
# DETERMINATION OF WATER RESOURCE CLASSES, RESERVE AND RESOURCE QUALITY OBJECTIVES STUDY FOR SECONDARY CATCHMENTS A5 – A9 WITHIN THE LIMPOPO WATER MANAGEMENT AREA (WMA 1) AND SECONDARY CATCHMENT B9 IN THE OLIFANTS WATER MANAGEMENT AREA (WMA 2)

## EWR REPORT: RIVER ASSESSMENT

## VOLUME 1 – ECOCATEGORISATION REPORT

## FINAL

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Cover page photo credit: View of the Luvuvhu River, Makuleke area. Photo from Lee Berger's Lanner Gorge expedition. 29 July 2007. Author Profberger at English Wikipedia.

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Date

## DOCUMENT INDEX

Reports that will be produced as part of this project are indicated below.

**The bold** type indicates this report.

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| 02 | WEM/WMA01&02/00/CON/RDM/0222 | Water Resources Information Gap Analysis Report |
| 03 | WEM/WMA01&02/00/CON/RDM/0322 | Delineation and Status Quo Report |
| 04 | WEM/WMA01&02/00/CON/RDM/0422 | Linking the value and condition of the Water Resources Report |
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| 17 | WEM/WMA01&02/00/CON/RDM/0625 | Project Close-Out Report |

## TERMINOLOGY AND ABBREVIATIONS

| ACRONYMS | DESCRIPTION |
|---|---|
| AEC | Alternate Ecological Category |
| ASPT | Average Score per Taxon |
| CD: RDM | Chief Directorate: Resource Directed Measures |
| DWAF | Department of Water Affairs and Forestry |
| DWS | Department of Water and Sanitation |
| EIS | Ecological Importance and Sensitivity |
| EWR | Ecological Water Requirements |
| GSM | Gravel Sand Mud |
| INVERTS | Invertebrates |
| IUA | Integrated Unit of Analysis |
| KNP | Kruger National Park |
| N/A | Not Applicable |
| PES | Present Ecological Status |
| REC | Recommended Ecological Category |
| RQIS | Resource Quality Information Services |
| SASS | South African Scoring System |
| SEZ | Special Economic Zone |
| SA | South Africa |
| SnA | Southern Africa |
| VEG | Vegetation |
| WMS | Water Monitoring System |

# EXECUTIVE SUMMARY

## Background

The Department of Water and Sanitation (DWS), Chief Directorate (CD): Water Ecosystems Management (WEM) initiated a three-year study, extended to a fourth year, to Determine Water Resource Classes, the Ecological Reserve and Resource Quality Objectives for Secondary Catchments A5-A9 in the Limpopo Water Management Area (WMA 1) and Secondary Catchment B9 in the Olifants Water Management Area (WMA 2). This project aligns with the Department's mandate to protect water resources as stipulated in Chapter 3 of the National Water Act.

## Objective of the EcoCategorisation Report

This report covers the EcoCategorisation work needed to determine the Ecological Reserve for rivers. It is one of three volumes describing activities and results of work required to determine EWRs for the rivers.

EcoCategorisation aimed to determine the Present Ecological Status of each river site. These were the Present Ecological State conditions that each team member selected after data was collected on the high and low-flow survey data collection trips. The river components assessed were water quality, geomorphology, riparian vegetation, aquatic macroinvertebrates and fish.

## Study Area and EWR Sites

The study area comprises secondary catchments A5 (Lephalale), A6 (Mogalakwena), A7 (Sand), A8 (Nzhelele), A9 (Luvuvhu) in the Limpopo Water Management Area (WMA 1), and Secondary Catchment B9 (Shingwedzi) in the Olifants Water Management Area (WMA 2). These rivers were delineated into Integrated Units of Analysis (IUA), the process of which is described in the Delineation and Status Quo Report.

There were 19 Intermediate EWR sites across the study area; 14 are the focus of work done in this project, and the other five sites are from another project where work was done by the IWMI (International Water Management Institute) for LIMCOM (Limpopo Commission) (Table 1). The distribution of the EWR sites, including the IWMI sites, across the study area is provided in Figure 1.

The five IWMI sites were included in this project because of their strategic importance but also because the E-Flow work was recently completed and so could easily be incorporated into this study to boost the coverage of detailed information gathering and assessment, as well as providing the data needed for the Classification process.

**Table 1. Intermediate EWR Sites (14 DWS and 5 IWMI*)**

| DWS Nodes | IUA | IWMI site code | DWS EWR site code | River | Quaternary Catchment |
|---|---|---|---|---|---|
| Riv11 | Upper Lephalala | | 1_Lephalala | Lephalala | A50B |
| | *Lower Lephalala | LEPH-A50H-SEEKO | | Lephalala | A50H |
| Rvi1 | Kalkpan se Loop | | 2_Rietfontein | Kalkpan se Loop | A63C |
| Ri1 | Upper Nyl/Sterk | | 3_Olifantspruit | Olifantspruit | A61B |
| Ri5 | Upper Nyl/Sterk | | 4_Mogalakwena1 | Mogalakwena | A62B |
| Ri14 | Mogalakwena | | 5_Mogalakwena2 | Mogalakwena | A63A |
| | *Mogalakwena | MOGA-A63D-LIMPK | | Mogalakwena | A63D |
| Riv32 | Mapungubwe | | 6_Kolope | Kolope | A63E |
| Ri20 | Upper Sand | | 7_Sand | Sand | A71D |
| | Lower Sand | SAND-A71K-R508B | | Sand | A71K |
| Ri27 | Nzhelele /Ṅwaneḍi | | 8_Nzhelele | Nzhelele | A80G |
| Ri28 | Nzhelele /Ṅwaneḍi | | 9_Ṅwaneḍi | Ṅwaneḍi | A80J |
| Riii6 | Upper Luvuvhu | | 10_Latonyanda | Latonyanda | A91D |
| Ri30 | Upper Luvuvhu | | 11_Mutshindudi | Mutshindudi | A91G |
| Ri32 | Upper Luvuvhu | | 12_Luvuvhu | Luvuvhu | A91H |
| | *Lower Luvuvhu/ Mutale | LUVU-A91K-OUTPO | | Luvuvhu | A91K |
| Ri33 | Lower Luvuvhu/ Mutale | | 13_Mutale1 | Mutale | A92B |
| Ri34 | Lower Luvuvhu/ Mutale | | 14_Mutale2 | Mutale | A92D |
| | *Lower Luvuvhu/ Mutale | LUVU-A91K-OUTPO | | Luvuvhu | A91K |
| | *Shingwedzi | SHIN-B90H-POACH | | Shingwedzi | B90H |

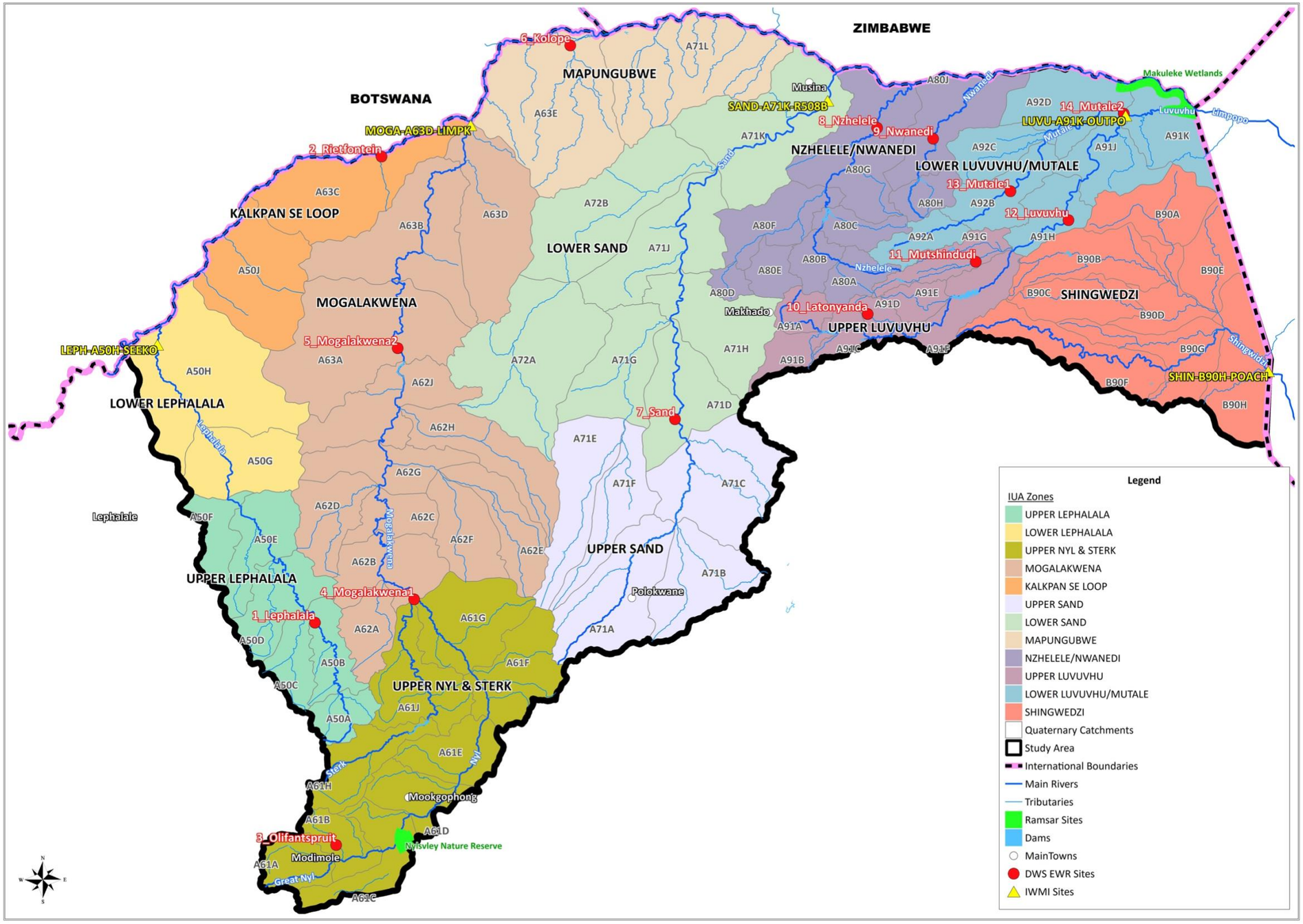


**Figure 1. EWR Sites distributed across the study area**

### Approach

The theory of, approach to, and methods used to classify the ecological condition of rivers are described in a series of DWS EcoStatus manuals published in 2007.

The EcoCategorisation process aims to gain insights and understanding into the causes and sources of the deviation of the Present Ecological State (PES) of each attribute from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river. (Kleynhans and Louw (2007).

The steps followed in the EcoCategorisation process, extracted from Kleynhans and Louw (2007), are:

- Determine the reference conditions for each component.
- Determine the PES for each component and the EcoStatus. The EcoStatus refers to integrating individual components toward the overall condition of the site.
- Determine each component's trend (i.e., moving toward or away from the reference condition) and the EcoStatus.
- Determine the cause for the PES and whether these are flow or non-flow related.
- Determine the biota and habitat's Ecological Importance (EI) and Ecological Sensitivity (ES).
- Considering the PES and the EIS, suggest a realistic and practically attainable Recommended Ecological Category (REC) for each component and the EcoStatus[1].

The EcoCategorisation of the river state is based on Table 2 below (Kleynhans, 2008), which can be used for all response variables.

**Table 2. Generic Ecological Categories (EC) for Ecological Integrity Categories (modified from Kleynhans 1996)**

| Ecological Category | Description of Ecological Conditions | % of Change from Natural |
|---|---|---|
| A | Unmodified/natural. Close to natural or pre-development conditions within the natural variability of the system drivers: hydrology, physico-chemical and geomorphology. The habitat template and biological components can be considered close to natural or pre-development conditions. The resilience of the system has not been compromised. | >92 - 100 |
| A/B | The system and its components are mostly in a close to natural condition. Conditions may rarely and temporarily decrease below the upper boundary of a B category. | >88 - ≤92 |
| B | Largely natural with few modifications. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance. Ecosystem functions and resilience are essentially unchanged. | >82 - ≤88 |
| B/C | Close to largely natural most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a C category. | >78 - ≤82 |
| C | Moderately modified. Loss and change of natural habitat and biota have occurred in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged. The system's resilience to recover from | >62 - ≤78 |

[1] This was done at the second EWR workshop held in September 2023; the entire team and the DWS officials present discussed and decided upon the RECs for each site together.

| Ecological Category | Description of Ecological Conditions | % of Change from Natural |
|---|---|---|
| | human impacts has not been lost, and its ability to recover to a moderately modified condition following disturbance has been maintained. | |
| C/D | The system is in a close to moderately modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a D category. | >58 - ≤62 |
| D | Largely modified. A large change or loss of natural habitat, biota and basic ecosystem functions have occurred. The system's resilience to sustain this category has not been compromised, and the ability to deliver Ecosystem Services has been maintained. | >42 -≤58 |
| D/E | The system is mostly in a close to largely modified condition. Conditions may rarely and temporarily decrease below the upper boundary of an E category. The system's resilience is often under severe stress and may be lost permanently if adverse impacts continue. | >38 - ≤42 |
| E | Seriously modified. The change in the natural habitat template, biota and basic ecosystem functions are extensive. Only resilient biota may survive, and invasive and problem (pest) species may likely dominate. The system's resilience and capacity to provide Ecosystem Services are severely compromised. However, geomorphological conditions are largely intact, but extensive restoration may be required to improve the system's hydrology and physico-chemical conditions. | 20 - ≤38 |
| F | Critically / Extremely modified. Modifications have reached a critical level, and the system has been entirely modified with an almost complete change of the natural habitat template, biota, and basic ecosystem functions. Ecosystem Services have largely been lost. This likely includes severe catchment and hydrological, physico-chemical, and geomorphological changes. In the worst instances, the basic ecosystem functions have been destroyed, and the changes are irreversible. Restoration of the system to a synthetic but sustainable condition acceptable for human purposes and to limit downstream impacts is the only option. | <20 |

Similar processes were followed in the DWS (this study) and the IWMI projects to determine the EcoStatus and set the ecological flow requirements. The disciplines assessed in both projects were water quality, geomorphology, riparian vegetation, aquatic macroinvertebrates and fish.

The EWR processes for the five IWMI study sites are reported in a series of E-flows for the Limpopo River Basin reports from 2020 to 2023. The assessments of the Present Ecological Status for the five IWMI sites are described in the E-Flows for the Limpopo River Basin – Drivers of Ecosystem Change Report (Dickens et al. 2020b) and the E-Flows for the Limpopo River Basin – Ecological Responses to Change (O'Brien et al. 2022a).

It is important to note that the five IWMI sites are transboundary, so their management decisions were made in discussion with the member countries. This is why those data must be used as is and cannot be updated or changed in this project without the knowledge and consent of all member countries. LIMCOM have initiated new studies (2023/2024) to review the E-Flows of the 2022 study, undertake additional stakeholder engagements, and analyse new scenarios. These further studies imply that the E-Flows put forward may change.

### Summary of results

Table 3 provides a summary of the results for the 14 DWS EWR sites that were assessed in this project and the EcoStatus of the IWMI sites[2].

**Table 3. EcoCategorisation of the river EWR sites**

| EWR Site | Quaternary Catchment | Present Ecological State (PES) | Ecological Importance and Sensitivity (EIS) | Recommended Ecological Category (REC) | Mitigation to achieve REC |
|---|---|---|---|---|---|
| 1_Lephalala | A50B | C | Moderate | B/C | Restocking of fish, alien vegetation removal, and management of sedimentation. |
| LEPH-A50H-SEEKO | A50H | C | | C | Updates are currently underway.[3] |
| 2_Rietfontein | A63C | B/C | Moderate | B/C | None, as no negative trend. Maintain PES condition. |
| 3_Olifantspruit | A61B | C | Moderate | C | Alien vegetation removal and sedimentation management. |
| 4_Mogalakwena1 | A62B | C | Moderate | C | Management of land use practices and alien vegetation clearing. Improved management of wastewater treatment works. |
| 5_Mogalakwena2 | A63A | C | Moderate | C | Improvements in land and agricultural practices, such as rotation of cattle feeding areas. |
| MOGA-A63D-LIMPK | A63D | C | | C | Updates are currently underway. |
| 6_Kolope | A63E | C | Moderate | C | Rehabilitation and improvement of trampling pressures; add gabions. Manage the effects of wildlife such as elephants. |
| 7_Sand | A71D | C | Moderate | C | Improvement in catchment management. |
| SAND-A71K-R508B | A71K | C | | C | Updates are currently underway. |
| 8_Nzhelele | A80G | C | Moderate | C | Improvement of catchment management and agricultural practices. |
| 9_Ṅwaneḍi | A80J | C | Moderate | C | Alien vegetation removal, management of agricultural practices, preventing the encroachment of watercourse, and |

[2] . Readers are referred to the LIMCOM reports for the results for the five IWMI sites (Section 2).

[3] LIMCOM have commissioned new studies currently underway (in 2023/2024) that are going to review the E-Flows set, undertake additional stakeholder engagement, and analyse new scenarios. The implication is that these data, and the E-Flows may change.

| EWR Site | Quaternary Catchment | Present Ecological State (PES) | Ecological Importance and Sensitivity (EIS) | Recommended Ecological Category (REC) | Mitigation to achieve REC |
|---|---|---|---|---|---|
| | | | | | management of return flows. |
| 10_Latonyanda | A91D | C | Moderate | B/C | Management of catchment land use practices. |
| 11_Mutshindudi | A91G | C | Moderate | C | Management of land use practices – manage trampling by humans, livestock, and grazing. |
| 12_Luvuvhu | A91H | C | Moderate | C | Management of sand mining and land use practices. |
| LUVU-A91K-OUTPO | A91K | C | | C | Updates are currently underway. |
| 13_Mutale1 | A92B | C | Moderate | B/C | Management of catchment land use, sedimentation, and alien vegetation removal. |
| 14_Mutale2 | A92D | C | Moderate | B/C | Management of land use activities, reduce sedimentation and trampling. |
| SHIN-B90H-POACH | B90H | B/C | | B/C | Updates are currently underway. |

### Conclusions

All the rivers are in good condition. In most cases the REC was the same as the Present Ecological State (PES 2022). There were four sites where a half category higher was put forward as the REC. At all of these, this was done by making statements to encourage better management of non-flow related activities that were predicted to improve the ecological condition of each site. There were few opportunities to enhance or manipulate flow in ways different from what is being done because, for the most part, the surface water use is overallocated. The implication of this for setting the EWRs, or E-Flows, at Present Ecological State (PES 2022) is to target maintaining Present Ecological State conditions, i.e., not allowing the ecological condition of the rivers to degrade from what they were.

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# 1 INTRODUCTION

## 1.1 Background to the study

The Department of Water and Sanitation (DWS), Chief Directorate (CD): Water Ecosystems Management (WEM) initiated a three-year study, extended to a fourth year, to Determine Water Resource Classes, the Ecological Reserve and Resource Quality Objectives for Secondary Catchments A5-A9 in the Limpopo Water Management Area (WMA 1) and Secondary Catchment B9 in the Olifants Water Management Area (WMA 2). This project aligns with the Department's mandate to protect water resources as stipulated in Chapter 3 of the National Water Act.

The Resource Directed Measure (RDM) tools implemented in these catchments aim to ensure sustainable utilisation of water resources to meet the ecological, social and economic needs of the communities dependent on them and provide a mechanism against which the objectives set can be monitored for compliance.

## 1.2 Study objectives

This project aims to classify and determine the Reserve and Resource Quality Objectives for all significant water resources in the Secondary catchments (A5-A9) of the Limpopo WMA and B9 in the Olifants WMA.

The Scope of Work, as stipulated in the Terms of Reference, calls for the following:

- Coordinate the implementation of the Water Resources Classification System (WRCS), as required in Regulation 810 in Government Gazette 33541, by classifying all significant water resources in the Limpopo WMA (secondary catchments A5-A9) and Olifants WMA (secondary catchment B9).
- Determine the water quantity and quality components of the groundwater and surface water (rivers and wetlands) Reserve.
- Determine Resource Quality Objectives (RQOs) using the Department of Water and Sanitation Procedures to Determine and Implement Resource Quality Objectives.

This report covers some of the work needed to determine the Ecological Reserve for rivers (Figure 1.1). There are eight steps, some of which are completed. Step 1 (Define study) was reported on in the Inception Report. Step 2 (Resource Units) was reported in the Delineation and Status Quo Report, and Step 2 (EWR sites) was reported in the Site Selection and Verification Report.

This report focuses on Step 3 (EcoCategorisation) and is one of three volumes describing activities and results of work needed to determine EWRs for the rivers. The three volumes are:
River Assessment (Volume 1): EcoCategorisation Report (this report)
River Assessment (Volume 2): Ecological Water Requirements Report
River Assessment (Volume 3): Supporting Specialists' Report

The aim of EcoCategorisation was to determine the Present Ecological Status of each river site. These were the Present Ecological State conditions that each team member determined after data was collected on the high and low-flow survey data collection trips. The river components that were assessed

were water quality, geomorphology, riparian vegetation, aquatic macroinvertebrates and fish and details on the approach used to do so are given in Section 3.

Steps 4 and 5 (Figure 1.1) will be dealt with in Volume 2, the EWR assessment report for rivers and Volume 3, the EWR Supporting Specialist Report for rivers.

