Glencore Operations South Africa (Pty) Ltd

LAKENVLEI WETLAND REHABILITATION PROJECT PHASE 2

Aquatic Biodiversity and Impact Assessment

OUR REF.: 41106116-REP-00004
AUGUST 2024

PUBLIC

Glencore Operations South Africa (Pty) Ltd

LAKENVLEI WETLAND REHABILITATION PROJECT PHASE 2

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Aquatic Biodiversity and Impact Assessment

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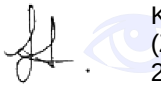
Signature	 Khoza, Tebogo (ZATK05201) 21-May-25
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EXECUTIVE SUMMARY

Glencore Operations South Africa (Pty) Ltd – Goedgevonden Colliery (GGV) is an existing opencast coal mining operation near Ogies in Mpumalanga. GGV was issued with a Water Use License (WUL 24084063) in April 2007. Amongst others, WUL 24084063 requires an offsite wetland rehabilitation as an offset for the wetland loss in GGV mining. The WUL requires that an offset must be in the ratio 1:2 (for every 1 hectare lost, 2 hectares must be rehabilitated).

Golder Associates Africa (Pty) Ltd (now WSP) developed the preliminary engineering, high-level costing and prioritization framework costing for the implementation of Lakenvlei rehabilitation. The prioritization framework also identified and grouped rehabilitation interventions as small and large – depending on the impacts associated with installation. Dongalocks were identified as one rehabilitation intervention for smaller intervention erosion. Other small interventions include the stabilisation of head cuts in existing gabion structures. Larger interventions include the removal of the dam, formalising road crossing, formalising spillway and removal of vegetation. These trigger notice 1 activity 12, 19, 27 and notice 3 activity 14, 23.

WSP was appointed by GGV to undertake the necessary ecological baseline surveys and impact assessment reports, in support of the environmental regulatory process required to authorise the larger structures/earthworks. This report describes the baseline aquatic biodiversity within areas that will be impacted by the proposed intervention structures.

The wetland rehabilitation project is situated within the upper Lakenvlei wetland system in the Greater Lakenvlei Protected Environment (GLPE) located 15 km North of Belfast and 16 km South of Dullstroom in the Mpumalanga Province.

The study area has been divided into eight wetland clusters for the purpose of implementing the offset strategy. All the wetland clusters were accessed during the field survey, however the aquatic ecology assessment was undertaken at clusters 4, 6 and 7 where riparian habitat with flowing streams were observed to occur.

The assessed watercourses are located within the primary drainage region B of the Olifants Water Management Area (WMA) and the B41A quaternary catchment and form part of the Lakensvleispruit Sub-Quaternary Reach (SQR; B41A-01005).

The following key findings are highlighted as part of the current aquatic biodiversity and impact assessment study:

Each of the assessed *in situ* water quality parameters remained within the recommended target water quality range (TWQR) throughout the sites except the dissolved oxygen levels at a site in cluster 4 (site 4C). A total of 34 aquatic macroinvertebrate taxa were collected from the six sites, 20 at the two Cluster 4 sites; 21 at the single Cluster 6 site; and 26 at the three Cluster 7 sites. As expected, the macroinvertebrate assemblages were dominated by none-sensitive taxa and there was no species of conservation concern (SCC). The macroinvertebrate based ecological condition was *Largely Modified* throughout the sites except at site 6A (in Cluster 6) which recorded the highest diversity and subsequently presented a *Moderately Modified* ecological condition.

Only a single out of the four expected fish species was recorded at sites 4A and 7D (with 11 and 4 individuals respectively), thus the diversity and abundance of fish within the project area was low.

Consequently, the fish based ecological condition indicated *Critically Modified* condition at all the other sites whilst sites 4A and 7D were *Seriously Modified* and *Largely Modified* respectively.

The integrated EcoStatus for the sampled sites were determined to be *Moderately to Largely Modified* except at site 7F which represented a *Largely Modified* EcoStatus. The slightly more deteriorated state at site 7F was largely attributed to the instream ecological condition represented by the macroinvertebrate and fish results. In relation to the Recommended Ecological Category (REC) of *Moderately Modified* (Ecological Category of C) (DWS, 2016a), all the sites indicated a Present Ecological State (PES) close to the REC whilst site 7F indicated a slightly more deteriorated state.

Reasoned opinion whether Project should proceed

Based on the findings of the current aquatic biodiversity and impact assessment study, no sensitive species nor species of conservation concern (SCC) occur within the assessed aquatic ecosystems. Although the proposed project is expected to negatively impact inhabiting aquatic biota during the construction phase, it is the specialist's opinion that this is outweighed by the objectives of the wetland rehabilitation project, especially because the recorded species are common in the region.

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1. INTRODUCTION

Glencore Operations South Africa (Pty) Ltd. (GOSA) manages several coal mining operations operated by various legal entities, which include the Goedgevonden Colliery (GGV). GGV is an existing opencast coal mining operation in eMakhazeni Local Municipality, Nkangala District Municipality.

Wetland offsets were proposed as an offset for the impact associated with the loss of large wetland habitat at the GGV Mine. The GGV Water Use License (WUL) 24084063 of 19 April 2007 was issued on condition that wetland rehabilitation takes place as an offset for the wetland loss in GGV mining. The WUL required that the wetland offset be a ratio of 1:2 (for every 1 hectare lost, 2 hectares must be rehabilitated). The direct wetland loss of 584 hectares at the GGV mine, resulted in a wetland offset target of 1 168 hectares. To find a wetland area this large to conserve and manage, GGV had to look for sites beyond its catchment borders. The Lakenvlei wetland clusters 1-7 (within The Greater Lakenvlei Protected Environment (GLPE)) was identified as a suitable offset option.

The proposed wetland rehabilitation work has been implemented in a phased approach. Phase 1 of the offset plan involved the installation of small dongalock structures in Cluster 1 and 2 under the ambits of a GA (DWS Ref 27/2/2/B141/14/3). The small structures associated with Phase 1 did not require EA. This BAR process is for the larger structures that will trigger NEMA Listed Activities, that require EA within Clusters 1-7 associated with Phase 2 of the wetland rehabilitation.

WSP was appointed by GGV to undertake the necessary ecological baseline surveys and impact assessment reports, in support of the environmental regulatory process required to authorise the larger structures/earthworks.

1.1. MOTIVATION

The GLPE is located 8km north of Belfast in Wards 4 and 6 of the eMakhazeni Local Municipality, Nkangala District Municipality, within the Mpumalanga Province. The Greater Lakenvlei Wetland was declared a Protected Environment, in terms of sections 28(1)(a)(i) and (b) of NEM:PAA, by MEC, Mr. Vusi Shongwe, of the Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) on 7 April 2017. There are plans to further expand the GLPE by a further 7000ha. The project site is in quaternary catchment B41A of the Steelpoort sub-catchment within the Olifants Water Management Area (WMA2), primary drainage region B in the Mpumalanga Province (WSP, 2023).

The GLPE area comprises 9365 ha of which 1131 ha are delineated wetlands, known as the Lakenvlei wetland system. The GLPE area is considered an extremely important bird habitat and is home to all three of South Africa's cranes species (Blue, Wattled and Grey Crowned Crane) as well as the elusive and critically endangered, White-winged Fluff Tail. Lakenvlei currently holds one of the only two regular breeding pairs of Wattled Cranes remaining in Mpumalanga, and its catchment, one of only two wintering flocks of Grey Crowned Cranes on the Steenkampsberg (GreenGab, 2021).

The greater Lakenvlei wetland systems provide crucial ecosystem services as healthy wetland systems support human livelihoods, purify water and trap nitrates, regulate stream flow, maintain biodiversity, help flood attenuation, and prevent erosion due to the vegetation cover typically present in wetlands.

Being a large wetland system with a conservation status makes the GLPE an ideal project site for the GGC Wetland Offset. Improving the wetland functionality and "Present Ecological Status" (PES) of the wider wetland system will be of great value for the wider catchment, the GLPE area, the project site, the private land owners, and GGV to be able to realise and achieve their wetland offsetting goals and targets.

1.1.1. THE OFFSET STRATEGY

The main objective of the GGV wetland offset strategy is to help improve the Present Ecological Status (PES) in all the wetland Clusters within the GLPE through rehabilitation and management initiatives. 162 rehabilitation initiatives have been proposed for the project area. The larger rehabilitation structures associated with Phase 2, are planned for Clusters 1-7.

Cluster 8 is the biggest and most ecologically sensitive wetland cluster. No rehabilitation measures have been proposed for Cluster 8, as Clusters 1-7 feed into Cluster 8. Improving the PES of Clusters 1-7 is anticipated to have a direct positive impact on the PES of Cluster 8.

The rehabilitation initiatives proposed for GLPE that require environmental authorisation include:

- Maintaining existing wetland rehabilitation structures already in place. Some of the existing structures in the wetlands require repair and maintenance, some additional structural construction, and others no intervention at all. Forty-four (44) existing structures have been identified for maintenance and repair work;
- Repairing and formalising damaged spillways. Seventeen (17) spillways have been identified for repair and upgrade;
- Formalising existing wetland crossings/access routes. Twenty (20) crossings within the wetlands have been identified for formalising/upgrade;
- Stabilizing headcuts. Six (6) headcuts have been identified for stabilising,
- Constructing new wetland rehabilitation structures (dongalocks) in strategic locations within the wetlands. Five (5) single-sheet dongalocks, sixty (60) double-sheet dongalocks and two (2) triple-cascading dongalock systems have been proposed;
- Erecting bird-friendly fences to restrict future and further agricultural infringement in the wetlands. Seven (7) areas have been identified for fencing. This activity does not require EA, and;
- Removing heavy alien invasive vegetated areas within the GLPE area. Eight areas (up to 97.78ha) of alien invasive vegetation have been identified for clearing from within the wetland areas.

The larger structures and instream rehabilitation activity planned for clusters 2, 3, 4, 5, 6 and 7 trigger the need for a Water Use Licence under the ambits of a General Authorisation (for obstructing and diverting flow) in terms of WULA Regulations GN R 267 and environmental authorisation (for infill and removal of more than 10m^3 of material within a watercourse and the clearance of more than 300m^2 of indigenous vegetation within a protected ecosystem type) in terms of the EIA Regulations GN R.324 to GN R.327 as amended, published under the National Environmental Management Act (NEMA), 1998 (Act 107 of 1998) (NEMA).

1.2. THE PLANNED ACTIVITIES THAT REQUIRE EA

The planned activities provided in

Table 1-1 below require environmental authorisation (EA). The wetland rehabilitation activities have been grouped into wetland clusters 1-7. The calculations regarding wetland infill / removal, structure sizing and vegetation clearing (

Table 1-1) are based on the conceptual design drawings.

The activities that require EA are those associated with placing infrastructure within a watercourse, the associated clearing of indigenous vegetation within the project footprint and infill and excavation activity that will take place within the watercourse / wetland areas. It is, therefore, import to understand how big the cumulative footprints and volumes would be, how much vegetation would be cleared and how much infill and excavation within the wetland is anticipated.

A desktop analysis and ground truthing site work was conducted by WSP to identify areas that require rehabilitation initiatives and to calculate the footprint areas for each planned activity. These calculations where based on the following parameters, as advised by the design engineers:

- Maintaining the existing wetland rehabilitation structures already in place (44 x structures). Some of the existing structures require repair and maintenance and minor structural modification. Most of the maintenance work planned for the existing structures will not require EA. The planned work will not involve clearing indigenous vegetation or excavation or infilling within the wetlands;
- Repairing and formalising damaged spillways (17 x spillways). The current informal spillway area (m^2) x 0.2m (depth) was used to calculate the area of impact and volume of infill and excavation for the 6 x spillways that are planned to be formalised;
- Formalising existing wetland crossings (20 x crossings). The current footprint of the existing crossings (area) x 0.2m (volume) of crusher stone was used to calculate the area and volumes that are expected to be placed within the wetlands to formalise the crossings;
- Repairing a dam wall within the wetland. The parameters were calculated using the area of the damaged dam wall, multiplied by the height of the dam wall to calculate the area and volume that would be required for the repair;
- Stabilizing headcuts (6 x drop structures). These calculations were based on the size of the incised wetland channel or erosion area needing repair. The drop structure anchors will typically be 0.3m deep and as wide as the width of the necessary drop structure. There is an anchor trench at the top and bottom of the slope which helps anchor in the concrete macmat or canvas to the ground. The volumes of the anchor trenches and area of the macmat / concrete canvas were used to calculate area and volume of infill for these structures;
- Constructing new wetland rehabilitation structures (dongalocks) in strategic locations (67 x new structures). The length, breadth and height of the proposed structures were used to calculate the area and volume of infill; and
- Removing heavy alien invasive vegetated areas within the GLPE area (up to 97.78ha). The identified areas of alien invasive species were identified on-site and measured on desktop, with Google Earth Pro.

Table **1-1** presents the cumulative calculations (areas and volumes) for the activities that require Environmental Authorisation in each cluster:

- The total cumulative construction footprint area for all the rehabilitation initiatives will be 0.39ha (3971.75m^2). Approximately 0.39ha of indigenous vegetation will be "cleared" within the project footprint for the rehabilitation sites;
- The total anticipated infill volumes within the wetland will be 7192.56m^3; and
- Approximately 97.78ha of alien vegetation has been earmarked for removal within the current GLPE.

