WEM/WMA3/4/00/CON/CLA/0623, volume 1

water and sanitation

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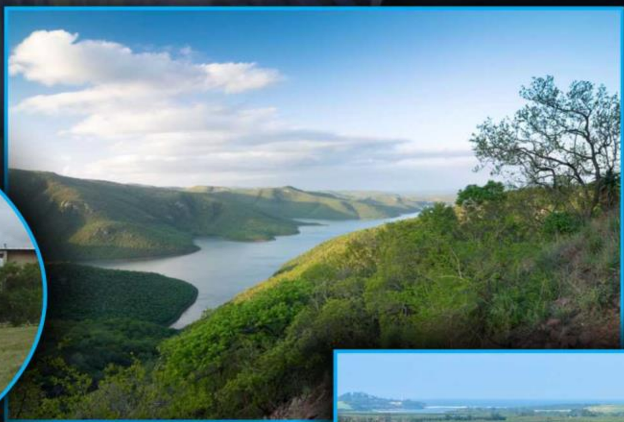
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments

RESOURCE QUALITY OBJECTIVES REPORT, VOLUME 1: RIVERS



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Resource Quality Objectives Report, Volume 1: Rivers Report

CLASSIFICATION OF SIGNIFICANT WATER RESOURCES AND DETERMINATION OF RESOURCE QUALITY OBJECTIVES FOR WATER RESOURCES IN THE USUTU TO MHLATHUZE CATCHMENTS

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REPORT SCHEDULE

Index Number	DWS Report Number	Report Title
1	WEM/WMA3/4/00/CON/CLA/0122	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Inception Report including Gap Analysis chapter**
2	WEM/WMA3/4/00/CON/CLA/0222	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Status Quo and Delineation of Integrated Units of Analysis and Resource Unit Report**
3	WEM/WMA3/4/00/CON/CLA/0322	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Units Delineation and Prioritisation Report**
4	WEM/WMA3/4/00/CON/CLA/0422	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Hydrology Systems Analysis Report**
5	WEM/WMA3/4/00/CON/CLA/0522	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **River EWR estimates for Desktop Biophysical Nodes Report**
6	WEM/WMA3/4/00/CON/CLA/0622	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **River Survey Report**
7	WEM/WMA3/4/00/CON/CLA/0722	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Basic Human Needs Report**
8	WEM/WMA3/4/00/CON/CLA/0822	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Groundwater Report**
9	WEM/WMA3/4/00/CON/CLA/0922	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **River specialist meeting Report**
10	WEM/WMA3/4/00/CON/CLA/1022	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Estuary Survey Report**
11	WEM/WMA3/4/00/CON/CLA/1122	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Wetland Report**
12	WEM/WMA3/4/00/CON/CLA/1222	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Water Requirements Report**
13	WEM/WMA3/4/00/CON/CLA/1322	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Scenario Description Report**

Index Number	DWS Report Number	Report Title
14	WEM/WMA3/4/00/CON/CLA/0123, volume 1	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Consequences Report, Volume 1: Rivers**
	WEM/WMA3/4/00/CON/CLA/0123, volume 2	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Consequences Report, Volume 2: Estuaries**
15	WEM/WMA3/4/00/CON/CLA/0323	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecosystem Services Consequences Report**
16	WEM/WMA3/4/00/CON/CLA/0423	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Economic & User water quality Consequences Report**
17	WEM/WMA3/4/00/CON/CLA/0523	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Water Resource Classes Report**
18	WEM/WMA3/4/00/CON/CLA/0623, volume 1	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Quality Objectives Report, Volume 1: Rivers**
	WEM/WMA3/4/00/CON/CLA/0623, volume 2	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Quality Objectives Report, Volume 2: Estuaries**
	WEM/WMA3/4/00/CON/CLA/0623, volume 3	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Quality Objectives Report, Volume 3: Wetlands and Groundwater**
19	WEM/WMA3/4/00/CON/CLA/0723	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Monitoring and Implementation Report**
20	WEM/WMA3/4/00/CON/CLA/0124	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Main Report**
21	WEM/WMA3/4/00/CON/CLA/0224	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Issues and Responses Report**
22	WEM/WMA3/4/00/CON/CLA/0324	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Close out Report**

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APPROVAL

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EXECUTIVE SUMMARY

BACKGROUND

Chapter 3 of the National Water Act, 1998 (NWA) (Act 36 of 1998), deals with the protection of water resources. Section 12 of the NWA requires the Minister to develop a system to classify water resources. In response to this, the Water Resource Classification System (WRCS) was gazetted on 17 September 2010 and published in the Government Gazette no. 33541 as Regulation 810. The WRCS is a step-wise process, whereby water resources are categorised according to specific classes that represent a management vision of a particular catchment. This vision takes into account, the current state of the water resource, the ecological, social, and economic aspects that are dependent on the resource. Once significant water resources have been classified through the WRCS, Resource Quality Objectives (RQOs) have to be determined to give effect to the class.

The Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS), initiated a study to determine the Water Resource Classes and RQOs for all significant water resources in the Usutu to Mhlathuze Catchment. The Usutu to Mhlathuze Catchments are amongst many water-stressed catchments in South Africa. These catchment areas are important for conservation and contain a number of protected areas such as natural heritage sites, cultural and historic sites, as well as other conservation areas that need protection.

STUDY AREA

The study area is the Usutu to Mhlathuze Catchment, which has been divided into six drainage areas, as well as secondary catchment areas:
W1 catchment (main river: Mhlathuze).
W2 catchment (main river: Umfolozi).
W3 catchment (main river: Mkuze).
W4 catchment (main river: Pongola) - part of this catchment area falls within Eswatini.
W5 catchment (main river: Usutu) - much of this catchment falls within Eswatini.
W7 catchment (Kosi Bay and Lake Sibaya).

PURPOSE OF THIS REPORT

The purpose of this report is to present the RQOs for rivers of the Usutu to Mhlathuze Catchments, as well as the user water quality RQOs. Ecosystem water quality RQOs are presented as part of river RQOs. The results form part of Task 6: Determine Resource Quality Objectives (narrative and numerical limits).

RESULTS

The table below shows the RUs with detailed RQOs for all components. The RU Priority column provides the RU Priority as determined during Task 2 of this project and documented in the **Resource Units Delineation and Prioritisation Report** (DWS, 2022a). Priority ratings of 3 and 4 are deemed High Priority. Note that where a link to another EWR site is indicated the statement refers to extrapolation of the hydrological RQO.

RU	Main river	PES	Key Drivers	RU Priority	EWR site
W1 Secondary Catchment (Main River: Mhlathuze)					
W11-2	Matigulu	B/C	Flow, WQ[1], Non-flow	2	EWR MA1
W12-3	Mhlathuze	C	Flow, WQ, Non-flow	4	Linked to historical EWR 3
W12-6	Mhlathuze	C	Flow, WQ, Non-flow	4	Historical EWR 3
W12-8	Nseleni	C	Flow, WQ, Non-flow	4	EWR NS1
W12-9	Nseleni	C	Flow, WQ, Non-flow	4	Linked to lakes and estuary
W2 Secondary Catchment (Main River: Umfolozi)					
W21-5	White Mfolozi	B/C	Flow, Non-flow	4	EWR WM1
W22-1	Black Mfolozi	C	Flow	3	EWR BM1
W22-5	Black Mfolozi	B	Flow, Non-flow	3	Linked to EWR BM1
W23-1	Mfolozi	B		3	Linked to EWR BM1 and WM1
W3 Secondary Catchment (Main River: Mkuze)					
W31-1	Mkuze	C	Flow, WQ, Non-flow	3	Linked to EWR MK1
W31-2	Mkuze	B		3	Linked to EWR MK1
W31-3	Mkuze	B/C	Flow, WQ, Non-flow	4	Linked to EWR MK1
W31-4	Mkuze	C		4	Linked to EWR MK1
W31-5	Mkuze	C	Flow, WQ, Non-flow	3	EWR MK1
W32-1	Mkuze	B/C	Flow, Non-flow	4	Linked to EWR MK1
W32-6	Munywana	B		4	Linked to St Lucia
W4 Secondary Catchment (Main River: Pongola - excluding Eswatini)					
W42-2	Phongolo	C	Flow Non-flow (WQ)	2	EWR UP1
W45-1	Phongolo	C	Flow, Non-flow (WQ)	4	Linked to EWR UP1
W5 Secondary Catchment (Main River: Usutu - excluding Eswatini)					
W51-2	Assegaai	C	Flow, Non-flow	4	Linked to EWR AS1
W51-3	Mhkondvo	C	Flow, Non-flow (WQ)	4	EWR AS1
W53-2	Mpama	B/C	Flow, Non-flow	4	Use IUCMA monitoring information where available (IUCMA, 2020).
W53-3	Ngwempisi	B/C	Flow, Non-flow (WQ)	2	EWR NG1
W54-1	Usutu	B		4	Use IUCMA monitoring information where available (IUCMA, 2020).
W57-1	Usutu	B/C	Flow	4	Linked to pans and floodplains (Ndumo)

1 Water Quality

The following table shows any additional High Priority water quality RUs (water quality hotspots impact ratings 3 to 5, or Large to Critical) for which water quality RQOs are set for the key driving variables. Although WQ RQOs will be set per RU, the table shows the specific issue within the sub-quaternary reaches nested within the RU. Different shading indicates blocks of RUs for which a single set of water quality RQOs will be set.

High priority water quality RUs (excluding EWR sites). Shading indicates RUs for which a single set of RQOs will be set.

RU	SQ reach	River name	Impact rating	WQ role players	WQ driving variables	WQ notes
W11-2	W11C-03713	Nyezane	3.0	Dryland cultivation; Gingindlovu oxidation ponds (High Risk)	Turbidity, nutrients, salts, *E. coli* / coliforms	Same RU as EWR MA1
W12-5	W12C-03263	Mfulazane	3.0	Melmoth oxidation ponds. Sewage pumpstation overflows.	Nutrients, salts, *E. coli* / coliforms	Melmoth WWTW upgrade planned (tender May 2021
W12-6	W12E-03475	Mhlathuze	3.0	Dryland cultivation	Turbidity	
W12-8	W12H-03401	Okula	3.0	Dryland cultivation; erosion; Tronox	Turbidity, nutrients, *E. coli* / coliforms. Tronox: Fe, metals, sulphate, i.e. toxics.	Tronox KZN sands. Tronox CPC sewage pumpstation. Hillview sewage pumpstation. Sewage overflows near Qalakbusha Correctional Services.
W12-9	W12F-03611	Mzingwenya (inflow into Lake Cubhu); Lake Cubhu	3.0	Urban impacts. Eutrophication of the lake.	Nutrients, toxics, *E. coli* / coliforms	Short urban stream running next to Uzimgwenya township. Gobandlovu on the other bank at the top end of the Estuary Functional Zone (EFZ): *Lake Cubu covered by estuary RQOs for Zone D of Mhlatuze Estuary complex (Volume 2)*
	W12J-03290	Nhlabane	3.0	Eutrophication of the lake.	Nutrients, *E. coli* / coliforms	*Lake Nhlabane covered by estuary RQOs (Volume 2).*
	W12J-03411		3.0	Eutrophication of the lake.	Nutrients, *E. coli* / coliforms	
W12-10	W12J-03392	Mpisini	3.0	Smelter	Toxics	Richards Bay Minerals (RBM) smelter
W21-1	W21A-02527	White Mfolozi	3.0	Waste Water Treatment Works (WWTW)	Nutrients, salts, *E. coli* / coliforms	Stilwater Hotel with package plant that is non-compliant; discharges into the river. Reach is long; instream point downstream (d/s) discharge at bottom of reach
W21-1	W21B-02539	iShoba	4.0	Hlobane Mine; erosion	Toxics, salts, nutrients, turbidity, sulphate	Highest salts and sulphates in W2
W21-1	W21B-02546	White Mfolozi	3.0	WWTW	Nutrients, salts, *E. coli* / coliforms	WWTW discharges into White Mfolozi upstream (u/s) dam. High nutrients into Klipfontein Dam
W21-4	W21D-02676	Mvunyane	3.0	Urban impacts, incl. WWTW; erosion	Toxics, salts, nutrients, turbidity, *E. coli* / coliforms	Mondlo WWTW discharges into small tributary (Ugoqo) and into dam. 1.5 km from dam.

RU	SQ reach	River name	Impact rating	WQ role players	WQ driving variables	WQ notes
W21-4	W21D-02788	Vumankala	3.0	Erosion	Turbidity	
W21-4	W21D-02832	Jojosi	3.0	Erosion; over-grazing	Turbidity	
W21-4	W21D-02848	Jojosi	3.0	Erosion; over-grazing	Turbidity	
W21-4	W21E-02963	Nondweni	3.5	Erosion; over-grazing	Turbidity	
W21-4	W21E-02912	Nondweni	3.0	Erosion; over-grazing	Turbidity	
W21-4	W21E-02873	Nondweni	3.0	Erosion; over-grazing	Turbidity	Recommendations for data collection, e.g. turbidity/Total Suspended Solids (TSS)
W21-7	W21K-02976	Mbilane	3.0	Ulundi WWTW; urban impacts	Nutrients, salts, toxics	WWTW discharge point into W21K-02981
W21-7	W21K-03019	Nhlungwane	3.0	Erosion; over-grazing; anthracite mine	Turbidity, salts, toxics	Zululand Anthracite Collieries (ZAC)
W21-7	W21K-02981	White Mfolozi	3.0	Commercial forestry; irrigation	Turbidity, salts, toxics	Afrimat quarry upstream; Oxidation ponds
W22-5	W22J-02942	Mvalo	3.5	Coal mining impact; over-grazing	Nutrients, salts, toxics, turbidity	ZAC; border of the Hluhluwe-Imfolozi Game Reserve
W23-1	W23A-03058	Mbukwini	3.0	Mining	Toxics, salts	Tendele Mine - number of mining sites. Not being mined as no access to extended mining area. Not closed; on care and maintenance. License valid until 2025.
W23-1	W23A-03083	Mfolozi	3.0	Erosion; over-grazing; mining	Turbidity, toxics, salts	Extension of Tendele Mine - straddles both SQ reaches
W23-3	W23B-03231	Msunduzi	4.0	Cultivation; fertilizers/ biocides	Nutrients, salts, toxics	
W23-3	W23C-03180	Msunduzi	4.0	Cultivation; fertilizers/ biocides	Nutrients, salts, toxics	
W23-3	W23D-03108	Mfolozi	4.0	Cultivation; fertilizers/ biocides; sugar mill discharge point; urban impacts	Nutrients, salts, toxics, *E. coli* / coliforms	Three WWTWs in larger area. Mtubatuba, St Lucia oxidation ponds, KwaMsane WWTW
W31-1	W31A-02494	Nkongolwana	4.0	Mining; cultivation; erosion	Toxics, salts, nutrients, turbidity	
W31-1	W31B-02477	Mkuze	3.0	Erosion	Turbidity	
W31-4	W31J-02469	Mkuze	3.0	WWTW	Nutrients, salts, toxics, *E. coli* / coliforms	Mkuze WWTW medium risk
W42-1	W42B-02331	Bazangoma	3.0	Cultivation	Nutrients, salts, toxics, pH, sulphate	Makateeskop - tributary to Bazangoma. Coal discard dumps

RU	SQ reach	River name	Impact rating	WQ role players	WQ driving variables	WQ notes
W42-2	W42D-02327	Gode	3.0	Urban impacts; cultivation	Nutrients, salts, toxics, *E. coli* / coliforms	eDumbe (Paulpietersburg) oxidation ponds
W43-1	W43F-02099	Ngwavuma	3.0	Erosion; extensive cultivation	Turbidity, toxics, nutrients, salts	
W44-1	W44B-02248	Manzawakho	3.5	Erosion; feedlots; WWTW; extensive cultivation	Turbidity, toxics, nutrients, salts, *E. coli* / coliforms	Pongola WWTW
W44-1	W44B-02351	Phongolo	4.0	Mill discharges; extensive cultivation	Toxics, nutrients, salts	
W44-1	W44C-02338	Phongolo	4.0	Extensive cultivation	Toxics, nutrients, salts	
W44-1	W44D-02304	Phongolo	3.0	Extensive cultivation	Toxics, nutrients, salts	
W45-1	W45A-02368	Phongolo	4.0	WWTW; extensive cultivation	Toxics, nutrients, salts, *E. coli* / coliforms	
W45-1	W45B-02105	Phongolo	3.0	Extensive cultivation; erosion; settlements	Toxics, nutrients, salts, turbidity, *E. coli* / coliforms	Extensive rural and subsistence farming in Pongola floodplain/Makitini Flats
W51-1	W51A-02082	Assegaai	3.0	Mine decant; erosion; cultivation	Nutrients, salts, toxics, *E. coli* / coliforms	
W51-1	W51B-02101	Ngulane	3.0	Cultivation; mining	Toxics, nutrients, salts, *E. coli* / coliforms	Streams upstream of Heyshope Dam; mining
	Tributaries flowing into Heyshope Dam (Northern part of the Dam) within W51B		3.0	Driefontein settlements; WWTWs; coal mines	Toxics, nutrients, salts, *E. coli* / coliforms	Mining activities
	Heyshope Dam		4.0		Salts	Water source for Eskom
W51-3	W51D-02044	Assegaai	3.0	Urban impacts; Piet Retief WWTW	Nutrients, salts, toxics, *E. coli* / coliforms	Klipmisselspruit drains into this SQ and is highly impacted by urban impacts: Jindal Coal Mine Siding, industries and Piet Retief WWTW.
W51-4	W51F-01986	Blesbokspruit	3.0	Cultivation; wood-processing	Toxics, nutrients, salts	Wood-processing plant
W51-4	W51F-02019	Blesbokspruit	4.0	Industries (Woodchem and PG Bison and Mpact); saw mills; residential settlements	Toxics, nutrients, salts, *E. coli* / coliforms	
W53-3	W53C-01679	Thole	3.0	Urban impacts; WWTW; cultivation	Toxics, nutrients, salts, *E. coli* / coliforms	
W55-1	W55C-01395	Mpuluzi	3.0	Erosion (sand-mining); residential settlements; WWTW oxidation ponds in lower reaches.	Turbidity, toxics, nutrients, salts	WWTWs oxidation ponds overflow into the river

RU	SQ reach	River name	Impact rating	WQ role players	WQ driving variables	WQ notes
W55-1	Chrissiesmeer Lake area within W55A		3.0	Residential settlements; WWTWs	Nutrients, salts, *E. coli* / coliforms	WWTWs overflow into the lakes
W70-1	W70A-02079	Swamanzi	3.0	Urban impacts; cultivation	Toxics, nutrients, salts, *E. coli* / coliforms	Manguzi oxidation ponds, KZN Wildlife lodge near Kosi Bay, Manguzi landfill site. *Inflow to Kosi Lake covered by estuary RQOs (Volume 2).*
W70-3	W70A-02301	Wetland/groundwater-driven	3.0	Effluent discharge points; cultivation	Toxics, nutrients, salts, *E. coli* / coliforms	Mseleni Hospital oxidation ponds.

THE WAY FORWARD

The proposed Classes and Catchment Configuration have been documented and concludes the National Water Resource Classification phase of this study. That information leads to the final phase, i.e., the determination of Resource Quality Objectives, as shown in this RQO series of report. All Target Ecological Categories (TECs) of high priority Resource Units (RUs) are defined in terms of flow, water quality, riparian and instream habitat and biota. In addition to this quantitative information, a suggested monitoring programme with ecological specifications to achieve and maintain the RQOs (and TEC) will be provided in the next report for the study, i.e. the Implementation and Monitoring Report. This will also form part of information that will/can be input into an implementation plan.

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TERMINOLOGY AND ACRONYMS

AEV	Acute Effects Value
ASPT	Average Score Per Taxon
BHN(R)	Basic Human Needs (Reserve)
CD: WEM	Chief Directorate: Water Ecosystems Management
DD	Data Deficient
DDT	dichlorodiphenyltrichloroethane
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
d/s	Downstream
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EcoSpecs	Ecological Specifications
EWR	Ecological Water Requirements
EFZ	Estuarine Functional Zone
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurrence
Geom	Geomorphology
GAI	Geomorphology Driver Assessment Index
IUCMA	Inkomati Usuthu Catchment Management Agency
I IHI	Instream Index of Habitat Integrity
IRS	Indoor residual spraying
IUA	Integrated Unit of Analysis
IUCN	International Union for Conservation of Nature
IWUAB	Integrated Water Use Application Bioassay toolkit
LC	Least Concern
MCB	Macro Channel Bank
MIRAI	Macro Invertebrate Response Assessment Index
MCM	Million Cubic Metres
NMMP	National Microbial Monitoring Programme
NWA	National Water Act
NWRS	National Water Resource Strategy
nMAR	Natural Mean Annual Runoff
OCP	Organochlorine pesticide
PAI	Physico-chemical Driver Assessment Index
PC	Physico Chemical
PES	Present Ecological State
PES/EI/ES	Present Ecological State, Ecological Importance and Ecological Sensitivity
POPs	Persistent Organic Pollutants
REC	Recommended Ecological Category
RDM	Resource Directed Measures
RQO	Resource Quality Objectives
RU	Resource Unit
RDRMv2	Revised Desktop Reserve Model version 2
RBM	Richards Bay Minerals
R IHI	Riparian Index of Habitat Integrity

Rip Veg	Riparian Vegetation
VEGRAI	Riparian Vegetation Response Assessment Index
SC	Scenario
SASS5	Scoring System version 5
SQ	Sub-quaternary
TEC	Target Ecological Categories
TIN	Total Inorganic Nitrogen
TWQR	Target Water Quality Range
TTG	Technical Task Group
TPC	Threshold of Potential Concern
TSS	Total Suspended Solids
u/s	Upstream
WWTW	Waste Water Treatment Works
WMS	Water Management System
WQ	Water Quality
WRCS	Water Resource Classification System
WRPM	Water Resource Planning Model
WRYM	Water Resource Yield Model
ZAC	Zululand Anthracite Collieries

Velocity Depth Classes of Fish and Macroinvertebrate habitat used in descriptions:

FD	Fast deep habitat
FFCS	Fast flow over coarse substrate
FS	Fast shallow habitat
GSM	Gravel, sand, mud
SD	Slow deep habitat
SIC	Stones-in-Current
SS	Slow shallow habitat
VFCS	Very fast over coarse substrate

SPELLING

There are multiple references to the spelling of various Rivers, Lakes, Dams and Estuaries, depending on the source of information. For the purposes of this report, the following Table presents the selected spelling of indicated water resources and places.

Selected Spelling for this Study	Alternate spellings
Usutu River	Usuthu River
Mhlathuze River	Mhlatuze, uMhlatuze River
Pongola (river, Town & Pongolapoort Dam)	Phongola, Phongolo
Lake Sibaya	Lake Sibiya, Lake Sibhayi, Lake Sibhaya
Eswatini	eSwatini
Umfolozi River	Mfolozi River
Amatigulu River	Amatikulu, Matigulu River
Goedertrouw Dam	Lake Phobane
Mfuli River	Mefule River
aMatigulu/iNyoni Estuary	
Sibiya Estuary	
Mlalazi Estuary	
uMhlathuze /Richards Bay Estuary	
iNhlabane Estuary	
uMfolozi/uMsunduze Estuary	
St Lucia Estuary	
uMgobezeleni Estuary	
Kosi Estuary	
Hluhluwe Game Reserve	
iMfolozi Game Reserve	
Ithala Game Reserve	
Ndumo Game Reserve	
Tembe Elephant Reserve	
iSimangaliso Wetland Park	
Kosi Bay and Coastal Forest Area	
uMkhuze Game Reserve	

The names adopted in the estuaries report are the official names assigned to the systems in the 'South African National Ecosystem Classification System' (and the KwaZulu-Natal Department of Economic Development and Environmental Affairs) (Dayaram *et al.,* 2021).

GLOSSARY

Basic Human Needs (BHN)	Water needs to be set aside for basic human needs such as drinking, food preparation, and health and hygiene purposes. This is referred to as the Basic Human Needs Reserve (BHNR).
Ecological Water Requirements (EWR)	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.
Ecosystem services	The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth.
EcoClassification	The term used for the Ecological Classification process - refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers relative the natural or close to the natural reference condition. The purpose of the EcoClassification process is to gain insights and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river.
EcoSpecs	Ecological specifications are the outcome of the EWR part of the study, and are provided for all components (hydrology, geomorphology, water quality, riparian vegetation, fish and macroinvertebrates) at the EWR sites. These then represent the most detailed RQOs that can be provided based on existing information.
Integrated Unit of Analysis (IUAs)	An IUA is a homogeneous area that can be managed as an entity. It is the basic unit of assessment for the Classification of water resources, and is defined by areas that can be managed together in terms of water resource operations, quality, socio-economics and ecosystem services.
Resource Quality Objectives (RQOs)	RQOs are numeric or descriptive goals or objectives that can be monitored for compliance to the Water Resource Classification, for each part of each water resource. “The purpose of setting RQOs is to establish clear goals relating to the quality of the relevant water resources” (NWA, 1998).
Sub-quaternary (SQ) reaches	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments), to a sub-quaternary reach or quinary level.
Target Ecological Category (TEC)	This is the ecological category toward which a water resource will be managed once the Classification process has been completed and the Reserve has been finalised. The draft TECs are therefore related to the draft Classes and selected scenario.
Thresholds of Potential Concern (TPCs)	TPCs are upper and lower levels along a continuum of change in selected environmental indicators and are used and interpreted according to the guidelines of Rogers and Bestbier (1997) and are linked to EcoSpecs.
UserSpecs	Where water quality is a high priority from a user perspective, user water quality specifications (UserSpecs) will be supplied for selected variables and specific users. Note that these UserSpecs are related to users such as domestic use

	(assumes primary treatment, i.e. water for drinking, laundry, cooking and personal hygiene), agriculture (stock-watering and irrigation), recreation and industry.
Water Resource Class	The Water Resource Class (hereafter referred to as Class) defines three management classes, Class I, II, and III, based on extent of use and alteration of ecological condition from the predevelopment condition.

