Aquatic Baseline & Impact Assessment – Xhariep Export Programme (XEP) Agricultural Development and associated infrastructure

Xhariep District Municipality, Free State

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CLIENT

Prepared by:

The Biodiversity Company

Cell: +27 81 319 1225

Fax: +27 86 527 1965

info@thebiodiversitycompany.com

www.thebiodiversitycompany.com

Executive Summary

The Biodiversity Company was appointed by Savannah Environmental (Pty) Ltd (Savannah) to conduct an aquatic baseline and impact assessment for the proposed Agricultural and Pivot Expansion project in the Letsemeng Local Municipality, Free State Province.

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.

A single dry season survey was conducted from the 31st of May 2022 to 1st of June 2022 by a freshwater ecologist. The baseline assessment established a single main watercourse with an associated tributary network draining the project area, namely the Lemoenspruit ecosystem. Additionally, numerous ephemeral drainage lines and some wetlands occur in the project area. The Lemoenspruit flows into the Orange River downstream of the project area. Due to flood conditions at the time of the survey the Orange River could not be assessed. The ecological assessment of the Lemoenspruit indicated moderate modifications attributed to varying land use, comprising mostly open/ natural land with some agriculture and widespread livestock activities present in the project areas catchment. The land use activities and erodible soils have cumulatively resulted in a moderate deterioration in water quality, flow, and instream habitat, and subsequently to the biotic communities (macroinvertebrate and fish) within the systems. The baseline water quality indicated exceedance of the Orange Water Management Area Resource Water Quality Objectives (RWQOs) for electrical conductivity of 550 µS/cm at all of the investigation sites and increased in a downstream direction from 953 µS/cm in the upper Lemoenspruit at site LS US to 1 686 µS/cm in the lower reaches at LS DS. Despite modifications, the Lemoenspruit met the RWQOs Management Class for the Orange River (which incorporates the Lemoenspruit), and all the water resources and their associated habitats associated with the project area are considered sensitive to further disturbance. Given the findings of this assessment, the Lemoenspruit was classed as moderately modified (class C).

The entire drainage network is presented by a well defined riparian zone consisting of woody vegetation. The soils within the catchment and 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 directly influenced Lemoenspruit is listed as *not protected*, and the ecosystem is classified as *Endangered*. The indirectly affected Orange River system downstream of the project area is listed as *poorly protected*, and is classified as *Critically Endangered*. Additionally, Freshwater Priority Areas are assigned to them. The Lemoenspruit catchment serves as an *upstream management area* to assist in limiting impacts to the downstream Orange River which serves as a Fish Sanctuary area for threatened fish species such as Largemouth Yellowfish (*Labeobarbus kimberleyensis*). Largemouth Yellowfish are red listed as Near Threatened and are showing population declines due to habitat fragmentation and water quality deterioration. The Lemoenspruit includes an additional Species of Conservational Concern (SCC), namely the recently described Orange River Chubbyhead barb (*Enteromius oraniensis*). The species currently has no threatened status and should be conserved through the precautionary principle and be treated as highly threatened. This barb was collected during the survey at LS DS. The

poorly protected nature of the systems, the high Ecological Importance and Sensitivity (EIS) and presence of SCC indicates that strict mitigation measures should be adhered to ensure no further deterioration of the watercourses should the project proceed.

The riparian zones of the lower foothills geoclass Lemoenspruit require a buffer of 100 m, and Lemoenspruit tributary network comprising non-perennial systems, ephemeral drainage lines and wetlands require a buffer of 50 m. These buffers would ensure adequate ecological integrity maintenance adjacent to the proposed agricultural activities

Impact Assessment

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 centre pivots, impoundments (several options), powerline and bulk water pipeline intersect with the water resources posing risk to these receptors. The relocation of the aforementioned infrastructure to avoid sensitive water resources and the prescribed buffer zones (no-go zones) will lower the impacts to these receptors. The relocation of the centre pivots outside of no-go zones would result in an overall reduction in the number of proposed centre pivots, lowering the associated negative ecological impacts expected.

The Main impoundment Option 1 and Secondary impoundment Option 1 are preferred due to the avoidance of sensitive areas. The preferred options would still require mitigation efforts as their construction and operational presence would influence natural soil and water movement and associated ecological processes within their local and downstream catchment areas.

No shapefiles were available for the pipeline reticulation network required to transport water from the impoundments to the centre pivots. Similarly, no shapefiles were available for the road network required for the proposed activities. The placement of the pipeline reticulation and road network is expected to traverse water features with associated disturbance impacts expected. Avoidance of no-go zones would lower their impacts, and should be considered. Additionally, the project should consider the least number of river crossing structures possible to limit further watercourse disturbance.

The solar area and Battery Energy Storage System (BESS) infrastructure are expected to have no impacts towards local watercourses.

Impacts associated with the proposed infrastructure are related to habitat disturbance and fragmentation, contamination of water quality and alteration of catchment hydrology which cumulatively result in negative ecology impacts within watercourses. The construction and operational phase impacts range from moderate to high, with the majority of impacts being reduced to low and moderate following the implementation of adequate mitigation measures. Due to the nature of the project, the footprint of the proposed agricultural infrastructure has a large localised impact, while cumulatively the project poses regional water quality impacts and threat to SCC.

Specialist Recommendation

It is the specialist's opinion that no fatal flaws have been identified for the proposed activities, and authorisation of the proposed development must be carefully considered. Considerations must take into account the carrying capacity of the local and regional watercourses potentially influenced by the proposed activities and their resilience to future disturbances.

The alternative positioning of infrastructure is preferred due to the avoidance of water resource sensitive areas (no-go zones). 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.

Due to the high threat level of water quality deterioration and negative ecological impacts expected, notably from typically used Organophosphates, the project must consider environmentally friendly alternatives to Organophosphates. This together with the prescribed mitigation must be implemented in totality in order to proceed in a sustainable manner.

A competent ECO must oversee the construction and operational activities, with watercourse areas as a priority. Additional reccomendations listed in this report should be considered for this project.

Abbreviations

Abbreviation	Definition
ASPT	Average Score Per Recorded Taxon
BESS	Battery Energy Storage System
CBA	Critical Biodiversity Area
DO	Dissolved Oxygen
DWS	Department of Water and Sanitation
EA	Environmental authorisation
ECO	Environmental control officer
EI	Ecological Importance
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMP	Environmental Management Plan
EN	Endangered
ESA	Ecological Support Area
ETS	Ecosystem threat status
FRAI	Fish Response Assessment Index
IHIA	Intermediate Habitat Integrity Assessment
IUCN	International Union for Conservation of Nature
LC	Least Concerned
MASL	Meters Above Sea Level
MIRAI	Macroinvertebrate Response Assessment Index
NEMA	The National Environmental Management Act
NFEPA (FEPA)	National Freshwater Ecosystem Priority Areas
NT	Near threatened
NWA	National Water Act
NWBEST	National Web Based Environmental Screening Tool
PAOI	Project Area Of Influence
PES	Present ecological state
RQO's	Resource Quality Objectives
SAIIAE	South African Inventory of Inland Aquatic Ecosystems
SANBI	South African National Biodiversity Institute
SASS5	South African Scoring System version 5
SCC	Species of Conservation Concern
SQR	Sub Quaternary Reach
TBC	The Biodiversity Company
TWQR	Target Water Quality Range
VU	Vulnerable
WMA	Water Management Area

Document Guide

The table below provides the minimum requirements for aquatic specialist assessments, and the relevant sections in the reports where these requirements are addressed. These are as per the "Protocol for the Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Aquatic Biodiversity" gazetted 20 March 2020, published in Government Notice No. 320.

Item	Section	Comment
The assessment must be prepared by a specialist registered with the South African Council for Natural Scientific Professionals (SACNASP) with expertise in the field of aquatic sciences.	Section 2	
Contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae.	Section 2	CV available on request
A signed statement of independence by the specialist(s).	Appendix A	
The assessment must be undertaken on the preferred site and within the proposed development footprint.	Section 1.1	
A baseline description of the aquatic biodiversity and ecosystems on the site, including: (a) aquatic ecosystem types; (b) presence of aquatic species, and composition of aquatic species communities, their habitat, distribution and movement patterns.	Sections 7 & 9	
The threat status of the ecosystem and species as identified by the screening tool;	Section 7	
An indication of the national and provincial priority status of the aquatic ecosystem, including a description of the criteria for the given status (i.e. if the site includes a wetland or a river freshwater ecosystem priority area (NFEPA) or sub catchment, a strategic water source area (SWSA), a priority estuary, whether or not they are free -flowing rivers, wetland clusters, a critical biodiversity or ecologically sensitivity area);	Section 7	
A description of the ecological importance and sensitivity of the aquatic ecosystem including: (a) the description (spatially, if possible) of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site (e.g. movement of surface and subsurface water, recharge, discharge, sediment transport, etc.); and (b) the historic ecological condition (reference) as well as present ecological state of rivers (in-stream, riparian and floodplain habitat), wetlands and/or estuaries in terms of possible changes to the channel and flow regime (surface and groundwater).	Sections 7, 9 & 10.1	
A statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment.	Section 8.1	
A description of the methodology used to undertake the site verification and impact assessment and site inspection, including equipment and modelling used, where relevant.	Section 8	
A description of the assumptions made and any uncertainties or gaps in knowledge or data.	Section 5	
The assessment must identify any alternative development footprints within the preferred site which would be of a "low" sensitivity as identified by the screening tool and verified through the site sensitivity verification.	Section 11.2.1	Recommendation have been included to avoid sensitive areas
Related to impacts, a detailed assessment of the potential impacts of the proposed development on the following aspects must be undertaken to answer the following questions: Is the proposed development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal? Is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present? How will the proposed development impact on fixed and dynamic ecological processes that operate within or across the site? This must include: (a) impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes); (b) will the proposed development change the sediment regime of the aquatic ecosystem and its sub -catchment (e.g. sand movement, meandering river mouth or estuary, flooding or sedimentation patterns);	Section 11	

(c) what will the extent of the modification in relation to the overall aquatic ecosystem be (e.g. at the source, upstream or downstream portion, in the temporary I seasonal I permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.); and (d) to what extent will the risks associated with water uses and related activities change.		
How will the proposed development impact on the functioning of the aquatic feature? This must include: (a) base flows (e.g. too little or too much water in terms of characteristics and requirements of the system); (b) quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over -abstraction or instream or off stream impoundment of a wetland or river); (c) change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an unchannelled valley- bottom wetland to a channelled valley -bottom wetland); (d) quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication); (e) fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); and (f) the loss or degradation of all or part of any unique or important features associated with or within the aquatic ecosystem (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.);	Section 11	
How will the proposed development impact community composition (numbers and density of species) and integrity (condition, viability, predator - prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?	Section 11	
A location of the areas not suitable for development, which are to be avoided during construction and operation (where relevant).	Section 11	
Additional environmental impacts expected from the proposed development.	Section 11	
Any direct, indirect and cumulative impacts of the proposed development.	Section 11.2.5.4	
The degree to which impacts and risks can be mitigated.	Section 11.2.5	
The degree to which the impacts and risks can be reversed.	Section 11.2.5	
The degree to which the impacts and risks can cause loss of irreplaceable resources.	Section 11.2.5	
A suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies.	Section 0	
Proposed impact management actions and impact management outcomes proposed by the specialist for inclusion in the Environmental Management Programme (EMPr).	Section 11.3	
A motivation must be provided if there were development footprints identified as per above that were identified as having a "low" aquatic biodiversity sensitivity and that were not considered appropriate.	-	N/A
A substantiated statement, based on the findings of the specialist assessment, regarding the acceptability, or not, of the proposed development, if it should receive approval or not;	Section 14.3	
Any conditions to which this above statement is subjected	Section 12 & 14.3	

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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 agriculture 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 Savannah Environmental (Pty) Ltd (Savannah) to conduct an aquatic baseline and impact (risk) assessment for the proposed Agricultural and Pivot Expansion project in the Letsemeng Local Municipality, Free State Province. A single dry season survey was conducted from the 31st of May 2022 to 1st of June 2022 by a freshwater ecologist.

This assessment was conducted in accordance with the amendments to the Environmental Impact Assessment (EIA) 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 (NWBEST) has characterised the aquatic sensitivity of the project area as “Low” with a “Very High” sensitivity given to the watercourses within the project footprint (Figure 1-3), and therefore an aquatic biodiversity specialist assessment was completed for the proposed project.

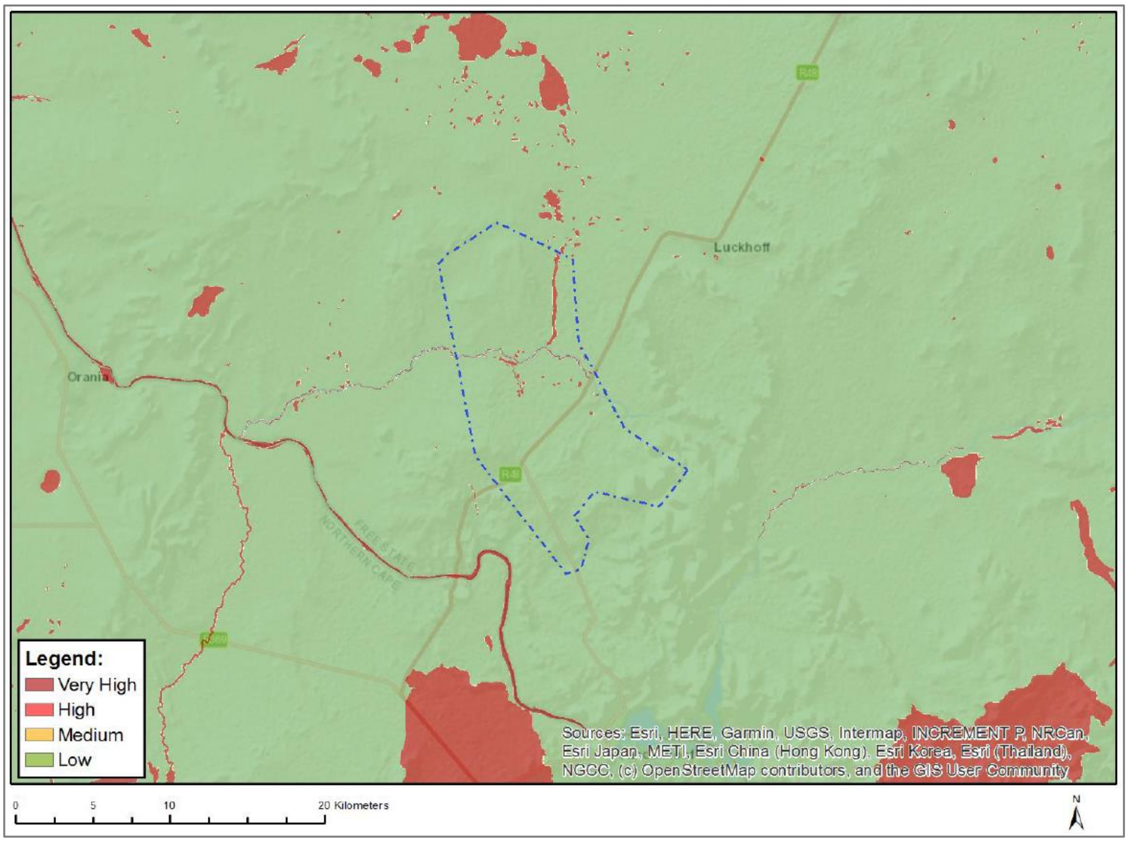


Figure 1-1 Sensitivity of aquatic biodiversity features for the project area

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.

1.1 Project Description

The applicant JN Venter Beleggings Trust is proposing the agricultural development and associated infrastructure on a site located Southwest of Luckhoff and Koffiesfontein in the Letsemeng Local Municipality of the Xhariep District Municipality in the Free State Province. The full extent of the development area is ~2690 ha and is located across the following 10 interlinked properties (farm portions):

- Portion 3 of Farm Dieodraai 754
- Farm Excelsior 800
- Farm Weltevreden 755
- Farm OU Ronderfontein 1251
- Farm Lemoen- spruit 667
- Farm Scheiding 1252
- Portion 5 of Farm Naauwpoort 417
- Farm Vinger Kraal 368
- Portion 1 and RE of Farm Grootpoorte 168

The site is accessible via the R48 road which pass directly through the centre of the proposed site. The R369 links to R48 south-west of the proposed site.

The project site is proposed to accommodate agricultural development (cultivation), as well as the associated infrastructure, which is required for such development, and this infrastructure will include:

- A centre pivot irrigation system;
- An irrigation pipeline network from the proposed dams to the centre pivots;
- Centre pivot pipelines;
- Two water storage dams;
- A new pump station;
- A 9 ha solar PV with 3 alternative sites and a 5 MW overhead power line; and
- A Battery Energy Storage System (BESS).

The current proposed water pipeline crossing will be approximately 68 m downstream and north west of an existing road bridge crossing. It is proposed that ~2690 ha will be transformed across the property for the establishment of the agricultural development.

The proposed development will require the following infrastructure:

Infrastructure	Purpose, Footprint and dimensions
Centre Pivot Irrigation System	The underground PVC pipeline will provide water to a centre pivot irrigation system. A centre pivot irrigation system is a moveable pipe structure which usually spans the length of a field and rotates around a pivot in the centre of the field. As the irrigation system rotates around its central pivot, it supplies water to crops through sprinklers along its length. 2 154 ha for cultivation
315 mm PVC pipeline	Water for the pivots will be sourced from the Oranje Riet Water User Association's canal pumped 6 km underground through 2 x 1.4 m fibreglass pipes, which will be extended by further 500 m to reach the pivots
Two Water Storage Systems	Two main storage dams, with a combined surface area of 82 ha in extent are proposed for utilization on the agricultural development. This dam system will feed the planned additional expansion: • Dam 1 – Diepkloof with 3.1 million m^3 • Dam 2 – (Sump): 1 million m^3
Pump station	A new pumpstation covering a total surface area of 549 m^2 will facilitate the required water from the Oranje Riet canal to the proposed storage dams
Solar PV area and overhead power line	5 MW Solar PV facility is proposed as the main energy source for the pump and pipeline system which will irrigate the entire development area as well as the dams. • 9 ha surface area with three alternative sites being considered • Overhead powerline of approximately 6.9 km in extent
BESS	A battery system will be used to collect any additional power generated by the PV facility for use as and when required. The battery system will cover a surface area of 0.36 ha.

The Oranje Riet Water User Association's canal will form the source of water for the irrigation development. The Oranje-Riet canal was built as a water transfer scheme which carries water from Vanderkloof Dam to the Riet River catchment via a concreted open top canal as depicted in Figure 1-2

Figure 1-2 Oranje-Riet canal associated with the project (Dry for maintenance during May 2022)

A map illustrating the proposed project infrastructure is presented on the next page in Figure 1-3.

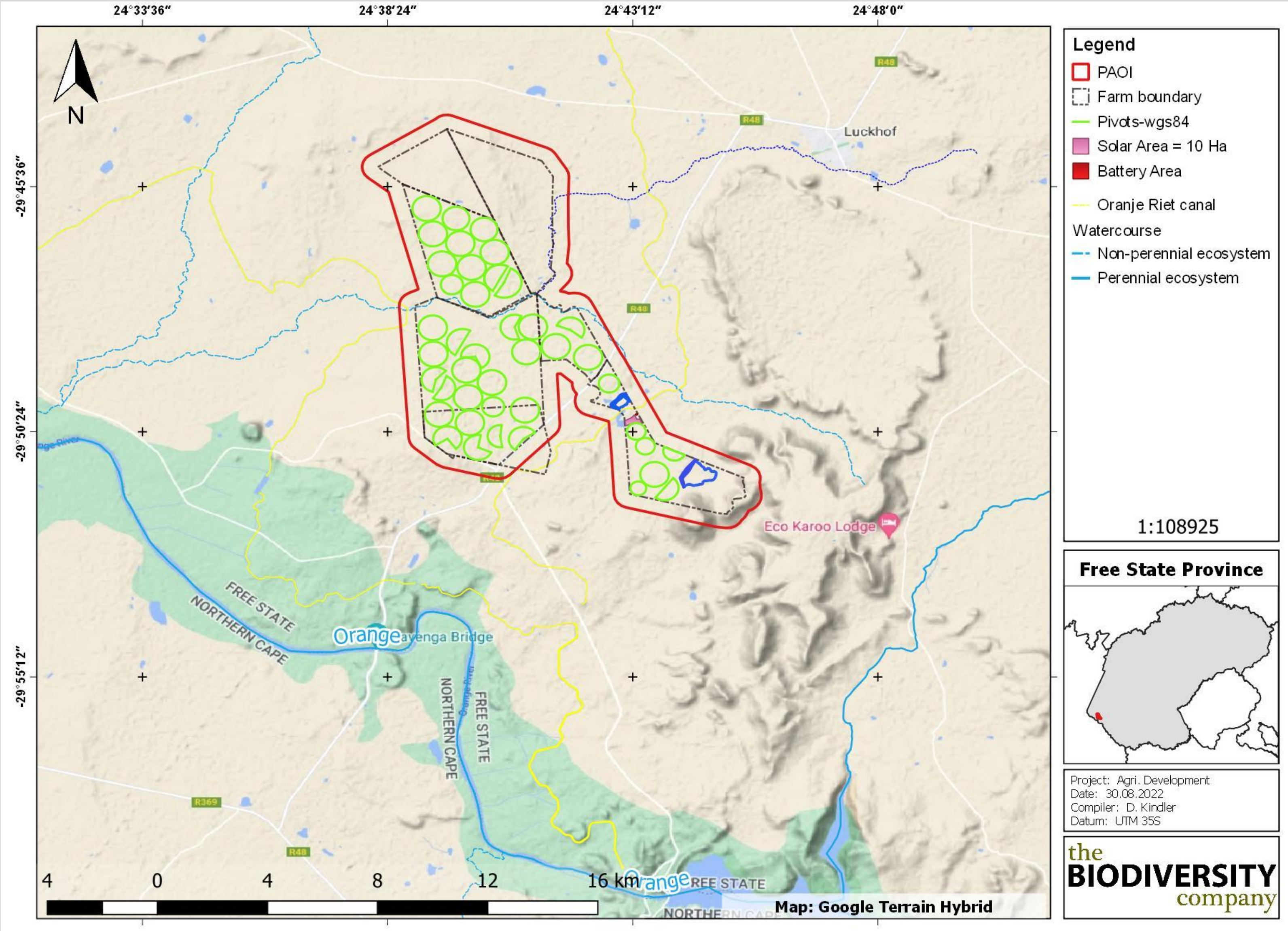


Figure 1-3 Spatial layout of the proposed project infrastructure

2 Specialist Details

Report Name	**Aquatic Baseline & Impact Assessment for the proposed Agricultural Development and Associated Infrastructure Project**	
Submitted to	savannah environmental	
Fieldwork Surveyor & Report Writer	**Dale Kindler**	
	Dale Kindler is a registered Professional Natural Scientist (Pr. Sci. Nat. 114743) in aquatic science and completed his M. Sc. in Aquatic Health at the University of Johannesburg. He has nine (9) years' experience in conducting Aquatic Specialist Assessments and is SASS 5 Accredited with the Department of Water and Sanitation (DWS). Dale has completed numerous specialist studies locally and internationally, ranging from basic assessments to Environmental Impact Assessments (EIAs) following IFC standards.	
Reviewer	**Christian Fry**	
	Christian Fry is Pr Sci Nat registered (Pr. Sci Nat 119082) in the fields of Aquatic Science. Christian has nine years of experience of consulting in the Aquatic Science. Christian has completed numerous training courses for buffers and riverine ecology, and is an accredited SASS5 practitioner.	
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.	

3 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 impact/ risk assessments relevant to the proposed activity;
- Recommendations relevant to associated impacts; and
- Report compilation detailing the baseline findings.

4 Key Legislative Requirements

The legislation, policies and guidelines listed below in Table 4-1 are applicable to the current project. The list below, although extensive, may not be complete and other legislation, policies and guidelines may apply in addition to those listed below.

Table 4-1 A list of key legislative requirements relevant to biodiversity and conservation in the Free State

Region	Legislation / Guideline
International	Convention on Biological Diversity (CBD, 1993)
	The Convention on Wetlands (RAMSAR Convention, 1971)
	The United Nations Framework Convention on Climate Change (UNFCC,1994)
	The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 1973)
	The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, 1979)
National	Constitution of the Republic of South Africa (Act No. 108 of 1996)
	The National Environmental Management Act (NEMA) (Act No. 107 of 1998)
	The National Environmental Management: Protected Areas Act (Act No. 57 of 2003)
	The National Environmental Management: Biodiversity Act (Act No. 10 of 2004), Threatened or Protected Species Regulations
	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, GNR 320 of Government Gazette 43310 (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, GNR 1150 of Government Gazette 43855 (October 2020)
	The National Environmental Management: Waste Act, 2008 (Act 59 of 2008);
	The Environment Conservation Act (Act No. 73 of 1989)
	National Protected Areas Expansion Strategy (NPAES)
	Natural Scientific Professions Act (Act No. 27 of 2003)
	National Biodiversity Framework (NBF, 2009)
	National Forest Act (Act No. 84 of 1998)
	National Veld and Forest Fire Act (101 of 1998)
	National Water Act (NWA) (Act No. 36 of 1998)
	National Spatial Biodiversity Assessment (NSBA)
	World Heritage Convention Act (Act No. 49 of 1999)
	Municipal Systems Act (Act No. 32 of 2000)
	Alien and Invasive Species Regulations and, Alien and Invasive Species List 20142020, published under NEMBA
	South Africa's National Biodiversity Strategy and Action Plan (NBSAP)
	Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983) (CARA)
	Sustainable Utilisation of Agricultural Resources (Draft Legislation).
	White Paper on Biodiversity
Provincial	Boputhatswana Nature Conservation Act 3 of 1973
	Free State Nature Conservation Ordinance 8 of 1969

4.1 National Environmental Management Act (NEMA, 1998)

The National Environmental Management Act (Act No. 107 of 1998) (NEMA) and the associated EIA Regulations, as amended in April 2017, state that prior to certain listed activities taking place, an environmental authorisation application (EA) process needs to be followed. This could follow either the Basic Assessment (BA) process or the Scoping and EIA process, depending on the scale of the impact. A Scoping and EIA process is being undertaken for the project.