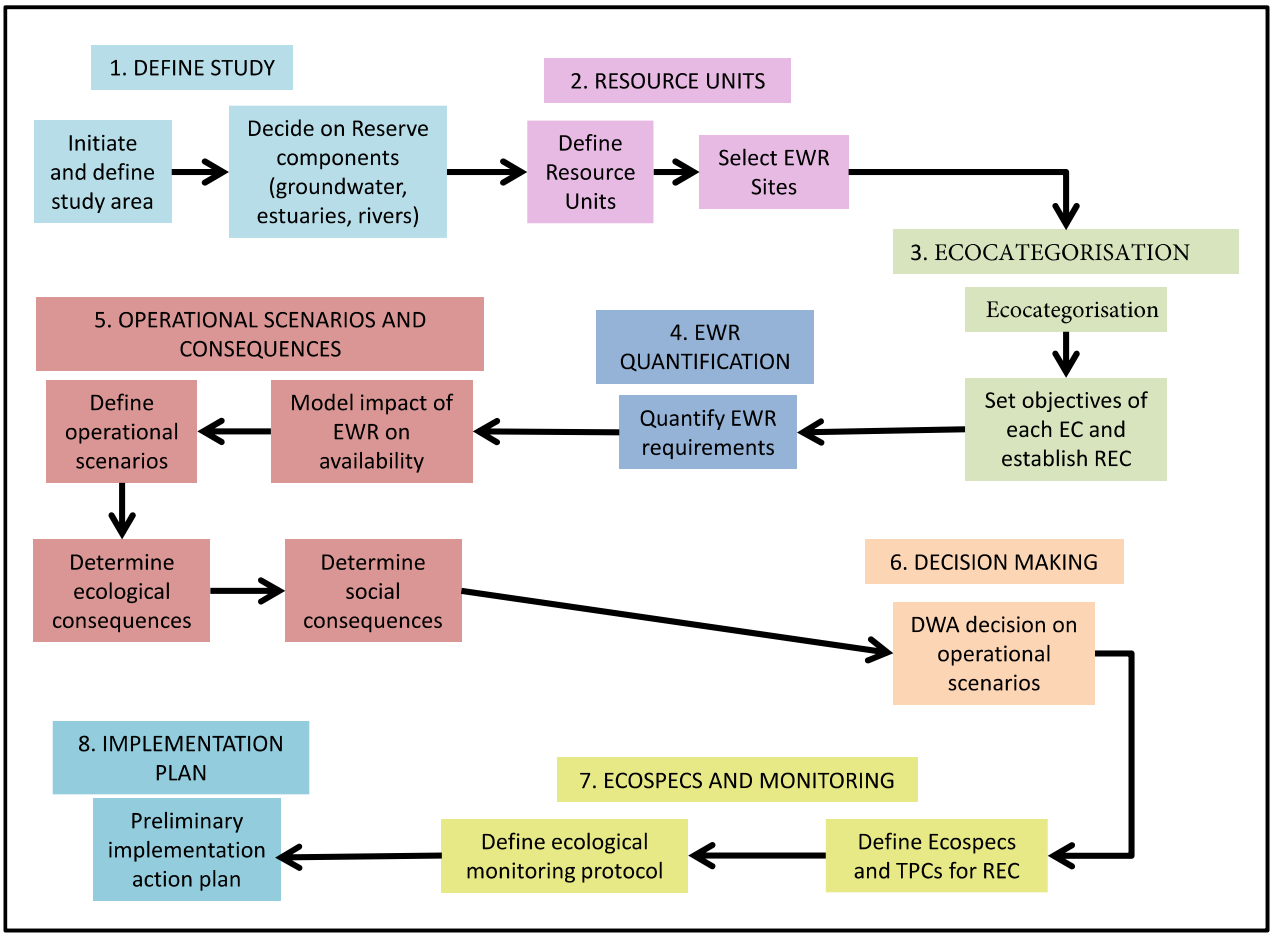


**Figure 1.1 Generic procedure for the determination of the Ecological Reserve**

# 2 STUDY AREA AND EWR SITES

The study area falls in the northern region of South Africa within the Limpopo WMA and a portion of the Olifants WMA. It comprises secondary catchments A5 (Lephalale), A6 (Mogalakwena), A7 (Sand), A8 (Nzhelele), A9 (Luvuvhu) in the Limpopo WMA (WMA 1), and Secondary Catchment B9 (Shingwedzi) in the Olifants WMA (WMA 2). These rivers were delineated into Integrated Units of Analysis (IUA), described in the Delineation and Status Quo Report, which also details the river catchments in terms of their conservation status, water use, and socio-economic profile.

The study area is important in terms of its Protected and Conservation areas, Strategic Water Source Areas and Freshwater Ecosystem Priority Areas. Protected areas are dotted throughout the study area. The Mapungubwe Nature Reserve is located north, and the Kruger National Park is east of the study area. Strategic surface Water Source Areas requiring protection and management are located at the confluence of the Mogalakwena and the Sterk Rivers, the upper catchment of the Sand, the lower reaches of the Luvuvhu and Mutale Rivers and the mid-section of the Shingwedzi River.

Two RAMSAR-declared floodplain wetlands fall within the footprint of the study area. The Nylsvley wetland, in the upper reaches of the Mokgalakwena catchment provides water to downstream users. The Makuleke Contractual Park in the northern Kruger National Park is bordered by the Limpopo River on the north side and the Luvuvhu River to the south. It is considered to be the most biodiverse area in Kruger. The Makuleke area was designated a RAMSAR Wetland in 2007, and the wetlands are regarded as important bird habitats and are of international importance.

The rivers in the Limpopo WMA form part of the internationally shared Limpopo River Basin between South Africa, Botswana, Zimbabwe and Mozambique. There were 19 Intermediate EWR sites in the study area (Table 2.1 and Figure 2.1); 14 are the focus of work done in this project and reported in Volumes 1, 2 and 3 of the river DWS EWR report series. The other five sites are from another project where work was done by the IWMI (International Water Management Institute) for LIMCOM (Limpopo Commission), which takes care of and manages all the rivers in the Limpopo River basin as international transboundary rivers on behalf of Zimbabwe, Botswana, South Africa and Mozambique.

The five IWMI sites were included in this project because of their strategic importance but also because the E-Flow work was recently completed and so could easily be incorporated into this study to boost the coverage of detailed information gathering and assessment, as well as provide the data needed for the Classification process.

**Table 2.1 Intermediate EWR sites, 14 (DWS) and 5 (IWMI)**

| DWS Nodes | IUA | IWMI site code | DWS EWR site code | River | Quaternary Catchment |
|---|---|---|---|---|---|
| Riv11 | Upper Lephalala | | 1_Lephalala | Lephalala | A50B |
| | Lower Lephalala | LEPH-A50H-SEEKO | | Lephalala | A50H |
| Rvi1 | Kalkpan se Loop | | 2_Rietfontein | Kalkpan se Loop | A63C |
| Ri1 | Upper Nyl/Sterk | | 3_Olifantspruit | Olifantspruit | A61B |
| Ri5 | Upper Nyl/Sterk | | 4_Mogalakwena1 | Mogalakwena | A62B |
| Ri14 | Mogalakwena | | 5_Mogalakwena2 | Mogalakwena | A63A |
| | Mogalakwena | MOGA-A63D-LIMPK | | Mogalakwena | A63D |
| Riv32 | Mapungubwe | | 6_Kolope | Kolope | A63E |
| Ri20 | Upper Sand | | 7_Sand | Sand | A71D |
| | Lower Sand | SAND-A71K-R508B | | Sand | A71K |
| Ri27 | Nzhelele /Ṅwanedi | | 8_Nzhelele | Nzhelele | A80G |
| Ri28 | Nzhelele /Ṅwanedi | | 9_Ṅwanedi | Ṅwanedi | A80J |
| Riii6 | Upper Luvuvhu | | 10_Latonyanda | Latonyanda | A91D |
| Ri30 | Upper Luvuvhu | | 11_Mutshindudi | Mutshindudi | A91G |
| Ri32 | Upper Luvuvhu | | 12_Luvuvhu | Luvuvhu | A91H |
| | Lower Luvuvhu/ Mutale | LUVU-A91K-OUTPO | | Luvuvhu | A91K |
| Ri33 | Lower Luvuvhu/ Mutale | | 13_Mutale1 | Mutale | A92B |
| Ri34 | Lower Luvuvhu/ Mutale | | 14_Mutale2 | Mutale | A92D |
| | Lower Luvuvhu/ Mutale | LUVU-A91K-OUTPO | | Luvuvhu | A91K |
| | Shingwedzi | SHIN-B90H-POACH | | Shingwedzi | B90H |

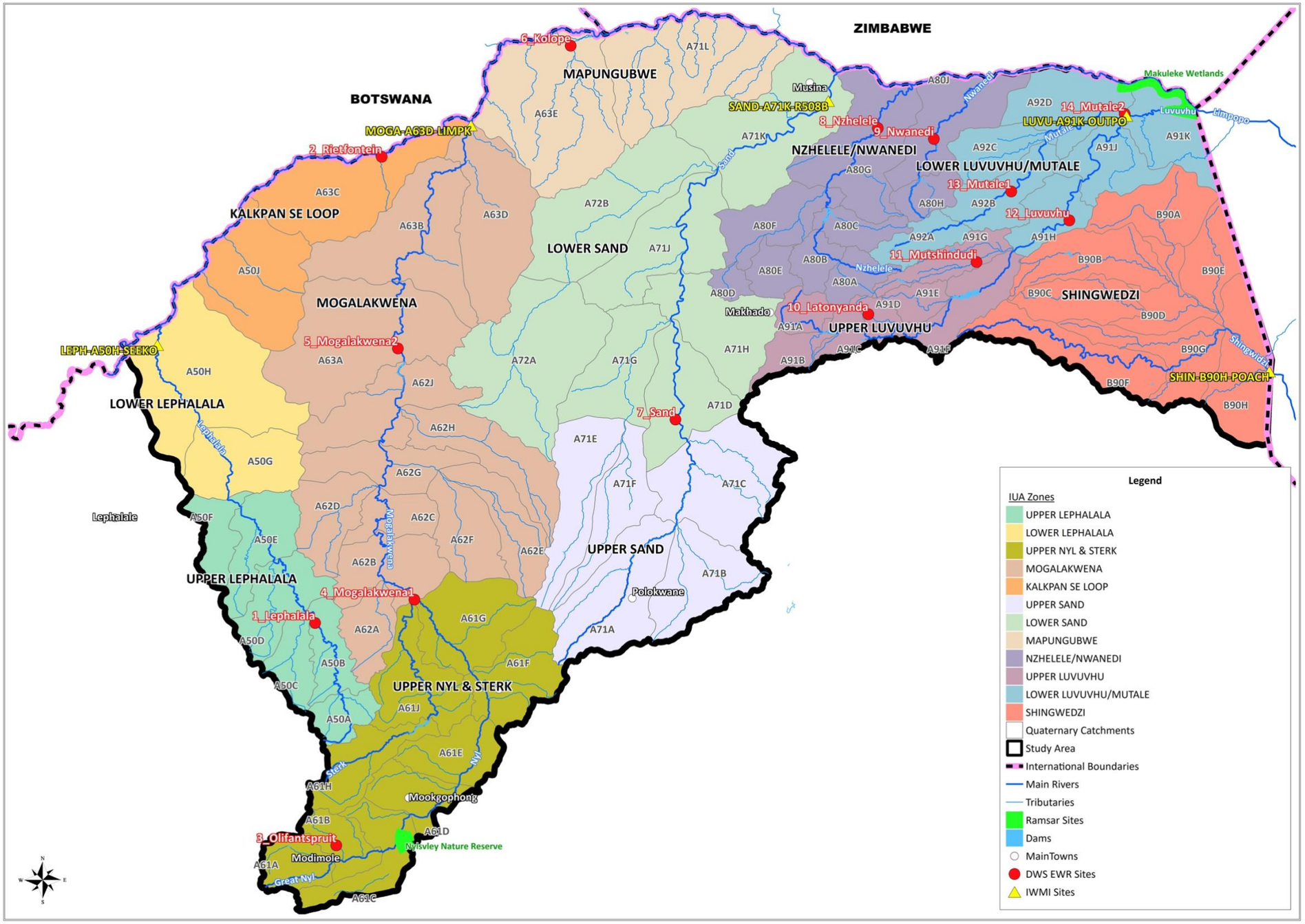


Figure 2.1 EWR sites distributed across the study area

# 3 APPROACH

The theory of, approach to, and methods used to classify the ecological condition of rivers are described in a series of DWS EcoStatus manuals published in 2007:

- Module A – EcoClassification[4] and Ecostatus models (Kleynhans and Louw 2007)
- Module B – Geomorphological Driver Assessment Index (GAI, Rowntree 2013)
- Module C – Physico-Chemical Driver Assessment Index (PAI, DWAF 2008)
- Module D – Fish Response Assessment Index (FRAI) volumes 1 and 2 (Kleynhans 2007)
- Module E – Macroinvertebrate Response Assessment Index (MIRAI, Thirion 2007)
- Module F – Riparian Vegetation Response Assessment Index (VEGRAI, Kleynhans et al. 2007)

A summary of the steps followed in the EcoCategorisation process has been taken from Kleynhans and Louw (2007), the manual that describes how to complete the tasks in detail.

'EcoCategorisation refers to determining the Present Ecological Status (PES, or statement of Present Ecological State conditions assessed on the field trips) that represents the ecological health or integrity of some biophysical attributes of the rivers relative to a reference condition.' Components of the river were given scores relative to natural (Table 3.1) that show how far away from natural the assessed condition was, with natural being 100%. These scores were grouped into different categories, A-F, based on how far away from natural they were; A was natural, and F was completely unnatural. The DWS EcoStatus manual describes how to go about this for each river component and guides the user through the spreadsheets set up to score different impacts in different categories that automatically calculate the percentage score and resulting Ecological Category.'

'The purpose of the EcoCategorisation process is to gain insights and understanding into the causes and sources of the deviation of the PES of each attribute from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river.'

'The steps followed in the EcoCategorisation process are:

- Determine the reference conditions for each component.
    - Literature, historical and observed data were used to describe the reference conditions, which are recorded in the EcoStatus spreadsheets.
- Determine the Present Ecological State for each component and the EcoStatus. The EcoStatus refers to integrating individual components toward the overall condition of the site.
    - Impacts are scored in the EcoStatus spreadsheets, following the guidance given in the manuals, which automatically calculates the % score and Ecological Category. The outputs from the various spreadsheets for each river attribute assessed are provided in the EWR Assessment Report Volume 3 – Supporting Specialist Report.
- Determine the trend (i.e. moving toward or away from the reference condition) for each component and the EcoStatus.
    - Literature, historical and observed data were used to describe the trends, which were recorded in the summary spreadsheets.

[4] The term EcoClassification is no longer used because of confusion between this part of the Ecological Reserve process, and that followed for the Classification process. The new term is EcoCategorisation.

- Determine the cause for the PES and whether these are flow or non-flow related.
    - Literature, historical and observed data were used to describe the causes, which were recorded in the summary spreadsheets.
- Determine the Ecological Importance (EI) and Ecological Sensitivity (ES) of the biota and habitat.
    - Literature, historical and observed data were used to score the EI and ES in the spreadsheets provided that automatically calculate the ratings.
- Considering the PES and the EIS, suggest a realistic and practically attainable Recommended Ecological Category for each component and the EcoStatus[5].'

'The EcoCategorisation process is an integral part of the Ecological Reserve process, and any Environmental Flow method, because flows cannot be recommended without predictions being made on the resulting state, the EcoStatus.'

**Table 3.1. Generic Ecological Categories (EC) for Ecological Integrity Categories (modified from Kleynhans 1996)**

| Ecological Category | Description of Ecological Conditions | % Of Change from Natural |
|---|---|---|
| A | Unmodified/natural. Close to natural or pre-development conditions within the natural variability of the system drivers: hydrology, physico-chemical and geomorphology. The habitat template and biological components can be considered close to natural or pre-development conditions. The resilience of the system has not been compromised. | >92 - 100 |
| A/B | The system and its components are mostly in a close to natural condition. Conditions may rarely and temporarily decrease below the upper boundary of a B category. | >88 - ≤92 |
| B | Largely natural with few modifications. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance. Ecosystem functions and resilience are essentially unchanged. | >82 - ≤88 |
| B/C | Close to largely natural most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a C category. | >78 - ≤82 |
| C | Moderately modified. Loss and change of natural habitat and biota have occurred in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged. The resilience of the system to recover from human impacts has not been lost, and its ability to recover to a moderately modified condition following disturbance has been maintained. | >62 - ≤78 |
| C/D | The system is in a close to moderately modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a D category. | >58 - ≤62 |
| D | Largely modified. A large change or loss of natural habitat, biota and basic ecosystem functions has occurred. The resilience of the system to sustain this category has not been compromised and the ability to deliver Ecosystem Services has been maintained. | >42 -≤58 |
| D/E | The system is mostly in a close to largely modified condition. Conditions may rarely and temporarily decrease below the upper boundary of an E category. The resilience of the system is often under severe stress and may be lost permanently if adverse impacts continue. | >38 - ≤42 |
| E | Seriously modified. The changes in the natural habitat template, biota and basic ecosystem functions are extensive. Only resilient biota may survive, and invasive | 20 - ≤38 |

[5] This was done at the second EWR workshop held in September 2023; the entire team and the DWS officials present discussed and decided upon the RECs for each site together.

| Ecological Category | Description of Ecological Conditions | % Of Change from Natural |
|---|---|---|
| | and problem (pest) species may likely dominate. The resilience of the system is severely compromised, as is the capacity to provide Ecosystem Services. However, geomorphological conditions are primarily intact, but extensive restoration may be required to improve the system's hydrology and physico-chemical conditions. | |
| F | Critically / Extremely modified. Modifications have reached a critical level, and the system has been entirely altered with an almost complete change of the natural habitat template, biota, and basic ecosystem functions. Ecosystem Services have largely been lost. This likely includes severe catchment and hydrological, physico-chemical, and geomorphological changes. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible. Restoration of the system to a synthetic but sustainable condition acceptable for human purposes and to limit downstream impacts is the only option. | <20 |

The EWR processes for the five IWMI study sites are reported on in:

- E-Flows for the Limpopo River Basin – Inception Report (Dickens and O'Brien 2020)
- E-Flows for the Limpopo River Basin – Basin Description (Dickens et al. 2020a)
- E-Flows for the Limpopo River Basin – From Vision to Management (Dickens et al. 2020b)
- E-Flows for the Limpopo River Basin – Specialist Literature and Data Review (Dickens et al. 2020a)
- E-Flows for the Limpopo River Basin – Drivers of Ecosystem Change (Dickens et al. 2020b)
- E-Flows for the Limpopo River Basin – Ecological Responses to Change (O'Brien et al. 2022a)
- E-Flows for the Limpopo River Basin – Environmental Flow Determination for the Limpopo Basin (O'Brien et al. 2022b)
- Risk of Altered Flows to the ecosystem services of the Limpopo Basin (O'Brien et al. 2022c).

Similar processes were followed in both the DWS (this) and the IWMI projects. The study area was delineated, and study sites were selected. Field trips to visit the sites and collect EWR/E-Flow[6] related data used to determine EWRs/E-Flows were collected on both projects' high and low-flow field trips. The disciplines assessed in both projects were water quality, geomorphology, riparian vegetation, aquatic macroinvertebrates and fish.

The collected data was first used to decide upon the ecological condition and assign a category to this from A-F for each discipline. This report focused on the 14 DWS study sites; the approach is summarised in Section 3 and the results are given in Section 4.

The assessments of the Present Ecological Status for the five IWMI sites are described in the E-Flows for the Limpopo River Basin – Drivers of Ecosystem Change Report (Dickens et al. 2020b). The outcomes of these assessments are given in the summary table at the end of this report, along with the other 14 sites (Section 5).

[6] DWS use the term Environmental Water Requirements (EWR). International studies use the term E-Flows. EWR and E-Flow are the same thing.

From the information gathered, decisions were made on what the Recommended Ecological Category (REC) for each site should be in the future. This is mostly based on the Ecological Importance and Sensitivity of the site, along with whether the site was in a good or bad condition. The RECs for all 19 sites are summarised in Section 5.

The E-Flows determined for the five IWMI sites are described and provided in the E-Flows for the Limpopo River Basin Report (O'Brien et al. 2022b), provided at a monthly time step for the REC put forward. The EWRs determined for the 14 DWS EWR sites will be described and provided in the EWR Assessment for Rivers Report Volume 2, and the supporting specialist study information that describes all the data collected, analysed and used in the Supporting Specialist Report Volume 3. These will also be summarised at a monthly time step for the REC.

All the EWRs (DWS) and E-Flows (IWMI) put forward for the 19 sites will be summarised in the main EWR Report (DWS Deliverable 9). These data will be provided in the same and compatible format as needed for the Classification Process. EWRs will be provided at a monthly time step (volume, discharge, %) predicted to maintain the Recommended Ecological Category put forward for each site.

It is important to note that the five IWMI sites are transboundary, so their management decisions were made in discussion with the member countries. This is why those data must be used as is and cannot be updated or changed in this project without the knowledge and consent of all member countries. LIMCOM have initiated new studies (2023/2024) to review the E-Flows of the 2022 study, undertake additional stakeholder engagements, and analyse new scenarios. These further studies imply that the E-Flows put forward may change.

# 4 RESULTS

The results provided are for the 14 DWS EWR sites that were assessed in this project[7], and include the following:

- Data availability.
- Ecological Importance and Sensitivity (EIS)
- Reference conditions.
- Present ecological condition, including:
    - individual component EcoCategorisation.
    - cause and sources.
    - trends.
    - EcoStatus.
- Recommended Ecological category (REC) for each specialist component and EcoStatus.
- Confidence in the results.

## 4.1 EWR site 1_Lephalala

This site is just downstream of a REMP site and strategically located upstream of a number of nature reserves. It is downstream of one of the main tributaries, the Melk River. The river is in a very good condition, with fantastic aquatic habitat for fish and invertebrates. The vegetation is diverse but there are some exotic trees present. Flow is also contained in one channel during low and high flows. Figure 4.1 shows the site under low flow and high flow conditions.

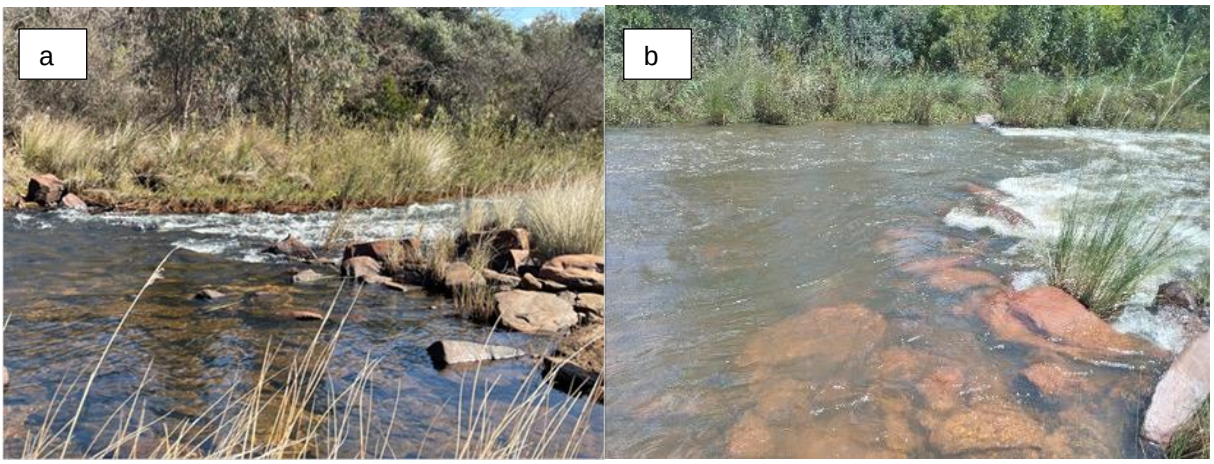


**Figure 4.1 1_Lephalala, Riv11, Upper Lephalala IUA, a=low flow conditions, b=high flow conditions**

[7] . Readers are referred to the LIMCOM reports for the results for the five IWMI sites (Section 2).

### 4.1.1 Data availability

The data available at 1_Lephalala are summarised in Table 4.2. The confidence rating used in the report is described in Table 4.1.