1 INTRODUCTION

1.1 BACKGROUND

Chapter 3 of the National Water Act, 1998 (NWA) (Act 36 of 1998), deals with the protection of water resources. Section 12 of the NWA requires the Minister to develop a system to classify water resources. In response to this, the Water Resource Classification System (WRCS) was gazetted on 17 September 2010 and published in Government Gazette 33541 as Regulation 810. The WRCS is a stepwise process whereby water resources are categorised according to specific classes that represent a management vision of a particular catchment. This vision takes into account the current state of the water resource, the ecological, social and economic aspects that are dependent on the resource. Once significant water resources have been classified following the WRCS, Resource Quality Objectives (RQOs) must be determined to give effect to the class. The implementation of the WRCS therefore assesses the costs and benefits associated with utilisation versus protection of a water resource. Section 13 of the NWA requires that Water Resource Classes and RQOs be determined for all significant water resources.

Thus, the Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS) initiated a study for determining the Water Resource Classes and RQOs for all significant water resources in the Usutu to Mhlathuze Catchment. The Usutu to Mhlathuze Catchments are amongst many water-stressed catchments in South Africa. These catchment areas are important for conservation and contain a number of protected areas, natural heritage sites, cultural and historic sites as well as other conservation areas that need protection. There are five RAMSAR[1] sites within the catchment, which includes the world heritage site and St Lucia. The others are Sibaya, Kosi Bay, Ndumo Game Reserve and Turtle Beaches.

1.2 STUDY AREA

The study area is the Usutu to Mhlathuze Catchment that has been divided into six drainage areas and secondary catchment areas as follows (refer to the locality map provided as **Figure 1.1**):

- W1 catchment (main river: Mhlathuze).
- W2 catchment (main river: Umfolozi).
- W3 catchment (main river: Mkuze).
- W4 catchment (main river: Pongola) - part of this catchment area falls within Eswatini.
- W5 catchment (main river: Usutu) - much of this catchment falls within Eswatini.
- W7 catchment (Kosi Bay estuary and Lake Sibaya).

Note that all assessments within Eswatini are excluded apart from the hydrological modelling required to assess any downstream rivers in South Africa that either run through Eswatini or originate (source) in Eswatini.

River Ecological Water Requirements (EWR) sites are shown on **Figure 1.1**.

[1] A Ramsar site is a wetland site designated to be of international importance under the Ramsar Convention, also known as "The Convention on Wetlands", an intergovernmental environmental treaty established in 1971 by UNESCO in the Iranian city of Ramsar, which came into force in 1975.

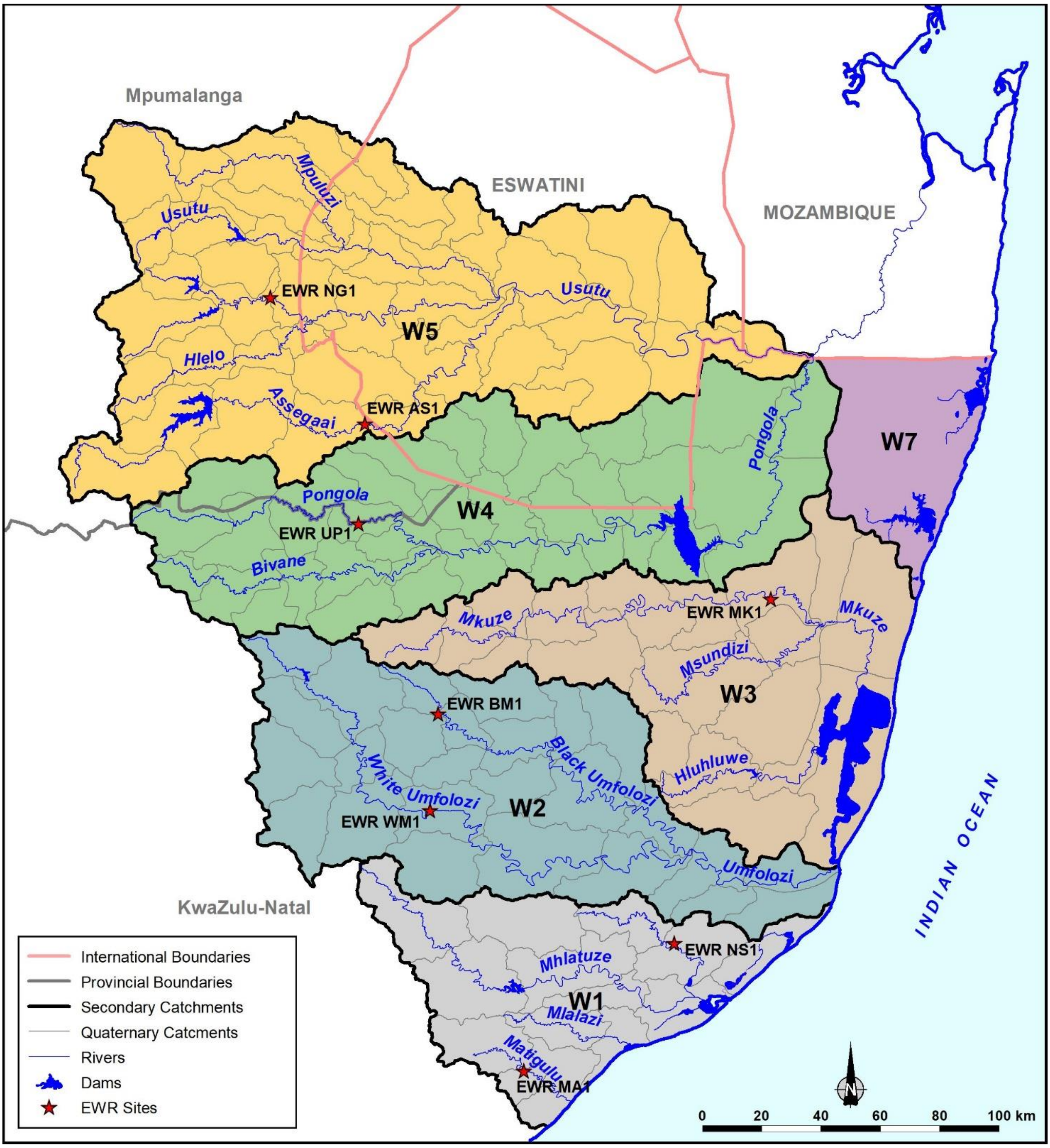

Figure 1.1 Locality Map of the Study Area

1.3 PURPOSE OF THIS REPORT

The purpose of this report is to document the Resource Quality Objectives. The results form part of Task 6: Determine Resource Quality Objectives (RQO) (narrative and numerical limits) and provide implementation information (**Figure 1.2**).

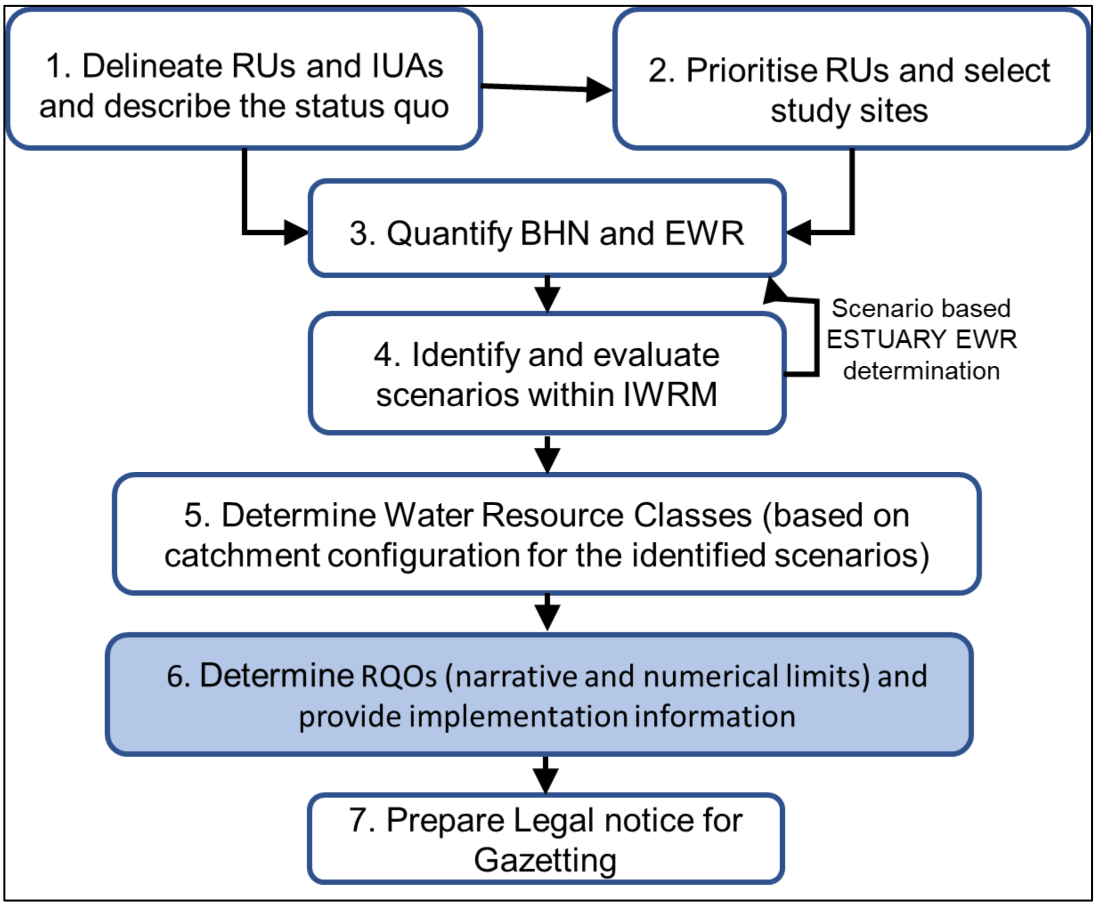

Figure 1.2 Project Plan for the Usutu-Mhlathuze Classification study

1.4 INTRODUCTION TO RESOURCE QUALITY OBJECTIVES

RQOs are numerical and/or descriptive statements about the biological, chemical and physical attributes that characterise a resource for the level of protection defined by its Class. The *National Water Resource Strategy* (NWRS) stipulates that “Resource Quality Objectives might describe, among other things, the quantity, pattern and timing of instream flow; water quality; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota”.

1.5 OPERATIONAL SCENARIOS, WATER RESOURCE CLASS AND RQOs

Operational scenarios, Water Resource Classes and RQOs are inherently linked as operational scenarios (Sc) to inform the Water Resource Class, and RQOs define and/or describe the Water Resource Class (**Figure 1.3**).

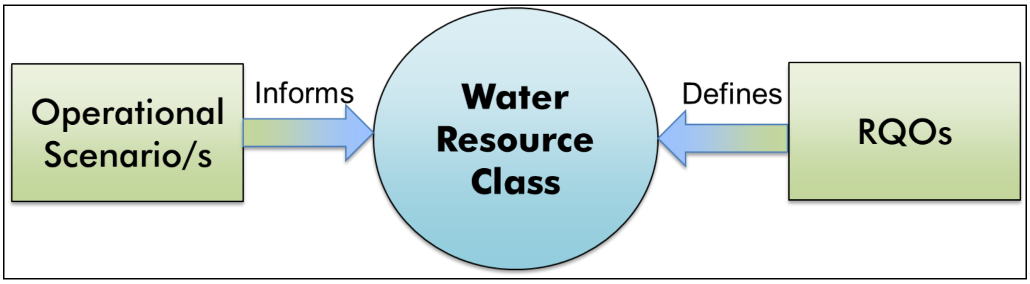

Figure 1.3 Links between RQOs and the Water Resource Class and operational scenarios

Various scenarios were tested and the selected Water Resource Class and catchment configuration (in terms of Target Ecological Categories (TEC)) are provided in **Table 1.1**.

Table 1.1 TECs and Water Resource Classes

Resource unit (RU)	River/Estuary	PES[1]	REC[2]	TEC
IUA & CLASS: W11 (Matigulu) - Class I				
W11-1	Matigulu	B	B	**B**
W11-2	Matigulu	B/C	B/C	**B/C**
W11-3	Nyoni	C/D	C/D	**C/D**
W1-Matigulu Estuary	Matigulu	B/C	B	**B**
IUA & CLASS: W12-a (Upper Mhlathuze) - Class I				
W12-1	Mhlatuze	B	B	**B**
W12-2	Mhlatuze	B	B	**B**
W12-3	Mhlatuze	C	B	**B**
W12-4	KwaMazula	C	B	**B**
IUA & CLASS: W12-b (Mfule, Mhlatuzane, Nseleni Tributary systems) - Class II				
W12-5	Mfule	C	B	**B**
W12-7	Mhtatuzana	B	B	**B**
W12-8	Nseleni	C	C	**C**
IUA & CLASS: W12-c (Lower Mhlathuze) - Class III				
W12-6	Mhlathuze	C	C	**C**
W12-uMhlathuze Estuary	Mhlathuze	D	D	**D**
IUA & CLASS: W12-d (Lake Nhlabane) - Class III				
W12-9	Nhlabane	C	C	**C**
W12-iNhlabane Estuary	Nhlabane	E	D	**D**
IUA & CLASS: W12-e (Lake Msingazi) - Class III				
W12-10	Msingazi	C	C	**C**
W12-Lake Msingazi	Msingazi	D/E	D	**D**
IUA & CLASS: W13 (Mlalazi) - Class I				
W13-1	Mlalazi	C	B	**B**
W13-2	Manzamnyama	B/C	B	**B/C**
W13-Mlalazi Estuary	Mlalazi	B/C	B	**B**
W13-Siyaya Estuary	Siyaya	D/E	C	**D**
IUA & CLASS: W21 (Upper and Middle White Mfolozi) - Class II				

Resource unit (RU)	River/Estuary	PES[1]	REC[2]	TEC
W21-1	White Mfolozi	C	B	**B**
W21-2	White Mfolozi	B	B	**B**
W21-3	White Mfolozi	C	B	**C**
W21-4	Mvunyane	D	D	**D**
W21-5	White Mfolozi	B/C	B/C	**B/C**
W21-6	White Mfolozi	B/C	B/C	**B/C**
W21-7	White Mfolozi	B/C	B/C	**B/C**
IUA & CLASS: W22 (Upper Black Mfolozi) - Class II				
W22-1	Black Mfolozi	C	C	**C**
W22-2	Black Mfolozi	B/C	B/C	**B/C**
W22-3	Sikwebezi	C	C	**C**
W22-4	Black Mfolozi	C	C	**C**
IUA & CLASS: W23 (Umfolozi-Hluhluwe Game Reserve) - Class I				
W21-8	White Mfolozi	B	B	**B**
W22-5	Black Mfolozi	B	B	**B**
W23-1	Mfolozi	B	B	**B**
W23-2	Ntobozi	B	B	**B**
IUA & CLASS: W31-a (Upper Mkuze) - Class I				
W31-1	Mkuze	C	B	**B**
W31-2	Mkuze	B	B	**B**
W31-3	Mkuze	B/C	B/C	**B/C**
IUA & CLASS: W31-b (Lower Mkuze) - Class II				
W31-4	Mkuze	C	B	**B**
W31-5	Mkuze	C	C	**C**
W31-6	Msunduzi	B	B	**B**
W32-1	Mkuze	B/C	B/C	**B/C**
IUA & CLASS: W32-a (Upper Hluhluwe) - Class I				
W32-2	Hluhluwe	B	B	**B**
IUA & CLASS: W32-b (Nyalazi & Mzinene) - Class II				
W32-4	Nyalazi	C	C	**C**
W32-5	Mzinene	C	C	**C**
W32-6	Munywana	B	B	**B**
IUA & CLASS: W41 (Bivane River) - Class I				
W41-1	Bivane	C	B	**B/C**
W41-2	Manzana	B	B	**B**
IUA & CLASS: W42-a (Upper Pongola) - Class II				
W42-1	Phongolo	C	B	**C**
W42-2	Phongolo	C	C	**C**
IUA & CLASS: W42-b (Middle Pongola (Itala))- Class I				
W41-3		C	C	**C**
W42-3	Phongolo	B	B	**B**
W42-4	Mozana	B	B	**B**

Resource unit (RU)	River/Estuary	PES[1]	REC[2]	TEC
W42-5	Phongolo	B	B	**B**
IUA & CLASS: W44 (Middle Pongola (Grootdraai))- Class III				
W44-1	Phongolo	D	D	**D**
IUA & CLASS: W45 (Lower Pongola (Floodplain))- Class III				
W43-1	Ngwavuma	C	C	**C**
W45-1	Phongola	C	C	**C**
W45-Pongola Floodplain	Phongola	D	C	**D**
IUA & CLASS: W51-a (W5 upstream major dams (Assegaai)) - Class II				
W51-1	Assegaai	C/D	B/C	**B/C**
IUA & CLASS: W51-b (W5 upstream major dams (Ngwempisi, Usutu))- Class III				
W53-1	Ngwempisi	D	D	**D**
W53-2		B/C	B/C	**B/C**
W54-1	Usutu	B	B	**B**
IUA & CLASS: W52 (downstream major dams & Hlelo River) - Class II				
W51-2	Assegaai	C	C	**C**
W51-3	Mhkondvo	C	C	**C**
W51-4	Blesbokspruit	C	C	**C**
W52-1	Hlelo	B/C	B/C	**B/C**
W53-3	Ngwempisi	B/C	B/C	**B/C**
W54-2	Usutu	C	C	**C**
IUA & CLASS: W55 (Mpuluzi & Lusushane River Systems) - Class I				
W55-1	Mpuluzi	B/C	B/C	**B/C**
W55-2	Lusushwana	C	C	**C**
W55-pans incl. Chrissiesmeer	W55 pans	B	B	**B**
IUA & CLASS: W57 (Lower Usutu River) - Class I				
W57-1	Usutu	B/C	B	**B/C**
W57-Ndumo Pans	Ndumo Pans	A	A	**A**
IUA & CLASS: W70-a (Kosi Bay) - Class I				
W70-1		D	D	**D**
W70-2		B	B	**B**
W70-Kosi Lakes & Estuary		A/B	A	**A**
IUA & CLASS: W70 (Muzi Swamps) - Class II				
W70-Muzi Swamps		C	C	**C**
IUA & CLASS: W70-b (Sibaya) - Class I				
W70-3		D	D	**D**
W70-Lake Sibaya		B	B	**B**
W70-uMgobezeleni Estuary		B	A	**A/B**
IUA & CLASS: St. Lucia - Class I (long term)				
St. Lucia, W2 & W3 feeder streams	St. Lucia	D	B	**C→B**
W32-Mkuze Floodplain/Swamp	Mkuze	B	B	**B**

[1] Present Ecological State [2] Recommended Ecological Category

Note that the estuary and wetland RUs have been included in the above table. RQOs for these systems will however be addressed in separate reports (Volume 2 and 3).

1.6 PURPOSE AND OUTLINE OF THIS REPORT

The purpose of this document is to provide a summary of the narrative and numerical RQOs for the Usutu to Mhlathuze catchment river sites.

The report outline is as follows:

- **Chapter 1** provides general background information on the study area and the Project Plan.
- **Chapter 2** is an overview of the important Resource Units in the study area, the approach and format of selected RQO components.
- **Chapter 3** outlines the various multi-disciplinary methodologies adopted during this task.
- **Chapter 4 – 11** provide the RQOs of the various components of high priority RUs containing EWR sites.
- **Chapter 12** provide the RQOs of the various components of high priority RUs where no EWR site is present.
- **Chapter 13** consists of user water quality RQOs for high priority RUs.
- **Chapter 14** provides hydrological RQOs for low and moderate priority RUs.
- **Chapter 15** provides additional information on future monitoring at moderate priority RUs.
- **Chapter 16** lists the references used in the report.
- **Chapter 17 lists the references used in this report.**
- **Appendix A** lists the RUs and associated sub quaternary reaches for the respective secondary catchments. Maps for each secondary catchment are also provided showing the RUs and the associated sub quaternary reaches.
- **Appendix B** provides numerical limits for toxic substances as sourced from aquatic ecosystem water quality guidelines (DWAF, 1996a) and methods for assessing the water quality part of the Ecological Reserve for rivers (DWAF, 2008a).

2 PRIORITISING RESOURCE UNITS AND INDICATOR COMPONENTS

As part of the classification process, once the Integrated Unit of Analysis (IUAs) have been defined, Resource Units (RUs) and biophysical nodes must be identified for different levels of EWR assessment and the setting of RQOs. RUs are sections of a river that frequently have different natural flow patterns, react differently to stress according to their sensitivity, and therefore require individual specifications of the Reserve appropriate for that reach. The guiding principle is that if the hydrology, geomorphic characteristics (i.e. geomorphic zone), physico-chemical attributes and river size remains relatively similar, a RU can be demarcated (DWAF, 2008b).

Management requirements (DWAF, 1999, volume 3) also play a role in the delineation. An example could be where large dams and/or transfer schemes occur. Furthermore, the type of disturbance/impact on the river plays a role in selecting homogenous river reaches from a biophysical basis under present circumstances. Hydrological changes due to incremental runoff must also be taken into account (DWAF, 2008b).

RU priority is based on the outcome of the RU priority assessment (DWS, 2022a). RUs and associated priorities were therefore defined during the initial steps of this study and are documented in DWS (2022a).

2.1 FORMAT OF RQO COMPONENTS

The Water Act (1998) requires RQOs to be set for the following components:

- Quantity, pattern and timing of instream flow (hydrology).
- Water quality (as part of rivers for EWR sites and high priority water quality sites).
- Geomorphology
- Characteristics and condition of riparian habitat and biota.
- Characteristics and condition of instream habitat and biota.

Hydrological RQOs are provided as a flow regime (described by means of a time series) associated with the Ecological Category (EC) associated with the final Water Resource Classes, i.e. the Target EC or TEC. The output is provided as the following:

- Flow duration table based on a hydrological time series. The full EWR rule is available electronically.
- Summary using various statistics.
- Defined quantity and frequency.

Habitat and biota are described as the habitat and biota associated with an EC. The EC is the target resulting from the Water Resource Class that will be implemented, i.e. the TEC. RQOs are provided for the high priority RUs. EcoSpecs (Ecological specifications) for components (as outcome of the EWR part of the study) are provided at the EWR sites. These represent the most detailed RQOs that can be provided based on existing information. If there are high priority RUs without EWR sites, then any existing information will be used to supply qualitative RQOs (a narrative) rather than quantitative RQOs.

Where water quality is a high priority from a user perspective, user water quality specifications (UserSpecs) will be supplied for selected variables and specific users. Note that these UserSpecs are related to users such as domestic use (assumes primary treatment, i.e. water for drinking, laundry, cooking and personal hygiene), agriculture (stock-watering and irrigation), recreation and industry. UserSpecs may be different from Ecological Specifications (EcoSpecs), although these can inform the user water quality RQOs. Note that high priority water quality sites may still select the ecology as the driving role player, even if not an EWR site, and set objectives accordingly.

RQOs will be set for a different suite of components depending on the priority of the RUs as follows:

- **RUs with EWR sites:**
  - Flow RQOs as generated in Step 3 (rivers) (DWS, 2022b; DWS, 2023).
  - Habitat and biota RQOs for the sub-components.
  - Water quality RQOs
- **High Priority RUs with no EWR sites**:
  - Broad (desktop level) flow RQOs (EWR) as generated during Step 3 (DWS, 2022b; DWS, 2023).
  - Available information will be used to provide qualitative biota and habitat RQOs.
  - Broad water quality information (unless it is a water quality hotspot (see last bullet) will be provided.
- **Other priority RUs**:
  - Flow RQOs as generated in Step 3 (rivers) (DWS, 2022b; DWS, 2023)
- **Water quality hotspots (high priority water quality RUs):** In addition to RQOs being provided at EWR sites, water quality RQOs may need to be provided at a range of other areas where water quality issues of importance have been identified.

2.2 HIGH PRIORITY RUs FOR DETAILED RQO DETERMINATION

Table 2.1 provides the High Priority RUs and/or RUs with EWR sites which may not be within High Priority RUs. The RU Priority column provides the RU Priority as determined during Task 2 of this project and documented in the **Resource Units Delineation and Prioritisation Report** (DWS, 2022a). Priority ratings of 3 and 4 are deemed High Priority. Note that where a link to another EWR site is indicated, the statement refers to extrapolation of the hydrological RQO. **Appendix A** lists the RUs and associated sub quaternary reaches for the respective secondary catchments. Maps for each secondary catchment are also provided showing the RUs and the associated sub quaternary reaches.