Table 1-1 - Activities that require Environmental Authorisation

Location	Activity	NEMA Listed activity	Farm	Land Owner
Cluster 1	Removal of 20.06ha of alien vegetation	LN3, Activity 19	Portion 15 of Middlepunt 320 JT	Pat McClintock
Cluster 2	Install double donga locks (x 2) Clearing approx. 8.75m^2 within the proposed structure footprints. Infill approx. 4.3m^3 within wetland	LN1, Activity 12 LN1, Activity 19	Lakenvlei 355 JT, Portions 6 Portion 0, and 19 of Middlepunt 320 JT	DARDLEA - Rural Development Mabote Montshosi
Cluster 3	The formalisation of 7 x spillways, Stabilize 1 x headcut Install 3 x double dongalock structures, Infill – 5 628m^3 within wetland Indigenous vegetation "clearance" – 879m^2 within the proposed structure footprints.	LN1, Activity 12 LN1, Activity 19 LN 3, Activity 12	Lakenvlei 355 JT, Portions 6	DARDLEA - Rural Development Mabote Montshosi
	Remove 71.37 ha of alien vegetation	LN3, Activity 19		
Cluster 4	Install 25 new dongalock structures Repair 36 existing rehabilitation structures Upgrade/formalise 6 road crossings Upgrade 3 spillways Construction footprint – 665m^2 of "structure" within	LN1, Activity 12 LN1, Activity 19 LN 3, Activity 12	Lakenvlei 355 JT, Portions 11	Highland Monarch Inv PTY LTD Willem Jansen Lyncam Inv PTY LTD

Location	Activity	NEMA Listed activity	Farm	Land Owner
	wetland and clearance of indigenous vegetation. Infill – 87.33m^3 within wetland			
	Removal of 6.35ha of alien vegetation	LN3, Activity 19		
Cluster 5	Install 23 new dongalock structures Existing Structure maintenance/ repair Upgrade 2 spillways Upgrade/formalise 6 road crossings Infill of 243.13m^3 within wetland Indigenous vegetation "clearance" – 923.5m^2	LN1, Activity 19 LN1, Activity 12	Lakenvlei 355, Portion 4	Danie Holtshauzen
Cluster 6	Installing one dongalock structure Repairing one dam wall Upgrading 2 wetland road crossings Infill of 206.2m^3 within wetland Indigenous vegetation "clearance" – 370m^3	LN1, Activity 19 LN1, Activity 12	Middelpunt 320 JT, Portions 3, 11, 18, 19	Isabella Maria Beyers Trust Danie Holtshauzen (PTN 3, 19) Pieter dryer (PTN 11) Mauve Grass Trading CC Alex Kilbride (PTN18) Alex Kilbride
			Zwartkoppies 316 JT, Portions 7	Jocobus Francois Swarts RSA (PTN 9)
Cluster 7	Installing 16 new dongalock structures Repairing 2 x spillways Installing 2 x headcuts Formalising 6 x Farm Tracks, Infill of 969.8m^3 within wetland Removal of 945m^2 of indigenous vegetation within the proposed structure footprints.	LN3, Activity 19	Zwartkoppies 316 JT, Portions 9 – no new structures Middelpunt 320 JT, Potions 7, 17, 2	RSA (PTN 9) Dr Piet Botha

Location	Activity	NEMA Listed activity	Farm	Land Owner
Totals	The cumulative area of indigenous vegetation to be cleared – **3971.75m^2 /0.39ha** Cumulative infill in the watercourse/wetland – **7192.56m^3**	LN1, Activity 12 LN1, Activity 19 LN3, Activity 19		

1.3. PURPOSE OF THE REPORT

This report describes the baseline aquatic biodiversity within areas that will be impacted by the proposed intervention structures. Potential impacts, positive or negative, were assessed and practical mitigation/management measures developed for inclusion in the Environmental Management Programme (EMPr).

1.4. PROJECT LOCATION AND EXTENT

The wetland rehabilitation project (*Hereafter, the Project*) is situated within the upper Lakenvlei wetland system in the Greater Lakenvlei Protected Environment (GLPE) located 15 km North of Belfast and 16 km South of Dullstroom in the Mpumalanga Province.

The study area has been divided into wetland clusters for the purpose of implementing the offset strategy Figure 1-1. It should be noted that the current study focuses on wetland clusters 4, 6 and 7 where riparian habitat with flowing streams were observed to occur.

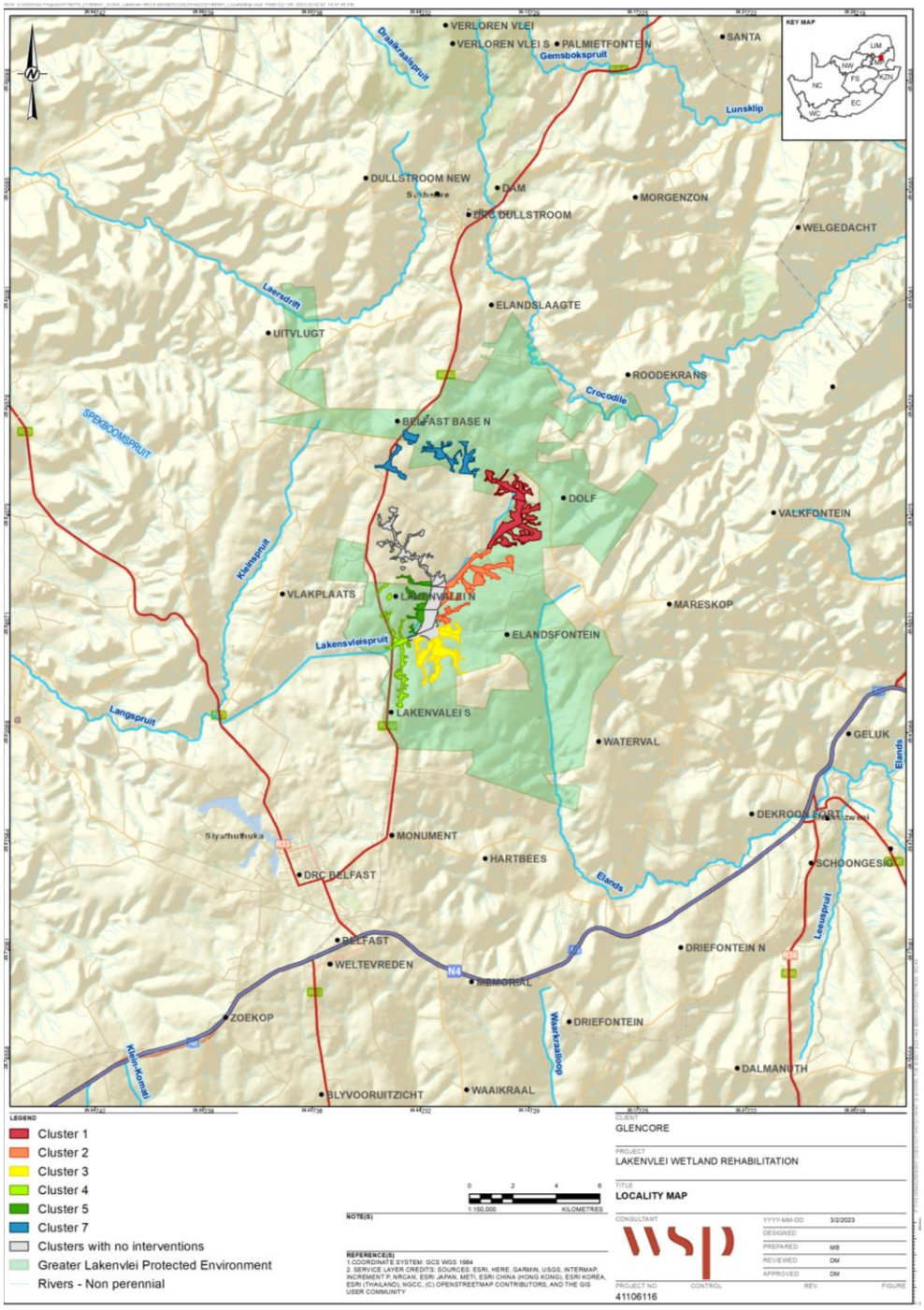

Figure 1-1 - Project locality map

1.5. LEGAL REQUIREMENTS, STANDARDS AND GUIDELINES

The legislative context for aquatic ecology studies which applies to the proposed project are listed and discussed below.

- **National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA)** – Section 24 (1)(a) and (b) states that "the potential impact on the environment and socio-economic conditions of activities that require authorisation or permission by law and which may significantly affect the environment must be considered, investigated and assessed before their implementation and

reported to the organ of state charged by law with authorizing, permitting, or otherwise allowing the implementation of an activity.

- **National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (NEM:BA)** – The NEM:BA regulates the management and conservation of the biodiversity of South Africa within the framework provided under NEMA. This Act regulates the protection of species and ecosystems that require national protection and considers the management of alien and invasive species.
- **National Water Act (Act No. 27 of 2014) (NWA)** – The NWA aims to protect, use, develop, conserve, manage and control water resources including rivers, dams, wetlands, the surrounding land, groundwater, as well as human activities that influence them. The NWA intends to protect these water resources against over exploitation and to ensure that there is water for social and economic development and water for the future.
- **Mpumalanga Nature Conservation Management Act (Act No. 10 of 1998)** – aims to consolidate and amend the laws relating to nature conservation within the Province and to provide for matter connected therewith.

1.6. STUDY LIMITATIONS

The following limitation are expressed as part of the current study:

- The biotic indices SASS5 and IHAS were designed for the evaluation of perennial streams and rivers with low/moderate flow hydrology (Dickens & Graham, 2002), as such, only the riparian systems with sufficient flow were assessed in the current study. All seven wetland clusters were accessed however only clusters 4, 6 and 7 were observed to consist of suitable habitat, thus the aquatic assessment was undertaken at these clusters only.
- Most of the assessed systems are non-perennial, therefore results obtained from sites resembling impoundments/wetlands should be interpreted with caution.
- In order to obtain a comprehensive understanding of the dynamics of the biota present within a watercourse (e.g., migratory pathways, seasonal prevalence, etc.), studies should include investigations conducted during different seasons, over a number of years and through extensive sampling efforts. Given the time constraints of the present study, such long-term research could not be conducted. Instead, conclusions provided within this report are based on data collected during a single early high flow sampling event, a literature review, and professional experience.

1.7. DETAILS OF THE SPECIALIST

Name:	**Tebogo Khoza**
Cell phone number:	078 230 1762
Telephone number:	011 300 6131
Email:	tebogo.khoza@wsp.com
Qualification:	M.Sc. Biodiversity and Conservation
Professional Affiliations:	**South African Council for Natural Scientific Professions (SACNASP)** *Pr.Sci.Nat*. – 119651 (Aquatic Science) **DWS accreditation** South African Scoring System (SASS5)

DECLARATION OF INDEPENDENCE BY SPECIALIST

I, Tebogo Khoza, declare that I –

- Act as the independent specialist in this application;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed;
- Do not have nor will have a vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity; and
- Undertake to disclose, to the competent authority, any information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document.

2. METHODOLOGY

This aquatic biodiversity and impact assessment took cognisance of Government Notice No. 320, published in 2020 under the National Environmental Management Act (1998) concerning 'Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Theme in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act (1998), when applying for Environmental Authorisation'.

In line with the assessment and reporting requirements set out in the protocol, this report includes two main study components; a desktop literature review, supplemented by a field survey within the proposed development footprint and extended areas of influence. The objectives and tasks associated with these components are described below.

2.1. LITERATURE REVIEW AND GAP ANALYSIS

The aim of the desktop literature review component was to collate and review the extensive available ecological information related to important biodiversity and conservation features in the project area, key ecological processes and function, and the likely composition and structure of local aquatic fauna communities (specifically macroinvertebrates and fish).

The following sources were consulted for the desktop literature review:

- The Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Compiled by RQIS-RDM (DWS, 2014);
- Lakenvlei Wetland Offset Strategy – Monitoring Report (WSP, 2022);
- National spatial planning datasets were consulted to provide a regional/national context for assessing the biodiversity significance of the site, namely
    - The Mpumalanga Biodiversity Sector Plan (MBSP)
    - National Freshwater Ecosystem Priority Areas (NFEPA)
    - National Wetland Map 5 (NWM5)
    - National Environmental Management Biodiversity Act (NEMBA) Threatened Ecosystems
    - National Protected Area Expansion Strategy (NPAES).

2.2. FIELD SURVEY

This section provides a brief description of the aquatic biodiversity study approach and methodologies utilised during the field surveys (undertaken on 21st to 24th November 2023) and the locations wherein the assessments were undertaken.

2.2.1. STUDY APPROACH

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

Water Quality

- *In situ* water quality assessment including temperature, pH, electrical conductivity, dissolved oxygen and comparison to applicable guideline values and identification of variables of potential concern;

Habitat Indicators

- General habitat assessment including site location (GPS coordinates), site photographs (for future identification of major changes and documentation of habitat conditions); and surrounding features such as land uses, potential sources of pollution, erosion etc;
- Index for Habitat Integrity (IHI): a rapid, visual assessment of modifications to a number of pre-selected biophysical drivers and used to determine the PES or Ecological Category of associated instream and riparian habitats; and
- Integrated Habitat Assessment System (IHAS, Version 2.2): This index evaluates habitat suitability specifically for aquatic macroinvertebrates and is used in conjunction with the South African Scoring System Version 5 (SASS5) index.

Response Indicators

- Aquatic macroinvertebrate assessment, including the determination of ecological condition through the South African Scoring System (SASS Version 5) and the Macro-Invertebrate Response Assessment Index (MIRAI);
- Ichthyological assessment, including the evaluation of reference conditions and determination ecological condition through the Fish Response Assessment Index (FRAI); and
- Determination of the integrated EcoStatus (EcoStatus 4, Version 1.02).

A detailed description of the aquatic biomonitoring methodologies used for the survey is provided in Appendix A.

2.2.2. MONITORING SITES

Selection of the monitoring sites was largely based on the placement of structures and the availability of riparian habitat consisting of flowing streams. A total of 15 sites were selected for investigation, of these, only six had suitable habitat for sampling. Site names, GPS coordinates and brief descriptions are provided in Table 2-1 and a map of the study area showing the location of the sampling sites is presented in Figure 2-1. Photographs showing the upstream and downstream views at each monitoring location are provided in Appendix B.