**Table 4.1 Description of confidence ratings**

| Confidence rating | Description |
|---|---|
| 1 | Low confidence |
| 2 | Low to medium confidence |
| 3 | Medium confidence |
| 4 | Medium to high confidence |
| 5 | High confidence |

**Table 4.2 Data available at 1_Lephalala**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | A5H004Q01 (2008-2018) n=90 (DWS WMS database). | 4 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology, centres of Plant Endemism, historical anecdotal information, vegetation maps and associated conservation information, plant species distribution records and community descriptions, GoogleEarth© and historical satellite imagery, Land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020). | 3 |
| Macroinvertebrates | Macroinvertebrate data collected for this project, 19 data sets available since February 2017 (DWS Regional Office and DWS RQIS). | 5 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.1.2 Ecological importance and sensitivity

The EIS of 1_Lephalala, with motivations, is provided in Table 4.3.

**Table 4.3 EIS of 1_Lephalala**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 0.75 | VEG: 1 protected tree species at the National scale: *Boscia albitrunca.* FISH: No rare or endangered fish found. High level of instream barriers inhibits recruitment from downstream. INVERTS: We do not have the information to assess this. |
| Unique | 0.75 | VEG: *Buxus macowanii* (SA endemic); *Miscanthus junceus* (SnA endemic). FISH: Reference data shows are present but none were sampled. High level of instream barriers inhibits recruitment from downstream. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Aquatic vegetation. FISH: Many fish spp flow habitat specialists, many of which occur in fast shallow habitats. INVERTS: Many taxa dependent on flowing water during part/most of their life cycle. |
| Taxon richness | 1.50 | VEG: 26 indigenous riparian and wetland species. FISH: High level of instream barriers inhibits recruitment from downstream. Possible water quality issues from upstream users as well. INVERTS: 62 taxa under natural conditions and 46 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 2.00 | VEG: Bedrock channel, woody banks, flood bench flood channel, mixed bedrock / alluvium. FISH: High diversity. INVERTS: Instream habitat dominated by boulders and bedrock, limited GSM and veg mostly comprised of graminoids. |
| Refugia | 2.00 | VEG: Aquatic vegetation. FISH: High level. INVERTS: Habitat types functions moderately well as refuge areas. |
| Sensitivity to change in flows | 2.00 | VEG: Low. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Habitat not particularly sensitive to flow changes. |
| Sensitivity to change in water quality | 2.00 | VEG: Low. FISH: Relatively large water volumes create a buffer to changes. INVERTS: Water quality and hydrology not changed much. Size of river not particularly sensitive. |
| Migration route/corridor | 1.00 | VEG: Fragmented. FISH: Historically important but large number of instream barriers have drastically decreased the relevance of this watercourse to support meaningful migrations. INVERTS: No instream migratory invertebrate taxa but Odonata may use the riparian zone as a corridor. |
| Importance of conservation and natural areas | 2.00 | VEG: Low. FISH: Much of the catchment area falls within privately owned land with a conservation-based ethos. INVERTS: Unproclaimed natural areas and game farms. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.1.3 Reference condition

The expected reference condition of 1_Lephalala is described in Table 4.4.

**Table 4.4 Reference condition at EWR site 1_Lephalala**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | The Lephalala River in its reference state would probably be in an A water quality category with low salinity, low turbidity, and low nutrient concentrations. It is presently in a B category due to elevated nutrient concentrations only, probably the result of irrigation return flows. | 3 |
| Geomorphology | The Lephalala River in its reference state is a lower gradient mixed bed cobble and boulder channel with limited lateral migration along a confined valley setting, resulting in a straight-to-wandering channel and pool-riffle or pool-rapid reach types. Sand bars are common in pools, with pool length exceeding riffle and rapid length. A floodplain can often be present with banks of a moderate gradient. The historical images suggest that the channel margin vegetation has increased with sand filling the large pool to some extent in recent years. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Central Bushveld Bioregion and Waterberg Mountain Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. The aquatic zone was in its reference state. The marginal zone is expected to be mostly dominated by non-woody vegetation (grasses, sedges, reeds) but with a scattered woody component comprising indigenous woody species such as *Syzygium cordatum*, *S, guineense* or *Breonadia salicina*. Historical aerial photographs show that there has been an increase in reed cover in the active channel over time. The flood bench is expected to be dominated by non-woody vegetation, mostly grasses and sedges with varying degrees of woody encroachment that should be held at bay by flooding with the correct frequency and magnitude. A woody riparian component would also be expected, particularly with *Combretum erythrophyllum* in the system. Also apparent from historical aerial photographs for this reach of the Lephalala River beyond the active channel is that the bank has been mostly dominated by fragmented riparian woodland/ thicket, with short to tall dense to open trees / shrubs, but also with some non-woody or open areas. | 3 |
| Macroinvertebrates | SASS Total Score 200, ASPT 7. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 5 |
| Fish | Reference habitat conditions would dictate the fish species community structures. Cobble and boulders with shallow to deep flowing habitats would support Anguilids (eels), together with *Clarias* spp, *Chiloglanis* spp, and *Amphilius uranoscopus*. *Labeobarbus marequensis*, *Labeo* spp, *Opsaridum peringuey*, and a variety of *Enteromius* spp. Slower velocity zones with this substrate would support a variety of cichlid species, *Clarias* spp, and again, a variety of *Enteromius* spp. Deeper water would support larger Cichlidae species, together with *Clarias gariepinus* and *Labeo molybdinus*. Shallow peripheral water with good rock and vegetation habitat cover would support smaller and weaker-swimming *Enteromius* spp, and the smaller Cichlids (*Chetia flaviventris*, *Tilapia sparrmanii* and *Pseudocrenilabrus philander*). Shoals of opportunistic *Enteromius* spp and *Micralestes acutidens* would move between habitat types to exploit the resources. | 4 |

### 4.1.4 Causes and sources of PES at 1_Lephalala

Causes and sources for the Present Ecological State at 1_Lephalala are summarised in Table 4.5.

**Table 4.5 Causes and sources of PES at 1_Lephalala**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Slight increase in salinity and nutrients. | Irrigation return flows. | Non-flow. | 3 |
| Geomorphology | Sedimentation in pools; bench erosion and trampling. | Localised farming, grazing and roads. | Non-flow. | 3 |
| Vegetation | Altered species composition. | Annual and perennial alien plant species. | Non-flow. | 5 |
| | Increased reed density and cover. | Flow regulation and reduction, flood peak reduction. | Flow. | 2 |
| Macroinvertebrates | Water quality, instream habitat modification. | Potential nutrient enrichment. | Non-flow. | 3 |
| Fish | Instream barriers blocking migration; high sediment loads. | Sediment management weirs (DWS) and abstraction weirs (landowners). | Flow. | 4 |

### 4.1.5 Trends

Trends in the Present Ecological State for all components of 1_Lephalala are summarised in Table 4.6.

**Table 4.6 Trends in the PES for 1_Lephalala**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Slight negative (increasing) trend in electrical conductivity & nutrients. | 4 |
| Geomorphology | Absent, geomorphological processes are in balance. | 3 |
| Vegetation | Negative because the perennial alien plant species found on site are invasive and will increase / expand if left unchecked. | 3 |
| Macroinvertebrates | Absent, there were no discernible trends visible in the data. | 5 |
| Fish | Negative because of instream barriers that fragment habitat and prevent migration so there is no recruitment from downstream. | 4 |

### 4.1.6 EcoStatus (2022)

The Present Ecological Status of each component at 1_Lephalala is summarised below in Table 4.7.

**Table 4.7 Present Ecological Status of all components at 1_Lephalala**

| Component | Score % | Ecological Category | REC |
|---|---|---|---|
| Water quality | 84.5 | B | B |
| Geomorphology | 76.0 | C | B/C |
| Vegetation | 71.9 | C | B/C |
| Macroinvertebrates | 80.8 | B/C | B/C |
| Fish | 39.5 | D/E | D |
| PES score | 70.5 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **B/C** | | |
| Mitigation to achieve REC | Restocking of fish and inter-governmental co-operation on alien vegetation removal, management of sedimentation. | | |

## 4.2 EWR site 2_Rietfontein

This site is in a non-perennial river with the marginal zone of the riparian vegetation comprising wetland vegetation that is groundwater fed. The rest of the riparian area consists of arid adapted *Acacia* trees that also persist on groundwater during the dry periods, and are situated along the edges of a channel that flows irregularly (Figure 4.2).

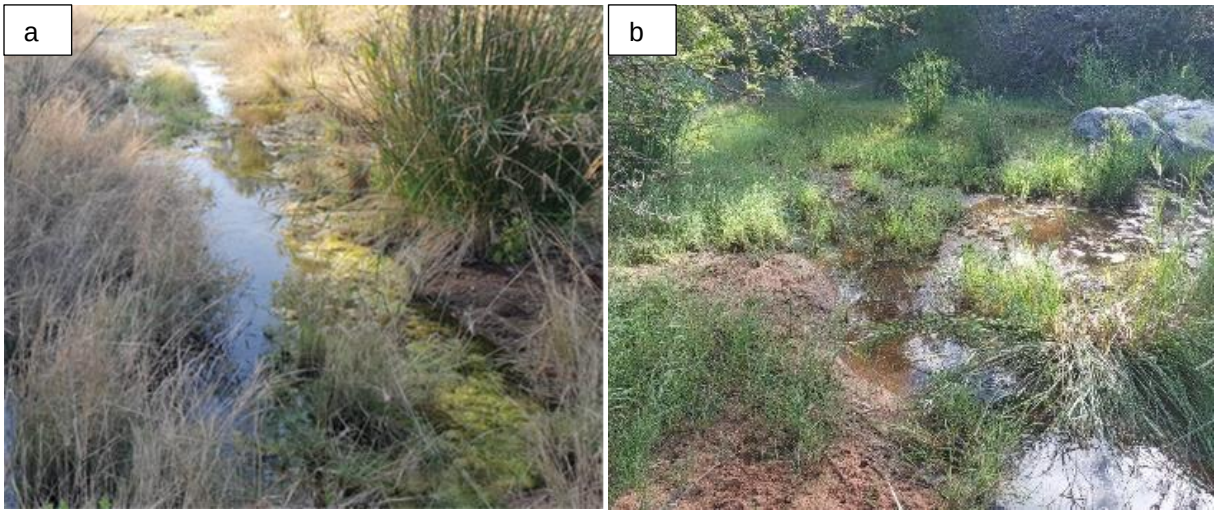


**Figure 4.2 2_Rietfontein, Rvi1, Kalkpan se Loop IUA, a=low flow conditions, b=high flow conditions**

### 4.2.1 Data availability

The data available at 2_Rietfontein are summarised in Table 4.8. The confidence rating used in the report is described in Table 4.1.

**Table 4.8 Data available at 2_Rietfontein**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | No surface water quality sampling points in tributary in A63C catchment other than the Spring called Tugela Bad (WMS A63_89777). | 2 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | No SASS sample data for this seasonal river, but there is an invertebrate list from an ecological assessment report of artesian springs at Vele Colliery, east of Mapungubwe (Grundig et al. 2014). | 1 |
| Fish | Fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 2 |

### 4.2.2 Ecological importance and sensitivity

The EIS of 2_Rietfontein, with motivations, is provided in Table 4.9.

**Table 4.9 EIS of 2_Rietfontein**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 0.50 | VEG: Leadwoods (*Combretum imbirbe*) are protected national trees. FISH: Naturally high salinity limits fish diversity to one species. INVERTS: We do not have the information to assess this. |
| Unique | 0.50 | VEG*: Cyperus sexangularis* is endemic to SA. FISH: Naturally high salinity limits fish diversity to one species. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 1.00 | VEG: Wetland sedges and grasses dependent on localised permanent wetness. FISH: Sampled species is highly adaptable to both lentic and lotic conditions. INVERTS: N/A. |
| Taxon richness | 1.00 | VEG: 15 riparian species. FISH: Only 1 taxon sampled. INVERTS: N/A. |
| Instream and riparian habitats | | |
| Diversity | 2.50 | VEG: Spring fed and riparian, bedrock controlled areas and alluvial areas, in-channel wetland. FISH/INVERTS: N/A. |
| Refugia | 2.00 | VEG: Spring fed pools / wetland areas different from rest of dry river. FISH/INVERTS: N/A. |
| Sensitivity to change in flows | 2.00 | VEG: Marginal zone / wetland species need permanent spring water. FISH/INVERTS: N/A. |
| Sensitivity to change in water quality | 2.00 | VEG: Potentially to temperature. FISH/INVERTS: N/A. |
| Migration route/corridor | 0.00 | VEG: Minimal. FISH/INVERTS: N/A. |
| Importance of conservation and natural areas | 2.00 | VEG: Natural area with wetland habitats in ephemeral systems. FISH/INVERTS: N/A. |
| MEDIAN | 1.50 | |
| EIS | **MODERATE** | |

### 4.2.3 Reference condition

The expected reference condition of 2_Rietfontein is described in

Table 4.10.

**Table 4.10 Reference condition at 2_Rietfontein**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | The river is largely fed by a spring with high salinities. In its reference state the river would have naturally elevated salinities that are diluted with the occasional rainfall runoff. The reference condition would be close to an A water quality category but with naturally high salinities. | 3 |
| Geomorphology | This river in its reference state is a moderate gradient mixed bed channel with limited lateral migration along a partly confined valley setting, resulting in a straight to wandering channel and plain-bed, pool-riffle pool-rapid reach types. Gravel and sand are the main sediment types with a flat sand bed along lower gradient reaches and steeper bedrock rapids along steeper reaches. A narrow floodplain is often present, composed of sand, gravel or cobble, with banks of a moderate gradient with inset benches present. The historical aerial images suggest that the channel morphology has been relatively stable over the past ~70 years. | 3 |
| Vegetation | The site has few impacts and is close to the expected reference state i.e. near natural, so the following descriptions of present day also represent what is expected: The marginal zone was well developed and dominated by wetland sedges and grasses, comprising wetland habitats supported by permanent wetness from an upstream spring, although the zone existed with a confined channel subject to riparian flood dynamics. Dominant species included *Cyperus sexangularis, Juncus rigidus and Agrostis lachnantha* (riparian/ wetland species) and terrestrial creeping grasses such as *Cynodon dactylon*. Filamentous green algae was common in the slow-flowing, shallow channel. Dominant habitats along the flood benches were alluvial with grasses and sedges (the same species as in the marginal zone) or a woody component (shrubs and trees such as *Carissa bispinosa, Combretum imberbe, Euclea divinorum, Gymnosporia glaucophylla, Schotia brachypetala, Phoenix reclinata* and *Vachellia karroo*). The macro-channel bank was predominantly alluvial in nature, confining the channel and was dominated by short and tall woody vegetation, mostly the same woody species as found on the flood bench, with the addition of *Boscia albitrunca, Senegalia burkei* and *S.nigrescens*. | 4 |
| Macroinvertebrates | N/A, no water was present so no samples were taken. | |
| Fish | The watercourse was fed from the upwelling of groundwater that has a particularly high salinity concentration. The majority of Limpopo fish are predominantly freshwater species that don't tolerate high salinity. *Oreochromis mossambicus* is one of the few species that tolerates salinity and therefore would be the only species expected to occur here. The substrate of the watercourse would be dominated by bedrock, overlain by gravel in deeper pools. Gravel substrates would dominate other areas. | 4 |

### 4.2.4 Causes and sources of PES at 2_Rietfontein

Causes and sources for the Present Ecological State 2_Rietfontein are summarised in Table 4.11.

**Table 4.11 Causes and sources of PES at 2_Rietfontein**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Probable increase in salinity due to non-perennial nature of tributaries. | Evaporation in pools. | Flow. | 3 |
| Geomorphology | Sedimentation of pool habitats. | Localised farming, areas with bare soil, roads and widespread grazing, farm dams. | Flow. | 3 |
| Vegetation | Altered species composition. | Alien plant species (minimal at this site and limited to annual weed species). | Non-flow. | 5 |
| Macroinvertebrates | N/A | | | |
| Fish | Upwelling of mineral rich groundwater creates a chemical barrier to most fish. | Natural processes. | Non-flow. | 4 |

### 4.2.5 Trends

Trends in the Present Ecological State for all components of 2_Rietfontein are summarised in Table 4.12.

**Table 4.12 Trends in the PES for 2_Rietfontein**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Absent, mostly fed from groundwater spring. | 3 |
| Geomorphology | Slight negative due to recent dam development upstream. | 3 |
| Vegetation | Neutral, stable trend because the alien plant species present were minimal and mostly annual weeds. | 5 |
| Macroinvertebrates | N/A. | |
| Fish | Absent, is a small and stable system, fish population and abundances will fluctuate naturally. | 4 |

### 4.2.6 EcoStatus (2022)

The Present Ecological Status of each component at 2_Rietfontein is summarised below in Table 4.13.

**Table 4.13 Present Ecological Status of all components at 2_Rietfontein**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 78.3 | B/C | B/C |
| Geomorphology | 76.0 | C | C |
| Vegetation | 90.3 | A/B | A/B |
| Macroinvertebrates | N/A | | |
| Fish | N/A | | |
| PES score | 81.5 | | |
| PES category | **B/C** | | |
| EIS | **MODERATE** | | |
| REC | **B/C** | | |
| Mitigation to achieve REC | None. Maintain PES. No negative trend. | | |

## 4.3 EWR site 3_Olifantspruit

This EWR site is on an inflowing tributary to the Nylsvley. It is one of the REMP sites and in good ecological condition. The site at low flow and high flow conditions is shown in Figure 4.3.

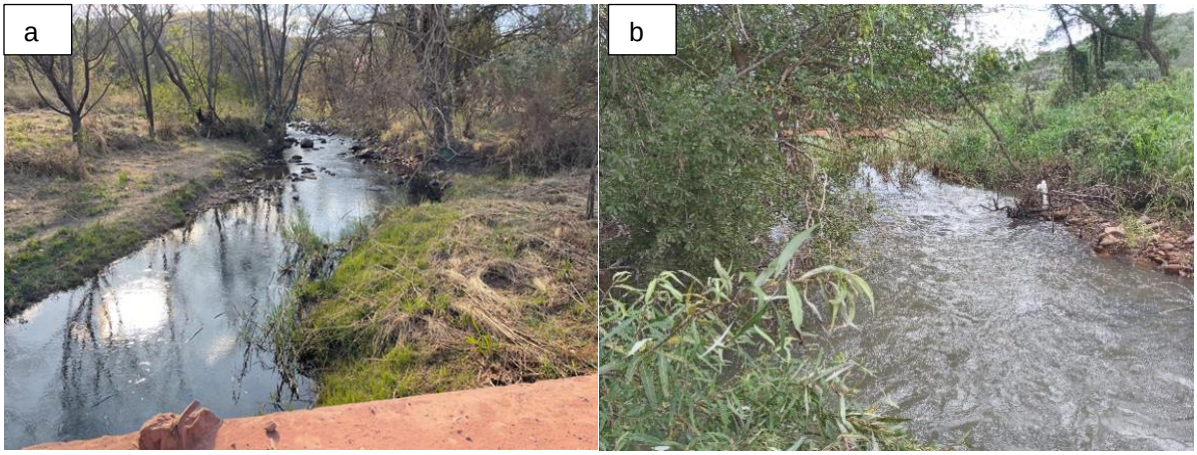


**Figure 4.3 3_Olifantspruit, Ri1, Upper Nyl Sterk IUA, a=low flow conditions, b=high flow conditions**

### 4.3.1 Data availability

The data available at 3_Olifantspruit are summarised in Table 4.14. The confidence rating used in the report is described in Table 4.1.

**Table 4.14 Data available at 3_Olifantspruit**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | A6H012Q01 (2008-2018) n=80 (DWS WMS database). | 4 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | Macroinvertebrate data collected for this project. | 3 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.3.2 Ecological importance and sensitivity

The EIS of 3_Olifantspruit, with motivations, is provided in Table 4.15.

**Table 4.15 EIS of 3_Olifantspruit**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 0.00 | VEG: None. FISH: Reference data show there are but none were sampled. INVERTS: We do not have the information to assess this. |
| Unique | 0.50 | VEG: *Combretum erythrophyllum* is endemic to SnA. FISH: Reference data show there are but none were sampled. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Marginal zone sedges & grasses. FISH: Many fish are flow habitat specialists, many preferring fast shallow habitats. INVERTS: Many taxa dependent on flowing water during part/most of their life cycle. |
| Taxon richness | 2.00 | VEG: 24 indigenous riparian and wetland species. FISH: Reference data show high values but samples collected were less diverse. INVERTS: 52 taxa under natural conditions and 31 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 2.00 | VEG: Woody banks and floodplain, rocky narrow marginal zone, reed beds. FISH: High level. INVERTS: Instream habitat dominated by cobbles, limited GSM and veg. |
| Refugia | 2.00 | VEG: None. FISH: High level. INVERTS: Habitat types functions moderately well as refuge areas. |
| Sensitivity to change in flows | 3.00 | VEG: None. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Habitat is sensitive to flow changes. |
| Sensitivity to change in water quality | 3.00 | VEG: None. FISH: Relatively small watercourse and therefore limited buffer capacity to tolerate changes. INVERTS: Change in hydrology will negatively impact the water quality of the system. |
| Migration route/corridor | 1.00 | VEG: Fragmented. FISH: A generally open and longitudinally connected watercourse that would promote migration movements in support of breeding and dispersal. There is a weir downstream of the site. INVERTS: No instream migratory invertebrate taxa but Odonata may use the riparian zone as a corridor. |
| Importance of conservation and natural areas | 2.00 | VEG: None. FISH: Much of the catchment area falls within natural areas that cumulatively act to conserve the resource. INVERTS: Unproclaimed natural areas and game farms. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.3.3 Reference condition

The expected reference condition of 3_Olifantspruit is described in Table 4.16.

**Table 4.16 Reference condition at 3_Olifantspruit**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | The Olifantspruit in its reference state would be in an A water quality category with low salinity, low nutrient concentrations and low turbidity. Its present state is a B category due to elevated nutrients probably from irrigation return flows. | 3 |
| Geomorphology | The Olifantspruit in its reference state is a moderate gradient mixed bed channel with limited lateral migration along a confined valley setting, resulting in a straight channel and pool-riffle reach type. Boulder, cobble, gravel and sand are the main sediment types along the riffle with a sand bed along pool sections. Bedrock is locally present, forming short rapid sections and bedrock pools. Riffles and pools of similar length. Narrow flood benches should be present, composed of fine gravel, sand and silt, with banks of a moderate gradient with inset benches present. Historical aerial images give the impression that the channel was wider and less overgrown 80 years ago. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Central Bushveld Bioregion and Waterberg Mountain Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. Historically the channel appeared more open (1932 and 1979 aerial photographs), with less woody vegetation, less shading and more non-woody vegetation. Similarly the Macro Channel Bank is also expected to be less woody with more open and grass areas. Some indigenous riparian tree species, such as *Combretum erythrophyllum* should be better represented, with low numbers likely due to competition from alien tree species. | 3 |
| Macroinvertebrates | SASS Total Score 180, ASPT 6.5. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 4 |
| Fish | This watercourse is fed through the confluence of mountain streams, implying that, under reference conditions, the Olifantspruit would have good water quality. The watercourse would also not have gauging weirs or other instream barriers. Being close to the source zone, and the high level of canopy cover of the riparian zones, the water would be relatively cool and favour *Enteromius neefi*. These headwater streams would provide valuable breeding habitat for *Labeobarbus, Labeo, Amphilius, Clarias,* and a variety of *Entermomius* species. Other opportunistic cichlids would occur. Aquatic habitat and hydraulic diversity would be high, providing better conditions for a wider diversity of fish species then were present; the water is oligotrophic. Many fish would migrate into the upper reaches of the river for breeding purposes, so a high proportion of different sized fish would be expected. Shallow (and deeper) riffles would be dominated by demersal species such as *Chiloglanis* and *Amphilius*, together with benthopelargic species such as the *Labeos*. Deeper pools would be dominated by *Labeobarbus*, some *Enteromius* spp, *Labeo* and *Clarias*. | 4 |

### 4.3.4 Causes and sources of PES at 3_Olifantspruit

Causes and sources for the Present Ecological State at 3_Olifantspruit are summarised in Table 4.17.