Table 2.1 RUs with detailed RQOs for all components

RU	Main river	PES	Key Drivers	RU Priority	EWR site
W1 Secondary Catchment (Main River: Mhlathuze)					
W11-2	Matigulu	**B/C**	Flow, WQ[1], Non-flow	**2**	EWR MA1
W12-3	Mhlathuze	**C**	Flow, WQ, Non-flow	**4**	Linked to historical EWR 3
W12-6	Mhlathuze	**C**	Flow, WQ, Non-flow	**4**	Historical EWR 3
W12-8	Nseleni	**C**	Flow, WQ, Non-flow	**4**	EWR NS1
W12-9	Nseleni	**C**	Flow, WQ, Non-flow	**4**	Linked to lakes and estuary
W2 Secondary Catchment (Main River: Umfolozi)					
W21-5	White Mfolozi	**B/C**	Flow, Non-flow	**4**	EWR WM1
W22-1	Black Mfolozi	**C**	Flow	**3**	EWR BM1
W22-5	Black Mfolozi	**B**	Flow, Non-flow	**3**	Linked to EWR BM1

RU	Main river	PES	Key Drivers	RU Priority	EWR site
W23-1	Mfolozi	B		3	Linked to EWR BM1 and WM1
W3 Secondary Catchment (Main River: Mkuze)					
W31-1	Mkuze	C	Flow, WQ, Non-flow	3	Linked to EWR MK1
W31-2	Mkuze	B		3	Linked to EWR MK1
W31-3	Mkuze	B/C	Flow, WQ, Non-flow	4	Linked to EWR MK1
W31-4	Mkuze	C		4	Linked to EWR MK1
W31-5	Mkuze	C	Flow, WQ, Non-flow	3	EWR MK1
W32-1	Mkuze	B/C	Flow, Non-flow	4	Linked to EWR MK1
W32-6	Munywana	B		4	Linked to St Lucia
W4 Secondary Catchment (Main River: Pongola - excluding Eswatini)					
W42-2	Phongolo	C	Flow Non-flow (WQ)	2	EWR UP1
W45-1	Phongolo	C	Flow, Non-flow (WQ)	4	Linked to EWR UP1
W5 Secondary Catchment (Main River: Usutu - excluding Eswatini)					
W51-2	Assegaai	C	Flow, Non-flow	4	Linked to EWR AS1
W51-3	Mhkondvo	C	Flow, Non-flow (WQ)	4	EWR AS1
W53-2	Mpama	B/C	Flow, Non-flow	4	Use IUCMA monitoring information where available (IUCMA, 2020).
W53-3	Ngwempisi	B/C	Flow, Non-flow (WQ)	2	EWR NG1
W54-1	Usutu	B		4	Use IUCMA monitoring information where available (IUCMA, 2020).
W57-1	Usutu	B/C	Flow	4	Linked to pans and floodplains (Ndumo)

1 Water Quality

Table 2.2 provides the table for any additional High Priority water quality RUs (water quality hotspots impact ratings 3 to 5, or Large to Critical) for which water quality RQOs will be set for the key driving variables. Although WQ RQOs will be set per RU, **Table 2.2** shows the specific issue within the sub-quaternary reaches nested within the RU. Different shading indicates blocks of RUs for which a single set of water quality RQOs will be set.

Table 2.2 High priority water quality RUs (excluding EWR sites). Shading indicates RUs for which a single set of RQOs will be set

RU	SQ reach	River name	Impact rating	WQ role players	WQ driving variables	WQ notes
W11-2	W11C-03713	Nyezane	3.0	Dryland cultivation; Gingindlovu oxidation ponds (High Risk)	Turbidity, nutrients, salts, *E. coli* / coliforms	Same RU as EWR MA1
W12-5	W12C-03263	Mfulazane	3.0	Melmoth oxidation ponds. Sewage pumpstation overflows.	Nutrients, salts, *E. coli* / coliforms	Melmoth WWTW upgrade planned (tender May 2021
W12-6	W12E-03475	Mhlathuze	3.0	Dryland cultivation	Turbidity	
W12-8	W12H-03401	Okula	3.0	Dryland cultivation; erosion; Tronox	Turbidity, nutrients, *E. coli* / coliforms. Tronox: Fe, metals, sulphate, i.e. toxics.	Tronox KZN sands. Tronox CPC sewage pumpstation. Hillview sewage pumpstation. Sewage overflows near

RU	SQ reach	River name	Impact rating	WQ role players	WQ driving variables	WQ notes
						Qalakbusha Correctional Services.
W12-9	W12F-03611	Mzingwenya (inflow into Lake Cubhu); Lake Cubhu	3.0	Urban impacts. Eutrophication of the lake.	Nutrients, toxics, *E. coli* / coliforms	Short urban stream running next to Uzimgwenya township. Gobandlovu on the other bank at the top end of the Estuary Functional Zone (EFZ): *Lake Cubu covered by estuary RQOs for Zone D of Mhlatuze Estuary complex.*
	W12J-03290	Nhlabane	3.0	Eutrophication of the lake.	Nutrients, *E. coli* / coliforms	*Lake Nhlabane covered by estuary RQOs.*
	W12J-03411		3.0	Eutrophication of the lake.	Nutrients, *E. coli* / coliforms	
W12-10	W12J-03392	Mpisini	3.0	Smelter	Toxics	Richards Bay Minerals (RBM) smelter
W21-1	W21A-02527	White Mfolozi	3.0	Waste Water Treatment Works (WWTW)	Nutrients, salts, *E. coli* / coliforms	Stilwater Hotel with package plant that is non-compliant; discharges into the river. Reach is long; instream point downstream (d/s) discharge at bottom of reach
W21-1	W21B-02539	iShoba	4.0	Hlobane Mine; erosion	Toxics, salts, nutrients, turbidity, sulphate	Highest salts and sulphates in W2
W21-1	W21B-02546	White Mfolozi	3.0	WWTW	Nutrients, salts, *E. coli* / coliforms	WWTW discharges into White Mfolozi upstream (u/s) dam. High nutrients into Klipfontein Dam
W21-4	W21D-02676	Mvunyane	3.0	Urban impacts, incl. WWTW; erosion	Toxics, salts, nutrients, turbidity, *E. coli* / coliforms	Mondlo WWTW discharges into small tributary (Ugoqo) and into dam. 1.5 km from dam.
W21-4	W21D-02788	Vumankala	3.0	Erosion	Turbidity	
W21-4	W21D-02832	Jojosi	3.0	Erosion; over-grazing	Turbidity	
W21-4	W21D-02848	Jojosi	3.0	Erosion; over-grazing	Turbidity	
W21-4	W21E-02963	Nondweni	3.5	Erosion; over-grazing	Turbidity	
W21-4	W21E-02912	Nondweni	3.0	Erosion; over-grazing	Turbidity	
W21-4	W21E-02873	Nondweni	3.0	Erosion; over-grazing	Turbidity	Recommendations for data collection, e.g. turbidity/Total Suspended Solids (TSS)
W21-7	W21K-02976	Mbilane	3.0	Ulundi WWTW; urban impacts	Nutrients, salts, toxics	WWTW discharge point into W21K-02981
W21-7	W21K-03019	Nhlungwane	3.0	Erosion; over-grazing; anthracite mine	Turbidity, salts, toxics	Zululand Anthracite Collieries (ZAC)
W21-7	W21K-02981	White Mfolozi	3.0	Commercial forestry; irrigation	Turbidity, salts, toxics	Afrimat quarry upstream;oxidation ponds

RU	SQ reach	River name	Impact rating	WQ role players	WQ driving variables	WQ notes
W22-5	W22J-02942	Mvalo	3.5	Coal mining impact; over-grazing	Nutrients, salts, toxics, turbidity	ZAC; border of the Hluhluwe-Imfolozi Game Reserve
W23-1	W23A-03058	Mbukwini	3.0	Mining	Toxics, salts	Tendele mine - number of mining sites. Not being mined as no access to extended mining area. Not closed; on care and maintenance. License valid until 2025.
W23-1	W23A-03083	Mfolozi	3.0	Erosion; over-grazing; mining	Turbidity, toxics, salts	Extension of Tendele mine - straddles both SQ reaches
W23-3	W23B-03231	Msunduzi	4.0	Cultivation; fertilizers/ biocides	Nutrients, salts, toxics	
W23-3	W23C-03180	Msunduzi	4.0	Cultivation; fertilizers/ biocides	Nutrients, salts, toxics	
W23-3	W23D-03108	Mfolozi	4.0	Cultivation; fertilizers/ biocides; sugar mill discharge point; urban impacts	Nutrients, salts, toxics, *E. coli* / coliforms	Three WWTWs in larger area. Mtubatuba, St Lucia oxidation ponds, KwaMsane WWTW
W31-1	W31A-02494	Nkongolwana	4.0	Mining; cultivation; erosion	Toxics, salts, nutrients, turbidity	
W31-1	W31B-02477	Mkuze	3.0	Erosion	Turbidity	
W31-4	W31J-02469	Mkuze	3.0	WWTW	Nutrients, salts, toxics, *E. coli* / coliforms	Mkuze WWTW medium risk
W42-1	W42B-02331	Bazangoma	3.0	Cultivation	Nutrients, salts, toxics, pH, sulphate	Makateeskop - tributary to Bazangoma. Coal discard dumps
W42-2	W42D-02327	Gode	3.0	Urban impacts; cultivation	Nutrients, salts, toxics, *E. coli* / coliforms	eDumbe (Paulpietersburg) oxidation ponds
W43-1	W43F-02099	Ngwavuma	3.0	Erosion; extensive cultivation	Turbidity, toxics, nutrients, salts	
W44-1	W44B-02248	Manzawakho	3.5	Erosion; feedlots; WWTW; extensive cultivation	Turbidity, toxics, nutrients, salts, *E. coli* / coliforms	Pongola WWTW
W44-1	W44B-02351	Phongolo	4.0	Mill discharges; extensive cultivation	Toxics, nutrients, salts	
W44-1	W44C-02338	Phongolo	4.0	Extensive cultivation	Toxics, nutrients, salts	
W44-1	W44D-02304	Phongolo	3.0	Extensive cultivation	Toxics, nutrients, salts	
W45-1	W45A-02368	Phongolo	4.0	WWTW; extensive cultivation	Toxics, nutrients, salts, *E. coli* / coliforms	
W45-1	W45B-02105	Phongolo	3.0	Extensive cultivation; erosion; settlements	Toxics, nutrients, salts, turbidity, *E. coli* / coliforms	Extensive rural and subsistence farming in Pongola floodplain/Makitini Flats
W51-1	W51A-02082	Assegaai	3.0	Mine decant; erosion; cultivation	Nutrients, salts, toxics, *E. coli* /coliforms	

RU	SQ reach	River name	Impact rating	WQ role players	WQ driving variables	WQ notes
W51-1	W51B-02101	Ngulane	3.0	Cultivation; mining	Toxics, nutrients, salts, *E. coli* /coliforms	Streams upstream of Heyshope Dam; mining
	Tributaries flowing into Heyshope Dam (Northern part of the Dam) within W51B		3.0	Driefontein settlements; WWTWs; coal mines	Toxics, nutrients, salts, *E. coli* / coliforms	Mining activities
	Heyshope Dam		4.0		Salts	Water source for Eskom
W51-3	W51D-02044	Assegaai	3.0	Urban impacts; Piet Retief WWTW	Nutrients, salts, toxics, *E. coli* / coliforms	Klipmisselspruit drains into this SQ and is highly impacted by urban impacts: Jindal Coal Mine Siding, industries and Piet Retief WWTW.
W51-4	W51F-01986	Blesbokspruit	3.0	Cultivation; wood-processing	Toxics, nutrients, salts	Wood-processing plant
W51-4	W51F-02019	Blesbokspruit	4.0	Industries (Woodchem + PG Bison and Mpact); saw mills; residential settlements	Toxics, nutrients, salts, *E. coli* / coliforms	
W53-3	W53C-01679	Thole	3.0	Urban impacts; WWTW; cultivation	Toxics, nutrients, salts, *E. coli* / coliforms	
W55-1	W55C-01395	Mpuluzi	3.0	Erosion (sand-mining); residential settlements; WWTW oxidation ponds in lower reaches.	Turbidity, toxics, nutrients, salts	WWTWs oxidation ponds overflow into the river
W55-1	Chrissiesmeer Lake area within W55A		3.0	Residential settlements; WWTWs	Nutrients, salts, *E. coli* / coliforms	WWTWs overflow into the lakes
W70-1	W70A-02079	Swamanzi	3.0	Urban impacts; cultivation	Toxics, nutrients, salts, *E. coli* / coliforms	Manguzi oxidation ponds, KZN Wildlife lodge near Kosi Bay, Manguzi landfill site. *Inflow to Kosi Lake covered by estuary RQOs.*
W70-3	W70A-02301	Wetland/groundwater-driven	3.0	Effluent discharge points; cultivation	Toxics, nutrients, salts, *E. coli* / coliforms	Mseleni Hospital oxidation ponds

3 APPROACH FOR DETERMINING RQOs FOR RIVERS

For the purpose of RQO determination, the following differentiation is made between biota and habitat EcoSpecs and RQOs.

EcoSpecs are associated with the Ecological Reserve process and are usually provided at EWR sites. As explained in **Chapter 2**, EWR sites are situated in High Priority SQs (hotspots) and therefore High Priority RUs requiring detailed RQOs. EcoSpecs are seen as detailed RQOs as they are quantifiable, measurable, verifiable and enforceable to ensure protection of all components of the resource, which make up ecological integrity (DWA, 2009). Therefore, EcoSpecs are numerical and can be used for monitoring. Thresholds of Potential Concern (TPCs) are upper and lower levels along a continuum of change in selected environmental indicators and are used and interpreted according to the guidelines of Rogers and Bestbier (1997) and are linked to EcoSpecs. When setting EcoSpecs, input is usually based on fieldwork that has been undertaken, meaning a monitoring baseline is therefore available and monitoring to determine whether the specifications (or Ecological Category) are being achieved can be undertaken.

If there are no EWR sites in a High Priority Area, then biota and habitat RQOs are usually determined rather than EcoSpecs. The RQOs will be broader and less detailed, which would be expected where no field validation has been undertaken. A monitoring baseline is therefore not available and EcoSpecs cannot be determined. As sufficient data are not available to set specifications, only broad objectives for the EC are provided which entails numerical flow RQOs and a desktop PES for the EcoStatus, as a surrogate for biota and habitat RQOs.

3.1 WATER QUALITY

3.1.1 General approach

The approach to User Water Quality tasks is encapsulated in DWS (2016), which is a document containing all water quality tools and standardized inputs and outputs currently used for the operationalizing of Resource Directed Measures (RDM). During Steps 1 and 2 and associated sub-steps of the Integrated framework (DWS, 2016) and Project Plan for the Usutu-Mhlathuze study (**Figure 1.1**), data is gathered on the following to inform the water quality process for both ecological water quality and users:

- Identify water quality users or role players and associated uses, and water quality issues/problems that may impact on use (Step 1.2.3 and Step 2.3 and 2.5, respectively for rivers and estuaries, of the integrated framework).
- Identify pollution priority areas, or water quality hotspots (Step 1.2.3 of the integrated framework). Priority protection areas, e.g. springs where drinking water is collected, may also be identified.
- Identify driving variables responsible for water quality state (Step 1.2.3 of the integrated framework).
- Gather information on users, issues and driving variables from stakeholders at Technical Task Group (TTG) and information meetings and prepare water quality users spreadsheet (Step 2.1.3 of the integrated framework). *The river water quality TTG meeting for the Usutu-Mhlathuze study was held in Richards Bay on 3 November 2022. Information was also gathered at a subsequent online meeting on 1 December 2022 with the KZN regional DWS office and Geert Grobler of DWS Head Office. Additional information was obtained*

electronically from selected stakeholders, with information for W5 gathered subsequent to the RQO workshop held in Mbombela on 24 August 2023.

- Test information with stakeholders (this information feeds into Integrated Step 6, the selection of RQOs for water quality) (Step 2.1.3 of the integrated framework). *This step was undertaken at the TTG meeting in November 2022.*
- Catchment water quality (status quo) and processes (Step 2.1.6 of the integrated framework).

The output of these two steps is a spreadsheet or tables containing the following information for High Priority RUs other than RUs containing EWR sites, as information for all variables is required for those RUs:

- Study area delineated into Sub Quaternary (SQ) catchments, clustered into RUs and within the framework of Integrated Units of Analysis (IUAs).
- Water quality priority resource units.
- Water quality role players/users and their locations within RUs.
- Driving users/role players in terms of water quality.
- Water quality variables that drive water quality state or requirements.

Where objectives for aquatic ecosystems were not available from a Reserve study and the Reserve water quality manual (DWAF, 2008a), water quality guidelines were used (DWAF, 1996a–e). Note that guidelines are not linked to an Ecological Category, but rather a level of protection, e.g. a Target Water Quality Range (TWQR; which is equivalent to a level or concentration related to an A (least impacted) category).

Water quality RQOs that are immediately applicable are ONLY those where monitoring data are available for comparative purposes. Monitoring recommendations and provisional RQOs are set for identified driving variables for which RQOs are not immediately applicable, but for which a database needs to be developed. Once an adequate dataset has been produced, evaluate the provisional RQOs provided and update the RQOs for the driving variables identified during this Classification study.

3.1.2 Setting numerical and narrative RQOs

Numerical and narrative RQOs were therefore produced using all existing data sources for identified monitoring points. Note that Reserve data available as A - D categories were converted to Ideal to Tolerable categories (required for water quality gazetting purposes), as follows:

Categories A and A/B: Ideal
Categories B, B/C and C: Acceptable
Categories C/D and D: Tolerable

To summarise, the user water quality state per relevant RU was evaluated by determining the driving water quality variables linked to the primary water quality user(s). Note that although the aquatic ecosystem is the **resource base** rather than a “user”, it was grouped and evaluated with other users for purposes of this step of the Classification process. The driving user and set of variables were identified and the water quality RQOs set accordingly.

Note that RQOs that are *immediately applicable* (and will therefore be gazetted) are only for those sites and variables where monitoring is currently taking place. Other RQOs are *provisional* and can only be evaluated and confirmed once adequate monitoring data are available for assessment and use. Short-term (in 5 years) and long-term (in 10 years) RQOs are also proposed where water quality intervention is critical to reaching RQOs and assigned ECs for instream components, e.g. fish, such as the Mkuze system.

3.1.3 Priority levels

Water quality RQOs were set for all High (Level 3), Very High (Level 4) and Critical (Level 5) Water Quality (WQ) High Priority sites. Note that EWR sites, and two additional nodes (Mpama and Usuthu rivers in W53-2 and W54-1 respectively) not containing EWR sites, are delineated High Priority.

Detailed RQOs were produced for water quality where data are available, and EWR sites. Note that a water quality assessment was often not available for sites other than EWR sites, and sites flagged and monitored by regional offices.

Detailed water quality assessments have been conducted for EWR sites using methods such as the Physico-chemical Driver Assessment Index (PAI models) (DWAF, 2008a).

3.1.4 Assumptions/rules when setting RQOs

The following set of assumptions and rules were developed and followed when setting RQOs.

a) Dams
RQOs were generally not set for dams, although Heyshope Dam is addressed due to its significance as a water source for Eskom.

b) Format of values used for setting RQOs
Values used for setting RQOs were linked to standard DWS methods and procedures, i.e. the manner in which variables are analysed and curated on DWS's Water Management System (WMS) database (e.g. NO_2 and NO_3**-N** and PO_4**-P**), and Reserve methods for water quality in rivers (DWAF, 2008a). It is acknowledged that different ways of evaluating nutrients are available (e.g. Total Phosphate), but standard DWS approaches were followed.

c) Data availability
RQOs were set based on real data were available and used for assessing water quality state at EWR and other monitored sites, i.e. monitoring data available and verified at the time of writing the reports. Note that monitoring data to be collected for measurement against RQOs that are immediately applicable and to be gazetted, should be collected from the monitoring points as identified in the water quality section of the River EWR documentation for this study, if possible. The data from these routine monitoring points were used for analyses and subsequently, RQO development.

Where data were not available, extrapolation from real data was undertaken where possible, or land-use and all other available information sources used. It is acknowledged that these RQOs are PROVISIONAL and will only become applicable once a database of information has been set up through monitoring, to evaluate whether the RQO is valid and appropriate, or needs adjusting. An adaptive management approach is therefore recommended for these sites.

d) Data quality
Standard DWS methods (e.g. DWAF, 2008a) have been followed for the analysis of water quality data and preparation of RQOs. Although the use of percentiles is acceptable practise, it is necessary

to define data quality and length of an acceptable data record when calculating percentiles. When compliance to a percentile is evaluated, it is important to know the associated statistical confidence of the data, and therefore the confidence in the result. The following guidelines regarding data frequency and hence quality are taken from DWAF (2008a).

The general rule for data selection is the following:
*Select the RC (or Reference Condition/natural state) data as the **first** 3 - 5 yrs (**minimum of 60 data points for high confidence, 25 samples for moderate confidence and 12 samples for low confidence**) of the data record, and the PES as the **last** 3 - 5 years of data (again a minimum of 60, 25 or 12 data points for difference confidence levels). The monitoring point suitable for Reference Condition must therefore either be in an unimpacted tributary (this can be in an adjacent catchment, but in the same Level II EcoRegion) or a very early data record (e.g. from the 1960s – early 1980s). It is possible to use the same monitoring point for Reference Condition and PES data, if the appropriate data record is available.*

Note that although a low confidence desktop assessment can be run using 12 data points, these points should preferably be spread across the hydrological cycle. Alternatively, weekly monitoring over a 60 day period can be undertaken.

It is difficult to specify a time window of observation, as the frequency of monitoring would be dependent on the implementing agent undertaking and financing the monitoring, but it is acceptable to say that at least 12 data records over a hydrological regime should be used for any level of confidence (which would be low confidence, in this instance). Note that DWAF (2008a) states the following regarding confidence in water quality data for conducting a Reserve assessment in High or Very High Ecological Importance and Sensitivity (EIS) systems. The same rule should apply to testing compliance against RQOs at EWR sites.

Note: If inadequate data exists for an assessment in a *High / Very High* EIS area **(i.e. n<25)**, recommend that monitoring is initiated (preferably over one hydrological cycle) before a Reserve can be determined, including at the Desktop level. This constraint may be waived if sufficient biological monitoring and site-specific information is available.

Note that data collected for compliance monitoring at EWR sites must be taken from the same site used for the Reserve study, as a general rule. It is possible that a DWS monitoring site might be discontinued as a better site becomes available; the data from the “new” site should then be used. Comparisons of data against Reserve quality EcoSpecs (i.e. the ecological water quality RQOs) must be done with care. Note that if the monitoring points are within the same Level II EcoRegion, RQOs and monitoring data should be comparable.

Data used for the derivation of percentiles could include baseline monitoring data, as the sampled time windows then increase, with an associated increase in statistical power. Although a smaller data set would be more sensitive to short-term variation, it would also have a shorter “memory” for historic non-compliance than a larger data set. However, a smaller data set is more prone to being affected by natural variation, and sampling and laboratory error. In contrast, a larger monitoring data set will comprise samples drawn from a longer time-frame. Together with the greater statistical power implicit in a larger sample size, such a larger data set will amalgamate data over a longer time-frame and, in this way, the impact of short term variations in water quality will be decreased (Griffin and Palmer, 2011).

e) Microbial compliance targets

Although microbial compliance targets for WWTW should be specified in the water use license for the discharge, an objective for *E. coli* and faecal coliforms was set below each WWTW, town and large settlement. As a clear relationship has been reported between the concentration of *Escherichia coli* (or *E. coli*) in a particular water sample and the probability of gastroenteritis symptoms in humans exposed to the water through drinking or full-contact recreation (e.g. swimming), *E. coli* is used as a microbial indicator organism.

In areas where concentrations are already non-compliant to full or partial contact recreational guidelines (e.g. swimming, DWAF (1996a): 0 - 130 counts/ml), without a possibility of reducing significantly in the short term, risk level guidelines used by the National Microbial Monitoring Programme (NMMP) of South Africa, were adopted (see **Table 3.1**).

The NMMP measures *E. coli*, pH and turbidity at a number of priority sites across the country, based on a site prioritisation system (Kühn *et al*., 2000; DWAF, 2002). Although turbidity does not in itself have direct health effects, it is one of the indicators of microbiological water quality. Depending on the nature of the origin of the suspended matter causing the turbidity, there may be associated health effects. Suspended clay particles, often a major contributor to turbidity in surface waters, provide large surfaces for colonisation by bacteria and other micro-organisms.

The following updated NMMP objectives were used for this study **(Table 3.1)**, largely due to the dearth of information on faecal coliform concentrations, and on what and where recreational or other activities are taking place in the study area. There are also localised instances of faecal coliform and *E. coli* pollution which cannot easily be addressed in the short-term. A phased approach may be necessary in many areas to improve faecal coliform and *E. coli* conditions. RQOs for faecal coliforms and *E. coli* have therefore been written as an evaluation against potential health risk rather than achieving absolute values (i.e. 0 - 130 counts/ml, as stated in recreational use water quality guidelines). A risk warning and acknowledgement of risk by the appropriate local or district authority (e.g. local or district municipality) is considered an appropriate first step to improving coliform state. It is assumed that this microbial parameter will also be addressed in license conditions for effluent discharge points, e.g. at WWTWs.

The NMMP objectives includes potential health risks for drinking water after limited treatment (e.g. boiling) and irrigation of crops (e.g. carrots, lettuce, tomatoes) to be eaten raw. As the risk table **(Table 3.1)** refers to levels of coliforms, implicit to its use by the local authority is an assessment of the levels of faecal coliforms in the water body being used by communities.

Note that this health risk table was developed specifically for the NMMP and has not been tested in other contexts (DWAF, 2002).

Table 3.1 Health risk guidelines or RQOs for faecal coliforms/*Escherichia coli*

Water use attribute	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
1. Drinking untreated water	0	1 - 10	>10
2. Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
3. Full or partial contact**	<600	600 – 2 000	>2 000
4. Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place, so the *E. coli* counts shown on the table are BEFORE treatment. Limited treatment refers to treatment such as boiling, and does not refer to more conventional and format treatment such as flocculation, sedimentation, filtration and disinfection.
** Full contact refers to full-body immersion activities such as swimming or baptism, whereas partial contact refers to activities such as canoeing, where water may be splashed on to the body.

f) Toxics

In certain areas, where specific information on toxics is not available or where the identity of contaminants is not known, biotic responses and biological monitoring can be used to indicate toxicity.

Instream toxicity testing can also be conducted, particularly where extensive biocide/fertilizer use is indicated. It is recommended that toxicity testing be conducted on a suite of aquatic organisms, such as bacteria, algae, crustaceans and fish as test taxa, using river water as the diluent. A number of texts can be consulted regarding toxicity testing, e.g. Griffin *et al.* (2019), which introduces the Integrated Water Use Application Bioassay toolkit (IWUAB). The toolkit includes details of tests that can be undertaken under various conditions.