GN 350 was gazetted on the 20 March 2020, which has replaced the requirements of Appendix 6 of the EIA Regulations in respect of certain specialist reports. These regulations provide the criteria and minimum requirements for specialist's assessments, in order to consider the impacts on soil for activities which require EA.

4.2 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) of the NWA.

5 Limitations

The following limitations are applicable:

- Results for the study are based on a single low 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;
- The Project Area of Influence (PAOI) was a 500 m buffer around the proposed development infrastructure;
- No shapefiles were available for the pipeline reticulation network required to transport water from the impoundments to the centre pivots. Similarly, no shapefiles were available for the road network required for the proposed activities. The impacts associated with these were assessed;
- The Orange River could not be assessed as a cumulative impact investigation site due to safety issues related to flooding conditions at the time of the survey;
- Access to the full project footprint was limited by locked gates during the survey, limiting access to the tributary network;
- It should be noted that sites LS US and LS Mid were not suitable for biological sampling due to intensive sedimentation and shallow surface waters; and
- Additionally, several ephemeral systems were dry. These sites remain critical to ecosystem services and are regarded as highly sensitive.

6 Project Area

The location of the Project Area Of Influence (PAOI) falls southwest of Luckhoff and Koffiesfontein in the Free State Province. The project area falls within the Letsemeng Local Municipality within the Xhariep District Municipality (Figure 6-1).

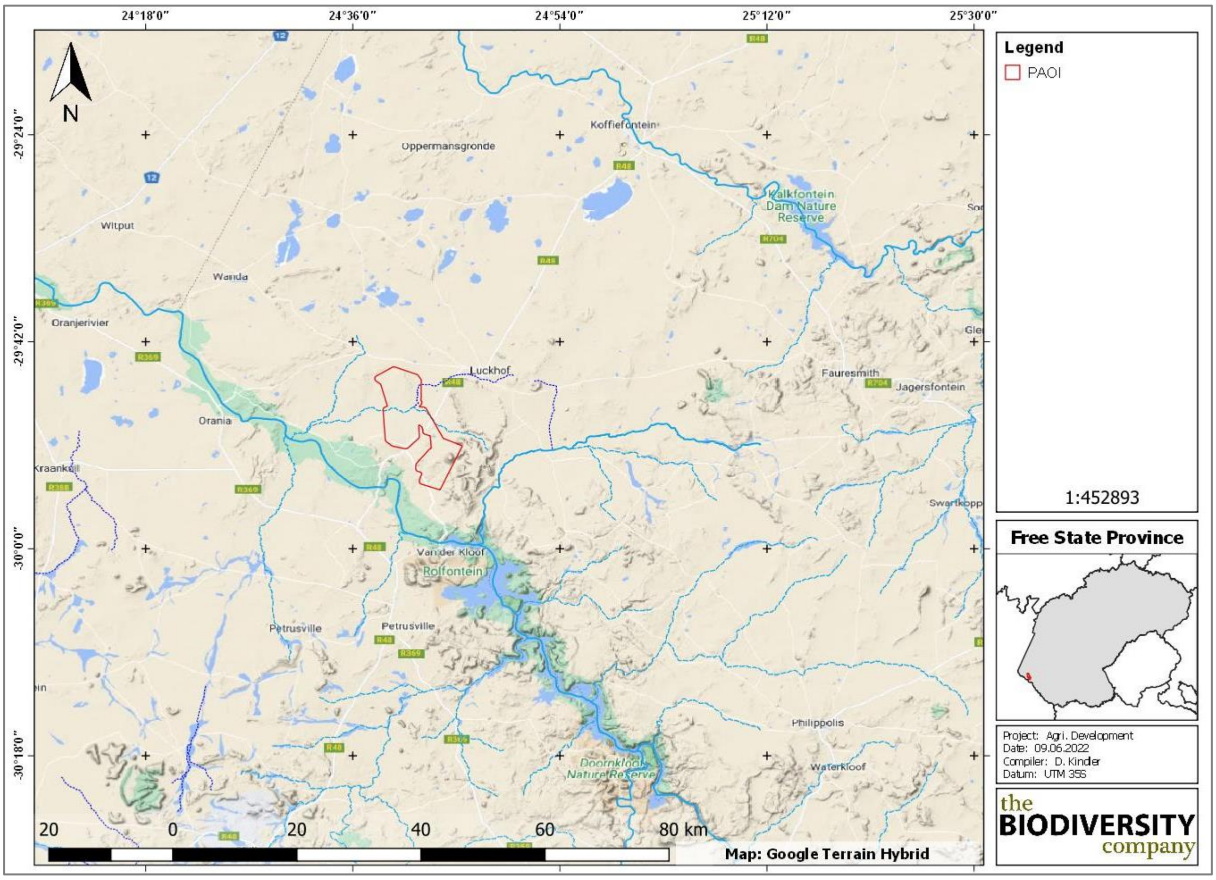


Figure 6-1 Locality of the project area

7 Desktop Baseline Assessment

7.1 Hydrological Setting (Receiving Catchment)

As presented in Figure 7-1, the project area is approximately 2690 ha and is drained by several non-perennial, ephemeral and perennial watercourses, which falls predominantly within the D33C quaternary catchment (sub-catchment), with small portions (powerline and bulk water pipeline) within the D33A quaternary catchments, and the larger Orange Water Management Area (WMA 6 - NWA, 2016). The non-perennial and ephemeral are unnamed and drain into the Lemoenspruit which traverses the middle of the PAOI and forms the watercourse of focus in this study. The Lemoenspruit is a non-perennial system which flows in a westerly direction into the Orange River at the catchment boundary. The spatial framework for the PES assessment of the watercourses falls within the Orange WMA and includes the Lemoenspruit, as well as several unnamed tributaries of the Lemoenspruit which drain the project area.

According to StatsSA (2010), the Upper Orange WMA lies in the centre of South Africa, and extends over the southern Free State, and areas of the Eastern and Northern Cape. The system drains the highlands of Lesotho and the Senqu River contributes 60% of the surface water. Climate within the WMA varies over the region, and rainfall ranges from over the 1000 mm/annum in the foothills, to 200 mm/annum in the west. The Gariep and Vanderkloof Dams in the Upper Orange WMA, where the two largest conventional hydropower installations in the country are located, also command the two largest storage reservoirs in South Africa. From the Gariep Dam a major inter-water management area transfer occurs via the 80 km long Orange-Fish Tunnel to the Fish to Tsitsikamma WMA. A significant portion of the yield of the Orange River is also released down the river for use in the Lower Orange WMA and by Namibia.

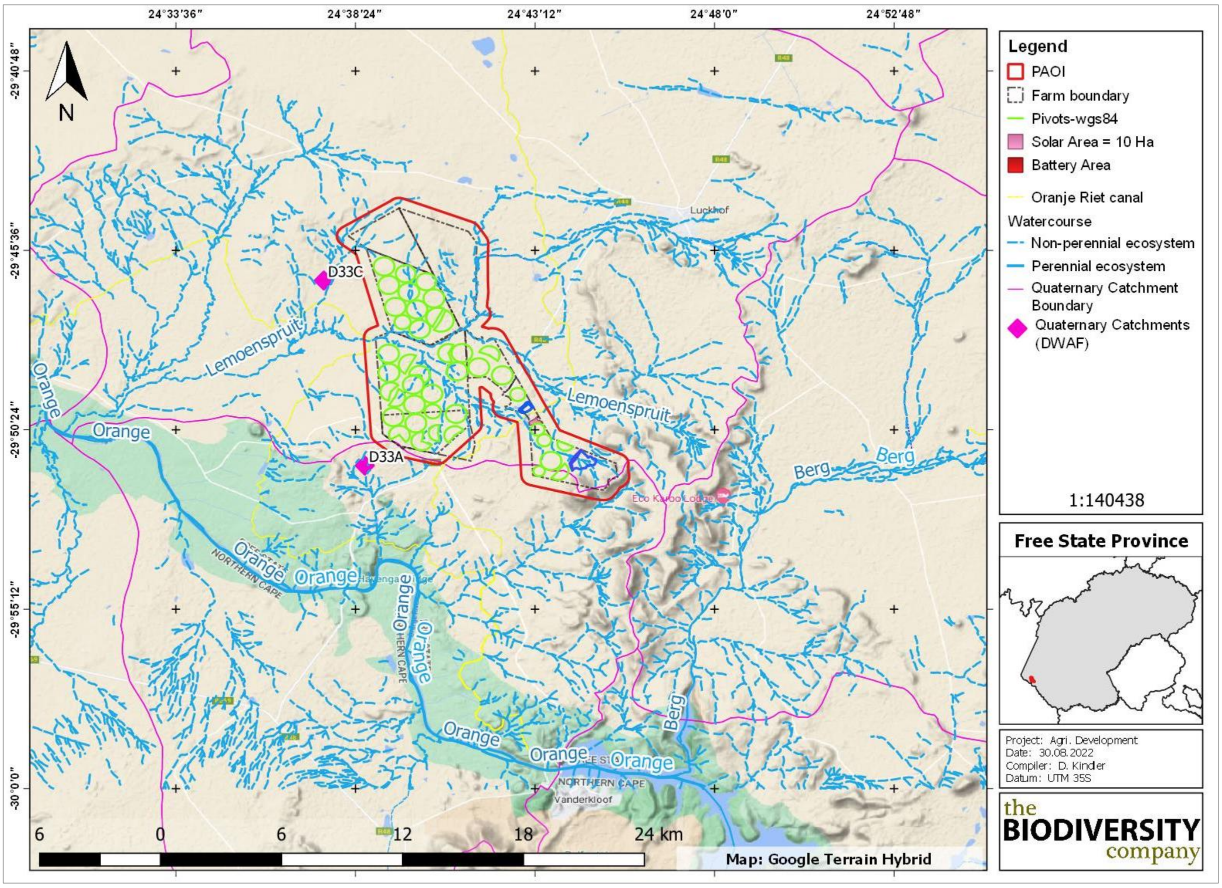


Figure 7-1 Hydrological setting associated with the project area

7.2 Freshwater Ecological Setting

The study area is located across a single Freshwater Ecoregion, the Southern Temperate Highveld (Ecoregion ID: 575 - Figure 7-2), with the rivers eventuating into the Orange 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 Orange River system, with fewer species expected within the associated tributaries based on species habitat requirements. The species assemblage expected within the study area are typically widely distributed over a large geographic range.

The study area predominantly falls within the Nama Karoo 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.

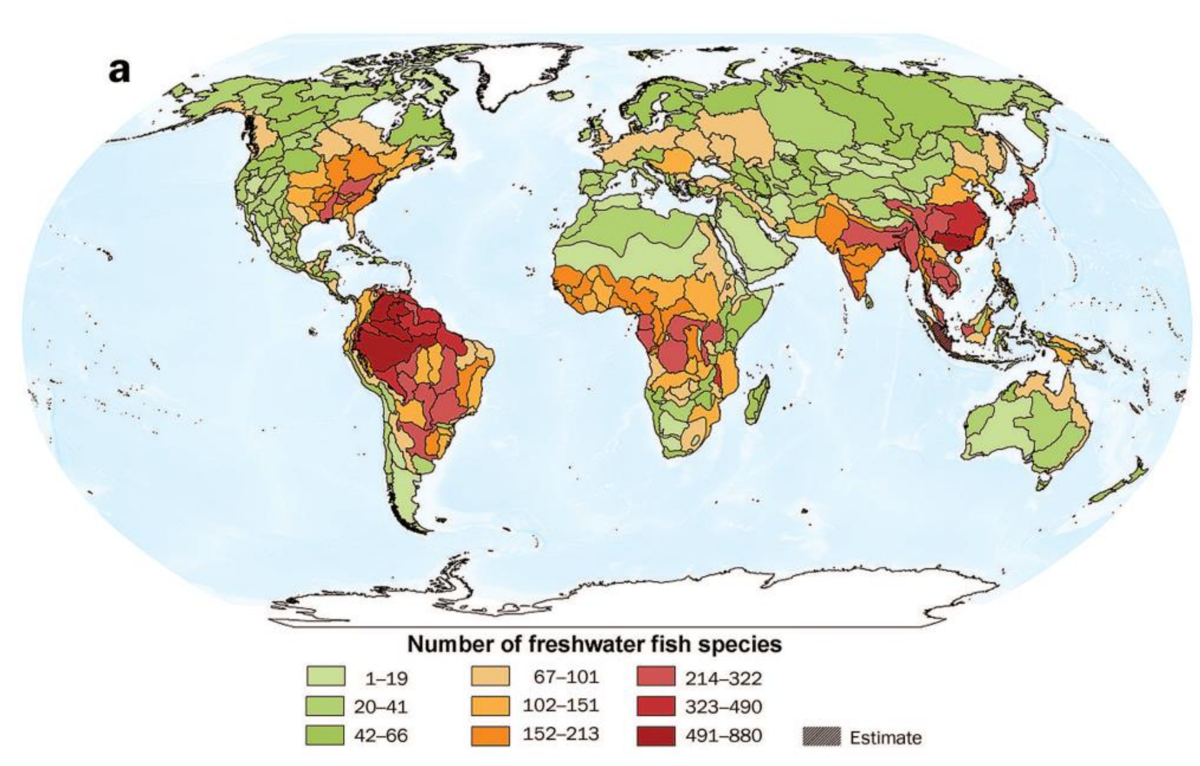


Figure 7-2 Freshwater Ecoregions of the World (Abell et al., 2008)

7.3 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 of Southern Africa. The nearest SWSA is 262 km to the east of the PAOI.

7.4 Climate

This region's climate is characterised by rainfall peaks in autumn (March). Mean Annual Precipitation (MAP) ranges from about 190 mm in the west to 400 mm in the northeast (Figure 7-3). Mean maximum and minimum monthly temperatures for Britstown are 37.9°C and –3.6°C for January and July, respectively. Corresponding values are 37.1°C and –4.8°C for De Aar and 39.0°C and –2.3°C for Kareekloof (northwest of Strydenburg) (Mucina and Rutherford, 2006).

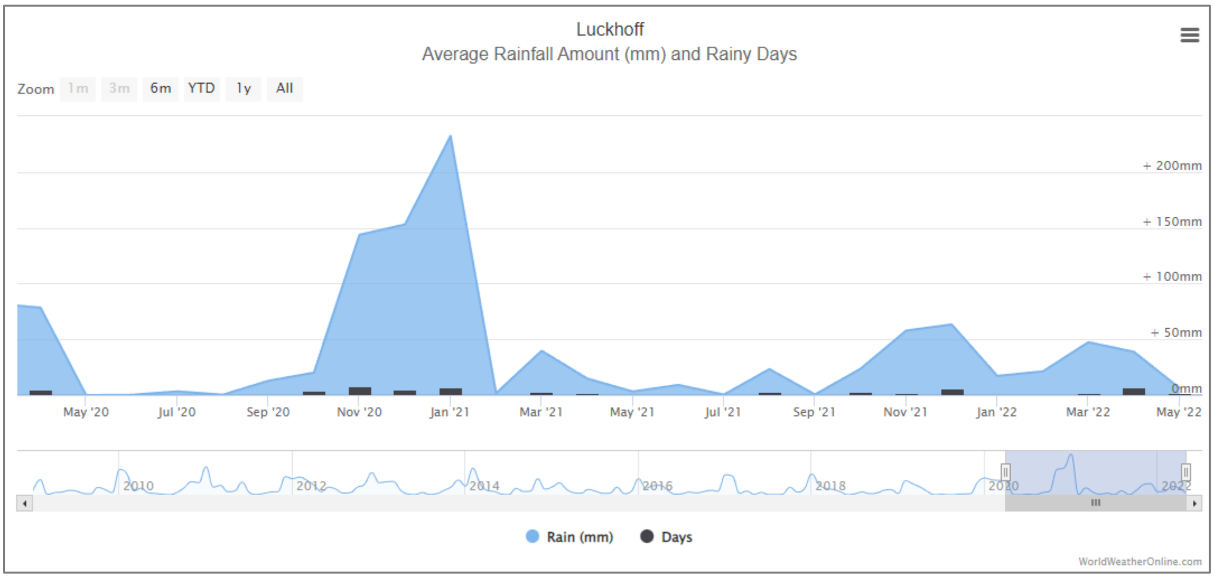


Figure 7-3 Climate for the Luckhoff area (WWO, 2022)

7.5 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).

In an attempt to better conserve aquatic ecosystems, South Africa has categorised its river systems according to set ecological criteria (i.e. ecosystem representation, water yield, connectivity, unique features, and threatened taxa) to identify Freshwater Ecosystem Priority Areas (FEPAs) (Driver et al., 2011). The FEPAs 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 (NEM:BA) biodiversity goals (Nel *et al.,* 2011).

The project area falls across two SQRs with several NFEPAs listed within the project area (Table 7-1). These FEPAs are associated with wetland type ecosystems and no aquatic biodiversity FEPAs are designated to the watercourses within the project area. The catchment does however serves as an *upstream management area* (Figure 7-4).

Conserving the water quality, riverine and wetland habitat and associated ecological functioning within the project area and associated catchments, 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 (lower reaches of the Lemoenspruit and the Orange River). The Orange River serves as a Fish Sanctuary area for threatened fish species such as Largemouth Yellowfish (*Labeobarbus kimberleyensis*) which are showing population declines from anthropogenic activities. The catchments in which human activities occur need to be managed to maintain water quality and prevent further degradation of local and downstream water resources in order to contribute to national biodiversity goals and support sustainable use of water resources.

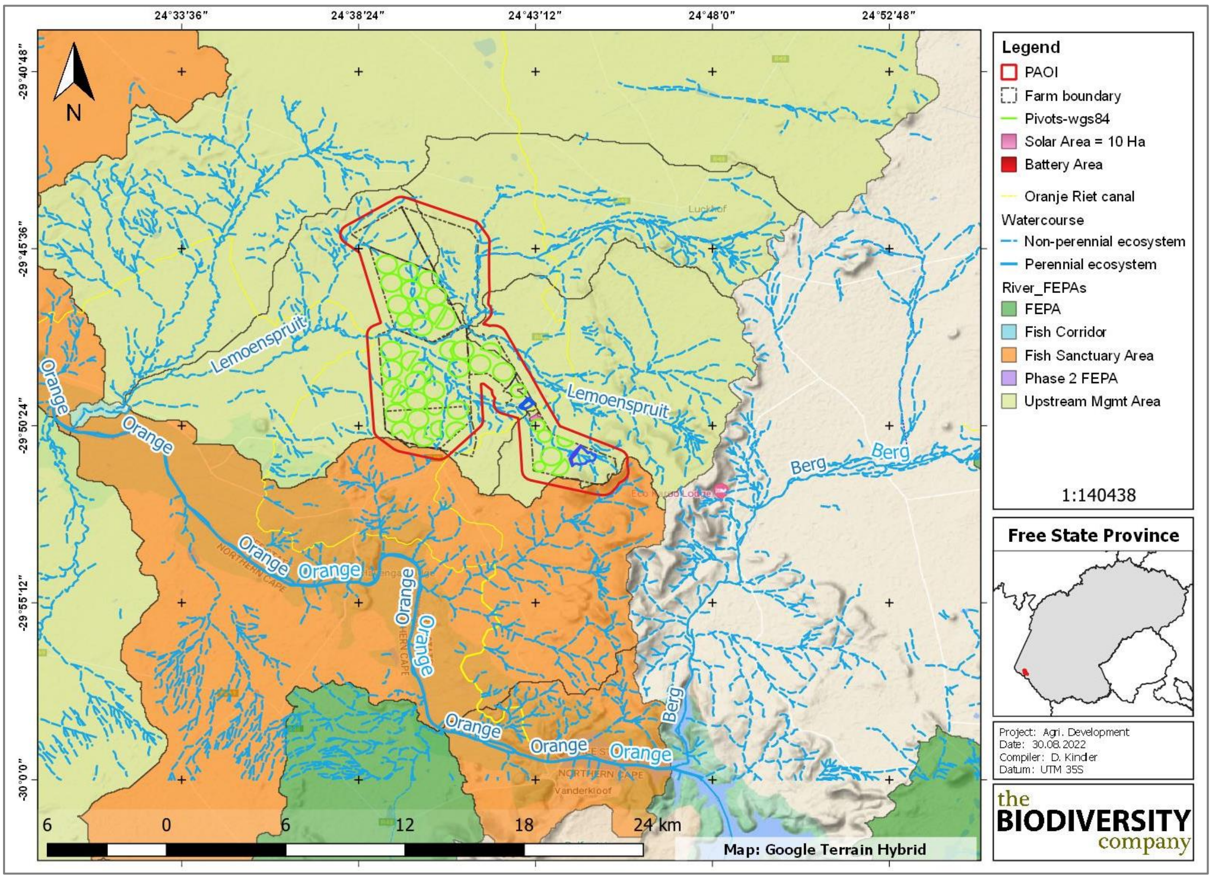


Figure 7-4 Aquatic FEPAs associated with the project area (Nel et al., 2011)

Table 7-1 NFEPAs listed for the project area

Type of FEPA map category	Biodiversity features
Lemoenspruit SQR D33C-4458	
Wetland ecosystem type	2 WetCluster FEPAs
Wetland ecosystem type	Upper Nama Karoo_Channelled valley-bottom wetland
Wetland ecosystem type	Upper Nama Karoo_Flat
Wetland ecosystem type	Upper Nama Karoo_Unchannelled valley-bottom wetland
Wetland ecosystem type	Upper Nama Karoo_Valleyhead seep

7.6 Freshwater Critical Biodiversity Area and Ecological Support Areas

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).

Ecological Support Areas (ESA) are the areas of land that are adjacent to and can envelope CBAs and are not essential for achieving biodiversity targets, but they play a vital role in the continued functioning of adjacent CBAs. Additionally, it was recommended by Collins (2016) to treat all NFEPA wetlands as Ecological Support Areas (ESA) within the region. Figure 7-5 shows the project area superimposed on the Terrestrial CBA map. The project area traverses several CBA1 & 2 and ESA1 & 2 areas.

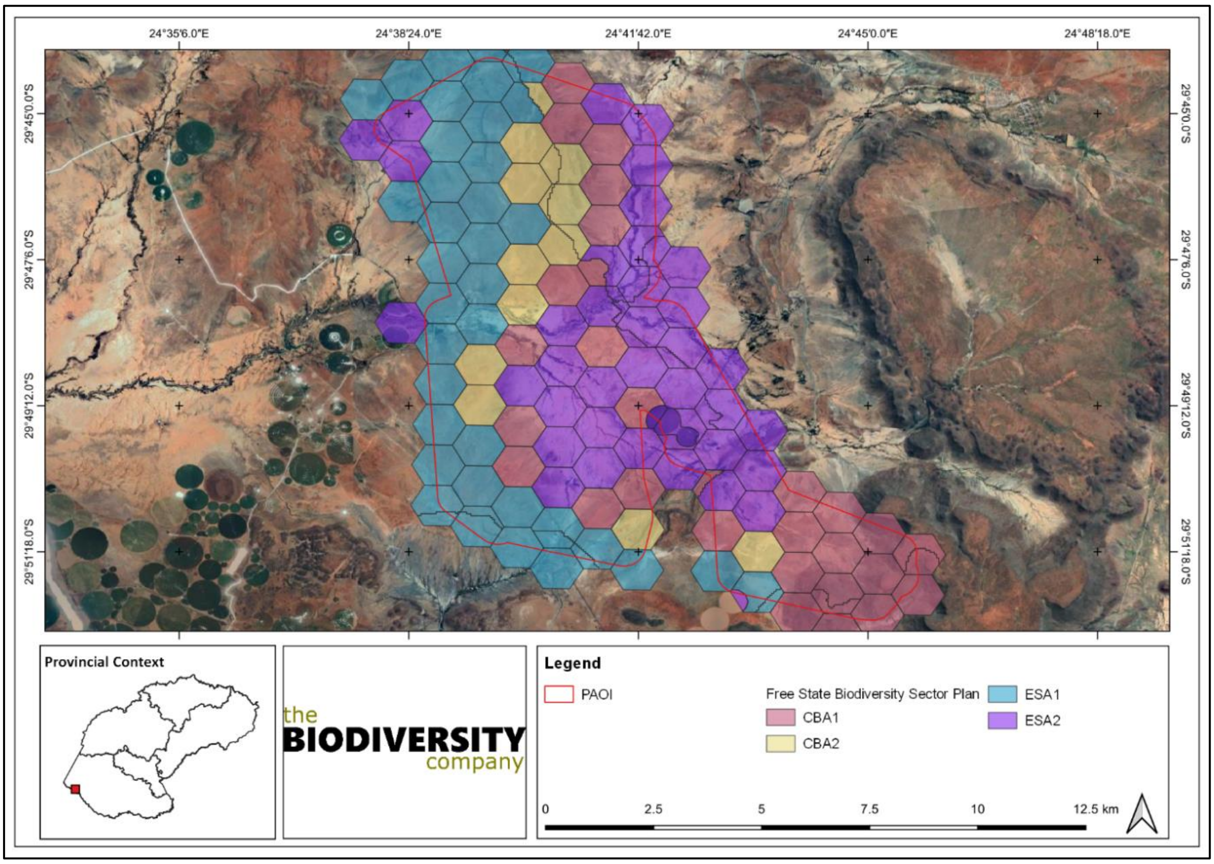


Figure 7-5 Illustration of the Critical Biodiversity Areas within the project area

7.7 Aquatic Ecosystem Threat Status

The South African Inventory of Inland Aquatic Ecosystems (SAIIAE) was released with the NBA 2018. The Ecosystem threat status of river and wetland ecosystem outlines the degree to which the 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 (Van Deventer et al., 2019; 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 SAIIAE dataset, the project area is drained by the interconnected *Endangered* Lemoenspruit ecosystem which flows into the *Critically Endangered* Orange River downstream of the project area (Figure 7-6).