**Table 4.17 Causes and sources of PES at 3_Olifantspruit**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Moderate increase in salinity and nutrients probably caused by irrigation return flows. | Irrigation return flows. | Non-flow. | 4 |
| Geomorphology | Increased erosion along channel margins with siltation in pools. | Localised farming, areas with bare soil, roads and widespread grazing; localised farm dams. | Flow. | 3 |
| Vegetation | Altered species composition. | Alien plant species (high at this site and includes woody perennial species). | Non-flow. | 5 |
| | Increased woody cover and abundance. | Alien plant species (high at this site and includes woody perennial species). | Non-flow. | 4 |
| Macroinvertebrates | Water quality & instream habitat modification | Potential nutrient enrichment. | Non-flow. | 3 |
| Fish | Degraded water quality. | Surrounding land users/ catchment management. | Non-flow. | 4 |
| | Instream barriers inhibiting migrations and recruitment from downstream. | Barriers = gauging weir downstream of the site. | Flow. | 4 |

### 4.3.5 Trends

Trends in the Present Ecological State for all components of 3_Olifantspruit are summarised in Table 4.18.

**Table 4.18 Trends in the PES for 3_Olifantspruit**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Moderate negative (increasing) trend in electrical conductivity & nutrients. | 4 |
| Geomorphology | Negative, channel scour and siltation increasing. | 3 |
| Vegetation | Negative, the perennial alien plant species are invasive and will increase if left unchecked. | 4 |
| Macroinvertebrates | Absent, ASPT stable, slight decrease in total SASS score. | 2 |
| Fish | Negative, the gauging weir downstream limits migration of fish into the upper reaches, which fish abundance and diversity. | 4 |

### 4.3.6 EcoStatus (2022)

The Present Ecological Status of each component at 3_Olifantspruit is summarised below in Table 4.19.

**Table 4.19 Present Ecological Status of all components at 3_Olifantspruit**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 87.3 | B | B |
| Geomorphology | 76.0 | C | C |
| Vegetation | 57.3 | D | C/D |
| Macroinvertebrates | 79.7% | B/C | B/C |
| Fish | 76.9 | C | B/C |
| PES score | 75.4 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **C** | | |
| Mitigation to achieve REC | Intergovernmental co-operation to manage alien vegetation and sedimentation. | | |

## 4.4 EWR site 4_Mogalakwena1

This site is situated downstream of the confluence with the Sterk River, and it is at the downstream end of the IUA, so captures all the incremental effects of the upstream activities. Ecologically the site was in a moderate to poor condition because of poor water quality and some disturbance to the riparian vegetation and the channel banks. Site conditions during low and high flow are depicted in Figure 4.4.

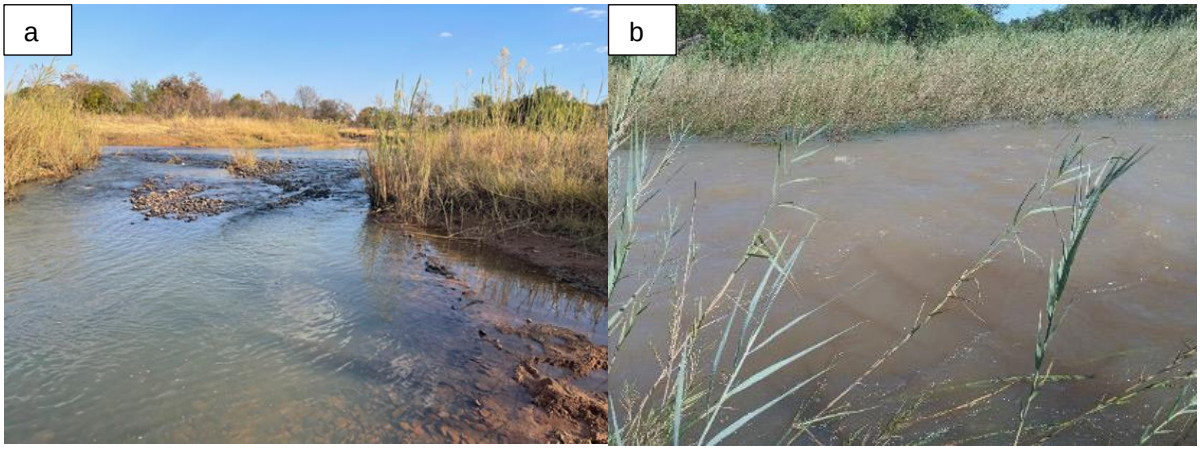


**Figure 4.4 4_Mogalakwena1, Ri5, Upper Nyl/ Sterk IUA, a=low flow conditions, b=high flow conditions**

### 4.4.1 Data availability

The data available at 4_Mogalakwena1 are summarised in Table 4.20. The confidence rating used in the report is described in Table 4.1.

**Table 4.20 Data available at 4_Mogalakwena1**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | WMS 1000004273 (2008-2017) N = 21 for electrical conductivity | 2 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | Macroinvertebrate data collected for this project. | 3 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.4.2 Ecological importance and sensitivity

The EIS of 4_Mogalakwena1, with motivations, is provided in Table 4.21.

**Table 4.21 EIS of 4_Mogalakwena1**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 0.00 | VEG: None. FISH: Reference data indicate there are some species but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Unique | 0.50 | VEG: *Combretum erythrophyllum* (SnA endemic). FISH: Reference data indicate there are some species but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: None. FISH: Many fish species are flow habitat specialists, many preferring fast shallow habitats. INVERTS: Many taxa are dependent on flowing water for part of their life cycles. |
| Taxon richness | 2.00 | VEG: There are 16 indigenous riparian species. FISH: Reference data show many species but samples collected were less diverse. INVERTS: There are 53 taxa under natural conditions and 41 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 2.50 | VEG: Pool-riffle/run, woody banks, with flood bench and floodplain, complex at confluence. FISH: High diversity. INVERTS: Instream habitat dominated by cobbles, GSM and marginal vegetation mostly graminoids. |
| Refugia | 2.00 | VEG: None. FISH: High level. INVERTS: Moderate refugia available given the composition of the existing instream habitat. |
| Sensitivity to change in flows | 2.00 | VEG: None. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Some habitat sensitive to flow changes. |
| Sensitivity to change in water quality | 3.00 | VEG: None. FISH: Relatively small watercourse and therefore limited buffer capacity to tolerate changes. INVERTS: Some habitat sensitive to water quality related flow changes. |
| Migration route/corridor | 1.00 | VEG: Corridor functionality intact in places but community is fragmented. FISH: A generally open and longitudinally connected watercourse that would promote migration movements in support of breeding and dispersal. INVERTS: No instream migratory invertebrate taxa but Odonata may use the riparian zone as a corridor. |
| Importance of conservation and natural areas | 1.00 | VEG: Low. FISH: Much of the catchment area falls within natural areas that cumulatively act to conserve the resource. INVERTS: Open areas present, may be of importance on a local scale. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.4.3 Reference condition

The expected reference condition of 4_Mogalakwena1 is described in Table 4.22.

**Table 4.22 Reference condition at 4_Mogalakwena1**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | The Mogalakwena River in its reference state would probably be in a B water quality category due to its location in the middle reaches of the catchment. It would have naturally low to moderate nutrient and salt concentrations, and low turbidity. | 3 |
| Geomorphology | The Mogalakwena River in its reference state is a lower gradient alluvial cobble and sand bed channel with limited lateral migration along a partly confined valley setting, resulting in a straight to wandering channel and pool-riffle reach types. Sand bars are common in pools, with pool length exceeding riffle length. A floodplain is often present with banks of a moderate gradient with inset benches. Based on the historical images, it can be seen that the planform has adjusted laterally, possibly after river training took place earlier in the century. The channel seems larger in the recent air photo, possibly due to increased flood runoff. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Central Bushveld Bioregion and Makhado Sweet Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. As shown from historical aerial photographs dating back to 1965 this zone appears as a narrow channel not dominated by woody vegetation, but rather a mix of open alluvia and non-woody vegetation, notably reeds. Similarly, the flood bench is expected to be dominated by reeds with varying degrees of density, or open area of un-vegetated alluvia/ gravels depending on when last flooding disturbance occurred. Also apparent from historical aerial photographs for this reach of the Mogalakwena beyond the active channel is the expected dominance by short to tall, open or dense woody vegetation (trees and shrubs) forming a clear riparian zone. | 3 |
| Macroinvertebrates | SASS Total Score 200, ASPT 7. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 4 |
| Fish | This site was at the confluence of two streams, implying that a wide diversity of fish species should be present if the habitat types supported it. Shallow riffles with a gravel and cobble substrate would support the typical demersal species of the system, namely *Chiloglanis paratus* and *C. pretoriae*. Deeper riffles with a similar substrate would support stronger-swimming *Enteromius* spp, together with *Labeos* and *Labeobarbus marequensis*. The transitional flow zones would see shoals of *Micralestes acutidens*, juvenile *Labeobarbus*, juvenile *Labeo* spp. Deeper pools would occur, which would be dominated by pelagic species such as *Schilbe intermedius* and the benthopelagic *Clarias gariepinus*, whereas the peripheral zones and those areas that offer good vegetation cover or cover from snagged debris would be dominated by cichlid species, and the weaker-swimming *Enteromius* spp. *Micropanchax johnstonii* would occur in shallow to deeper peripheral areas away from strong currents in zones that offer good cover from predators. | 4 |

### 4.4.4 Causes and sources of PES at 4_Mogalakwena

Causes and sources for the Present Ecological State at 4_Mogalakwena1 are summarised in Table 4.23.

**Table 4.23 Causes and sources of PES at 4_Mogalakwena1**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Probable increase in salinity and nutrients. | Mining and WWTW effluents and irrigation return flows. | Non-flow. | 3 |
| Geomorphology | Sedimentation of pools and low velocity habitat, trampling, bank disturbance where river is accessed. | Localised farming, settlements with bare soil, roads and widespread grazing. Localised farm dams in upper catchment. | Non-flow. | 3 |
| Vegetation | Altered species composition. | Annual and perennial alien plant species. | Non-flow. | 5 |
| | Increased reed density and cover. | Flow regulation and reduction, flood peak reduction. | Flow. | 3 |
| | Bush encroachment of flood features (mainly *D. cinerea).* | Flow regulation and reduction, flood peak reduction. | Flow. | 3 |
| Macroinvertebrates | Water quality, instream habitat modification. | Nutrient enrichment from upstream settlements, towns, agriculture, livestock watering, mining. | Non-flow. | 4 |
| Fish | Sedimentation of substrates. | Catchment land use (mining & informal residential sectors), with poor catchment management. | Non-flow. | 4 |
| | Water quality degradation (general & turbidity). | | | 4 |

### 4.4.5 Trends

Trends in the Present Ecological State for all components of 4_Mogalakwena1 are summarised in Table 4.24.

**Table 4.24 Trends in the PES for 4_Mogalakwena1**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Probably negative (increasing) trend due to cumulative impacts of WWTW and mining upstream of the site. | 2 |
| Geomorphology | Negative, bank erosion and habitat modification is ongoing. | 3 |
| Vegetation | Negative, because the perennial alien plant species are invasive and will increase if left unchecked. | 3 |
| Macroinvertebrates | Negative, decrease in total SASS scores and number of taxa, ASPT is more stable. | 3 |
| Fish | Negative, ongoing negative trends in water quality and geomorphology, eroding river banks. | 4 |

### 4.4.6 EcoStatus (2022)

The Present Ecological Status of each component at 4_Mogalakwena1 is summarised below in Table 4.25.

**Table 4.25 Present Ecological Status of all components at 4_Mogalakwena1**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 68.8 | C | B/C |
| Geomorphology | 67.0 | C | C |
| Vegetation | 61.6 | C/D | C/D |
| Macroinvertebrates | 73.1 | C | C |
| Fish | 72.1 | C | C |
| PES score | 68.5 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **C** | | |
| Mitigation to achieve REC | Management toward sustainable land use practices and alien vegetation clearing. Management of wastewater treatment works. | | |

## 4.5 EWR site 5_Mogalakwena2

This site is one of the REMP sites and it is strategically important because it is downstream of Glen Alpine Dam. The site is good ecologically because the riparian vegetation is in relatively good condition, despite there being some exotic plants, and the channel has a nice range of aquatic habitat for invertebrates and fish (Figure 4.5).

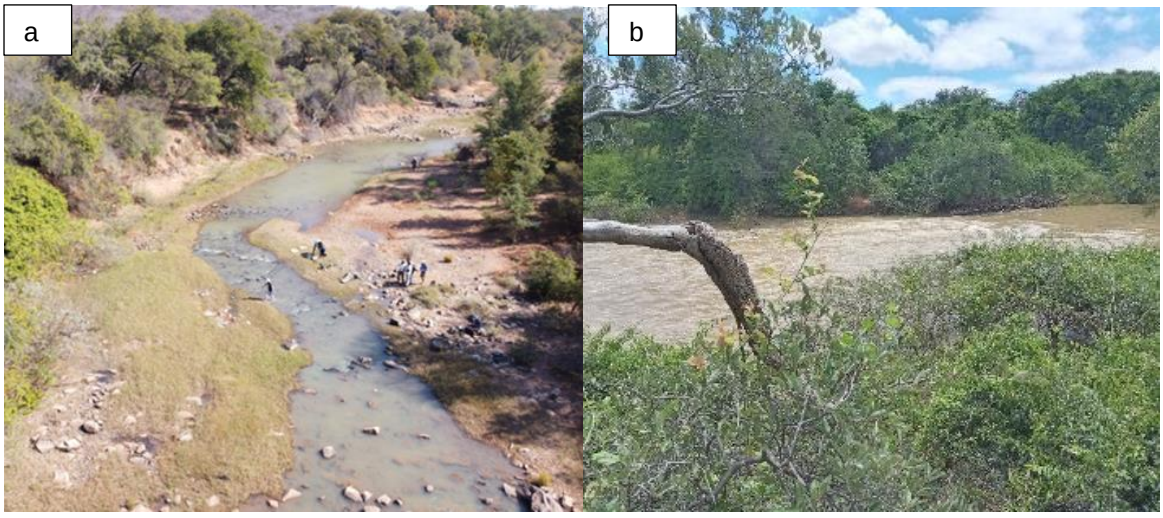


**Figure 4.5 5_Mogalakwena2, Ri14, Mogalakwena IUA, a=low flow conditions, b=high flow conditions**

### 4.5.1 Data availability

The data available at 5_Mogalakwena2 are summarised in Table 4.26. The confidence rating used in the report is described in Table 4.1.

**Table 4.26 Data available at 5_Mogalakwena2**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | A6R002Q01 (2008-2018) n=127 (DWS WMS database). | 4 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | 13 data sets from April 2018 (DWS Regional Office and RQIS). | 5 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.5.2 Ecological importance and sensitivity

The EIS of 5_Mogalakwena2, with motivations, is provided in Table 4.27.

**Table 4.27 EIS of 5_Mogalakwena2**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 1.50 | VEG: 3 Nationally protected species: Apple Leaf (*Philenoptera violacea*), Leadwood (*Combretum imberbe*) and Camel Thorn (*Vachellia erioloba* ). FISH: Reference data indicate there may be but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Unique | 0.50 | VEG: *Schotia brachypetala* (SnA endemic). FISH: Reference data indicate there may be but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Marginal zone grasses (*Ischaemum fasciculatum*) and sedges (*Juncus lomatophyllus*). FISH: Many fish species are flow habitat specialists, many prefer fast shallow habitats. INVERTS: Many taxa dependent on flowing water during part/most of their life cycle. |
| Taxon richness | 2.00 | VEG: There are 22 indigenous riparian species. FISH: Ref indicates, but surveys showed lesser diversity. INVERTS: There are 51 taxa under natural conditions and 43 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 2.00 | VEG: Pool-riffle/run, woody banks, with flood bench. FISH: High diversity. INVERTS: Instream habitat dominated by cobbles, GSM, some graminoids. |
| Refugia | 2.00 | VEG: None. FISH: High level. INVERTS: Moderate refugia available given the composition of the existing instream habitat. |
| Sensitivity to change in flows | 2.00 | VEG: Marginal zone. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Some habitat sensitive to flow changes. |
| Sensitivity to change in water quality | 3.00 | VEG: Marginal zone. FISH: Relatively small watercourse and therefore limited buffer capacity to tolerate changes. INVERTS: Some habitat sensitive to water quality related flow changes. |
| Migration route/corridor | 1.50 | VEG: Corridor functionality generally intact. FISH: A generally open and longitudinally connected watercourse that would promote migration movements in support of breeding and dispersal. INVERTS: No instream migratory invertebrate taxa but Odonata may use the riparian zone as a corridor. |
| Importance of conservation and natural areas | 2.00 | VEG: Moderate due to protected species and stability over time. FISH: Much of the catchment area falls within natural areas that cumulatively act to conserve the resource. INVERTS: Open areas present, may be of importance on a local scale. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.5.3 Reference condition

The expected reference condition of 5_Mogalakwena2 is described in Table 4.28.

**Table 4.28 Reference condition at 5_Mogalakwena2**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | The Mogalakwena River in its reference state would probably be in a B water quality category due to its location in the middle reaches of the catchment. It would have naturally low to moderate nutrient and salt concentrations, and low turbidity. | 3 |
| Geomorphology | The Middle Mogalakwena River in its reference state is a lower gradient alluvial boulder and cobble bed channel with limited lateral migration along a confined valley setting, resulting in a straight to wandering channel pattern and pool-riffle reach types. Sand bars can be common in pools, with the pool length exceeding riffle length. A narrow floodplain is often present with banks of a moderate gradient with inset benches. Based on the aerial images, it seems that the channel has contracted with increased vegetation on bars over the past ~60 years. | 3 |
| Vegetation | The site occurs in the Savanna Biome, Central Bushveld Bioregion and Limpopo Sweet Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. As shown from historical aerial photographs dating back to 1957 this zone appears as a narrow channel not dominated by woody vegetation, but rather a mix of open presumably alluvial and non-woody vegetation. Reeds are in the system, as seen along the upstream Mogalakwena site, but are absent at this site. This is unexpected and may be related to flushing/ scouring from Glen Alpine dam. Similarly, the flood bench is expected to be dominated by non-woody vegetation of varying degrees of density, including reeds, or open area of un-vegetated alluvia/ gravels depending on when last flooding disturbance occurred. Since *Salix mucronata* is in the system a woody component is expected with taller, but scattered individuals. Also apparent from historical aerial photographs for this reach of the Mogalakwena beyond the active channel is the expected dominance by short to tall, open or dense woody vegetation (trees and shrubs) forming a clear riparian zone. | 3 |
| Macroinvertebrates | SASS Total Score 180, ASPT 6.5. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 5 |
| Fish | There were a wide diversity of habitat types and hydraulic conditions so a high species diversity and abundance would be expected. Peripheral flood benches with good cover of grasses and sedges would support many juveniles where they are safe from harsh currents and predators. Fast-deep flow over boulders and cobble would support stronger-swimming adult and sub-adult *Labeobarbus marequensis* and *Labeos*, together with the demersal *Chiloglanis* spp. The hydraulically quieter peripheral zones would support a variety of *Enteromius* spp, together with *Micralestes acutidens* and many juvenile *Labeobarbus* and *Labeo* species. Sheltered zones in the lee of large boulders, snagged debris and vegetation would support a variety of smaller *Enteromius* species and many cichlids. Gaps between submerged boulders in slow flow would support cichlid species such as *Tilapia sparrmanii*. Undercut banks with high vegetation cover would be inhabited mostly by species such as *Marcusenius macrolepidotus*. Open waters would be dominated by *Schilbe intermedius, Coptodon rendalii, Synodontis zambazensis,* and *Labeo molybdinus.* | 4 |

### 4.5.4 Causes and sources of PES at 5_Mogalakwena2

Causes and sources for the Present Ecological State at 5_Mogalakwena2 are summarised in Table 4.29.

**Table 4.29 Causes and sources of PES at 5_Mogalakwena2**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Increase in salinity, no trends in nutrients, cold water discharges and possible anoxic outflow from Glen Alpine Dam. | Urban sprawl upstream of dam, operations of the dam (bottom outlet). | Non-flow. | 4 |
| Geomorphology | Channel narrowing, bar stabilisation, sedimentation of pools. | ~5k downstream of Glen Alpine dam trapping coarse bedload and reducing flood flows. | Non-flow. | 3 |
| | Trampling and bank erosion. | Localised overgrazing and trampling. | | |
| Vegetation | Altered species composition. | Annual and perennial alien plant species. | Non-flow. | 5 |
| | Altered species composition. | Flow regulation and reduction, flood peak reduction. | Flow. | 3 |
| Macroinvertebrates | Water quality impacts. | Human settlements, livestock watering, agriculture. | Non-flow. | 4 |
| | Flow modification. | Downstream of Glen Alpine Dam. | Flow. | |
| Fish | Sedimentation of substrates. Water quality degradation (general turbidity from catchment). | Catchment land use (agriculture). | Non-flow. | 4 |

### 4.5.5 Trends

Trends in the Present Ecological State for all components of 5_Mogalakwena2 are summarised in Table 4.30.

**Table 4.30 Trends in the PES for 5_Mogalakwena2**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Negative (increasing) trend in salinity, none in nutrients. Strong seasonality in salinity. | 4 |
| Geomorphology | Negative, siltation and channel contraction is likely to continue/worsen. | 3 |
| Vegetation | Negative because the perennial alien plant species are invasive and will increase if left unchecked. | 3 |
| Macroinvertebrates | Absent, no discernible trends visible in the data. | 3 |
| Fish | Negative, continued degrading water quality and habitat conditions. | 4 |

### 4.5.6 EcoStatus (2022)

The Present Ecological Status of each component at 5_Mogalakwena2 is summarised below in Table 4.31.

**Table 4.31 Present Ecological Status of all components at 5_Mogalakwena2**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 80.6 | B/C | B/C |
| Geomorphology | 55.0 | D | C/D |
| Vegetation | 70.5 | C | C |
| Macroinvertebrates | 75.8 | C | C |
| Fish | 91.7 | A/B | A/B |
| PES score | 74.7 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **C** | | |
| Mitigation to improve the REC | Improvements in land use practices (agriculture), such as rotation of cattle feeding areas. | | |

## 4.6 EWR site 6_Kolope

This site is on a non-perennial river on the largest of three rivers in this IUA. It is located in the Mapungubwe National Park. Figure 4.6 shows the distinct change in river during the dry and wet season.