Table 2-1 - Location of the sampling points and brief descriptions

Wetland Cluster	Site Code	GPS Co-ordinates	Site Description	Assessed Parameters
7	7A	25°30'45.47"S 30° 5'28.97"E	Located below a series of dongalocks within a slow flowing, narrow and shallow stream	Photos
	7B	25°30'53.54"S 30° 5'27.91"E	Located below a confluence of two small streams which both consist of a series of dongalocks	Photos; In situ WQ; SASS5; IHAS; IHI
	7C	25°31'6.02"S 30° 5'38.25"E	Located adjacent a farm house, within a moderately flowing stream with varying depth and width profiles	Photos; In situ WQ; SASS5; IHAS; IHI; Fish

Wetland Cluster	Site Code	GPS Co-ordinates	Site Description	Assessed Parameters
	7D	25°31'19.57"S 30° 5'40.47"E	Located at a small road crossing, within a moderately flowing stream with varying depth and width profiles	Photos; In situ WQ; SASS5; IHAS; IHI; Fish
	7E	25°30'36.15"S 30° 6'3.61"E	Located within a narrow and shallow headwater stream, upstream of a series of dongalocks	Photos
	7F	25°31'24.28"S 30° 5'54.24"E	Located within a slow flowing stream with varying depth and width profiles, downstream of a series of dongalocks	Photos; *In situ* WQ; SASS5; IHAS; IHI; Fish
3	3A	25°36'29.15"S 30° 5'17.87"E	Located upstream of a farm dam, within a wetland system	Photos
	3B	25°36'15.36"S 30° 5'22.21"E	Located downstream of a farm dam within a floodplain wetland	Photos
	3C	25°35'40.70"S 30° 5'23.42"E	Located downstream of a farm dam within a floodplain wetland system	Photos
4	4A	25°36'14.43"S 30° 4'27.32"E	Located at a small road crossing with gabion structures recently placed. Within a moderately flowing stream with varying depth and width profiles	Photos; *In situ* WQ; SASS5; IHAS; IHI; Fish
	4B	25°35'41.56"S 30° 4'26.80"E	Located with a floodplain wetland downstream of site 4A	Photos
	4C	25°35'47.89"S 30° 4'1.04"E	Located within a moderately flowing stream with varying depth and width profiles. Serves as the furthest downstream site for the project	Photos; *In situ* WQ; SASS5; IHAS; IHI; Fish
5	5A	25°34'30.77"S 30° 4'51.96"E	Located adjacent a agricultural lands at a low water crossing.	Photos
6	6A	25°33'52.62"S 30° 5'4.74"E	Located at a low water crossing bridge, stream with varying depth and width profiles	Photos; *In situ* WQ; SASS5; IHAS; IHI; Fish
8	8A	25°34'0.22"S 30° 5'44.81"E	Located within a flood plain wetland adjacent agricultural land	Photos

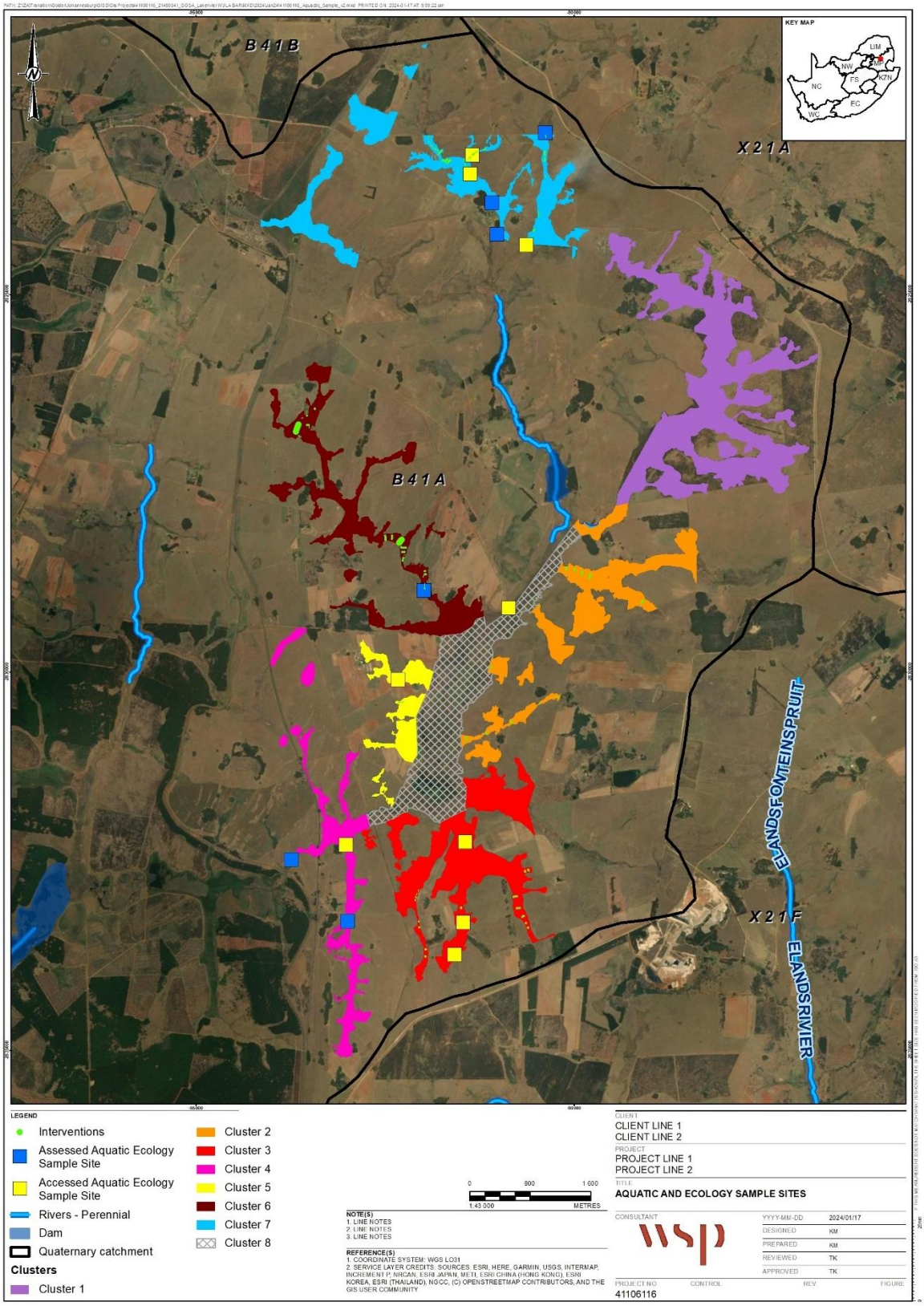

Figure 2-1 - Locations of the Aquatic Ecology sampling points

3. AQUATIC BIODIVERSITY DESKTOP ASSESSMENT

The following sections describe the physical and biological characteristics for the region within which proposed Project is located.

3.1. ASSOCIATED WATER RESOURCES

The Project lies within the primary drainage region B of the Olifants Water Management Area (WMA) and the B41A quaternary catchment. The Lakensvleispruit Sub-Quaternary Reach (SQR; B41A-01005) – a first order stream which flows for approximately 19.3 km in a south west direction – drains the project area (Figure 3-1).

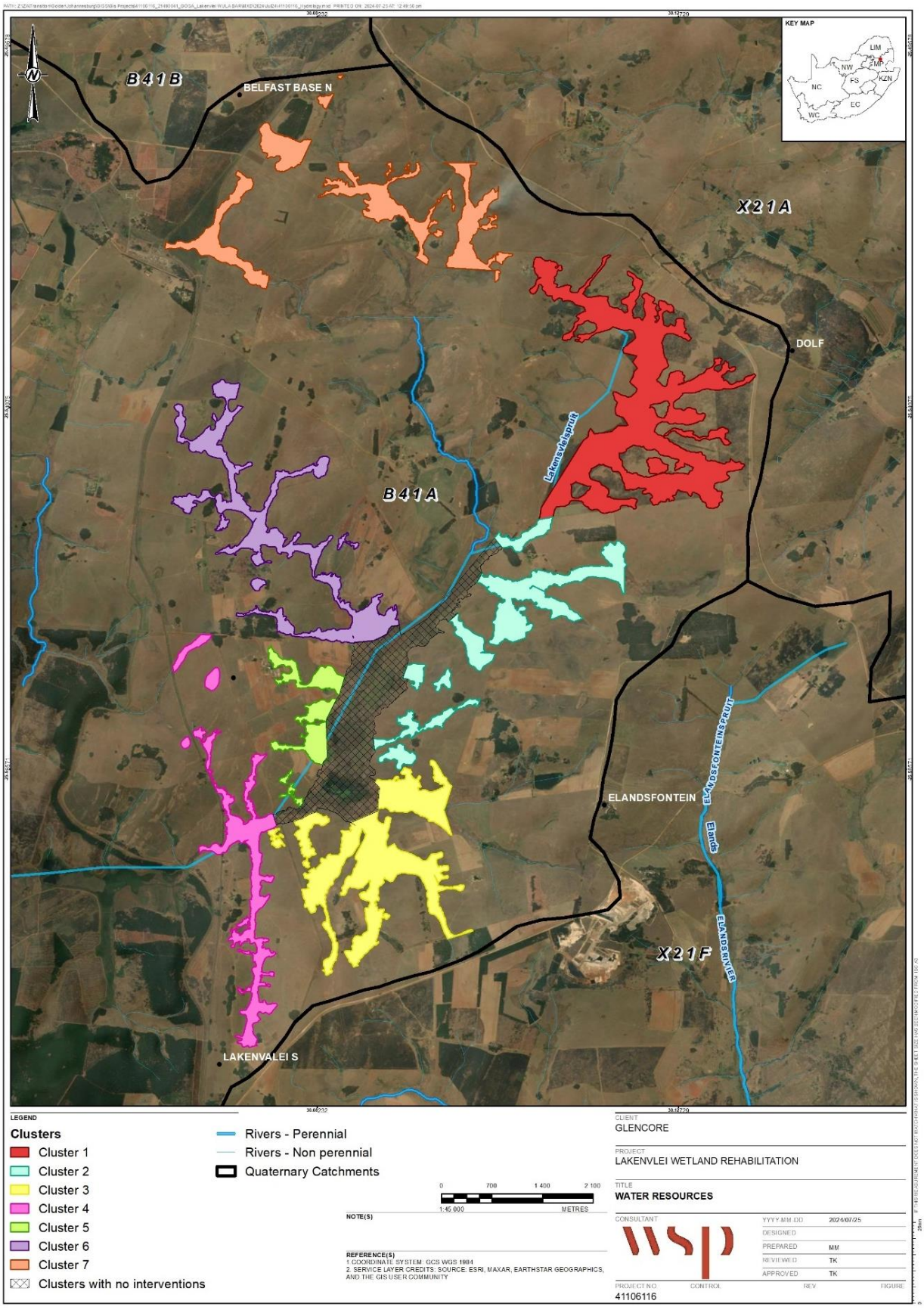

Figure 3-1 - Quaternary catchments and rivers associated with the proposed Project

3.2. REGIONAL BIODIVERSITY CONTEXT

3.2.1. PRESENT ECOLOGICAL STATE, IMPORTANCE AND SENSITIVITY

According to the DWS (2016) desktop data, the Present Ecological State (PES) for the Lakenvleispruit SQR B41A-01005 is Largely Modified. The Ecological Importance (EI) is High and the Ecological Sensitivity is Moderate (ES). Only four fish species and 36 aquatic macroinvertebrate taxa are expected within this SQR.

3.2.2. EXPECTED AQUATIC BIOTA

The expected fish species and aquatic macroinvertebrate taxa for the SQR associated with the Project are presented in Table 3-1 and Table 3-2 respectively. Of the four expected fish species, two are tolerant to modified water quality (*Tilapia sparrmanii* and *Pseudocrenilabrus philander*), one is moderately tolerant (*Enteromius anoplus*) and one is moderately intolerant (*Enteromius neefi*). The fish species' tolerance to no-flow conditions follows the same pattern as the tolerance to modified water quality (DWS, 2014). Based on the IUCN Red List of Threatened Species, the conservation status of each of the species is Least Concern (LC).

Thirty six aquatic macroinvertebrate taxa are expected within the SQR. The community assemblage is predominantly comprised of taxa with a very high sensitivity to no-flow conditions, and with moderate sensitivities toward water quality modifications.

Table 3-1 - Expected fish species, respective tolerance/intolerance to water quality modifications and no-flow conditions and IUCN conservation status

Fish Species	Tolerance		Conservation Status
	Modified Water Quality	No-Flow	
Enteromius anoplus	Moderately Tolerant	Moderately Tolerant	LC
Enteromius neefi	Moderately Intolerant	Moderately Intolerant	LC
Tilapia sparrmanii	Tolerant	Tolerant	LC
Pseudocrenilabrus philander	Tolerant	Tolerant	LC

Table 3-2 – Expected aquatic macroinvertebrates

Taxa/Family names		
Turbellaria	Corixidae	Gyrinidae
Oligochaeta	Gerridae	Ceratopogonidae
Hirudinea	Hydrometridae	Chironomidae
Potamonautidae	Naucoridae	Culicidae
Hydracarina	Nepidae	Muscidae
Baetidae > 2 sp	Notonectidae	Simuliidae
Caenidae	Pleidae	Tabanidae
Coenagrionidae	Veliidae/Mesoveliidae	Tipulidae
Aeshnidae	Hydropsychidae	Ancylidae
Gomphidae	Hydroptilidae	Bulininae

Taxa/Family names		
Libellulidae	Leptoceridae	Planorbinae
Belostomatidae	Dytiscidae	Sphaeriidae

3.2.3. SPECIES OF IMPORTANCE

A new semi-terrestrial burrowing freshwater crab *Potamonautes flavusjo* sp. nov. has been reported to occur in the Highveld of the Mpumalanga province (Daniels et al., 2014). Specimens of this species were collected at Verloren Vallei Nature Reserve and at two farms, Lona Farm and Miss Chrissie's Country House Farm. The Nature Reserve is located approximately 22 km north of the Lakenvlei area (25°18'39.09"S 30° 7'17.90"E) and the two neighbouring farms are located approximately 80 km south (26°21'28.75"S 30°12'33.50"E). Based on the locations where the specimens were collected and the similarity in habitat, it is suspected that the Lakenvlei area may host this new species. The presence of this species was therefore investigated during the current aquatic ecology assessment. Photographs of the live specimens are provided in Figure 3-2.

Figure 3-2 - Photographs showing *Potamonautes flavusjo* sp. Nov. Female specimen (left) and male specimen (right). Taken from Daniels et al. (2014)

3.2.4. MPUMALANGA BIODIVERSITY SECTOR PLAN (MBSP)

The Mpumalanga Biodiversity Sector Plan (MBSP) is a spatial tool that forms part of the national biodiversity planning tools and initiatives that are provide

d for national legislation and policy. The MBSP was published in 2014 by the Mpumalanga Tourism and Parks Agency (MTPA) and comprises a set of maps of biodiversity priority areas accompanied by contextual information and land-use guidelines for use in land-use and development planning, environmental assessment and regulation, and natural resource management (MTPA, 2014).