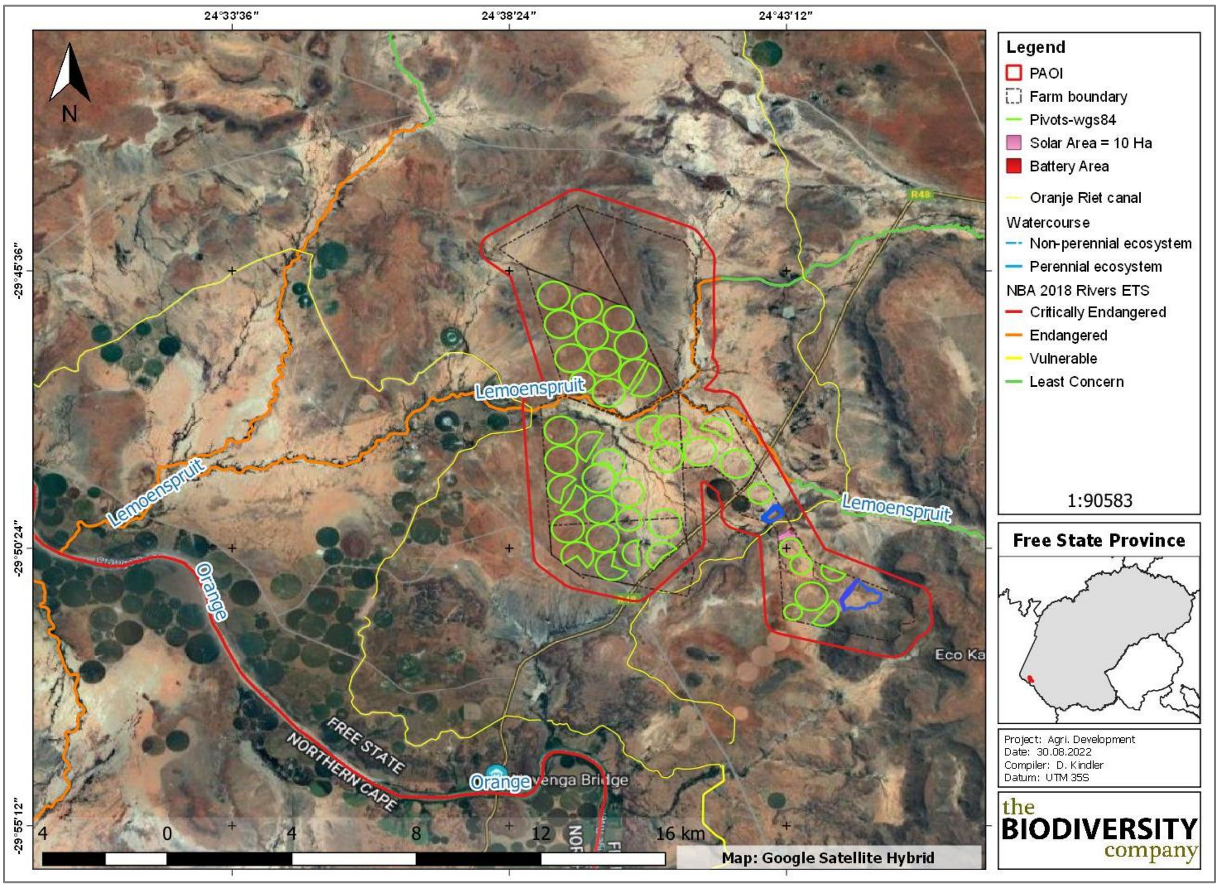


Figure 7-6 Illustration of the Ecosystem Threat Status of the project area (NBA, 2018)

7.8 Aquatic 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 7-7). This indicates that the aquatic ecosystems associated with the project area are predominantly rated as *not protected* (Lemoenspruit) and *poorly protected* (Orange River). The protected areas in the region are presented in Figure 7-8.

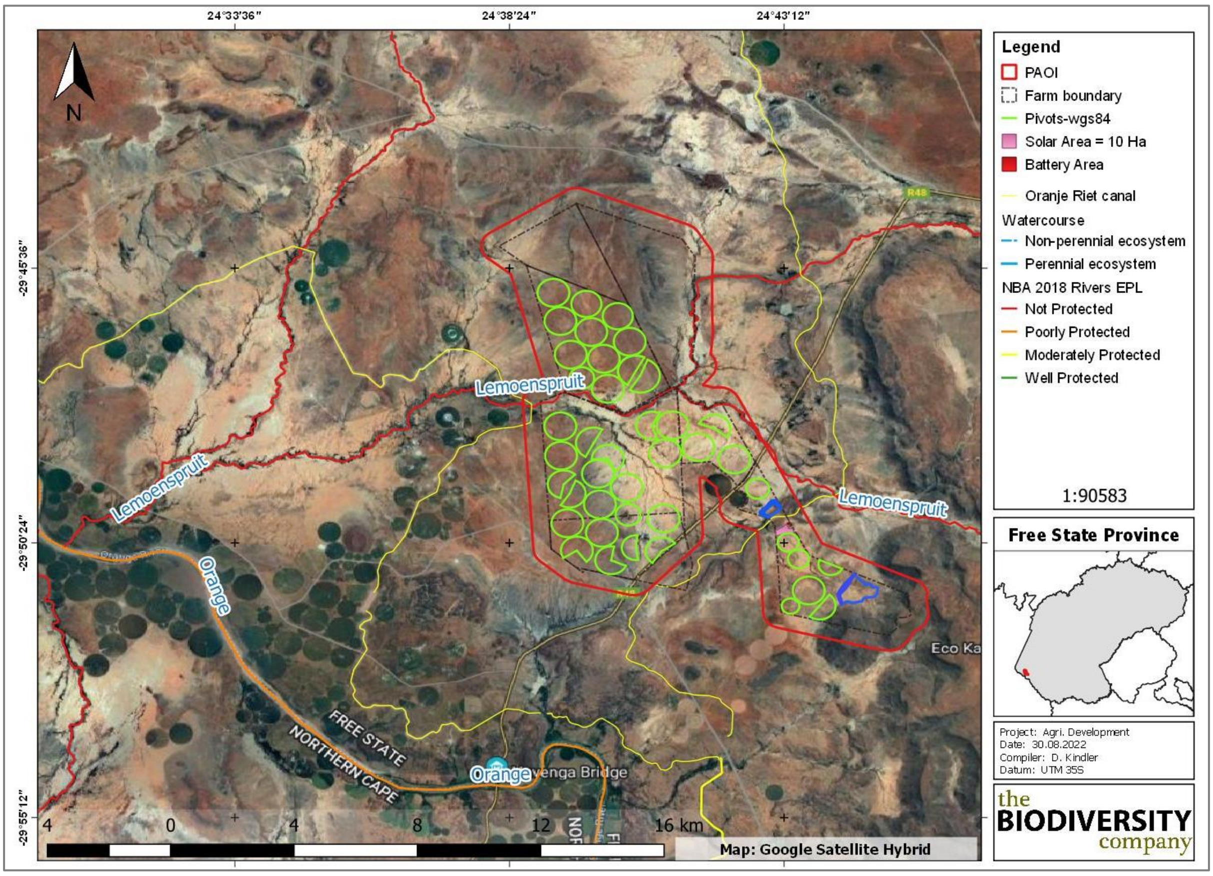


Figure 7-7 Illustration of the Ecosystem Protection Level of the project area (NBA, 2018)

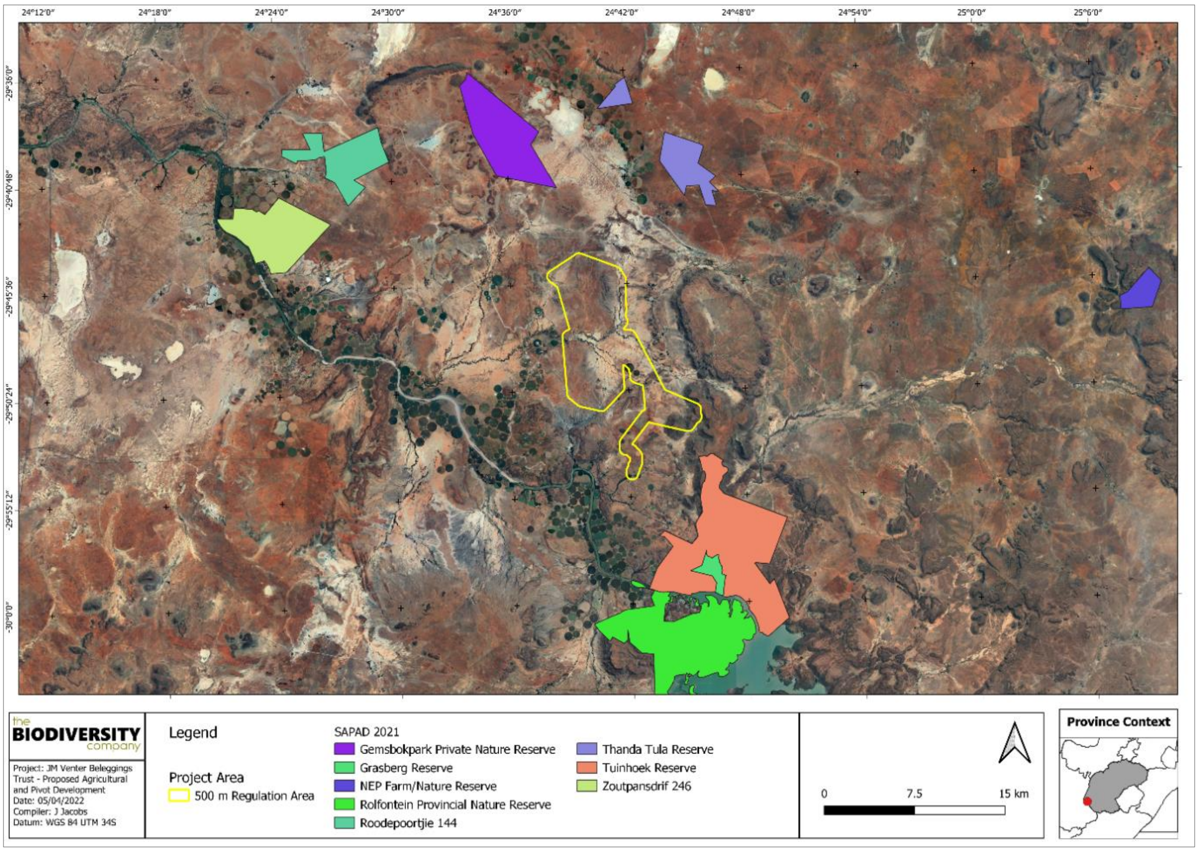


Figure 7-8 Illustration of the protected areas in the area (SAPAD, 2021)

7.9 National Wetland Map 5

The National Wetland Map 5 (NWM5) spatial data was published in October 2019 (Deventer *et al*. 2019), in collaboration with the South African National Biodiversity Institute (SANBI), with the specific aim of spatially representing the location, type and extent of wetlands in South Africa. The data represents a synthesis of a wide number of official watercourse data, including rivers, inland wetlands and estuaries. This database does recognise the presence of wetlands within the extent of the project area, these include valley bottom systems and depressions.

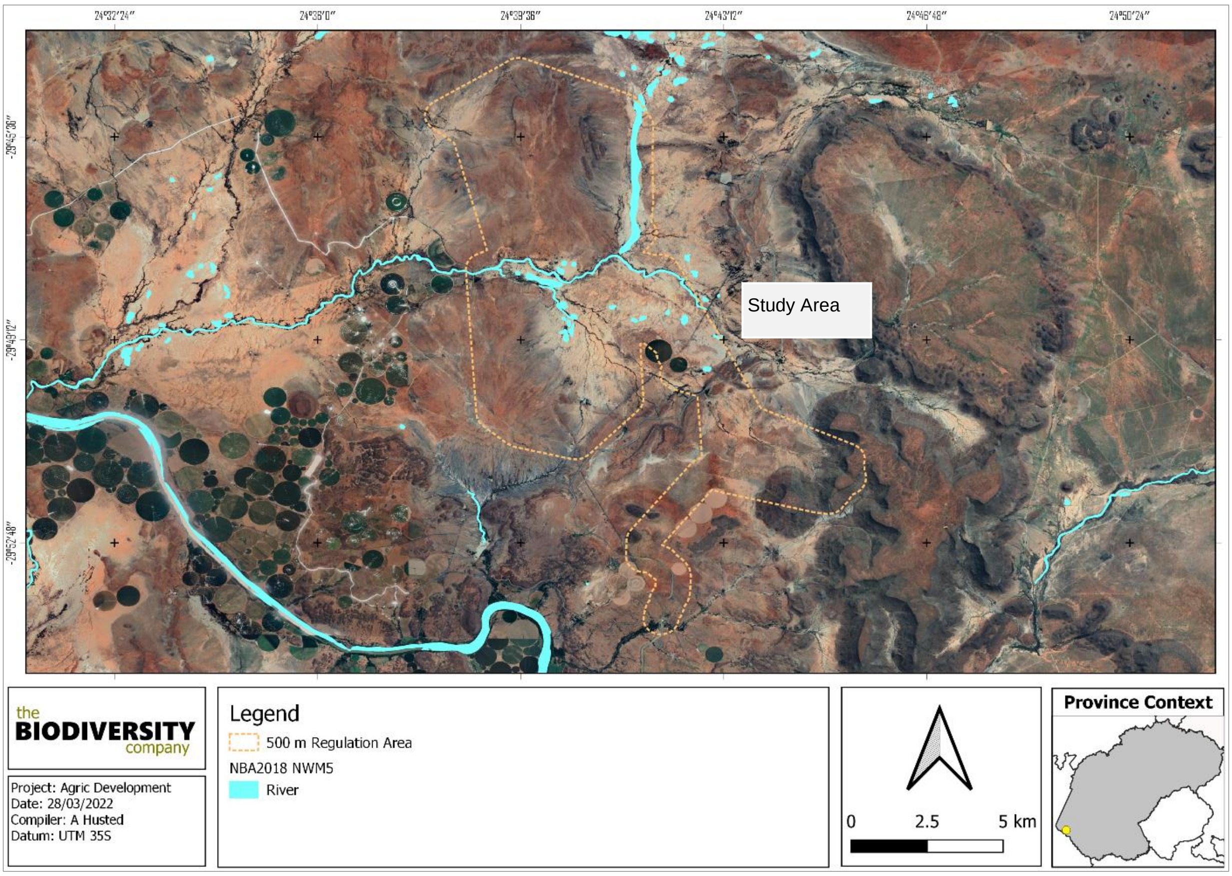


Figure 7-9 Map illustrating the NWM5 for the project area

7.10 Environmental Screening Tool

This approach has also taken cognisance of the recently published Minimum Criteria for Reporting on Identified Environmental Themes (DWS, 2020). The aquatic biodiversity theme sensitivity as indicated in the screening tool report indicates some "Very High" sensitivity areas which are associated with the Endangered Lemoenspruit and its tributary network (Figure 7-6) and some wetland areas (Figure 7-9). The project footprint predominantly consists of areas of "Low" sensitivity between the freshwater resources (Figure 7-11). 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 7-11).

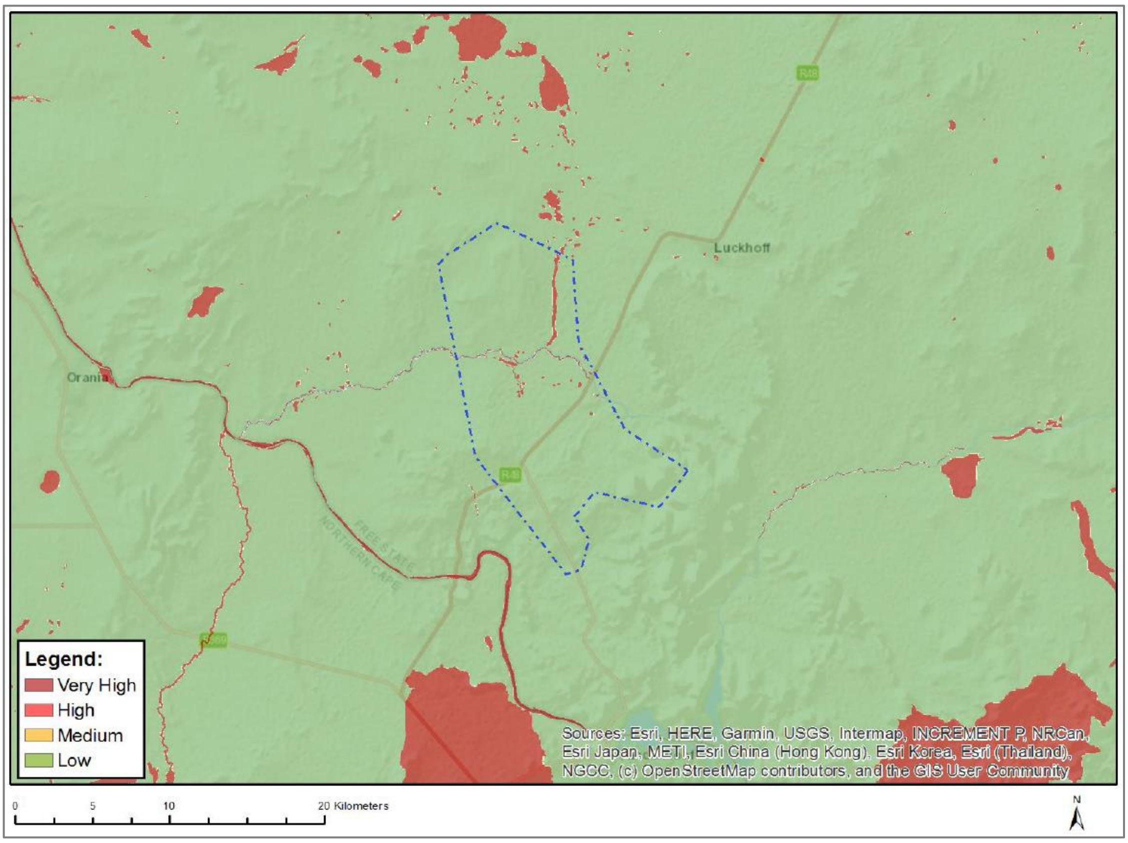


Figure 7-10 Aquatic Biodiversity Combined Sensitivity (National Web based Environmental Screening Tool)

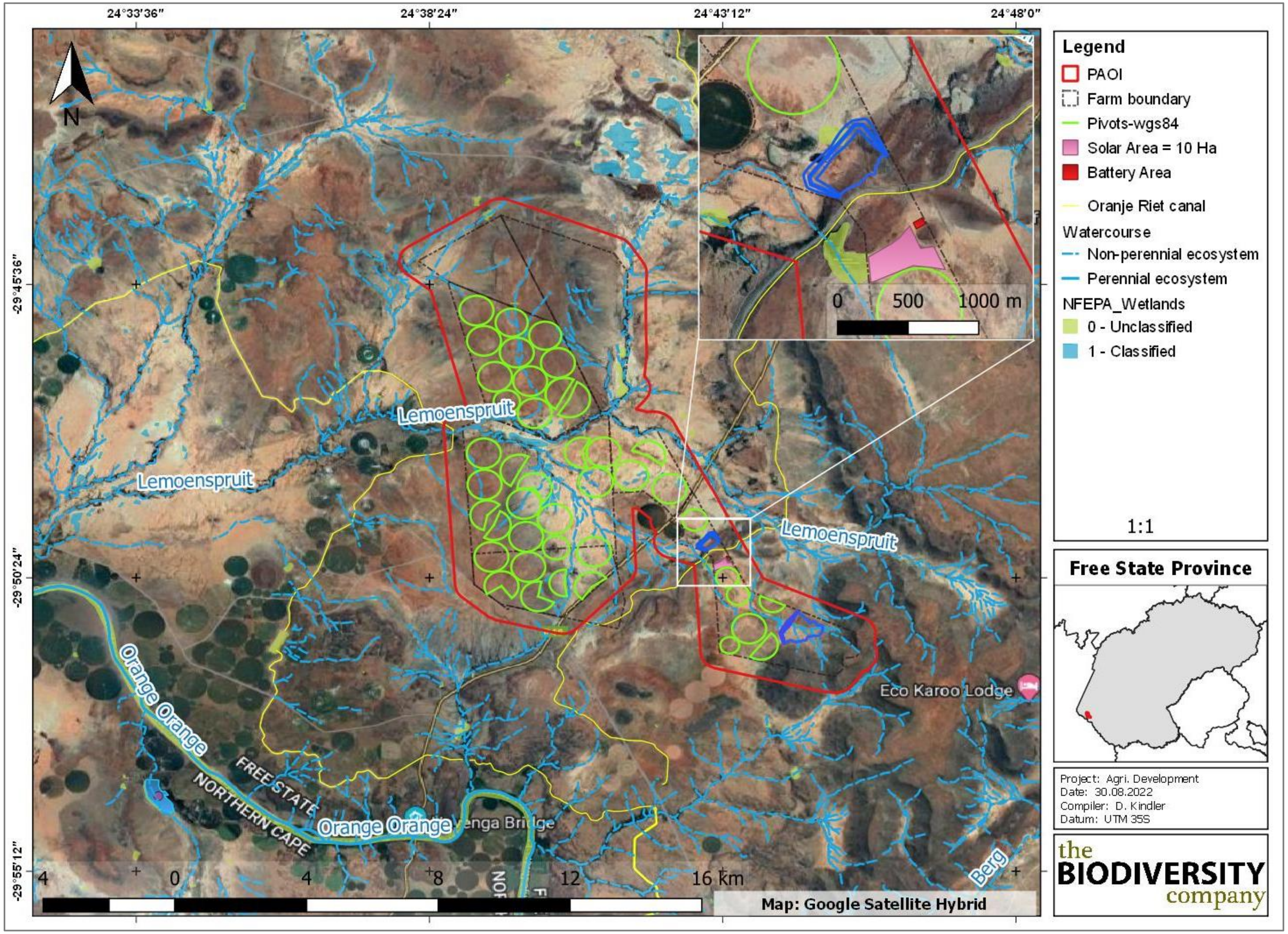


Figure 7-11 Proposed infrastructure in relation to aquatic features

7.11 Status of Watercourses

The locally affected Lemoenspruit is classified as a lower foothills geoclass river system (Rountree *et al*., 2000), with a gentle gradient alluvial bed and meandering channel. A distinctive macro-channel is visible with sand and silt deposits occurring throughout the watercourse. The area surrounding the proposed project site consists of predominantly natural vegetation (grasslands and bushveld) between the Lemoenspruit and its tributary network which are lined with well-developed riparian vegetation.

The Present Ecological Status (PES) of the watercourse's catchments in relation to project area are illustrated in Figure 7-12. The Lemoenspruit and its tributary network are ecologically interlinked and are affected by various land use activities such as agriculture and need to be managed to prevent degradation of the catchment condition, water quality and ecological integrity of the downslope watercourses. Catchment mismanagement within a Sub-Quaternary Reach (SQR) is well documented to degrade its catchment and associated watercourses due to damaged ecological drivers.