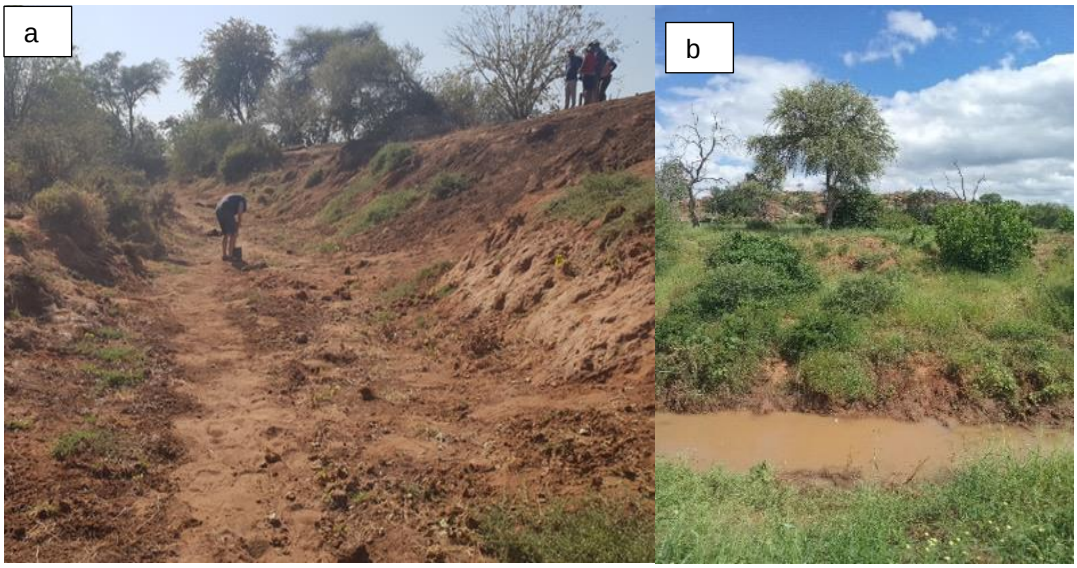


**Figure 4.6 6_Kolope, Riv32, Mogalakwena IUA, a=dry season, b=wet season**

### 4.6.1 Data availability

The data available at 6_Kolope are summarised in Table 4.32. The confidence rating used in the report is described in Table 4.1.

**Table 4.32 Data available at 6_Kolope**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | No water quality monitoring of tributaries in A63E catchment. A qualitative assessment was done. | 2 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | N/A, no water was present so no samples were taken. | |
| Fish | Fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 3 |

### 4.6.2 Ecological importance and sensitivity

The EIS of 6_Kolope, with motivations, is provided in Table 4.33.

**Table 4.33 EIS of 6_Kolope**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 1.50 | VEG: 2 protected tree species at the National scale: *Combretum imberbe* and *Philenoptera violacea*. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: We do not have the information to assess this. |
| Unique | 0.50 | VEG: None. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 2.00 | VEG: None. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Taxon richness | 1.50 | VEG: 11 indigenous riparian and wetland species. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Instream and riparian habitats | | |
| Diversity | 1.50 | VEG: Woody banks and alluvial bench, ephemeral alluvial channel. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Refugia | 2.00 | VEG: Protected riparian tree species. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Sensitivity to change in flows | 1.50 | VEG: None. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Sensitivity to change in water quality | 2.00 | VEG: None. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Migration route/corridor | 1.25 | VEG: Fragmented. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Importance of conservation and natural areas | 3.50 | VEG: Mapungubwe National Park. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| MEDIAN | 1.50 | |
| EIS | **MODERATE** | |

### 4.6.3 Reference condition

The expected reference condition of 6_Kolope is described in Table 4.34.

**Table 4.34 Reference condition at 6_Kolope**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | In its reference state, the Kolope River would have the water quality characteristics of a non-perennial river. When there is the occasional flow, the water would have moderate salinity and nutrient concentrations, and high suspended sediment concentrations. When pools start to form, the salinity would increase due to evaporative concentration of salts in the pools. Clarity would increase in the pools and internal nutrient cycling would become the dominant process driving primary production (Day et al., 2019). | 3 |
| Geomorphology | Based on its river slope, the Kolope River in its reference state is a low gradient mixed bed channel with limited lateral migration along a partly confined valley setting, resulting in a straight-to-wandering channel and plain-bed and pool-riffle reach types. Gravel and sand are the main bed sediment types with a flat sand bed along lower gradient reaches. A narrow floodplain is often present, composed of sand and silt, with banks of a moderate gradient with inset benches present. Under natural conditions, the system could be less incised, but the drivers of the incision are not clear at present. From the historical aerial images it can be seen that the Kolope River has incised with widespread gully erosion propagating upstream into the pan. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Mopane Bioregion and Musina Mopane Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. Historically the channel did not appear as open as it is now *c* 1955 aerial photographs where the channel was more woody. It is likely that this woody cover was more overhanging from woody bank species than woody species growing in the channel. More recently the channel appears as a narrow confined, sandy, mostly dry riverbed with little to no vegetation that would be non-woody. The flood bench is expected to be dominated by woody vegetation, mostly shrubs or short trees including *Combretum microphyllum, Flueggea virosa, Lycium cinereum, Salvadora australis* and *Vachellia tortilis*. Similarly the macro-channelbank is also expected to be densely woody with taller trees and shrubs including *Combretum imberbe, Croton megalobotrys Dichrostachys cinerea Philenoptera violacea Vachellia tortilis* and *Xanthocercis zambesiaca.* | 3 |
| Macroinvertebrates | N/A. | |
| Fish | Fish occur during mid-summer to early autumn when water flows. There are permanent pools further upstream fed by tributaries where *Amphilius uranoscopus* occur. Opportunistic species and those that tend to migrate during the summer cycle would migrate upstream when the river is flowing to breed. This sand/gravel system would support substrate dwellers such as *Chiloglanis* spp. The data describe larger-bodied species that inhabit isolated pools. A variety of *Enteromius* spp would migrate upstream from the Limpopo River when flow within the Kolope begins, together with other shoaling species such as *Brycinus imberi, Engraulicypris brevianalis* and *Micralestes acutidens*. The typical migrators within the system, such as *Labeobarbus marequensis* would be present, together with *Clarias gariepinus* and a variety of Cichlid species. The watercourse would support a relatively high diversity of species as it feeds directly into the Limpopo River, which is known to support a high species diversity, but in relatively low abundance. | 3 |

### 4.6.4 Causes and sources of PES at 6_Kolope

Causes and sources for the Present Ecological State at 6_Kolope are summarised in Table 4.35.

**Table 4.35 Causes and sources of PES at 6_Kolope**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Probable increase in salinity due to non-perennial nature of tributaries. | Evaporation and increase in salinity. | Flow. | 3 |
| Geomorphology | Incision of the channel and bank erosion. | Widespread trampling and bank erosion. | Non-flow. | 2 |
| Vegetation | Altered species composition. | Alien plant species (minimal at this site and limited to annual weed species). | Non-flow. | 5 |
| | Reduced woody cover and abundance. | High impacts by elephants. | Non-flow. | 4 |
| Macroinvertebrates | N/A. | | | |
| Fish | Sedimentation is a major driver within the system. Assumed high turbidity levels also due to this. | Catchment land use that aggravates soil erosion, smothering of habitat and increase in turbidity. | Non-flow. | 3 |

### 4.6.5 Trends

Trends in the Present Ecological State for all components of 6_Kolope are summarised in Table 4.36.

**Table 4.36 Trends in the PES for 6_Kolope**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Absent, no data. | 3 |
| Geomorphology | Negative, bank and incision is likely to increase. | 3 |
| Vegetation | Absent, because the alien plant species present were minimal and mostly annual weeds. | 3 |
| Macroinvertebrates | N/A, was no surface water. | |
| Fish | N/A, was no surface water. | |

### 4.6.6 EcoStatus (2022)

The Present Ecological Status of each component at 6_Kolope is summarised below in Table 4.37.

**Table 4.37 Present Ecological Status of all components at 6_Kolope**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 79.4 | B/C | B/C |
| Geomorphology | 57.0 | D | C/D |
| Vegetation | 73.1 | C | B/C |
| Macroinvertebrates | N/A | | |
| Fish | N/A | | |
| PES score | 69.8 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **C** | | |
| Mitigation to achieve PES | Rehabilitation and improvement of trampling pressures, add gabions. Manage effects of wildlife such as elephants. | | |

## 4.7 EWR site 7_Sand

This site is downstream of intensive dryland and irrigated agriculture and is at the outlet of the Upper Sand IUA. This site flows naturally, it is in a good ecological condition and is non-perennial (Figure 4.7).

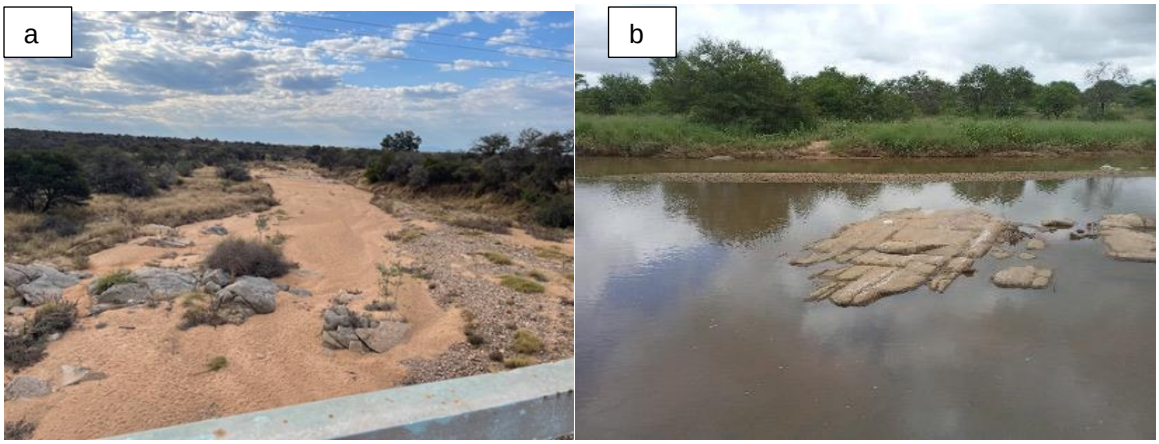


**Figure 4.7 7_Sand, Ri20, Upper Sand IUA, a=dry season, b=wet season**

### 4.7.1 Data availability

The data available at 7_Sand are summarised in Table 4.38. The confidence rating used in the report is described in Table 4.1.

**Table 4.38 Data available at 7_Sand**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | No water quality monitoring near the EWR site. Nearest points downstream of EWR site is about 40km, nearest one upstream of EWR site is some 60km away. Qualitative assessment was done. | 2 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | N/A. | |
| Fish | Fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 3 |

### 4.7.2 Ecological importance and sensitivity

The EIS of 7_Sand, with motivations, is provided in Table 4.39.

**Table 4.39 EIS of 7_Sand**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 0.50 | VEG: None. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: We do not have the information to assess this. |
| Unique | 1.00 | VEG: *Combretum erythrophyllum* (SnA endemic). FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 2.00 | VEG: None. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Taxon richness | 1.50 | VEG: 15 indigenous riparian species. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Instream and riparian habitats | | |
| Diversity | 1.50 | VEG: ephemeral sandy / bedrock channel, woody banks, flood bench (consolidated). FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A |
| Refugia | 1.00 | VEG: None. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A |
| Sensitivity to change in flows | 2.00 | VEG: None. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A |
| Sensitivity to change in water quality | 2.00 | VEG: None. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A |
| Migration route/corridor | 1.75 | VEG: Corridor functionality generally intact. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| Importance of conservation and natural areas | 1.25 | VEG: Low. FISH: As "natural" is based on reference data, the "Present Ecological State" is matched, but with low confidence. INVERTS: N/A. |
| MEDIAN | 1.50 | |
| EIS | **MODERATE** | |

### 4.7.3 Reference condition

The expected reference condition of 7_Sand is described in Table 4.40.

**Table 4.40 Reference condition at 7_Sand**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | The Sand River in its reference state would probably be in a B water quality category due to its location in the middle reaches of the catchment. It would have naturally low to moderate nutrient and salt concentrations, and low turbidity. | 3 |
| Geomorphology | In its reference condition, based on channel gradient, the Sand River should be a low-gradient alluvial fine bed channel with limited lateral migration along unconfined reaches, resulting in a straight-to-wandering channel, with a braided pattern at very low flows. Deeper channels, pools and vegetated or bare (recently deposited) inset benches provide habitat along the margins. The bank will have a moderate gradient and will have a narrow active floodplain, set between the higher-lying terraces. From the historic aerial images, it would suggest that infrastructure (bridge and roads) has increased with the channel remaining dominated by sand and possibly less perennial. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Central Bushveld Bioregion and Makhado Sweet Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. The Sand River is ephemeral and as shown from historical aerial photographs dating back to 1937 this zone appears as an open sandy channel not dominated by woody vegetation, or with much non-woody vegetation. The flood bench is expected to be dominated by non-woody vegetation, mostly grasses with varying degrees of woody encroachment that should be held at bay by flooding with the correct frequency and magnitude. Also apparent from historical aerial photographs for this reach of the Sand beyond the active channel is the expected dominance by short to tall, open or dense woody vegetation (trees and shrubs) forming a clear riparian zone which is expected to be un-fragmented along the river's length. | 3 |
| Macroinvertebrates | N/A, not sampled because the river was dry. | |
| Fish | The Sand River supports fish from mid-summer to early autumn when water is flowing. Receding water would stimulate fish to migrate back downstream again, although many individuals would be stranded in isolated pools. Opportunistic species and those that tend to migrate during the summer cycle would migrate upstream when the river is flowing to breed. Being a sand/gravel dominated system, substrate dwellers (demersal species such as *Chiloglanis paratus* & *C. pretoriae*) would be limited, the community would be dominated by open water species such as *Schilbe intermedius,* surface-dwelling species such as *Enteromius* spp, benthopelagic fish such as Cichlids, *Labeobarbus, Clarias* and *Enteromius* spp. The watercourse would support a limited diversity of species in relatively low abundance. | 3 |

### 4.7.4 Causes and sources of PES at 7_Sand

Causes and sources for the Present Ecological State at 7_Sand are summarised in Table 4.41.

**Table 4.41 Causes and sources of PES at 7_Sand**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | No data, probably negative trend in salts and nutrients. | Evaporation, WWTW and mining effluents around Polokwane & Seshego about 60km upstream of EWR site. | Non-flow. | 3 |
| Geomorphology | Increased silt load, bed and bank disturbance. | Widespread grazing, settlements, roads; sand mining; river access and trampling. | Non-flow. | 2 |
| Vegetation | Altered species composition. | Annual and perennial alien plant species. | Non-flow. | 5 |
| Macroinvertebrates | N/A. | | | |
| Fish | N.A. | | | |

### 4.7.5 Trends

Trends in the Present Ecological State for all components of 7_Sand are summarised in Table 4.42.

**Table 4.42 Trends in the PES for 7_Sand**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | No data, probably negative trend in salts and nutrients. | 3 |
| Geomorphology | Absent, geomorphic processes are in balance. | 3 |
| Vegetation | Stable, because the alien plant species present were minimal and most annual weeds. | 3 |
| Macroinvertebrates | N/A, was no surface water. | |
| Fish | N/A, was no surface water. | |

### 4.7.6 EcoStatus (2022)

The Present Ecological Status of each component at 7_Sand is summarised below in Table 4.43.

**Table 4.43 Present Ecological Status of all components at 7_Sand**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 53.5 | D | C/D |
| Geomorphology | 77.0 | C | B/C |
| Vegetation | 69.7 | C | C |
| Macroinvertebrates | N/A | | |
| Fish | N/A | | |
| PES score | 66.7 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **C** | | |
| Mitigation to achieve REC | Improvement in catchment management. | | |

## 4.8 EWR site 8_Nzhelele

This site is one of the REMP sites situated on the lower end of the Nzhelele River and is a good representative for the incremental impacts of the activities upstream. It is situated in a conservation area. Figure 4.8 shows the site during the dry season and wet season.

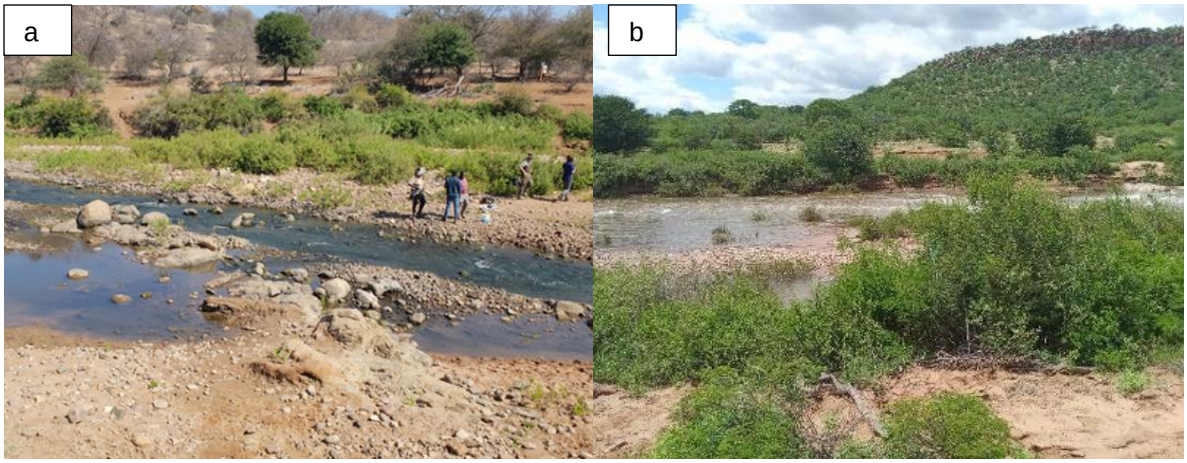


**Figure 4.8 8_Nzhelele, Ri27, Nzhelele/Ṅwaneḍi IUA, a=low flow conditions, b=high flow conditions**

### 4.8.1 Data availability

The data available at 8_Nzhelele are summarised in Table 4.44. The confidence rating used in the report is described in Table 4.1.

**Table 4.44 Data available at 8_Nzhelele**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | WMS 194545 & 194544 combined (2008-2018) n=8 for electrical conductivity | 2 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | 17 data sets available since April 2021 (DWS Regional Office and RQIS). | 5 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.8.2 Ecological importance and sensitivity

The EIS of 8_Nzhelele, with motivations, is provided in Table 4.45.

**Table 4.45 EIS of 8_Nzhelele**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 0.75 | VEG: Leadwood (*Combretum imbirbe*) and Apple Leaf (*Philonoptera violaceae*) are protected national tree species. FISH: Reference data indicate there may be but none was captured in the samples. INVERTS: We do not have the information to assess this. |
| Unique | 0.00 | VEG: None. FISH: Reference data indicate there may be but none was captured in the samples. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Wetland sedges and grasses. FISH: Many fish species are flow habitat specialists, many prefer fast shallow habitats. INVERTS: Many taxa are dependent on flowing water for part of their life cycle. |
| Taxon richness | 3.00 | VEG: There are 25 indigenous riparian species. FISH: Reference data and samples collected indicator high fish diversity. INVERTS: There are 58 taxa under natural conditions and 42 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 2.00 | VEG: Pool-riffle/run, reed beds and woody banks, with flood bench and channels. FISH: High diversity. INVERTS: Instream habitat dominated by cobbles, GSM and graminoids. |
| Refugia | 2.00 | VEG: None. FISH: High level. INVERTS: Moderate refugia available given the composition of the existing instream habitat. |
| Sensitivity to change in flows | 2.00 | VEG: Marginal zone species. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Some habitats are sensitive to flow changes. |
| Sensitivity to change in water quality | 3.00 | VEG: Potentially to nutrients for e.g. reeds. FISH: Relatively small water volumes that limits buffer capacity to changes. INVERTS: Some habitat sensitive to water quality related flow changes. |
| Migration route/corridor | 2.00 | VEG: Moderately intact. FISH: Historically important but instream barriers have decreased the relevance of this watercourse to support migrations. INVERTS: Paleomonidae occur within the system, as well as Odonata that may use the riparian zone as a corridor. |
| Importance of conservation and natural areas | 3.00 | VEG: Upstream Reserve and intact corridor, with game farming in the area. FISH: Much of the catchment area falls within privately owned land with a conservation-based ethos. INVERTS: Within a regional conservation area, the Maremani Nature Reserve. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.8.3 Reference condition

The expected reference condition of 8_Nzhelele is described in Table 4.46.

**Table 4.46 Reference condition at 8_Nzhelele**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | In its reference water quality state, the lower Nzhelele River would probably have been in a B water quality category due to its location in the catchment, and the semi-arid nature of the area. The river would have exhibited strong seasonal fluctuations in quality. | 3 |
| Geomorphology | The Nzhelele River in its reference state is a low-gradient mixed bed channel with limited lateral migration along a partly confined valley setting, resulting in a straight-to-wandering channel and pool-rapid and pool-riffle reach types. Cobble, gravel and sand are the main sediment types along the riffle with a sand bed along lower gradient pool sections. Bedrock is locally present, forming steeper rapid sections. Sand bars are common in pools. Narrow flood benches are often present, composed of fine gravel, sand and silt, with banks of a moderate gradient with inset benches present. The historic images indicate that the riparian tree cover has been reduced with possible increases in reed extent. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Mopane Bioregion and Limpopo Ridge Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. The within channel habitats, including the marginal and lower zones are expected to be dominated by un-vegetated areas with some reeds associated with more consolidated alluvia, mostly non-woody but a woody component is also expected however, and should include shrubs such as *Pluchea bojeri* and *Gomphostigma virgatum* and trees such as *Breonadia salicina*. Cobble / gravel benches are expected to be unvegetated or with scant vegetation cover, mainly less flow sensitive species such as *C. sexangularis, P. mauritianus* or *Pluchea bojeri*. Alluvial benches are also expected to be mixed woody/ non-woody but with higher cover than cobble features and with a taller shrub / tree component. The macro-channel bank is expected to be dominated by open or dense woody dominated woodland or thicket (trees and shrubs), including riparian and terrestrial species, with a well-developed understorey. | 3 |
| Macroinvertebrates | SASS Total Score 180, ASPT 6.5. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 5 |
| Fish | This river has a high diversity of habitat types and hydraulic conditions so a high species diversity and abundance is expected. Side channels and flood benches with grasses, sedges and woody debris would provide habitat for juveniles of many species. Fast, flow over cobbles would support stronger-swimming *Labeobarbus marequensis,* other *Labeos*, *Chiloglanis* spp and Anguilla spp. Slower-flowing areas would *Enteromius* spp, *Glossogobius* spp, *Engraulicypris brevianalis, Brycinus imberi, Micralestes acutidens* and juvenile *Labeobarbus* spp. and other Labeos. Natural pools would be dominated by Cichlids such as *Coptodon rendalii* and *Oreochromis mossambicus*, together with *Synodontis zambezensis* and *Schilbe intermedius*. Open water areas would support Hydrocinus vittatus, while slow flowing areas between boulders would support many smaller *Enteromius* species and cichlids such as *Tilapia sparrmanii*. *Micropanchax johnstonii* would occur in well-vegetated deeper areas on the channels edge. | 4 |

### 4.8.4 Causes and sources of PES at 8_Nzhelele

Causes and sources for the Present Ecological State 8_Nzhelele are summarised in Table 4.47.