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

Based on the MBSP, the freshwater biodiversity areas within which the Project lie are categorised as Ecological Support Areas (ESAs) and Heavily Modified (Table 3-3 and Figure 3-3).

Table 3-3: Mpumalanga Biodiversity Sector Plan Categories Associated with the proposed Project (MTPA, 2014)

Map Category	Description	Sub-Category	Description
Ecological Support Areas (ESA)	Areas that are not essential for meeting targets, but that play an important role in supporting the functioning of CBAs and that deliver important ecosystem services	ESA: Wetlands	All non-FEPA wetlands. Although not classed as FEPAs, these wetlands support the hydrological functioning of rivers, water tables and freshwater biodiversity, as well as providing a host of ecosystem services through the ecological infrastructure that they provide.
		Important Sub-catchments	Sub-catchments that either contain river FEPAs and/or Fish Support Areas.
Heavily modified areas	Areas in which significant or complete loss of natural habitat and ecological function has taken place due to activities such as ploughing, building of dams, hardening of surfaces, open-cast mining, cultivation, and so on	Dams	Artificial water bodies that have impacted on wetland or river ecosystems. These areas may still have a recharge effect on wetlands, groundwater and river systems and may support river- or water-dependent fauna and flora, such as water birds and wetland vegetation.

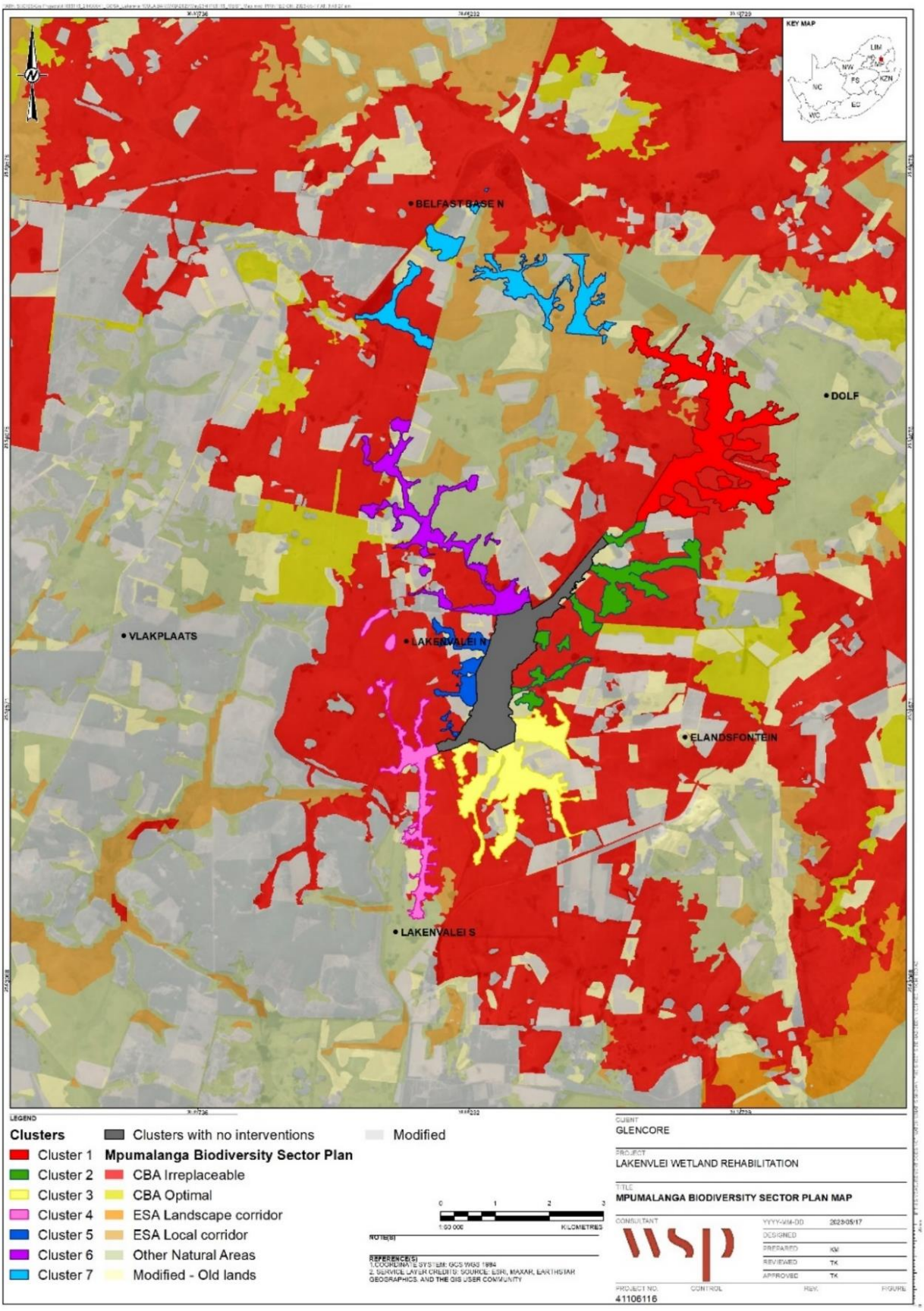

Figure 3-3 - Mpumalanga Biodiversity Sector Plan (MBSP)

3.2.5. NATIONAL FRESHWATER ECOSYSTEM PRIORITY AREAS

The National Freshwater Ecosystem Priority Areas (NFEPA) project (Driver et al., 2011) represents a collaboration of multiple organisations including the South African National Biodiversity Institute (SANBI), Council for Scientific and Industrial Research (CSIR), Water Research Commission (WRC), Department of Environmental Affairs (DEA), Department of Water Affairs (DWA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). The project is aimed to "*provide 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), the National Environmental Management: Biodiversity Act (Act 10 of 2004) and the National Environmental Management: Protected Areas Act (Act 57 of 2003)*" (Water Research Commision, 2011).

Based on the outputs of the NFEPA project, the sub-quaternary catchment associated with the proposed Project is classified as Wetland Cluster, wetland and river FEPA. Wetland clusters are groups of wetlands embedded in a relatively natural landscape, thus allows for important ecological processes such as migration of biota between wetlands. In many areas of the country, wetland clusters no longer exist because the surrounding land has become too fragmented by human impacts (Table 3-4 and Figure 3-4).

Table 3-4 - FEPA categories associated with the Project

FEPA Category	Description
Wetland Cluster	Wetland clusters are groups of wetlands embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands. In many areas of the country, wetland clusters no longer exist because the surrounding land has become too fragmented by human impacts.
Wetland FEPA	Wetland FEPAs were identified using ranks that were based on a combination of special features and modelled wetland condition. Wetland condition was modelled using the presence of artificial water bodies as well as by quantifying the amount of natural vegetation in and around the wetland (within 50 m, 100 m and 500 m of the wetland). Based on these factors, wetlands were ranked in terms of their biodiversity importance. Biodiversity targets for wetland ecosystems were met first in high-ranked wetlands, proceeding to lower ranked wetlands only if necessary.
River FEPA	River FEPAs achieve biodiversity targets for river ecosystems and threatened/near threatened fish species, and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicates that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources.

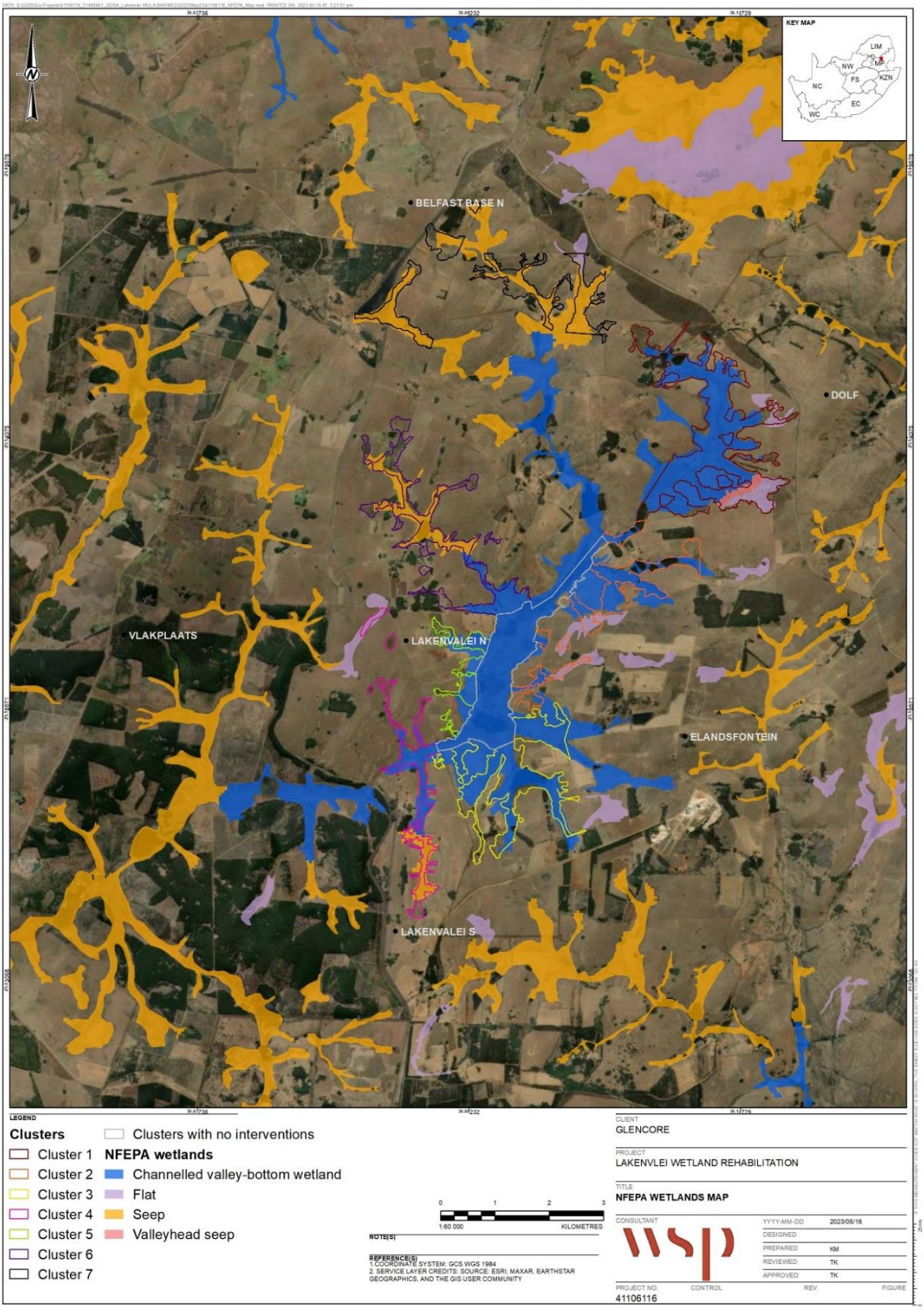

Figure 3-4 - FEPA map for the proposed Project

4. RESULTS AND DISCUSSION

Results for the aquatic biodiversity assessment undertaken on the 21st to 24th November 2023 are discussed in the below sections. The results have been separated per Wetland Cluster and presented from upstream site to downstream site for ease of interpretation.

It should be noted that eight of the fifteen accessed sites were not suitable for the application of the SASS5, IHAS and fish assessments due to the lack of suitable habitat, therefore only visual assessments were conducted and photographs were taken (see Appendix B). These sites are excluded in the below sub-sections and the reader is referred to the Wetlands Monitoring Report (WSP, 2022) for the ecological condition of the systems within which these sites form part of.

4.1. FLOW CONDITIONS

Flow conditions influence the processes that determine the size, shape, structure and dynamics of the aquatic ecosystems, and subsequently linked to habitats and biotic communities (Thoms & Thoms, 2006). Thus flow conditions and water levels aid in the interpretation of biological results.

The assessed sites presented channelled valley bottom and hillslope seep hydrogeomorphic types (Figure 4-1). The stream flow conditions are briefly described as follows:

Cluster 4

Sites 4A and 4C were located within channelled valley bottom HGM types with variable stream width and depth profiles and slow flows.

Cluster 6

Site 6A was located within a hillslope seep with a shallow and narrow channel. Flows varied from slow – within sections dominated by sediment – to moderate within sections of gravel and cobbles.

Cluster 7

Sites 7C and 7D were located within channelled valley bottom HGM types with variable stream width and depth profiles and slow to moderate flows. Site 7F was located within a hillslope seep with a shallow and narrow channel. Flows varied from slow to moderate.

Figure 4-1 – Stream flow conditions at the assessed sites

4.2. *IN SITU* WATER QUALITY

The variables temperature, pH, electrical conductivity and dissolved oxygen were measured onsite by means of portable water meters. The obtained data were referenced against various water quality guidelines shown in Table 4-1 and the results are presented in Table 4-2.

These data are important to assist in the interpretation of biological results due to the direct influence water quality has on aquatic life forms, and provide an indication of the physico-chemical status of the water at a sampling site at the time of the survey. In the current study, each of the assessed parameters remained within the recommended target water quality range (TWQR) throughout the sites except the dissolved oxygen levels at site 4C. The results are discussed in further detail in the sub-sections below.

Table 4-1 - Sources for the recommended water quality guidelines for aquatic ecosystems

Variable	Source	Guideline limit
Temperature	South African Water Quality Guidelines: *Aquatic Ecosystems (Volume 7)* (Department Of Water Affairs And Forestry, 1996)	5 – 30 ˚C
pH		6 – 8
Dissolved Oxygen % Saturation		80 – 120 %
Dissolved Oxygen concentration	Minimum Dissolved Oxygen concentration for aquatic macroinvertebrates (Nebeker et al., 1996)	> 5 mg/ℓ
Electrical Conductivity	Conductivity guideline value of 500 µS/cm stipulated in U.S. U.S. Environmental Protection Agency (2010)	< 500

Table 4-2 – *In situ* water quality data

Sites	Time	Temp. (ºC)	pH	EC (µS/m)	DO (mg/ℓ)	DO (%)
TWQR	**-**	**5 - 30º**	**6 – 8**	**<500**	**>5.0**	**80 - 120**
Site 4A	09H19	18.4	6.11	38	6.69	88.5
SIte 4C	08H54	19.4	6.91	79	**4.92**	**69.8**
Site 6A	12H04	20.9	6.58	99	6.78	97.3
Site 7C	16H56	22.8	6.77	50	6.46	94.8
SIte 7D	18H07	21.1	7.07	57	6.40	91.4
Site 7F	12H32	26.0	6.53	154	5.26	80.7
EC = Electrical Conductivity; DO = Dissolved Oxygen; Red indicates values that exceed the TWQR						

4.2.1. TEMPERATURE

Temperature plays an important role in water by affecting the rates of chemical reactions and consequently the metabolic rates of organisms. Temperature is therefore one of the major factors controlling the distribution of aquatic organisms (DWAF, 1996). In the current study, temperature values ranged between 18.4 ºC (at site 4A) and 22.8 ºC (at site 7C), thus all the values fell within the range for inland water temperatures in South Africa. The temperature at all sites were not expected to limit the occurrence aquatic biota.

