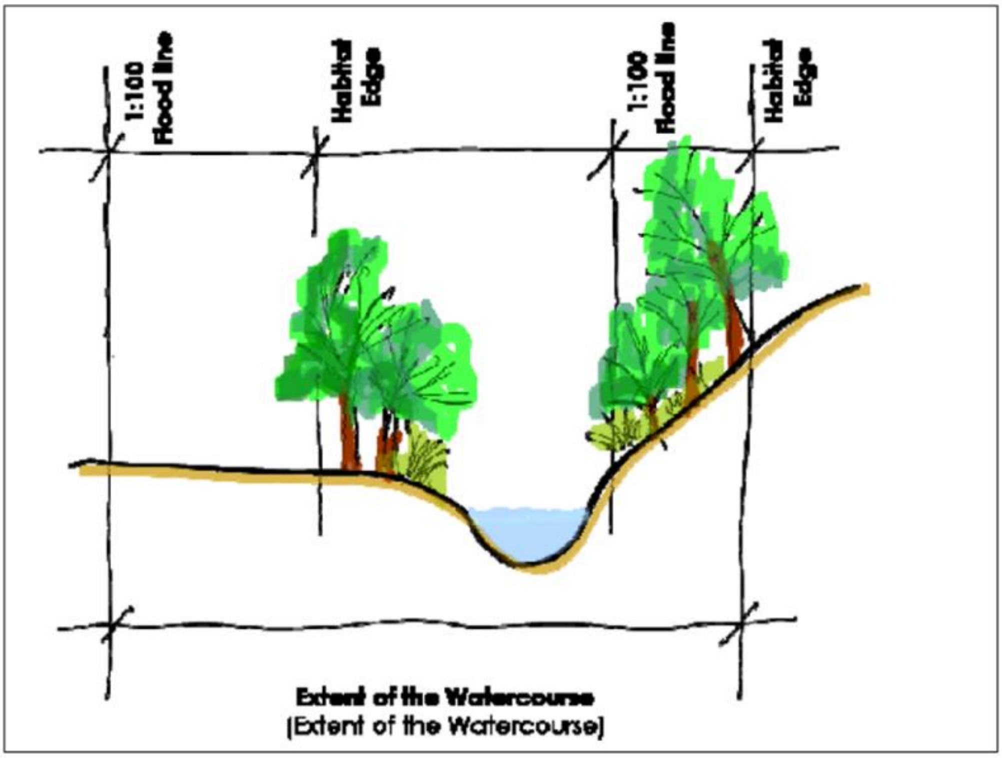

Figure 6-11 Illustration of the extent of a watercourse (DWA, 2012)

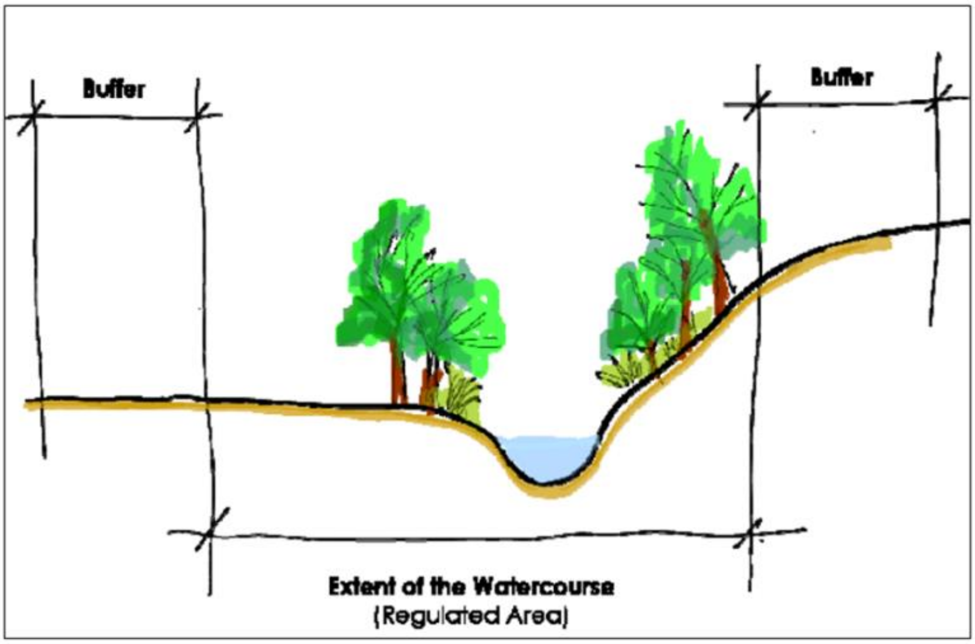

Figure 6-12 Illustration of the extent of a watercourse and the Regulated Area (DWA, 2012)

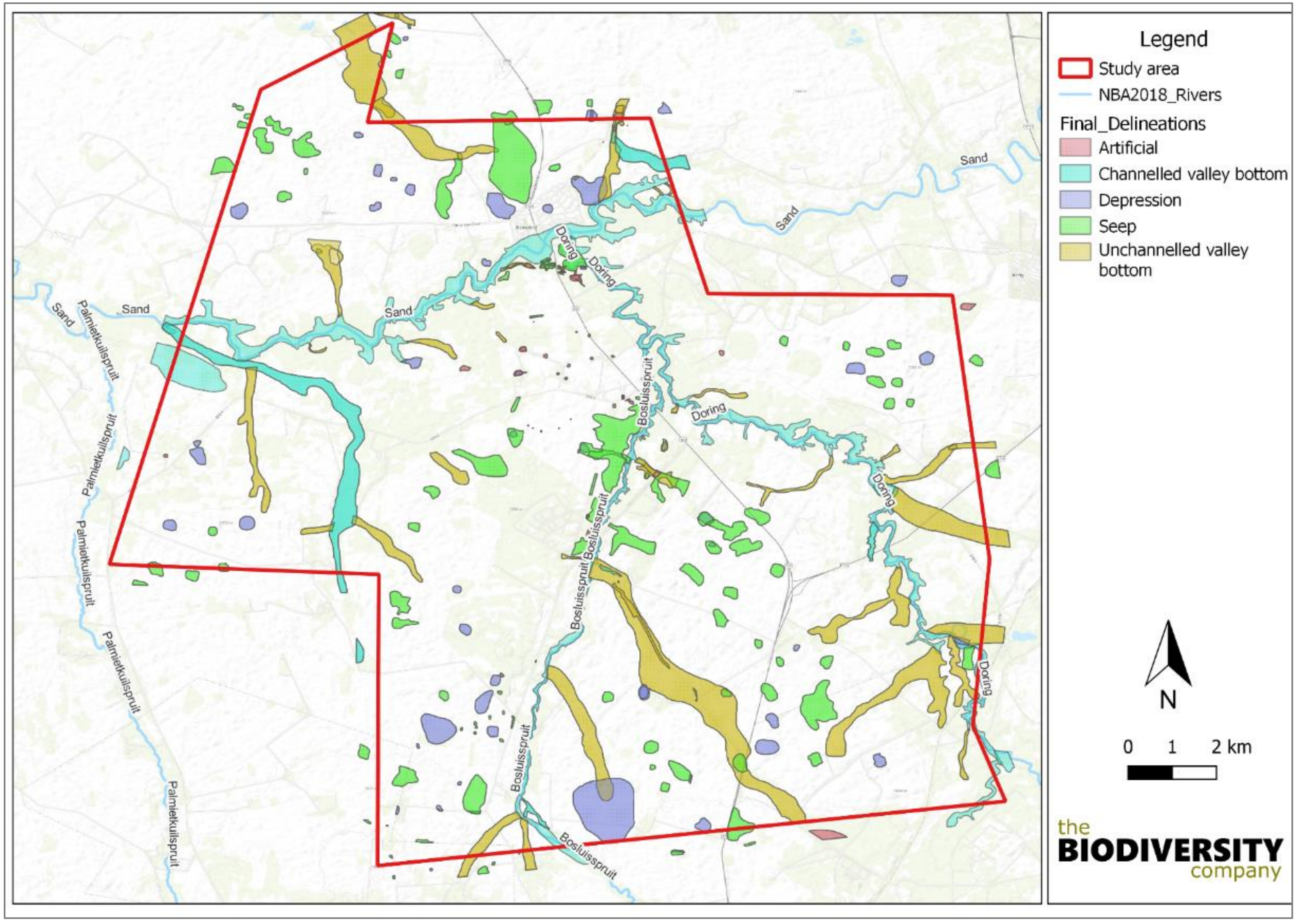

Figure 6-13 Tetra4 Cluster 2 project area and associated sensitive freshwater resources (TBC, 2022)

The overall Ecological Importance and Sensitivity (EIS) of the river reaches in this study were assessed according to Kleynhans (1999). The results of the EIS assessment are provided in the table below (Table 6-13). The results of the EIS assessment derived a moderate EIS for the river reaches assessed in this study from the Vaal WMA.