The default state should be to eliminate toxics from rivers, but again it is acknowledged that this may require a phased approach, and that the first step is to be aware of instances where toxics are, or seem to be, problematic. Through recent research and surveys, areas of organochlorine pesticide (OCP) contamination, e.g. dichlorodiphenyltrichloroethane or DDT, have been noted in northern KZN (Bowman *et al.*, 2019; Horak *et al.*, 2021). DDT is a legacy pesticide albeit with a remaining legal use for malaria control in some African countries through indoor residual spraying (IRS) (Bowman *et al.*, 2019), and is used in various parts of South Africa to combat malaria transmission. Note that the spraying regime has changed over the past 30 years from solely relying on DDT to a combination of DDT and pyrethroids (Bowman *et al.*, 2019).

g) Aquatic ecosystems driver

It can be seen from the detailed RQOs in the report that the driver is often *aquatic ecosystems*. This seems suitable as often the water quality data is linked to the maintenance or reaching of a particular water quality category, which is part of a specific EC, catchment configuration and Water Resource Class.

h) Immediately applicable vs. Provisional RQOs

As previously mentioned, not all RQOs mentioned in this report are linked to a current monitoring programme or can be immediately applicable. The first step with all water quality RQOs listed in this report is to assess whether sites are part of a monitoring programme and whether the variable of interest is being monitored by that programme. If not, or if insufficient data are available to test compliance, a monitoring database must be developed before the RQO can be evaluated and applied. This would apply to DDT, for example, where it is recommended that monitoring be instituted in, and adjacent to the malaria-endemic areas of northern KZN where spraying takes place for malaria control, e.g. Phongola floodplain, Ndumo Game Reserve, Nsumo and Muzi pans (Mkuze system), Lake Sibaya, Lake St Lucia, Kosi Bay and iSimangaliso Wetland Park (Bowman *et al.*, 2019).

3.2 GEOMORPHOLOGY

3.2.1 General approach

The approach to setting RQOs for the Mzimvubu EWR sites was similar to that described by Rowntree for the Mzimvubu River (DWA, 2017). In line with the Mzimvubu study, EcoSpec and TPC metrics were generated in relation either to the geomorphological character of the site – the condition of the site as could be assessed from morphological features and key processes, or to the condition of critical habitats that are determined by the geomorphology.

RQOs for geomorphology were only set at priority sites – the eight EWR sites on the Matigulu, Nseleni, Black Mfolozi and White Mfolozi, Mkuze, Upper Pongolo, Assegaai and Ngwempisi rivers. They were based on desktop studies of Google Earth undertaken prior to site visits and on data collected during site visits. Data collection methods at the eight EWR sites was modified to fit the time available, which was never more than four hours at a site and, in the case of EWR NS1, significantly less. This meant that much of the assessment was based on qualitative observations based on time spent walking over the site. The surveyed site at NS1 was not visited due to time constraints. A brief inspection was made of an upstream site.

The data used to set EcoSpecs and TCPs at all eight EWR sites were as described below.

3.2.2 Bed sediment

Bed sediment has a direct effect on habitat quality for instream aquatic organisms and is likely to change in the short term in response to flood events that distribute sediment sourced from upstream and from the catchment. At all sites sand was the most prevalent fine grade material, with a low presence of silt. Excessive sand deposition leads to embeddedness of coarse material and infilling of pools. Where sites are impacted by upstream dams (EWR AS1 and EWR NG1) bed armouring through excessive loss of fine material (sand and gravels) can be a significant response. In addition to loss of sand and gravel coarser material becomes less mobile.

No quantitative measure of the particle size distribution was taken at any site due to time constraints. No such data was available from the 2014 survey. The EcoSpec metric is therefore given using a qualitative scale. Bed sediment in fast flow areas and pools is assessed separately using a qualitative scale as follows: negligible (<5%); low (localised patches on less the 25% of the bed); moderate (sediment patches cover 25 - 50% of the bed); high (sediment patches cover 50 - 80% of the bed); very high (most of the bed is covered in sediment - >80%).

Given the dynamic nature of sediment deposition in response to floods, Threshold of Potential Concern (TPCs) relating to sediment deposition should be applied to a long-term trend identified over at least three years. The cyclical nature of weather patterns and associated hydrology should also be taken into account.

3.2.3 Channel cross section

The channel cross section was surveyed at one transect at each site across critical riffle or rapid habitat. Changes to channel width would impact on the total availability of instream or channel bank habitat. It would also impact the long-term hydraulic relationship between discharge, water depth and velocity. Noticeable changes to channel width therefore flag likely changes to other habitat variables. The EcoSpec was given in terms of the channel width between the edge of the upper flood zone, assumed to be the edge of the active channel. Widths were measured from the surveyed transect where the upper flood bench could be clearly identified. At sites where this was not the case, channel width was not used as an EcoSpec.

Cross section changes are likely to take place over the long term (5 - 10 years) or following extreme events. A resurvey of the transect will be required in order to measure the extent of change.

3.2.4 Flood benches

Flood benches provide habitat for riparian vegetation. The EcoSpec was based on presence/ absence of indicator benches and presence/absence and extent of fine sediment deposits. Changes to flood benches should also be detected from resurveys of the cross section transects.

Flood benches could be removed or develop in response to changes in the balance of lateral erosion and deposition. Erosional changes would be most likely to occur following a disturbance such as a large flood whereas increased deposition will be a more ongoing process in response to reduced flood flows and/or increased sediment loads.

3.2.5 Channel pattern

Channel pattern determines the assemblage of habitat types within the channel and riparian zone. It is the response to the external drivers of flow discharge and sediment load and calibre and to local conditions of channel gradient and valley confinement. Although a change in channel pattern is unlikely, any observed change would flag a serious TPC. Channel pattern was classified at the reach scale from aerial imagery and the site visit according to categories given in the Geomorphology Assessment Index (GAI) assessment manual (Rowntree, 2013).

3.3 FISH

3.3.1 Approach for setting RQOs for fish at EWR sites

RQOs, EcoSpecs and TPCs for fish are presented in two different approaches. The approach (first table) for each site is based on the Frequency of Occurrence (FROC) of a fish species within the EWR reach and utilises the FROC values using the Fish Response Assessment Index (FRAI) model (Kleynhans, 2007) as calculated during the EcoClassification proses to determine the PES as part of this EWR study. The FROC under the PES is used as the RQO/EcoSpecs for the reach and any deviation (decrease) of the FROC category of the PES can be seen as a Threshold of Potential Concern (TPC). This approach therefore describes the estimated frequency of occurrence of each expected species in the reach and provides a description of the EcoSpecs and TPCs on a reach base (if more than one sites are sampled per reach). The FROC categories is (as per FRAI model):

- 0 = Absent.
- 1 = Present at very few sites (≤10%).
- 2 = Present at few sites (>10 - 25%).
- 3 = Present at about >25 - 50% of sites.

- 4 = Present at most sites (>50 - 75%).
- 5 = Present at almost all sites (>75%).

The second approach (second table) of RQOs/EcoSpecs and TPCs were aimed to be metric specific and can be applied on both EWR reach and EWR site levels. The aim of this approach is to use specific indicator species/groups to provide insight into the potential aspects of concern (such as loss of certain velocity-depth habitats, loss of vegetative cover, impact by alien species or migratory impacts). The different metrics used include aspects such as ecological status, species richness, requirement for specific habitat features (flowing water, substrate, slow or deep habitats, vegetated habitats, etc.) and unmodified water quality, migratory requirements, and presence of alien species. Primary indicator species were identified (based on reach and for EWR site specifically) for all these various metrics and EcoSpecs and TPCs were described. Preference was given to fish species confirmed or previously sampled, especially on EWR site level. A change detected in the specific indicator species/group may indicate towards specific stressors that should then be verified and further investigated and addressed. The TPCs should be tested and refined during future monitoring programmes as the confidence will improve with increased data sets.

3.3.2 RQOs for high importance RUs without EWR sites

RUs that do not include EWR sites were assessed based on other available information and was done on a lower level of confidence and detail. The assessment included an indication of indicators/metrics, a narrative RQO and a numerical RQO. The primary data sources used were the PESEIS (DWS, 2014) and IUCMA EcoStatus monitoring report (IUCMA, 2020). These sources were used to estimate the fish species composition of all sub-quaternary reaches and hence the overall resource unit. The most adequate indicator species for different metrics (such as flow, water quality, migration etc.) were identified and listed and a short description of these requirements mentioned. Since this is based on desktop information it is essential that the information should be verified and amended during future monitoring surveys.

The abbreviations used for the fish species are provided in **Table 3.2**.

Table 3.2 Abbreviated fish species names

Abbreviation	Scientific name
AAEN	*Awaous aeneofuscus*
ABER	*Acanthopagrus berda*
MKAT	*Micropanchax (aplocheilichthys) katangae*
ALAB	*Anguilla bengalensis labiata*
AMAR	*Anguilla marmorata*
AMOS	*Anguilla mossambica*
MMYA	*Micropanchax (aplocheilichthys) myaposae*
AURA	*Amphilius uranoscopus*
BGUR	*Enteromius gurneyi*
BANN	*Enteromius annectens*
BANO	*Enteromius anoplus*
BARG	*Enteromius crocodilensis (argenteus)*
BEUT	*Enteromius eutaenia*
BLAT	*Brycinus lateralis*
BTOP	*Enteromius toppini*
BTRI	*Enteromius trimaculatus*

Abbreviation	Scientific name
BUNI	*Enteromius unitaeniatus*
BPAU	*Enteromius paludinosus*
BVIV	*Enteromius viviparus*
CGAR	*Clarias gariepinus*
CTHE	*Clarias theodorae*
GCAL	*Glossogobius callidus*
GGIU	*Glossogobius giuris*
LMAR	*Labeobarbus marequensis*
LPOL	*Labeobarbus polylepis*
LNAT	*Labeobarbus natalensis*
LCYL	*Labeo cylindricus*
LMOL	*Labeo molybdinus*
LROS	*Labeo rosae*
MACU	*Micralestes acutidens*
MBRE	*Mesobola brevianalis*
MMAC	*Marcusenius macrolepidotus/pongolensis*
MFAL	*Monodactylus falciformis*
MSAL*	*Micropterus salmoides**
OMOS	*Oreochromis mossambicus*
PPHI	*Pseudocrenilabrus philander*
RDEW	*Redigobius dewaali*
SINT	*Schilbe intermedius*
SZAM	*Synodontis zambezensis*
TREN	*Coptodon rendalli*
TSPA	*Tilapia sparrmanii*
VNEL	*Labeobarbus (varicorhinus) nelspruitensis*

* Alien/introduced species

3.4 MACROINVERTEBRATES

3.4.1 Approach for setting RQOs for macroinvertebrates at EWR sites

EcoSpecs and TPCs were provided only for the EWR sites, and the detail of the approach and methodology is available from the Reserve study of 2009 (DWAF, 2010).

By using the taxa preference data in the Macro Invertebrate Response Assessment Index (MIRAI) sheets (Thirion, 2016), the indicator taxa for different criteria were selected. These sheets indicate the habitat value and preference (1 - 5) for each taxon related to the different variables (flow, water quality and habitat). The physical and hydraulic-habitat criteria are considered to be those relevant to the indicator taxa per reach or site:

- Preference for fast-flowing water.
- Optimal substrate types.
- Integrity of marginal vegetation habitats.
- Moderate to good water quality.

A suite of indicator taxa was selected from all possible taxa occurring in the catchment. These are taxa known to occur throughout the catchment and with a preference for the type of habitat typical to the upper, middle and lower reaches of the river. Flow dependent macroinvertebrate taxa are the most important of these indicator taxa as they indicate the critical flow habitat.

These indicator taxa are listed in **Table 3.3** with their respective preferences for velocity, habitat and water quality (these preferences are extracted from a spreadsheet in the MIRAI model of Thirion (2016). **Table 3.3** lists the macroinvertebrate indicator taxa (families) linked to preferred habitat attributes at the site or in the EWR reach.

Key taxa that were instrumental in the establishment of the relevant RQOs for macroinvertebrates are listed in **Table 3.3**.

Table 3.3 Macroinvertebrate indicator taxa used to determine RQOs

Taxa	Flow (m/s)	Substrate	Quality
Hydropsychidae >2spp	>0.6	Cobbles	High
Hydropsychidae 1 or 2spp	>0.6	Cobbles	Low
Tricorythidae, Philopotamidae Elmidae	>0.6	Cobbles	Moderate
Heptageniidae Perlidae	0.3 - 0.6	Cobbles	High
Psephenidae Leptophlebiidae	0.3 - 0.6	Cobbles	Moderate
Atyidae	<0.1	Vegetation	Moderate
Coenagrionidae	<0.1	Vegetation	Low
Gomphidae	<0.1	GSM[1]	Low

1 Gravel, sand, mud.

The actual setting of EcoSpecs and TPCs was guided by the data described above. South African Scoring System version 5 (SASS5) and MIRAI scores also integrate these habitat parameters, thus these scores are also translated into EcoSpecs. Macroinvertebrate EcoSpecs are described for each criterion, and once the EcoSpecs are described, TPCs are then derived for each of the selected criteria for the EWR site, supplying measurable biotic TPCs.

The following data was used for determining EcoSpecs and TPCs:

- Data collected during the EWR site visits.
- Relevant historic data and observations from surveys in the catchment.

By making use of the Level 1 River Ecoregional Classification System for South Africa (Kleynhans *et al.,* 2005), the SASS5 and MIRAI scores could also be used to establish EcoSpecs and TPCs.

It is important to note that the Average Score Per Taxon (ASPT) score becomes an unreliable indicator of river health at very low SASS5 Scores, since a single taxon with a medium or high sensitivity weighting can increase the ASPT considerably. Caution should be applied when using the biological bands in such instances. For that reason, a range of SASS5 Scores are supplied as a guideline for surveys in specific Ecoregion Level 1 zones.

Measurable reaction (presence/absence or population trends) of the sensitive or key taxa to changes in the system, will indicate the integrity of the river reach, and should be quantifiable with the specific TPC.

3.4.2 RQOs for high importance RUs without EWR sites

RUs that do not include EWR sites were assessed based on other available information and was done on a lower level of confidence and detail. A similar method and approach to that of the fish assessments was used, making use of macro-invertebrates as indicators and verify it through the MIRAI application.

3.5 RIPARIAN VEGETATION

The approach to setting RQOs for riparian vegetation was via the generation of EcoSpecs and TPCs in relation to the general riparian character of each EWR site. The following vegetation components, assessed in the field for higher confidence, and when considered together, describe the overall state of the riparian zone:

- Dominant vegetation cover riparian zone and sub-zones).
- Invasion by perennial (and in some cases annual) alien species.
- Terrestrialisation (the disproportionate abundance of terrestrial species within the riparian zone).
- General vegetation structure as shown by proportions of riparian woody species, reeds and non-woody species (grasses, sedges and dicotyledonous forbs) expressed by measures such as aerial cover, density, abundance or population structure.
- General vegetation composition as shown by taxon richness, rarity and endemism.
- Threatened riparian plant species.

3.5.1 Dominant vegetation cover

Different types of riparian ecosystems are characterised by different dominant riparian vegetation e.g. grass-dominated Highveld / mountainous streams, tree and shrub-dominated Lowveld / lowland rivers flowing through Bushveld, tall tree-dominated (forest) streams through forested / kloof areas, or mixed vegetation e.g. reed and tree / shrub dominated rivers which are common in the Usutu-Mhlathuze Catchment. The dominant vegetation type (riparian) is a key component of the structure and function of the riparian zone as a whole, but also to sub-zone for example: the marginal zone may frequently be dominated by reeds or grasses while the Macro Channel Bank (MCB) may be dominated by tall, dense woody vegetation.

3.5.2 Invasion of the riparian zone by alien species

The hypothesis relating aerial cover of alien species to the EC of the riparian zone is shown in **Table 3.4**. Data from the Crocodile and Sabie rivers were used to establish the hypothesis. The relation of the EC (as determined by an overall approach using the Vegetation Response Assessment Index (VEGRAI – Kleynhans *et al*., 2007) of a site/reach to the permissible aerial cover of perennial alien species is a general rule of acceptance rather than a deterministic relationship, since the overall EC is a function of multiple deviations from the reference condition, and not merely the abundance of alien species.

Table 3.4 Hypothesis for the acceptance levels (% aerial cover) of perennial alien species within the riparian zone, or a sub-zone in relation to expectation for the desired ecological category of the zone or sub-zone

Ecological Category	% Cover (Perennial aliens)
A	0
A/B	1 - 5
B	5 - 10
B/C	10 - 15
C	15 - 20
C/D	20 - 30
D	30 - 50
D/E	50 - 60
E	60 - 70
E/F	70 - 80
F	>80

3.5.3 Terrestrialisation

Terrestrialisation is the disproportionate abundance, density or occurrence of terrestrial species within the riparian zone. Under reference conditions woody terrestrial species are not expected in the marginal or lower zones; are expected to be transient (if any) along flood features in the upper zone due to frequent flooding disturbance; and are expected to occur on the MCB in numbers concurrent with natural flooding frequency, magnitude and duration for the reach (i.e. hydrologically controlled abundance). In cases where RQOs were set for the riparian obligate/terrestrial species mix, it was always for flood features along the upper zone since this is the area where terrestrialisation first manifests. **Table 3.5** outlines the hypothesis used to relate the degree of terrestrialisation to the Ecological Category.

Table 3.5 Hypothesised relationship between degree of terrestrialisation and Ecological Category for different sub-zones within the riparian zone

Ecological Category	Marginal / Lower zones	Flood features / Upper zone	Upper zone / MCB	Note
A	0	0	5 - 10	This hypothesis is based on the phenomenon that terrestrial species occur naturally in the riparian zone but are reduced in cover and abundance by increased flooding disturbance. Data of terrestrial: riparian plant ratios (on the Sabie River) showed a distinct reduction in terrestrial individuals with increasing exposure to flooding disturbance.
A/B	0	0	5 - 10	
B	0	0	10 - 15	
B/C	0	1 - 5	15 - 20	
C	0	5 - 10	20 - 30	
C/D	0	10 - 15	30 - 40	
D	1 - 5	15 - 20	40 - 50	
D/E	5 - 10	20 - 30	50 - 60	
E	10 - 15	30 - 40	60 - 70	
E/F	15 - 20	40 - 50	70 - 80	
F	>20	>50	>80	

3.5.4 Vegetation Structure

General vegetation structure is characterised by relative proportions of riparian and terrestrial woody species, reeds and non woody species, including grasses, sedges and dicotyledonous forbs, as well as open unvegetated areas. The exact relative proportions characterise the site, usually expressed by measures such as aerial cover, density, abundance (numbers of individuals) or population structure (diversity of cohorts / age). This measure is based on a dynamic whereby riparian vegetation in infrequently flooded zones or along banks will usually tend towards increased woody cover with diminishing non-woody cover (including reeds), this being "reset" by large flood events. "Reset" here refers to the removal of woody plants by floods, the resulting open space being available for quick colonising non-woody species (including reeds). The RQO assumes that if woody cover increases beyond a given value and remains high, that the flooding regime has been changed so that large floods are smaller or less frequent or both.

3.5.5 Riparian plant endemism

Based on the observed presence of endemic riparian species at the site. These data were used to develop RQOs that highlight the presence of these species at EWR sites or within respective RUs.

3.5.6 Threatened riparian species

Based on the observed presence of threatened riparian species (those with International Union for Conservation of Nature (IUCN) status other than Least Concern (LC) or Data Deficient (DD). These data were used to develop RQOs that highlight the presence and protection of these species at EWR sites or within respective RUs.

3.5.7 Riparian taxon richness

Based on the observed presence of riparian species at each EWR site. These data were used to develop RQOs that highlight the maintenance of baseline species (riparian) richness or specific key riparian species.

4 RQOs FOR EWR MA1 (MATIGULU RIVER)

EWR MA1: Matigulu River

Coordinates	S29.02010 E31.47040
SQ[1] code	W11A-03612
RU[2]	RU W11-2
IUA[3]	IUA W11
Level 2 EcoRegion	17.01
Geomorph Zone[4]	Upper foothills

PRESENT ECOLOGICAL STATE: PES								
I IHI[4]	**R IHI[5]**	**PC[6]**	**Geom[7]**	**Rip Veg[8]**	**Fish**	**Inverts[9]**	**Instream**	**EcoStatus**
B/C (80%)	**B/C (78%)**	**B (84.5%)**	**B (87%)**	**B/C (79.4%)**	**B (86.4%)**	**B/C (80.9%)**	**B (83.3%)**	**B/C (81.3%)**
ECOLOGICAL IMPORTANCE AND SENSITIVITY								
MODERATE								
RECOMMENDED ECOLOGICAL CATEGORY (REC) = PES								
REC = B/C for ECOSTATUS								
TEC = B/C for ECOSTATUS								

1 Sub-quaternary reach
2 Resource Unit.
3 Integrated Unit of Analysis
4 Instream component of Index of Habitat Integrity
5 Riparian component of Index of Habitat Integrity
6 Physico-Chemical (Water Quality)
7 Geomorphology
8 Riparian Vegetation
9 Macro-invertebrates

4.1 HYDROLOGICAL (FLOW) RQOs

The flow RQOs for EWR MA1 are provided in **Table 4.1**. The full EWR rule is provided as part of the electronic data for the project.

Table 4.1 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 4.1** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 4.1 Flow RQOs (EWRs) for EWR MA1

ECOLOGICAL WATER REQUIREMENTS (EWR)			
Natural MAR: 55.17 MCM[1]		Present Day MAR: 41.85 MCM	
Low flow EWR		**Total flow EWR**	
MCM	% of nMAR[2]	MCM	% of nMAR
13.04	23.6	18.75	34

1 Milllion Cubic Metres 2 Natural Mean Annual Runoff

Low Flow Assurance Rules (m^3/s)										
m^3/s	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**99%**
Oct	0.682	0.680	0.678	0.603	0.485	0.386	0.299	0.254	0.216	0.136
Nov	0.706	0.706	0.706	0.614	0.492	0.376	0.299	0.236	0.201	0.134
Dec	0.682	0.682	0.682	0.559	0.480	0.355	0.287	0.225	0.199	0.133
Jan	0.583	0.583	0.583	0.530	0.416	0.337	0.278	0.208	0.151	0.064
Feb	0.605	0.538	0.536	0.498	0.417	0.347	0.265	0.190	0.151	0.056
Mar[1]	0.735	0.614	0.552	0.499	0.431	0.348	0.267	0.200	0.149	0.063
Apr	0.646	0.578	0.576	0.508	0.437	0.342	0.288	0.212	0.152	0.093
May	0.643	0.595	0.589	0.517	0.433	0.352	0.290	0.225	0.162	0.094
Jun	0.560	0.559	0.557	0.515	0.444	0.358	0.294	0.233	0.174	0.100
Jul	0.583	0.583	0.583	0.529	0.442	0.358	0.295	0.239	0.180	0.106
Aug[1]	0.456	0.432	0.413	0.389	0.357	0.280	0.192	0.172	0.142	0.084
Sep	0.608	0.606	0.605	0.543	0.452	0.372	0.292	0.236	0.196	0.122
Total assurance rules (MCM)										
MCM	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	2.581	2.161	2.155	1.711	1.396	1.068	0.802	0.679	0.578	0.364
Nov	2.716	2.188	2.169	1.687	1.372	1.07	0.776	0.612	0.522	0.348
Dec	2.714	2.167	2.008	1.594	1.382	0.952	0.768	0.602	0.533	0.355
Jan	1.900	1.900	1.900	1.516	1.211	0.902	0.745	0.556	0.404	0.172
Feb	2.241	1.652	1.589	1.311	1.114	0.846	0.646	0.463	0.369	0.136
Mar	2.854	1.984	1.762	1.433	1.25	1.029	0.716	0.536	0.399	0.168
Apr	2.424	1.836	1.831	1.451	1.228	0.983	0.747	0.549	0.395	0.24
May	2.542	1.76	1.578	1.39	1.16	0.942	0.776	0.602	0.434	0.253
Jun	2.00	1.787	1.611	1.431	1.248	0.927	0.761	0.603	0.452	0.259
Jul	1.901	1.901	1.652	1.452	1.23	0.96	0.791	0.641	0.481	0.285
Aug	1.56	1.496	1.201	1.139	1.053	0.751	0.513	0.461	0.381	0.226
Sep	1.915	1.899	1.663	1.504	1.267	0.964	0.758	0.613	0.509	0.317

1 The low flows for the 60th and 90th percentiles for the wettest (March) and driest (August) month.

4.2 GEOMORPHOLOGY

Key concerns related to geomorphology at EWR MA1 were:

- Increased sediment deposition of fine sediment (sand) in fast flowing areas (runs and glides) due to increased catchment erosion and/or reduced flow capacity.
- Expansion of sand bars (lateral and mid-channel) in low flow areas (pools).
- Loss of gravel habitat in low flow areas (pools).
- Increased flood bench sediment leading to increased elevation and terrestrialisation of vegetation.

EcoSpecs and TPCs are presented in **Table 4.2**, with the surveyed transect shown diagrammatically in **Figure 4.1**.

Table 4.2 EWR MA1: Geomorphology EcoSpecs and TPCs (PES and TEC: B)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Extent of sand in fast flowing habitat	Sand patches in runs or glides should not exceed low (<25%).	Sand deposits exceed 20% in fast flowing habitat.
Extent of sand in pool habitat	Sand bars should not exceed low (<25%).	Sand bars exceed 25% of pool habitat.
Gravel patches upstream of pools	Clean medium gravel patches should be present at the upstream end of the pool under shallow runs.	No evidence of clean medium gravel patches.
Channel cross-section		
Width of rapid at transect	Width between upper flood benches (active channel) should be stable at 20 m on transect line.	Visible erosion along either bank, width at transect line exceeds 20.5 m.
Lower flood bench (marginal zone)		
Present-absent	Lower flood bench should be present on both banks.	Lower flood bench actively eroding, absence of marginal vegetation.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent fine sediment deposits or excessive deposits; marginal zone encroaching into channel.
Upper flood bench		
Present-absent	Upper flood bench should be present on both banks.	Upper flood bench actively eroding.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent sediment deposits linked to the last wet season. Evidence of excessive deposition and terrestrialisation indicating elevated flood bench.
Channel pattern		
Channel type	Channel should not change from a single thread channel with pool-rapid morphology.	Change to a different channel type.