**Table 4.47 Causes and sources of PES at 8_Nzhelele**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | High salinity. | Evaporation & irrigation return flows. | Flow. | 3 |
| | High nutrients. | Irrigation return flows. | Non-flow. | 3 |
| Geomorphology | Increased fine sediment input; bank erosion. | Increased fine sediment due to agriculture, bare areas, grazing and bank erosion; Nzhelele Dam trapping bedload; trampling by game. | Non-flow. | 3 |
| Vegetation | Altered species composition. | Annual and perennial alien plant species. | Non-flow. | 5 |
| | Reduced non-woody cover and increase shrub cover in-channel features. | Flow regulation and reduction, flood peak reduction. | Flow. | 3 |
| Macroinvertebrates | Water quality, instream habitat modification. | Nutrient enrichment, agriculture. | Non-flow. | 4 |
| Fish | Sedimentation of substrates. | Catchment land use (agriculture). | Non-flow. | 4 |
| | Instream barriers that inhibit migrations for both spawning and recruitment. | Weir downstream of EWR site. | Flow. | 4 |

### 4.8.5 Trends

Trends in the Present Ecological State for all components of 8_Nzhelele are summarised in Table 4.48.

**Table 4.48 Trends in the PES for 8_Nzhelele**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Moderate negative (increasing) trend at Nzhelele Dam in electrical conductivity & nutrients. Strong seasonality in electrical conductivity. | 4 |
| Geomorphology | Slight negative with ongoing bank erosion and siltation. | 3 |
| Vegetation | Absent, trend considered stable because the alien plant species present were minimal and mostly annual weeds. | 3 |
| Macroinvertebrates | Absent, no discernible trends visible in the data. | 3 |
| Fish | Absent, strong and diverse fish community, diverse habitat features. | 4 |

### 4.8.6 EcoStatus (2022)

The Present Ecological Status of each component at 8_Nzhelele is summarised below in Table 4.49.

**Table 4.49 Present Ecological Status of all components at 8_Nzhelele**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 71.2 | C | C |
| Geomorphology | 59.0 | C/D | C |
| Vegetation | 77.8 | C | C |
| Macroinvertebrates | 75..0 | C | C |
| Fish | 84.8 | B | B |
| PES score | 73.5 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **C** | | |
| Mitigation to achieve REC | Improvement of catchment management and agricultural practices. | | |

## 4.9 EWR site 9_Ṅwaneḍi

This site is one of the REMP sites in the lower reaches of the basin downstream of Cross Dam and upstream of the Vhembe Biosphere Reserve. Figure 4.9 illustrates the EWR site at low flow and high flow conditions.

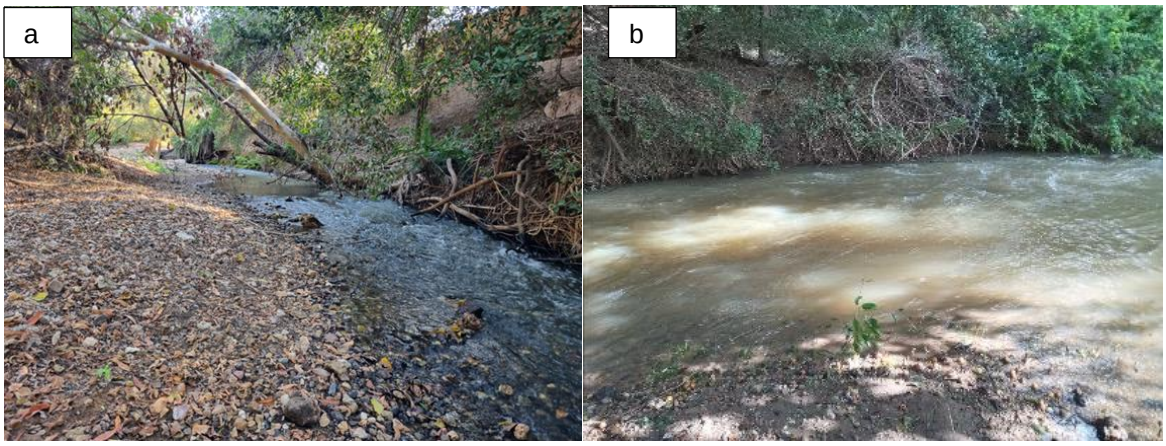


**Figure 4.9 9_Ṅwaneḍi, R28, Nzhelele/Ṅwaneḍi IUA, a=low flow conditions, b=high flow conditions**

### 4.9.1 Data availability

The data available at 9_Ṅwaneḍi are summarised in Table 4.50. The confidence rating used in the report is described in Table 4.1.

**Table 4.50 Data available at 9_Ṅwaneḍi**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | WMS 194545 & 194544 combined (2008-2018) n=8 for electrical conductivity | 3 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | 24 data sets since July 2017 (DWS Regional Office and RQIS). | 5 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.9.2 Ecological importance and sensitivity

The EIS of 9_Ṅwaneḍi, with motivations, is provided in Table 4.51.

**Table 4.51 EIS of 9_Ṅwaneḍi**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 0.50 | VEG: Matumi (*Breonadia salicina*) is a protected national tree species. FISH: Reference data suggest there may be but none were captured in the samples taken. INVERTS: We do not have the information to assess this. |
| Unique | 0.50 | VEG: *Buxus macowanii* (SA endemic) and *Schotia brachypetala* (SnA endemic). FISH: Reference data suggest there may be but none were captured in the samples taken. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Mostly absent. FISH: Many fish species are flow habitat specialists, many prefer fast shallow habitats. INVERTS: Many taxa dependent on flowing water for part of their life cycle. |
| Taxon richness | 3.00 | VEG: There are 21 indigenous riparian species. FISH: Reference data and samples collected showed comparable diversity. INVERTS: There are 63 taxa under natural conditions and 41 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 2.00 | VEG: Pool-riffle/run, woody banks, with flood bench. FISH: High diversity. INVERTS: Instream habitat dominated by cobbles, GSM, some graminoids and other broadleaved marginal vegetation. |
| Refugia | 2.00 | VEG: None. FISH: High level. INVERTS: Moderate refugia available given the composition of the existing instream habitat. |
| Sensitivity to change in flows | 2.00 | VEG: Mostly absent. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Some habitat sensitive to flow changes. |
| Sensitivity to change in water quality | 2.00 | VEG: None. FISH: Relatively small watercourse and therefore limited buffer capacity to tolerate changes. INVERTS: Some habitat sensitive to water quality related flow changes. |
| Migration route/corridor | 2.00 | VEG: Moderately intact corridor functionality. FISH: Many instream barriers, including a large impoundment upstream that block migration of fish. INVERTS: Paleomonidae occur within the system, as well as Odonata that may use the riparian zone as a corridor. |
| Importance of conservation and natural areas | 1.00 | VEG: Low. FISH: Low - much of the catchment is commercial farmland. INVERTS: Open areas present. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.9.3 Reference condition

The expected reference condition of 9_Ṅwaneḍi is described in Table 4.52.

**Table 4.52 Reference condition at 9_Ṅwaneḍi**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | In its reference water quality state, the lower Ṅwaneḍi River would probably have been in a B water quality category due to its location in its catchment, and the semi-arid nature of the area. The river would have exhibited strong seasonal fluctuations in quality. | 3 |
| Geomorphology | The Ṅwaneḍi River in its reference state is a low gradient mixed bed channel with limited lateral migration along a partly confined valley setting, resulting in a straight-to-wandering channel and plain-bed and pool-riffle reach types. Cobble, gravel and sand are the main sediment types along the riffle with a flat sand bed along lower gradient sections. Narrow flood benches are often present, composed of fine gravel, sand and silt, with banks of a moderate gradient with inset benches present. Under natural conditions, the system could be less incised. Not much can be learnt from the historical aerial images regarding the reference condition due to the dense tree canopy. | 2 |
| Vegetation | The site occurs within the Savanna Biome, Mopane Bioregion and Musina Mopane Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. As shown from historical aerial photographs dating back to 1937 this reach of the Ṅwaneḍi is expected to be dominated by tall woody and dense vegetation and because the channel is narrow and confined the marginal zone is expected to be well shaded with shade-loving species in low densities and opportunistic species in sun spots where disturbance has cleared out vegetation. Both the flood bench and macro-channel bank are expected to be dominated by dense tall tree and shrub, forming a clear riparian corridor along the narrow and confined channel, with deep shade preventing many of the otherwise non-woody species associated with the riparian zone, mainly due to confinement. | 3 |
| Macroinvertebrates | SASS Total Score 220, ASPT 6.5. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 5 |
| Fish | A relatively small forest stream that would incorporate a wide diversity of habitat types and hydraulic conditions. Substrates would be dominated by gravel and sand, with lesser inclusion of cobble. Boulders and bedrock would occur where rocky intrusions occur on the banks, but would also not be a dominant feature. Root wads and undercut banks, with high cover from overhanging vegetation would feature prominently, and would most likely be the driver behind the species diversity under natural/reference conditions. Deeper pools would occur at the naturally eroded bend points within the watercourse, which would support most of the occurrence of cichlid species and larger-bodied species such as Clarias gariepinus. Undercut banks and root wads would support a myriad of species, including *Marcusensius macrolepidotus, Petrocephalus wesselsi*, and a diversity of *Enteromius* spp, including *E. bifrenatus, E. neefi, E. topinii*, and *E. viviparus*. The watercourse would also support migratory routes of *Anguillia mossambica*. Zones of higher water velocity would support *Chiloglanis pretoriae* and *C. paratus*, together with *Labeobarbus marequensis, Labeo cylindricus* and *Labeo molybdinus*. *Micropanchax johnstonii* would occur in well-vegetated deeper | 4 |

| Component | Reference condition | Confidence |
|---|---|---|
| | areas along the periphery of hydraulically sheltered zones, and in relatively high abundance. | |

### 4.9.4 Causes and sources of PES at 9_Ṅwaneḍi

Causes and sources for the Present Ecological State at 9_Ṅwaneḍi are summarised in Table 4.53.

**Table 4.53 Causes and sources of PES at 9_Ṅwaneḍi**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | High salinity downstream\|\| of EWR site and increasing nutrients trend. | Irrigated agriculture in riparian zone. | Non-flow. | 4 |
| Geomorphology | Bank erosion; siltation, channel access, channel incision and armouring. | Trampling, overgrazing; reduced longitudinal sediment transport due to upstream dams. | Flow. | 3 |
| Vegetation | Altered species composition. | Annual and perennial alien plant species. | Non-flow. | 5 |
| | Reduced woody cover along banks. | Agricultural encroachment and wood removal. | Non-flow. | 5 |
| Macroinvertebrates | Water quality. | Agriculture. | Non-flow. | 4 |
| | Flow modification. | Upstream dam. | Flow. | 4 |
| Fish | Sedimentation of substrates. Solid waste that deteriorates water quality. Alien vegetation. | Catchment land use (agriculture). | Non-flow. | 4 |
| | Instream barriers that inhibit migrations for both spawning and recruitment. | A dam upstream of the EWR site. Other migratory barriers are poorly-designed road crossings. | Flow. | 4 |

### 4.9.5 Trends

Trends in the Present Ecological State for all components of 9_Ṅwaneḍi are summarised in Table 4.54.

**Table 4.54 Trends in the PES for 9_Ṅwaneḍi**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Absent based on a limited data at site. | 3 |
| Geomorphology | Negative, channel and bank erosion are ongoing. | 3 |
| Vegetation | Absent, trend is stable because the alien plant species present were minimal and mostly annual weeds. | 3 |
| Macroinvertebrates | Absent, no discernible trends present with variable total SASS and ASPT scores. | 3 |
| Fish | Negative, continued reduction in habitat conditions for fish and are barriers to migration. | 4 |

### 4.9.6 EcoStatus (2022)

The Present Ecological Status of each component at 9_Ṅwaneḍi is summarised below in Table 4.55.

**Table 4.55 Present Ecological Status of all components at 9_Ṅwaneḍi**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 71.2 | C | C |
| Geomorphology | 57.0 | D | C/D |
| Vegetation | 76.3 | C | C |
| Macroinvertebrates | 68.7 | C | C |
| Fish | 78.7 | B/C | B/C |
| PES score | 70.4 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **C** | | |
| Mitigation to improve REC | Alien vegetation removal, management of agricultural practices, preventing encroachment of water course. Management of return flows. | | |

## 4.10 EWR site 10_Latonyanda

This site is one of the REMP sites. It is one of the three main tributaries of the Luvuvhu River and is situated upstream of intensive dryland and irrigated agriculture, so acts as a good pre-disturbance reference point. The river is also in good condition because despite there being a few exotic plants, the water quality and habitat for invertebrates and fish are good (Figure 4.10).

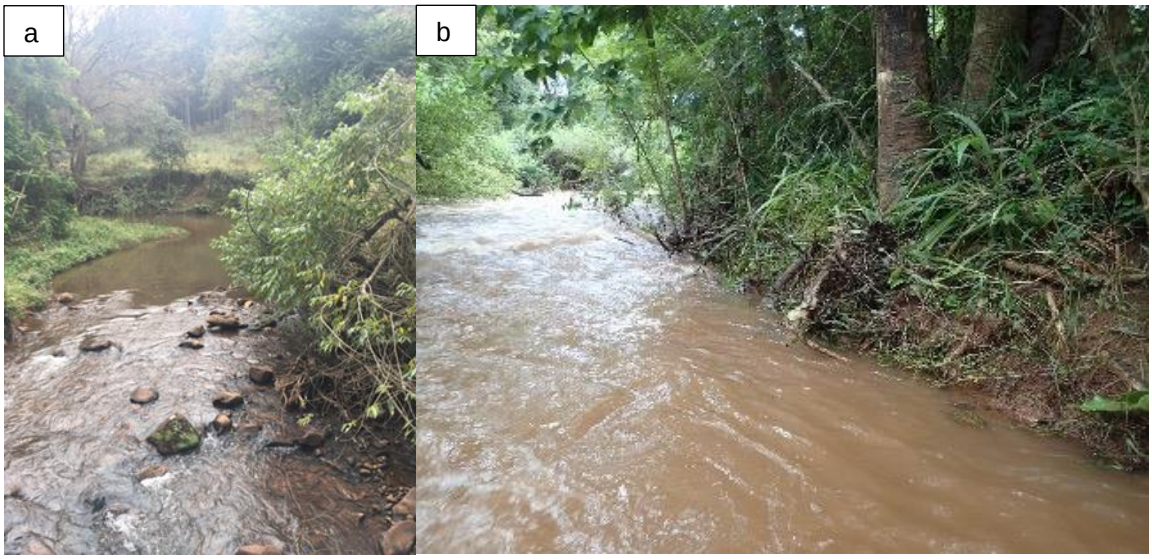


**Figure 4.10 10_Latonyanda, Riii6, Upper Luvuvhu IUA, a=low flow conditions, b=high flow conditions**

### 4.10.1 Data availability

The data available at 10_Latonyanda are summarised in Table 4.56. The confidence rating used in the report is described in Table 4.1.

**Table 4.56 Data available at 10_Latonyanda**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | A9H027Q01 (2008-2018) n=91 (DWS WMS database). Upstream of EWR site. | 3 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | 20 data sets since May 2017 (DWS Regional Office and RQIS). | 5 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.10.2 Ecological importance and sensitivity

The EIS of 10_Latonyanda, with motivations, is provided in Table 4.57.

**Table 4.57 EIS of 10_Latonyanda**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 0.00 | VEG: None. FISH: Reference data indicate there may be but none were captured in the samples taken. INVERTS: We do not have the information to assess this. |
| Unique | 0.75 | VEG: Combretum erythrophyllum and Dietes butcheriana endemic SnA. FISH: Reference data indicates there may be, but none sampled. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Marginal zone sedges & grasses. FISH: Many fish spp flow habitat specialists, many of which occur in fast shallow habitats. INVERTS: Many taxa dependent on flowing water during part/most of their life cycle. |
| Taxon richness | 3.00 | VEG: 17 indigenous riparian and wetland species. FISH: Reference data indicates there may be, but surveys showed lesser diversity. INVERTS: 66 taxa under natural conditions and 51 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 2.00 | VEG: Alluvial woody banks, incised narrow channel, alluvial & bedrock. FISH: High diversity. INVERTS: Instream habitat dominated by cobbles, GSM, and broadleaved marginal vegetation. |
| Refugia | 2.00 | VEG: Low. FISH: High level. INVERTS: Moderate refugia available given the composition of the existing instream habitat. |
| Sensitivity to change in flows | 2.00 | Veg: Low. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Some habitat sensitive to flow changes. |
| Sensitivity to change in water quality | 3.00 | VEG: None. FISH: Relatively small watercourse and therefore limited buffer capacity to tolerate changes. INVERTS: Some habitat sensitive to water quality related flow changes. |
| Migration route/corridor | 1.00 | VEG: Some. FISH: A generally open and longitudinally connected watercourse that would promote migration movements in support of breeding and dispersal. INVERTS: Odonata may use the riparian zone as a corridor for movement. |
| Importance of conservation and natural areas | 1.00 | VEG: Some. FISH: Much of the catchment area falls within commercial forestry areas. Although watercourses are generally conserved in principle, the land use tends to be relatively high impact. INVERTS: Within a forestry area. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.10.3 Reference condition

The expected reference condition of 10_Latonyanda is described in Table 4.58.

**Table 4.58 Reference condition at 10_Latonyanda**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | In its reference water quality state, the Latonyanda River would be in an A water quality category due to its location almost in the headwaters of the river. The river would be characterised by low salinity, nutrients and suspended sediment concentrations. | 3 |
| Geomorphology | In its reference state, the Latonyanda River will have a moderate gradient mixed bed cobble and boulder channel with limited lateral migration along a confined valley setting, resulting in a straight-to-wandering channel and pool-riffle or pool-rapid reach types. Limited bar formation and narrow flood features. The bank will have a moderate gradient and be composed of cobble, gravel, sand and silt. The historical aerial image shows that the tree cover has increased drastically due to afforestation. | 2 |
| Vegetation | The site occurs within the Savanna Biome, Central Bushveld Bioregion and Soutpansberg Mountain Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. There are also pockets of Northern Mistbelt Forest in the area so indigenous forest species could also be expected. Historically the channel would likely have had a band of woody vegetation along the banks which would have shaded out the channel and marginal zone plants; there would be fewer than now. The macro-channel bank is expected to be dominated by woody riparian and terrestrial species from Savanna or Forest communities. The 1939 historical aerial photographs show the vegetation beyond the narrow riparian corridor as mostly non-woody but this is likely due to clearing of vegetation during forestry activities. | 3 |
| Macroinvertebrates | SASS Total Score 240, ASPT 7.5. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 5 |
| Fish | A relatively small forest stream that would incorporate a wide diversity of habitat types and hydraulic conditions. Substrates would be dominated by gravel, sand and mud, with a relatively high inclusion of cobble within riffle zones, where *Labeo cylindricus, Labeobarbus marequensis, Amphilius uranoscopus* and *Chiloglanis* spp would congregate. Root wads and undercut banks, with a high cover of overhanging vegetation and large woody debris with organic detritus would include many cichlid species, some larger-bodied species such as *Clarias gariepinus, Enteromius* spp, including *E. bifrenatus, E. neefi, E. topinii*, and *E. viviparus*. The watercourse would also support migratory *Anguillia mossambica* and *Anguilla bengalensis*. | 4 |

### 4.10.4 Causes and sources of PES at 10_Latonyanda

Causes and sources for the Present Ecological State at 10_Latonyanda are summarised in Table 4.59.

**Table 4.59 Causes and sources of PES at 10_Latonyanda**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Increasing & seasonality in salinity, slight increases in nutrients, impacts of urban sprawl at EWR site. | Possible forestry activities upstream of sampling site. | Non-flow. | 3 |
| Geomorphology | Siltation, bank erosion, trampling, flashier flows. | Roads, harvested forestry areas, bridges and river access by livestock. | Non-flow. | 3 |
| Vegetation | Altered species composition | Alien plant species (high at this site and includes woody perennial species) | Non-flow. | 5 |
| | Elevated woody cover and stature. | Forestry. | Non-flow. | 3 |
| Macroinvertebrates | Instream habitat modification, water quality. | Afforestation, sedimentation. | Non-flow. | 4 |
| Fish | Sedimentation of substrates and erosion of banks. Water quality degradation (general turbidity from catchment). | Catchment land use (forestry). | Non-flow. | 4 |

### 4.10.5 Trends

Trends in the Present Ecological State for all components of 10_Latonyanda are summarised in Table 4.60.

**Table 4.60 Trends in the PES for 10_Latonyanda**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Slight negative (increasing) trend in salinity & nutrients. Some seasonality in salinity. | 4 |
| Geomorphology | Negative, catchment processes are increasing siltation and bank erosion. | 3 |
| Vegetation | Negative, because the perennial alien plant species present are invasive and will increase if left unchecked, and the proximity to forestry means disturbance will remain high. | 3 |
| Macroinvertebrates | Absent, no discernible trends in the data, variable total SASS and ASPT scores. | 3 |
| Fish | Negative, ongoing catchment activities negatively affect fish habitat. | 4 |

### 4.10.6 EcoStatus (2022)

The Present Ecological Status of each component at 10_Latonyanda is summarised below in Table 4.61.

**Table 4.61 Present Ecological Status of all components at 10_Latonyanda**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 91.8 | A/B | A/B |
| Geomorphology | 74.0 | C | B/C |
| Vegetation | 60.3 | C/D | C/D |
| Macroinvertebrates | 79.3 | B/C | B/C |
| Fish | 78.8 | B/C | B |
| PES score | 76.8 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **B/C** | | |
| Mitigation to achieve the REC | Management of catchment land use practices. | | |

## 4.11 EWR site 11_Mutshindudi

This site is one of the REMP sites and it is one of the three main tributaries of the Luvuvhu River downstream of Nandoni Dam. It is in very good condition with little disturbance visible to the vegetation or aquatic habitats, apart from some cow pats and access routes that people and livestock make use of. Site conditions during the dry and wet season are shown in Figure 4.11.