Table 6-13 Ecological Importance and Sensitivity Ratings for the Watercourses in the project area located Sand River and Doring River

Biological Determinants		
Determinant	Rating	Comment
Rare and endangered biota	3	More than one taxon rare or endangered at a local scale
Unique biota	2	The aquatic fauna are distributed widely throughout the Middle Vaal WMA
Intolerant biota	2	Source zone conditions make the presence of flowing water rare. Therefore, flow intolerant taxa make up only a small portion of the aquatic fauna
Species richness	2	On a local scale the species richness is moderate
Habitat Determinants		
Diversity of aquatic habitat	2	Impacted system, most of which are permanent impacts (erosion)
Refuge value of habitat types	2	Limited refuge areas
Sensitivity of habitat to flow modification	2	Moderate sensitivity to flow modifications
Sensitivity to flow related water quality changes	1	Low number of impoundments within the project area
Migration route corridor for instream and riparian biota	1	The watercourses are in the mid to upper reaches of the river systems
National parks and wilderness areas	0	No NFEPA listing and no nature reserves associated with the watercourses.
Mean	**1.7**	
EIS class	**Moderate**	

6.7.1 Buffer Requirements

The "Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries" (Macfarlane et al*.* 2014) was used to determine the appropriate buffer zone for the proposed activity. The buffer size for the delineated water resources has been calculated according to the various water resources, and are as follows:

- Riparian zones of lower foothill rivers – 50 m; and
- Wetlands, non-perennial systems and drainage lines – 35 m.

Buffers and sensitive receptors are presented in Figure 6-14 to Figure 6-17. Linear infrastructure includes pipelines and, river crossings, and non-linear infrastructure includes compressor stations that intersect with riparian zones and buffers. Alternatives have been provided and are illustrated in Figure 6-14 to Figure 6-17. The re-aligned compressor stations are preferred due to avoidance of sensitive areas. The allocated buffers consider the high erodibility of the soils within the catchment. Areas associated with the watercourses that are eroded should be avoided or stabilised to minimise additional channel and bank erosion and subsequent sedimentation to downstream systems.

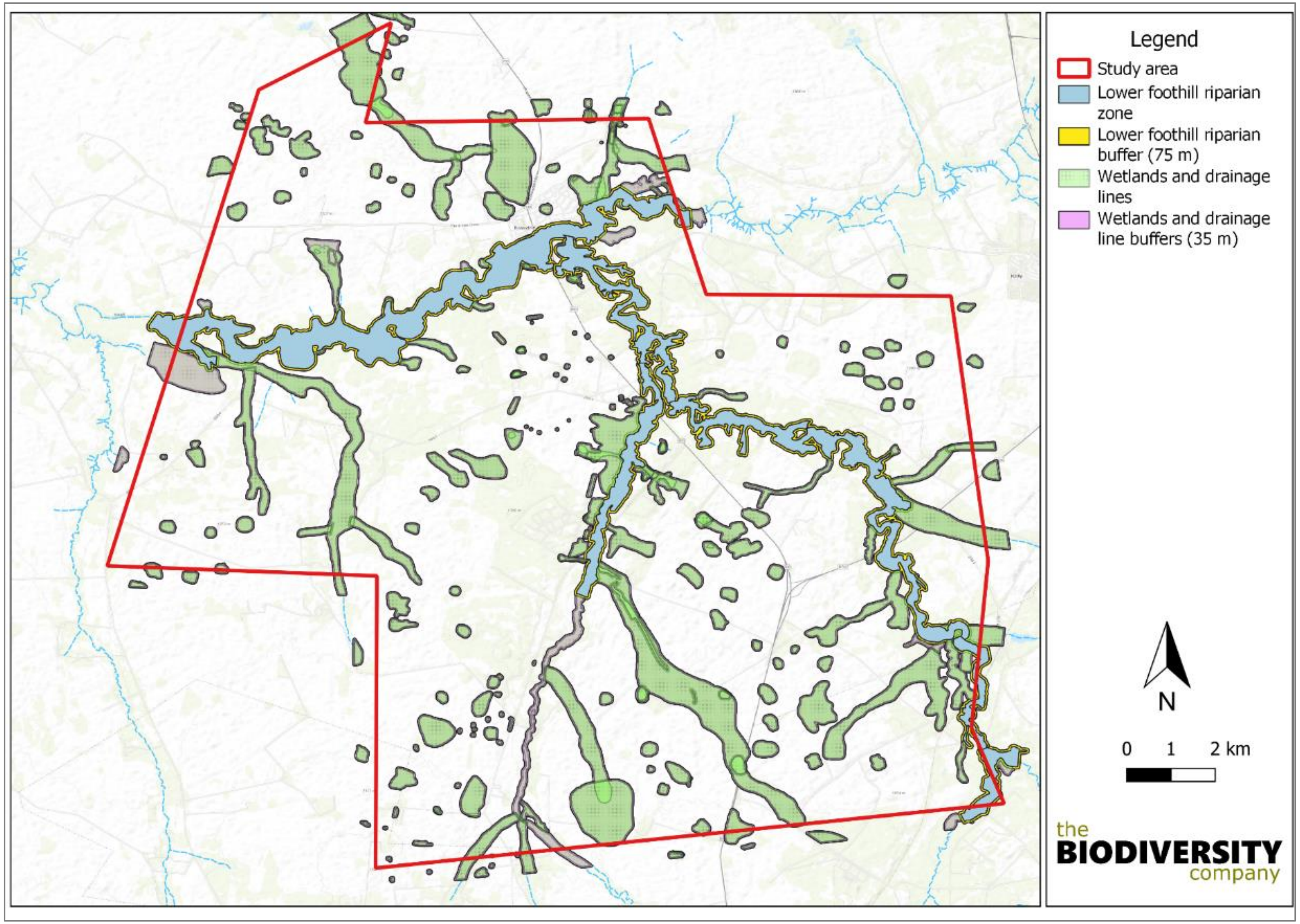

Figure 6-14 Sensitive freshwater resources and buffers

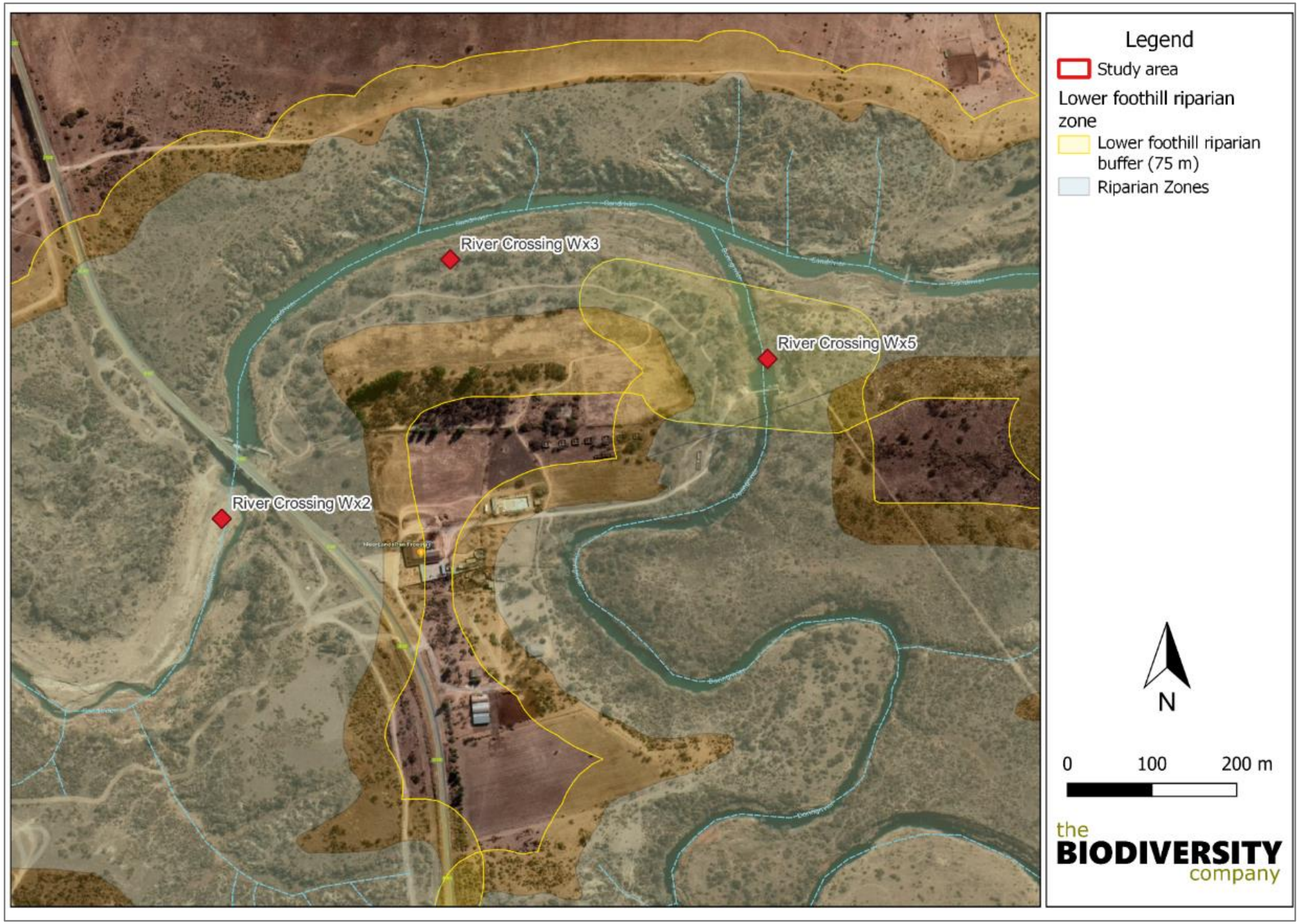

Figure 6-15 Sensitive freshwater resources and buffers and proposed Sand and Doring River crossings