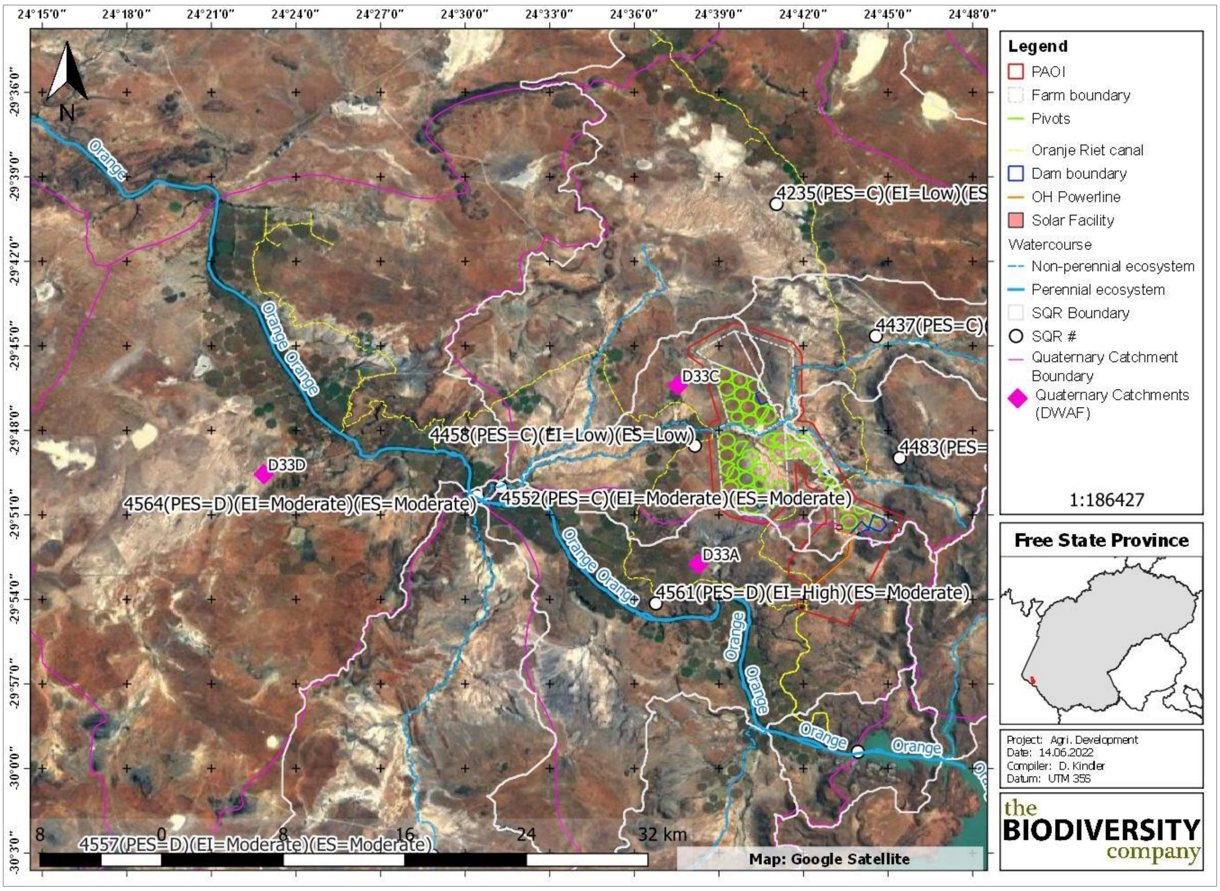


Figure 7-12 Illustration of the Present Ecological State within the relevant catchments (DWS, 2014)

The Lemoenspruit and tributary reach within the PAOI are represented by two adjacent SQRs. These two SQRs comprise the upper reaches of the project area D33C-4483 which drains into the adjacent and downstream D33C-4458 SQR. Water draining from these two SQRs drains downstream through another *Endangered* SQR Lemoenspruit (D33C-4552) eventuating in the *Critically Endangered* Orange River SQR requiring upstream management.

The PES of the two Lemoenspruit SQRs are moderately modified (class C) at a desktop level (DWS, 2014). The desktop listed impacts to the watercourses are attributed to runoff from agricultural activities 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 7-2 on the next page.

Table 7-2 Desktop Ecological summary for the relevant quaternary catchments

SQR	Stream order	Length (km)	PES (DWS, 2014)	ES	EI	Default Ecological Category
Upper Lemoenspruit Catchment (This upper reach SQR drains into the Middle Lemoenspruit Catchment SQR D33C-4458)						
D33C-4483	**1**	**14.77**	**C (Moderately Modified)**	**Moderate**	**Low**	**D (Largely Modified)**
PES-EIS Justification		Moderate impacts to instream habitat and connectivity. Unknown level of water quality perturbations and flow modifications. High instream habitat integrity class. Low to moderate sensitivity of aquatic biota to changes in flow and physicochemical modifications. Impacts include instream weirs/dams crossings and bridges associated with road network and irrigated agriculture with associated effluent and return flows.				
Middle Lemoenspruit Catchment (This SQR drains into the Lower Lemoenspruit Catchment SQR D33D-4452)						
D33C-4458	**2**	**19.12**	**C (Moderately Modified)**	**Low**	**Low**	**D (Largely Modified)**
PES-EIS Justification		Small impacts to instream habitat and connectivity. Unknown level of water quality perturbations and flow modifications. Moderate instream habitat integrity class. Low to moderate sensitivity of aquatic biota to changes in flow and physicochemical modifications. Impacts include crossings and bridges associated with road network and irrigated agriculture with associated effluent and return flows.				
Lower Lemoenspruit & Orange Confluence Catchment (This SQR assessed the lower section of the Lemoenspruit catchment until and included a small reach of the immediate Orange River confluence. This SQR is also located between SQRs D33A-4561, and an several unassessed Orange SQRs)						
D33C-4552	**2** (upper) **5** (Confluence)	**3.45**	**C (Moderately Modified)**	**Moderate**	**Moderate**	**C (Moderately Modified)**
PES-EIS Justification		Small impacts to instream habitat connectivity and large impacts to instream habitat modification. Unknown level of water quality perturbations and flow modifications however the level of land use change from natural to cultivated is higher than the other 2 Lemoenspruit SQRs. Moderate instream habitat integrity class serving as very high instream migration link/corridor. Low to high sensitivity of aquatic biota to changes in flow and physicochemical modifications with a greater fish diversity at confluence. Impacts include crossings and bridges associated with road network and irrigated agriculture with associated effluent and return flows.				
Adjacent Downstream influenced Orange Catchment (Orange River downstream of the Lemoenspruit SQRs influence, with lateral influence on the adjacent and upstream Orange River SQR and ecological functioning)						
D33A-4561	**5**	**57.66**	**D (Largely Modified)**	**Moderate**	**Moderate**	**C (Moderately Modified)**
PES-EIS Justification		Moderate to serious impacts to instream and riparian/wetland connectivity and large impacts to instream and riparian habitat modification. Moderate level of water quality perturbations with serious flow modifications present. Moderate instream and riparian habitat integrity class serving as a high instream migration link/corridor. High to very high sensitivity of aquatic biota to changes in flow and physicochemical modifications with red listed fish present. Impacts include crossings and bridges associated with road network and irrigated agriculture with associated effluent and return flows.				
Downstream Orange Catchments						
There is no available desktop PES data for the Orange River catchments (D33D, D33E, and D33F) downstream of the Lemoenspruit (SQR D33C-4552) confluence with the Orange River until the next downstream SQR that was assessed for PES (SQR D33G-4051). Further desktop information for the catchments downstream in the Orange WMA can be sourced from the DWS website.						
Lower Orange Catchments (Orange River downstream of SQRs D33A-4561, and D33G-4051)						
D33G-4051	**5**	**240.59**	**C (Moderately Modified)**	**High**	**High**	**B (Largely Natural)**
PES-EIS Justification		Moderate impacts to instream and riparian/wetland connectivity and small to moderate impacts to instream and riparian habitat modification. Moderate level of water quality perturbations with serious flow modifications present. High instream and very high riparian habitat integrity class serving as a high instream migration link/corridor. Very high sensitivity of aquatic biota to changes in flow and physicochemical modifications with red listed fish present. Impacts include crossings and bridges				

SQR	Stream order	Length (km)	PES (DWS, 2014)	ES	EI	Default Ecological Category
		associated with road network, instream weirs serving as abstraction areas for extensive irrigation and agriculture with associated effluent and return flows, riparian zone removal for farming and the urban area of Hopetown and its sewage facilities and associated effluent and return flows.				

7.12 Expected Fish Species

An expected species list was generated from DWS (2014), and Skelton (2011) for the Lemoenspruit D33C-4483 and D33C-4458 SQR's and the associated downstream Orange River SQR. A total of 11 fish species are expected to occur within the watercourses potentially influenced (cumulatively) by the project and these are presented in Table 7-3.

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 Lemoenspruit reach does however have limited habitat diversity and cover features associated with the non-perennial and heavily sedimented nature of the watercourse which would likely limit the diversity of the fish community. This has resulted in a single species expected within the Lemoenspruit, while the downstream Orange river with a high habitat diversity has a much higher number of expected species. The conservational status of the fish species was assessed against the latest IUCN database to identify Species of Conservation Concern (SCC) (IUCN, 2022).

The small barb species previously known as *Enteromius anoplus* (Chubbyhead barb) was thought to be widely distributed across southern Africa with an IUCN listed status of Least Concern (LC) due to an extensive distribution range. However, according to a recent genetic study conducted by Kambikambi *et al.* (2021), *Enteromius anoplus* was reclassified into four distinct genetic lineages separated by major river systems, with *Enteromius oraniensis* (Orange River Chubbyhead barb) forming the Orange River lineage, a distinct species endemic to the Orange River system. These results render the current IUCN Red List assessment of *E. anoplus* obsolete. Kambikambi *et al.* (2021), suggest that there is thus the need for generating baseline information, including knowledge of ecological requirements, habitat utilization, distribution, life history and feeding ecology to support conservation and protection of these endemic fish. In absence of a threatened status these fish should be conserved through the precautionary principle and be treated as highly threatened for proposed developments until otherwise proven to be less threatened.

An additional indigenous species of conservational concern is expected within the downstream systems, namely *Labeobarbus kimberleyensis* (Largemouth yellowfish) which is listed as Near Threatened (NT) requiring management of water quality and habitat (IUCN, 2022). This large predator species is subjected to threat from water pollution (Vaal and Orange Rivers and their tributaries which receive effluent water), habitat destruction and fragmentation, migration barriers and river regulation by impoundments, destruction of spawning areas due to siltation and inundation, subsistence fisheries (netting) and the spread of alien and invasive fish across its distributional range (IUCN, 2022). Additional species of conservational concern are expected in the Orange River and these include alien species such as Common Carp (*Cyprinus carpio*) and Grass Carp (*Ctenopharyngodon idella*). These are known habitat modifiers degrading instream habitat integrity (IUCN, 2022).

Both *Enteromius oraniensis* and *Labeobarbus kimberleyensis* are SCC taxa potentially influenced from the proposed agricultural project with water quality impacts of key concern to their survival. The latter two species are not SCC taxa for the project due to their tolerance to water quality alterations.

Table 7-3 Expected fish species for the SQRs potentially influenced by the project

Species	Common Name	IUCN (2022)*	D33C-4483 (Upper Lemoenspruit)	D33C-4458 (Lower Lemoenspruit)	D33C-4552 (Lemoenspruit & Orange Confluence)	D33A-4561 (Downstream Orange River)
Austroglanis sclateri	Rock-catfish	LC				1
Clarias gariepinus	Sharptooth catfish	Unknown (High)			1	1
Enteromius oraniensis	Orange River Chubbyhead barb	LC	1	1	1	1
Enteromius paludinosus	Straightfin barb	LC				1
Enteromius trimaculatus	Threespot barb	LC				1
Labeo capensis	Mudfish	LC			1	1
Labeo umbratus	Moggel	LC			1	1
Labeobarbus aeneus	Smallmouth yellowfish	LC			1	1
Labeobarbus kimberleyensis	Largemouth yellowfish	NT				1
Pseudocrenilabrus philander	Southern mouthbrooder	LC				1
Tilapia sparrmanii	Banded tilapia	LC				1
Total expected species	**11**		**1**	**1**	**5**	**11**
	*LC - Least concern; NT - Near Threatened; NA - Not assessed					

7.13 Resource Water Quality Objectives

The NWA sets out to ensure that water resources are used, managed and controlled in such a way that they benefit all users. In order to achieve this, the Act has prescribed a series of measures such as Resource Quality Objectives (RQOs) to ensure comprehensive protection of water resources so that they can be used sustainably (DWA, 2011). Results from the aquatic assessment are ideally compared to the RQOs for the WMA and at a finer level for specific catchments (where available).

Results from the aquatic assessment are compared to the Resource Water Quality Objectives (RWQOs) for the Orange WMA, RWQO site code OS6 at Marksdrift on Orange River (DWAF, 2009). The Lemoenspruit does not have RWQOs specific to this system therefore, the RWQOs for the nearest downstream watercourses RWQO site code OS6 serves as the allocated RWQOs to be monitored against. The RWQOs for the project related watercourses are presented in Table 7-4. The stipulated RWQOs should be considered for the Environmental Management Plan (EMP) and monitoring protocols should environmental authorisation be granted for this project.

Table 7-4 Summary of resources assigned RQOs for the relevant Orange River region (DWAF, 2009)

RWQO site code	Study Unit	Quaternary Catchment	Hydro ID	Electrical Conductivity	Present Ecological State	Management Class	Recommended Ecological Category
Orange River (OS6)	Marksdrift	D33K	D3H008	550 µS/cm	D	C	B

8 Methods Employed During the Study

8.1 Approach and Field Assessment

In line with the minimum requirements for aquatic biodiversity surveys a single aquatic sampling survey was conducted from the 31st of May 2022 to 1st of June 2022. The survey constituted a dry season/ low flow/ winter assessment. The site conditions experienced infield presented abnormally wet conditions for the region for early June with many of the watercourses presenting flow from the wet season that extended into the autumn period (Figure 7-3).

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.

8.1.1 Investigation Sites

A total of 3 sampling sites were assessed during the study, with emphasis placed on the systems within the project area and a downstream receiving environment on the Lemoenspruit. Additional points were visually investigated along the potentially influenced upper reach tributaries of the Lemoenspruit. Figure 8-1 illustrates the sampling points for the study, and Table 8-1 presents site photographs, Global Positioning System (GPS) coordinates. It should be noted that several sites were not suitable for biological sampling due to intensive sedimentation and shallow surface waters. The Orange River could not be assessed as a cumulative impact investigation site due to safety issues related to flooding conditions at the time of the survey.

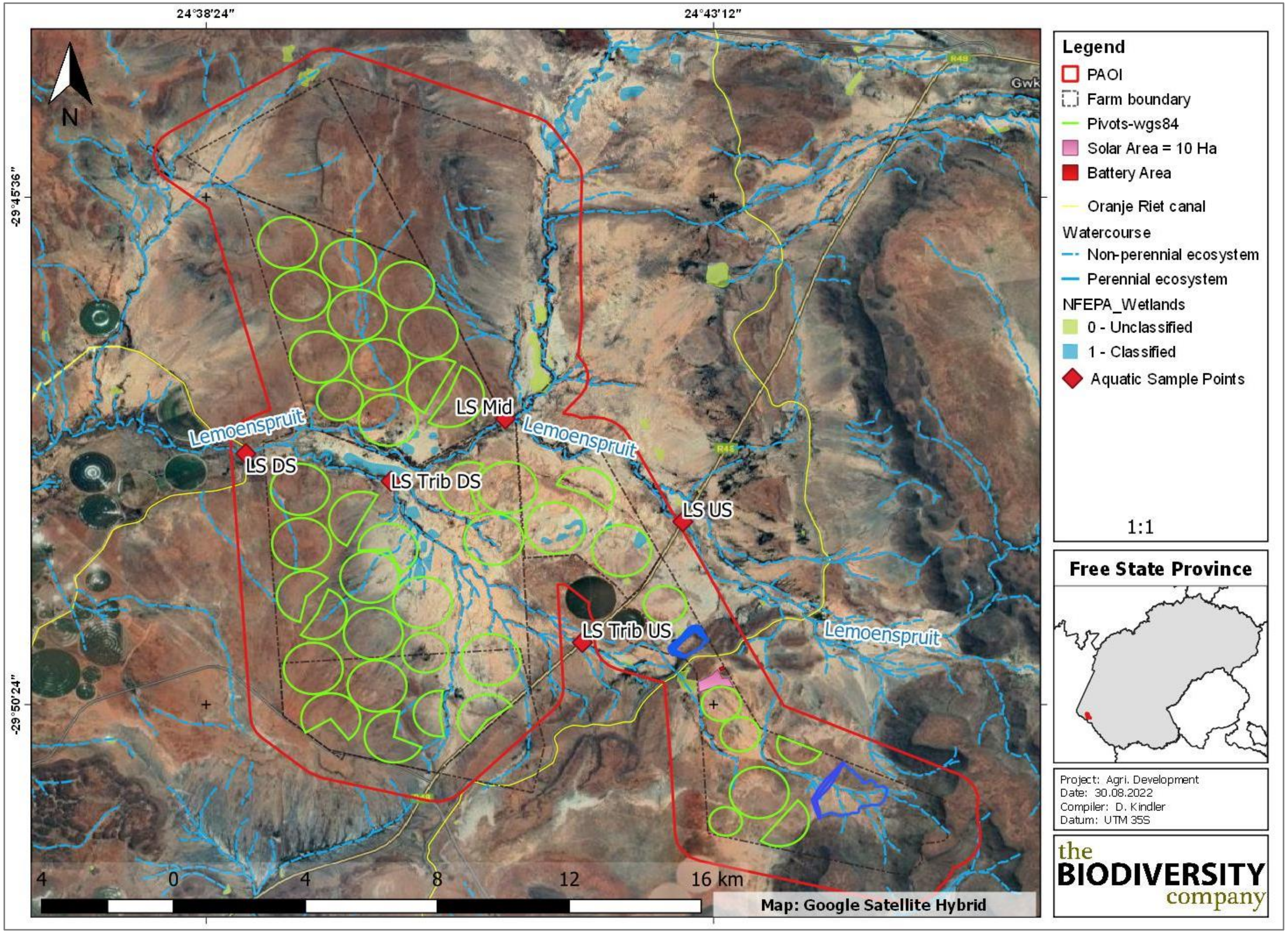


Figure 8-1 Study sampling points

Table 8-1 Investigation site photographs and coordinates (May 2022)

Site	Upstream	Downstream
	Lemoenspruit	
LS US		
Comments	Upstream (reference) Lemoenspruit River site, upstream of proposed infrastructure. The watercourse has been subjected to extensive erosion and sedimentation limiting the depth of the surface water availability for biological sampling. The site was deemed too shallow and unsuitable for standard aquatic sampling methods and was limited to *in situ* water quality analysis only.	
GPS-coordinates	29°48'40.25"S 24°42'54.45"E	
LS Mid		
Comments	Midstream Lemoenspruit River site, midstream of proposed infrastructure and 150 meters downstream of a confluence with an unnamed tributary that drains from the north. The site presented similarity to LS US and was limited to *in situ* water quality analysis only.	
GPS-coordinates	29°47'41.88"S 24°41'13.67"E	
LS DS		
Comments	Downstream Lemoenspruit site, situated downstream of the project area boundary where the Oranje-Riet canal traverses the Lemoenspruit. Adequate water depth and instream habitat available for full biological analysis.	

Site	Upstream	Downstream
GPS-coordinates	29°48'1.65"S 24°38'46.30"E	
Lemoenspruit tributaries (Visual assessment)		
LS Trib US		
Comments	An example of a Lemoenspruit tributary that will be influenced by placement of centre pivots.	
GPS-coordinates	29°49'48.85"S 24°41'57.40"E	
LS Trib DS		
Comments	Located on a Lemoenspruit tributary downstream of LS Trib US, downstream of numerous proposed centre pivots.	
GPS-coordinates	29°48'17.28"S 24°40'8.77"E	

8.1.2 Water Quality

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

8.1.3 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 8-2 and Table 8-3 respectively.

Table 8-2 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 8-3 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
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

8.1.4 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.

8.1.4.1 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 lower foothill rivers (slope class E) were used to categorize biotope ratings (Rowntree *et al.,* 2000; Rowntree & Ziervogel, 1999).

8.1.4.2 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 Nama Karoo Lower - Ecoregion (Figure 8-2). 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.

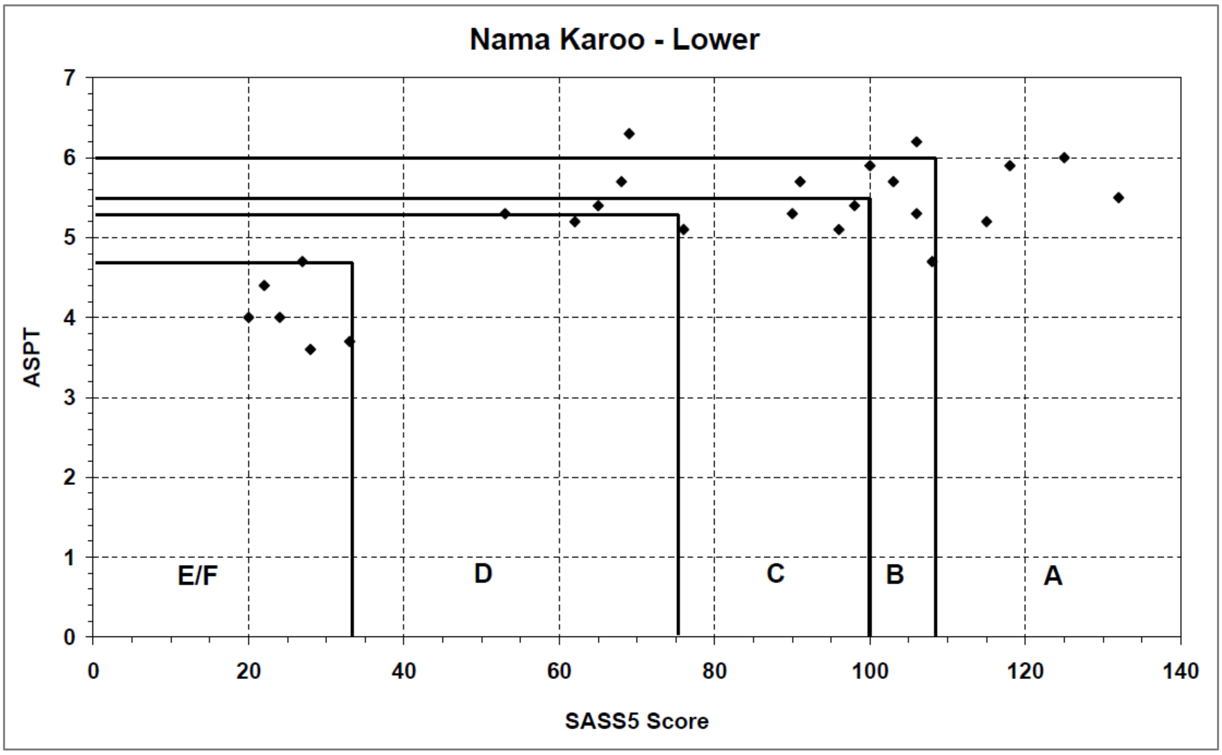


Figure 8-2 Biological Bands for the Nama Karoo Lower - Ecoregion, calculated using percentiles

8.1.5 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 Lemoenspruit River.

8.1.6 Fish Presence

Fish were sampled through electroshocking (Figure 8-3). All fish were identified in the field and released at the point of capture, in order not to cross fish populations between sites and watercourses. 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 8-3 Example of electroshocking used to catch fish species (Mpumalanga, 2019).

8.1.7 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.

8.2 Determining Buffer Requirements

Macfarlane *et al.* (2009) was consulted to determine the appropriate watercourse buffer zone for the proposed activity.

9 Results

9.1 *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. These results are important to assist in the interpretation of biological results due to the direct influence water quality has on aquatic life forms. Results have been compared to limits stipulated in the Target Water Quality Range (TWQR) for aquatic ecosystems (DWAF, 1996) and the RWQOs for the Orange WMA. The results of the May 2022 assessment are presented in Table 9-1.

Table 9-1 In situ surface water quality results (May 2022)

Site	pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)
TWQR* RWQOs**	6.5-9*	550**	>5.0 mg/l*	5-30*
LS US	8.10	953	5.9	16.0
LS Mid	8.56	1 034	9.1	15.5
LS DS	7.91	1 686	6.8	13.3

*TWQR – Target Water Quality Range (DWAF, 2006); **RWQOs - Resource Water Quality Objectives (DWAF, 2009); Levels exceeding guideline levels are indicated in red

Water quality results indicate pH levels within the catchment were alkaline and fell within the TWQR for aquatic biota, and ranged from 7.91 at site LS DS to 8.56 at site LS Mid.

The concentrations of dissolved solids as measured in Electrical Conductivity (EC) were elevated above the RWQOs at all sites and increased in a downstream direction from 953 µS/cm in the upper Lemoenspruit at site LS US to 1 686 µS/cm in the lower reaches at LS DS. The dissolved solid concentrations increased by 8.5% from LS US to LS Mid and again by 63% between LS Mid and LS DS, indicating inputs of unknown contaminants from the tributary systems feeding into the Lemoenspruit between the three sample sites. The elevated EC levels and marked increases would contribute to adverse conditions limiting the diversity of local aquatic biota, notably the more sensitive biota, as such increases interfere with osmotic balances in metabolism and respiration. Altered land use activities which includes agricultural runoff within the catchment contribute to the elevated levels (Figure 9-2). It is likely that the local geology is contributing to the baseline concentrations recorded during the survey, however increases such as 63% over a relatively short distance is considered unnatural and a limiting factor to aquatic biota.

The Dissolved Oxygen (DO) levels were recorded within the TWQR for aquatic biota, and ranged from 5.9 mg/l at site LS US to 9.1 mg/l at site LS Mid. Water temperatures fell within expected ranges for the Nama Karoo ecoregion during the winter survey period.