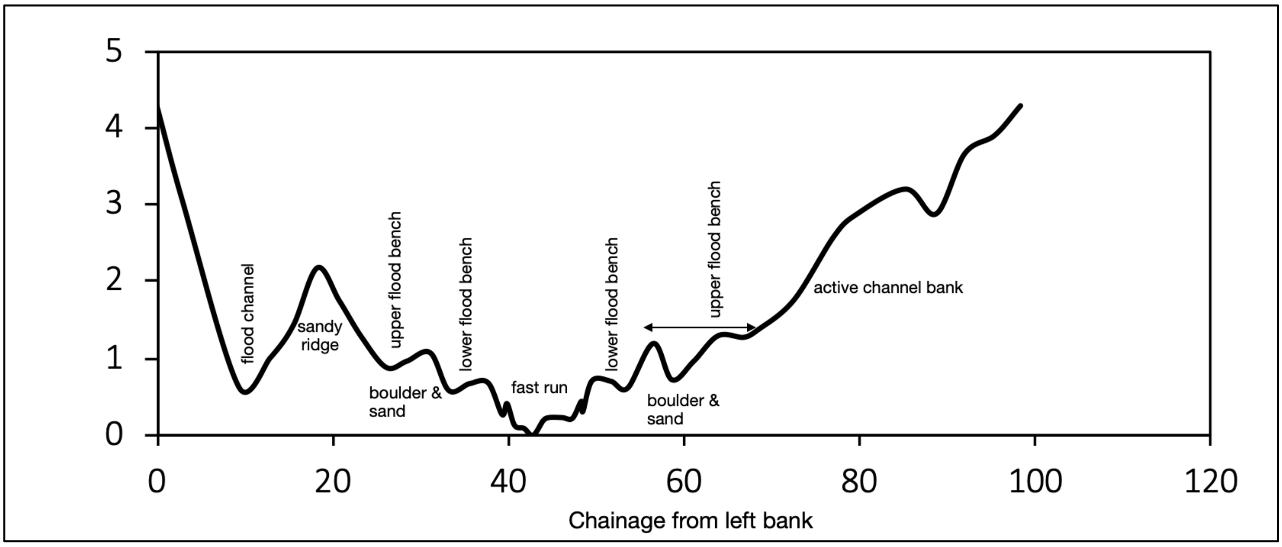

Figure 4.1 Surveyed transect line at MA1

4.3 WATER QUALITY

Water quality EcoSpecs and TPCs are shown in **Table 4.3**.

Table 4.3 EWR MA1: Water quality EcoSpecs and TPCs (PES and TEC: B)

Water quality metrics	EcoSpecs	TPC
Inorganic salts*		
$MgSO_4$	The 95th percentile of the data must be ≤23 mg/L.	The 95th percentile of the data is 19 - 23 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤33 mg/L.	The 95th percentile of the data is 27 - 33 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤30 mg/L.	The 95th percentile of the data is 24 - 30 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤57 mg/L.	The 95th percentile of the data is 46 - 57 mg/L.
NaCl	The 95th percentile of the data must be ≤191 mg/L.	The 95th percentile of the data is 153 - 191 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤351 mg/L.	The 95th percentile of the data is 280 - 351 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤55 mS/m.	The 95th percentile of the data is 44 - 55 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.4.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.2.
Temperature	Largely natural temperature range is expected.	Abundance and frequency of occurrence of temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥7.5 mg/L.	The 5th percentile of the data is ≤7.7 mg/L.
Turbidity	Moderate impact expected due to land–use and sediment deposits at the site.	Unnaturally high sediment loads and turbidity during runoff events. Impacts are mostly temporary, but some sediment deposits are evident. Check biotic response for habitat-related changes.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be <0.25 mg/L.	The 50th percentile of the data is 0.2 - 0.25 mg/L
PO_4-P	The 50th percentile of the data must be ≤0.015 mg/L.	The 50th percentile of the data is 0.012 - 0.015 mg/L
Response variables#		
Chl-*a* phytoplankton	The 50th percentile of the data must be ≤15 mg/L	The 50th percentile of the data is 12 - 15 μg/L.
Chl-*a* periphyton	The 50th percentile of the data must be ≤12 mg/m^2	The 50th percentile of the data is 10 - 12 mg/m^2.
Toxics		
Ammonia (NH_3-N)	The 95th percentile of the data must be ≤0.1 mg/L	The 95th percentile of the data is 0.08 - 0.1 mg/L.
Other variables (#)	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008a), or within the Acute Effects Value (AEV) as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the Target Water Quality Range (TWQR) as stated in DWAF (1996a).

* Inorganic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
\# Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

4.4 RIPARIAN VEGETATION

EcoSpecs and TPCs for riparian vegetation are shown in **Table 4.4**.

Table 4.4 EWR MA1: Riparian vegetation EcoSpecs and TPCs (PES and TEC: B/C)

Assessed metric	EcoSpec	TPC
Marginal / Lower zones		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody, mostly reeds, sedges, and grasses, with high vegetative cover and an absence of tall trees.	Reduced proportion of non-woody cover below 40% in the zone.
Key Species	The presence of *Ischaemum fasciculatum Juncus oxycarpus, J. lomatophyllus* and *Miscanthus ecklonii.*	The absence of *Ischaemum fasciculatum* or *Juncus oxycarpus,* or *J. lomatophyllus* or *Miscanthus ecklonii.*
Alien species invasion	Maintain an absence of perennial alien plant species in the zone.	An occurrence of perennial alien plant species in the zone.
Terrestrial woody species aerial cover	Maintain an absence of terrestrial woody species in the zone.	An occurrence of terrestrial woody species in the sub-zone in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover (% aerial) below 10% in the zone.	An increase in woody species cover above 20% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 40% in the zone.	A decrease in non-woody cover (% aerial) below 40% in the zone.
Reed cover (% aerial)	Maintain reed cover (% aerial) below 10% in the zone.	An increase in reed cover above 10% in the zone.
Flood features / Upper zone		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody, mostly reeds, sedges, and grasses, with high vegetative cover.	Reduced proportion of non-woody cover below 40% in the zone.
Key Species	The presence of *Ficus sycomorus.*	The absence of *Ficus sycomorus.*
Alien species invasion	Maintain perennial alien plant species cover (% aerial) below 10% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species aerial cover	Maintain an absence of terrestrial woody species in the zone.	An increase in terrestrial woody species cover above 10% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover (% aerial) below 20% in the zone.	An increase in woody species cover above 30% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 40% in the zone.	A decrease in non-woody cover (% aerial) below 40% in the zone.
Reed cover (% aerial)	Maintain reed cover (% aerial) below 10% in the zone.	An increase in reed cover above 10% in the zone.
MCB		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain woody vegetation.	Reduced proportion of woody cover below 40% in the zone.
Alien species invasion	Maintain perennial alien plant species cover (% aerial) below 10% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species aerial cover	Maintain indigenous terrestrial woody species cover (% aerial) below 60% in the zone.	An increase in terrestrial woody species cover above 60% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover indigenous riparian woody species (% aerial) above 30% in the zone.	A decrease in woody species cover below 30% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 20% in the zone.	A decrease in non-woody cover (% aerial) below 20% in the zone.

Assessed metric	EcoSpec	TPC
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 78% for the riparian zone.	A decrease in PES score below 77% for the riparian zone.
Species richness	Maintain the presence of at least 30 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 25.
Endemic riparian species	The presence of *Miscanthus ecklonii,* which is riparian and endemic to southern Africa.	The absence *Miscanthus ecklonii.*
Threatened riparian species / ecosystems	The presence of *Crinum bulbispermum*, which has an IUCN threat status of LC but noted that population is in decline.	The absence of *Crinum bulbispermum.*

4.5 FISH

Table 4.5 outlines the spatial FROC (Frequency of Occurrence) of fish for the EWR reach and indicates the FROC under reference and PES (baseline conditions). Reach and EWR site specific EcoSpecs and TPCs based on the specific metrics or variables, as included in the Fish Response Assessment Index (FRAI; Kleynhans, 2007) are provided in **Table 4.6**.

Table 4.5 EWR MA1: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions (REACH)

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: B EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
LNAT*	***Labeobarbus natalensis***	**5**	**4.5**	**FROC <4 (present at <50% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
AAEN*	***Awaous aeneofuscus***	**5**	**5**	**FROC <5 (present at <75% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
MFAL*	***Monodactylus falciformis***	**3**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
OMOS*	***Oreochromis mossambicus***	**3**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
GGIU*	***Glossogobius giuris***	**3**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
AMOS*	***Anguilla mossambica***	**1**	**1**	**FROC = 0 (absent from all suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
TSPA	*Tilapia sparrmanii*	5	5	FROC <5 (present at <75% of suitable sites sampled in reach).	
CGAR	*Clarias gariepinus*	3	3	FROC <3 (present at <25% of suitable sites sampled in reach).	
PPHI	*Pseudocrenilabrus philander*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BGUR	*Enteromius gurneyi*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BPAU	*Enteromius paludinosus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BTRI	*Enteromius trimaculatus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BVIV	*Enteromius viviparus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
GCAL	*Glossogobius callidus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
LMOL	*Labeo molybdinus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: B EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
AMAR	*Anguilla marmorata*	1	1	FROC <1 (absent from all suitable sites sampled in reach).	
CTHE	*Clarias theodorae*	1	1	FROC <1 (absent from all suitable sites sampled in reach).	
TREN	*Tilapia rendalli*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MMYA	*Micropanchax myaposae*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MBRE	*Mesobola brevianalis*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MMAC	*Marcusenius macrolepidotus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

* Species confirmed/sampled in reach during EWR surveys.

Table 4.6 EWR MA1: Fish EcoSpecs and TPCs (PES and TEC: B)

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	PES of fish is in a B (FRAI = 86.4%).	Decrease of PES towards a lower EC than PES (FRAI <83%).	Any deterioration in a habitat feature that results in decrease in FROC of species that lead to deterioration of PES.
Species richness	**Reach:** All indigenous species expected. **EWR site:** Indigenous species confirmed at site during EWR surveys.	**Reach:** All of the expected indigenous fish species (21) estimated to be present in the reach under PES. **EWR site:** Six indigenous fish species confirmed (sampled) previously at EWR site (2014 and 2022).	**Reach:** Loss of any indigenous species from reach. **EWR site:** Less than three (3) indigenous fish species sampled at EWR site during any survey OR absence of range of life stages (juveniles to adults) during various surveys	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water	LNAT	**Reach:** LNAT estimated to be present at >50% of sites in reach (FROC = 4.5). **EWR site:** sampled at EWR site 100% of surveys (2014/07 and 2022/07).	**Reach:** LNAT Present at <50% of sites in reach. **EWR site:** LNAT absent from EWR site during any survey.	Reduced suitability (abundance and quality) of flowing habitats (i.e., decreased flows, increased zero flows, altered seasonality).
Fast-Deep (FD) habitats				Reduced suitability (abundance and quality) of FD habitats (i.e., decreased flows, increased zero flows)
Fast-Shallow (FS) habitats				Reduced suitability (abundance and quality) of FS habitats (i.e. decreased flows, increased zero flows).
Substrate	AAEN	**Reach:** Estimated to be present at >75% of sites in reach (FROC = 5). **EWR site:** sampled at EWR site 100% of surveys (2014/07 and 2022/07).	**Reach:** AAEN present at <75% of sites in reach. **EWR site:** AAEN absent from EWR site during any survey.	Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Water quality intolerance	MMYA, BGUR & LNAT	**Reach:** Fish species with highest requirement for unmodified water quality in reach is MMYA and BGUR. Both species estimated to be very scarce in reach (MMYA <10% of sites and BGUR <50% of sites). **EWR site:** Most water quality intolerant species previous sampled at EWR site is LNAT. Estimated to be present at >50% of sites in reach (FROC = 4.5) and sampled at EWR site 100% of surveys (2014/07 and 2022/07).	**Reach:** MMYA absent from all sites during any survey and/or BGUR present at <10% of sites. at FROC of <0.5. Absence of range of life stages (juveniles to adults) during various surveys. **EWR site:** LNAT absent from EWR site during any survey OR present at FROC of <50% of sites in reach.	Decreased water quality (especially flow related water quality variables such as oxygen).
Overhanging vegetation	BVIV, OMOS, GGIU	**Reach:** BVIV most applicable indicator in reach, estimated to be present at 10 to 25% of sites in reach (FROC = 2). **EWR site:** OMOS and GGIU most applicable indicator of this metric previously sampled	**Reach:** BVIV present at <10% of sites. **EWR site:** OMOS and/or GGIU sampled <50% of times at site (absent during two consecutive surveys).	Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
		at site. Both species sampled 50% of surveys.		
Instream vegetation	TREN, OMOS, MFAL	**Reach:** TREN most applicable indicator in reach, estimated to be very scarce (present at <10% of sites in reach) (FROC = 1). **EWR site:** OMOS and MFAL most applicable indicator of this metric previously sampled at site. MFAL sampled 100% and OMOS 50% of surveys.	**Reach:** TREN absent from all sites. **EWR site:** MFAL absent from any survey and OMOS sampled <50% of times at site (absent during two consecutive surveys).	Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes)
Undercut banks	MMAC, AMOS & MFAL	**Reach:** MMAC most applicable indicator in reach, estimated to be very scarce (present at <5% of sites in reach) (FROC = 0.5). **EWR site:** AMOS and MFAL most applicable indicator of this metric previously sampled at site. MFAL sampled 100% and AMOS 50% of surveys.	**Reach:** MMAC absent from all sites during two consecutive surveys. **EWR site:** MFAL absent from any survey and AMOS sampled <50% of times at site (absent during two consecutive surveys).	Significant change in undercut bank and rootwads habitats (e.g. bank erosion, reduced flows).
Slow-Deep (SD) habitats	TREN/OMOS	**Reach:** TREN most applicable indicator in reach, estimated to be very scarce (present at <10% of sites in reach) (FROC = 1). **EWR site:** OMOS most applicable indicator of this metric previously sampled at site, sampled 50% of previous surveys.	**Reach:** TREN absent from all sites. **EWR site:** OMOS sampled <50% of times at site (absent during two consecutive surveys). Absence of range of life stages (juveniles to adults) during various surveys.	Significant change in SD habitat suitability (i.e., increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
Slow-Shallow (SS) habitats	BVIV	**Reach:** BVIV most applicable indicator in reach, estimated to be present at 10 to 25% of sites in reach) (FROC = 2). **EWR site**: GGIU most applicable indicator of this metric previously sampled at site, sampled 50% of previous surveys.	**Reach:** BVIV present at <10% of sites. **EWR site:** GGIU sampled <50% of times at site (absent during two consecutive surveys). Absence of range of life stages (juveniles to adults) during various surveys.	Significant change in SS habitat suitability (i.e., increased flows, altered seasonality, increased sedimentation of slow habitats).
Alien fish species	Presence of any alien/introduced spp.	One alien species namely MSAL confirmed to be present in reach (sampled 50% of surveys at EWR site).	Presence of any additional alien/introduced species in reach or at EWR site.	N/A
Migratory success	Anguillids (eels) and LNAT	Catadromous AMOS confirmed in reach (50% of survey at EWR site) and other eels expected in reach. Potamodromous LNAT confirmed at site (100% of surveys) and various other potamodromous species expected in reach.	**Reach:** AMOS absent from all sites during two consecutive surveys or LNAT Present at <50% of sites in reach. **EWR site:** LNAT absent from EWR site during any survey OR AMOS sampled <50% of times at site (absent during two consecutive surveys). Absence of range of life stages (juveniles to adults) during various surveys.	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

4.6 MACROINVERTEBRATES

Table 4.7 lists the macro-invertebrate indicator taxa (families) linked to preferred habitat attributes at the site or in the EWR reach. Site specific EcoSpecs and TPCs based on the specific metrics or variables, as established in the MIRAI (Thirion, 2016) during field surveys, are provided in **Table 4.8**. All the project sites were assigned to an ecoregion level 1 (Kleynhans *et al.*, 2005).

According to the MIRAI compiled by C. Todd as part of the initial Reserve Study (2014), the reference condition for Site MA1 was established as: SASS 220 and ASPT 7, while a SASS score of 204 and ASPT of 6 were recorded at the site at the time of the 2014 reserve survey (no recent data was available at the time of the current study).

Table 4.7 EWR MA1: Macro-invertebrate indicator taxa

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	Hydropsychidae 1 or 2spp	>0.6	Cobbles	Low
2	Philopotamidae	>0.6	Cobbles	Moderate
3	Leptophlebiidae	0.3 - 0.6	Cobbles	Moderate
4	Atyidae	<0.1	Vegetation	Moderate
5	Coenagrionidae	<0.1	Vegetation	Low
5	Gomphidae	<0.1	GSM	Low

Table 4.8 EWR MA1: Macro-invertebrate EcoSpecs and TPCs (PES and TEC: B/C)

EcoSpecs/RQOs	TPCs
Ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score range 180 to 204; ASPT value: >6.5.	ASPT below 6.7.
Ensure that the MIRAI score is within the range of a B/C Category (>77.99 and <82) using the same reference data used in this study (DWS, 2022c).	A MIRAI score of 78% or less.
Maintain suitable flow velocity (maximum >0.6 m/s) and clean, unembedded surface area (cobbles) to support the Hydropsychidae (1 or 2 species) and Philopotamidae assemblage in the Very fast flow over coarse sediment biotope (VFCS).	Any of Philopotamidae or Hydropsychidae (1 or 2 species) assemblage missing in any two consecutive surveys.
Maintain suitable conditions for the following flow-dependent species in the Stones-in-Current (SIC) biotope: ▫ Leptophlebiidae: Abundance B.	Leptophlebiidae missing in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the Coenagrionidae and Atyidae.	Any one of Coenagrionidae and Atyidae missing in two consecutive surveys.
To maintain suitable coarse alluvial sediment and habitat conditions for: ▫ Gomphidae	This taxon missing during a survey.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000) over more than two consecutive surveys.	Any taxon occurring in an abundance of >500 for two consecutive surveys.

5 RQOs FOR EWR NS1 (NSELENI RIVER)

<table>
<tr><th colspan="9">EWR NS1: Nseleni River</th></tr>
<tr><td colspan="7" rowspan="6"></td><td>Coordinates</td><td>S28.63410
E31.92517</td></tr>
<tr><td>SQ code</td><td>W12G-03229</td></tr>
<tr><td>RU</td><td>RU W12-8</td></tr>
<tr><td>IUA</td><td>IUA W12-b</td></tr>
<tr><td>Level 2 EcoRegion</td><td>13.03</td></tr>
<tr><td>Geomorph Zone</td><td>Lower foothills</td></tr>
<tr><th colspan="9">PRESENT ECOLOGICAL STATE: PES</th></tr>
<tr><th>I IHI</th><th>R IHI</th><th>PC</th><th>Geom</th><th>Rip Veg</th><th>Fish</th><th>Inverts</th><th>Instream</th><th>EcoStatus</th></tr>
<tr><td>B/C
(81%)</td><td>C
(70.3%)</td><td>B
(82.7%)</td><td>B
(85%)</td><td>C
(64.4%)</td><td>C
(67.9%)</td><td>B/C
(79.4%)</td><td>C
(74.3%)</td><td>C
(68.4%)</td></tr>
<tr><th colspan="9">ECOLOGICAL IMPORTANCE AND SENSITIVITY</th></tr>
<tr><td colspan="9">MODERATE</td></tr>
<tr><th colspan="9">RECOMMENDED ECOLOGICAL CATEGORY (REC) = PES = TEC</th></tr>
<tr><td colspan="9">REC = C for ECOSTATUS</td></tr>
<tr><td colspan="9">TEC = C for ECOSTATUS</td></tr>
</table>

5.1 HYDROLOGICAL (FLOW) RQOs

The flow RQOs for EWR MA1 are provided in **Table 5.1.** The full EWR rule is provided as part of the electronic data for the project.

Table 5.1 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 5.1** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 5.1 Flow RQOs (EWRs) for EWR NS1

ECOLOGICAL WATER REQUIREMENTS (EWR)			
Natural MAR: 31.23 MCM		Present day MAR: 31.56 MCM	
Low flow EWR		Total flow EWR	
MCM	% of nMAR	MCM	% of nMAR
4.76	15.2	6.85	21.9

Low Flow Assurance Rules (m^3/s)										
m^3/s	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**99%**
Oct	0.24	0.24	0.19	0.17	0.14	0.13	0.12	0.09	0.07	0.05
Nov	0.24	0.24	0.19	0.18	0.15	0.14	0.12	0.09	0.07	0.06
Dec	0.24	0.24	0.19	0.17	0.15	0.14	0.12	0.09	0.06	0.06
Jan	0.24	0.23	0.19	0.16	0.14	0.14	0.13	0.09	0.07	0.06
Feb	0.23	0.23	0.17	0.15	0.15	0.14	0.12	0.09	0.07	0.06
Mar	0.24	0.23	0.19	0.18	0.15	0.15	0.13	0.10	0.08	0.07
Apr[1]	0.25	0.23	0.22	0.20	0.18	0.16	0.14	0.12	0.10	0.08
May	0.23	0.23	0.19	0.17	0.15	0.15	0.12	0.09	0.07	0.06
Jun	0.23	0.23	0.19	0.16	0.16	0.14	0.12	0.10	0.08	0.06
Jul	0.24	0.23	0.19	0.15	0.15	0.14	0.12	0.10	0.07	0.06
Aug[1]	0.14	0.13	0.13	0.12	0.11	0.10	0.08	0.06	0.04	0.03
Sep	0.24	0.23	0.18	0.14	0.14	0.12	0.12	0.09	0.06	0.06
Total assurance rules (MCM)										
MCM	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.034	0.884	0.612	0.511	0.371	0.36	0.32	0.232	0.178	0.143
Nov	1.077	0.873	0.593	0.553	0.459	0.367	0.306	0.228	0.177	0.148
Dec	1.056	0.892	0.608	0.546	0.398	0.386	0.316	0.241	0.174	0.154
Jan	0.875	0.834	0.599	0.44	0.388	0.384	0.336	0.236	0.183	0.154
Feb	0.825	0.805	0.524	0.471	0.372	0.342	0.297	0.216	0.161	0.149
Mar	1.078	0.871	0.666	0.582	0.494	0.389	0.335	0.277	0.211	0.187
Apr	0.94	0.852	0.665	0.616	0.568	0.418	0.362	0.308	0.255	0.217
May	0.988	0.862	0.61	0.566	0.492	0.395	0.323	0.25	0.188	0.174
Jun	0.847	0.844	0.595	0.51	0.41	0.363	0.314	0.249	0.199	0.163
Jul	0.875	0.872	0.618	0.505	0.406	0.377	0.319	0.255	0.183	0.153
Aug	0.607	0.584	0.442	0.359	0.304	0.269	0.215	0.152	0.112	0.084
Sep	0.857	0.754	0.572	0.396	0.364	0.311	0.311	0.227	0.165	0.163

1 The low flows for the 60th and 90th percentiles for the wettest (April) and driest (August) month.

5.2 GEOMORPHOLOGY

Key concerns related to geomorphology at EWR NS1 were:

- Increased sediment deposition of fine sediment (silt and sand) in fast flowing areas due to increased catchment erosion and/or reduced flow capacity.
- Increased deposition of fine sediment (silt and sand) in pools.
- Increased erosion of marginal zone and channel banks.

EcoSpecs and TPCs are presented in **Table 5.2**, with the surveyed transect shown diagrammatically in **Figure 5.1**. Important: Low confidence in recommendations due to lack of information from the EWR site.

Table 5.2 EWR NS1: Geomorphology EcoSpecs and TPCs (PES and TEC: B)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Extent of sand in fast flowing habitat	Sand patches should not exceed low (<25%).	Sand deposits exceed 20% in fast flowing habitat.
Extent of sand and silt in pool habitat	Fine sediment cover should not exceed medium (<50%).	Sand or silt cover exceeds 40% of pool habitat.
Channel cross-section		
Width of riffle at transect	Width between upper flood benches (active channel) should be stable at 11 m on transect line.	Visible erosion along either bank, width at transect line exceeds 12 m or less than 10 m.
Lower flood bench (marginal zone)		
Present-absent	Lower flood bench should be present on at least one bank.	Lower flood bench actively eroding, absence of marginal vegetation.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent fine sediment deposits or excessive deposits. Marginal zone encroaching into channel.
Upper flood bench		
Present-absent	Upper flood bench should be present on at least one bank.	Upper flood bench actively eroding.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent sediment deposits linked to the last wet season; evidence of excessive deposition and terrestrialisation indicating elevated flood bench.
Channel pattern		
Channel type	Channel should not change from a single thread channel with pool-riffle morphology.	Change to a different channel type.