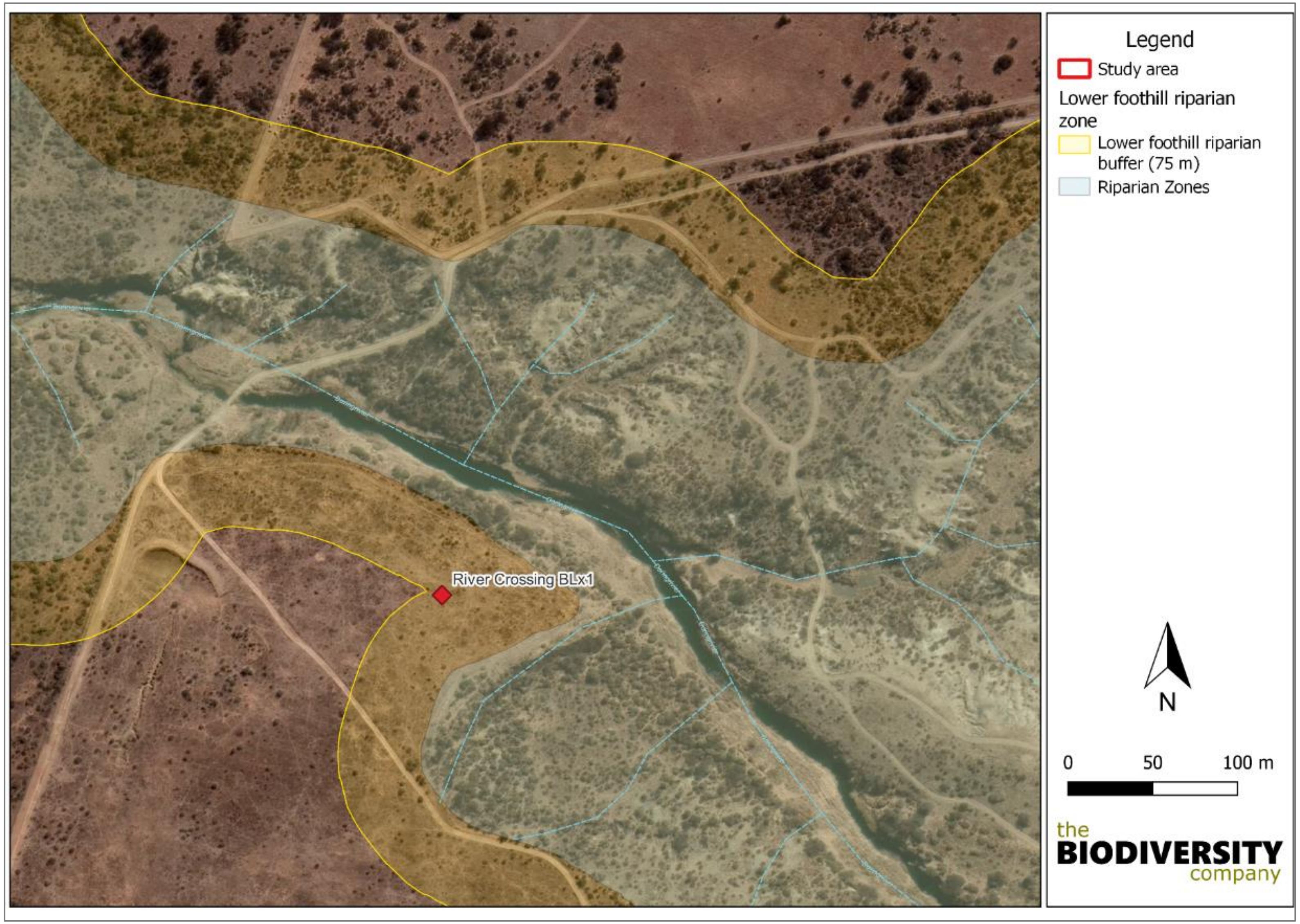

Figure 6-16 Sensitive freshwater resources and buffers and proposed Doring River crossing

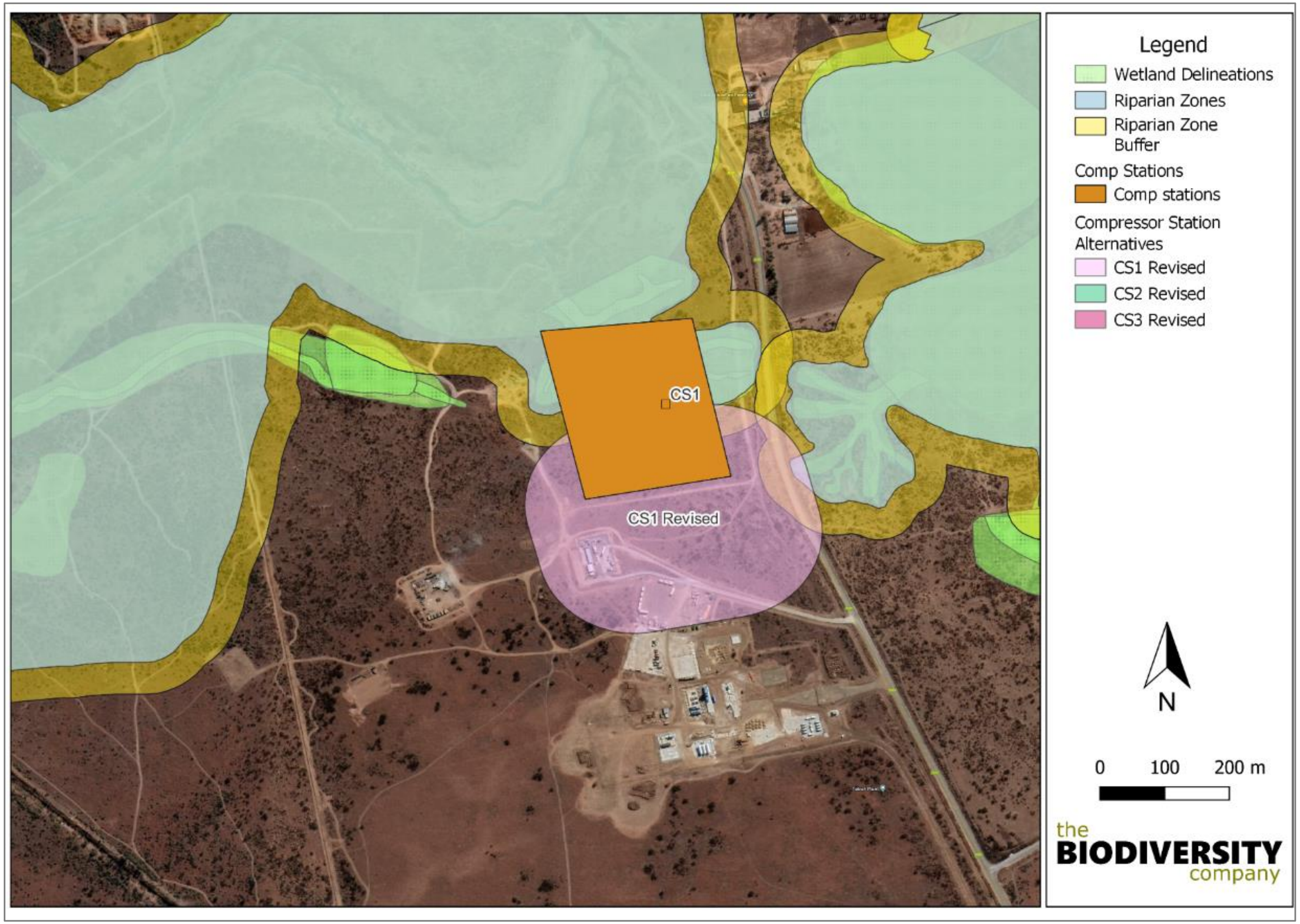

Figure 6-17 Illustration of proposed compressor station CS1 and CS1 Alternative within the water resource and buffer

7 Impact Assessment

The sections below serve to outline and summarise the types of perceived impacts from the proposed activities on the aquatic ecosystems, as well as responses to the concerns raised by stakeholders. The associated significance of each impact is evaluated as relevant to the local biodiversity and the likely project activities.

7.1 Anticipated Activities

It is evident from the figure that the following may have a negative effect on more sensitive water resources, most impacts involve the water resources and the habitats connected to these:

- Expansions to the current LNG and Helium production plant located on the Farm Mond van Doorn Rivier. The planned expansions will be to increase the helium and LNG production capacities significantly (~30 fold increase) and increase the footprint of the existing approved plant by approximately 10 ha;
- The drilling of new gas wells ~300 wells spread over a total study area (Cluster 2) of approximately ~27 500 ha;
- The installation of trenched pipelines connecting the wells to localised booster compressors and then to in-field compressor stations (~3 sites) and subsequently the compressor stations to the main plant area; and
- There will be a requirement to have short powerlines (132kV and 33kV) and water connections to the compressor sites."