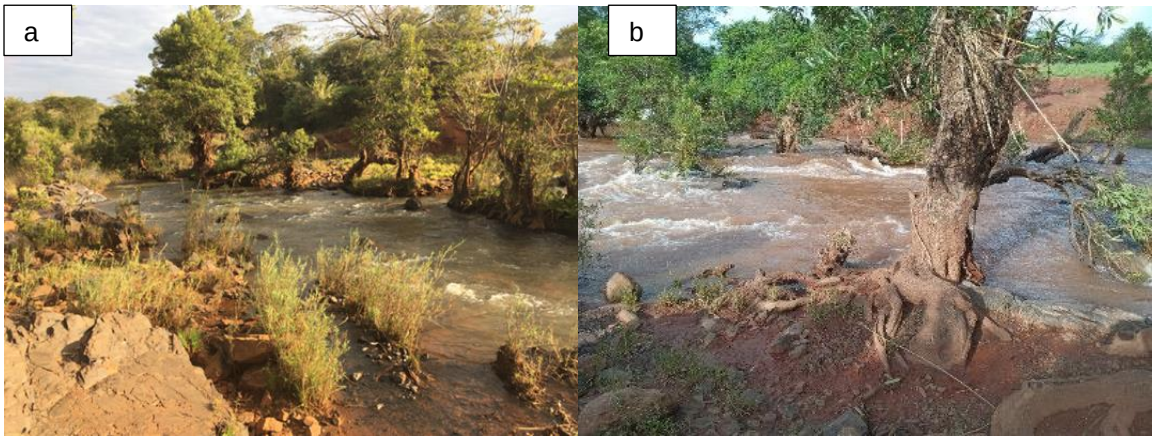


**Figure 4.11 11_Mutshindudi, Ri30, Upper Luvuvhu IUA, a=low flow conditions, b=high flow conditions**

### 4.11.1 Data availability

The data available at 11_Mutshindudi are summarised in Table 4.62. The confidence rating used in the report is described in Table 4.1.

**Table 4.62 Data available at 11_Mutshindudi**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | A9H025Q01 (2008-2018) n=11 (DWS WMS database). | 3 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | 16 data sets since May 2017 (DWS Regional Office and RQIS). | 5 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.11.2 Ecological importance and sensitivity

The EIS of 11_Mutshindudi, with motivations, is provided in Table 4.63.

**Table 4.63 EIS of 11_Mutshindudi**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 2.25 | VEG: 3 Nationally protected tree species: *Breonadia salicina, Philenoptera violacea, Sclerocarya birrea* subsp. *Caffra* and *Crinum moorie*. FISH: Reference data indicate there may be but none were captured in the samples taken. INVERTS: We do not have the information to assess this. |
| Unique | 0.50 | VEG: None. FISH: Reference data indicate there may be but none were captured in the samples taken. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Marginal zone sedges & grasses. FISH: Many fish species are flow habitat specialists and prefer fast shallow habitats. INVERTS: Many taxa are dependent on flowing water for part of their life cycles. |
| Taxon richness | 2.00 | VEG: There are 27 indigenous riparian and wetland species. FISH: Reference data indicate a high diversity of fish than was seen in the samples collected. INVERTS: There are 67 taxa under natural conditions and 47 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 3.00 | VEG: Alluvial woody banks, bedrock woody in-channel features, pools, reed beds. FISH: High diversity. INVERTS: Is a cascade present in the upper reach, cobbles, boulders, rapids, riffles and runs, GSM and graminoids. |
| Refugia | 2.00 | VEG: Rare & endangered species listed above, especially *B. salicina*. FISH: High level. INVERTS: Moderate refugia available given the composition of the existing instream habitat. |
| Sensitivity to change in flows | 3.00 | VEG: Bedrock, rheophytic areas. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Some habitat sensitive to flow changes, namely the cascade and some sections of rapids. |
| Sensitivity to change in water quality | 2.00 | VEG: None. FISH: Relatively larger watercourse and therefore water volume allows for a buffer to tolerate changes. INVERTS: Some habitat sensitive to water quality related flow changes. |
| Migration route/corridor | 2.00 | VEG: Fragmented but distinct from upland cultivated areas. FISH: A generally open and longitudinally connected watercourse that would promote migration movements in support of breeding and dispersal. INVERTS: Paleomonidae occur in this river and Odonata may use the riparian zone as a corridor for movement. |
| Importance of conservation and natural areas | 1.00 | VEG: Some. FISH: Low - much of the catchment is commercial farmland. INVERTS: Open area present. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.11.3 Reference condition

The expected reference condition of 11_Mutshindudi is described in Table 4.64.

**Table 4.64 Reference condition at 11_Mutshindudi**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | In its reference water quality state, the Mutshindudi River would be in an A water quality category due to its location in the upper catchment of the river. The river would be characterised by low salinity, nutrients and suspended sediment concentrations. | 3 |
| Geomorphology | The Mutshindudi River in its reference state is likely to be a low gradient mixed bed channel with limited lateral migration along a partly confined valley setting, resulting in a straight-to-wandering channel and pool-riffle reach types. Boulder, cobble, gravel and sand are likely to be the main sediment types along the riffle with a sand bed along pool sections. Bedrock is locally present, forming short rapid sections and bedrock pools. Sand bars can be common in pools. Narrow flood benches can be present, composed of fine gravel, sand and silt, with banks of a moderate gradient with inset benches present. From the historical aerial images, it would suggest that the current channel is in a more stable state due to increased marginal vegetation and fewer bare sand and gravel bars. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Central Bushveld Bioregion and Soutpansberg Mountain Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. Due to the mixed bedrock/ alluvial nature of the active channel the vegetation is expected to be dominated by woody rheophytic species in bedrock areas (species such as *Breonadia salicinia*, *Salix mucronata* and *Gomphostigma virgatum* while alluvial areas are expected to be more non-woody with reeds in particular on lateral bars and around pools. Flood bench vegetation is expected to be a continuation of the marginal and lower zones with less sedge and taller trees but of the same species. The macro-channel bank is expected to be dominated by woody riparian and terrestrial species. Despite the impacts at the site (cultivation, overgrazing, clearing of vegetation and wood removal) it appears that this zone has gained woodiness over time (since 1937). | 3 |
| Macroinvertebrates | SASS Total Score 200, ASPT 7.5. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 5 |
| Fish | Rocky intrusions create natural cascades and also play a role in the shape of the watercourse, forcing confinement of the channel into a fast-deep central main channel over bedrock in places. This would be inhabited by larger-bodied species such as *Labeo molybdinus, Labeo cylindricus* and *Labeobarbus marequensis*. Riffles would support a high diversity of *Enteromius* spp., *Chiloglanis* spp, *Micralestes acutidens, Amphilius uranoscopus*, *Opsaridium peringueyi, Brycinus imberi and Engraulicypris brevianalis.* These shallower cobble and gravel beds would provide valuable spawning beds for a variety of *Labeos*. Deeper zones that are more hydraulically sheltered would support Anguillid eels.. Marginal vegetation would promote undercutting of banks to provide valuable habitat for *Marcusenius macrolepidotus* and *Petrocephalus wesselsi*. Floodplain-type habitat, side channels and flood terraces would also be commonplace throughout the river reach, which are activated seasonally under higher flow conditions. These habitat units would be extremely valuable for spawning of a | 4 |

| Component | Reference condition | Confidence |
|---|---|---|
| | great variety of fish species. The relatively shallower and hydraulically calmer zones would also provide suitable nursery areas for young fish. Open and deeper waters would support species such as larger *Coptodon rendalii* and *Oreochromis mossambicus*, with juveniles occurring amongst the emergent and marginal vegetation. | |

### 4.11.4 Causes and sources of PES at 11_Mutshindudi

Causes and sources for the Present Ecological State at 11_Mutshindudi are summarised in Table 4.65.

**Table 4.65 Causes and sources of PES at 11_Mutshindudi**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Limited data at EWR site. Stable salinity, increase in phosphates. | Urban sprawl upstream of the EWR site. | Non-flow. | 3 |
| Geomorphology | Bank erosion due to trampling, siltation of slow flow habitats due to increased fine sediment input. | Widespread agriculture, overgrazing, livestock tracks, rural housing with bare areas around houses, and a moderate density of roads. | Non-flow. | 3 |
| Vegetation | Altered species composition. | Alien plant species (high at this site and includes woody perennial species). | Non-flow. | 5 |
| Macroinvertebrates | Water quality impacts. | Human settlements | Non-flow. | 4 |
| Fish | Water quality degradation. Smothering of habitat. Harvesting of riparian vegetation. | Catchment land use (informal/semi-formal residential and agriculture). | Non-flow. | 4 |

### 4.11.5 Trends

Trends in the Present Ecological State for all components of 11_Mutshindudi are summarised in Table 4.66.

**Table 4.66 Trends in the PES for 11_Mutshindudi**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Absent, very limited data set. | 3 |
| Geomorphology | Negative, high pressure at the site due to trampling and bank erosion with siltation in pools and coarser habitats. | 3 |
| Vegetation | Negative, because the perennial alien plant species present will increase if left unchecked and the site is prone to constant high disturbance from humans and livestock. | 3 |
| Macroinvertebrates | Absent, no discernible trends present, are variable total SASS and ASPT scores. | 3 |
| Fish | Negative, ongoing habitat changes due to cultivated land surfaces across the catchment. | 4 |

### 4.11.6 EcoStatus (2022)

The Present Ecological Status of each component at 11_Mutshindudi is summarised below in Table 4.67.

**Table 4.67 Present Ecological Status of all components at 11_Mutshindudi**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 81.8 | B/C | B/C |
| Geomorphology | 65.0 | C | C |
| Vegetation | 66.9 | C | C |
| Macroinvertebrates | 76.9 | C | C |
| Fish | 65.7 | C | C |
| PES score | 71.3 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **C** | | |
| Mitigation to achieve the REC | Management of land use practices – manage trampling by human and livestock, and grazing. | | |

## 4.12 EWR site 12_Luvuvhu

This site is a FEPA situated in a protected area in the upper reaches of the IUA. Ecologically the site had little disturbance to the riparian vegetation and there was good quality habitat for invertebrates and fish (Figure 4.12).

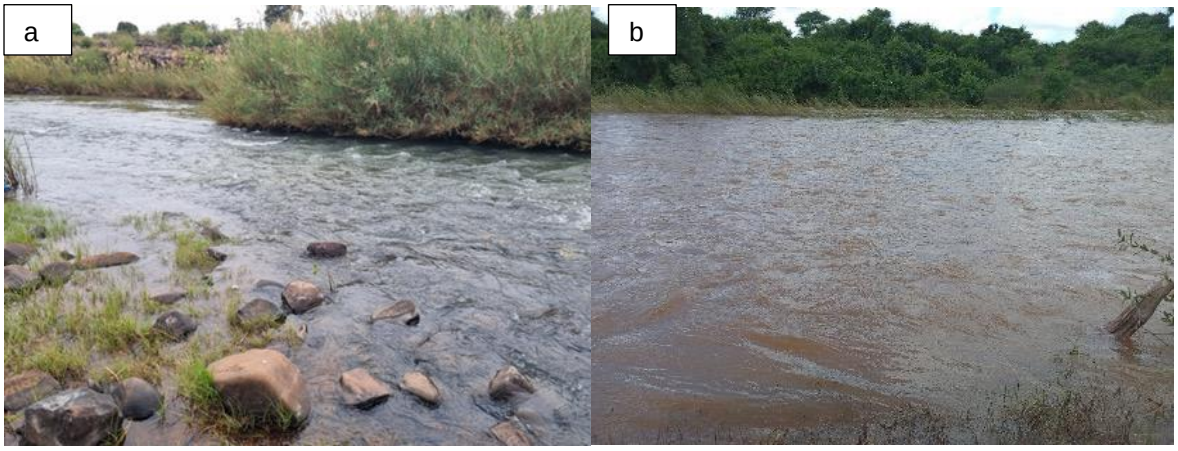


**Figure 4.12 12_Luvuvhu, Ri32, Upper Luvuvhu IUA, a=low flow conditions, b=high flow conditions**

### 4.12.1 Data availability

The data available at 12_Luvuvhu are summarised in Table 4.68. The confidence rating used in the report is described in Table 4.1.

**Table 4.68 Data available at 12_Luvuvhu**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | A9H012Q01 (2008-2018) n=93 (DWS WMS database). | 4 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | 8 data sets since July 2017 (DWS Regional Office and RQIS). | 5 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.12.2 Ecological importance and sensitivity

The EIS of 12_Luvuvhu, with motivations, is provided in Table 4.69.

**Table 4.69 EIS of 12_Luvuvhu**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 1.25 | VEG: Matumi (*Breonadia salicina*) and Apple Leaf (*Philonoptera violaceae*) are protected national tree species. FISH: Reference data show they may be but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Unique | 0.50 | VEG: None. FISH: Reference data show they may be but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Wetland sedges and grasses. FISH: Many fish species are flow habitat specialists that prefer fast shallow habitats. INVERTS: Many taxa are dependent on flowing water for part of their life cycles. |
| Taxon richness | 2.00 | VEG: There are 35 indigenous riparian species. FISH: Reference data show higher diversity than was collected in the samples. INVERTS: There are 70 taxa under natural conditions and 52 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 2.00 | VEG: Pool-riffle/run, reed beds and woody banks, with flood channels. FISH: High diversity. INVERTS: Cobbles, boulders, riffles and runs, GSM and graminoids. |
| Refugia | 2.00 | VEG: None. FISH: High level. INVERTS: Moderate refugia available given the composition of the existing instream habitat. |
| Sensitivity to change in flows | 3.00 | VEG: Marginal zone species. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Many invertebrates need water for part of their life cycles. |
| Sensitivity to change in water quality | 2.00 | VEG: Potentially to nutrients for e.g. reeds. FISH: Relatively larger watercourse and therefore water volume allows for a buffer to tolerate changes. INVERTS: Some habitat sensitive to water quality related flow changes. |
| Migration route/corridor | 2.00 | VEG: Minimal as fragmented. FISH: A generally open and longitudinally connected watercourse that would promote migration movements in support of breeding and dispersal. INVERTS: Paleomonidae occur in this river, Odonata may use the riparian zone as a corridor for movement. |
| Importance of conservation and natural areas | 1.00 | VEG: Highly disturbed and developed area. FISH: Mixed land use catchment, including urbanised, private conserved, and conserved. INVERTS: Open areas present. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.12.3 Reference condition

The expected reference condition of 12_Luvuvhu is described in Table 4.70.

**Table 4.70 Reference condition at 12_Luvuvhu**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | In its reference water quality state, the Luvuvhu River is likely to be in an A/B water quality category characterised by low salinity and nutrient concentrations, but low to moderate turbidity. This is due to its location in the middle reaches of the catchment. | 3 |
| Geomorphology | The Luvuvhu River in its reference state is likely to be a low gradient mixed bed channel with limited lateral migration along a partly confined valley setting, resulting in a straight-to-wandering channel and pool-riffle reach types. Boulder, cobble, gravel and sand are the main sediment types along the riffle with a sand bed along pool sections. Bedrock is locally present, forming short rapid sections. Sand bars can be common in pools. Narrow flood benches are often present, composed of fine gravel, sand and silt, with banks of a moderate gradient with inset benches present. Historical aerial images suggest that sand bars, sand mining and reed extent have increased. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Lowveld Bioregion and Makuleke Sandy Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by woody species. The within channel habitats, including the marginal zone are expected to be dominated by reed beds and associated, mostly non-woody species that can withstand high degrees of hydrological disturbance. A woody component is also expected however, even dominant in localised bedrock-dominated portions of the channel, mostly represented by *Breonadia salicinia* and *Gomphostigma virgatum*. The within channel habitats, including the flood benches and flood channels are expected to be dominated by a mixture of reed beds (with varying degrees of density) and associated, mostly with non-woody species that can withstand high degrees of hydrological disturbance as well as a scattered but present woody component, mostly shrubs. The macro-channel bank is expected to be dominated by dense to open woody riparian and terrestrial woodland species (trees and shrubs) with a well-developed understorey. | 3 |
| Macroinvertebrates | SASS Total Score 200, ASPT 7.0. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 5 |
| Fish | A fast-deep central main channel with a bedrock substrate would be inhabited by the larger-bodied stronger swimming species such as a variety of *Labeos* (*L. congoro, L. ruddi, L. rosae, L. molybdinus, L. cylindricus*) as well as *Hydrocynus vittatus*, and *Labeobarbus marequensis*. The juveniles of these fish would congregate on the edges of the together with many *Enteromius* spp., *Micralestes acutidens, Brycinus imberi* and *Opsaridium peringueyi*. Deeper zones that are more hydraulically sheltered support Anguillid eels. Shallower cobble and gravel beds also provide spawning beds for the *Labeos, Chiloglanis* spp and *Amphilius uranoscopus*. Riparian roots promote undercutting of banks and root wads would provide valuable habitat for *Marcusenius macrolepidotus* and *Petrocephalus wesselsi*. Marginal vegetation, large woody debris and overhanging vegetation would provide habitat *Enteromius* spp. and smaller cichlids such as *Pseudicrenilabrus philander*. Floodplain-type habitat, side channels and flood terraces would also be commonplace throughout the river reach, which are activated | 4 |

| Component | Reference condition | Confidence |
|---|---|---|
| | seasonally under higher flow conditions. These habitat units would be extremely valuable for spawning of a great variety of fish species. The relatively shallower and hydraulically calmer zones would also provide suitable nursery areas for young fish. Open and deeper waters would support *Synodontis zambezensis, Schilbe intermedius, Hydrocinus vittatus, Coptodon rendalii, Oreochromis mossambicus* and *Labeo molybdinus*. | |

### 4.12.4 Causes and sources of PES at 12_Luvuvhu

Causes and sources for the Present Ecological State at 12_Luvuvhu are summarised in Table 4.71.

**Table 4.71 Causes and sources of PES at 12_Luvuvhu**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | High seasonality in electrical conductivity. | Urban sprawl & urban runoff. | Flow. | 4 |
| | Increasing trends in nutrients. | WWTW upstream of EWR site. | Non-flow. | 4 |
| Geomorphology | Reduced bed sediment input with increased fine sediment input; reduced high flows; reed encroachment; bank erosion. | Widespread agriculture, overgrazing, livestock tracks, and rural housing with bare areas around houses; a moderate density of roads increasing fine sediment input; Sand mining; trampling. | Non-flow. | 3 |
| | Reduced bed sediment input, reduced high flows. | Nandoni Dam | Flow. | 3 |
| Vegetation | Altered species composition | Annual and perennial alien plant species. | Non-flow. | 5 |
| | Reduced vegetation cover and abundance. | Vegetation removal/ clearing/ access paths and roads. | Non-flow. | 5 |
| | Increased reed density and cover | Flow regulation and reduction, flood peak reduction. | Flow. | 3 |
| Macroinvertebrates | Flow modification. | Downstream of Albasini & Nandoni Dams. | Flow. | 4 |
| | Instream habitat modification. | Nutrient enrichment, human settlements. | Non-flow. | 4 |
| Fish | Sedimentation of substrates. Water quality degradation (general & turbidity). | Catchment land use (formal & informal residential sectors, and commercial sectors). | Non-flow. | 4 |

### 4.12.5 Trends

Trends in the Present Ecological State for all components of 12_Luvuvhu are summarised in Table 4.72.

**Table 4.72 Trends in the PES for 12_Luvuvhu**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Slight positive (decreasing) trend in electrical conductivity, slight increasing trends in nutrients. | 4 |
| Geomorphology | Negative, catchment degradation is ongoing with possible growth of bank and bar habitat due to sand mining. | 3 |
| Vegetation | Negative, because the perennial alien plant species present are invasive and will increase if left unchecked, and the site is prone to high levels of disturbance from humans and livestock. | 3 |
| Macroinvertebrates | Absent, there is high variability in the total SASS and ASPT scores. | 3 |
| Fish | Negative, impact of dams ongoing with resultant changes to habitat. | 4 |

### 4.12.6 EcoStatus (2022)

The Present Ecological Status of each component at 12_Luvuvhu is summarised below in Table 4.73.

**Table 4.73 Present Ecological Status of all components at 12_Luvuvhu**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 85.5 | B | B |
| Geomorphology | 54.0 | D | C/D |
| Vegetation | 66.5 | C | C |
| Macroinvertebrates | 79.3 | B/C | B/C |
| Fish | 68.3 | C | C |
| PES score | 70.7 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **C** | | |
| Mitigation to achieve the REC | Management of sand mining and land use practices. | | |

## 4.13 EWR site 13_Mutale1

This site is one of the REMP sites and it is strategically important because there are plans to dam the Mutale River upstream, to provide water for the planned SEZ. This site is also useful because it is situated just upstream of the gorge, it captures all the incremental activities upstream before this important geographical feature. Ecologically it is important because it is a FEPA that is in very good ecological condition; with good riparian vegetation, habitat for invertebrates and fish, and good quality water (Figure 4.13). It is also interesting because of the groundwater upwelling onto the floodplain.

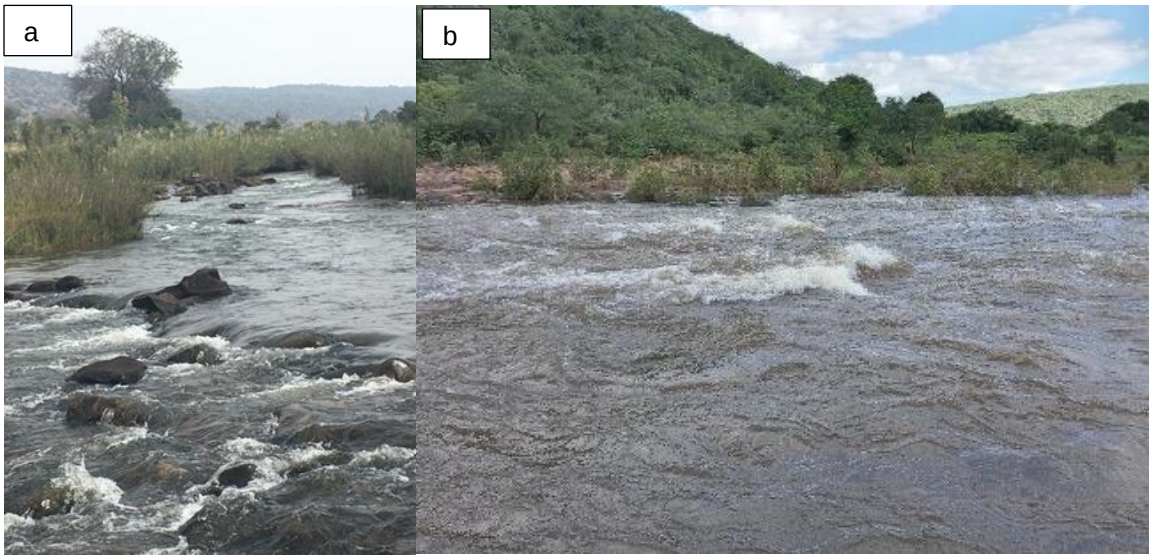


**Figure 4.13 13_Mutale1, Riv11, Lower Luvuvhu/Mutale IUA, a=low flow conditions, b=high flow conditions**

### 4.13.1 Data availability

The data available at 13_Mutale1 are summarised in Table 4.74. The confidence rating used in the report is described in Table 4.1.

**Table 4.74 Data available at 13_Mutale1**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | WMS A92_188507 - Tshandama Tengwe S 255 MT Bridge 2 km to Tshandama Tribal Office near Studam on Mutale River (2008-2017) N=35 for electrical conductivity | 4 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | 20 data sets since May 2017 (DWS Regional Office and RQIS). | 5 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.13.2 Ecological importance and sensitivity

The EIS of 13_Mutale1, with motivations, is provided in Table 4.75.