9.2 Habitat Integrity Assessment

The IHIA was completed for the Lemoenspruit as described in the IHIA methodology component of this study. The spatial framework of which constitutes a 5 km reach was used to complete the IHIA and represented in Table 9-2.

The condition of the watercourse and associated aquatic biodiversity is largely dependent on the condition and degree of modification of the surrounding catchment. The more intact and natural the catchment is, the greater the watercourse condition and ecosystem functioning, and services will be with an associated high aquatic and terrestrial biodiversity presence. An altered catchment compromises the watercourse condition, ecosystem functioning, and services offered with deleterious effects depending on the degree and type of catchment modification. The more modified catchment will ultimately have a low ecological value watercourse offering limited services with an absence of key services such as phytoremediation (cleaning of water by vegetation) with the cumulative loss of its original biodiversity with only the most tolerant biota remaining in the most negatively modified catchments.

Table 9-2 Results for the watercourse and catchment habitat integrity assessment

Criterion	Impact Score	Justification
Instream		
Water abstraction	8	Limited areas are cultivated with 2 by center pivots present in PAOI. The rivers are further used for free-range drinking by livestock
Flow modification	6	A small number of impoundments & a few instream crossing structures & bridges present in catchment
Bed modification	21	Intensive instream sedimentation from bank and catchment erosion with low to moderate levels of trampling by livestock. Limited crossing structures with minor influence on substrate movement. The sedimentation levels have smothered course substrates important for aquatic biota.
Channel modification	12	Low to moderate levels of trampling of vegetation by livestock with subsequent bank erosion & instream sedimentation. Besides intensive sedimentation the channel is largely unmodified from natural levels.
Water quality	18	Active agriculture and livestock (nutrients, pesticides & herbicides) in immediate catchment with R48 Regional road (hydrocarbons & miscellaneous spillages) in upper reaches. Limited informal river crossings where farm vehicles drive through watercourse washing hydrocarbons from vehicle. Limited farmsteads serving as points of pollution. Nearest sewage works is located in Luckhoff. Elevated EC levels above the RWQOs for the Orange WMA indicate influenced water quality.
Inundation	7	A small number of weirs/ impoundments & a few instream crossing structures.
Exotic macrophytes	0	No duckweed, hyacinth, parrots feather or similar observed.
Exotic aquatic fauna	0	None observed.
Solid waste disposal	5	Limited, indicating adequate management of the catchment and associated watercourses.
Total Instream	**63.4**	
Category	**C (Moderately Modified)**	
Riparian		
Indigenous vegetation removal	10	Areas denuded for cultivation are outside of riparian zones, with moderate levels of grazing and trampling by livestock & erosion. Moderate to high levels of invasion and competition from alien vegetation (Black jacks and others) throughout catchment.
Exotic vegetation encroachment	17	Large areas of the riparian zone invaded by alien & invasive vegetation notably Black Jacks with some species legally requiring management. The level of invasion can decrease the buffering function of the riparian zone.
Bank erosion	12	Moderate due to the high erodibility of the catchment exacerbated by livestock trampling & presence of instream structures
Channel modification	10	Low to moderate due to livestock trampling & instream structures, road network and non-cultivated watercourse buffer areas with impacts from encroachment of alien vegetation
Water abstraction	6	Limited areas are cultivated with 2 by center pivots present in PAOI. The rivers are further used for free-range drinking by livestock
Inundation	5	A small number of weirs/ impoundments & a few instream crossing structures. with lower impact to the riparian areas than the instream areas
Flow modification	6	A small number of impoundments & a few instream crossing structures & bridges present in catchment These structures concentrate flows resulting in bank erosion while altering the sediment regime of the catchment.

Criterion	Impact Score	Justification
Water quality	12	Active agriculture and livestock (nutrients, pesticides & herbicides) in immediate catchment with R48 Regional road (hydrocarbons & miscellaneous spillages) in upper reaches. Limited informal river crossings where farm vehicles drive through watercourse washing hydrocarbons from vehicle. Limited farmsteads serving as points of pollution. Elevated EC levels above the RWQOs for the Orange WMA indicate influenced water quality.
Total Riparian	**60.7**	
Category	**C (Moderately Modified)**	

The results of the instream and riparian habitat assessment in the Lemoenspruit indicated class C or moderately modified habitat condition in the watercourse and its tributaries. This class indicated that a loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged. The ecological condition of the watercourses was derived to be within the recommended management class C (moderately modified) of the RWQOs for the catchment (Table 7-4 - DWAF, 2009). While these RWQOs are not specific for the Lemoenspruit, the deterioration of these catchments below class C contributes to the deterioration of the downstream Orange River. The relatively low intensity of anthropogenic activities (farmsteads, two centre pivots and livestock land uses (Figure 9-1) within the catchment contributes to moderate modifications to the riparian and instream habitat integrity as described in the results table.

Instream habitat modifications within the catchment was noted at all sites, with sedimentation considered to be extensive (Figure 9-3). The source of the increased sediment yield can be attributed to the erosion of channel edges within the catchment, compounded by livestock activities (Figure 9-1). The soils observed within the river banks was noted to be composed of moderate to 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 (alien vegetation encroachment and livestock trampling) of the riparian zone due to erosion has compromised the riparian zone integrity within the catchment although still considered largely intact with the aforementioned impacts present in low intensities across the catchment. As depicted in Figure 9-5, instream river crossings through the Lemoenspruit contribute to flow, bed and channel modifications with lateral movement of sediment from the roads while contributing to water quality impacts.

Figure 9-1 Altered land use within the Lemoenspruit catchment (Google Earth, 2022)

Figure 9-2 Illustration of agricultural activities (centre pivots within the Lemoenspruit tributary catchment (Google Earth, 2022)

Figure 9-3 Extensive instream sedimentation present across the catchment

Figure 9-4 Livestock within the catchment (Photo taken 1 June 2022) and trampling of instream areas (picture insert)

Figure 9-5 Instream river crossings through Lemoenspruit (Photo taken 1 June and 31 May 2022)

9.3 Aquatic Macroinvertebrate Assessment

9.3.1 Macroinvertebrate Habitat

Biological SASS5 assessments were completed at representative sites in the considered river reaches. A biotope rating of available habitat was conducted at each sampled site to determine the suitability of habitat to macroinvertebrate communities. The lower foothills (slope geoclass E) sampled reach was assigned different weightings for the various biotopes according to importance value. The categories were calculated according to the biotope rating assessment as applied in Tate and Husted (2015). A rating system of 0 to 5 was applied, whereby 0 represents a biotope as not available (absent) and 5 as abundant and diverse for sampling. The results of the biotope assessment are provided in Table 9-3.

Table 9-3 Biotope availability at the sites during the survey (Rating 0-5)

Biotope, Weighting & Sites		LS US	LS Mid	LS DS
Stones in current (SIC)	18*			1.5
Stones out of current (SOOC)	12			1.5
Bedrock	3			0
Aquatic vegetation	1			0
Marginal vegetation in current	2			2
Marginal vegetation out of current	2	Site not suitable for sampling	Site not suitable for sampling	1
Gravel	4			1
Sand	2			3
Mud	1			2
Total Score (X / 45)				**12**
Weighted Biotope Score (%)				**28**
Biotope Category (Tate and Husted, 2015)				**F**

*Weighting value for Lower foothills geoclass

Sites LS US and LS Mid were not suitable for aquatic macroinvertebrate sampling due to intensive sedimentation and shallow surface waters and were excluded from sampling. Site LS DS presented similar levels of sedimentation to LS US and LS Mid, however due to a poorly designed instream crossing structure, small instream areas were deep enough for macroinvertebrate sampling. This is illustrated in Figure 9-3 below.

Figure 9-6 Instream habitat suitability for sampling at A) LS US; B) LS Mid; and C) LS DS

The biotope rating assessment indicated a low diversity of instream habitat at site LS DS, with a low diversity of substrates present, with substrate dominated by sand with patches of stones in and out of current, gravel and mud. Sedimentation has reduced the availability of course substrates such and gravel and stones in and out of current due to instream smothering. The site was naturally low in biotope diversity and low in hydraulic habitat variations due to the lower foothills nature of the system within a highly erodible catchment and naturally sedimented watercourses. The low habitat diversity would limit the diversity and abundances of macroinvertebrate taxa with preferences to flow and stones biotopes. Limited marginal and no aquatic vegetation were present, reducing the expected macroinvertebrate taxa orders namely, Odonata (Dragon and Damselflies), Hemiptera (Bugs) and Coleoptera (Beetles). Examples of the instream habitat sampled within the reach are presented below in Figure 9-7. Overall the sampled site is considered to have habitat types capable of supporting a low diversity of macroinvertebrates and is therefore habitat is considered a hindrance on a highly diverse macroinvertebrates assemblage.

Figure 9-7 Instream habitat present at LS DS A) Marginal vegetation; B) Various substrates and C) Stones (1 June 2022)

9.3.2 South African Scoring System

The SASS5 score and SASS5 ecological classes obtained for each site sampled during the survey are presented in Table 9-4 and Figure 9-8.

Table 9-4 Macroinvertebrate assessment results (May 2022)

Site	LS US	LS Mid	LS DS
SASS Score	Site not suitable for sampling	Site not suitable for sampling	112
No. of Taxa			27
ASPT*			4.2
Category (Dallas, 2007)			Natural (class A)
Biotope Score % & Comment			28 Low diversity of substrates and flow classes

*ASPT: Average score per taxon; ** Nama Karoo Lower - Ecoregion

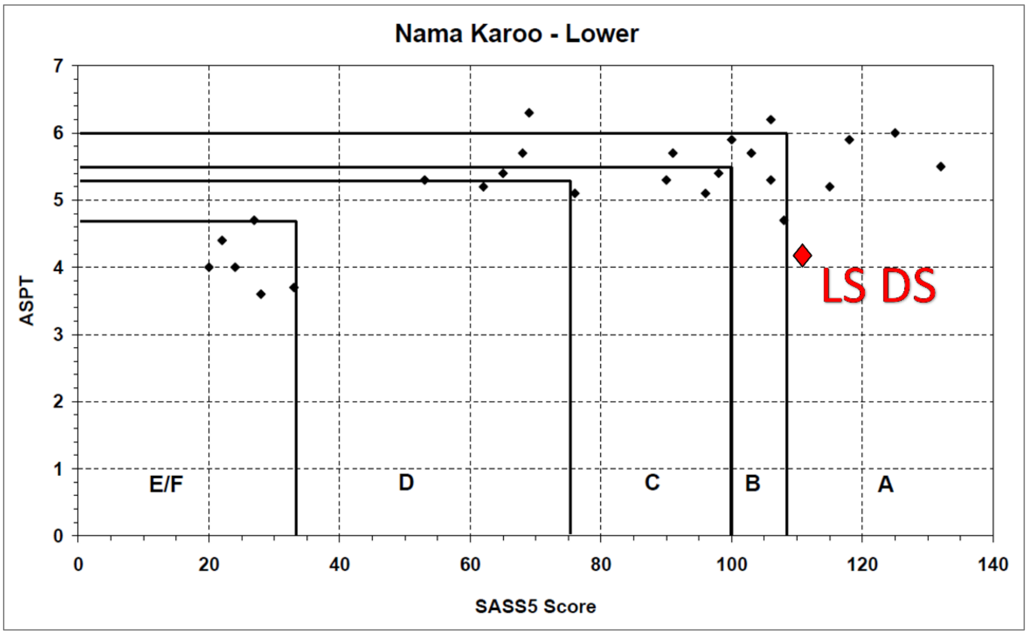


Figure 9-8 SASS5 results according to biological banding for the Ecoregion (Dallas, 2007)

The results of the SASS5 assessment at LS DS indicated that the sampled community had a total sensitivity score of 112, a moderate diversity comprising 27 taxa and a derived ASPT value (average sensitivity score) of 4.2. An ASPT value of 4.2 indicates that the sampled community was dominated by tolerant taxa. Based on the recorded taxa and sensitivities the site was placed in a class A (Natural) ecological category for the ecoregion indicating that the biotic integrity was largely intact (Figure 9-8). The sampled community was dominated by tolerant taxa [22 taxa of low (1-5) sensitivity] with few (5 taxa) sampled of moderate (6 - 10) sensitivity. The most sensitive taxa collected had a sensitivity rating of 8 and included a single family group Aeshnidae (Hawkers and Emperor dragonflies). Additional moderately tolerant taxa collected included Baetidae 2 species (Mayflies), Caenidae (Squaregills/Cainflies), Gomphidae (Clubtail dragonflies) and Naucoridae (Creeping water bugs). No intolerant taxa (11-15 sensitivity rating) were collected indicating water quality impacts. An illustration of some of the sampled macroinvertebrates is presented in Figure 9-9, while the full list of macroinvertebrates collected during the survey is presented in Table 9-5.

Despite a largely natural biotic integrity of the site, modifications to instream habitat (lowered by sedimentation smothering) and water quality (elevated dissolved solids) contributed to the modifications to the macroinvertebrate community with a few key indicator species expected for the sampled habitat absent.

Figure 9-9 Examples of sampled macroinvertebrates Baetidae (left), Nepidae (Centre) and Aeshnidae (right)

Table 9-5 Macroinvertebrate families collected during the survey (May 2022)

Taxon	Sensitivity Score	LS DS
Annelida (Ringed/segmented worms)		
Hirudinea (Leeches)	3	A
Ephemeroptera (Mayflies)		
Baetidae 2 sp (Mayflies)	6	B
Caenidae (Squaregills/Cainflies)	6	A
Odonata (Dragonflies & Damselflies)		
Coenagrionidae (Sprites & Blues)	4	A
Aeshnidae (Hawkers & Emperors)	8	1
Gomphidae (Clubtails)	6	B
Libellulidae (Darters)	4	A
Hemiptera (Bugs)		
Belostomatidae* (Giant water bugs)	3	1
Corixidae* (Water boatmen)	3	B
Gerridae* (Pond skaters/Water striders)	5	B
Naucoridae* (Creeping water bugs)	7	1
Nepidae* (Water scorpions)	3	1
Notonectidae* (Backswimmers)	3	B
Pleidae* (Pygmy backswimmers)	4	A
Veliidae/M * (Ripple bugs)	5	1
Trichoptera (Caddisflies)		
Hydropsychidae 1 sp.	4	1
Coleoptera (Beetles)		
Dytiscidae/ Noteridae* (Diving beetles)	5	B
Gyrinidae* (Whirligig beetles)	5	B

Taxon	Sensitivity Score	LS DS
Hydrophilidae* (Water scavenger beetles)	5	A
Diptera (Flies)		
Ceratopogonidae (Biting midges)	5	1
Chironomidae (Midges)	2	A
Culicidae* (Mosquitos)	1	1
Ephydridae (Shore flies)	3	A
Muscidae (House & Stable flies)	1	1
Psychodidae (Moth flies)	1	1
Simuliidae (Blackflies)	5	B
Tabanidae (Horse flies)	5	1
Total Taxa		**27**

Sensitivity scores:
1 – 5: Highly tolerant to pollution
6 -10: Moderately tolerant to pollution
11 – 15: Very low tolerance to pollution
*Airbreathing taxa

Abundance estimates:
1: A single individual
A: 2 - 10 individuals
B: 11 - 100 individuals

9.4 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 the Lemoenspruit should be interpreted with caution as scores were determined from a single site (LS DS) on the reach, reducing the confidence of the scores. Ideally, several sites sampled across a reach provides a greater representation of the riverine conditions and holistic macroinvertebrate community present, increasing the confidence in the MIRIA scores. The reference condition for the study sites was selected based on the geomorphological setting and longitudinal zonation of the Lemoenspruit with weightings for macroinvertebrate drivers scored accordingly. 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 9-6.

Table 9-6 MIRAI Score for the sampled watercourse

Invertebrate Dependant Driver	Lemoenspruit
Flow Modifications	63.1
Habitat	76.6
Water Quality	62.5
Ecological Score	**67.9**
Category	**C**

The MIRAI results for the sampled reach indicates that the macroinvertebrate community is moderately modified (class C). The drivers (with the lowest score) predominantly contributing to the modified state were water quality and flow modification with habitat modifications further contributing to the modified community. The results indicated that sensitive taxa and a large portion of taxa with a moderate to strong affiliation for flow missing from the sampled macroinvertebrate community. The Lemoenspruit is a non-perennial lower foothills system that is naturally subjected to instream sedimentation with a low diversity of hydraulic habitat variations, with a higher weighting given to taxa with a low to moderate affiliation for flow. The flow related driver was considered moderately intact for this type of watercourse with sedimentation impacting on the surface flow volumes and availability, with majority of the water within the system present as subsurface flow influencing the macroinvertebrate community. The stones dependant taxa were poorly represented due to extensive levels of instream sedimentation with subsequent smothering of rocky habitats. As a result, the sampled community was largely dominated by species adapted to the vegetation and finer substrate biotopes. Water quality impairment and habitat alterations within the reach were considered moderate and limiting factors, cumulatively contributing to a modified macroinvertebrate community from reference conditions. Based on the *in situ* water quality section and available habitat, the system should be supporting a greater diversity of sensitive taxa that were absent from the sampled reach. As previously mentioned, due to the use of a single suitable site, these results should be interpreted with caution.

9.5 Fish Communities

Sampling for fish was conducted only at site LS DS due to habitat suitability. No sampling was conducted in the flooding Orange River. A single fish species was expected in the Lemoenspruit due to the limited habitat diversity and cover features available for fish. The electroshocking efforts resulted in the collection of the single expected species namely, *Enteromius oraniensis* (Orange River Chubbyhead barb). The species is unlisted and is therefore treated as a species of high conservational concern. A summary of expected species and fish collected is presented in Table 9-7 and illustrated in Table 9-8.

Table 9-7 Presence/absence of fish species for the Lemoenspruit

Species	Common Name	IUCN (2022)*	LS US	LS Mid	LS DS
Enteromius oraniensis	Orange River Chubbyhead barb	Unknown (High)	Site not suitable for sampling	Site not suitable for sampling	1
Total expected species	**1**				**1**
Total sampled species					**1**
*Unknown and considered highly threatened					

Table 9-8 Illustration of fish species observed

Species/Site	Photograph
Enteromius oraniensis (Orange River Chubbyhead barb)	

Results indicate the fish community within the Lemoenspruit is unmodified, which is attributed to the presence of a single expected and collected species. The fish community is likely to deteriorate should sedimentation and water quality impacts increase from current levels.

Table 9-9 FRAI results for the Lemoenspruit

FRAI	Lemoenspruit
Automated Score	91.8
Category	**A/B**

The hydraulic biotope preferences and water quality intolerances for expected and collected species for the region are presented in Table 9-10. This information should be taken into account for the proposed development and associated impacts to watercourses both local and downstream (cumulative). Caution should be afforded to the supplied data for *Enteromius anoplus* as this may differ for *Enteromius oraniensis.*

Table 9-10 Hydraulic biotope preferences and water quality intolerances for expected and collected species for the region of influence

	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	3,8	3,4	0	0	3,2	0	0	0	3,5	4,4	0	0	0	0	2,6	0
Clarias gariepinus	0	0	4,3	3,4	0	0	0	1,7	0	0	0	0	0	0	0	0	1,0
Enteromius anoplus	0	0	4,1	4,3	0	0	2,3	0	4,0	0	0	3,2	0	0	0	2,6	0
Enteromius paludinosus	0	0	3,9	3,9	0	0	2,3	0	4,2	0	0	3,6	3,5	0	0	0	1,8
Enteromius trimaculatus	0	0	3,9	3,2	0	0	2,7	0	3,9	0	0	0	0	0	0	0	1,8
Labeo capensis	3,3	0	4,2	0	0	3,5	0	0	0	0	4,2	0	3,2	0	0	2,8	0
Labeo umbratus	0	0	4,5	0	0	0	2,7	0	0	0	4,2	0	0	0	0	0	1,6
Labeobarbus aeneus	3,0	4,0	3,5	0	0	3,3	0	0	0	0	4,0	0	4,0	0	0	2,5	0
Labeobarbus kimberleyensis	4,3	3,8	3,7	0	0	3,8	0	0	0	0	0	0	3,3	0	3,6	0	0
Pseudocrenilabrus philander	0	0	0	4,3	0	0	0	1,0	4,5	3,2	0	0	0	0	0	0	1,4
Tilapia sparrmanii	0	0	0	4,3	0	0	0	0,9	4,5	0	0	3,6	0	0	0	0	1,4

9.6 Present Ecological Status

The PES assessment for the Lemoenspruit is based on the collective data collected based on the May 2022 survey and the results are provided in Table 9-11.

Table 9-11 Present Ecological Status of the Lemoenspruit (May 2022)

Aspect Assessed	Survey Results
Instream Ecological Category	C
Riparian Ecological Category	C
Aquatic Invertebrate Ecological Category	C
Fish Community	A/B
Ecostatus	**C**
RWQOs Management Class	**C**

The results of the PES assessment in the Lemoenspruit derived a moderately modified status. The anthropogenic activities within the catchment have resulted in moderate modifications to the riparian and instream habitat integrity of the reach. These activities have contributed to encroachment of riparian zones by alien vegetation and trampling and erosion of the river banks resulting in increased instream sedimentation, with evidence of water quality perturbations and flow modification, cumulatively reducing the biotic integrity of the reach. It should be noted that large areas are still intact and considered largely natural offering moderate to high importance levels to aquatic and terrestrial wildlife.

Despite current activities and deterioration to the system, the Lemoenspruit has achieved the RWQOs Management Class of class C within the project area. However, due to the sensitivity of soils to erosion within the catchment, an increase in anthropogenic activities poses a risk to the ecological integrity of the watercourse and its associated tributary network. 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.

10 Sensitivity Assessment

As noted in the geomorphological description of the project area, the watercourses considered in this assessment represented non-perennial lower foothills system characteristics that have naturally been subjected to instream sedimentation with a low diversity of hydraulic habitat variations. As can be observed in Figure 10-1 and Figure 10-2, riparian areas were well defined and comprised of woody species with widespread encroachment by alien vegetation. Despite encroachment these areas were considered to largely intact with impacts to their integrity presented in the IHIA section (Table 9-2).

Figure 10-1 Typical lower foothills zone and associated instream and riparian areas in the upper reaches of the Lemoenspruit (LS US)

Figure 10-2 Typical Lemoenspruit tributary and well defined riparian zone within the PAOI

The ecological sensitivity of the watercourses draining the PAOI was determined to be largely uniform across the project area. Limited presence of 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 Aeshnidae (Hawkers and Emperor dragonflies), Baetidae 2 species (Mayflies), Caenidae (Squaregills/Cainflies), Gomphidae (Clubtail dragonflies) and Naucoridae (Creeping water bugs) were determined to be the most sensitive aquatic macroinvertebrates observed during the baseline assessment. The ichthyofauna community was also found to be dominated by a single endemic cyprinid, namely *Enteromius oraniensis* (Orange River Chubbyhead barb). The species is unlisted and is therefore to be treated as a species of high conservational concern. Considering the presence of such aquatic taxa, and the reliance/ dependence of these systems by terrestrial biota for drinking, foraging, nesting and refugia (Figure 10-3), the watercourses in the project area are regarded as sensitive environments in relation to changes in habitat integrity, flow and water quality.

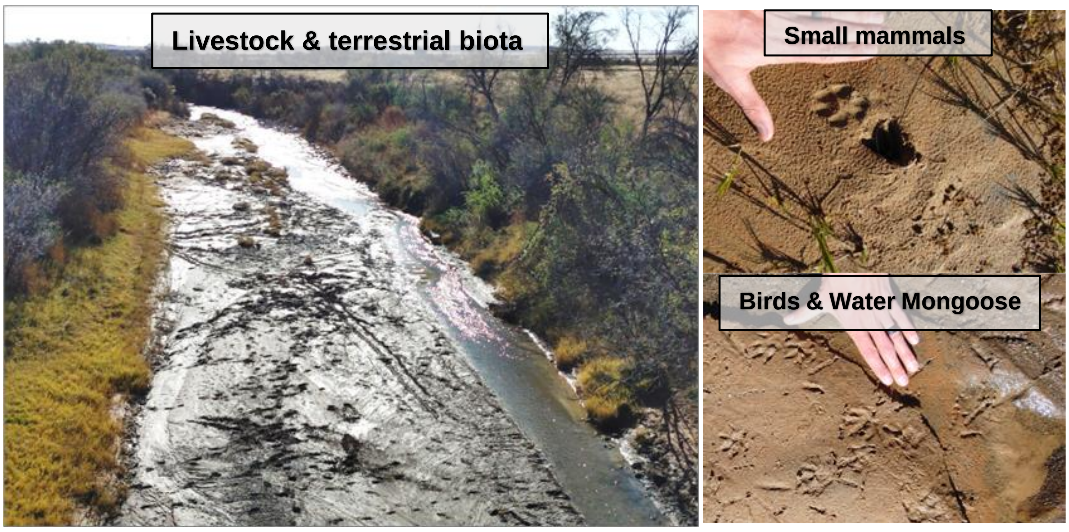


Figure 10-3 High volume of terrestrial biodiversity tracks observed within the Lemoenspruit (June 2022)

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 lower foothill Lemoenspruit and tributary networks riparian zones were delineated by identifying vegetation features on aerial imagery and confirmation through ground truthing during the survey. An example of the proposed watercourse extent as well as where appropriate buffer areas are provided in Figure 10-4. The various layouts and their respective delineated sensitive areas are depicted in Figure 10-5.