7.2 Stakeholder Comments

Highlighted concerns/comments from stakeholders relevant are represented and discussed in Table 7-1 below.

Table 7-1 Stakeholder considerations relevant to the report

Comment	Tetra4 EIA formal response	Specialist Response
The impact of erosion, construction and operational phases. (Seen from cluster 1's 'rehabilitation')	The majority of erosion concerned have been on areas that has minimal or no vegetation, such as access road. Tetra4 has and implements and erosion and stormwater management plan to continuously monitor and address these areas of concern	Continuous monitoring is required to assess whether revegetation efforts are successful to reduce erosion, particularly prior to the wet season. Stormwater management plan needs to include energy dissipation measures to reduce the probability of erosion.
Alien and invader plant species, all phases. (Viewed from Cluster 1)	Tetra4 has and implement an alien and invasive plant species management plan and continuously monitors and applies control measures as required. It has been noted that the areas of most concern, is areas where the background site is already predominated by these species.	As indicated in the terrestrial study: Fourteen (14) IAP species listed under the Alien and Invasive Species List 2020, Government Gazette No. GN1003 as Category 1b were recorded within the project area. As per the Tetra4 response, due to the predominant land uses (agriculture), the AIP are numerous and have proliferated Due to this the infestation will require tedious and long during management and control. Any landowner is responsible for any Category 1b species within their 'property' and must be controlled by implementing an IAP Management Programme, in compliance of section 75 of the NEMBA

7.3 Review of Cluster 1 EIA and EMPr

Several impacts were identified for the aquatic ecology and wetland assessment completed by Imperata Consulting CC (2017), which were also considered for the Cluster 2 gas exploration project. The impacts and mitigation measures from Cluster 1 that are still relevant/adequate are represented and discussed in Table 7-2 below.

Table 7-2 Cluster 1 Environmental Impacts and EMPr

Ref #	Activities	Impact/ Aspect	Management/ Mitigation Measures	Planned Outcomes and/or Targets
1	All	Water quality baseline	The pre-production condition of the water resources must be utilised as the target for post-production closure objectives. All necessary measures must be taken to ensure that the post-production water quality as the same as pre-production baseline levels. In order to achieve this relevant water pre-construction water sampling must be undertaken to determine the baseline.	Reliable baseline data
2	All	Management of sensitive areas	Any drill sites or infrastructure routes located inside medium, high or very high sensitive sites on the sensitivity /constraint map require a site-specific pre-commencement assessment. The pre-commencement assessment must address the sensitive aspects on site, as identified in the overall sensitivity / constraint map. The pre-commencement assessment must be compiled by the site Environmental Officer (EO) with a suitable environmental qualification and experience. All recommendations of the pre-commencement assessment must be implemented on site. The completeness and adequacy of the pre-commencement assessment in respect of identifying and managing on site sensitivities must be included in the monthly ECO reports and annual independent audit. [Amendment 2019/05].	Avoidance and/or management / mitigation of sensitive environmental areas.
15	All	Loss of watercourse habitat	Locate pipeline/ trunkline alignments/ compressors outside of buffered watercourses (sensitive watercourse habitat) as far as possible. Buffered watercourses within proximity to the construction footprints should be demarcated on site for the entire construction process to help indicate sensitive areas and prevent unauthorized access. Unavoidable crossings should ideally be located perpendicular to the direction of flow at the shortest possible crossing distances. Long crossings along the length of wetlands, rivers and drainage lines should be avoided as far as practically possible. Aboveground pipeline watercourse crossings that are suspended on plinths are recommended as opposed to the excavation, lowering and infilling of pipelines in watercourses. Tetra4 should make provision in the design phase for permanent access tracks/ roads that will be required for the maintenance of the pipeline. A construction method statement should be prepared by the contractor with input from a watercourse specialists prior to the start of construction.	Avoid or minimise damage to watercourse habitats.
20	All	Disruption of watercourse hydrology	Pipeline crossings through wetlands and other watercourses should ideally be raised aboveground on plinths to prevent preferential flow along their length. In areas where this is not possible, trench breakers with a low hydrological conductivity should be used to reduce water movement in bedding and padding material along the buried pipeline in wetlands and other watercourses. Long and/or steep approaches that border watercourses (specifically wetlands) should receive trench breakers that will help to restrict the desiccation impact on wetlands due to preferential drainage. It is recommended that input be obtained from a geotechnical specialist or geohydrologist regarding the use and positioning of trench breakers along buried sections of the pipeline. Other crossings through depression (pan) and flat wetland require trench-breakers or other forms of underground barriers/plugs to prevent preferential drainage along the pipeline/trunkline alignment.	Ensure continued watercourse integrity and functionality.
21	Processing facilities	Decrease in surface water quality	Design and implement a site specific stormwater management plan for the compressor and helium/LNG plant that will enable dispersed release of runoff at outlets, with outlets located outside (upslope) of buffered watercourses (where possible). ensure separation of clean and dirty water and provide for adequate dirty water containment. Ensure that sufficient ablution facilities are available on site and that septic tanks are located outside of buffered watercourses. Stabilise new channels that form as a result of headcut erosion or other forms of erosion once they are recorded [Amendment 2019/05].	Minimise pollution and sedimentation of water resources and minimise and control erosion.
36	Exploration/ Production drilling	Water pollution and waste management	<u>To mitigate the effluent from long term drilling sites (>3 years)</u>: Separation pits (sumps) for wastewater and grease and oil polluted fluids should be excavated and constructed to treat wastewater; Where excavating these pits, topsoil and subsoil should be stored separately; Sump areas should be lined with PVC to prevent seepage; In order to contain non-biodegradable oil and fuel spills, drip pans or PVC lining should be provided for mobile pans and drip pans; For stationary drill rigs, thin concrete slabs and/or with PVC lining should be installed before the stationary drill rigs are erected; Sump	Control effluent and waste to minimise impact on environment.

			areas must be designed to accommodate the 1:100 year flood event. Clean and dirty water streams must be separated. Sump areas must be designed to accommodate the 1:100 year flood event. Clean and dirty water streams must be separated. The location and design of the sumps must be in accordance with the applicable GN 704 conditions [Amendment 2019/05]; and Sump areas should be constructed in such a way that clean water (stormwater) is diverted away from these areas. <u>To mitigate effluent from short term drillings sites (<3 years):</u> The topsoil layer of the surface area required for the drill should be excavated and stored according to accepted topsoil management practices; A contiguous impervious PVC layer (e.g. large silage sheets) is placed under the drill (within the excavated area) to collect any spills; Spills of hazardous substances should be collected and disposed of according to the approved EMPR requirements at a suitably licensed facility; Collected spills from the drill must not be allowed to contaminate the soils and/or the closed water system utilised for the drilling fluids; and It is recommended that where possible, closed, above ground tanks are utilised for future drilling as opposed to sumps/pits.	
37	Construction areas	Stormwater control and management	All clean water should be diverted away from the site. Minimize the area that is disturbed during production activities in order to minimize the potential stormwater disturbance and to reduce the sediment loads to receiving water courses. Adequate drainage and erosion protection in the form of cut-off berms or trenches should be provided where necessary.	Minimise pollution and sedimentation of water resources and minimise and control erosion.
48	All	Disruption of aquatic communities	Ideally, no vehicle access tracks/roads should transect through watercourses. Access tracks/roads should be designed in such a way to minimise overlap with watercourses. Use existing access roads/tracks as far as possible. Construction and unavoidable access tracks/roads through wetlands, rivers and other watercourses must provide habitat connectivity between upstream and downstream reaches (e.g. flume pipes and/or culverts) and to reduce the risk of scour erosion and channel incision within the watercourse. . No unauthorised driving should be allowed through watercourses. Driving can only occur on specially designed tracks/roads that minimised the risk of erosion and surface flow concentration. No perched flumes should be present in temporary construction running tracks and/or permanent access tracks. In the case of aboveground pipelines, the pipeline should not be located 'flush' along the surface profile of the watercourse with no gap between the natural ground level and the pipeline. Aboveground pipelines should rather be suspended on plinths of a sufficient height that will allow the free movement of indigenous fauna present within the study area, such as tortoises, as recorded in the Bosluisspruit channel near existing well SPG3.	Ensure continued aquatic habitat and community integrity.
49	All	Watercourse erosion	Prevent the use of only one or two flume pipes in access/running tracks located in watercourses, specifically unchannelled valley bottom wetland and seep wetlands where concentrated flows can result in headcut development and the formation of a channel. Surface flows should also be spread out in channelled watercourse crossings though the use of several flume pipes to prevent channel incision and scour erosion. Access tracks should be maintained during the entire construction process and removed once construction is completed. Flume pipes should be monitored and kept free of blockages. Construction in watercourses should ideally occur during the dry season. Any new erosion features identified should be stabilised during the construction process (soft interventions such as hay bales, rock packs, runoff control berms and 'bio-socks' are recommended). Erosion control features should be maintained. Keep vegetation clearing to a minimum on the adjacent slopes to prevent erosion on approaches bordering watercourses. Small temporary contour berms may be used to help control runoff on approaches should it be required. Drainage furrows that may be required to create dry working conditions should ideally be avoided as they can easily erode during high flow events. Development of a watercourse monitoring plan before the onset of the construction phase, and the development and implementation of a watercourse rehabilitation plan during the latter half of the construction phase to ensure the eroded wetlands and other watercourses are stabilised and rehabilitated. Dewatering discharges at construction sites should be done in a silt bay to prevent erosion and sedimentation in adjacent watercourses. Runoff from the construction footprint should be controlled on site to prevent concentrated point releases of water into downslope watercourses. Care needs to be taken not to initiate or aggravate erosion in watercourses.	Ensure continued watercourse services and functionality.