**Table 4.75 EIS of 13_Mutale1**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 1.50 | VEG: *Crinum macowanii* (Not threatened but population declining). FISH: Reference data indicate there may be but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Unique | 2.00 | VEG: *Combretum erythrophyllum* and *Miscanthus junceus* (SnA endemic), *Schoenoplectus brachyceras* (SA endemic). FISH: Reference data indicate there may be but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Aquatic zone and pools within seepage wetlands. FISH: Many fish species are flow habitat specialists that prefer fast shallow habitats. INVERTS: Many taxa are dependent on flowing water for part of their life cycle. |
| Taxon richness | 3.00 | VEG: There are 36 indigenous riparian and wetland species. FISH: Reference data shows comparable diversity to the samples collected. INVERTS: There are 69 taxa under natural conditions and 49 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 3.00 | VEG: Bedrock channel, woody banks, flood bench and levee, seepage wetland, aquatic zone, pools and alluvial lateral bars. FISH: High diversity. INVERTS: Bedrock/boulder rapids, runs and graminoids. |
| Refugia | 2.00 | VEG: Wetland and aquatic species. FISH: High level. INVERTS: Moderate refugia available given the composition of the existing instream habitat. |
| Sensitivity to change in flows | 3.00 | VEG: Aquatic zone and pools within seepage wetlands. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Some habitat sensitive to flow changes. |
| Sensitivity to change in water quality | 2.00 | VEG: Aquatic zone. FISH: Relatively large watercourse and therefore water volume allows for a buffer to tolerate changes. INVERTS: Some habitats are sensitive to water quality related flow changes. |
| Migration route/corridor | 2.00 | VEG: Corridor functionality fragmented and deteriorated. FISH: A generally open and longitudinally connected watercourse that would promote migration movements in support of breeding and dispersal. INVERTS: Paleomonidae occur in this river, Odonata may use the riparian zone as a corridor for movement. |
| Importance of conservation and natural areas | 2.00 | VEG: High species diversity with riparian, aquatic and wetland habitats. FISH: Mixed land use catchment, including urbanised and conservation areas. INVERTS: Open areas are present. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.13.3 Reference condition

The expected reference condition of 13_Mutale1 is described in Table 4.76.

### Table 4.76 Reference condition at 13_Mutale1

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | The middle Mutale River in its reference water quality state would probably be in an A/B water quality category due to its location in the middle reaches of the Mutale catchment. The river would probably be characterised by low salinity and nutrient concentrations, but low to moderate turbidity. This is due to its location in the middle reaches of the catchment. | 3 |
| Geomorphology | The middle Mutale River in its reference state is a low gradient mixed bed cobble and boulder channel with limited lateral migration along a confined valley setting, resulting in a straight-to-wandering channel with pool-riffle or pool-rapid reach types. Sand bars are common in pools, with pools length exceeding riffle and rapid length. The banks will have a moderate gradient and be composed of cobble, gravel, sand and silt. Historical aerial images of the middle Mutale River show a more open and narrower low-flow channel. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Central Bushveld Bioregion and Soutpansberg Mountain Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. The morphological and habitat complexity here is consistent over time, with some channel shifting and is likely the reason for high species diversity, including aquatic vegetation. In addition, extensive wetland areas upstream of the site contribute to species pool. The marginal zone is expected to have a scattered woody component with *Syzygium cordatum*, *S, guineense* or *Breonadia salicina*. The flood bench is expected to be dominated by non-woody grasses and sedges with recruiting juveniles trees and shrubs. Also apparent from historical aerial photographs for this reach of the Mutale River beyond the active channel is that the bank is not always well defined, nor continuously woody and vegetation appears to be mixed or more scant, especially since the site occurs just upstream of the gorge area and steep rocky habitats are expected. The wetland and pool components are as expected and from historic aerial photographs dating to 1937 seem to have remained mostly intact over time, likely being too wet for cultivation although some canalisation of the seepage wetlands feeding the site was apparent. The zone is expected to be perennially wet and support wetland and aquatic species. | 3 |
| Macroinvertebrates | SASS Total Score 200, ASPT 7.0. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 5 |
| Fish | The channel is confined and banks are steep meaning that water velocity will be high and the bed likely comprised of boulders and bedrock. Riparian vegetation would be well established with a high diversity of grasses, trees, shrubs. The fast, deep flow would support *Labeo molybdinus*, *L. cylindricus*, *Labeobarbus marequensis* and Anguillid eels. Marginal vegetation would provide valuable habitat for smaller *Enteromius* spp., Cichlids, *Petrocephalus wesselsi* and *Marcusenius macrolepidotus*. Pockets of sheltered areas along the banks would also provide valuable nursery and spawning areas for fish. Mid-water fish include *Enteromius* spp., *Engraulicypris brevianalis*, *Micralestes acutidens* and *Brycinus imberi*. Shallower cobble and gravel beds would also be common, which provide valuable spawning Seasonal floods would inundated the floodplain to provide breeding and nursery areas. | 4 |

### 4.13.4 Causes and sources of PES at 13_Mutale1

Causes and sources for the Present Ecological State 13_Mutale1 are summarised in Table 4.77.

**Table 4.77 Causes and sources of PES at 13_Mutale1**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Slight increase in salinity but seasonality in data, decreasing nutrients. | Evaporation during low flow periods. | Flow. | 3 |
| Geomorphology | Siltation, bank erosion. | Widespread subsistence farming, roads and bare areas around villages; trampling; overgrazing. | Non-flow. | 3 |
| Vegetation | Altered species composition. | Annual and perennial alien plant species. | Non-flow. | 5 |
| Macroinvertebrates | Instream habitat modification, water quality impacts. | Human settlements. | Non-flow. | 4 |
| Fish | Water quality degradation (mostly turbidity). | Catchment land use (formal & informal residential sectors, and commercial sectors). | Non-flow. | 4 |

### 4.13.5 Trends

Trends in the Present Ecological State for all components of 13_Mutale1 are summarised in Table 4.78.

**Table 4.78 Trends in the PES for 13_Mutale1**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Slight negative (increasing) trend in salinity, slight positive (decreasing) trend in nutrients. | 3 |
| Geomorphology | Negative, catchment degradation is likely to worsen, increasing siltation. | 3 |
| Vegetation | Absent, trend considered stable because the alien plant species present were minimal and were annual weeds. | 3 |
| Macroinvertebrates | Absent, no discernible trends in the data, there was high variability in the total SASS and ASPT scores. | 3 |
| Fish | Negative, following the trends in water quality and geomorphology (habitat). | 4 |

### 4.13.6 EcoStatus (2022)

The Present Ecological Status of each component at 13_Mutale1 is summarised below in Table 4.79.

**Table 4.79 Present Ecological Status of all components at 13_Mutale1**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 83.6 | B | B |
| Geomorphology | 72.0 | C | C |
| Vegetation | 80.1 | B/C | B |
| Macroinvertebrates | 70.4 | C | C |
| Fish | 73.1 | C | C |
| PES score | 75.8 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **B/C** | | |
| Mitigation to achieve REC | Management of catchment land use practices, sedimentation, and alien vegetation removal. | | |

## 4.14 EWR site 14_Mutale2

This site is situated in a conservation area just upstream of the confluence with the Luvuvhu, so it represents the lowermost flows and consequences of upstream activities on the Mutale River. It is a very beautiful river in good ecological condition despite there being some exotic plants on the left bank. The in-channel habitats and therefore conditions for invertebrates and fish are good (Figure 4.14).

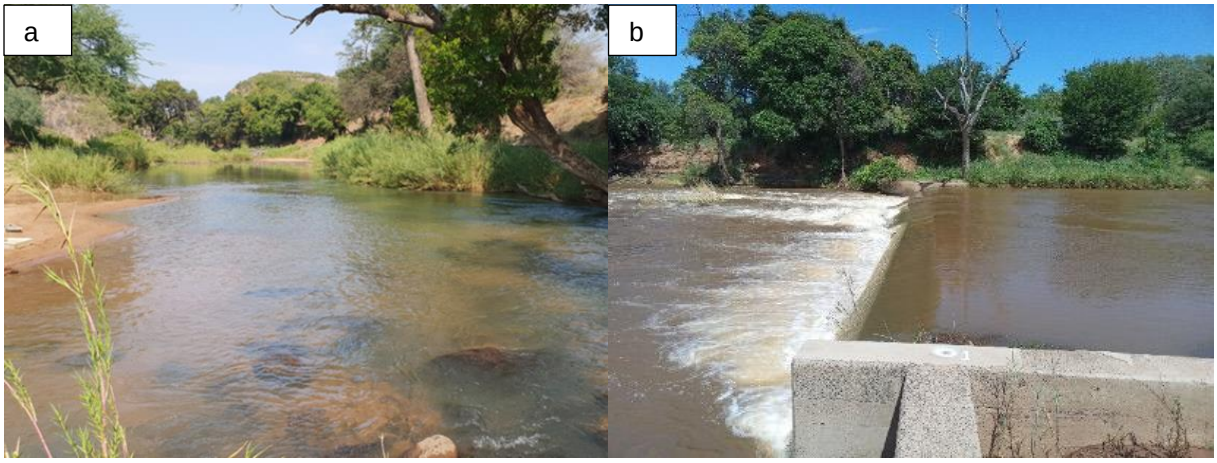


**Figure 4.14 14_Mutale2, Ri34, Lower Luvuvhu/Mutale IUA, a=low flow conditions, b=high flow conditions**

### 4.14.1 Data availability

The data available at 14_Mutale2 are summarised in Table 4.80. The confidence rating used in the report is described in Table 4.1.

**Table 4.80 Data available at 14_Mutale2**

| Component | Data availability | Confidence |
|---|---|---|
| Water quality | A9H013Q01 (200802018) n=57 (DWS WMS database). | 4 |
| Geomorphology | Regional data available based on the geomorphic provinces and basic reference condition based on slope (Rowntree and Wadeson 1999, Partridge et al. 2010). | 2 |
| Vegetation | Vegetation data collected for this project that links to hydraulic rating curves, lookup tables and hydrology; centres of Plant Endemism; historical anecdotal information; vegetation maps and associated conservation information; plant species distribution records and community descriptions; GoogleEarth© and historical satellite imagery; land cover data (Van Wyk & Smith 2001; Skead 2009; Mucina and Rutherford 2006, 2012, 2018; SANBI POSA 2009; National Geospatial Information Portal: http://cdngiportal.co.za/CDNGIPortal/; Desmet et al. 2013; DWS 2014; SANBI 2018; SANLA 2020. | 3 |
| Macroinvertebrates | 10 data sets since September 2012 (DWS Regional Office and RQIS). | 5 |
| Fish | Fish data collected for this project, fish abundance and distribution data, fish habitat quality data (Skelton 2001, Scott et al. 2006, Kleynhans et al. 2008, IUCN 2018, FBIS 2022, Frose and Pauly 2023). | 4 |

### 4.14.2 Ecological importance and sensitivity

The EIS of 14_Mutale2, with motivations, is provided in Table 4.81.

**Table 4.81 EIS of 14_Mutale2**

| Metrics | Present Ecological State Rating | Comments |
|---|---|---|
| Biota (instream and riparian) | | |
| Rare and endangered | 2.00 | VEG: There are 3 protected tree species at the National scale: *Breonadia salicina, Combretum imberbe, Philenoptera violacea*. FISH: Reference data indicate there may be but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Unique | 1.50 | VEG: *Schotia brachypetala, Senegalia burkei* (SA endemics). FISH: Reference data indicate there may be but none were captured in the samples collected. INVERTS: We do not have the information to assess this. |
| Intolerant (flow and/or water quality) | 3.00 | VEG: Marginal zone sedges. FISH: Many fish species are flow habitat specialists that prefer fast shallow habitats. INVERTS: Many taxa are dependent on flowing water for part of their life cycles. |
| Taxon richness | 3.00 | VEG: There are 30 indigenous riparian and wetland species. FISH: Reference data and samples collected have comparable diversity. INVERTS: There are 64 taxa under natural conditions and 51 under Present Ecological State. |
| Instream and riparian habitats | | |
| Diversity | 2.00 | VEG: Bedrock channel, woody banks, flood bench flood channel and mixed bedrock / alluvium. FISH: High diversity. INVERTS: Bedrock/boulder rapids, cobbles, runs and graminoids. |
| Refugia | 2.00 | VEG: Riparian tree species. FISH: High level. INVERTS: Moderate refugia available given the composition of the existing instream habitat. |
| Sensitivity to change in flows | 3.00 | VEG: Low. FISH: Substrate maintenance is dependent on suitable flows. INVERTS: Some habitat sensitive to flow changes. |
| Sensitivity to change in water quality | 2.00 | VEG: Low. FISH: Relatively larger watercourse and therefore water volume allows for a buffer to tolerate changes. INVERTS: Some habitats are sensitive to water quality related flow changes. |
| Migration route/corridor | 2.00 | VEG: Although tall trees are part of the corridor, it is fragmented and less important. FISH: A generally open and longitudinally connected watercourse that would promote migration movements in support of breeding and dispersal. There is a weir upstream which acts as a barrier to migration. INVERTS: Paleomonidae occur in this river, Odonata may use the riparian zone as a corridor for movement. |
| Importance of conservation and natural areas | 4.00 | VEG: KNP. FISH: Catchment area in formally conserved area of national importance. INVERTS: KNP. |
| MEDIAN | 2.00 | |
| EIS | **MODERATE** | |

### 4.14.3 Reference condition

The expected reference condition of 14_Mutale2 is described in Table 4.82.

**Table 4.82 Reference condition at 14_Mutale2**

| Component | Reference condition | Confidence |
|---|---|---|
| Water quality | The lower Mutale River in its reference water quality state would probably be in an A/B water quality category due to its location in the lower reaches of the Mutale catchment and healthy flow regime. The river would probably be characterised by low salinity and nutrient concentrations, but low to moderate turbidity. | 3 |
| Geomorphology | The lower Mutale River in its reference state is a moderate gradient mixed bed cobble and boulder channel with limited lateral migration along a confined valley setting, resulting in a straight-to-wandering channel and pool-riffle or pool-rapid reach types. Sand bars are common in pools, with pool length exceeding riffle and rapid length. A narrow floodplain could be present with banks of a moderate gradient that are composed of cobble, gravel, sand and silt. Historical images show a more vegetated channel and flood zone in 1970. | 3 |
| Vegetation | The site occurs within the Savanna Biome, Mopane Bioregion and Limpopo Ridge Bushveld vegetation type, and while this represents its terrestrial setting, the riparian zone should be influenced by the inclusion and dominance of its macro-channel features by predominantly woody species. The marginal zone is expected to be mostly dominated by non-woody vegetation (grasses, sedges, reeds) but with a scattered woody component such as *Syzygium cordatum, S, guineense* or *Breonadia salicina*. The upper zone bars and flood channels are expected to be high disturbance flood habitats and as such are expected to be sparsely vegetated with disturbance promoting non-woody vegetation and preventing woody dominance. The flood bench is expected to be dominated by non-woody vegetation, mostly grasses and sedges with varying degrees of woody encroachment that should be held at bay by flooding with the correct frequency and magnitude. A woody riparian component would also be expected, particularly with tall riparian tree species being in the system. Also apparent from historical aerial photographs for this reach of the Mutale River beyond the active channel is that the bank has been mostly dominated by well-defined riparian woodland to forest with tall dense to open trees / shrubs, but also with some non-woody or open areas. | 3 |
| Macroinvertebrates | SASS Total Score 220, ASPT 7.0. Macroinvertebrate reference conditions were derived using historic macroinvertebrate data, the reference taxa generator within the MIRAI model, as well as expert knowledge. | 5 |
| Fish | Fast, deep flow over bedrock and boulders support *Labeo congoro, L. ruddi, L. rosae, L. molybdinus, L. cylindricus, Hydrocynus vittatus* and *Labeobarbus marequensis*. Shallower cobbles and boulder provide habitat for smaller juveniles of these species and *Enteromius* spp., *Micralestes acutidens, Brycinus imberi* and *Opsaridium peringueyi*. Deeper zones that are more hydraulically sheltered support Anguillid eels and provide valuable habitat that they use during migrations. Shallower cobble and gravel beds provide valuable spawning beds for the *Labeos, Labeobarbus marequensis, Chiloglanis* spp. and *Amphilius uranoscopus*. Marginal vegetation, large woody debris and overhanging vegetation would provide habitat for *Enteromius* spp. and other smaller cichlids such as *Pseudicrenilabrus philander*. Floodplain-type habitat, side channels and flood terraces are present and inundated during high flow. These habitat units would be extremely | 4 |

| Component | Reference condition | Confidence |
|---|---|---|
| | valuable for spawning of a great variety of fish species. The relatively shallower and hydraulically calmer zones would be suitable nursery areas for young fish. Open and deeper waters would support species such as *Clarias gariepinus* and *Hydrocinus vittatus*, *Coptodon rendalii, Oreochromis mossambicus* and *Labeo molybdinus*. | |

### 4.14.4 Causes and sources of PES at 14_Mutale2

Causes and sources for the Present Ecological State 14_Mutale2 are summarised in Table 4.83.

**Table 4.83 Causes and sources of PES at 14_Mutale2**

| Component | Causes | Sources | Flow or non-flow related | Confidence |
|---|---|---|---|---|
| Water quality | Increasing trend in salinity. | Salinity driven by evaporation. | Flow. | 3 |
| | Slight increase in nutrients. | Localised subsistence farming. | Non-flow. | 3 |
| Geomorphology | Bank erosion; sedimentation in pools. | Trampling at site; weir; localised subsistence farming, grazing, roads and bare areas around villages in catchment. | Non-flow. | 3 |
| Vegetation | Altered species composition. | Annual and perennial alien plant species. | Non-flow. | 5 |
| Macroinvertebrates | Water quality. | Potential nutrient enrichment, lodges, settlements. | Non-flow. | 4 |
| Fish | Instream barriers. | Gauging weir. | Flow. | 4 |

### 4.14.5 Trends

Trends in the Present Ecological State for all components of 14_Mutale2 are summarised in Table 4.84.

**Table 4.84 Trends in the PES for 14_Mutale2**

| Component | Absent/positive/negative | Confidence |
|---|---|---|
| Water quality | Moderate negative (increasing) trend in salinity & nutrients. | 4 |
| Geomorphology | Negative, catchment degradation is likely to increase with more sedimentation at the site. | 3 |
| Vegetation | Absent, because the alien plant species found were minimal and mostly annual weeds. | 3 |
| Macroinvertebrates | Absent, no discernible trends due to high variability in total SASS and ASPT scores. | 3 |
| Fish | Negative, ongoing degradation of fish habitat and the weir is a barrier to migration. | 4 |

### 4.14.6 EcoStatus (2022)

The Present Ecological Status of each component at 14_Mutale2 is summarised below in Table 4.85.

**Table 4.85 Present Ecological Status of all components at 14_Mutale2**

| Component | Score | Ecological Category | REC |
|---|---|---|---|
| Water quality | 84.5 | B | B |
| Geomorphology | 71.0 | C | C |
| Vegetation | 83.5 | B | B |
| Macroinvertebrates | 77.0 | C | B/C |
| Fish | 66.5 | C | B/C |
| PES score | 76.5 | | |
| PES category | **C** | | |
| EIS | **MODERATE** | | |
| REC | **B/C** | | |
| Mitigation to achieve REC | Management of land use activities, reduce sedimentation and trampling. | | |

# 5 RECOMMENDED ECOLOGICAL CATEGORIES

The Present Ecological Condition (PES) and the Recommended Ecological Condition (REC) for each EWR site is given in Table 5.1, together with recommendations to achieve the REC.

**Table 5.1 The recommended ecological categories for the EWR sites**

| EWR Site | Quaternary Catchment | PES | EIS | REC | Mitigation to achieve REC |
|---|---|---|---|---|---|
| 1_Lephalala | A50B | C | Moderate | **B/C** | Restocking of fish, alien vegetation removal, and management of sedimentation. |
| LEPH-A50H-SEEKO | A50H | C | | **C** | Updates currently underway.[8] |
| 2_Rietfontein | A63C | B/C | Moderate | **B/C** | None, as no negative trend. Maintain PES condition. |
| 3_Olifantspruit | A61B | C | Moderate | **C** | Alien vegetation removal and sedimentation management. |
| 4_Mogalakwena1 | A62B | C | Moderate | **C** | Management of land use practices and alien vegetation clearing. Improved management of wastewater treatment works. |
| 5_Mogalakwena2 | A63A | C | Moderate | **C** | Improvements in land and agricultural practices, such as rotation of cattle feeding areas. |
| MOGA-A63D-LIMPK | A63D | C | | **C** | Updates currently underway. |
| 6_Kolope | A63E | C | Moderate | **C** | Rehabilitation and improvement of trampling pressures, add gabions. Manage effects of wildlife such as elephants. |
| 7_Sand | A71D | C | Moderate | **C** | Improvement in catchment management. |
| SAND-A71K-R508B | A71K | C | | **C** | Updates currently underway. |
| 8_Nzhelele | A80G | C | Moderate | **C** | Improvement of catchment management and agricultural practices. |
| 9_Ṅwaneḍi | A80J | C | Moderate | **C** | Alien vegetation removal, management of agricultural practices, preventing encroachment of water course, and management of return flows. |
| 10_Latonyanda | A91D | C | Moderate | **B/C** | Management of catchment land use practices. |
| 11_Mutshindudi | A91G | C | Moderate | **C** | Management of land use practices – manage trampling by human and livestock, and grazing. |
| 12_Luvuvhu | A91H | C | Moderate | **C** | Management of sand mining and land use practices. |
| LUVU-A91K-OUTPO | A91K | C | | **C** | Updates currently underway. |
| 13_Mutale1 | A92B | C | Moderate | **B/C** | Management of catchment land use, sedimentation, and alien vegetation removal. |
| 14_Mutale2 | A92D | C | Moderate | **B/C** | Management of land use activities, reduce sedimentation and trampling. |
| SHIN-B90H-POACH | B90H | B/C | | **B/C** | Updates currently underway. |

[8] LIMCOM have commissioned new studies currently underway (in 2023/2024) that are going to review the E-Flows set, undertake additional stakeholder engagement, and analyse new scenarios. The implication is that these data, and the E-Flows may change.

# 6 CONCLUSIONS

All the rivers are in good condition (Table 5.1), and at most EWR Sites, the REC was the same as the Present Ecological State (PES 2022). There were four sites where a half category higher was put forward as the REC. At all of these, this was done by making statements to encourage better management of non-flow related activities that were predicted to improve the ecological condition of each site. There were few opportunities to enhance or manipulate flow in ways different from what is being done because, for the most part, the surface water use is overallocated. The implication of this for setting the EWRs, or E-Flows, at Present Ecological State (PES 2022) is to target maintaining Present Ecological State conditions, i.e., not allowing the ecological condition of the rivers to degrade from what they were.

The opportunities and plans for water resource developments in the Limpopo River Basin are going to be assessed in the EWR Assessment Report for Rivers Volume 2, where the data presented in this report will become part of the DRIFT model that will be used to assess the outcomes of future water resource scenarios.

The objective of the EWR scenario assessment will be to determine whether the RECs put forward at each EWR site can still be maintained under the increased demand for water use and the consequences of any planned infrastructure developments, such as dams and increases in return flow.

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