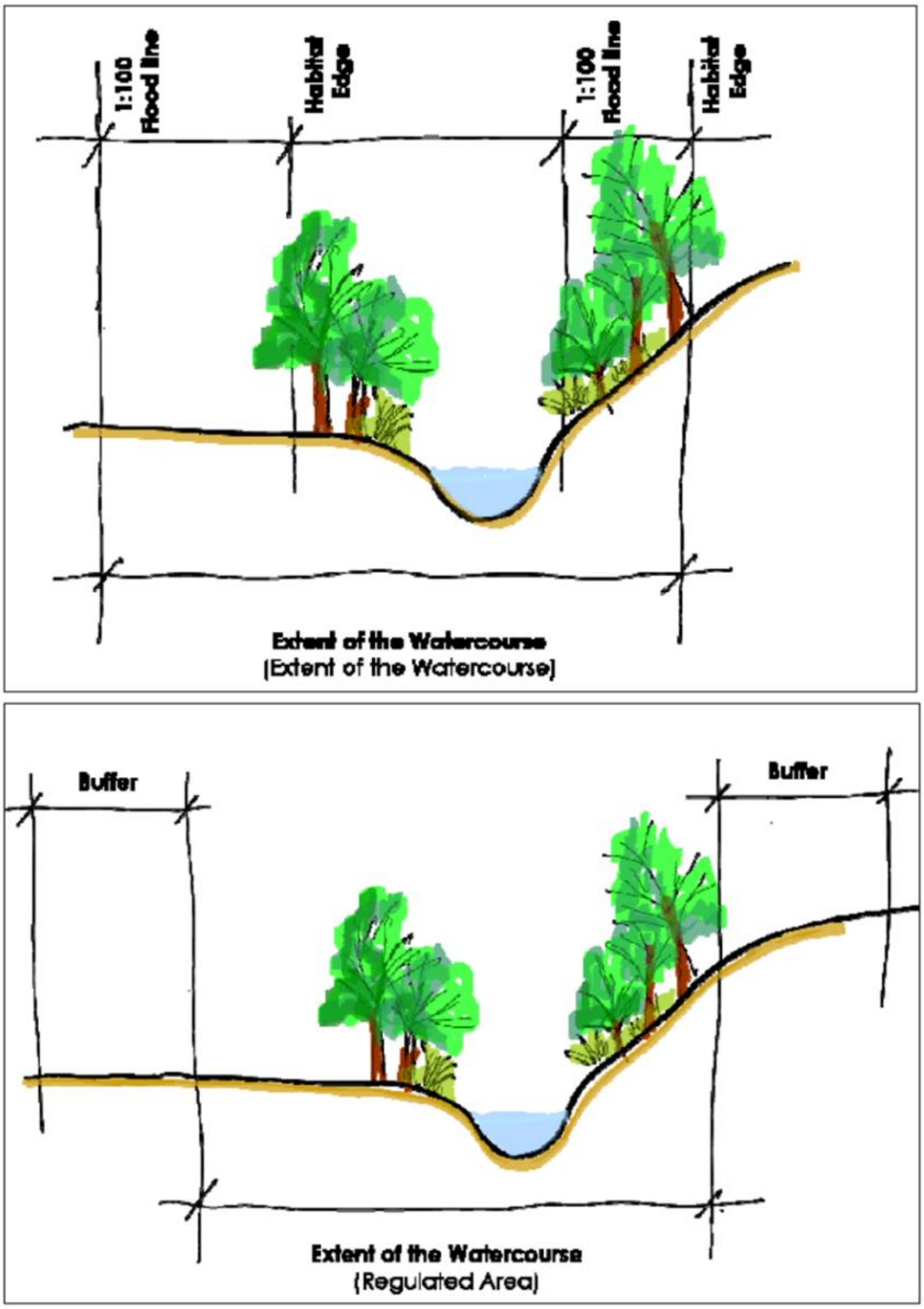


Figure 10-4 Illustration of the extent of a watercourse and the Regulated Area (DWA, 2012)

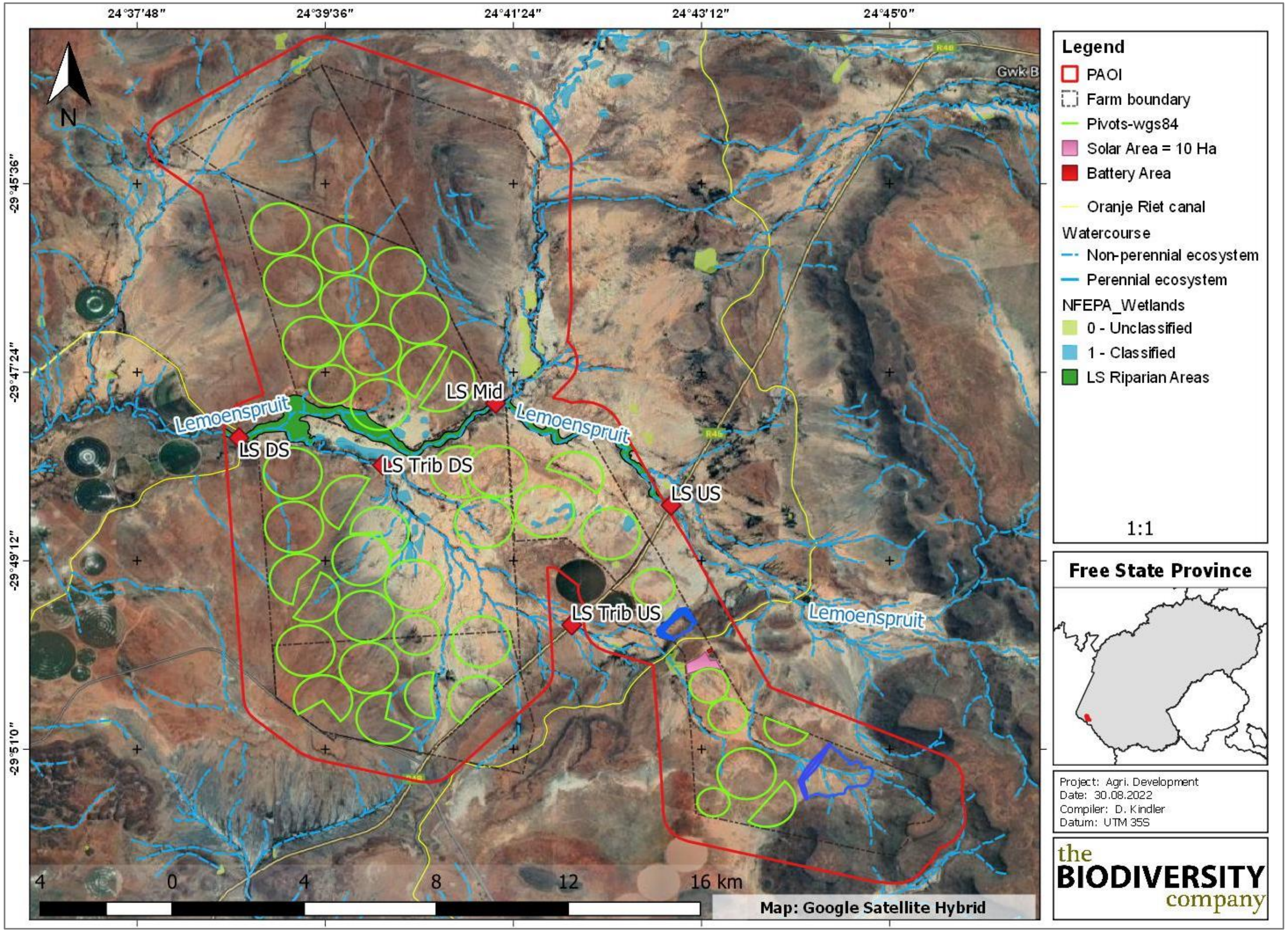


Figure 10-5 Project related infrastructure and associated sensitive freshwater resources

10.1 Ecological Importance and Sensitivity

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 10-1). The results of the EIS assessment derived a High EIS for the river reaches assessed in this study from the Orange WMA.

Table 10-1 Ecological Importance and Sensitivity Ratings for the Watercourses in the project area located

Biological Determinants		
Determinant	**Rating**	**Comment**
Rare and endangered biota	3	One or more species/taxon judged to be rare or endangered on a Provincial/regional scale: • Local scale (Lemoenspruit and Orange River) - *Enteromius oraniensis.* • Regional scale (Orange River) - NT *Labeobarbus kimberleyensis.*
Unique biota	4	*Labeobarbus kimberleyensis* and *Enteromius oraniensis* are endemic and distributed widely throughout the Vaal and Orange WMAs (Orange River Basin). Therefore, two taxa considered unique at National scale.
Intolerant biota	3	Non-perennial conditions of Lemoenspruit make the presence of flowing water rare. However, the taxa within the influenced watercourses are dependent on permanently flowing water during some phases of their life cycle. The threatened *Labeobarbus kimberleyensis* is sensitive to water quality changes and is currently experiencing population declines due to altered flow and water quality deterioration.
Species richness	2	On a local scale the species richness is moderate.
Habitat Determinants		
Diversity of aquatic habitat	2	Impacted Lemoenspruit system, most of which are permanent impacts (instream sedimentation). The downstream Orange River has a greater diversity. Overall habitat considered Moderate at a regional scale.
Refuge value of habitat types	3	Limited refuge areas in Lemoenspruit, while the perennial Orange River serves as a high value refugia during the dry season.
Sensitivity of habitat to flow modification	2.5	The Lemoenspruit has a high sensitivity to flow modifications which includes increases from return flows, while the Orange River has Moderate sensitivity.
Sensitivity to flow related water quality changes	2	Both watercourses have a Moderate sensitivity
Migration route corridor for instream and riparian biota	3	The Lemoenspruit is non-perennial offering limited migration for aquatic biota due to current sedimentation levels, while riparian biota use this system extensively with largely intact riparian zones connecting this system to the Orange River. The perennial Orange River is an important instream and riparian migration route at a Regional scale.
National parks and wilderness areas	2	NFEPA listing as Upstream management area (Lemoenspruit) and Fish Sanctuary area for threatened fish species (Orange River). No nature reserves associated with the watercourses at a local scale however the middle to upper reaches of the Lemoenspruit are largely undisturbed natural areas with important ecological functions.
Mean	**2.65**	
EIS class	**High**	

10.2 Buffer Requirements

The appropriate riparian vegetation buffer zone widths were determined for the proposed activity according to Macfarlane *et al.* (2009). These vegetation zone widths considered type the type and slope of each watercourse and their associated ecological requirements needed to maintain both the ecosystem functioning and services offered. Additionally, the watercourses potentially influenced by the proposed development have High EIS, requiring protection from the development.

The buffer size for the delineated water resources has been calculated according to the various watercourses, and are as follows:

- Riparian zones of the lower foothill Lemoenspruit – 100 m; and
- The riparian zones of Lemoenspruit tributary network comprising non-perennial systems and drainage lines and wetlands – 50 m.

According to Macfarlane *et al.* (2009), the "longitudinal zones of lower foothills rivers generally have more confined riparian zones than mountain streams and upper foothills and are generally threatened by agricultural practices. These larger buffers are particularly important to lower the amount of crop-spray reaching the river". Therefore, considering the aforementioned statement, baseline catchment condition, habitat integrity, water quality, presence of sensitive aquatic biota and terrestrial wildlife dependence on the assessed watercourses a no-go buffer zone of 100 m would ensure adequate ecological integrity maintenance adjacent to the proposed agricultural activities (Macfarlane *et al.,* 2009). Ensuring buffers are intact increases the resilience of a watercourse to future disturbances.

Buffers and sensitive receptors are presented in Figure 10-6 to Figure 10-8. Linear infrastructure includes pipelines (bulk and reticulation network), powerlines, road network and associated river crossings (no shapefiles available for proposed projects road network and associated river crossings), and non-linear infrastructure includes centre pivots and proposed impoundments that intersect with riparian zones and buffers, notably within the tributary system. The allocated buffers consider the project footprint's slope and 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.

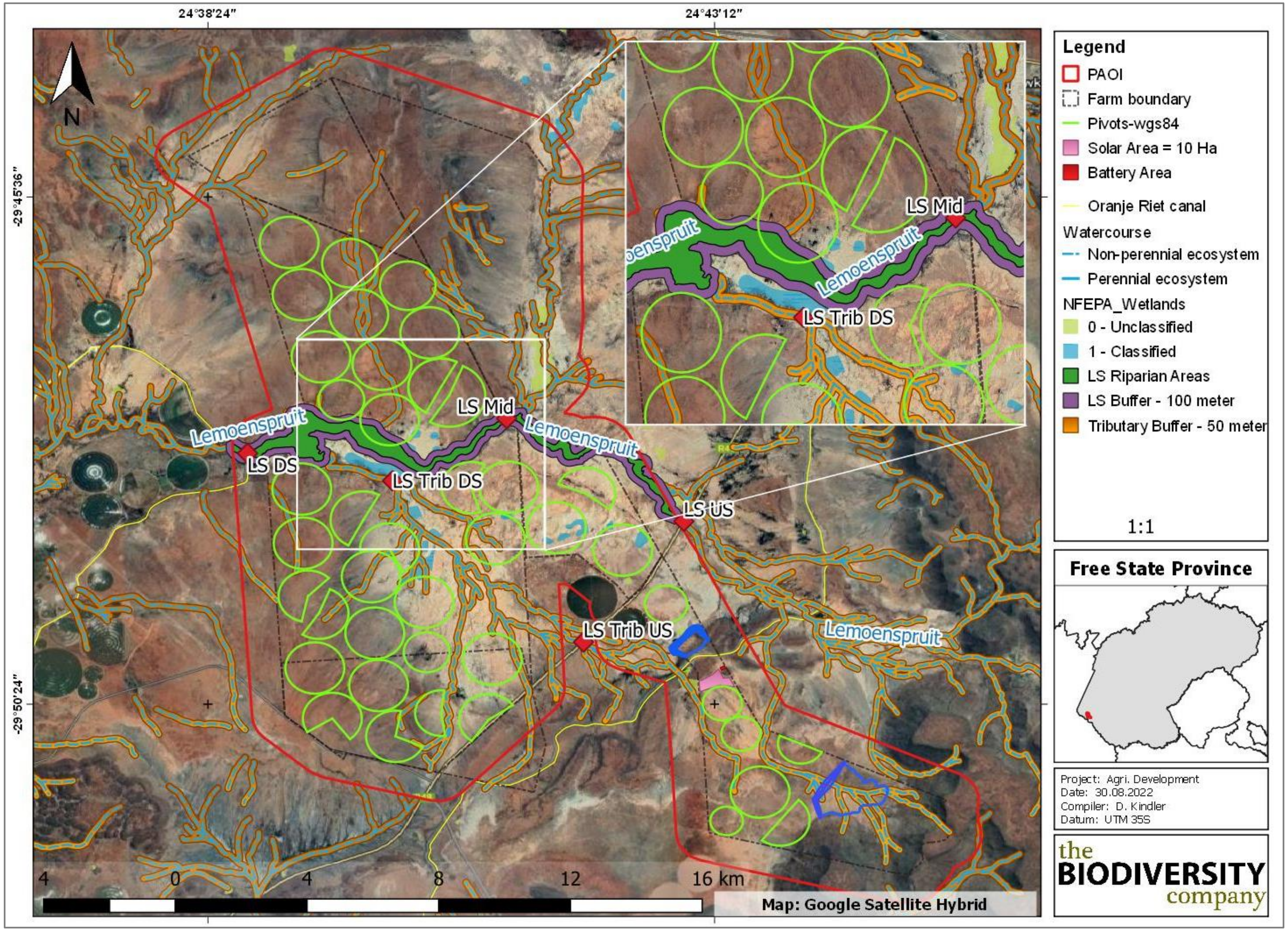


Figure 10-6 Sensitive freshwater resources and buffers overview map

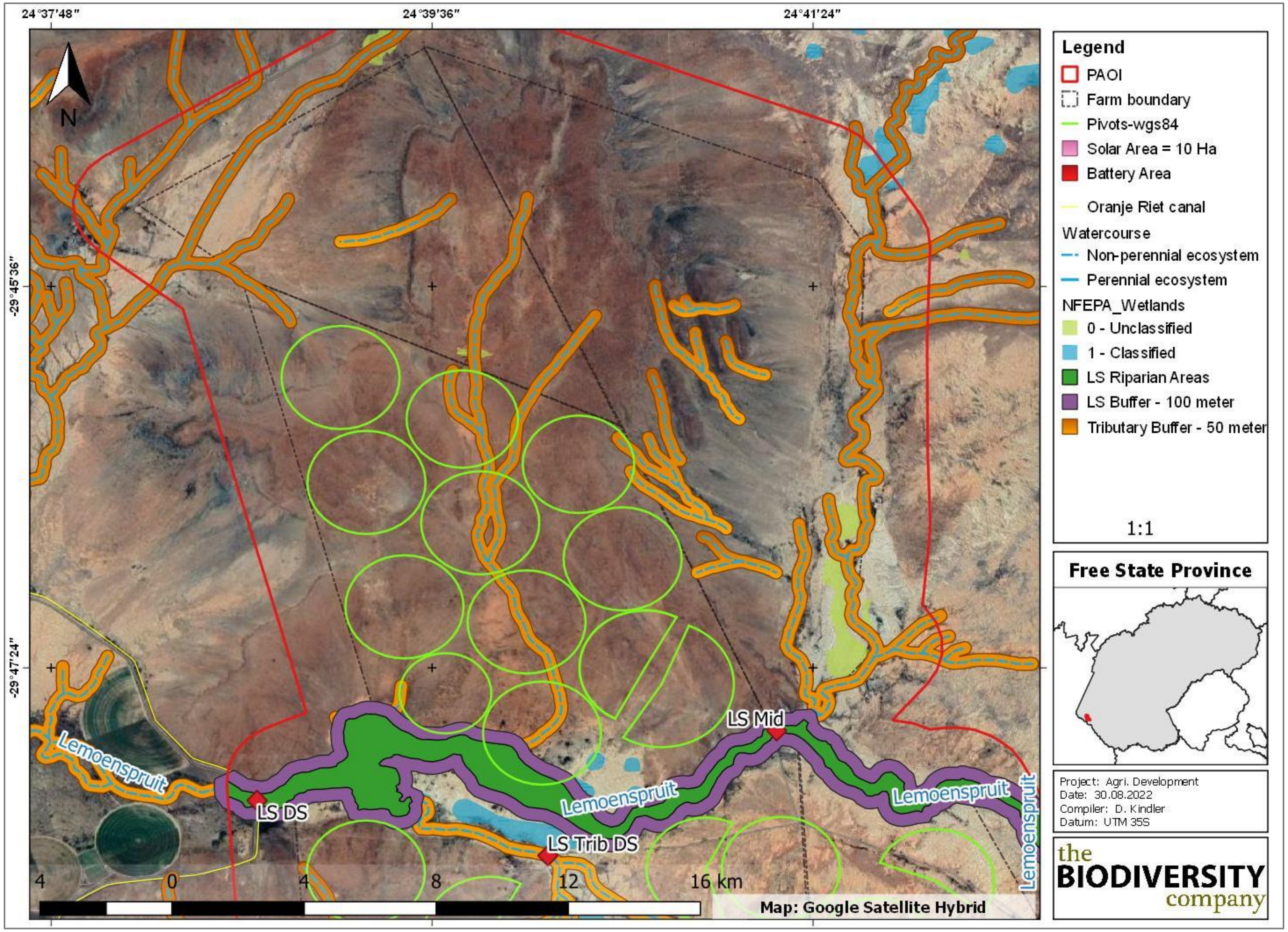


Figure 10-7 Sensitive freshwater resources and buffers and proposed infrastructures in the northern section

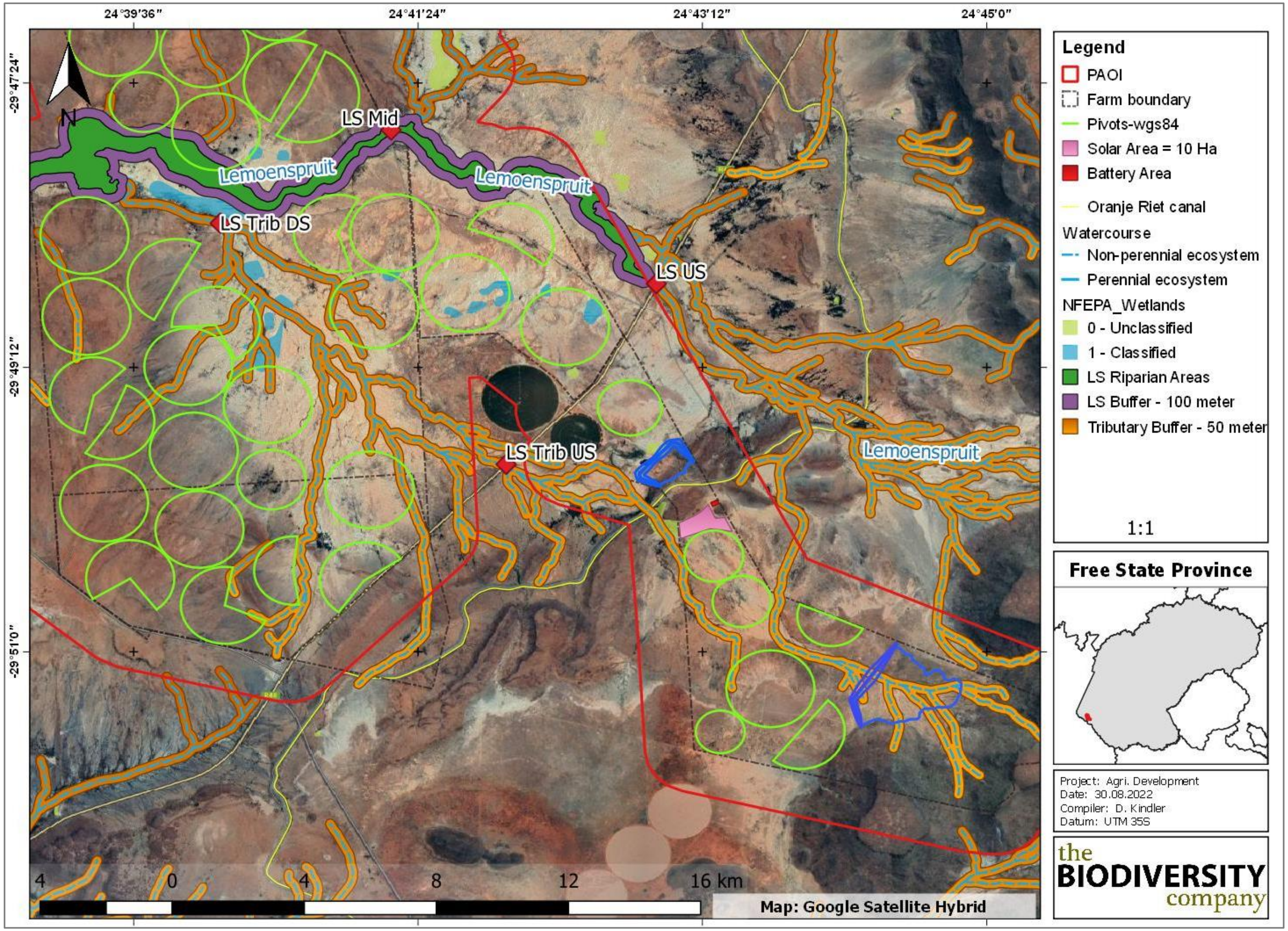


Figure 10-8 Sensitive freshwater resources and buffers and proposed infrastructures in the southern section

11 Impact Assessments

The section below and associated tables serve to indicate and summarise the significance of perceived impacts on the aquatic ecology of the project area. Potential impacts were evaluated against the data captured during the desktop and field assessment to identify relevance to the project area. The relevant impacts associated with the proposed construction of the development were then subjected to a prescribed impact assessment methodology which were provided by Savannah Environmental and is presented in Table 11-1.