55	All	Increase sediment loads	Progressive rehabilitation of disturbed land should be carried out to minimize the amount of time that bare soils are exposed to the erosive effects of rain and subsequent runoff. Traffic and movement over stabilised areas should be controlled (minimised and kept to certain paths), and damage to stabilised areas should be repaired timeously and maintained. The total footprint area to be cleared for drilling should be kept to a minimum by demarcating the drilling areas and restricting removal of vegetation to these areas only.	Avoid sediment build-up from exposed soil. Ensure timely rehabilitation of disturbed areas.
56	Exploration/ Production drilling	Spillage of oils, fuel and chemicals	The placement of drip trays under the drilling rigs should be implemented and recorded to minimize the contamination of waste oil from the drilling rig. Drilling fluids should be biodegradable and should be kept in a lined mud pit or surface container. Proper rehabilitation and off site removal of excess fluids should take place. Oil recovered from the drilling rigs and any vehicle on site should be collected, stored and disposed of at licenced facilities or provided to accredited vendors for recycling.	Avoid, minimise and remediate pollution.
57	All	Increased soil erosion	Ensure that topsoil (0-30 cm approx.) and subsoil (30 cm +) are stored separately during excavation, so they can be replaced in the correct order. Ensure that pipeline route is re-vegetated as soon as possible after construction and that soil surface is in good condition.	Avoid, minimise, and remediate erosion.
59	All	Spill response and pollution clean-up	All necessary measures should be taken to prevent spills from occurring on site. However, should a spill occur, the following procedure must be followed: A spill response kit should be available on site at all times. Where potential contaminants are transported along access roads, emergency containment and mitigation measures must be developed to minimize impacts should accidental spills occur. Any spillage will be investigated and immediate action must be taken. In the event of a significant spill (>35 litres) of any hazardous substance, these must also be recorded and reported to the PASA, DWA (DWS) and the local/provincial authority where necessary. Depending on the nature and the extent of the spill, contaminated soil must be either excavated or treated on-site. The EO should determine the exact method of treatment. Clean up should be immediate and to the satisfaction of the EO. A register of the treatment method and clean up close out report must be kept and be made available reviewed by the ECO during independent audits [Amendment 2019/05]. Treatment could include the use of absorbent material or hydrocarbon-digesting substances. It is therefore, recommended that a spill kit and hydrocarbon digesting substance should be kept on site at all times. Clean up should be immediate and to the satisfaction of the ECO. Excavation of contaminated soil must involve careful removal of soil using appropriate tools/machinery to storage containers until treated or disposed of at a licensed hazardous landfill site. Materials used for the remediation of spills must be used according to product specification and guidance for use. A record of all spills and actions taken to remediate the spills should be kept at all times. Proper and frequent maintenance should be done to minimise spillage risk.	Avoid, minimise and remediate pollution.
64	All	Decrease in surface water quality in watercourses	Store all hazardous materials (Incl. hydrocarbons) in a bunded area, outside of buffered watercourses. Stripped and excavated subsoil and topsoil stockpiles should be stored outside of buffered wetland areas and be protected from erosion. This may not be possible for long wetland crossings in seep and other wetlands, in which case topsoil can be stored on low berms within the wetland on geotextile material. Topsoil and subsoil should however be protected from erosion. Approaches that border watercourses, particularly those along steep and long slopes, should receive runoff control measures to prevent siltation and concentrated flow into watercourses. Inspect vehicles for leaks and repair all leaks immediately. Any generators used in watercourses should be used with a functional drip tray. Ensure that sufficient ablution facilities are available on site and that they are located outside of buffered watercourses. Stabilise new channels that form as a result of headcut erosion or other forms of erosion once they are recorded. Sediment deposition should be prevented in watercourses and especially watercourse channels through the following measures: Implementing stormwater control measures around construction areas; and Dewatering during excavation activities in watercourses should be released in a silt bay with sufficient capacity that filters and retains sediment before the water is released into the watercourses. Sediment deposition events into watercourses should be evaluated by an experienced ECO/ wetland specialist and based on the magnitude of the impact recommendations can be made regarding the removal of deposited material.	Ensure continued watercourse services and functionality.

75	All	Watercourse erosion	Use existing access roads as far as possible. Unavoidable new permanent access roads/tracks in watercourses should be designed to prevent erosion downstream of the crossings by using several flume pipes, preferably culverts, or other structures, such as concrete fords. All temporary and permanent vehicle access tracks/roads in watercourses will require approval from DWS in the form of a Water Use License. New permanent access roads/tracks should be located along existing infrastructure footprints as far as possible and at areas that will enable the shortage crossing distance through watercourses. Long crossings along the length of watercourses (parallel to its flow direction) should be avoided. Remnant erosion features that remain after the rehabilitation phase should be addressed until full rehabilitation and closure is achieved. Rehabilitation interventions should be considered with care and not worsen erosion once implemented [Amendment 2019/05]. Identified permanent access tracks should be maintained during the entire operational phase of the project and blockages should be removed, while erosion features should be repaired once observed. Concrete fords (low water bridges) are preferred as crossing structures in larger watercourse channels, compared to culverts and flume pipes, which are more likely to result in erosion and require more regular maintenance. The Helium plant should receive stormwater mitigation measures at its outlets that will prevent concentrated flow. Stormwater mitigation measures and flow outlets should be located outside of buffered watercourses.	Ensure continued watercourse services and functionality.
77	Exploration/ Production drilling and Processing facilities	Pollution prevention and usage of water sources	All contaminated water and spillage will be drained from the containment area into primary and secondary fully lined sumps. Drilling water should be kept in closed circuit and re-circulated to the drilling machine. Water condensate from the gas polishing process (Dehydration) should be treated to remove volatile compounds, before evaporation. Make up water will be introduced when required. All domestic effluent water from the site should be collected and disposed of in an appropriate and legal manner such as a French drain system which is situated not closer than 100 metres from any streams, rivers, pans, dams or boreholes. Do not exceed the water abstraction permit and General Authorisation (GA) limits for water use for drilling activities. All LNG processing facilities and storage vessels must include adequate (at least 110% containment volume) secondary liquid containment areas (e.g. bunds). [Amendment 2019/05].	Minimise pollution of water resources. No wasting of water, usage to be within licensed thresholds.
93	All	Water abstraction	The necessary DWS permits should be obtained if it is expected that DWS abstraction limits will be triggered before water abstraction is undertaken. Obtain agreement from landowner to abstract water from existing boreholes. If required, abstraction of water should be kept within the permit limits as issued to the landowner by DWA. Water may only be obtained from approved sources. [Amendment 2019/05].	Legal Compliance
102	All	Loss of watercourse habitat/ Alterations of the river banks and river bed	Locate pipeline/trunkline alignments outside of buffered watercourses (sensitive watercourse habitat) as far as possible. Buffered watercourses should be demarcated on site for the entire construction process to help indicate sensitive areas and prevent unauthorised access. Mitigation for pipeline construction primarily includes the avoidance of watercourse crossings. Where crossings are unavoidable, crossings should be located along existing infrastructure features, such as roads, dam walls and existing pipelines. Unavoidable crossings should ideally be located perpendicular to the direction of flow at the shortest possible crossing distances. Long crossings along the length of wetlands, rivers and drainage lines should be avoided as far as practically possible. Horizontal directional drilling is recommended for the Sand River and Bosluisspruit crossings, as opposed to the clearing, temporary damming, excavation, lowering and infilling of pipelines in these river watercourses. Vegetation clearing, topsoil stripping, trenching and infilling to bury the pipeline, are considered to be an acceptable approach in other types of watercourse crossings. The construction servitude should however not remain bare (stripped for longer than a month at a time), while trenches should not remain open for more than five days. It is therefore recommended that the pipeline be completely constructed in sections, rather than removing all of the topsoil and creating open trenches across the entire study area for prolonged periods of time. The servitude width should be restricted in watercourse crossings to reduce the footprint of the impact. Topsoil material should only be stripped in the area where trench excavation is required, while the surrounding area in the servitude is only cleared of vegetation. Limited topsoil stripping is conditional on the prevention of soil compaction by heavy motorised vehicles (HMVs) through the use and maintenance of running tracks. Examples of running tracks include bogmats or rock aggregate combined with geotextile fabric and flume	Avoid or minimise damage to watercourse habitats.