4.2.2. PH

The pH value is a measure of hydrogen (H^+), hydroxyl (OH^-), bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions in water (Dallas & Day, 2004). In natural water, pH is determined by geological influences and biotic activities, and may also vary both diurnally and seasonally. Diurnal fluctuations occur in productive systems, where the relative rates of photosynthesis and respiration vary over a 24-hour

period. Most fresh waters in South Africa are relatively well buffered and more or less neutral, with pH ranges between 6 and 8 (DWAF, 1996).

The pH values were predominantly circumneutral (close to neutral pH 7), ranging between 6.11 at site 4A and 7.07 at site 7D, thus each of the sites remained within the recommended pH range of 6-8.

4.2.3. ELECTRICAL CONDUCTIVITY

Electrical Conductivity (EC) is a measure of the ability of water to conduct an electrical current. This ability is a result of the presence in water of dissolved ions, which carry an electrical charge. The EC in natural waters varies in part on the characteristics of geological formations which the water has been in contact with and the dissolution of minerals in soils and plant matter. Anthropogenic sources of increased dissolved salts include domestic and industrial effluent discharges and surface runoff from urban, industrial and cultivated areas (DWAF, 1996).

The recorded EC levels were predominantly low (ranged between 38 µS/cm at site 4A and 154 at site 7F) and recorded within the recommended guideline of 500 µS/cm (USEPA, 2010) at all the sites. Therefore none of the sites were expected to deter aquatic biota as a result of EC at the time of the survey.

4.2.4. DISSOLVED OXYGEN

The maintenance of adequate Dissolved Oxygen (DO) is critical for the survival of aquatic biota as it is required for the respiration of all aerobic organisms (DWAF, 1996). Therefore, DO concentration provides a useful measure of the health of an ecosystem (DWAF, 1996). The median guideline for DO for the protection of freshwater fish, determined by a variety of fish faunas is > 4 - 5 mg/ℓ (Doudoroff & Shumway, 1970; DWAF, 1996) and that of aquatic macroinvertebrates is ≥ 5 mg/ℓ (Nebeker, Onjukka, Stevens, & Chapman, 1996). The amount of oxygen that can be dissolved in water is influenced by the temperature, as the temperature of the water increases, the concentration of dissolved oxygen decreases (Davies & Day, 1998), thus seasonal fluctuations in oxygen levels are expected.

The recorded dissolved oxygen levels were moderate and recorded within the recommended TWQR limits except at site 4C. The relatively lower DO levels at this site were suspected to be a result of aerobic decomposition of plant matter by micro-organisms (Amorim & Moura, 2021). A high abundance of *Phragmites australis* (Common Weed) and *Potamogeton thunbergia* (Floating Pondweed) were observed growing instream (Figure 4-2).

The low DO saturation levels indicate that the oxygen levels had been depleted from the theoretical equilibrium possibly due to the presence of contaminants. Therefore aquatic biota was expected to be deterred due to low DO levels at site 4C.

Figure 4-2 - *Phragmites australis* (light grey arrow) and *Potamogeton thunbergia* (dark grey arrow) at site 4C

4.3. HABITAT ASSESSMENT

Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason, habitat evaluation is conducted simultaneously with biological evaluations in order to facilitate the interpretation of results (Ollis et al., 2006). The quality of the instream and riparian habitat influences the structure and function of the aquatic community in a stream; therefore, assessment of the habitat is critical to any assessment of ecological integrity.

The Index for Habitat Integrity (IHI) was applied to determine the instream and riparian habitat integrity and the Integrated Habitat Assessment System (IHAS) was applied to determine the availability and integrity of aquatic macroinvertebrate habitat .

4.3.1. INDEX FOR HABITAT INTEGRITY

The Index for Habitat Integrity (IHI) is a rapid, visual assessment of modifications to a number of pre-selected biophysical drivers and used to determine the PES or Ecological Category of associated instream and riparian habitats (Kleynhans et al., 2008).

The IHI assessment was completed on a desktop-level for each aquatic ecosystem considered in the present study and populated with observations recorded during the field survey Results are presented in Table 4-3.

The findings from the IHI assessments indicate that the habitat integrity was *largely natural* (Class B) for the instream and riparian habitat components at the Cluster 4 river reach; *largely natural* for the instream habitat and *moderately modified* (Class C) for the riparian habitat at the Cluster 6 river reach;

moderately modified (Class C) for the instream habitat and *largely natural* for the riparian habitat at the Cluster 7 river reach.

The observed major impacts of the instream habitat were flow and bed modification; the removal of indigenous vegetation and exotic vegetation encroachment. The farming activities were the likely sources of these impacts i.e. presence of dams, road crossings and clearing of indigenous vegetation.

Table 4-3 - IHI findings for the watercourses associated with the Project

Cluster	Habitat	IHI Score	EC	Major Impacts
4	Instream	81.6	B	Flow and bed modifications due to presence of low water bridge
	Riparian	81.7	B	Exotic macrophytes - Eucalyptus trees in close proximity
6	Instream	81.3	B	Flow and bed modifications due to presence of low water bridge
	Riparian	76.5	C	Indigenous vegetation removal - Cultivation in close proximity to stream bank
7	Instream	69.0	C	Flow and bed modifications due to presence of Dongalocks
	Riparian	80.5	B	Exotic macrophytes - Eucalyptus trees in close proximity

4.4. AQUATIC MACROINVERTEBRATE ASSESSMENT

The following sections provide insight on the data collected as part of the aquatic macroinvertebrate assessment. The South African Scoring System (SASS, Version 5) and available habitat (Invertebrate Habitat Assessment System) that was sampled at each of the accessed sites, as well as the subsequent determination of the ecological condition of the observed assemblages in relation to reference conditions (Macroinvertebrate Response Assessment Index) are discussed.

4.4.1. INTEGRATED HABITAT ASSESSMENT SYSTEM

The Integrated Habitat Assessment System (IHAS) was developed by McMillan (1998) for use in conjunction with the South African Scoring System (SASS5) bioassessment. Results from the current study are provided in Table 4-4.

The assessed ecosystems lie within the upper foothills and lower foothills geomorphological zone (class D and E respectively). Characteristic channel features within these geomorphological zones include lower gradient, mixed-bed alluvial channels with sand and gravel dominating the bed and pools of significantly greater extent than rapids or riffles and flood plain are often present (Rowntree et al., 2000).

Based on the obtained IHAS scores, sites 4A, 6A and 7C presented *Good* macroinvertebrate habitat availability, each of these sites exhibited a variety of habitat features within various flow and depth profiles, therefore expected to host macroinvertebrate assemblages comprising of high diversity of taxa especially at site 4A. Sites 4C, 7D and 7F presented *Adequate* habitat availability, sites 4C and 7F lacked stones-in-current whilst site 7D lacked an abundance of marginal vegetation.

Table 4-4 - Integrated Habitat Assessment System scores

Site	Sampling Habitat				IHAS	
	Stones-in-Current	Vegetation	Other Habitat / General	Physical Stream Condition	Score	Description
Site 4A	8	14	12	37	71	Good
SIte 4C	0	15	11	36	62	Adequate
Site 6A	12	10	12	34	68	Good
Site 7C	16	5	10	35	66	Good
SIte 7D	12	5	15	28	60	Adequate
Site 7F	0	12	13	31	56	Adequate
Maximum possible scores for Stones-in-Current = 20; Vegetation = 15; Other Habitat/General = 20; Physical Stream Condition = 45						

4.4.2. AQUATIC MACROINVERTEBRATES: ECOLOGICAL CONDITION

The SASS5 protocol was conducted to sample macroinvertebrates. This protocol provides a general indication of the current state of the macroinvertebrate community and subsequently the 'health' of the river ((Dickens & Graham, 2002). The collected SASS5 data is provided in Table 4-5 and discussed below.

A total of 34 aquatic macroinvertebrate taxa were collected from the six assessed sites. The number of taxa collected ranged from 14 at sites 4A and 7C to 21 at site 6A. The collected macroinvertebrate assemblages were dominated by pollution-tolerant taxa (i.e., with a SASS5 sensitivity score of less than seven) with only four taxa that are moderately tolerant to pollution (Hydracarina, Leptophlebiidae Tricorythidae and Aeshnidae).

Table 4-5 – SASS5 data for the current survey

Site	SASS5	# of Taxa	ASPT
Site 4A	63	14	4,5
SIte 4C	74	17	4,4
Site 6A	91	21	4,3
Site 7C	74	14	5,3
SIte 7D	81	15	5,4
Site 7F	52	15	3,5
ASPT = Average Score Per Taxon			

The SASS5 data obtained was used in the MIRAI (Thirion, 2008) to determine the Present Ecological State (PES, or Ecological Category) of the associated macroinvertebrate assemblage. The MIRAI provides a habitat-based cause-and-effect basis to interpret the deviation of the aquatic macroinvertebrate community from the reference condition. Results for the site-based MIRAI are shown in Table 4-6.

Based on the MIRAI, the ecological condition of the aquatic macroinvertebrate communities was predominantly *Largely Modified* (Ecological Category D; at all sites) whilst site 6A presented *Moderately Modified* (Ecological Category C). The modified states recorded were as a result of the change from reference conditions, especially within the flow metric and the overall low diversity (in comparison to the 36 expected taxa per site) present within the assessed systems. The relatively better condition at site 6A was attributed to the higher number of invertebrate diversity collected.

Table 4-6 – MIRAI data for the current survey

Site	Metric Group	% change from Reference	MIRAI Value	EC	Description
Site 4A	Flow	60	46.4	D	Largely Modified
	Habitat	49			
	Water Quality	54			
Site 4C	Flow	56	49.5	D	Largely Modified
	Habitat	48			
	Water Quality	48			
Site 6A	Flow	39	60.0	C	Moderately Modified
	Habitat	40			
	Water Quality	42			
Site 7C	Flow	60	49.7	D	Largely Modified
	Habitat	42			
	Water Quality	53			
Site 7D	Flow	64	43.0	D	Largely Modified
	Habitat	53			
	Water Quality	55			
Site 7F	Flow	51	43.5	D	Largely Modified
	Habitat	62			
	Water Quality	54			
EC = Ecological Category					

A crab species identified as *Potamonautes calcaratus* (Burrowing Freshwater Crab) was collected at sites 4A, 6A and 7C. Photographs are provided in Figure 4-3. Based on the IUCN, the conservation status of this species is categorised a *Least Concern* with a stable population trend (Cumberlidge, 2008).

Figure 4-3 – Photos of *Potamonautes calcaratus* (Burrowing Freshwater Crab) taken during the current survey

4.5. ICHTHYOFAUNA

The composition of fish communities is often altered by anthropogenic activities in the catchment. Changes in water quality, flows and habitat can result in the absence or addition of species, ultimately altering the biotic integrity of the system. Thus, fish can effectively give an indication into the degree of modification of the aquatic environment.

Fish sampling was undertaken by means of the electroshocking technique at each site. The collected fish specimens were identified in the field and released back into the river. A single species (*Enteromius anoplus* or Chubby Head Barb) was collected at sites 4A and 7D only. The absence of fish at the other assessed sites was likely due to the non-perennial nature of the watercourses and lack of sufficient flows to allow for connectivity with the mainstem Lakenvleispruit.

The Chubby Head Barb is common in the region and occurs in a wide variety of habitats from small streams to large rivers and lakes. Feeds on insects, zooplankton, seeds, algae and diatoms and preyed on by larger fishes and birds. Breeds among vegetation in summer when the water levels are high after (Bruton et al., 1982; Le Roux & Steyn, 1968; Skelton, 2001)

According to the IUCN Red List of Threatened Species (IUCN, 2023), this fish is categorized as Least Concern, however the population trend is unknown and identified threats include agriculture and aquaculture, Invasive and other problematic species, genes & diseases, pollution, climate change and severe weather (Woodford, 2017). A photograph of the collected specimen are provided in Figure 4-4.

Figure 4-4 - Photograph of *Enteromius anoplus* specimen

4.5.1. BIOTIC INTEGRITY BASED ON FISH COMMUNITIES

The Fish Response Assessment Index (FRAI) was applied to determine the ecological integrity of the fish community assemblages within the monitoring sites for the current study. The FRAI forms part of the River EcoStatus Monitoring Programme (REMP) which replaced the River Health Programme (RHP) in 2016 and is a component of the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) (Kleynhans, 2007).

The FRAI is based on a combination of fish species habitat preferences, as well as intolerance to habitat changes, and the present frequency of occurrence (FROC) of species compared to the reference FROC (Kleynhans, 2007), thus provides a cause-and-effect basis to interpret the deviation of the fish assemblage from the reference condition.

4.5.2. FISH HABITAT POTENTIAL ASSESSMENT

Fish habitat potential refers to the presence and abundance of suitable conditions for fish to inhabit, depending on the expected species' preferences for the particular river reach. The considered habitat metric groups are velocity-depth and cover – with five types of cover within each of the four velocity-depth classes (Table 4-7).

Table 4-7 - Fish habitat potential assessment metric groups

Slow-Deep	Slow-Shallow	Fast-Deep	Fast-Shallow
Overhanging veg.	Overhanging veg.	Overhanging veg.	Overhanging veg.
Undercut banks	Undercut banks	Undercut banks	Undercut banks
Substrate	Substrate	Substrate	Substrate
Aquatic veg.	Aquatic veg.	Aquatic veg.	Aquatic veg.
Water column	Water column	Water column	Water column

The sampled fish habitat potential was rated between 0 to 5 (1 = rare; 2 = sparse; 3 = common; 4 = abundant; 5 = very abundant) at each of the assessed sites (Figure 4-5) and these were considered in the determination of the expected frequency of occurrence (FROC) for each fish species.