Table 11-1 Impact assessment methodology

Extent of impact	Rating
Site specific	Very low (1)
Footprint & surrounding areas	Low (2)
Local area	Moderate (3)
Regional	High (4)
Entire habitat unit / Entire system	Very high (5)
Duration of impact	**Rating**
The lifetime of the impact will be of a very short duration (0–1 years)	Very short term (1)
The lifetime of the impact will be of a short duration (2-5 years)	Short term (2)
Medium term (5–15 years)	Moderate term (3)
Long term (> 15 years)	Long term (4)
Permanent	Permanent (5)
Consequence/Magnitude of impact	**Rating**
Small and will have no effect on the environment	None (0)
Minor and will not result in an impact on processes	Minor (2)
Low and will cause a slight impact on processes	Low (4)
Moderate and will result in processes continuing but in a modified way	Moderate (6)
High (processes are altered to the extent that they temporarily cease)	High (8)
Very high and results in complete destruction of patterns and permanent cessation of processes	Very high (10)
Probability of impact	**Rating**
Very improbable (probably will not happen)	Very improbable (1)
Improbable (some possibility, but low likelihood)	Improbable (2)
Probable (distinct possibility)	Probable (3)
Highly probable (most likely)	Highly probable (4)
Definite (impact will occur regardless of any prevention measures)	Definite (5)
Status	**Rating**
Positive	Positive
Negative	Negative
Neutral	Neutral
Reversibility	**Rating**
None	None
Low	Low
Moderate	Moderate
High	High
Irreplaceable loss of resources?	**Rating**

Yes	Yes
No	No
Can impacts be mitigated?	**Rating**
Yes	Yes
No	No
Significance	**Rating**
< 30 points	Low
30-60 points	Medium
> 60 points	High

11.1 Present Impacts to Aquatic Ecology

Considering the anthropogenic activities and influences within the landscape, several negative impacts to aquatic biodiversity were observed within the project area, however limited in intensity unless otherwise stated. These include:

- Historic land modification from reference conditions;
- Farm roads and main roads (and associated altered surface hydrology and wash of hydrocarbons into watercourses. Both formal and informal river crossing structures have altered instream flow characteristics);
- 2 Centre pivots and abstraction for these (and associated altered surface hydrology and wash of pesticides and herbicides into watercourses as contaminated return water);
- Grazing and trampling of natural vegetation by livestock in aquatic and riparian areas;
- Encroachment of riparian areas by Alien and/or Invasive Plants (IAP);
- Erosion from steep slopes, river banks and roads (especially roads lacking anti-erosion measures);
- Extensive Instream sedimentation; and
- Fences and associated maintenance resulting in habitat fragmentation.

11.2 Aquatic Impact Assessment

Anthropogenic activities drive habitat destruction causing displacement of aquatic and terrestrial fauna and flora and possibly direct mortality. Land clearing for development infrastructure (all inclusive) destroys local wildlife habitat and can lead to the loss of local breeding grounds, nesting sites and wildlife movement corridors such as rivers, streams and drainage lines and their associated riparian area, or other locally important features such as off channel wetlands. The removal of natural vegetation from these areas and their respective buffers will reduce the habitat available for fauna and may reduce ecological integrity and species diversity within the area depending on the intensity and footprint of clearing and destruction caused.

11.2.1 Alternatives considered

No alternatives were considered for the proposed development.

11.2.2 Loss of Irreplaceable Resources

Several CBA1 & 2 and ESA1 & 2 areas will be lost and replaced by the agricultural development.

11.2.3 Anticipated Impacts

The impacts anticipated for the proposed agricultural activities are considered in order to predict and quantify these impacts and assess & evaluate the magnitude on the identified aquatic biodiversity (Table 11-2). As presented in Section 10 it is evident that the following project related activities may have a negative effect on more sensitive biodiversity features, with most impacts involving the watercourses and their associated buffer areas.

The development of the area could result in the encroachment of the proposed infrastructure into water resources and result in the loss or degradation of these systems, most of which are functional and provide ecological services. Water resources are also likely to be traversed by linear infrastructure which might create a barrier to flow and biotic movement across the watercourses. Earthworks will expose and mobilise earth materials which could result in sedimentation of the receiving systems. A number of machines, vehicles and equipment will be required, aided by chemicals and concrete mixes for the project. Leaks, spillages or breakages from any of these could result in contamination of the receiving water resources. Contaminated water resources are likely to influence the associated biota.

It is important to note that the proposed centre pivots will be in high intensity across majority of the project area, traversing several tributaries. This will require the removal and levelling of topsoil and diverse indigenous vegetation cover for the replacement of crops (likely monoculture crops), which will lower the lateral buffering capacity of the catchment and increase in erosion potential, notably with the increased volumes of operational phase irrigation required across the catchment. The development is anticipated to alter the catchment drainage and increase stormwater runoff due to the altered land used and introduction of irrigation for cultivation, resulting in altered flow regimes in local watercourses during the construction and operational phases. The reporting of surface water run-off to the systems as return flows could result in physical changes (bed and channel characteristics) to the receiving systems caused by increased transport of sediment, erosion and increased water levels. Sedimentation of the watercourses will also contribute to impaired water and habitat quality. The reporting of return flows could also result in the contamination of the systems, transporting (in addition to sediment) diesel, hydrocarbons, pollutants, and soil from the construction areas. Additionally, the croplands (new land cover type for catchment) require regular spraying of pesticides and herbicides during the operational phase which degrades adjacent and downslope natural areas through non-target die off (acute and chronic exposure) of insect and wildlife with impacts to water quality expected during the operational phase. The farmers within the region currently spray with organophosphates which is expected to be used in the proposed development. Organophosphates are extensively used for the control of weeds, diseases, and pests of crops. Hence, these insecticides persist within the environment and thereby cause severe pollution problems and reductions in biotic communities. This practice should not be employed, and alternatives must be considered to avoid negative impacts to the terrestrial and aquatic biota. Marked changes in pH levels and concentrations of dissolved solids within the catchment would present to adverse conditions, limiting the abundances and diversity of sensitive aquatic biota with losses conservational taxa expected. This would be applicable to the application of fertilizers and spraying of the proposed crops with pesticides and herbicides which would alter the water quality locally within the Lemoenspruit and cumulatively within the receiving Orange River. Both *Enteromius oraniensis* and *Labeobarbus kimberleyensis* are SCC taxa potentially at risk from the proposed agricultural projects with water quality impacts of key concern to their survival.

These construction and operational phase disturbances could also result in further spread of alien vegetation which in turn would affect the functioning of the aquatic ecosystems.

Table 11-2 Anticipated impacts for the proposed activities on aquatic biodiversity

Aspect	Project activities that can cause loss/impacts to watercourse	Secondary impacts to watercourses
Destruction, fragmentation and degradation of habitats and ecosystems	1. Physical removal of vegetation, including riparian areas and buffer zones for project infrastructure and cultivation. 2. Physical alteration of surface topography and cover for cultivation and associated road network and servitudes. 3. Physical alteration of riparian and instream areas for river crossing infrastructure. 4. Soil management and soil wash from earth works, soil stock piles, crop lands and road network. 5. Soil dust precipitation. 6. Livestock activities. 7. Indiscriminate dumping of waste products. 8. Spread of alien plants via farming activities.	• Disturbance/ displacement/ loss of riparian, marginal and instream riverine habitat (Habitat fragmentation). • Reduced dispersal/ migration of fauna. • Erosion in key areas (steep and/or exposed areas). • Increase in sediment inputs & turbidity and associated smothering and loss of instream habitat. • Input of toxicants from construction and operation vehicles as well as from pesticide and herbicides (lateral movement into natural areas). • Trampling and loss of riparian and marginal vegetation by livestock. • Degradation of watercourse flora and fauna through the spread of alien and invasive species. • Displacement/loss of flora & fauna (including SCC). • Reduction of ecological integrity • Loss of ecosystem services.
Water quality	1. Pollution of water resources due to dust effects, improper storage of chemicals and spills, construction materials, fuel and machinery leaks. 2. Pollution of water resources from irrigation and return flows (surface runoff to local watercourses). 3. Pollution of water resources from spraying crops with pesticide and herbicides entering watercourse as return flow.	• Physical changes such as increased turbidity levels. • Chemical changes from baseline conditions (e.g. pH, salinity and toxicants) and exceedance of Orange WMA RWQOs. • Contamination of watercourse with toxicants associated with pesticides and herbicides and faunal mortality (direct and indirectly). • Disruption/alteration of ecological life cycles due to water quality perturbation. • Eutrophication (nutrient loading) of watercourses with nitrates, phosphates and other compounds associated with cropland fertilisation. • Alteration/degradation of aquatic habitat and biota through growth of nuisance algae and smothering of instream habitat. • Alteration/degradation of riparian and instream habitat integrity and lowered biodiversity potential. • Loss of SCCs • Groundwater pollution. • Loss of ecosystem services.

Aspect	Project activities that can cause loss/impacts to watercourse	Secondary impacts to watercourses
Flow dynamics	1. Physical removal of vegetation, including riparian areas. 2. Physical alteration of surface topography for cultivation and road network. 3. Irrigation via centre pivots. 4. Establishment of impoundments. 5. Potential for overflow/ discharge into adjacent landscape.	**Irrigation** • Alteration of sub-surface flow dynamics. • Increase in surface and groundwater availability from irrigation related return flows. • Increased instream flow within watercourse(s). • Alteration to flow patterns and velocities (flow dynamics) across catchment due to altered surface roughness, slope and irrigation. • Erosion in key areas (steep and/or exposed areas). **Impoundments** • Altered catchment hydrology and inundation of upslope areas. • Seepage from impoundment wall and downstream impacts. • Erosion (notably headcut erosion) of exposed surfaces and bank collapse due to changes in the catchment's sediment balance. • Alteration/degradation of downstream aquatic habitat and biota through erosion and sedimentation.
Compiled by Dale Kindler (Pr. Sci. Nat. 114743)		

11.2.4 Unplanned Events

The planned activities will have anticipated impacts as discussed; however, unplanned events may occur on any project and may have potential impacts which will need mitigation, management and pre-allocated funding for emergency situations.

Table 11-3 is a summary of the findings of an unplanned event assessment from an aquatic ecology perspective. Note, not all potential unplanned events may be captured herein, and this must therefore be managed throughout all phases of the project according to recorded events.

Table 11-3 Summary of unplanned events for aquatic biodiversity and their management measures

Unplanned Event	Potential Impact	Mitigation
Flooding during construction	Significant habitat degradation of downstream areas.	A flood emergency response plan should be drafted, with adequate stormwater management required.
Spills into the surrounding environment and watercourses	Contamination of habitat as well as water resources associated with a spillage.	A spill response kit must be available at all times. The incident must be reported on and if necessary, an experienced aquatic ecologist must investigate the extent of the impact and provide rehabilitation recommendations.
Uncontrolled erosion	Sedimentation of downslope watercourses	Erosion control measures must be put in place. Measures must include monthly inspections across the project footprint and should be adaptive based on site-conditions.
Fire	Uncontrolled/unmanaged fire that spreads to the surrounding natural Bushveld and ridge.	Appropriate/Adequate fire management plan need to be implemented to protect the riparian areas from potential loss.
Impoundments failure	Significant erosion and damage to downslope landscapes and habitat.	Dam walls must be designed and constructed to withstand a 1:100 year precipitation event (flood event). A storm water management plan must be compiled and implemented for the impoundments to protect the impoundment walls. Vegetate and maintain all exposed impoundment walls to prevent erosion. First signs of erosion must be remedied and revegetated immediately.

11.2.5 Assessment of Impact Significance

The assessment of impact significance considers pre-mitigation as well as implemented post-mitigation scenarios. Mitigation measures must be implemented to negate potential impacts to water resources. The mitigation actions required to lower the risk of the impact are provided in Section 11.2.5.5 of this report.

The solar area and BESS infrastructure have not been assessed during the impact assessment as these facilities are expected to have no impacts towards local watercourses.

Due to the nature of the project, the actual footprint of the proposed infrastructure has a large localised, impact, while regional water quality impacts are expected and are considered cumulatively.

11.2.5.1 Planning Phase Impacts

The planning phase activities are considered a low and insignificant risk as they typically involve desktop assessments and initial site inspections. This would include preparations and desktop work in support of waste management plans, environmental and social screening assessments, finalising placement of infrastructure sites and consultation with various contractors involved with a diversity of proposed project related activities going forward.

11.2.5.2 Construction Phase

The following potential main impacts on the watercourses and associated biodiversity dependent on these systems (based on the framework above) were considered for the construction phase of the proposed development. This phase refers to the period during construction when the proposed features are constructed; and is considered to have a large direct impact on aquatic ecology. This phase typically involves the removal of indigenous vegetation for infrastructure (laydown yards, centre pivots, water pipelines, impoundments, powerlines, solar area, BESS and the associated road network & river crossing structures), landscaping to desired topography, establishment of infrastructure and planting of crops. This involves earthworks activities (digging and soil stockpiling) and the use of construction chemicals and materials and machinery all of which influence adjacent habitats and includes watercourses. The following construction phase related impacts to aquatic ecology were considered:

- Disturbance/ displacement/ loss of riparian, marginal and instream riverine habitat (Habitat fragmentation) (Table 11-4),
- Contamination of watercourse and biotic community effects (Table 11-5); and
- Alteration of catchment hydrology and associated habitat ecology impacts (Table 11-6).

Table 11-4 Impacts to watercourse habitat and biotic community associated with the construction phase

Impact Nature: Disturbance/ displacement/ loss of riparian, marginal and instream riverine habitat (Habitat fragmentation)		
Destruction, loss and fragmentation of the of habitats, ecosystems and biotic community responses to the alteration of the catchment for cultivation.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Footprint & surrounding areas (2)	Footprint & surrounding areas (2)
Duration	Permanent (5)	The lifetime of the impact will be of a short duration (2-5 years) (2)
Magnitude	High (processes are altered to the extent that they temporarily cease) (8)	Moderate and will result in processes continuing but in a modified way (6)
Probability	Definite (5)	Probable (3)
Significance	**High**	**Medium**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as the loss of vegetation is unavoidable. However, the construction footprint can be realigned to avoid watercourses and associated buffers	
Mitigation:		
See section 11.3 of this report.		
Residual Impacts:		
The loss of currently intact vegetation is an unavoidable consequence of the project and cannot be entirely mitigated. The residual impact would however be medium for the construction phase with focus on limiting erosion required.		

Table 11-5 Contamination of watercourse and biotic community effects associated with the construction phase

Impact Nature: Pollution of water resources from construction activities		
Pollution stemming from construction activities that enters the natural environment and downslope watercourses, with associated impacts to habitat integrity and ecological function which in turn lowers the aquatic and terrestrial biodiversity dependent on the affected ecosystems. Potential loss of SCC.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Local area (3)	Site specific (1)
Duration	Moderate term (5–15 years) (3)	Very short term (0–1 years) (1)
Magnitude	Moderate and will result in processes continuing but in a modified way (6)	Low and will cause a slight impact on processes (4)
Probability	Definite (5)	Probable (3)
Significance	**Medium**	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	High
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as some level of pollution is unavoidable.	
Mitigation:		
See section 11.3 of this report.		
Residual Impacts:		

Some level of pollution is inevitable due to the nature of the construction activities and cannot be entirely mitigated. The residual impact would however be low and of short duration for the construction phase.

Table 11-6 Impacts to catchment hydrology associated with the proposed construction phase

Impact Nature: Alteration of catchment hydrology and associated habitat ecology impacts from construction activities		
Construction phase activities that result in the reshaping and change in vegetative cover type and density for cultivation with associated alterations of slope, runoff velocities, infiltration capacity and sediment movement from baseline conditions. This is expected to occur across the catchment, with associated impacts to habitat integrity and ecological function.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Local area (3)	Site specific (1)
Duration	Permanent (5)	The lifetime of the impact will be of a short duration (2-5 years) (2)
Magnitude	High (processes are altered to the extent that they temporarily cease) (8)	Low and will cause a slight impact on processes (4)
Probability	Definite (5)	Probable (3)
Significance	**High**	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	None	Moderate
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as the hydrology alterations are unavoidable. However, the construction footprint can be realigned to avoid watercourses and associated buffers	
Mitigation:		
See section 11.3 of this report.		
Residual Impacts:		
Alteration of the catchment hydrology is inevitable due to the nature of the construction activities and cannot be entirely mitigated. The residual impact would however be low and of short duration for the construction phase.		

11.2.5.3 Operation Phase

The operational phase impacts are related to daily agricultural and maintenance activities which are anticipated to have indirect impacts on aquatic ecology, as well as the deterioration of the riparian habitats due to the increase in soil salinity and dissolved constituents from crop activities which includes dust and its associated edge effect impacts from farm vehicles across the project footprint. The modification of the catchment drainage will alter watercourse habitats through altered drainage from baseline conditions with increased erosion and sedimentation, especially in exposed/ denuded areas. Stormwater management will therefore be crucial within the proposed operations footprint. This phase typically involves irrigation of the croplands via centre pivot and artificial impoundment systems, treatment through spraying and fertilization of crops and the operation of the road network and river crossing structures. The associated infrastructure (powerlines, solar area and BESS) are not located within watercourses with insignificant operational impacts to aquatic ecology expected and therefore not assessed for the operational phases. The following operational phase related impacts to aquatic ecology were considered:

- Continued fragmentation and degradation of habitats and ecosystems (Table 11-7);
- Contamination of watercourse and biotic community effects (including SCC) (Table 11-8);

- Alteration of catchment hydrology and associated habitat ecology impacts (Table 11-9).

Table 11-7 Impacts to watercourse habitat and biotic community associated with the operational phase

Impact Nature: Continued disturbance/ displacement/ loss of riparian, marginal and instream riverine habitat		
Disturbance created during the construction phase will leave the project area vulnerable to erosion and encroachment by alien vegetation. The operational phase activities that result in the continued destruction, loss and fragmentation of habitats, ecosystems and biotic community responses.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Low (2)	Site specific (1)
Duration	Long term (> 15 years) (4)	The lifetime of the impact will be of a short duration (2-5 years) (2)
Magnitude	Moderate and will result in processes continuing but in a modified way (6)	Low and will cause a slight impact on processes (4)
Probability	Definite (5)	Probable (3)
Significance	**Medium**	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	Moderate
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes, with proper management and avoidance, this impact can be mitigated to a low level.	
Mitigation:		
See section 11.3 of this report.		
Residual Impacts:		
Several CBA1 & 2 and ESA1 & 2 areas will be lost or degraded by the agricultural activities. Despite mitigation erosion is expected across the project footprint, influencing downslope watercourses. Potential influence on habitat required by SCC fauna. The residual impact would however be low.		

Table 11-8 Contamination of watercourses and biotic community effects associated with the operational phase

Impact Nature: Pollution of water resources from operational activities		
The operation and maintenance of the proposed development will involve the application of fertilizers, pesticides and herbicides which are environmental pollutants. These pollutants wash from their intended areas of application (centre pivot croplands) and escape into the natural environment and downslope watercourses, with associated impacts to habitat integrity and ecological function which in turn lowers the aquatic and terrestrial biodiversity dependent on the affected ecosystems. Potential loss of SCC locally and further downstream in the region. Impacts are limited to the watercourses draining the croplands with no impacts to water quality expected for the proposed operation of impoundments.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Regional (4)	Local area (3)
Duration	Long term (> 15 years) (4)	Moderate term (5–15 years) (3)
Magnitude	High (processes are altered to the extent that they temporarily cease) (8)	Moderate and will result in processes continuing but in a modified way (6)
Probability	Definite (5)	Highly probable (4)
Significance	**High**	**Medium**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as some level of pollution is unavoidable.	

Mitigation:
See section 11.3 of this report.
Residual Impacts:
Some level of pollution is inevitable due to the nature of the operational activities and cannot be entirely mitigated. The residual impact would be moderate and of medium duration following the implementation of mitigation. Potential loss of SCC or decline in their population numbers expected.

Table 11-9 Impacts to catchment hydrology associated with the operational phase

Impact Nature: Alteration of catchment hydrology and associated habitat ecology impacts from operational activities		
As a result of the landscaping to new topography and change in vegetative cover type and density for cultivation, new functioning regimes pertaining to surface runoff, infiltration and sediment movement patterns will influence the adjacent natural habitat characteristics. This in turn will influence habitat integrity and ecological functioning, notably from increased return flows, erosion and instream sedimentation impacts. This would be applicable to habitat and watercourse features in proximity to all of the proposed infrastructure, notably the centre pivots and downslope areas of the impoundments.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Local area (3)	Site specific (1)
Duration	Long term (> 15 years) (4)	The lifetime of the impact will be of a short duration (2-5 years) (2)
Magnitude	High (processes are altered to the extent that they temporarily cease) (8)	Low and will cause a slight impact on processes (4)
Probability	Definite (5)	Probable (3)
Significance	**High**	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as the hydrology alterations are unavoidable. However, the operational activities need to avoid direct impacts to watercourses and associated buffers, notably erosion.	
Mitigation:		
See section 11.3 of this report.		
Residual Impacts:		
Residual impacts are largely related to altered instream water levels associated with agricultural return flows and erosion due to altered hydro-dynamics and erodibility of the associated catchment.		

11.2.5.4 Cumulative Impacts

Cumulative impacts are assessed in context of the extent of the proposed project area; other developments in the area; and general habitat loss and transformation resulting from other activities in the area. 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 freshwater fauna and flora.

Localised cumulative impacts include the cumulative effects from operations that are close enough (such as nearby farming activities within the area) to potentially cause additive effects on the environment or sensitive receivers. These include disruption of ecological corridors or habitat such as watercourses, impacts to groundwater and surface water quality, and transport of soils and instream habitat smothering impacts.

Long-term cumulative impacts due to the proposed farm footprint, comprising high density centre-pivots in the middle reaches of the Lemoenspruit combined with the high density agricultural activities currently present on both the lower Lemoenspruit and receiving Orange River downstream (Figure 11-1) can lead to the loss of endemic species and threatened species (SCC), and degradation of watercourse habitat these species rely on. The cumulative impact of the project was rated as moderate should the project go ahead and involve the implementation of mitigation.

Figure 11-1 Current level of centre-pivots along the Lemoenspruit and Orange River (Google Earth 2022)

Table 11-10 Cumulative impacts to aquatic ecology associated with the proposed project

Impact Nature: The development of the proposed infrastructure will contribute to cumulative habitat loss within local CBAs and ESAs with water quality deterioration in both the Lemoenspruit and downstream Orange River and thereby will impact the ecological processes in the region		
The construction, operation and maintenance of the proposed development will result in the loss and alteration of habitat adjacent to watercourses with losses of portions of riparian habitat due to stream and pipeline crossings. The lowers the buffering capacity of the catchment to water quality impacts. The agricultural activities will deteriorate water quality even after the implementation of stipulated buffers and other mitigation. This will result in cumulative impacts to habitat integrity and ecological function which in turn lowers the aquatic and terrestrial biodiversity dependent on the affected ecosystems, with potential loss of SCC locally and further downstream in the region.		
	Without mitigation (Impact Rating)	**With mitigation (Impact Rating)**
Extent	Regional (4)	Local area (3)
Duration	Permanent (4)	Long term (> 15 years) (3)
Magnitude	High (processes are altered to the extent that they temporarily cease) (8)	Moderate and will result in processes continuing but in a modified way (6)
Probability	Definite (5)	Highly probable (4)
Significance	**High**	**Medium**
Status (positive or negative)	Negative	Negative
Reversibility	None	Moderate

Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, although this impact cannot be well mitigated as some level of pollution is unavoidable. Avoidance of riparian and buffer areas and the use of less hazardous products than Organophosphates in environmentally safe quantities will be of highest importance to mitigate impacts.	
Mitigation:		
See section 11.3 of this report.		
Residual Impacts:		
Some level of pollution is inevitable due to the nature of the operational activities and cannot be entirely mitigated. The residual impact would be moderate and of long term duration for the life of the project following the implementation of mitigation. Potential loss of SCC or decline in their population numbers expected.		

11.2.5.5 Decommissioning Phase

No decommissioning phase was considered based on the nature of the development.

11.3 Mitigation

In light of the expected impacts from proposed activities the following mitigation measure have been proposed to lower the intensity of the impacts on the ecological integrity of the catchment and its downslope watercourses.

11.3.1 Loss / Degradation of Riparian Habitat

During the site visit the Lemoenspruit riparian zone was observed to have undergone disturbance from access roads, livestock and alien vegetation encroachment. Although widespread, these were of low intensity. The integrity of the remaining riparian zone is largely intact and at risk from the proposed activities

Mitigation:

- This impact has already occurred, and thus pro-active mitigation is limited, reactive measures must now actively control and eradicate alien vegetation establishment in these disturbed areas;
- Strictly avoid any further loss of the riparian zone by avoiding any further development within the Lemoenspruit, its riparian zone and associated floodplain floodplain and its 100 m buffer as delineated in this report. Any supporting aspects and activities not required to be within the buffer area should adhere to the buffer zone;
- As per the DEA mitigation hierarchy this impact requires offsetting. It is recommended that this take the form of on-site rehabilitation of the riparian zone;
- Based on the site inspection and delineated riparian area map, portions of the centre pivot croplands and impoundments (and likely the associated road network too) are located within the riparian area of the Lemoenspruit and tributary network and respective buffer zones (Figure 10-6 to Figure 10-8.). It is recommended that these proposed areas of disturbance be relocated outside of the buffer zone, with the rehabilitation of adjacent disturbed areas not being used to serve as an offset against existing areas of disturbed riparian areas; and
- Rehabilitation should recognize and take into consideration adaptive management, and rehabilitation actions should be concurrent to ensure ongoing integrity.

11.3.2 Spread of Alien and Invasive Vegetation

Disturbance of soil and vegetation has the potential to be accompanied by the proliferation and spread of alien and invasive species.

Mitigation:

- Keep disturbances to within footprints and outside of buffer zones;
- Control new stands of alien species as they arise;
- Land users are required by law, to remove and / or control Category 1 alien and invasive vegetation according to the National Environmental Management: Biodiversity Act (NEMBA: Act 10 of 2004) (September 2020 List – GN1003). Additionally, unless authorised, in terms of the National Water Act, 1998 (Act No. 36 of 1998), no land user shall allow Category 2 plants to occur within 30 meters of the 1:50 year flood line of a river, stream, spring, natural channel in which water flows regularly or intermittently, lake, dam or wetland. Category 3 plants are also prohibited from occurring within proximity to a watercourse;
- It is recommended that Category 1 species are prioritised for control, with control of herbaceous weedy species (which would need to include follow-up control);
- Foliar herbicide spray must not be used within any of the sensitive riparian areas, rather opt for mechanical removal or direct dribbled application to stumps (use a dye); and
- Quarterly vegetation rehabilitation surveys need to be conducted of the vegetation within the project footprint to stay on top of the alien vegetation for the life of the project. This will improve the biotic integrity of the watercourses over the long term.