			pipes. Alternatively topsoil across the entire width of the construction servitude (often referred to as the right of way) can be stripped and stored separately outside of buffered watercourses. Removed topsoil and subsoil should be sorted separately in stockpiles and protected from erosion when required. Additional erosion protection measures should be implemented for stockpiles that are to be stored for an extended duration [Amendment 2019/05].	
103	All	Loss of watercourse habitat/ Alterations of the river banks and river bed	A construction method statement should be prepared by the contractor prior to the start of construction. Conditions stated in the water use license should also be implemented. The use of old and new quarry sites for bedding and padding material, as well as other needs (e.g. the discard of spoil material) should not be located within wetlands and other watercourse types. Watercourse crossings and construction methods affecting watercourse must comply with the approved water use licence and associated DWS approved method statements [Amendment 2019/05]. The use of sites outside the study are will also be subject to environmental authorisation. Provision should be made in the design phase for permanent access tracks/roads that will be required for the maintenance of the pipeline. After completion of the construction phase, the reinstatement of the original topography of the watercourse (its geomorphological template) should be undertaken followed by re-vegetation activities. The following mitigation measures are recommended: Limit the construction activities to the smallest area possible; Reinstate the geomorphological template of the watercourse crossing using subsoil material, followed by topsoil material on top. This should be done as soon as possible after completion of construction activities; During the reinstatement of watercourse profiles to the pre-construction profile, entrenched gullies and channels may have to be cut back to create a lower gradient that will not be susceptible to erosion; Once the crossing has been shaped and topsoil reintroduced to stripped areas, biojute can be applied according to specification to avoid rill formation and undercutting below biojute material. During the start of the growing season the annual grass *Eragrostis tef* can be introduced through manual broadcasting on reinstated watercourse surfaces. Rehabilitated areas within watercourse boundaries must be protected from overgrazing. Protection methods must be identified in consultation with the respective landowners [Amendment 2019/05].	Avoid or minimise damage to watercourse habitats.
105	All	Contamination of alluvial and sand aquifers	Implement good housekeeping practices, regular inspections as well as sound environmental training. An emergency response protocol must be implemented at the operations that are aimed at early detection and swift reaction speed. Where possible and reasonable daily inspections (focused on detecting leaks and spills) of drilling pads, pipelines, compressors and the helium plant must be implemented. An on-site communication system must be put in place to ensure that instructions are given and carried out with efficiency. In the event of a spill occurring, a method statement must be completed that describes how, where and when clean-ups will be undertaken. The on-site communication system must make provision for continual review and improvement of spill management. The necessary equipment and personal protection equipment (PPE) must be kept on site to clean spills up and leaks. Tetra4 personnel must receive adequate training on the use of the equipment and the disposal of waste material generated during a spill. All such wastes must be treated as hazardous. The waste must be placed in a dedicated sealed container on site, which must be disposed of to a licensed facility. All on-site vehicle and equipment maintenance must be undertaken within an area of secondary containment, such as a bund or over a drip tray, to prevent accidental soil contamination. Oil and diesel stored on site must be placed within a suitably sized bund. The dispensing of hydrocarbons must be undertaken with due care to prevent or contain spills. All hazardous waste generated must be contained and stored in suitably sealed, bunded and protected areas to avoid spills and leaks. Waste must be collected and disposed of off site in a responsible manner so as to prevent groundwater contamination off site.	Avoid and control pollution of water resources.
108	All	Encroachment/ invasion of alien plants (specifically into watercourses)	Restrict the clearing of watercourse vegetation as far as possible. Areas that have been cleared should be re-vegetated with indigenous species or other suitable plant species, such as *Eragrostis tef*, after construction and initial rehabilitation work (reinstatement of the geomorphological template) is completed. Compile and implement an alien plant control program with a particular focus on alien control in watercourses (including wetlands) during the rehabilitation phase of the project. Rehabilitate disturbed areas as soon as possible. Restrict new footprints to disturbed areas as far as possible. Regular monitoring should be undertaken in the watercourses to check any possible invasion by alien vegetation so that they can be weeded out before they grow and spread out.	Avoid, minimise and remediate invasion by alien plants particularly in watercourses.

7.4 Riverine Impact Assessment

Infrastructure within the study area assigned to riverine systems include compressor stations, gas pipelines, well heads and a transmission loop. The compressor stations are located within water resources, however, alternative localities have been provided with are preferable as they avoid sensitive areas. Should the alternatives be considered and adequate mitigation measures be implemented, the potential impacts to the water resources are predominantly low. However, some indirect impacts can still affect the water resources. Linear infrastructure including pipelines are expected to traverse the water resources and avoidance is not possible. The linear structures (Pipeline and Transmission Loop) will be assessed as one and the compressor station and wells will be assessed as one.

Potential impacts to the water resources associated with the proposed activities include loss of riparian vegetation due to erosion or direct loss through clearing; water quality deterioration through contamination from waste water and waste materials, spills and leaks from heavy machinery, and sanitation facilities; instream habitat loss due to sedimentation from erosion of channel banks and terrestrial areas within the catchment; altered flow dynamics due to increased runoff from hardened surfaces; and subsequent impacts to environmental responders including disturbances to the biotic communities.

Risks expected for the construction activities are associated with vegetation and topsoil removal, which is attributed to the locality of the selected structures within the riparian zone and delineated wetlands. Additionally, waste management is considered due to the potential of spills and leaks of contaminated water and sludge. As the infrastructure is linear, the watercourses cannot be avoided and therefore mitigation measures to reduce the risks to the watercourse should be prioritised. Alternatives to the river crossings type include Open Trenches or Horizontal Directional Drilling (HDD), however, due to the sensitivity of the watercourses, HDD is the preferred crossing methodology. Well placements fall outside of the water resources and respective buffers.

The additional impacts associated with the proposed activities, which weren't considered covered in the existing approved Cluster 1 EIA and EMPr, are considered in this section. No 'new' impacts are expected for the Cluster 2 gas exploration project, except for the powerlines (132kVand 33kV) (Figure 7-1).

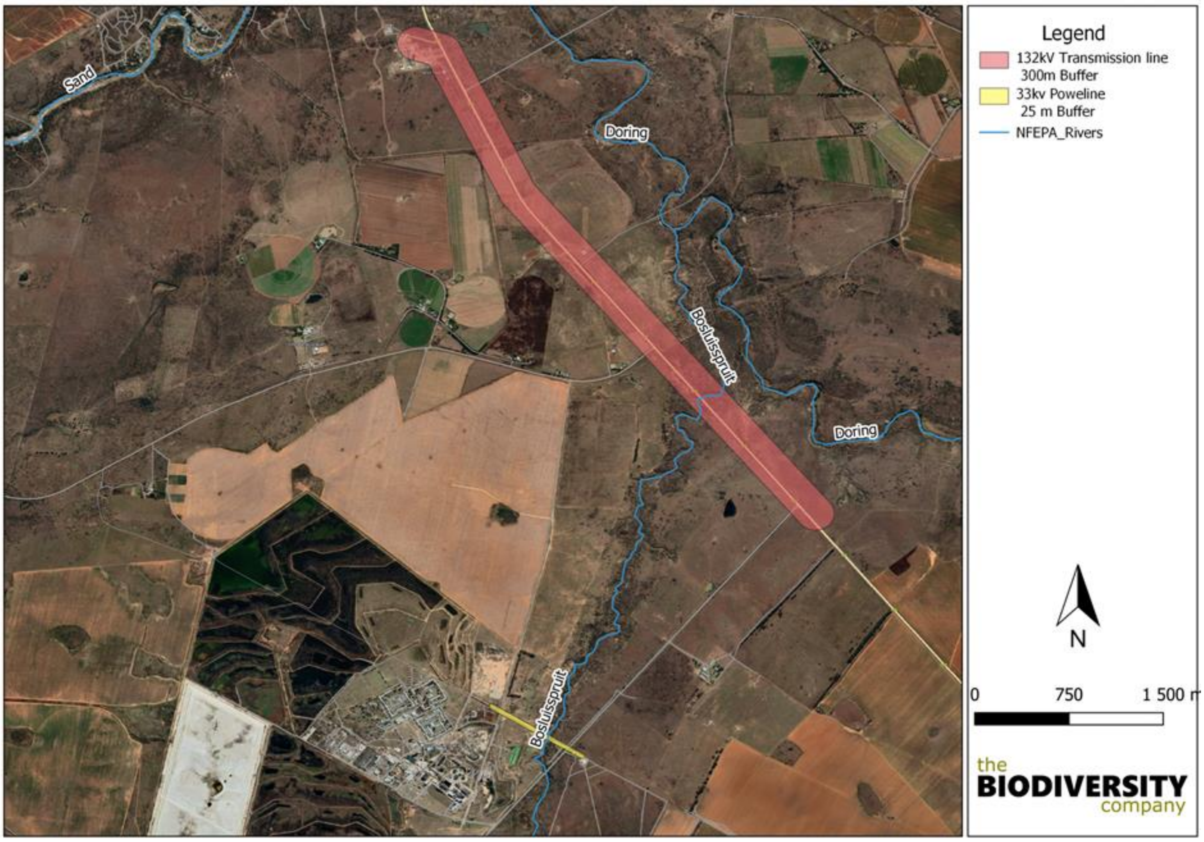

Figure 7-1 Proposed 33kVand 132kVPowerlines

The proposed powerline construction is regarded as low risk to the water resources should construction occur outside of the delineated areas as the footprint area is limited to the pylon base. However, the increase in traffic along the servitude is likely to increase erosion of channels and banks along drainage lines, larger riverine systems and wetland areas. Existing powerlines are currently in place on the proposed route and span across watercourses. Should pylon placement be within the riparian areas impacts would be considered moderate. The powerlines pose low risks to the watercourse during the operational phase should the pylons be constructed outside of the delineated water resources.