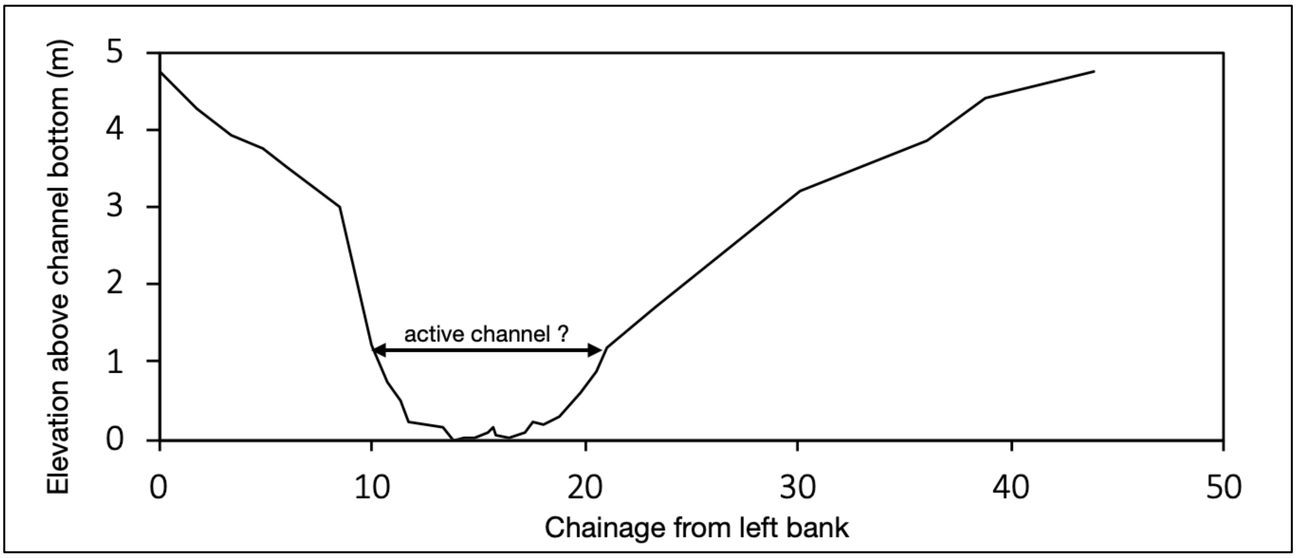

Figure 5.1 Surveyed transect line at NS1 across riffle

5.3 WATER QUALITY

EcoSpecs and TPCs are shown in **Table 5.3**. Note that elevated salts appear to be due to marine influence at the monitoring point, so high background levels are present.

Table 5.3 EWR NS1: Water quality EcoSpecs and TPCs (PES and TEC: B)

Water quality metrics	EcoSpecs	TPC
Inorganic salts*		
$MgSO_4$	The 95th percentile of the data must be ≤37 mg/L.	The 95th percentile of the data is 30 - 37 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤51 mg/L.	The 95th percentile of the data is 41 - 51 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤51 mg/L.	The 95th percentile of the data is 41 - 51 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤105 mg/L.	The 95th percentile of the data is 84 - 105 mg/L.
NaCl	The 95th percentile of the data must be ≤389 mg/L.	The 95th percentile of the data is 311 - 389 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤1105 mg/L.	The 95th percentile of the data is 884 - 1105 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤85 mS/m.	The 95th percentile of the data is 68 - 85 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.8.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.6.
Temperature	Largely natural temperature range is expected.	Abundance and frequency of occurrence of temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥7.5 mg/L.	The 5th percentile of the data is ≤7.7 mg/L.
Turbidity	Moderate impact expected due to land–use and sediment deposits at the site.	Unnaturally high sediment loads and turbidity during runoff events. Impacts are mostly temporary, but some sediment deposits are evident. Check biotic response for habitat-related changes.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be <0.25 mg/L.	The 50th percentile of the data is 0.2 - 0.25 mg/L.
PO_4-P	The 50th percentile of the data must be ≤0.015 mg/L.	The 50th percentile of the data is 0.012 - 0.015 mg/L.
Response variables#		
Chl-*a* phytoplankton	The 50th percentile of the data must be ≤15 mg/L	The 50th percentile of the data is 12 - 15 µg/L.
Chl-*a* periphyton	The 50th percentile of the data must be ≤12 mg/m^2	The 50th percentile of the data is 10 - 12 mg/m^2.
Toxics		
Other variables (#)	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008a), or within the AEV as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the TWQR as stated in DWAF (1996a).

* Inorganic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
[#] Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

5.4 RIPARIAN VEGETATION

EcoSpecs and TPCs for riparian vegetation are shown in **Table 5.4**.

Table 5.4 EWR NS1: Riparian vegetation EcoSpecs and TPCs (PES and TEC: C)

Assessed metric	EcoSpec	TPC
Marginal / Lower zones		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody, mostly reeds, sedges, and grasses, with high vegetative cover and an absence of tall trees.	Reduced proportion of non-woody cover below 40% in the zone.
Key Species	The presence of *Ischaemum fasciculatum Juncus oxycarpus, J. lomatophyllus* and *Miscanthus ecklonii.*	The absence of *Ischaemum fasciculatum* or *Juncus oxycarpus,* or *J. lomatophyllus* or *Miscanthus ecklonii.*
Alien species invasion	Maintain an absence of perennial alien plant species in the zone.	An occurrence of perennial alien plant species in the zone.
Terrestrial woody species aerial cover	Maintain an absence of terrestrial woody species in the zone.	An occurrence of terrestrial woody species in the sub-zone in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover (% aerial) below 10% in the zone.	An increase in woody species cover above 20% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 40% in the zone.	A decrease in non-woody cover (% aerial) below 40% in the zone.
Reed cover (% aerial)	Maintain reed cover (% aerial) below 10% in the zone.	An increase in reed cover above 10% in the zone.
Flood features / Upper zone		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody, mostly reeds, sedges, and grasses, with high vegetative cover.	Reduced proportion of non-woody cover below 40% in the zone.
Key Species	The presence of *Ficus sycomorus.*	The absence of *Ficus sycomorus.*
Alien species invasion	Maintain perennial alien plant species cover (% aerial) below 10% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species aerial cover	Maintain an absence of terrestrial woody species in the zone.	An increase in terrestrial woody species cover above 10% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover (% aerial) below 20% in the zone.	An increase in woody species cover above 30% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 40% in the zone.	A decrease in non-woody cover (% aerial) below 40% in the zone.
Reed cover (% aerial)	Maintain reed cover (% aerial) below 10% in the zone.	An increase in reed cover above 10% in the zone.
MCB		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain woody vegetation.	Reduced proportion of woody cover below 40% in the zone.
Key Species	The presence of *Ficus sycomorus.*	The absence of *Ficus sycomorus.*
Alien species invasion	Maintain perennial alien plant species cover (% aerial) below 10% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species aerial cover	Maintain indigenous terrestrial woody species cover (% aerial) below 60% in the zone.	An increase in terrestrial woody species cover above 60% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover indigenous riparian woody species (% aerial) above 30% in the zone.	A decrease in woody species cover below 30% in the zone.

Assessed metric	EcoSpec	TPC
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 20% in the zone.	A decrease in non-woody cover (% aerial) below 20% in the zone.
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 78% for the riparian zone.	A decrease in PES score below 77% for the riparian zone.
Species richness	Maintain the presence of at least 30 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 25.
Endemic riparian species	The presence of *Miscanthus ecklonii,* which is riparian and endemic to southern Africa.	The absence *Miscanthus ecklonii.*
Threatened riparian species / ecosystems	The presence of *Crinum bulbispermum*, which has an IUCN threat status of LC but noted that population is in decline.	The absence of *Crinum bulbispermum.*

5.5 FISH

Table 5.5 outlines the spatial FROC of fish for the EWR reach and indicates the FROC under reference and PES (baseline conditions). Reach and EWR site specific EcoSpecs and TPCs based on the specific metrics or variables, as included in the FRAI (Kleynhans, 2007) are provided in **Table 5.6**.

Table 5.5 EWR NS1: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
PPHI*	***Pseudocrenilabrus philander***	**5**	**4**	**FROC <4 (present at <50% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
GCAL*	***Glossogobius callidus***	**4**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
CGAR	*Clarias gariepinus*	3	2.5	FROC <2.5 (present at <10% of suitable sites sampled in reach).	
OMOS	*Oreochromis mossambicus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BPAU	*Enteromius paludinosus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BTRI	*Enteromius trimaculatus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BVIV	*Enteromius viviparus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
LMOL	*Labeo molybdinus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
LNAT	*Labeobarbus natalensis*	3	1.5	FROC <1.5 (absent from all suitable sites sampled in reach).	
AMOS	*Anguilla mossambica*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
MMAC	***Marcusenius macrolepidotus (Caudisquamatus Sp. Nov)***	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
TSPA	*Tilapia sparrmanii*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
GGIU	*Glossogobius giuris*	1	0.5	FROC < 0.5 (absent from all suitable sites sampled in reach).	

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
AAEN	*Awaous aeneofuscus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MKAT	*Macropanxhax katangae*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
ALAB	*Anguilla bengalensis labiata*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
AMAR	*Anguilla marmorata*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MMYA	*Macropanxhax myaposae*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
BGUR	*Enteromius gurneyi*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
CTHE	*Clarias theodorae*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MBRE	*Mesobola brevianalis*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

* Previously confirmed/sampled in reach during EWR survey.

Table 5.6 EWR NS1: Fish EcoSpecs and TPCs (PES and TEC: C)

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	PES of fish is in a C (FRAI = 67.9%).	Decrease of PES towards a lower EC than PES (FRAI <63%).	Any deterioration in a habitat feature that results in decrease in FROC of species that lead to deterioration of PES.
Species richness	All indigenous species	**Reach:** All of the expected indigenous fish species (21) estimated to be present in the reach under PES. **EWR site:** Two indigenous fish species confirmed (sampled) previously at EWR site (2014).	**Reach:** Loss of any indigenous species. **EWR site:** Less than two (2) indigenous fish species sampled at EWR site during any survey.	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water	LNAT / LMOL	**Reach:** LNAT and LMOL estimated to be present at >10% of sites in reach (FROC = 1.5 to 2). **EWR site:** No ideal indicator species for this metric previously sampled at site.	**Reach:** LNAT absent from all sites in reach or LMOL present at <10% of sites in reach during any survey. **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring. Absence of range of life stages (juveniles to adults) of all species sampled at site during various surveys may indicate deterioration.	Reduced suitability (abundance and quality) of flowing habitats (i.e., decreased flows, increased zero flows, altered seasonality).
Fast-Deep (FD) Habitats				Reduced suitability (abundance and quality) of FD habitats (i.e., decreased flows, increased zero flows).
Fast-Shallow (FS) habitats				Reduced suitability (abundance and quality) of FS habitats (i.e., decreased flows, increased zero flows).
Substrate	GCAL	**Reach:** GCAL estimated to be present at 25 to 50% of sites in reach (FROC = 3). **EWR site:** GCAL sampled at EWR site during 2014/07.	**Reach:** GCAL present at <25% of sites in reach. **EWR site:** GCAL absent from EWR site during any survey. Absence of range of life stages (juveniles to adults) during various surveys.	Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Water quality intolerance	AMYA/BGUR	**Reach:** Fish species with highest requirement for unmodified water quality in reach is *Micropanchax myaposae* (AMYA) and *Enteromius gurneyi* (BGUR). No ideal indicator species for this metric previously sampled at site.	**Reach:** AMYA or BGUR absent from all sites during any survey. **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring.	Decreased water quality (especially flow related water quality variables such as oxygen).
Overhanging vegetation	BVIV/PPHI	**Reach:** BVIV most applicable indicator in reach, estimated to be present at 10 to 25% of sites in reach (FROC = 2). **EWR site:** PPHI most suitable interim indicator species previously sampled at EWR site (2014/07).	**Reach:** BVIV present at <10% of sites. **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring. Interim indicator (PPHI) absent during any survey.	Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).
Slow-Shallow (SS) habitats				Significant change in SS habitat suitability (i.e. increased flows, altered seasonality, increased sedimentation of slow habitats).

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Instream vegetation	AKAT/PPHI	**Reach:** AKAT most applicable indicator in reach, estimated to be very scarce (present <10% sites in reach) (FROC = 0.5). **EWR site:** No ideal indicator species for this metric previously sampled at site. PPHI most suitable interim indicator species previously sampled at EWR site (2014/07).	**Reach:** AKAT absent from all sites in reach. **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring. Interim indicator (PPHI) absent during any survey.	Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes)
Slow-Deep (SD) habitats	OMOS	**Reach:** OMOS most applicable indicator in reach, estimated to be present at 10 to 25% of sites in reach) (FROC = 2). **EWR site:** No ideal indicator species for this metric previously sampled at sites.	**Reach:** OMOS present at <10% of sites in reach during any survey. **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring.	Significant change in SD habitat suitability (i.e., increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
Alien fish species	Presence of any alien/introduced spp.	No alien species previously sampled at EWR site or known from reach.	Presence of any alien/introduced species in reach or at EWR site during any survey.	N/A
Migratory success	Eels, LNAT	Three catadromous eel species expected in reach. Various potamodromous species expected at EWR site (none confirmed).	**Reach:** Eels or LNAT absent from all sites sampled in reach during two consecutive surveys. **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring.	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

5.6 MACROINVERTEBRATES

Table 5.7 lists the macro-invertebrate indicator taxa (families) linked to preferred habitat attributes at the site or in the EWR reach. Site specific EcoSpecs and TPCs based on the specific metrics or variables, as established in the MIRAI (Thirion, 2016) during field surveys, are provided in **Table 5.8**. All the project sites were assigned to an ecoregion level 1 (Kleynhans *et al.*, 2005).

According to the MIRAI compiled by C. Todd as part of the initial Reserve Study (2014), the reference condition for Site NS1 was established as: SASS 220 and ASPT 7, while a SASS 132 and ASPT 5.08 were recorded at the site at the time of the 2014 reserve survey (no recent data was available at the time of the current study).

Table 5.7 EWR NS1: Macro-invertebrate indicator taxa

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	Hydropsychidae >2spp	>0.6	Cobbles	High
2	Elmidae	>0.6	Cobbles	Moderate
3	Leptophlebiidae	0.3 - 0.6	Cobbles	Moderate
4	Atyidae	<0.1	Vegetation	Moderate
5	Coenagrionidae	<0.1	Vegetation	Low

Table 5.8 EWR NS1: Macro-invertebrate EcoSpecs and TPCs (PES and TEC: B/C)

EcoSpecs	TPCs
Ensure that the SASS5 scores and ASPT values occur in the following range SASS5 score range 120 to 180; ASPT value: >5.0.	ASPT below 5.5 - grading from a biological band C towards a C/D.
Ensure that the MIRAI score is within the range of a B/C Category (>77.99 and <82.0 using the same reference data used in this study (DWS, 2022c).	A MIRAI score of 78% or less.
Maintain suitable flow velocity (maximum >0.6 m/s) and clean, unembedded surface area (cobbles) to support the Hydropsychidae (>2 species) assemblages in the VFCS biotope.	Hydropsychidae (>2 species): This taxon missing in two consecutive surveys.
Maintain suitable conditions for the following flow-dependent species in the SIC biotope: ▫ Elmidae: Abundance A. ▫ Leptophlebiidae: Abundance B.	Any one of Elmidae and Leptophlebiidae missing in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the Coenagrionidae and Atyidae.	Any one of Coenagrionidae and Atyidae missing in two consecutive surveys.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000) over more than two consecutive surveys.	Any taxon occurring in an abundance of >500 for two consecutive surveys.

6 RQOs FOR EWR WM1 (WHITE MFOLOZI RIVER)

EWR WM1: White Mfolozi River								
							Coordinates	S28.23146 E31.18666
							SQ code	W21H-02897
							RU	RU W21-5
							IUA	IUA W21
							Level 2 EcoRegion	14.05
							Geomorph Zone	Lower foothills
PRESENT ECOLOGICAL STATE: PES								
I IHI	**R IHI**	**PC**	**Geom**	**Rip Veg**	**Fish**	**Inverts**	**Instream**	**EcoStatus**
B/C (79.3%)	**C (77.4%)**	**B (84.5%)**	**B/C (78.8%)**	**B/C (81.3)**	**C (73.1%)**	**B/C (81.1%)**	**C (77.08**	**B/C (79.2%)**
ECOLOGICAL IMPORTANCE AND SENSITIVITY								
MODERATE								
RECOMMENDED ECOLOGICAL CATEGORY (REC) = PES								
REC = B/C for ECOSTATUS								
TEC = REC = B/C for ECOSTATUS								

6.1 HYDROLOGICAL (FLOW) RQOs

The flow RQOs for EWR MA1 are provided in **Table 6.1**. The full EWR rule is provided as part of the electronic data for the project.

Table 6.1 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 6.1** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 6.1 Flow RQOs (EWRs) for EWR WM1

ECOLOGICAL WATER REQUIREMENTS (EWR)			
Natural MAR: 222.51 MCM		Present Day MAR: 191.8 MCM	
Low flow EWR		**Total flow EWR**	
MCM	% of nMAR	MCM	% of nMAR
54.74	24.6	89.31	40.1

Low Flow Assurance Rules (m^3/s)										
m^3/s	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**99%**
Oct	1.919	1.595	1.542	1.407	1.292	1.101	0.974	0.903	0.833	0.721
Nov	2.826	2.098	1.838	1.690	1.551	1.396	1.178	1.032	0.938	0.706
Dec	3.106	2.849	2.267	1.915	1.794	1.569	1.365	1.206	1.063	0.902
Jan	3.074	2.947	2.599	2.264	2.070	1.879	1.552	1.324	1.167	0.918
Feb[1]	3.247	3.073	2.825	2.539	2.257	1.979	1.699	1.439	1.262	0.942
Mar	3.106	3.094	2.816	2.531	2.433	2.091	1.804	1.576	1.446	0.933
Apr	2.805	2.801	2.631	2.324	2.263	2.029	1.743	1.464	1.385	1.181
May	2.626	2.491	2.288	2.101	2.056	1.813	1.561	1.324	1.140	0.941
Jun	2.312	1.967	1.855	1.721	1.677	1.523	1.270	1.098	1.011	0.833
Jul	1.962	1.759	1.673	1.510	1.378	1.262	1.132	1.001	0.952	0.758
Aug	1.671	1.505	1.415	1.258	1.165	1.090	1.016	0.938	0.844	0.724
Sep[1]	1.591	1.453	1.324	1.212	1.105	1.001	0.916	0.839	0.773	0.640
Total assurance rules (MCM)										
MCM	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	7.664	5.253	5.111	4.751	3.46	2.95	2.609	2.418	2.23	1.93
Nov	13.93	8.946	7.29	6.905	5.003	4.601	4.036	2.675	2.43	1.83
Dec	21.376	14.234	8.596	7.655	7.331	5.846	4.639	4.211	2.848	2.415
Jan	18.344	14.496	10.467	8.589	8.07	7.348	5.14	4.378	3.125	2.46
Feb	36.157	16.069	11.703	8.722	8.034	5.813	5.129	4.494	3.081	2.3
Mar	15.323	10.812	10.067	9.303	8.481	6.583	5.815	4.222	3.874	2.5
Apr	9.796	9.784	8.662	7.007	6.848	5.777	4.519	3.795	3.591	3.06
May	8.016	7.182	6.129	5.626	5.508	4.857	4.181	3.545	3.054	2.52
Jun	5.992	5.099	4.808	4.462	4.347	3.947	3.291	2.847	2.62	2.16
Jul	5.256	4.71	4.481	4.045	3.69	3.38	3.033	2.682	2.55	2.03
Aug	4.475	4.032	3.789	3.37	3.12	2.92	2.721	2.512	2.26	1.94
Sep	5.107	3.765	3.432	3.142	2.863	2.594	2.375	2.175	2.004	1.66

1 The low flows for the 60^{th} and 90^{th} percentiles for the wettest (February) and driest (September) month.

6.2 GEOMORPHOLOGY

Key concerns related to geomorphology at EWR WM1 were:

- Increased sediment deposition of fine sediment (sand) in fast flowing areas due to increased catchment erosion and/or reduced flow capacity.
- Expansion of sand bars (lateral and mid-channel) in low flow areas (pools).
- Increased flood bench sediment leading to increased elevation and terrestrialisation of vegetation.
- Low recovery of lower and upper flood benches scoured during high flows.

EcoSpecs and TPCs are presented in **Table 6.2**, with the surveyed transect shown diagrammatically in **Figure 6.1**.

Table 6.2 EWR WM1: Geomorphology EcoSpecs and TPCs (PES and TEC: B/C)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Extent of sand in fast flowing habitat	Sand patches should not exceed low (<25%) (but may increase temporarily after significant flood events).	Sand deposits exceeding 20% persist over several seasons in fast flowing habitat.
Extent of sand in pool habitat	Mid-channel sand bars should not be present.	Sand bars present in pool habitat.
Channel cross-section		
Width of active channel at transect	Width between upper flood benches should be stable at 64 m on transect line.	Visible erosion or sediment accretion along either bank, width at transect line exceeds 65 m or less than 63 m.
Lower flood bench (marginal zone)		
Present-absent	Lower flood bench should be present on both banks.	Lower flood bench actively eroding, absence of marginal vegetation.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent fine sediment deposits or excessive deposits.
Upper flood bench		
Present-absent	Upper flood bench should be present on both banks.	Upper flood bench actively eroding.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent sediment deposits linked to the last wet season; evidence of excessive deposition and terrestrialisation indicating elevated flood bench.
Channel pattern		
Channel type	Channel should not change from a single thread channel with pool-rapid morphology.	Change to a different channel type.

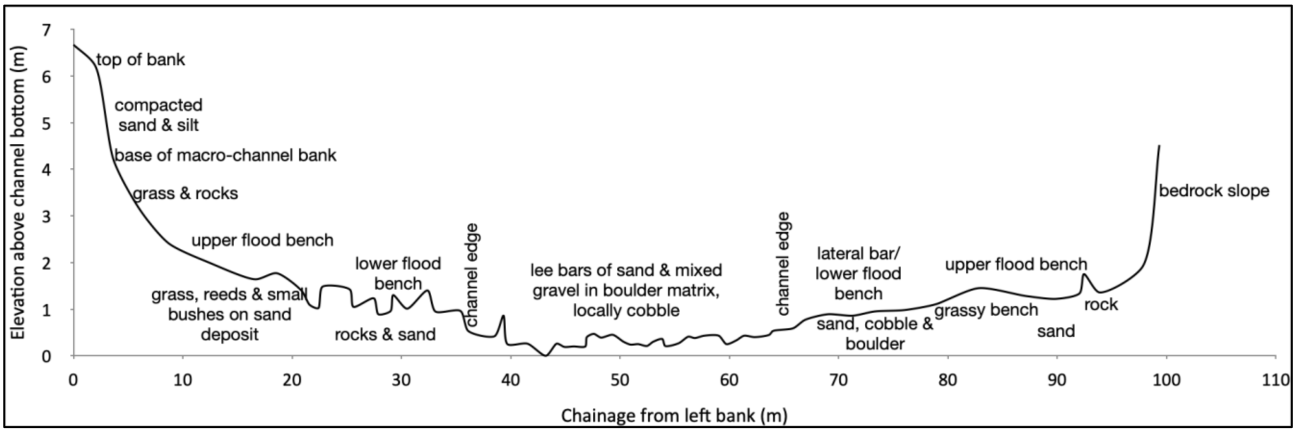

Figure 6.1 Surveyed transect line at EWR WM1

6.3 WATER QUALITY

EcoSpecs and TPCs are shown in **Table 6.3**.

Table 6.3 EWR WM1: Water quality EcoSpecs and TPCs (PES and TEC: B)

Water quality metrics	EcoSpecs	TPC
Inorganic salts*		
$MgSO_4$	The 95th percentile of the data must be ≤23 mg/L.	The 95th percentile of the data is 19 - 23 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤33 mg/L.	The 95th percentile of the data is 27 - 33 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤30 mg/L.	The 95th percentile of the data is 24 - 30 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤57 mg/L.	The 95th percentile of the data is 46 - 57 mg/L.
NaCl	The 95th percentile of the data must be ≤191 mg/L.	The 95th percentile of the data is 153 - 191 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤351 mg/L.	The 95th percentile of the data is 280 - 351 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤55 mS/m.	The 95th percentile of the data is 44 - 55 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.8.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.6.
Temperature	Largely natural temperature range is expected.	Abundance and frequency of occurrence of temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥7.5 mg/L.	The 5th percentile of the data is ≤7.7 mg/L.
Turbidity	Moderate impact expected due to land–use and sediment deposits at the site.	Unnaturally high sediment loads and turbidity during runoff events. Impacts are mostly temporary, but some sediment deposits are evident. Check biotic response for habitat-related changes.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be <0.25 mg/L.	The 50th percentile of the data is 0.2 - 0.25 mg/L.
PO_4-P	The 50th percentile of the data must be ≤0.015 mg/L.	The 50th percentile of the data is 0.012 - 0.015 mg/L.
Response variables#		
Chl-*a* phytoplankton	The 50th percentile of the data must be ≤15 mg/L.	The 50th percentile of the data is 12 - 15 µg/L.
Chl-*a* periphyton	The 50th percentile of the data must be ≤12 mg/m^2.	The 50th percentile of the data is 10 - 12 mg/m^2.
Toxics		
Ammonia (NH_3-N)	The 95th percentile of the data must be ≤0.02 mg/L.	The 95th percentile of the data is 0.016 - 0.02 mg/L
Other variables#	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008a), or within the AEV as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the TWQR as stated in DWAF (1996a).

* Inorganic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
# Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

6.4 RIPARIAN VEGETATION

EcoSpecs and TPCs for riparian vegetation are shown in **Table 6.4**.