11.3.3 Powerlines

The proposed powerline construction is regarded as low risk to the water resources should construction occur outside of the delineated sensitive 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, watercourses and wetland areas. Should pylon placement be within the riparian areas impacts would be considered moderate. The powerlines pose low risks to the watercourse network during the operational phase should the pylons be constructed outside of the delineated drainage network.

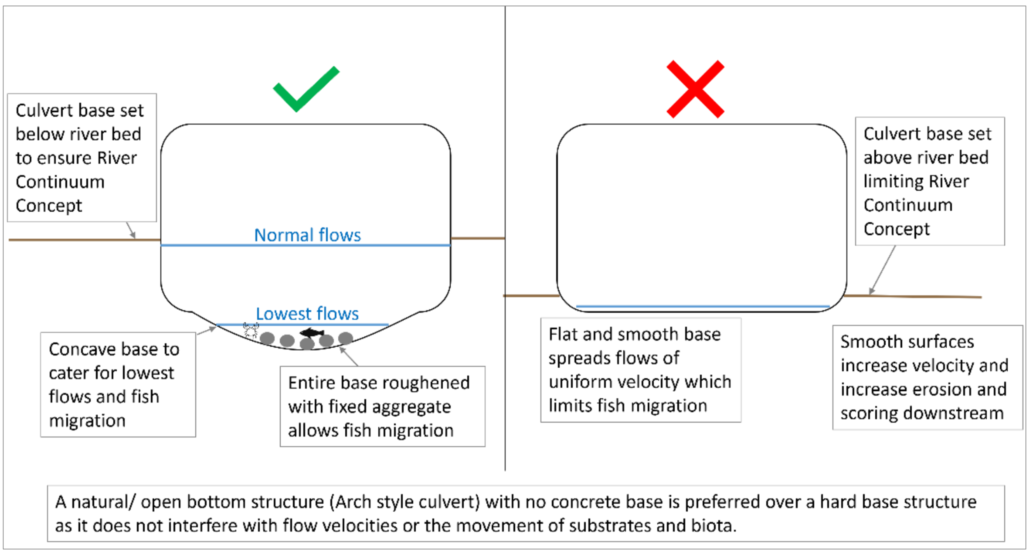
11.3.4 Watercourse crossings

Culverts are large pipes built into a watercourse crossing structure that allows water to pass under roads to protect roads from erosion or flooding. Culverts are commonly used for traversing small streams or in remote areas where building a bridge would be too expensive or impractical. Majority of South Africa's culverts do adequately allow water movement under the road, however they often do not allow fish to pass. The downstream end of the culvert may be too far above the water's surface for upstream migrating fish to enter. Water in the culvert may be moving too fast, or be too shallow for fish to pass in either direction. Due to the high number of road crossings, culverts therefore pose a significant barrier to fish movement and accessible habitat within a catchment. Debris may also collect in the culvert, not only blocking fish passage, but water as well. During floods, blocked culverts are responsible for many road failures. Considering the presence of the SCC namely *Enteromius oraniensis* sampled at site

LS DS, fish migration must be considered during the installation of any watercourse crossing structure(s) for the project. The crossing structure at site LS DS is an example of a poorly designed crossing structure as it does not acter for migration of aquatic biota. The operational risks of these structures can be lowered following the correct implementation mitigation actions.

Mitigation:

- Preparation of the crossing point and installation of the culverts must be undertaken during the low flow period to avoid the need for river diversions and associated impacts;
- Due to the potential of Vulnerable and Near Threatened species expected in the project area, construction activities need to keep impacts to the watercourse minimal with special consideration given to catering for fish migration;
- The width of the culvert should be at least equal to the average stream bed width, otherwise multicell box culverts with natural riverine bottoms (arch shaped with an open base) must be used;
- Box culverts that have a solid flat cement base (cube shaped) must be avoided as they result in a uniform depth and flow of water covering the full width of the culvert floor, resulting in an insufficient depth of water for the passage of fish, especially during low flow periods;
- Arch shaped box culverts with natural riverine bottoms allow for the natural stream depth and flow characteristics, with associated maintenance of a low flow channel that fish can utilise during dry periods;
- The use of precast arch shaped (with an open base) box culverts, could result in substantial cost savings associated with lower difficulty and less time spent on site (speed of construction), which in turn will lower the environmental impact at the crossing site;
- An alternative to natural bottoms, it is highly recommended that the base/floor of each of the box culverts as presented in the diagram below be redesigned to avoid a flat surface and incorporate a concave shape to cater for the lowest of flows and migration of biota (fish and macroinvertebrates) and substrates;



- The sides of the box culverts (the portal arch) and the concave shaped concrete bases should be left with a rough surface and the base can be roughened up with a course concrete mix using larger stone concrete mix to create broken hydraulic forces allowing smaller aquatic taxa (small fish and macroinvertebrates) a gripping surface to traverse the causeway structure during times of flow;
- Inlets and outlets of the culvert must be positioned below the stream bed for the continuation of the streambed and natural movement of riverine substrates as discussed for Arch shaped box culverts;
- The gradient and horizontal alignment of the culvert pipes must be the same as the existing stream;
- Rocky material (aggregate) must be placed at the base of the culvert discharge point(s) to avoid the concentrated flow from eroding and scouring the receiving area. Ideally this layer should incorporate a double layer with the bottom layer partially sunken into the riverbed, with the second layer placed on top of the base layer. Due to the increased flow velocities created by smooth concrete and box culverts flow dynamics, the sediments in the discharge area are expected to be washed away. The double aggregate layer will limit this;
- The rocks can be placed with a cascade pattern creating a rock ramp (step-like riffles) creating a natural fishway for fish movement (if needed) without the elevated costs of constructing fish-ladders. This should also incorporate a large variety of rock sizes placed at random in the rock pile to create a diversity of hydraulic conditions (microhabitats) within the rock ramp; and
- For best environmental practice implementation and least long term environmental impact, each watercourse crossing structure should incorporate larger box (single or multicell) culverts with natural riverine bottoms over the smaller culvert pipes.

11.3.5 Direct water level increases in local watercourses due to large-scale cropland irrigation

This impact is an inevitable consequence of this sort of crop cultivation practice and therefore cannot be entirely negated. The impact has the potential to degrade watercourses especially given that return flows in the lower Lemoenspruit catchment are relatively high due to the density of existing centre pivots along the Lemoenspruit and the arid nature of the region. Consequently, the residual risk is set as low following mitigation. This rating is however given in low confidence in the absence of a quantitative data from a hydrological / water balance study. However, there are various water conservation practices that can be implemented which could reduce the overall risk, but such a rating would need to backed by quantitative data. For now the precautionary principle applies.

Mitigation:

- Implement effective water conservation practices;
- The farm should have irrigation rights as set out by a reserve study conducted by the DWS. Any abstraction activities need to be metered so that the farm cannot irrigate more than their irrigation rights stipulate;
- Utilise variable rate irrigation (VRI) by managing irrigation according to in-field soil moisture levels:

- Monitor soil moisture either manually or through the deployment of wireless soil moisture sensors;
- Take into account spatial variation in soil moisture, considering soil moisture is not naturally evenly distributed throughout the lands. There will be places where soil moisture holds longer and requires less irrigation (e.g. within the seep zones or lower down the landscape catena or in areas with less well drained soil);
- React timeously and accordingly to any received rainfall.
- Employ the controlled deficit irrigation strategy (above a certain optimal irrigation amount the yield per unit water begins to decrease again); and
- Utilise temporal water conservation practices which minimise evapotranspirative losses by watering during the cooler times of the day such as night, early morning and late afternoon when wind is also generally lower.

- Utilise good quality efficient sprayer nozzles and service them promptly at any signs of failure;
- Carefully manage water pressure to obtain optimum sprayer efficiency and avoid excessive wastage through venting. The ideal flow rate for an irrigation system is dependent on various factors, such as required water application spread, peak crop evapotranspiration and area required to be irrigated. The more total pressure required is referred to as total dynamic head or TDH. Investigate the use of a VFD fitted to the pump;
- Tailor the irrigation system to the relevant crop to will reduce water losses; and
- Routine monitoring of abstraction and discharge points should be conducted to identify areas prone to erosion and bank collapse. Problem areas should be addressed immediately.

11.3.6 Indirect water losses to watercourses from increased water use for product washing and domestic purposes

This impact is likely necessary to the operation of the farm and should be considered.

Mitigation:

- Practice good water saving measures on site such as fixing leaking pipes, taps and sprayers timeously; and
- Consider rainwater harvesting for crop washing and other processing purposes without compromising health and safety standards.

11.3.7 Eutrophication of watercourses with nitrates, phosphates and other compounds associated with cropland fertilisation

Commercial crop cultivation often requires intensive soil management due to the high demands placed on the soil. This often involves the use of fertilizers which have the potential to eutrophy (contaminate with excess nutrients) nearby watercourses with organic nutrients such as nitrates and phosphates in return flows. This leads to an artificially increased primary productivity in the form of cyanobacterial and algal blooms at the expense of the natural plant and animal diversity due to competition, habitat modification, toxicant amplification and increased prevalence of anoxic events. The downstream and receiving Orange River is currently subjected to intensive agriculture of its riparian and adjacent buffer zones with further input of nutrients from the polluted upstream Vaal River. Further nutrient inputs stem from the discharge of treated and untreated sewage and wastewater across the Orange River Basin. The nutrient inputs are above the carry capacity of the Vaal and Orange rivers with impacts to water quality negatively impacting on the primary producer level and watercourse habitat, with deleterious effects current occurring to biota higher up in the food web, with SCC such as Largemouth yellowfish declining in population numbers in the heavily polluted upstream Vaal River catchment.

Enforcement from authorities is required to manage the number of agricultural developments within river basins due to pollution pressures that are above the carrying capacity of the river, and its local catchments in order to preserve the currently pressured watercourses and their sensitive aquatic and terrestrial biota depending on them. The Orange River has reached its carrying capacity and when not in flood, the river is expressing high nutrient levels presenting as water with a green tinge (eutrophic).

Mitigation:

- Carefully control the application, timing and amount of fertilizers to ensure responsible catchment management through best environmental practice methods;
- Current satellite and drone technology allow for the mapping of nutrient or moisture deprived areas which in turn allows farmers to use a GPS to apply fertilizers to only the areas that require it, thus saving on fertilizer cost and wastage. This is recommended for this project to lower the impacts from fertilizers;
- Actively and accurately track weather patterns using satellite data to avoid fertilizing ahead of a major predicted stormfront. Free software such as Windy may assist in this regard if other means are too costly; and
- All farm employees should undergo induction which is to include a component of environmental awareness. The induction is to include aspects such as the need to avoid littering, the reporting and cleaning of spills and leaks and general good “housekeeping”. The employees should also be shown where the buffer zones are located and the importance of avoiding them.

11.3.8 Contamination of watercourses with process wastewater and / or domestic sewage and greywater

Return water from the non-irrigation related project activities can add to water quality impacts.

Mitigation:

- It is recommended that septic tanks be opted for over a French drain systems for toilet systems;
- Utilize a French drain / artificial wetland to return process water in a diffuse manner to the nearest watercourse;
- It is recommended that artificially and densely vegetated areas be established in keys areas of surface runoff to increase plant cover (reeds, etc.) to polish any wastewater releases through phytoremediation. This will assist in limiting potential contamination of groundwater and downslope watercourses;

- The client should monitor wastewater discharge quality for the life of the project to ensure best environmental practice;
- During operation of the farm employees must have spill kits available to ensure that any fuel or oil spills are cleaned-up and discarded correctly;
- Have action plans on site, and training for employees in the event of spills, leaks and other impacts to the aquatic systems;
- All chemicals and toxicants must be stored in bunded areas;
- All machinery and equipment should be inspected regularly for faults and possible leaks, these should be serviced in a workshop and not near watercourses or drainage lines;
- All waste generated on-site during operation must be adequately managed. Separation and recycling of different waste materials should be supported;
- A suitable stormwater plan must be compiled for the development and implemented for the life of the project. This plan must attempt to displace and divert stormwater from areas where contaminants are used and/or stored and discharge the water into adjacent areas without eroding the receiving areas. It is preferable that run-off velocities be reduced with energy dissipaters (thick vegetative cover is preferred) and flows discharged into the local watercourses. This plan must be ongoing and adaptive based on on-site conditions. All stormwater infrastructure must be monitored and maintained addressing areas on non-efficacy; and
- It is preferred that during the operation phase, stormwater and return flow from crops and the road network should pass through vegetated depressions and channels with stepped and vegetated swales for flow attenuation, lowering erosion potential and phytoremediation before entering the watercourse.

11.3.9 Contamination of watercourses with toxicants associated with pesticides and herbicides

The management of weeds and pests is an ongoing problem with crop cultivation. One of the main ecological trade-offs is that watercourses are contaminated with herbicides and pesticides (Organophosphates) with adverse consequences for the native biota within them both in the short term (acute exposure) and the long-term (chronic exposure). According to Gill and Garg (2014), pesticides in watercourses that are within the acceptable concentration range can still pose harmful effects (ecotoxicological risk through damage to vital organs, reproduction success and behaviour) to aquatic communities such as fungi, zooplankton, phytoplankton, macroinvertebrates, amphibians and fish, with bioaccumulation risks in the food web expected. It is further noted that the pesticides might have a low conductivity level yet may still be lethal to aquatic receptors (fauna and flora). Long term negative effects (primary level deformity, lowered diversity of sensitive fauna and deformed fish offspring) are expected within the Orange River catchment due to short to long exposure to the hazardous substances with the likelihood of negative effects increasing with the increased establishment of agricultural developments and associated use of Organophosphates.

Mitigation:

- Avoid the use of rodenticides wherever possible. Excessive rodent populations can be effectively controlled with the use of large buckets baited with peanut butter, partially filled with water. Of course, these should be placed strategically so as to minimize incidental trapping of non-target organisms such as reptiles and amphibians. (i.e. place away from wetlands and natural areas);

- Minimise pesticide and herbicide use wherever possible. Do not apply in any of the watercourses unless used for alien control in which case apply directly to cut stumps (not foliar spray);
- Investigate incorporating biopesticides into the farm's Integrated Pest Management (IPM) system so as to rely less on higher-risk pesticides and effectively produce higher crop yields and quality with lower impact on the environment;
- Based on the survey findings, the baseline concentrations of dissolved solids are elevated, therefore the buffer zone widths need to be as wide as possible to limit further increases in contaminants within the watercourses and those downstream such as the Orange River (cumulative impacts); and
- It is recommended that artificially and densely vegetated areas be established in keys areas of surface runoff to increase plant cover (reeds, etc.) to polish any wastewater releases through phytoremediation. This will assist in limiting potential contamination of groundwater and downslope watercourses;

11.3.10 Erosion and sedimentation of catchment and downstream watercourses

The alteration of surface topography and hydrology together with tillage practices to prepare cropland beds and the increase exposed soil surfaces along road networks will inevitably be accompanied by an increase in erosion and sedimentation as rainwater erodes and washes exposed soils into downslope watercourses. This is a key consideration for the project due to the high erodibility of the catchment soils, and current levels of instream sedimentation.

Mitigation:

- Loose soils are particularly prone to loss due to wind or water. It is therefore preferable that construction takes place during the dry season to reduce the erosion potential of the exposed surfaces;
- Practice good soil management across the PAOI;
- Minimize the bare soil intercrop period as much as possible;
- Investigate the use of a cover crop (e.g. *Eragrostis* or better) if intercrop period is expected to be long. The cover species should not be exotic or invasive and should be chosen in consultation with a qualified vegetation specialist;
- Continue to grass all inter-cropland areas to prevent soil loss;
- Avoid the creation of concentrated flow paths wherever possible;
- Devise and implement a stormwater management plan for the croplands;
- Install sandbags as a temporary measure around key areas of soil loss to prevent soils washing into the local watercourse;
- Signs of erosion must be addressed immediately to prevent further erosion of the area to prevent headcut erosion from forming;

- Temporary and permanent erosion control methods may include silt fences, flotation silt curtains, retention basins, detention ponds, interceptor ditches, seeding and sodding, riprap of exposed embankments, erosion mats, and mulching;
- Any exposed earth should be rehabilitated promptly by planting suitable vegetation (vigorous indigenous grasses) to protect the exposed soil;
- Relandscape to gentler gradients and re-vegetate all cleared areas as soon as possible to limit erosion potential. Sandbags and geotextiles should be used to assist until vegetation has established in these reworked areas..
- Stem any headcut/ erosion gulley as it occurs by bulldozing, filling, re-contouring to gentler gradients and re-vegetating; and
- The rehabilitation of watercourse banks should take place as an offset to altered land use with associated negative ecological impacts. Key areas where erosion has occurred should be rehabilitated through bank reprofiling to gentler gradients and the revegetation of the marginal and riparian areas.

12 Recommendations

The following recommendations are provided for the project:

- A competent Environmental Control Officer (ECO) must oversee the construction and associated rehabilitation phase of the project, with watercourse areas as a priority to limit the listed impacts on the watercourses. 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 report to familiarise themselves with the mitigation and recommendations prior to construction;
- Organophosphates alternatives must be considered for this project;
- An infrastructure monitoring and service plan must be compiled and implemented during the operational phase. This will include the monitoring the road reserve route, all stormwater discharge points, energy dissipation structures, and stability of watercourse banks in the project footprint. This service plan should be adaptive based on on-site conditions;
- Dry season survey is recommended when the Orange River no longer under flood to assess the baseline levels, notably to determine the presence of SCC and baseline concentrations of hazardous substances in the lower Lemoenspruit and Orange River;
- Although livestock activities are not proposed, their presence in the project area is expected to continue concurrently with the proposed development activities. Livestock should be kept outside of the watercourses with fences to conserve the riparian integrity. Active management of the riparian areas is required, as sensitive aquatic biota (including fish) susceptible to modifications are present within the project area; and
- A biannual aquatic biomonitoring programme is recommended to establish biological trends and monitor the impacts of the proposed project with keys focus placed on water quality impacts.

13 Monitoring programme

Based on the outcomes of this assessment, the further actions are recommended. The monitoring programme proposed is presented in Table 13-1.

Table 13-1 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, notably on the tributaries	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
Site used in this assessment.	Determine if water quality deterioration is occurring.	Quarterly	Standard water quality monitoring together with chemical analysis
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, notably SCC.

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;
- Alien invasive vegetation assessments must be conducted in accordance with the terrestrial component of this overall application;

It is noted that the mitigation actions provided in this assessment must make use of the proposed mitigation actions as an EMP. The outcome based management plan for riverine resources is presented in Table 13-2.

Table 13-2 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
	Revegetate disturbed areas	Project lifespan
	Implement erosion control measures such as energy dissipation and vegetative cover	Project lifespan
	Implement alien invasive plan removal and monitoring programme	Project lifespan
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 and vegetative cover	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 return flows through vegetative cover	Project lifespan
Effective Water Resource Management	Implement water quality and aquatic biomonitoring studies	Project lifespan

14 Conclusion

14.1 Baseline Ecology

The baseline assessment established a single main watercourse with an associated tributary network draining the project area, namely the Lemoenspruit ecosystem. Additionally, numerous ephemeral drainage lines and some wetlands occur in the project area. The Lemoenspruit flows into the Orange River downstream of the project area and due to flood conditions at the time of the survey the Orange River could not be assessed. The ecological assessment of the Lemoenspruit indicated moderate modifications attributed to varying land use, comprising mostly open/ natural land with some agriculture and widespread livestock activities present in the project areas catchment. The land use activities and erodible soils have cumulatively resulted in a moderate deterioration in water quality, flow, and instream habitat, and subsequently to the biotic communities (macroinvertebrate and fish) within the systems. The baseline water quality indicated exceedance of the Orange WMA RWQOs for electrical conductivity of 550 µS/cm at all of the investigation sites and increased in a downstream direction from 953 µS/cm in the upper Lemoenspruit at site LS US to 1 686 µS/cm in the lower reaches at LS DS. Despite modifications, the Lemoenspruit met the RWQOs Management Class for the Orange River (which incorporates the Lemoenspruit), and all the water resources and their associated habitats associated with the project area are considered sensitive to further disturbance. Given the findings of this assessment, the Lemoenspruit was classed as moderately modified (class C).

The entire drainage network is presented by a well defined riparian zone consisting of woody vegetation. The soils within the catchment and 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 directly influenced Lemoenspruit is listed as *not protected*, and the ecosystem is classified as *Endangered*. The indirectly affected Orange River system downstream of the project area is listed as *poorly protected*, and is classified as *Critically Endangered*. Additionally, Freshwater Priority Areas are assigned to them. The Lemoenspruit catchment serves as an *upstream management area* to assist in limiting impacts to the downstream Orange River which serves as a Fish Sanctuary area for threatened fish species such as Largemouth Yellowfish (*Labeobarbus kimberleyensis*). Largemouth Yellowfish are red listed as Near Threatened and are showing population declines due to habitat fragmentation and water quality deterioration. The Lemoenspruit includes an additional species of conservational concern, namely the recently described Orange River Chubbyhead barb (*Enteromius oraniensis*). The species currently has no threatened status and should be conserved through the precautionary principle and be treated as highly threatened. This barb was collected during the survey at LS DS. The poorly protected nature of the systems, the high EIS and presence of SCC indicates that strict mitigation measures should be adhered to ensure no further deterioration of the watercourses should the project proceed.

The riparian zones of the lower foothills geoclass Lemoenspruit require a buffer of 100 m, and Lemoenspruit tributary network comprising non-perennial systems, ephemeral drainage lines and wetlands require a buffer of 50 m. These buffers would ensure adequate ecological integrity maintenance adjacent to the proposed agricultural activities

14.2 Impact Assessment

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 centre pivots, impoundments (several options), powerline and bulk water pipeline intersect with the water resources posing risk to these receptors. The relocation of the aforementioned infrastructure to avoid sensitive water resources and the prescribed buffer zones (no-go zones) will lower the impacts to these receptors. The relocation of the centre pivots outside of no-go zones would result in an overall reduction in the number of proposed centre pivots, lowering the associated negative ecological impacts expected.

The Main impoundment Option 1 and Secondary impoundment Option 1 are preferred due to the avoidance of sensitive areas. The preferred options would still require mitigation efforts as their construction and operational presence would influence natural soil and water movement and associated ecological processes within their local and downstream catchment areas.

No shapefiles were available for the pipeline reticulation network required to transport water from the impoundments to the centre pivots. Similarly, no shapefiles were available for the road network required for the proposed activities. The placement of the pipeline reticulation and road network is expected to traverse water features with associated disturbance impacts expected. Avoidance of no-go zones would lower their impacts, and should be considered. Additionally, the project should consider the least number of river crossing structures possible to limit further watercourse disturbance.

The solar area and BESS infrastructure are expected to have no impacts towards local watercourses.

Impacts associated with the proposed infrastructure are related to habitat disturbance and fragmentation, contamination of water quality and alteration of catchment hydrology which cumulatively result in negative ecology impacts within watercourses. The construction and operational phase impacts range from moderate to high, with the majority of impacts being reduced to low and moderate following the implementation of adequate mitigation measures. Due to the nature of the project, the footprint of the proposed agricultural infrastructure has a large localised impact, while cumulatively the project poses regional water quality impacts and threat to SCC.

14.3 Specialist Recommendation

It is the specialist's opinion that no fatal flaws have been identified for the proposed activities, and authorisation of the proposed development must be carefully considered. Considerations must take into account the carrying capacity of the local and regional watercourses potentially influenced by the proposed activities and their resilience to future disturbances.

The alternative positioning of infrastructure is preferred due to the avoidance of water resource sensitive areas (no-go zones). 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.

Due to the high threat level of water quality deterioration and negative ecological impacts expected, notably from typically used Organophosphates, the project must consider environmentally friendly alternatives to Organophosphates. This together with the prescribed mitigation must be implemented in totality in order to proceed in a sustainable manner.

A competent ECO must oversee the construction and operational activities, with watercourse areas as a priority. Additional reccomendations listed in this report should be considered for this project.

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Appendix A Specialist Declaration

I, Dale Kindler 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.

Dale Kindler

Freshwater Ecologist

The Biodiversity Company

June 2022

Appendix B – SASS Accreditation

NATIONAL AQUATIC ECOSYSTEM HEALTH MONITORING PROGRAMME

Water and Sanitation

Water Research Commission

CERTIFICATE OF ACCREDITATION

This is to certify that

Dale Kindler

has met the requirements of the River Health Programme as a SASS5 Practitioner

COMPETENCY IN THE FOLLOWING AREAS HAVE BEEN DEMONSTRATED:

UNDERSTANDING OF THE SCOPE AND APPLICATION OF THE SASS5 METHOD.

DEMONSTRATION OF THE CORRECT SAMPLING PROTOCOLS

DEMONSTRATION OF THE CORRECT SAMPLE PREPARATION PROTOCOLS

IDENTIFICATION OF AQUATIC MACROINVERTEBRATES

COMPETENCY IS VALID FOR 3 YEARS FROM CERTIFICATE DATE

NATIONAL SASS5 AUDITOR

30 September 2021

DATE