For the proposed powerline crossing points, mitigation measures are largely associated with avoiding the delineated watercourse areas and implementing recommended buffer zones, therefore the anticipated impacts and mitigation measures for the two powerlines are expected to be similar. Impacts are associated with the construction of pylons. The impact table for the 33kVpowerline construction is presented in Table 7-3 and for the 132kVin Table 7-4. The impact table for the powerline construction is presented in Table 7-4.

Table 7-3 Impact assessment for the proposed 33kVpowerline

Impact	Phase	Pre-mitigation ER	Post-mitigation ER	Confidence	Cumulative Impact	Irreplaceable loss	Final score
Powerlines - Habitat	Construction	-5.5	-3	High	1	1	-3
Powerlines - Water Quality	Construction	-2	-1.25	High	1	1	-1
Powerlines - Flow	Construction	-2.5	-1.25	High	1	1	-1

Powerlines - Habitat	Operation	-5	-3.5	High	1	1	-4
Powerlines - Water Quality	Operation	-1	-1	High	1	1	-1
Powerlines - Flow	Operation	-1	-1.25	High	1	1	-1
Powerlines - Habitat	Decommissioning	-5	-3	High	1	1	-3
Powerlines - Water Quality	Decommissioning	-2	-1.25	High	1	1	-1
Powerlines - Flow	Decommissioning	-2.5	-1.25	High	1	1	-1

Table 7-4 Impact assessment for the proposed 132kVpowerline

Impact	Phase	Pre-mitigation ER	Post-mitigation ER	Confidence	Cumulative Impact	Irreplaceable loss	Final score
Powerlines - Habitat	Construction	-5.5	-3	High	1	1	-3
Powerlines - Water Quality	Construction	-2	-1.25	High	1	1	-1
Powerlines - Flow	Construction	-2.5	-1.25	High	1	1	-1
Powerlines - Habitat	Operation	-5	-3.5	High	1	1	-4
Powerlines - Water Quality	Operation	-1	-1	High	1	1	-1
Powerlines - Flow	Operation	-1	-1.25	High	1	1	-1
Powerlines - Habitat	Decommissioning	-5	-3	High	1	1	-3
Powerlines - Water Quality	Decommissioning	-2	-1.25	High	1	1	-1
Powerlines - Flow	Decommissioning	-2.5	-1.25	High	1	1	-1

7.4.1 Mitigation Measures

The following mitigation measures are applicable for the powerline:

- Keep the number of towers in the wetland to a feasible minimum. The placement of towers in the assigned buffer (of 35 m) is preferred to minimise the number of towers placed within the wetland;
- Construction activities should be scheduled for the least sensitive periods, in order to avoid the migration, nesting and breeding seasons of SCC as far as practical;
- Locate powerline alignment outside of buffered watercourses (sensitive watercourse habitat) as far as possible;
- Buffered watercourses should be demarcated on site for the entire construction process to help indicate sensitive areas and prevent unauthorised access;
- The route should be located along existing infrastructure features, such as roads, dam walls and existing pipelines. Unavoidable crossings should ideally be located perpendicular to the direction of flow at the shortest possible crossing distances;
- The servitude width should be restricted in watercourse crossings to reduce the footprint of the impact;
- A construction method statement should be prepared by the contractor with input from a watercourse specialists prior to the start of construction. Conditions stated in the water use license should also be implemented; and
- Make provision in the design phase for permanent access tracks/roads that will be required for the maintenance of the powerline.

7.4.2 No-Go and Cumulative Impacts

The impacts of projects are often assessed by comparing the post-project situation to a pre-existing baseline. Where projects can be considered in isolation this provides a good method of assessing a project's impact. However, in areas where baselines have already been affected, or where future development will continue to add to the impacts in an area or region, it is appropriate to consider the cumulative effects of development. This is similar to the concept of shifting baselines, which describes how the environmental baseline at a point in time may represent a significant change from the original state of the system. This section describes the potential impacts of the project that are cumulative for the aquatic resources.

The area within the project area has previously and presently been impacted directly due to agricultural and mining activities, and urban runoff from Virginia. The activities have resulted in water quality perturbations and direct modifications to riverine habitats. The modifications have resulted in the Sand River being classed as moderately modified, and the Doring and Boschluispruit as largely modified.

Due to the nature of the proposed activities, particularly construction activities adjacent or within the delineated riparian zone and its buffers, and the pipeline crossings through the Sand and Doring Rivers, the cumulative impact of the project to habitat integrity was rated as moderate should the project go ahead due to the sensitivity of soils to erosion and locality of activities to the various affected water resources (Table 7-5).

Minor cumulative impacts are expected to water quality deterioration should the proposed activities proceed (Table 7-6). The proposed activities should contribute significant potential contaminants to the water resources should adequate mitigation measures be implemented and correct handling, storage and disposal of any solid or liquid waste/hazardous materials.

Table 7-5 Cumulative Impacts to habitat integrity of the project area

Nature of the impact: Habitat Quality Deterioration within the project area		
	Cumulative impact should the project not go ahead	**Cumulative impacts should the project go ahead**
Extent	Regional	Regional
Duration	Long term	Life of project
Magnitude	Medium	Medium
Probability	Definite	Definite
Calculated Significance Rating	Minor / Moderate	Moderate
Impact Status:	Negative	Negative/Positive
Reversibility:	Reversible	Reversible
Irreplaceable loss of resources:	No	Potentially
Can impacts be enhanced:	Yes	Yes

Table 7-6 Cumulative Impact to water quality within the project area

Nature of the impact: Water Quality Deterioration within the project area		
	Cumulative impact should the project not go ahead	Cumulative impacts should the project go ahead
Extent	Regional	Regional
Duration	Long term	Life of project
Magnitude	Medium	Minor
Probability	Definite	Possible
Calculated Significance Rating	Minor / Moderate	Minor
Impact Status:	Negative	Negative
Reversibility:	Reversible	Reversible
Irreplaceable loss of resources:	No	No
Can impacts be enhanced:	Yes	Yes

7.5 Recommendations

The following recommendations are provided for the project:

- No mitigation measures have been prescribed for the decommissioning phase of the project. It is recommended that the closure plan and objective be reviewed, and appropriate measures be included for the local water resources;
- Implement the "Working in Sensitive Areas" (document number T4-PP-SHERQ-051) detailed in the operating procedures document;
- Implement the "Erosion Control and Storm Water Management" (document number T4-PP-SHERQ-043) detailed in the operating procedures document;
- Once the pipeline has been installed, the disturbed area must be cleaned up in accordance with the Environmental Management Plan, and in accordance to the Tetra4 Rehabilitation Plan and Procedure; and
- All activities related to these works shall comply with all applicable Environmental Laws, Tetra4's approved Environmental Management Programme (EMPR) and Tetra4's Environmental Procedures when undertaking any works.

7.6 Monitoring programme

Based on the outcomes of this assessment, the further actions are recommended. The monitoring programme proposed is presented in Table 7-7.

Table 7-7 Proposed monitoring activities

Location	Monitoring objectives	Frequency of monitoring	Parameters to be monitored
Current sites used in this assessment and additional up and downstream monitoring points	Overall PES	Bi-annual	Standard River Ecosystem Monitoring Programme (Ecostatus) methods
Current sites used in this assessment and additional up and downstream monitoring points	Determine if water quality deterioration is occurring.	Bi-annual	SASS5 scores should not decrease as and be related to mining activities.
Site used in this assessment and the surface water assessment	Determine if water quality deterioration is occurring.	Monthly	Standard water quality monitoring, as per the surface water specialist report.
Current sites used in this assessment and additional up and downstream monitoring points	Determine if water/habitat quality deterioration is occurring.	Bi-annual	Monitor for presence of fish.

Based on the outcomes of this study, further actions are recommended:

- Annual auditing of the recommended mitigation actions for the project infrastructure must be conducted;
- Following completion of the construction activities, an audit should be completed to assess whether there will be requirements for the installation of sediment traps or other alterations to the stormwater drainage of the infrastructure footprint areas;
- An annual alien invasive vegetation assessment must be conducted in accordance with the floral component of this overall application;
- Bio-Monitoring:
    - Bi-annual aquatic biomonitoring must be conducted once during the construction phase and once following the completion of the construction phase; and
    - Riverine aquatic biomonitoring along with the implementation of the Rapid Habitat Assessment Method must be completed on a bi-annual basis during the operational phase. The aim of the study will be to assess and monitor the long terms trends and implications of the potential dewatering and water quality deterioration.

The further assessment of *L. kimberleyensis* within the study area is recommended. Should the species be present a management plan should be derived. It is noted that the mitigation actions provided in this assessment must make use of the proposed mitigation actions as an Environmental Management Plan. The outcome based management plan for riverine resources is presented in Table 7-8.