The dominant fish habitat cover types were as follows:

- Substrate and water column within the slow deep and slow shallow velocity-depth classes at site 4A;
- Overhanging vegetation and undercut banks within the slow deep and slow shallow velocity-depth classes at site 4C;
- Overhanging vegetation and substrate within the slow deep and slow shallow velocity-depth classes at sites 6A and 7C;
- Substrate within the slow deep, slow shallow and fast shallow velocity-depth classes at site 7D; and
- Water column within the slow deep and slow shallow velocity-depth classes at site 7F.

Thus, the expected fish species were largely those with a preference for the available habitat types within each of the river reaches.

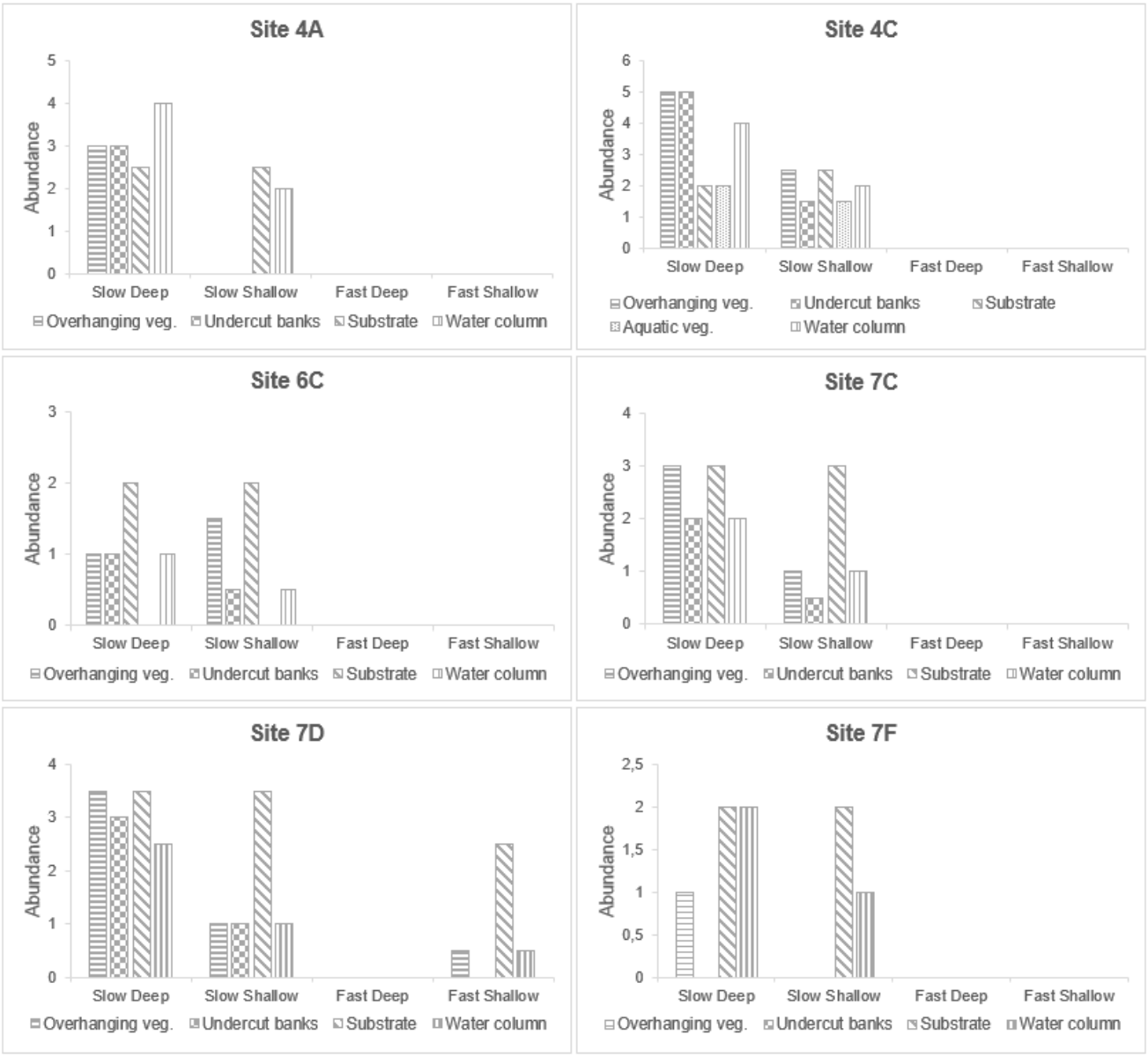

Figure 4-5 - Fish habitat metric group abundances per site

4.5.3. FISH RESPONSE ASSESSMENT INDEX (FRAI)

The FRAI Index is based on a combination of fish species habitat preferences as well as intolerance to habitat changes, and the present/observed frequency of occurrence (FROC) of species compared to the reference FROC (Kleynhans et al., 2007).

The FRAI-based Present Ecological State (PES) for the assessed river reaches is provided in (Table 4-8). Ratings for the FROC were based on the species habitat preferences.

Only a single out of the four expected species was recorded at sites 4A and 7D (with 11 and 4 individuals respectively), thus the diversity and abundance of fish within the project area was low. Consequently, all the other sites were *Critically Modified* whilst sites 4A and 7D were *Seriously Modified* and *Largely Modified* respectively based on the FRAI index. It should however be noted that

the project area is largely situated within the headwaters of the Lakensvleispruit catchment and some of the expected species may be migrating to these systems seasonally for spawning (Richardson, 2019). Therefore the absence of the other species at the time of the survey could have been influenced by their life history.

Table 4-8 – FRAI results for the assessed river reaches

Site	FRAI Score	Ecological Category	Description
Site 4A	37.9	**E**	Seriously Modified
SIte 4C	20.0	**E/F**	Critically Modified
Site 6A	20.0	**E/F**	Critically Modified
Site 7C	20.0	**E/F**	Critically Modified
SIte 7D	40.5	D	Largely Modified
Site 7F	20.0	**E/F**	Critically Modified

4.6. INTEGRATED ECOSTATUS DETERMINATION

The EcoStatus is defined as: "*The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services*" (Iversen *et al*., 2000). Thus the EcoStatus represents an integrated ecological state representing the drivers (hydro-morphology and physico-chemical) and responses (riparian vegetation, aquatic invertebrates and fish; Kleynhans & Louw, 2008). The integrated EcoStatus for the sampled sites are presented in Table 4-9.

Following integration of the defined ecological conditions obtained for the riparian component (i.e. IHI from riparian vegetation assessment) and the instream biological integrity (i.e. MIRAI from aquatic invertebrates and FRAI from fish), it was determined that sites 4A and 7D represented an integrated EcoStatus of *Moderately to Largely Modified* conditions whilst the rest of the sites represented *Largely Modified* conditions.

In relation to the Recommended Ecological Category (REC) of *Moderately Modified* (Ecological Category of C) (DWS, 2016a), all the sites indicated a Present Ecological State (PES) close to the REC except site 7F which indicated a slightly more deteriorated state.

Table 4-9 – Integrated EcoStatus categories for the current study – EcoStatus version 1.02 (Kleynhans and Louw, 2007)

River	Response Indices				EcoStatus	
	Riparian Vegetation EC (IHI)	MIRAI EC	FRAI EC	Instream EC	Score	Category
Site 4A	81.7	46.4	37.9	42.5	61.9	**C/D**
SIte 4C	81.7	49.5	20.0	36.1	58.7	**C/D**
Site 6A	76.5	60.0	20.0	41.9	59.0	**C/D**
Site 7C	80.5	49.7	20.0	36.2	58.1	**C/D**
SIte 7D	80.5	43.0	40.5	41.9	61.0	**C/D**
Site 7F	80.5	43.5	20.0	32.8	56.4	**D**

5. SITE SENSITIVITY VERIFICATION OUTCOME

The findings of the site sensitivity verification exercise, based on the data gathering activities conducted to date (review and consolidation of available desktop data, site sensitivity verification site visits), together with the anticipated reporting requirement as stipulated by the various protocols, are summarised below.

Table 5-1 – Site sensitivity verification

Theme	Screening tool sensitivity	Site-based sensitivity	Motivation
Aquatic biodiversity	Very high (see Figure 5-1)	Low	No sensitive species nor species of conservation concern (SCC) occur within the assessed aquatic ecosystems. The project area is dominated by wetland systems with low or no flow.

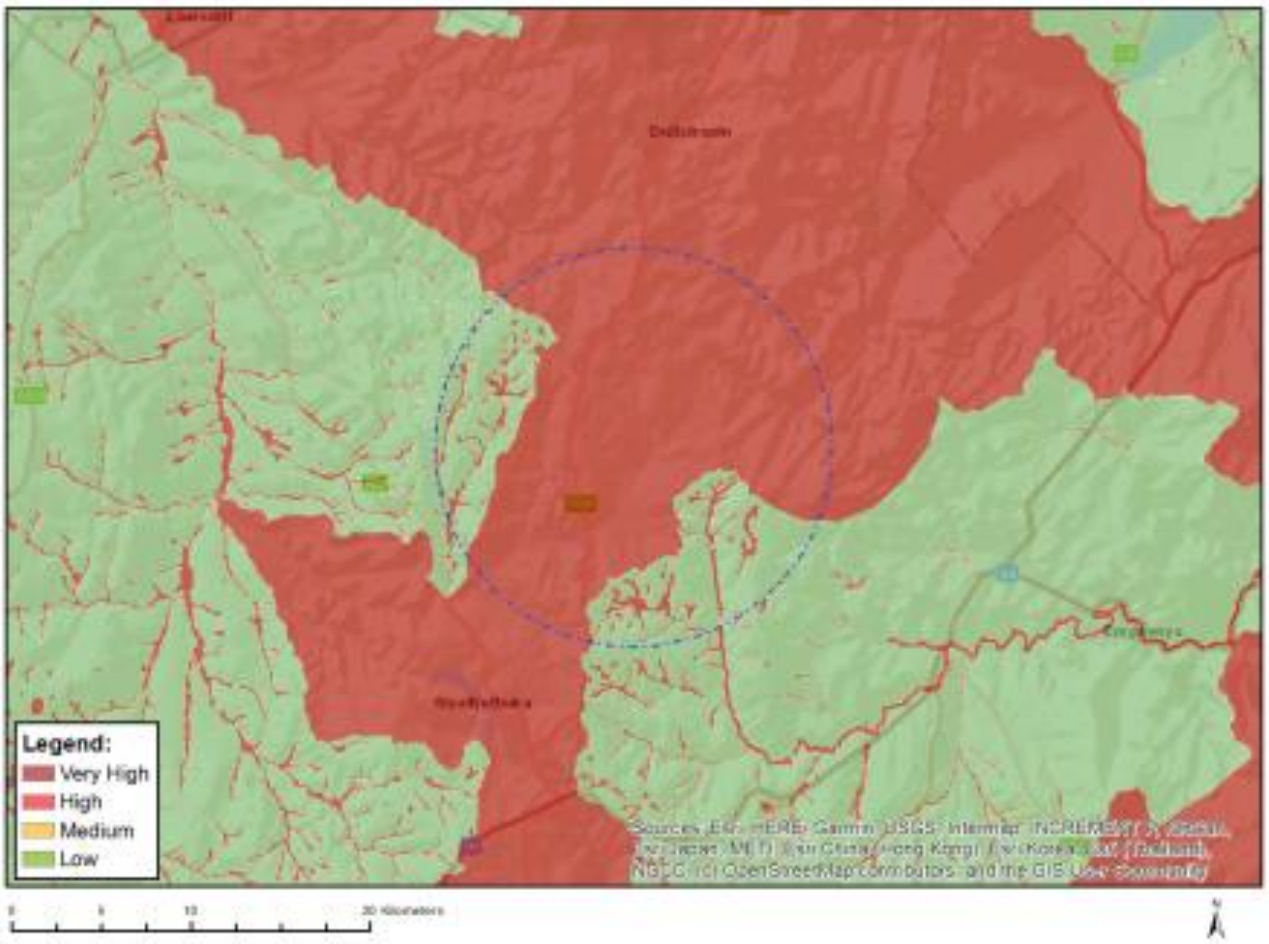

Figure 5-1 - Map of relative aquatic biodiversity theme sensitivity (DFFE Screening Tool)

6. IMPACT ASSESSMENT

This section identifies and assesses the significance of the impacts likely to arise during the proposed activities and provide a short description of the mitigation required to limit the magnitude of the potential impact on the aquatic biodiversity receptors.

The project activities relating to the proposed intervention structures which could potentially impact on the aquatic biodiversity receptors are indicated in Table 6-1 and were considered as part of the impact assessment.

Table 6-1 – Project activities per phase

Phase	Activity
Construction	▪ Bush clearing and soil disturbance (removal of alien vegetation, fencing) ▪ Development of required service infrastructure on the site ▪ Construction of project components (Dongalocks, concrete road crossing, dam wall)
Operational	▪ Maintenance of infrastructure (e.g. Dongalocks, concrete road crossing, dam wall) ▪ Vegetation management

6.1. CONSTRUCTION PHASE

The main foreseeable aquatic-related impacts associated with the construction phase are vegetation clearing, soil disturbance and the establishment of infrastructure. vegetation clearing and soil disturbances result in bare land which increase surface runoff, erosion and subsequently the amount of suspended and dissolved solids and potentially pollutants from the construction site and or areas down gradient of the construction site (hydrocarbons, fertilisers and domestic litter for example) entering the associated watercourses. Similarly, the main impact associated with the establishment of infrastructure is the generation of dust and pollutants reaching associated watercourses.

6.1.1. IMPACT DESCRIPTION

Erosion and runoff into the associated aquatic ecosystems can result in increased sedimentation and degradation of habitat. This can directly alter aquatic habitats after deposition (Wood & Armitage, 1997), which in turn will negatively impact biotic community structure by displacing biota that favour the affected habitat. Suspended solids can also directly impact aquatic biota through the accumulation of silt on respiratory organs (i.e. gills) and by decreasing visibility (i.e. increasing turbidity) which will affect feeding habits of specific taxa. Erosion and runoff from cleared land can also alter water quality by increasing turbidity, as aforementioned, and by increasing the number of contaminants entering the watercourses. This is expected to alter the physio-chemistry of water and deter water quality sensitive biota.