Table 6.4 EWR WM 1: Riparian vegetation EcoSpecs and TPCs (PES and TEC B/C)

Assessed metric	EcoSpec	TPC
Marginal / Lower zones		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody vegetation, mostly sedges and grasses, but also with open (unvegetated) cobble / boulder.	An absence of non-woody riparian vegetation or an increase in non-woody vegetation cover (% aerial) above 50%.
Key Species	The presence of *Cyperus longus* and *Juncus effusus.*	The absence of *Cyperus longus* or *Juncus effusus.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 5% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species (% aerial cover)	Maintain an absence of terrestrial woody species in the zone.	An occurrence of terrestrial woody species in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover below 20% in the zone.	An absence of indigenous woody species or an increase in woody species cover above 25% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 20% in the zone.	A decrease in non-woody vegetation cover below 10% in the zone.
Reed cover (% aerial)	Maintain the absence of reeds in the zone.	An increase in reed cover above 10% in the zone.
Flood features / Upper zone		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody vegetation, but with scattered woody individuals.	Reduced proportion of aerial non-woody cover below 30% in the zone.
Key Species	The presence of *Nuxia oppositifolia, Salix mucronata* and *Miscanthus junceus*.	The absence of *Nuxia oppositifolia* or *Salix mucronate* or *Miscanthus junceus.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 10% in the zone.	An increase in perennial alien plant species cover above 15% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 10% in the zone.	An increase in terrestrial woody species cover above 10% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover above 5% in the zone.	An absence of indigenous riparian woody species or an increase in woody species cover above 40% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 50% in the zone.	A decrease in non-woody vegetation cover below 40% in the zone.
Reed cover (% aerial)	Maintain reed cover below 10% in the zone.	An increase in reed cover above 10% in the zone.
MCB		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain woody vegetation, but also with open unvegetated areas.	Reduced proportion of woody aerial cover below 30% in the zone.
Key species	The presence of *Ficus sur.*	The absence of *Ficus sur.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 10% in the zone.	An increase in perennial alien plant species cover above 15% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 60% in the zone.	An increase in terrestrial woody species cover above 60% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover of indigenous riparian woody species above 10% in the zone.	A decrease in woody species cover below 5% in the zone.
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 78% for the riparian zone.	A decrease in PES score below 77% for the riparian zone.

Assessed metric	EcoSpec	TPC
Species richness	Maintain the presence of at least 26 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 20.

6.5 FISH

Table 6.5 outlines the spatial FROC of fish for the EWR reach and indicates the FROC under reference and PES (baseline conditions). Reach and EWR site specific EcoSpecs and TPCs based on the specific metrics or variables, as included in the FRAI (Kleynhans, 2007) are provided in **Table 6.6**

Table 6.5 EWR WM1: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
AURA*	***Amphilius uranoscopus***	**3**	**2.5**	**FROC <2.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
CGAR*	***Clarias gariepinus***	**3**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
LNAT*	***Labeobarbus natalensis***	**4**	**3.5**	**FROC <3.5 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
LMOL*	***Labeo molybdinus***	**4**	**3.5**	**FROC <3.5 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
TSPA	*Tilapia sparrmanii*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
ALAB	*Anguilla bengalensis labiata*	2	1	FROC<1 (absent from all suitable sites sampled in reach).	
AMAR	*Anguilla marmorata*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
AMOS	*Anguilla mossambica*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BANO	*Enteromius anoplus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BARG	*Enteromius argenteus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BPAU	*Enteromius paludinosus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BTRI	*Enteromius trimaculatus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BUNI	*Enteromius unitaeniatus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BVIV	*Enteromius viviparus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
MACU	*Micralestes acutidens*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
MMAC	*Marcusenius macrolepidotus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
OMOS	*Oreochromis mossambicus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
LCYL	*Labeo cylindricus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

* Priority indicator species (previously confirmed/sampled in reach during EWR surveys).

Table 6.6 EWR WM1: Fish EcoSpecs and TPCs (PES and TEC: C)

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	PES of fish is in a C (FRAI = 73.1%).	Decrease of PES towards a lower EC than PES (FRAI <65%).	Any deterioration in a habitat feature that results in decrease in FROC of species that lead to deterioration of PES.
Species richness	**Reach:** All indigenous species expected. **EWR site:** Indigenous species confirmed at site during EWR surveys.	**Reach:** All the expected indigenous fish species (18) estimated to be present in the reach under PES. **EWR site:** Four indigenous fish species confirmed (sampled) previously at EWR site (2014 and 2022).	**Reach:** Loss of any indigenous species from reach. **EWR site:** Less than three (3) indigenous fish species sampled at EWR site during any survey. Absence of range of life stages (juveniles to adults) of all species sampled at site during various surveys may also indicate deterioration.	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water	AURA	**Reach:** AURA estimated to be present at 10 to 25% of sites in reach (FROC = 2.5). **EWR site:** Sampled at EWR site 100% of surveys (2014/07 and 2022/07).	**Reach:** AURA present at <10% of sites in reach. **EWR site:** AURA absent from EWR site during any survey OR absence of range of life stages (juveniles to adults) during various surveys.	Reduced suitability (abundance & quality) of flowing habitats (i.e., decreased flows, increased zero flows, altered seasonality).
Fast-Deep (FD) habitats				Reduced suitability (abundance & quality) of FD habitats (i.e., decreased flows, increased zero flows).
Substrate				Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Water quality intolerance				Decreased water quality (especially flow related water quality variables such as oxygen).
Fast-Shallow (FS) habitats				Reduced suitability (abundance & quality) of FS habitats (i.e. decreased flows, increased zero flows).
Overhanging vegetation	BVIV	**Reach:** BVIV most applicable indicator in reach, estimated to be scarce in reach (present <10% of sites in reach: FROC = 1). **EWR site:** No ideal indicator species for this metric previously sampled at site.	**Reach:** BVIV absent from all sites sampled in reach (FROC=0). **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring.	Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).
Slow-Shallow (SS) habitats				Significant change in SS habitat suitability (i.e., increased flows, altered seasonality, increased sedimentation of slow habitats).
Slow-Deep (SD) habitats	BUNI	**Reach:** BUNI most applicable indicator in reach, estimated to be scarce in reach (present <10% of sites in reach: FROC = 1). **EWR site:** No ideal indicator species	**Reach:** BUNI absent from all sites sampled in reach (FROC = 0). **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring.	Significant change in SD habitat suitability (i.e., increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
		for this metric previously sampled at EWR site.		
Instream vegetation	BPAU	**Reach:** BPAU most applicable indicator in reach, estimated to be scarce in reach (present <10% of sites in reach: FROC = 1). **EWR site:** No ideal indicator species for this metric previously sampled at site.	**Reach:** BPAU absent from all sites sampled in reach (FROC = 0). **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring.	Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes).
Undercut banks	MMAC	**Reach:** MMAC most applicable indicator in reach, estimated to be scarce in reach (present <10% of sites in reach: FROC = 1). **EWR site:** No ideal indicator species for this metric previously sampled at site.	**Reach:** MMAC absent from all sites sampled in reach (FROC = 0). **EWR site:** No ideal indicator species for this metric previously sampled at site. Indicator should be established during future monitoring.	Significant change in undercut bank and rootwads habitats (e.g. bank erosion, reduced flows).
Alien fish species	Presence of any alien/introduced spp.	No alien species previously sampled at EWR site or known from reach.	Presence of any alien/introduced species in reach or at EWR site during any survey.	N/A
Migratory success	Eels, LNAT, LMOL, CGAR	Three catadromous eel species and various potamodromous species expected in reach. Potamodromous LNAT, LMOL and CGAR sampled at EWR site and various other potamodromous species expected at EWR site (none confirmed).	**Reach:** Eels or LNAT absent from all sites sampled in reach during two consecutive surveys. **EWR site:** Absence of LNAT, LMOL and CGAR from site during any survey.	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

6.6 MACROINVERTEBRATES

Table 6.7 lists the macro-invertebrate indicator taxa (families) linked to preferred habitat attributes at the site or in the EWR reach. Site specific EcoSpecs and TPCs based on the specific metrics or variables, as established in the MIRAI (Thirion, 2016) during field surveys, are provided in **Table 6.8**. All the project sites were assigned to an ecoregion level 1 (Kleynhans *et al*., 2005)

According to the MIRAI compiled by C. Todd as part of the initial Reserve Study (2014), the reference condition for Site WM1 was established as: SASS 220 and ASPT 7, while a SASS 152 and ASPT 6.08 were recorded at the site at the time of the 2014 reserve survey (no recent data was available at the time of the current study).

Table 6.7 EWR WM1: Macro-invertebrate indicator taxa

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	Hydropsychidae 1 or 2spp	>0.6	Cobbles	Low
2	Philopotamidae	>0.6	Cobbles	Moderate
3	Leptophlebiidae	0.3 - 0.6	Cobbles	Moderate
4	Atyidae	<0.1	Vegetation	Moderate
5	Coenagrionidae	<0.1	Vegetation	Low
6	Gomphidae	<0.1	GSM	Low

Table 6.8 EWR WM1: Macro-invertebrate EcoSpecs and TPCs (PES and TEC B/C)

EcoSpecs/RQOs	TPCs
Ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score range 180 to 204; ASPT value: >6.5.	ASPT below 6.7.
Ensure that the MIRAI score is within the range of a B/C Category (>77.99 and <82) using the same reference data used in this study (DWS, 2022c).	A MIRAI score of 78% or less.
Maintain suitable flow velocity (maximum >0.6 m/s) and clean, unembedded surface area (cobbles) to support the Hydropsychidae (1 or 2 species) and Philopotamidae assemblage in the Very fast flow over coarse sediment biotope (VFCS).	Any of Philopotamidae or Hydropsychidae (1 or 2 species) assemblage missing in any two consecutive surveys.
Maintain suitable conditions for the following flow-dependent species in the Stones-in-Current (SIC) biotope: ▫ Leptophlebiidae: Abundance B.	Leptophlebiidae missing in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the Coenagrionidae and Atyidae.	Any one of Coenagrionidae and Atyidae missing in two consecutive surveys.
To maintain suitable coarse alluvial sediment and habitat conditions for: ▫ Gomphidae	This taxon missing during a survey.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000) over more than two consecutive surveys.	Any taxon occurring in an abundance of >500 for two consecutive surveys.

7 RQOs FOR EWR BM1 (BLACK MFOLOZI RIVER)

EWR BM1: Black Mfolozi River								
							Coordinates	S27.93890 E31.21030
							SQ code	W22A-02610
							RU	RU W22-1
							IUA	IUA W22
							Level 2 EcoRegion	3.1
							Geomorph Zone	Upper foothills
PRESENT ECOLOGICAL STATE: PES								
I IHI	**R IHI**	**PC**	**Geom**	**Rip Veg**	**Fish**	**Inverts**	**Instream**	**EcoStatus**
C (77.7%)	**C (74.4%)**	**B/C (81.8%)**	**A (93.4%)**	**C (74.9%)**	**C (75.9%)**	**B/C (81.3%)**	**B/C (78.9%)**	**C (76.9%)**
ECOLOGICAL IMPORTANCE AND SENSITIVITY								
MODERATE								
RECOMMENDED ECOLOGICAL CATEGORY (REC) = PES								
REC = C for ECOSTATUS								
TEC = REC = C for ECOSTATUS								

7.1 HYDROLOGICAL (FLOW) RQOs

The flow RQOs for EWR BM1 are provided in **Table 7.1.** The full EWR rule is provided as part of the electronic data for the project.

Table 7.1 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 7.1** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 7.1 Flow RQOs (EWRs) for EWR BM1

ECOLOGICAL WATER REQUIREMENTS (EWR)			
Natural MAR: 166.72 MCM		Present Day MAR: 144.13 MCM	
Low flow EWR		**Total flow EWR**	
MCM	% of nMAR	MCM	% of nMAR
18.38	11	43.6	26.1

Low Flow Assurance Rules (m³/s)										
m³/s	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**99%**
Oct	0.62	0.44	0.40	0.39	0.37	0.31	0.24	0.19	0.19	0.17
Nov	1.11	0.78	0.67	0.61	0.52	0.42	0.31	0.24	0.19	0.14
Dec	1.26	0.99	0.89	0.79	0.68	0.55	0.41	0.31	0.22	0.19
Jan	1.46	1.43	1.09	0.87	0.79	0.65	0.49	0.37	0.32	0.25
Feb[1]	1.34	1.23	1.10	0.95	0.82	0.70	0.58	0.48	0.40	0.35
Mar	1.25	1.20	1.05	1.02	0.92	0.78	0.59	0.46	0.36	0.31
Apr	1.05	0.99	0.93	0.87	0.82	0.70	0.58	0.45	0.37	0.32
May	0.81	0.77	0.77	0.73	0.67	0.58	0.47	0.38	0.33	0.29
Jun	0.67	0.64	0.63	0.60	0.53	0.46	0.37	0.30	0.26	0.24
Jul[1]	0.60	0.58	0.56	0.52	0.46	0.39	0.31	0.24	0.20	0.17
Aug	0.40	0.40	0.39	0.37	0.35	0.31	0.26	0.22	0.20	0.20
Sep	0.41	0.37	0.35	0.34	0.32	0.28	0.21	0.18	0.18	0.15
Total assurance rules (MCM)										
MCM	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	3.817	1.95	1.082	1.054	0.996	0.822	0.644	0.506	0.506	0.45
Nov	7.507	4.187	3.903	3.747	1.584	1.094	0.803	0.613	0.484	0.37
Dec	12.209	8.315	5.563	4.277	3.964	2.489	1.539	0.823	0.602	0.506
Jan	18.035	9.475	6.105	4.488	4.268	2.766	1.897	0.994	0.855	0.658
Feb	29.178	9.667	5.855	4.478	4.146	2.711	1.424	1.172	0.979	0.845
Mar	12.184	6.381	4.959	4.901	3.495	2.082	1.592	1.241	0.974	0.839
Apr	4.88	3.584	2.963	2.245	2.119	1.807	1.496	1.173	0.959	0.831
May	3.185	2.066	2.065	1.945	1.786	1.555	1.249	1.01	0.889	0.78
Jun	1.731	1.664	1.638	1.568	1.381	1.189	0.97	0.769	0.661	0.618
Jul	1.612	1.562	1.488	1.385	1.235	1.047	0.84	0.632	0.524	0.446
Aug	1.083	1.079	1.057	0.987	0.943	0.841	0.699	0.593	0.541	0.541
Sep	1.055	0.951	0.903	0.88	0.838	0.715	0.557	0.478	0.478	0.4

1 The low flows for the 60th and 90th percentiles for the wettest (February) and driest (July) month.

7.2 GEOMORPHOLOGY

Key concerns related to geomorphology at EWR BM1 were:

- Increased sediment deposition of fine sediment (sand) in fast flowing areas due to increased catchment erosion and/or reduced flow capacity.
- Expansion of sand and silt deposits in pools.
- Increased flood bench sediment leading to increased elevation and terrestrialisation of vegetation.

EcoSpecs and TPCs are presented in **Table 7.2**, with the surveyed transect shown diagrammatically in **Figure 7.1**.

Table 7.2 EWR BM1: Geomorphology EcoSpecs and TPCs (PES and TEC: A)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Extent of sand in fast flowing habitat	Sand patches should not exceed very low (<15%) (but may increase temporarily after significant flood events).	Sand deposits exceeding 15% persist over several seasons in fast flowing habitat.
Extent of fines in pool habitat	Mid-channel sand bars should not be present.	Sand bars present in pool habitat.
Channel cross-section		

Geomorphology metrics	EcoSpecs	TPC
Width of active channel at transect	Width between upper flood benches should be stable at 20 m on transect line.	Visible erosion or sediment accretion along either bank, width at transect line exceeds 20.5 m or less than 19.5 m.
Lower flood bench (marginal zone)		
Present-absent	Lower flood bench should be present on at least one bank.	Lower flood bench actively eroding, absence of marginal vegetation.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent fine sediment deposits or excessive deposits; lower flood bench encroaching into channel.
Upper flood bench		
Present-absent	Upper flood bench should be present on both banks.	Upper flood bench actively eroding.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent sediment deposits linked to the last wet season; evidence of excessive deposition and terrestrialisation indicating elevated flood bench.
Channel pattern		
Channel type	Channel should not change from a single thread channel with pool-rapid morphology.	Change to a different channel type.

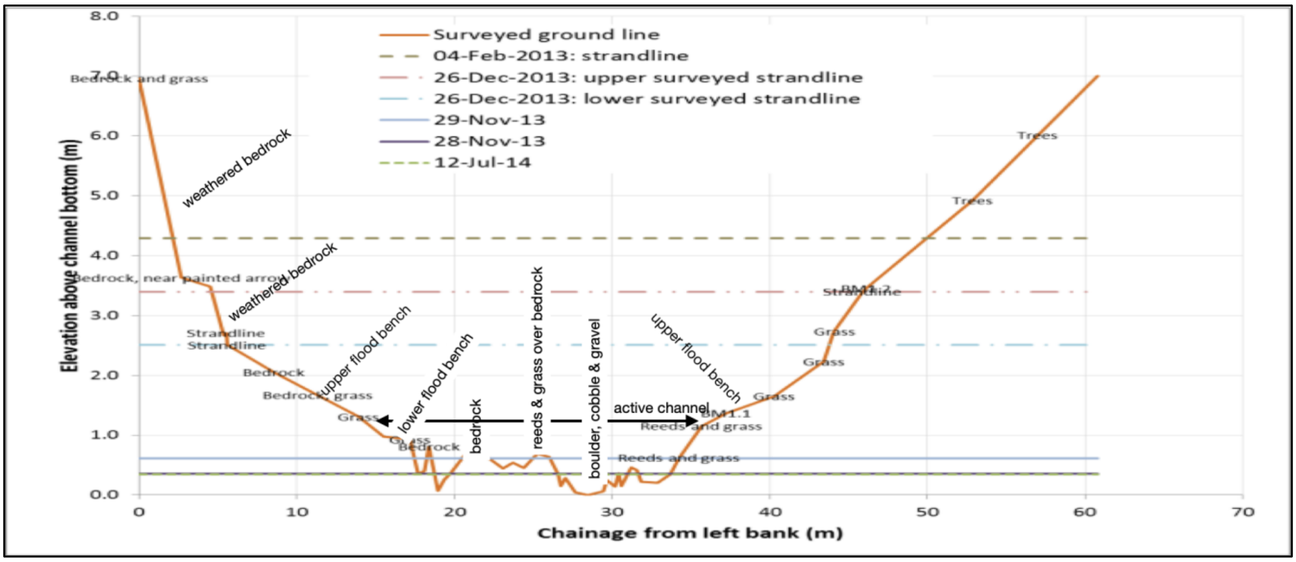

Figure 7.1 Surveyed transect line at EWR BM1

7.3 WATER QUALITY

EcoSpecs and TPCs are shown in **Table 7.3**. Intermittent elevated sulphates are evident at the site, so strict controls on sulphates and Electrical Conductivity are recommended. The current 95th percentile for EC is 58.2 mS/m, with the EcoSpec set to the upper boundary of a C Category, i.e. ≤55 mS/m. Little information is available as ecosystem guidelines for sulphate; the EcoSpec is therefore set tentatively based on available literature for the protection of aquatic life (BC MOE, 2013). Note that this guideline is dependent on the hardness of the receiving water.

Table 7.3 EWR BM1: Water quality EcoSpecs and TPCs (PES and TEC: B/C)

Water quality metrics	EcoSpecs	TPC
Inorganic salts*		
$MgSO_4$	The 95th percentile of the data must be ≤23 mg/L.	The 95th percentile of the data is 19 - 23 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤33 mg/L.	The 95th percentile of the data is 27 - 33 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤30 mg/L.	The 95th percentile of the data is 24 - 30 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤57 mg/L.	The 95th percentile of the data is 46 - 57 mg/L.
NaCl	The 95th percentile of the data must be ≤191 mg/L.	The 95th percentile of the data is 153 - 191 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤773 mg/L.	The 95th percentile of the data is 618 - 773 mg/L.
Inorganic salts ions**		
Sulphate as SO_4	The 95th percentile of the data must be ≤30 mg/L[2].	The 95th percentile of the data is 24 - 30 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤55 mS/m.	The 95th percentile of the data is 44 - 55 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.8.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.6.
Temperature	Largely natural temperature range is expected.	Abundance and frequency of occurrence of temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be >8.0 mg/L.	The 5th percentile of the data is ≤8.2 mg/L.
Turbidity	Small changes expected.	Some localized erosion at the site due to land use.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be <0.25 mg/L.	The 50th percentile of the data is 0.2 - 0.25 mg/L
PO_4-P	The 50th percentile of the data must be ≤0.015 mg/L.	The 50th percentile of the data is 0.012 - 0.015 mg/L.
Response variables#		
Chl-*a* phytoplankton	The 50th percentile of the data must be ≤15 mg/L.	The 50th percentile of the data is 12 - 15 µg/L
Chl-*a* periphyton	The 50th percentile of the data must be ≤12 mg/m^2	The 50th percentile of the data is 10 - 12 mg/m^2
Toxics		
Ammonia (NH_3-N)	The 95th percentile of the data must be ≤0.02 mg/L	The 95th percentile of the data is 0.016 - 0.02 mg/L
Other variables#	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008a), or within the AEV as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the TWQR as stated in DWAF (1996a).

* Inorganic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
** Information provided where available. Data could only be located for sulphate – see BC MOE (2013) guideline. This guideline is set in terms of the current state of sulphate, which is lower than the BC MOE (2013) guideline.
# Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

7.4 RIPARIAN VEGETATION

EcoSpecs and TPCs for riparian vegetation are shown in **Table 7.4**.

[2] A guideline of 309 mg/L SO_4 for aquatic ecosystem protection for moderately hard to hard water (average hardness at BM1 was 142.7 mg/L $CaCO_3$) (BC MOE, 2013) exists.

Table 7.4 Black Mfolozi River (BM 1): Riparian vegetation EcoSpecs and TPCs (PES and TEC: C)

Assessed metric	EcoSpec	TPC
Marginal / Lower zones		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody vegetation.	A decrease in non-woody riparian vegetation cover below 50%.
Key Species	The presence of *Ischaemum fasciculatum, Cyperus longus* and *Juncus lomatophyllus.*	The absence of *Cyperus longus* or *Juncus lomatophyllus* or *Ischaemum fasciculatum.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 10% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species (% aerial cover)	Maintain an absence of terrestrial woody species in the zone.	An occurrence of terrestrial woody species in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover below 20% in the zone.	An absence of indigenous woody species or an increase in woody species cover above 20% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 40% in the zone.	A decrease in non-woody vegetation cover below 30% in the zone.
Reed cover (% aerial)	Maintain the presence of reeds in the zone.	An increase in reed cover above 20% in the zone.
Flood features / Upper zone		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody vegetation, but with scattered woody individuals.	Reduced proportion of aerial non-woody cover below 30% in the zone.
Key Species	The presence of *Syzygium guineense* and *Combretum erythrophyllum.*	The absence of *Syzygium guineense* or *Combretum erythrophyllum.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 20% in the zone.	An increase in perennial alien plant species cover above 20% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 15% in the zone.	An increase in terrestrial woody species cover above 10% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover above 5% in the zone.	An absence of indigenous riparian woody species or an increase in woody species cover above 30% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 40% in the zone.	A decrease in non-woody vegetation cover below 40% in the zone.
Reed cover (% aerial)	Maintain reed cover below 10% in the zone.	An increase in reed cover above 10% in the zone.
MCB		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain woody vegetation.	Reduced proportion of woody aerial cover below 50% in the zone.
Key species	The presence of *combretum erythrophyllum* and *Spirostachys africana.*	The absence of *combretum erythrophyllum* or *Spirostachys africana.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 20% in the zone.	An increase in perennial alien plant species cover above 20% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 40% in the zone.	An increase in terrestrial woody species cover above 40% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover of indigenous riparian woody species above 10% in the zone.	A decrease in woody species cover below 5% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 10% in the zone.	A decrease in non-woody vegetation cover below 10% in the zone.
Riparian zone		

Assessed metric	EcoSpec	TPC
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 60% for the riparian zone.	A decrease in PES score below 60% for the riparian zone.
Species richness	Maintain the presence of at least 25 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 20.

7.5 FISH

Table 7.5 outlines the spatial FROC of fish for the EWR reach and indicates the FROC under reference and PES (baseline conditions). Reach and EWR site specific EcoSpecs and TPCs based on the specific metrics or variables, as included in the FRAI (Kleynhans, 2007) are provided in **Table 7.6**.

Table 7.5 EWR BM1: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
AURA*	***Amphilius uranoscopus***	**3**	**2.5**	**FROC <2.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
BEUT*	***Enteromius eutaenia***	**3**	**2.5**	**FROC <2.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
LNAT*	***Labeobarbus natalensis***	**2**	**1.5**	**FROC <1.5 (absent from all suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
BPAU*	***Enteromius paludinosus***	**2**	**1**	**FROC <1(absent from all suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07.**
BTRI*	***Enteromius trimaculatus***	**3**	**2.5**	**FROC <2.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
LMOL*	***Labeo molybdinus***	**3**	**2**	**FROC <2.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07.**
OMOS*	***Oreochromis mossambicus***	**3**	**2**	**FROC <2.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07.**
TSPA*	***Tilapia sparrmanii***	**4**	**3.5**	**FROC <3.5 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
PPHI	*Pseudocrenilabrus philander*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BUNI	*Enteromius unitaeniatus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BVIV	*Enteromius viviparus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
CGAR	*Clarias gariepinus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BANO	*Enteromius anoplus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
AAEN	*Awaous aeneofuscus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
ALAB	*Anguilla bengalensis labiata*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
AMOS	*Anguilla mossambica*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
BARG	*Enteromius argenteus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
CTHE	*Clarias theodorae*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

* Priority indicator species (previously confirmed/sampled in reach during EWR surveys).