Table 7-8 Outcome Based Management Plan

Outcome	Action	Timeframe
Limit riverine habitat degradation	Implement buffer and no-go areas;	Project lifespan
	Implement stormwater management plan	Project lifespan
	Implement mitigation actions to reduce dewatering/provide ecological reserve	Project lifespan
	Implement erosion control measures such as energy dissipation	Project lifespan
	Implement alien invasive plan removal and monitoring programme	Project lifespan
	Revegetate disturbed areas	Construction and Decommissioning
Limit water quality degradation	Implement buffer and no-go areas;	Project lifespan
	Implement stormwater management plan	Project lifespan
	Implement erosion control measures such as energy dissipation	Project lifespan
	Revegetate disturbed areas	Project lifespan
	Implement alien invasive plan removal and monitoring programme	Project lifespan
	Implement stockpile and waste management strategies whereby exposure to direct runoff can be reduced	Project lifespan
	Implement water treatment for mine water decant	Decommissioning and closure
Effective Water Resource Management	Implement water quality and aquatic biomonitoring studies	Project lifespan

8 Conclusion

The baseline assessment established three main watercourses within the project area, namely the Sand River, Doring River, and Boschluispruit, and a single system outside the project boundary, the Palmietkuilspruit. Additionally, numerous ephemeral systems and wetlands occur throughout the project area. The ecological assessment of the watercourses indicated moderate to large modifications attributed to varying land use, namely agriculture, mining, and urban activities upstream of the project area on the Sand River (Virginia). The land use activities have cumulatively resulted in a moderate deterioration in water quality, flow, and instream habitat, and subsequently to the biotic communities within the systems. Despite modifications, the Sand River met the Resource Quality Objectives for the reach, and all the water resources associated with the project area are considered sensitive. Given the findings of this assessment, no pristine or natural waterbodies were observed or expected in any of the project right areas, with the Doring River being classed as largely modified (class D), the Boschluispruit as largely modified (class D), and the Sand River as moderately modified (class C).

The upper reaches of the Boschluispruit and several tributaries within the project area are characteristic of wetland systems, and riparian zones and buffers were applied according to the wetland report (TBC, 2022). The Sand, Doring and lower reaches of the Boschluispruit presented well defined riparian zones consisting of woody vegetation. The soils along the watercourses are highly susceptible to erosion and considered sensitive to any potential anthropogenic activities along these systems which could potentially compromise the ecological integrity of the watercourses.

The water resources are poorly protected, and the ecosystems are critically endangered. Additionally, no Freshwater Priority Areas are assigned to them. *Labeobarbus kimberleyensis* (Largemouth Yellowfish) is expected within the Sand River and is the only species of conservational concern within the catchment and red listed as Near Threatened due to habitat fragmentation and water quality deterioration. The species was not collected during the survey, however, despite the absence of the species during the survey, the precautionary approach would assume the species to be within the project area and would likely be collected with increased sampling effort. The poorly protected nature of the systems indicates that strict mitigation measures should be adhered to ensure no further deterioration of the watercourses should the project proceed.

The buffers determined for the lower foothill systems was calculated at 50 m, and for the ephemeral systems, drainage lines and wetlands a buffer of 35 m.

The impact assessment considered both direct and indirect impacts, to the water resources. According to the layout provided and the delineated riparian zones and applicable buffers, the compression station, and pipeline crossings intersect with the water resources. Considering the pipelines are linear infrastructure, avoidance of the watercourses is not possible, strict mitigation implementation is required to ensure the minimisation of erosion and additional deterioration of the water resources are negated. The locality of compressor station CS1 falls within the riparian zone and buffer of the Sand River. This poses a moderate risk to the watercourse and alternative sites should be selected as erosion of the banks is likely. The position of compressor stations CS2 and CS3 are located within delineated wetlands and are addressed in the wetland specialist assessment.

Risks associated with the proposed infrastructure range from low to moderate, with the majority of moderate risks being reduced to low with the implementation of adequate mitigation measures, however, activities within the buffers and water resources remain moderate.

8.1 Specialist Recommendation

It is the specialist's opinion that no fatal flaws have been identified for the proposed activities, The alternative positioning of the compressor stations are preferred due to the avoidance of water resource sensitive areas. The soils within the catchment are prone to erosion and care is required to ensure proposed activities do not exacerbate erosion within the catchment. Monitoring of the aquatic resources is required during construction and operational activities.

A competent Environmental Control Officer (ECO) must oversee the construction activities and associated concurrent rehabilitation measures undertaken, with watercourse areas as a priority. Two follow up ECO assessments/audits must be carried out in the first and sixth months of operation. The ECO must be supplied with a copy of this and the other specialists reports and must be familiar with the mitigation and recommendations prior to construction.

9 References

Barbour, M.T., Gerritsen, J. & White, J.S. 1996. Development of a stream condition index (SCI) for Florida. Prepared for Florida Department of Environmental Protection: Tallahassee, Florida.

Collins, N.B. 2016. Free State Province Biodiversity Plan: Technical Report v1.0. Free State Department of Economic, Small Business Development, Tourism and Environmental Affairs. Internal Report.

Dallas, H.F. 2007. River Health Programme: South African Scoring System (SASS) Data Interpretation Guidelines. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Institute of Natural Resources.

Department of Water Affairs and Forestry (DWAF). 1996. South African Water Quality Guidelines. Volume 7: Aquatic Ecosystems.

Department of Water and Sanitation. 2014. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Secondary: C23K. Compiled by RQIS-RDM: https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx. Accessed on 05 February 2022.

Dickens, C. W. S. and Graham, P.M. 2002. The South African Scoring System (SASS) Version 5: Rapid bioassessment method for rivers. African Journal of Aquatic Science. 27 (1): 1 -10.

Dosskey, M.G. 2000. How much can USDA riparian buffers reduce agricultural nonpoint source pollution? In P.J. Wigington and R.L. Beschta, Riparian Ecology and Management in Multi-Land Use Watersheds. American Water Resources Association.

Fink, J. C. 2005. Chapter 4 – Establishing a Relationship Between Sediment Concentrations and Turbidity. In The Effects of Urbanization on Baird Creek, Green Bay, WI (Thesis). Retrieved from http://www.uwgb.edu/watershed/fink/Fink_Thesis_Chap4.pdf

Fry C. 2022. A Field Guide to Freshwater Macroinvertebrates of Southern Africa. 2022. Jacana Media. ISBN: 9781431431052

Gerber, A. & Gabriel, M.J.M. 2002. Aquatic Invertebrates of South African Rivers Field Guide. Institute for Water Quality Studies. Department of Water Affairs and Forestry. 150pp

International Union for Conservation of Nature and Natural Resources (IUCN). (2022). Red list of threatened species - 2012.2. www.iucnredlist.org. (Accessed in April 2022)

Kleynhans, CJ. 1996. A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo System, South Africa) Journal of Aquatic Ecosystem Health 5:41-54.

Kleynhans CJ. 2007. Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No.

Nel JL, Murray KM, Maherry AM, Petersen CP, Roux DJ, Driver A, Hill L, Van Deventer H, Funke N, Swartz ER, Smith-Adao LB, Mbona N, Downsborough L and Nienaber S. 2011. Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

Rowntree, K. and Ziervogel, G., 1999. Development of an Index of Stream Geomorphology for the Assessment of River Health. National Aquatic Ecosystem Biomonitoring Programme.

Rountree KM, Wadeson RA and O'Keeffe J. 2000. The Development of a Geomorphological Classification System for the Longitudinal Zonation of South African Rivers. South African Geographical Journal 82 (3): 163-172.

Skelton, P.H. (2001). A complete guide to the freshwater fishes of southern Africa. Struik Publishers, South Africa.

Skowno, A.L., Raimondo, D.C., Poole, C.J., Fizzotti, B. & Slingsby, J.A. (eds.). (2019). South African National Biodiversity Assessment 2018 Technical Report Volume 1: Terrestrial Realm. South African National Biodiversity Institute, Pretoria.

The Biodiversity Company (TBC). 2022. Wetland Baseline & Risk Assessment for the proposed Tetra4 Cluster 2 Project. April 2022.

Thirion, C.A., Mocke, A. & Woest, R. 1995. Biological monitoring of streams and rivers using SASS4. A User's Manual. Internal Report No. N 000/00REQ/1195. Institute for Water Quality Studies. Department of Water Affairs and Forestry.

Wepener V, Van Vuren JHJ, Chatiza FP, Mbizi Z, Slabbert L, Masola B. 2005. Active biomonitoring in freshwater environments: early warning signals from biomarkers in assessing biological effects of diffuse sources of pollutants. Physics and Chemistry of the Earth 30: 751–761.

Van Deventer, H., Smith-Adao, L., Mbona, N., Petersen, C., Skowno, A., Collins, N.B., Grenfell, M., Job, N., Lötter, M., Ollis, D., Scherman, P., Sieben, E. & Snaddon, K. 2018. South African National Biodiversity Assessment 2018: Technical Report. Volume 2a: South African Inventory of Inland Aquatic Ecosystems (SAIIAE). Version 3, final released on 3 October 2019. Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI): Pretoria, South Africa. Report Number: CSIR report number CSIR/NRE/ECOS/IR/2018/0001/A; SANBI report number http://hdl.handle.net/20.500.12143/5847.

10 Appendix A Specialist Declaration