Vegetation clearing near watercourses can result in the introduction of alien invasive species (both fauna and flora) which often negatively impact indigenous species. This can lead to the loss of invertebrates such as dragonflies, which in turn, has the potential to alter biological community structure. Most alien invasive trees are taller and characterised a greater root depth and are

responsible for the increased uptake of water thereby decreasing both surface water runoff and groundwater recharge. This can significantly affect river flows.

6.1.2. MITIGATION MEASURES

The following impact mitigation and management measures are recommended to avoid/minimise potential impacts on the watercourse arising from the construction activities:

- Limit vegetation removal to the infrastructure footprint area only. Where removed or damaged, vegetation areas (riparian or aquatic related) should be revegetated as soon as possible;
- Bare land surfaces downstream of construction activities must be vegetated to limit erosion from the expected increase in surface runoff from infrastructure;
- Environmentally friendly barrier systems, such as silt nets or, in severe cases, use trenches downstream from construction sites to limit erosion and possibly trap contaminated runoff from construction;
- Water used at construction sites should be utilised in such a manner that it is kept on site and not allowed to run freely into nearby watercourses;
- Construction chemicals, such as cement and hydrocarbons should be used in an environmentally safe manner with correct storage as per each chemical's specific storage descriptions;
- All vehicles must be frequently inspected for leaks;
- No material may be dumped or stockpiled within any rivers or drainage lines in the vicinity of the proposed project;
- All waste must be removed and transported to appropriate waste facilities; and
- High rainfall periods (usually November to March) should be avoided during the construction phase to possibly avoid increased surface runoff in attempt to limit erosion and the entering of external material (i.e. contaminants and/or dissolved solids) into associated aquatic systems.

6.1.3. IMPACT ASSESSMENT

Impact assessment ratings for activities associated with the construction phase are presented per wetland cluster in Table 6-2.

Activities associated with the fencing of springs and the removal of alien vegetation will result in bare surfaces and the resulting potential impacts include water quality modifications, increased sediment load and loss of habitat, erosion, and increased flows. However due to the distance between these activities and the associated watercourses, the potential impacts posed were determined to range between very low and low pre-mitigation and very low post-mitigation.

The construction of a road crossings, the removal of the dam wall and construction of formalised dam spillways will likely result in water quality modifications, increased flows and sediment load within the receiving downstream reaches. Due to the small size of the dams, the impacts posed were determined to be low pre-mitigation and very low post-mitigation.

The installation of dongalocks will be done using hand tools, therefore do not pose any significant impacts toward the watercourse. Therefore potential impacts were determined to be very low pre-mitigation and very low post-mitigation.

These impacts are, expected to be significantly reduced by avoiding construction in the rainy season, and effective implementation of the recommended sediment and pollutant control mitigation measures.

Table 6-2 - Impact assessment ratings for the construction phase

Activity	Impacts	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
				Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating	Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating
Wetland Cluster 4																	
Fencing of springs	Increased sediment load and loss of habitat	Negative	Moderate	1	1	1	2	2	**10**	**N1**	1	1	1	1	1	**4**	**N1**
			Significance	**N1 - Very Low**							**N1 - Very Low**						
Removal of dam wall	River water quality modifications; Increased sediment load and loss of habitat; Erosion; increased flows	Negative	Moderate	2	1	1	2	5	**30**	**N2**	1	1	1	1	1	**4**	**N1**
			Significance	**N2 - Low**							**N1 - Very Low**						
Removal of alien vegetation	River water quality modifications; Increased sediment load and loss of habitat; Erosion; increased flows due to bare surfaces following vegetation removal	Negative	Moderate	3	1	1	2	4	**28**	**N2**	1	1	1	1	2	**8**	**N1**
			Significance	**N2 - Low**							**N1 - Very Low**						
Improve road crossing	River water quality modifications; Increased sediment load and loss of	Negative	Moderate	2	1	1	2	5	**30**	**N2**	1	1	1	1	1	**4**	**N1**

Activity	Impacts	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
				Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating	Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating
	habitat; Erosion; increased flows																
			Significance	**N2 - Low**							**N1 - Very Low**						
Wetland Cluster 6																	
Installation of dongalocks	Vegetation disturbance; Erosion; Water quality modifications	Negative	Moderate	1	2	1	2	2	**12**	**N1**	1	1	1	1	1	**4**	**N1**
			Significance	**N1 - Very Low**							**N1 - Very Low**						
Improve road crossing	River water quality modifications; Increased sediment load and loss of habitat; Erosion; increased flows	Negative	Moderate	2	1	1	2	5	**30**	**N2**	1	1	1	1	1	**4**	**N1**
			Significance	**N2 - Low**							**N1 - Very Low**						
Stabilise dam spillway	River water quality modifications; Increased sediment load and loss of habitat; Erosion; increased flows	Negative	Moderate	2	1	1	2	3	**18**	**N2**	1	1	1	1	1	**4**	**N1**
			Significance	**N2 - Low**							**N1 - Very Low**						
Removal of alien vegetation	River water quality modifications; Increased sediment load and loss of habitat; Erosion;	Negative	Moderate	3	1	1	2	4	**28**	**N2**	1	1	1	1	2	**8**	**N1**

Activity	Impacts	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
				Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating	Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating
	increased flows due to bare surfaces following the removal f veg																
			Significance	**N2 - Low**							**N1 - Very Low**						
Fencing of springs	Increased sediment load and loss of habitat	Negative	Moderate	1	1	1	2	2	**10**	**N1**	1	1	1	1	1	**4**	**N1**
			Significance	**N1 - Very Low**							**N1 - Very Low**						
Wetland Cluster 7																	
Installation of dongalocks	Vegetation disturbance; Erosion; Water quality modifications	Negative	Moderate	1	2	1	2	2	**12**	**N1**	1	1	1	1	1	**4**	**N1**
			Significance	**N1 - Very Low**							**N1 - Very Low**						
Stabilise dam spillway	River water quality modifications; Increased sediment load and loss of habitat; Erosion; increased flows	Negative	Moderate	2	1	1	2	3	**18**	**N2**	1	1	1	1	1	**4**	**N1**
			Significance	**N2 - Low**							**N1 - Very Low**						
Improve road crossing	River water quality modifications; Increased sediment load and loss of habitat; Erosion; increased flows	Negative	Moderate	2	1	1	2	5	**30**	**N2**	1	1	1	1	1	**4**	**N1**

Activity	Impacts	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
				Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating	Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating
			Significance	**N2 - Low**							**N1 - Very Low**						
Removal of alien vegetation	River water quality modifications; Increased sediment load and loss of habitat; Erosion; increased flows due to bare surfaces following the removal of veg.	Negative	Moderate	3	1	1	2	4	**28**	**N2**	1	1	1	1	2	**8**	**N1**
			Significance	**N2 - Low**							**N1 - Very Low**						

6.2. OPERATIONAL PHASE

The operational phase entails the functioning of the structures that will aid in the rehabilitation of the wetlands, mainly through preventing erosion of the aquatic ecosystems.

6.2.1. IMPACT DESCRIPTION

The installed intervention structures such as fences around springs, improved road crossings, improved dam spillways; the removal of some of the dams and alien vegetation management will result in improved hydrology and water chemistry within the receiving watercourses.

6.2.2. IMPACT ASSESSMENT

Impact assessment ratings for activities associated with the operational phase are presented in Table 6-3.

Table 6-3 - Impact assessment ratings for the operational phase

Intervention	Impact	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
				Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating	Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating
Wetland Cluster 4																	
Fenced springs	Increased flows; improve water quality	Positive		3	3	3	4	5	**65**	**P4**	3	3	3	4	5	**65**	**P4**
			Significance	**P4 - High**							**P4 - High**						
Removed dam wall	Increased flows; improve water quality	Positive		4	3	3	5	5	**75**	**P4**	4	3	3	5	5	**75**	**P4**
			Significance	**P4 - High**							**P4 - High**						
Alien vegetation management	Increased flows	Positive		3	3	3	4	5	**65**	**P4**	3	3	3	4	5	**65**	**P4**
			Significance	**P4 - High**							**P4 - High**						
Improved road crossing	Increased flows	Positive		4	3	3	5	5	**75**	**P4**	4	3	3	5	5	**75**	**P4**
			Significance	**P4 - High**							**P4 - High**						
Wetland Cluster 6																	
Improved road crossing	Increased flows	Positive		4	3	3	5	5	**75**	**P4**	4	3	3	5	5	**75**	**P4**
			Significance	**P4 - High**							**P4 - High**						
Stabilised dam spillway	Increased flows	Positive		3	3	3	5	5	**70**	**P4**	3	3	3	5	5	**70**	**P4**
			Significance	**P4 - High**							**P4 - High**						
Alien vegetation management	Increased flows	Positive		3	3	3	4	5	**65**	**P4**	3	3	3	4	5	**65**	**P4**

Intervention	Impact	Character	Ease of Mitigation	Pre-Mitigation							Post-Mitigation						
				Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating	Magnitude	Extent	Reversibility	Duration	Probability	Significance	Rating
			Significance	**P4 - High**							**P4 - High**						
Fenced springs	Increased flows; improve water quality	Positive		3	3	3	4	5	**65**	**P4**	3	3	3	4	5	**65**	**P4**
			Significance	**P4 - High**							**P4 - High**						
Wetland Cluster 7																	
Stabilised dam spillway	Increased flows	Positive		3	3	3	5	5	**70**	**P4**	3	3	3	5	5	**70**	**P4**
			Significance	**P4 - High**							**P4 - High**						
Improved road crossing	Increased flows	Positive		4	3	3	5	5	**75**	**P4**	4	3	3	5	5	**75**	**P4**
			Significance	**P4 - High**							**P4 - High**						
Alien vegetation management	Increased flows	Positive		3	3	3	4	5	**65**	**P4**	3	3	3	4	5	**65**	**P4**
			Significance	**P4 - High**							**P4 - High**						

7. CUMULATIVE IMPACTS

The study area was declared a Protected Environment, in terms of sections 28(1)(a)(i) and (b) of NEM:PAA, by MEC, Mr. Vusi Shongwe, of the Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) on 7 April 2017.

The Greater Lakenvlei Protected Environment (GLPE) area comprises 9365 ha and is considered an extremely important bird habitat. This area is therefore maintained as a natural environment with land use activities being limited to agriculture. Consequently, major impacts within the study area are water quality modification, increased sedimentation and invasive species encroachment.

7.1. MONITORING PROGRAMME

An aquatic biomonitoring programme has been developed for the monitoring and preservation of the aquatic ecosystems assessed for the Project. The programme is aimed at better determining the ecological health of the ecosystems, provide long term trends in ecosystem integrity as well as aid in early detection of potential impacts that might severely affect the expected aquatic biota in the associated riverine systems.

Table 7-1 outlines the aquatic monitoring methods to be undertaken at the monitoring points set out above (see section 2.2) on a biannual basis by a suitably qualified aquatic ecologist. The annual programme comprises of a single survey during the dry season (or low flow season) for the Project Area and a single survey during the wet season (or high flow) at the monitoring points indicated. This will determine the PES for the assessed aquatic ecosystems which will further determine whether the proposed Project is impacting the associated aquatic ecology and to what extent.

Table 7-1 – Proposed aquatic biomonitoring programme

Method and Aquatic Component of Focus	Details	Goal/Target	REC
Water Quality: *In situ* water testing focusing on temperature, pH, conductivity and oxygen content.	Water quality should be tested on a biannual basis at each monitoring site to determine the extent of change from baseline results.	No noticeable change from determined baseline (current report) water quality for each respective season.	Salt concentrations must be at levels that do not threaten the ecosystem and are suitable for users. The river water should not be toxic to aquatic organisms or be a threat to human health.
Habitat Quality: Instream and riparian habitat integrity; and Availability/suitability of macroinvertebrate habitat at each monitoring site.	The application of the IHI should be done for the associated watercourses; The IHAS must be applied at each monitoring site prior to sampling.	The Ecological Category determined for each assessed site must be improved for the watercourses under study); and The baseline IHAS scores should improve.	Must be in a Moderately Modified or better condition ≥ C (≥ 42)
Aquatic Macroinvertebrates:	This must be done through the application of the latest SASS protocol,	The baseline SASS5 scores should not	MIRAI score must be in a Moderately

Method and Aquatic Component of Focus	Details	Goal/Target	REC
Aquatic Macroinvertebrate assemblages must be assessed biannually.	incorporated with the application of the MIRAI as outlined in this Aquatic Study.	noticeably deteriorate; and Baseline Ecological Categories should not be allowed to drop in category for each assessed site.	Modified or better condition ≥ C (≥ 60)
Fish: Fish assemblages must be assessed biannually	Sampling of fish must be undertaken by utilising the electro-narcosis technique at sites presenting suitable fish habitat.	Baseline Ecological Categories should not be allowed to drop in category for each assessed site. The main goal for the Project must be to conserve the expected sensitive species.	FRAI score must be in a Moderately Modified or better condition ≥ C (≥ 60)
REC = Recommended Ecological Category			

8. CONCLUSION

The proposed project location, the Greater Lakenvlei Protected Environment (GLPE)) is dominated by wetland habitat, however riverine habitat occur within incised systems representing channelled valley bottom wetlands. Within these riverine habitats thrives aquatic biota, particularly macroinvertebrates and fish as shown in the current study. The following key findings are highlighted as part of the aquatic biodiversity and impact assessment study:

The current study focused on the wetland clusters observed to consist of riverine habitat with a potential to host aquatic biota, as such three of the seven wetland clusters (clusters 4, 6 and 7) were assessed. The six assessed sites were characterised by stream flow ranging from slow to moderate velocity, shallow to moderately deep and narrow (less than a meter) to wide (over two meters) stream width. The diversity of stream bed substrates was well represented and included mud, gravel and cobbles.

A total of 34 aquatic macroinvertebrate taxa were collected from the six sites, 20 at the two Cluster 4 sites; 21 at the single Cluster 6 site; and 26 at the three Cluster 7 sites. As expected, the macroinvertebrate assemblages were dominated by none-sensitive taxa and there was no species of conservation concern (SCC). The macroinvertebrate based ecological condition was *Largely Modified* throughout the sites except at site 6A (in Cluster 6) which recorded the highest diversity and subsequently presented a *Moderately Modified* ecological condition.

Only a single out of the four expected fish species was recorded at sites 4A and 7D (with 11 and 4 individuals respectively), thus the diversity and abundance of fish within the project area was low. Consequently, the fish based ecological condition indicated *Critically Modified* condition at all the other sites whilst sites 4A and 7D were *Seriously Modified* and *Largely Modified* respectively.

The integrated EcoStatus for the sampled sites were determined to be *Moderately to Largely Modified* except at site 7F which represented a *Largely Modified* EcoStatus. The slightly more deteriorated state at site 7F was largely attributed to the instream ecological condition represented by the

macroinvertebrate and fish results. In relation to the Recommended Ecological Category (REC) of *Moderately Modified* (Ecological Category of C) (DWS, 2016a), all the sites indicated a Present Ecological State (PES) close to the REC whilst site 7F indicated a slightly more deteriorated state.

8.1. REASONED OPINION WHETHER PROJECT SHOULD PROCEED

Based on the findings of the current aquatic biodiversity and impact assessment study, no sensitive species nor species of conservation concern (SCC) occur within the assessed aquatic ecosystems. Potential negative impacts during the construction phase can be significantly reduced through the implementation of the proposed mitigation measures. Therefore, from an aquatic biodiversity perspective the project is not fatally flawed and can be considered for environmental authorisation, especially in light of the anticipated positive impacts during the operational phase.

8.2. RECOMMENDATIONS

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

- The developed Aquatic Biomonitoring Programme must be adopted on a biannual basis. This programme should continue for at least two years following the completion of the Construction Phase.
- The proposed Project should adopt a water and habitat quality preservation mindset throughout the life of the Project to prevent the deterioration of the said aquatic ecosystems.

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Appendix A

METHODOLOGY

<table>
<tr><th>Methodology</th><th>Measurement description</th><th colspan="3">Guidelines/Description</th></tr>
<tr><td rowspan="5">In Situ Water Quality</td><td rowspan="5">Determined using portable field instruments:
pH: Eutech pHTester2;
Electrical Conductivity: Eutech ECTester11 Dual Range;
Dissolved oxygen: Eutech CyberScan DO300; and
Temperature: Eutech CyberScan DO300.</td><td>In situ water variable</td><td>Guideline</td><td>Guideline referenced</td></tr>
<tr><td>Temperature (ºC)</td><td>5 - 30</td><td rowspan="3">South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) (Department Of Water Affairs And Forestry, 1996)</td></tr>
<tr><td>pH</td><td>6 - 8</td></tr>
<tr><td>Dissolved Oxygen Saturation (%)</td><td>80 – 120</td></tr>
<tr><td>Dissolved Oxygen concentration (mg/ℓ)</td><td>>5</td><td>Minimum Dissolved Oxygen concentration for aquatic macroinvertebrates (Nebeker et al., 1996)</td></tr>
<tr><td>Electrical Conductivity (µS/m)</td><td>< 500</td><td>Conductivity guideline value of 500 µS/cm stipulated in U.S. U.S. Environmental Protection Agency (2010)</td></tr>
<tr><td>Habitat Assessment</td><td colspan="4">Habitat assessment can be defined as the evaluation of the structure, of the surrounding physical habitat, that influences the quality of the water resource, and the condition of the resident aquatic community (Barbour et al., 1999).
Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason, habitat evaluation is conducted simultaneously with biological evaluations in order to facilitate the interpretation of results.</td></tr>
</table>

<table>
<tr><th>Methodology</th><th>Measurement description</th><th colspan="4">Guidelines/Description</th></tr>
<tr><td>Integrated Habitat Assessment System (IHAS)</td><td colspan="2">The quality of the instream and riparian habitat influences the structure and function of the aquatic community in a stream; therefore, assessment of the habitat is critical to any assessment of ecological integrity. The IHAS, Version 2 was developed specifically for use with the SASS5 index and rapid biological assessment protocols in South Africa (McMillan, 1998).</td><td colspan="2"><table><tr><th>IHAS</th><th>Description</th></tr><tr><td>>65%</td><td>Good</td></tr><tr><td>55% – 65%</td><td>Adequate/Fair</td></tr><tr><td><55%</td><td>Poor</td></tr></table></td></tr>
<tr><td rowspan="3">Intermediate Habitat Integrity Assessment</td><td colspan="2" rowspan="2">Habitat integrity refers to the maintenance of a balanced, integrated composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996).</td><td colspan="2">Descriptive classes for the assessment of modifications to habitat integrity (Kleynhans, 1996).<table><tr><th>Score</th><th>Impact Category</th><th>Description</th></tr><tr><td>0</td><td>None</td><td>No discernible impact, or the factor is located in such a way that it has no impact on habitat quality diversity, size and variability.</td></tr><tr><td>1 – 5</td><td>Small</td><td>The modification is limited to a very few localities and the impact on habitat quality, diversity, size and variability is also very small.</td></tr><tr><td>6 – 10</td><td>Moderate</td><td>The modification is present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.</td></tr><tr><td>11 – 15</td><td>Large</td><td>The modification is generally present with a clearly detrimental impact on quality habitat quality, diversity, size and variability. Large areas are, however, not influenced.</td></tr><tr><td>16 – 20</td><td>Serious</td><td>The modification is frequently present and the habitat quality, diversity, size and variability almost the whole of the defined section are affected. Only small areas are not influenced.</td></tr><tr><td>21 – 25</td><td>Critical</td><td>The modification is present overall with a high intensity; the habitat quality, diversity, size and variability in almost the whole of the defined section are detrimentally influenced.</td></tr></table></td></tr>
<tr><td colspan="3">Intermediate habitat integrity assessment classes/categories (Kleynhans, 1996)<table><tr><th>Score</th><th>Class (% of total)</th><th>Description</th></tr><tr><td>90 - 100</td><td>A</td><td>Unmodified, natural.</td></tr><tr><td>80 - 90</td><td>B</td><td>Largely natural with few modifications.</td></tr></table></td></tr>
</table>

Methodology	Measurement description		Guidelines/Description		
	60 - 79	C	Moderately modified.		
	40 - 59	D	Largely modified.		
	20 - 39	E	The loss of natural habitat, biota and basic ecosystem functions is extensive.		
	0 - 19	F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota.		
Aquatic Macroinvertebrates	Aquatic macroinvertebrates were sampled using the qualitative kick sampling method called South African Scoring System (SASS, *version 5*) (Dickens & Graham, 2002)and identified using the hand guide from Gerber & Gabriel (2002). The SASS5 data obtained was used in the Macroinvertebrate Response Assessment Index (MIRAI) (Thirion, 2008) to determine the Present Ecological State (PES, or Ecological Category) of the associated macroinvertebrate assemblages.		**MIRAI Score**	**Class**	**Description**
			90-100	A	Unmodified and natural. Community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
			80-89	B	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
			60-79	C	Moderately modified. Community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
			40-59	D	Largely modified. Fewer species present then expected due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
			20-39	E	Seriously modified. Few species present due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
			0-19	F	Critically modified. Few species present. Only tolerant species present, if any.

Methodology	Measurement description	Guidelines/Description		
		FRAI Score (%)	Class	Description of generally expected conditions for integrity classes
Ichthyofauna	Fish samples were collected using an electro-fishing device (Smith-Root LR24). Based on a survey of available literature and previous assessments, an expected species list was compiled, utilising the following sources: Skelton (2001), (Kleynhans et al., 2007) and IUCN. The PES or Ecological Category of the fish assemblage of the watercourses associated with the Project Area was conducted by means of the Fish Response Assessment Index (FRAI) (Kleynhans, 2008)	90 – 100	A	Unmodified, or approximate natural conditions closely.
		80 – 89	B	Largely natural with few modifications.
		60 – 79	C	Moderately modified. A lower than expected species richness and presence of most intolerant species.
		40 – 59	D	Largely modified. A clearly lower than expected species richness and presence of most intolerant species.
		21 – 39	E	Seriously modified. A strikingly lower than expected species richness and general absence of intolerant and moderately intolerant species.
		0 – 20	F	Critically modified. Extremely lowered species richness and an absence of intolerant and moderately intolerant species.

Appendix B

SITE PHOTOGRAPHS

Upstream View	Downstream View
Site 4A	
	
Site 4C	
	
Site 6A	
	
Site 7C	

Upstream View	Downstream View
	
Site 7D	
	
Site 7F	
	

Appendix C

AQUATIC MACROINVERTEBRATES DATA

Taxon	Sensitivity	Site 4A	SIte 4C	Site 6A	Site 7C	SIte 7D	Site 7F
Porifera (Sponge)	5					1	
COELENTERATA (Cnidaria)	1						
Turbellaria (Flatworms)	3			1		A	
ANNELIDA							
Oligochaeta (Earthworms)	1	A	A	A	A		A
Hirudinea (Leeches)	3						
CRUSTACEA							
Amphipoda	13						
Potamonautidae* (Crabs)	3	A		A	A		
Atyidae (Freshwater Shrimps)	8						
Palaemonidae (Prawns)	1						
HYDRACARINA (water mites)	8		A				
PLECOPTERA (Stoneflies)							
Notonemouridae	14						
Perlidae	12						
EPHEMEROPTERA (Mayflies)							
Baetidae 1sp	4						
Baetidae 2sp	6	B	A	B			
Baetidae >2sp	12				A	A	
Caenidae (Squaregills/Cainfles)	6	A	B			A	
Ephemeridae	15						
Heptageniidae (Flatheaded mayflies)	13						
Leptophlebiidae (Prongills)	9	A			B	B	
Oligonueuridae (Brushlegged mayflies)	15						
Polymitarcydae (Pale burrowers)	1						
Prosopistomatidae (Water specs)	15						
Teloganodidae SWC	12						
Tricorythidae (Stout Crawlers)	9			B			
ODONATA (Dragonflies & Damselflies)							
Calopterygidae ST,T	1						
Chlorocyphidae (Jewels)	1						
Synlestidae (Chlorolestidae)(Sylphs)	8						
Coenagrionidae (Sprites and blues)	4	B	A	A	A	A	
Lestidae (Emerald Damselflies / Spreadwings)	8						
Platycnemidae (Brook Damselflies)	1						
Protoneuridae	8						
Aeshnidae (Hawkers and Emperors)	8		A	1	A	A	
Corduliidae (Cruisers)	8						
Gomphidae (Clubtails)	6						
Libellulidae (Darters/Skimmers)	4		A				1
Lepidoptera (aquatic caterpillars/moths)							
(Crambidae (=Pyralidae)	12						
HEMIPTERA (Bugs)							
Belostomatidae* (Giant water bugs)	3						
Corixidae* (Water boatmen)	3	B	A	B	B	B	B
Gerridae* (Pond skaters/Water striders)	5			A			1

Taxon	Sensitivity	Site 4A	Site 4C	Site 6A	Site 7C	Site 7D	Site 7F
Hydrometridae* (Water measurers)	6						
Naucoridae* (Creeping water bugs)	7						
Nepidae* (Water scorpions)	3			1			A
Notonectidae*(Backswimmer)	3			A	A	1	1
Pleidae* (Pygmy backswimmers)	4		1				A
Veliidae/M...veliidae* (Ripple bugs)	5			A			
Megaloptera (fishflies, dobsonflies, alderflies)							
Corydalidae (fishflies & dobsonflies)	8						
Sialidae (alderflies)	6						
TRICHOPTERA (Caddisflies)							
Dipsodopsidae	1						
Ecnomidae	8						
Hydropsychidae 1 sp	4			A			
Hydropsychidae 2 sp	6				A	A	
Hydropsychidae >2 sp	12						
Philopotamidae	1						
Polycentropodidae	12						
Psychomyiidae	8						
Cased caddis:							
Barbarochthonidae SWC	13						
Calamoceratidae ST	11						
Glossosomatidae SWC	11						
Hydroptilidae	6						
Hydrosalpingidae SWC	15						
Lepidostomatidae	1						
Leptoceridae	6	1	A	1			
Petrothrincidae SWC	11						
Pisuliidae	1						
Sericostomatidae SWC	13						
COLEOPTERA (Beetles)							
Dytiscidae/Noteridae* (Diving beetles)	5			1			A
Elmidae / Dryopidae* (Riffle beetles)	8						
Gyrinidae* (Whirligig beetles)	5	A	A	1	A	A	A
Haliplidae (crawling water beetles)	5						
Helodidae (Marsh beetles)	12						
Hyraenidae (minute moss beetles)	8						
Hydrophilidae* (Water scavenger beetles)	5	1			A		1
Limnichidae	1						
Psephenidae SWC	13						
DIPTERA (Flies)							
Athrecidae	1						
Blephariceridae (Mountain midges)	15						
Ceratopogonidae (Biting midges)	5	A	1	A	A	1	A
Chironomidae (Midges)	2	A	A	A		1	A
Culicidae* (Mosquitoes)	1		1	1			A
Dixidae (Dixid midge)	1						
Empididae (Dance flies)	6						

Taxon	Sensitivity	Site 4A	SIte 4C	Site 6A	Site 7C	SIte 7D	Site 7F
Ephydridae (Shore flies)	3						
Muscidae (House flies)	1						
Psychodidae (Moth flies)	1						
Simuliidae (Blackflies)	5	B	A	B	B	B	
Syrphidae (Rat tailed maggots)	1						
Tabanidae (Horse flies)	5						
Tipulidae (Crane flies)	5			1	A	A	
GASTROPODA (Snails)							
Ancylidae (Limpets)	6						
Bulininae	3		B				
Hydrobiidae	3						
Lymnaeidae* (Pond snails)	3						
Physidae* (Pouch snails)	3	A	A				A
Planorbinae* (Orb snails)	3						1
Thiaridae (=Melanidae)	3						
Viviparidae ST	5						
PELECYPODA (Bivalvles)							
Corbiculidae (Clams)	5						
Sphaeriidae (Pill clams)	3						
Unionidae (Perly mussels)	6						
SASS		63	74	91	74	81	52
Number of Taxa		14	17	21	14	15	15
ASPT		4.5	4.4	4.3	5.3	5.4	3.5

Appendix D

DOCUMENT LIMITATIONS

Building 1, Maxwell Office Park
Magwa Crescent West, Waterfall City
Midrand, 1685
South Africa

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