Table 7.6 EWR BM1: Fish EcoSpecs and TPCs (PES and TEC C)

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	Present ecological status of fish is in a C (FRAI = 75.9%).	Decrease of PES towards a lower EC than PES (FRAI <68%).	Any deterioration in a habitat feature that results in decrease in FROC of species that lead to deterioration of PES.
Species richness	**Reach:** All indigenous species expected. **EWR site:** Indigenous species confirmed at site during EWR surveys.	**Reach:** All the expected indigenous fish species (18) estimated to be present in the reach under PES. **EWR site:** Eight (8) indigenous fish species confirmed (sampled) previously at EWR site (2014 and 2022).	**Reach:** Loss of any indigenous species from reach. **EWR site:** Less than five (5) indigenous fish species sampled at EWR site during any survey. Absence of range of life stages (juveniles to adults) of all species sampled at site during various surveys may also indicate deterioration.	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water	AURA	**Reach:** AURA estimated to be present at 10 to 25% of sites in reach (FROC =2.5). **EWR site:** Sampled at EWR site 50% of surveys (2014/07).	**Reach:** AURA present at <10% of sites in reach (FROC = 1). **EWR site:** AURA absent from EWR site during two consecutive surveys.	Reduced suitability (abundance and quality) of flowing habitats (i.e., decreased flows, increased zero flows, altered seasonality).
Fast-Deep (FD) habitats				Reduced suitability (abundance and quality) of FD habitats (i.e., decreased flows, increased zero flows).
Substrate				Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Fast-Shallow (FS) habitats	BEUT	**Reach:** BEUT estimated to be present at 10 to 25% of sites in reach (FROC = 2.5). **EWR site:** Sampled at EWR site 100% of surveys (2014/07 and 2022/07).	**Reach:** BEUT present at <10% of sites in reach (FROC = 1). **EWR site:** BEUT absent from EWR site during two consecutive surveys.	Reduced suitability (abundance and quality) of FS habitats (i.e., decreased flows, increased zero flows).
Water quality intolerance				Decreased water quality (especially flow related water quality variables such as oxygen).
Undercut banks				Significant change in undercut bank and rootwads habitats (e.g., bank erosion, reduced flows).
Overhanging vegetation	BPAU/TSPA	**Reach:** BPAU and TSPA most applicable indicator in reach (BPAU scarce estimated to occur at <10% sites: FROC = 1 and TSPA abundant, occurring at 25 to 50% of sites: FROC = 3.5). **EWR site:** BPAU sampled 50% of surveys at EWR site (2022/07) and TSPA during 100% of survey (2014 and 2022).	**Reach:** BPAU absent from all sites sampled in reach (FROC = 0) and TSPA present at <25% of sites (FROC<3). **EWR site:** BPAU and/or TSPA absent during two consecutive surveys.	Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).
Slow-Shallow (SS) habitats				Significant change in SS habitat suitability (i.e., increased flows, altered seasonality, increased sedimentation of slow habitats).

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Instream vegetation				Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes).
Slow-Deep (SD) habitats				Significant change in SD habitat suitability (i.e., increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
Water column	OMOS	**Reach:** OMOS most applicable indicator in reach, estimated to be present at between 10 to 25% of sites in reach: FROC =2. **EWR site:** OMOS sampled 50% of surveys at EWR site (2022/07).	**Reach:** OMOS present at <10% of sites in reach (FROC = -1). **EWR site:** OMOS absent during two consecutive surveys.	Reduction in suitability of water column (i.e., increased sedimentation of pools, reduced flows).
Alien fish species	Presence of any alien/introduced spp.	No alien species previously sampled at EWR site or known from reach.	Presence of any alien/introduced species in reach or at EWR site during any survey.	N/A
Migratory success	Eels, LNAT, LMOL, CGAR	Two catadromous eel species (ALAB and AMOS) and various potamodromous species expected in reach. Various potamodromous (including LNAT, LMOL) sampled at EWR site and various other potamodromous species expected at EWR site.	**Reach:** Eels, LNAT or LMOL absent from all sites sampled in reach during two consecutive surveys. **EWR site:** Absence of LNAT and LMOL from site during two consecutive surveys.	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

7.6 MACROINVERTEBRATES

Table 7.7 lists the macro-invertebrate indicator taxa (families) linked to preferred habitat attributes at the site or in the EWR reach. Site specific EcoSpecs and TPCs based on the specific metrics or variables, as established in the MIRAI (Thirion, 2016) during field surveys, are provided in **Table 7.8**. All the project sites were assigned to an ecoregion level 1 (Kleynhans *et al*., 2005).

According to the MIRAI compiled by C. Todd as part of the initial Reserve Study (2014), the reference condition for Site BM1 was established as: SASS 220 and ASPT 7, while a SASS 170 and ASPT 6.5 were recorded at the site at the time of the 2014 reserve survey (no recent data was available at the time of the current study).

Table 7.7 EWR BM1: Macro-invertebrate indicator taxa

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	Hydropsychidae 1 or 2spp	>0.6	Cobbles	Low
2	Philopotamidae	>0.6	Cobbles	Moderate
3	Elmidae			
4	Perlidae	0.3 - 0.6	Cobbles	High
5	Heptageniidae			
6	Leptophlebiidae	0.3 - 0.6	Cobbles	Moderate
7	Psephenidae			
8	Atyidae	<0.1	Vegetation	Moderate
9	Coenagrionidae	<0.1	Vegetation	Low
10	Gomphidae	<0.1	GSM	Low

Table 7.8 EWR BM1: Macro-invertebrate EcoSpecs and TPCs (TEC B/C)

EcoSpecs	TPCs
Ensure that the SASS5 scores and ASPT values occur in the following range SASS5 score range 120 to 200; ASPT value: >6.3.	ASPT below 6.0 and SASS 130.
Ensure that the MIRAI score is within the range of a B/C Category (>77.99 and <82.) using the same reference data used in this study (DWS, 2022c).	A MIRAI score of 80% or less.
Maintain suitable flow velocity (maximum >0.6 m/s) and clean, unembedded surface area (cobbles) to support the Hydropsychidae (2 species) and Philopotamidae assemblages in the VFCS.	More than one of or Hydropsychidae (2 species) or Philopotamidae assemblages missing in a survey.
To maintain suitable flow velocity (0.3 - 0.6 m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the FFCS biotope: ▫ Perlidae ▫ Psephenidae	More than one of Perlidae or Psephenidae, or assemblage missing in a survey.
Maintain suitable conditions in the SIC habitat regarding moderate velocity (0.3 - 0.6 m/s) and good water quality to support Heptageniidae.	Heptageniidae This taxon missing in two consecutive surveys.
Maintain suitable conditions for the following flow-dependent species in the SIC biotope: ▫ Elmidae: Abundance A. ▫ Leptophlebiidae: Abundance B.	Any one of Elmidae and Leptophlebiidae missing in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the Coenagrionidae and Atyidae.	More than one of Coenagrionidae and Atyidae assemblages missing in a survey.
To maintain suitable coarse alluvial sediment and habitat conditions for Gomphidae	This taxon missing during a survey.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000) over more than two consecutive surveys.	Any taxon occurring in an abundance of >500 for two consecutive surveys.

8 RQOs FOR EWR MK1 (MKUZE RIVER)

<table>
<tr><th colspan="9">EWR MK1: Mkuze River</th></tr>
<tr><td colspan="7" rowspan="6"></td><td>Coordinates</td><td>S27.59210
E32.21800</td></tr>
<tr><td>SQ code</td><td>W31J-02480</td></tr>
<tr><td>RU</td><td>RU W31-5</td></tr>
<tr><td>IUA</td><td>IUA W31-b</td></tr>
<tr><td>Level 2 EcoRegion</td><td>3.08</td></tr>
<tr><td>Geomorph Zone</td><td>Lowland</td></tr>
<tr><th colspan="9">PRESENT ECOLOGICAL STATE: PES</th></tr>
<tr><th>I IHI</th><th>R IHI</th><th>PC</th><th>Geom</th><th>Rip Veg</th><th>Fish</th><th>Inverts</th><th>Instream</th><th>EcoStatus</th></tr>
<tr><td>C (66.3%)</td><td>C (72.1%)</td><td>C/D (58.3%)</td><td>B (82.3%)</td><td>C (73%)</td><td>C (75.4%)</td><td>C (77.7%)</td><td>C (76.6%)</td><td>C (74.8%)</td></tr>
<tr><th colspan="9">ECOLOGICAL IMPORTANCE AND SENSITIVITY</th></tr>
<tr><td colspan="9">HIGH</td></tr>
<tr><th colspan="9">RECOMMENDED ECOLOGICAL CATEGORY (REC) = PES</th></tr>
<tr><td colspan="9">REC = B/C for ECOSTATUS (Impacts non-flow related and flows will be set for a C EC)</td></tr>
<tr><td colspan="9">TEC = REC = B/C for ECOSTATUS (Impacts non-flow related and flows will be set for a C EC)</td></tr>
<tr><th colspan="9">TARGET ECOLOGICAL STATE: TEC</th></tr>
<tr><th>I IHI</th><th>R IHI</th><th>PC</th><th>Geom</th><th>Rip Veg</th><th>Fish</th><th>Inverts</th><th>Instream</th><th>EcoStatus</th></tr>
<tr><td>B/C (79.2%)</td><td>B (83.6%)</td><td>C (68.8%)</td><td>B (82.3%)</td><td>C (76.4%)</td><td>B/C (80.7%)</td><td>C (79.1%)</td><td>B/C (79.88%)</td><td>B/C (78.14%)</td></tr>
</table>

8.1 HYDROLOGICAL (FLOW) RQOS

The flow RQOs for EWR MK1 are provided in **Table 8.1.** The full EWR rule is provided as part of the electronic data for the project.

Table 8.1 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 8.1** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 8.1 Flow RQOs (EWRs) for EWR MK1

<table>
<tr><th colspan="4">ECOLOGICAL WATER REQUIREMENTS (EWR)</th></tr>
<tr><td colspan="2">Natural MAR: 158.75 MCM</td><td colspan="2">Present Day MAR: 106.13 MCM</td></tr>
<tr><th colspan="2">Low flow EWR</th><th colspan="2">Total flow EWR</th></tr>
<tr><td>MCM</td><td>% of nMAR</td><td>MCM</td><td>% of nMAR</td></tr>
<tr><td>34.74</td><td>21.9</td><td>58.87</td><td>37.1</td></tr>
</table>

Low Flow Assurance Rules (m^3/s)										
m^3/s	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**99%**
Oct	1.47	1.20	1.01	0.88	0.79	0.67	0.57	0.48	0.35	0.34
Nov	2.40	1.83	1.33	1.10	0.93	0.77	0.65	0.54	0.45	0.38
Dec	2.44	2.16	1.74	1.41	1.08	0.86	0.69	0.57	0.47	0.43
Jan	2.49	2.15	2.01	1.49	1.18	0.91	0.73	0.59	0.50	0.44
Feb[1]	2.53	2.23	1.86	1.52	1.19	0.90	0.72	0.58	0.48	0.39
Mar	2.57	2.25	2.25	1.98	1.54	1.12	0.80	0.74	0.59	0.45
Apr	2.35	2.03	1.76	1.50	1.16	0.91	0.72	0.59	0.48	0.47
May	1.86	1.67	1.47	1.27	1.07	0.84	0.69	0.58	0.45	0.42
Jun	1.60	1.43	1.21	1.05	0.89	0.73	0.60	0.51	0.43	0.40
Jul	1.39	1.31	1.06	0.90	0.80	0.68	0.58	0.50	0.42	0.40
Aug[1]	1.23	1.06	0.93	0.83	0.73	0.64	0.55	0.47	0.40	0.35
Sep	1.08	0.97	0.77	0.69	0.63	0.51	0.42	0.36	0.32	0.32
Total assurance rules (MCM)										
MCM	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	6.81	4.555	2.699	2.351	2.106	1.79	1.527	1.291	0.944	0.904
Nov	16.293	7.637	6.338	4.187	3.764	2.9	1.678	1.398	1.162	0.981
Dec	17.49	12.316	8.909	6.67	4.248	3.645	1.843	1.533	1.261	1.14
Jan	18.968	11.338	8.907	6.89	4.504	3.793	1.942	1.583	1.334	1.168
Feb	26.837	13.912	8.709	6.606	4.242	3.326	1.747	1.424	1.175	0.963
Mar	13.4	10.27	8.922	7.962	5.465	3.606	2.145	1.982	1.577	1.202
Apr	8.969	6.61	5.423	3.886	3.012	2.353	1.878	1.532	1.238	1.22
May	4.971	4.477	3.937	3.404	2.854	2.257	1.857	1.542	1.212	1.113
Jun	4.151	3.703	3.129	2.723	2.305	1.899	1.564	1.33	1.105	1.042
Jul	3.724	3.509	2.844	2.416	2.137	1.821	1.558	1.336	1.116	1.065
Aug	3.285	2.84	2.492	2.212	1.96	1.716	1.477	1.252	1.075	0.939
Sep	2.809	2.503	1.999	1.787	1.635	1.322	1.081	0.928	0.831	0.82

1 The low flows for the 60th and 90th percentiles for the wettest (February) and driest (August) month.

8.2 GEOMORPHOLOGY

Key concerns related to geomorphology at EWR MK1 were:

- Expansion of sand bars (lateral and mid-channel).
- Silt deposition over sand bars.
- Increased flood bench sediment leading to increased elevation and terrestrialisation of vegetation.
- Erosion of lower banks; disturbance from livestock.

EcoSpecs and TPCs are presented in **Table 8.2**, with the surveyed transect shown diagrammatically in **Figure 8.1**.

Table 8.2 EWR MK1: Geomorphology EcoSpecs and TPCs (TEC B/C)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Extent of sand bars	Exposed sand bars should not exceed moderate (<50%) at “normal” low flows (exposure will increase during drought flows.	Exposed sand bars exceed 45% of instream habitat at “normal” low flows.
Extent of silt deposits	Silt deposition over sand bars should be negligible.	Significant and persistent silt deposits over sand bars.
Channel cross-section		
Width of rapid at transect	Width between lower flood benches should be stable at 12 m on transect line.	Visible erosion along either bank, width at transect line exceeds 12.5 m.
Lower flood bench (marginal zone)		
Present-absent	Lower flood bench supporting marginal zone vegetation locally present as narrow bench and point bars occupying 50 - 60% of channel length (from low flow images in Google Earth).	Stabilising point bars (i.e. with vegetation) <50% or >60% of channel length; trend changing over time.
Upper flood bench		
Present-absent	Upper flood bench should be present on both banks.	Upper flood bench actively eroding.
Sediment deposits	Evidence of fine sediment deposits (fine to medium sand) but not excessive.	No recent sediment deposits linked to the last wet season evidence of excessive deposition and terrestrialisation indicating elevated flood bench.
Channel pattern		
Channel type	Channel should not change from a single thread sand bed river.	Change to a different channel type.

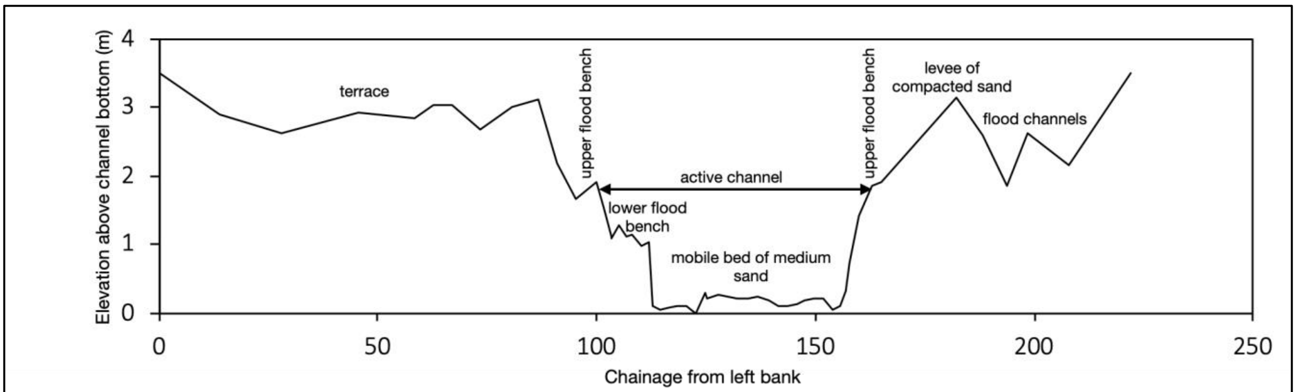

Figure 8.1 Surveyed transect line at EWR MK1

8.3 WATER QUALITY

Current water quality state is a C/D category; 58.3%. The main drivers of water quality include forestry, coal mining in the upper catchment, dams (including an IBT from Pongolapoort Dam upstream of the EWR site), rural areas, irrigated crops, alien vegetation, instream dams, erosion and sedimentation. Extensive commercial agriculture and subsistence farming is found upstream of the site, as well as the High Risk Mkuze WWTW. The sources of poor water quality can therefore be primarily attributed to elevated salts, particularly sodium and sulphates from upstream mining activities, and expected toxics due to upstream activities such as coal-mining, settlements, irrigated crops (use of biocides, pesticides, fertilizers etc.) and the WWTW. Elevated nutrients and turbidities are evident, but these factors are not as significant in terms of water quality as salts and toxics.

However, large abstractions by irrigators reduce the natural dilution capacity of the river, impacting further on water quality state.

The REC and TEC for this site is to improve through non flow-related means, particularly for the fish that are reacting to poor water quality state. It would not be possible to improve the fish category without first addressing the water quality concerns. The areas of improvement include salts, nutrients, turbidity levels and toxics.

Non-point sources of pollution, e.g. saline irrigation water and increasing salinity through return flows, are the most difficult to control, and would require significant resources in terms of expertise and budget to address. RQOs are therefore presented as immediately applicable, short-term (5-year) and long-term (10-year) objectives.

To improve the overall state of the site through non flow-related interventions, the following would be required:

- Improvement in the management and quality of discharges from the Mkuze WWTW.
- Improvement in the management and quality of discharges from coal-mining facilities upstream. An appropriate strategy must be developed to deal with the problem of mine decant, especially from closed and abandoned mines. It is difficult to predict what level of improvement can be achieved, and it is unlikely that salts can be moved from the current 95th percentile of 275 mS/m to that of 85 mS/m for a D Category in the short term.
- Improvement in land management and controlled use of biocides and fertilizers; reducing sedimentation and toxics released into the system.
- Reported hight silt loads in the system must be verified, considered and addressed. DWS (2020) proposes that a strategy/action plan needs to be developed to achieve this. This study must include the question of the role of silt in the Mkuze swamps (capacity of the swamps to absorb this silt) and the impacts of phosphates associated with the silt.

DWS's Planning Level Review of 2020 (DWS, 2020) provides more information, and recommends that a detailed water quality management strategy be drawn up for the Mkuze catchment to contain the potential water quality threats to the catchment.

EcoSpecs and TPCs are shown in **Table 8.3** (immediate), **Table 8.4** (short-term) and **Table 8.5** (long-term). Note that due to problems with elevated salts at the site, EcoSpecs and TPCs are set for the sulphate anion, using available water quality guidelines and planning levels statistics to assist with setting this objective.

Table 8.3 EWR MK1: Water quality EcoSpecs and TPCs (prevent further deterioration, i.e. at least maintain a C/D; 58.3%)

Water quality metrics	EcoSpecs	TPC
Inorganic salts		
Data cannot be provided with any level of confidence.		
Inorganic salts ions*		
Sulphate as SO_4	The 95th percentile of the data must be ≤208 mg/L[3].	The 95th percentile of the data is 166 - 208 mg/L.

[3] A guideline of 429 mg/L SO_4 for aquatic ecosystem protection for very hard water (average hardness at MK1 was 336.4 mg/L $CaCO_3$) (BC MOE, 2013) exists.

Water quality metrics	EcoSpecs	TPC
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤275 mS/m, *based on present state*.	The 95th percentile of the data is 220 - 275 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.8.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.6.
Temperature	Largely natural temperature range is expected.	Abundance and frequency of occurrence of highly temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥7.0 mg/L.	The 5th percentile of the data is <7.2 mg/L.
Turbidity	Moderate to large impacts expected due to widespread erosion in upper and middle catchment.	Check biotic response for habitat-related changes. Institute turbidity monitoring.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be ≤0.5 mg/L.	The 50th percentile of the data is 0.4 - 0.5 mg/L.
PO_4-P	The 50th percentile of the data must be ≤0.025 mg/L.	The 50th percentile of the data is 0.012 - 0.015 mg/L.
Response variables (#)		
Chl-*a* phytoplankton	The 50th percentile of the data must be ≤20 mg/L.	The 50th percentile of the data is 16 - 20 µg/L.
Chl-*a* periphyton	The 50th percentile of the data must be ≤21 mg/m^2.	The 50th percentile of the data is 17 - 21 mg/m^2.
Toxics		
Ammonia (NH_3-N)	The 95th percentile of the data must be ≤0.043 mg/L.	The 95th percentile of the data is 0.034 - 0.043 mg/L.
Fe#	The 95th percentile of the data must be ≤0.1 mg/L.	The 95th percentile of the data is 0.08 - 0.1 mg/L.
Al#	The 95th percentile of the data must be ≤0.07 mg/L.	The 95th percentile of the data is 0.057 - 0.07 mg/L.
Pb#	The 95th percentile of the data must be ≤0.054 mg/L.	The 95th percentile of the data is 0.043 - 0.054 mg/L.
Zn#	The 95th percentile of the data must be ≤0.154 mg/L.	The 95th percentile of the data is 0.123 - 0.154 mg/L.
Other variables#	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008a), or within the AEV as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the TWQR as stated in DWAF (1996a).

* Data could only be located for sulphate – see BC MOE (2013) guideline. This guideline is set in terms of the current state of sulphate, which is lower than the BC MOE (2013) guideline. The following boundary categories used for the preparation of DWS (2020) also considered. Ideal: 80 mg/L; Acceptable: 165 mg/L; Tolerable: 250 mg/L SO_4.

Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

Table 8.4 EWR MK1: Water quality EcoSpecs and TPCs to be achieved over the short-term (TEC:C; 68.8%)

Water quality metrics	EcoSpecs	TPC
Inorganic salts ions*#		
$MgSO_4$	The 95th percentile of the data must be ≤45 mg/L	The 95th percentile of the data is 36 - 45 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤64 mg/L.	The 95th percentile of the data is 51 - 64 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤66 mg/L.	The 95th percentile of the data is 53 - 66 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤141 mg/L.	The 95th percentile of the data is 113 - 141 mg/L.
NaCl	The 95th percentile of the data must be ≤535 mg/L.	The 95th percentile of the data is 428 - 535 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤1105 mg/L.	The 95th percentile of the data is 884 - 1105 mg/L.

Water quality metrics	EcoSpecs	TPC
Inorganic salts ions**		
Sulphate as SO_4	The 95th percentile of the data must be ≤165 mg/L.	The 95th percentile of the data is 132 - 165 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤185 mS/m. *This is a provisional value as conductivity needs to improve from around 275 mS/m to 85 mS/m to reach D category status for salts.*	The 95th percentile of the data is 148 - 185 mS/m for a D category river.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.8.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.6.
Temperature	Largely natural temperature range is expected.	Abundance and frequency of occurrence of highly temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥7.0 mg/L.	The 5th percentile of the data is <7.2 mg/L.
Turbidity	Moderate changes expected due to localized erosion in upper and middle catchments.	Check biotic response for habitat-related changes. Continue turbidity monitoring.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be ≤0.25 mg/L.	The 50th percentile of the data is 0.2 - 0.25 mg/L.
PO_4-P	The 50th percentile of the data must be ≤0.015 mg/L.	The 50th percentile of the data is 0.012 - 0.015 mg/L.
Response variables[#]		
Chl-*a* phytoplankton	The 50th percentile of the data must be ≤15 mg/L.	The 50th percentile of the data is 12 - 15 µg/L.
Chl-*a* periphyton	The 50th percentile of the data must be ≤12 mg/m^2.	The 50th percentile of the data is 10 - 12 mg/m^2.
Toxics		
Ammonia (NH_3-N)	The 95th percentile of the data must be ≤0.043 mg/L.	The 95th percentile of the data is 0.034–0.043 mg/L
Fe [(#)]	The Fe concentration should not vary more than 10% of the background dissolved Fe concentration.	The Fe concentration is varying ≥8% of the background dissolved Fe concentration.
Al [(#)]	The 95th percentile of the data must be ≤0.055 mg/L (ANZ, 2000 - 2023).	The 95th percentile of the data is 0.044 - 0.055 mg/L.
Pb [(#)]	The 95th percentile of the data must be ≤0.003 mg/L (ANZ, 2000 - 2023).	The 95th percentile of the data is 0.002 - 0.003 mg/L.
Zn [(#)]	The 95th percentile of the data must be ≤0.008 mg/L (ANZ, 2000 - 2023).	The 95th percentile of the data is 0.006 - 0.008 mg/L.
Other variables[#]	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008), or within the AEV as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the TWQR as stated in DWAF (1996a).

* Inorganic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
** Information provided where available. Data could only be located for sulphate – see BC MOE (2013) guideline. This guideline is set in terms of the current state of sulphate, which is lower than the BC MOE guideline. Statistics used for the preparation of DWS (2020) also considered.
[#] Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

Table 8.5 EWR MK1: Water quality EcoSpecs and TPCs to be achieved over the long-term (TEC: B/C; 79.4%)

Water quality metrics	EcoSpecs	TPC
Inorganic salts*		
$MgSO_4$	The 95th percentile of the data must be ≤37 mg/L, *as indicated for a D Category river*.	The 95th percentile of the data is 30 - 37 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤51 mg/L, *as indicated for a D Category river*.	The 95th percentile of the data is 41 - 51 mg/L.

Water quality metrics	EcoSpecs	TPC
$MgCl_2$	The 95th percentile of the data must be ≤51 mg/L, *as indicated for a D Category river*.	The 95th percentile of the data is 41 - 51 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤105 mg/L, *as indicated for a D Category river*.	The 95th percentile of the data is 84 - 105 mg/L.
NaCl	The 95th percentile of the data must be ≤389 mg/L, *as indicated for a D Category river*.	The 95th percentile of the data is 311 - 389 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤1105 mg/L, *as indicated for a D Category river*.	The 95th percentile of the data is 884 - 1105 mg/L.
Inorganic salts ions**		
Sulphate as SO_4	The 95th percentile of the data must be ≤100 mg/L.	The 95th percentile of the data is 80 - 100 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤85 mS/m, *as indicated for a D Category river*.	The 95th percentile of the data is 68 - 85 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.8.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.6.
Temperature	Largely natural temperature range is expected.	Abundance and frequency of occurrence of highly temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥7.0 mg/L.	The 5th percentile of the data is <7.2 mg/L.
Turbidity	Small to moderate changes linked to some erosion in upper and middle catchments.	Check biotic response for habitat-related changes. Continue turbidity monitoring.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be ≤0.25 mg/L.	The 50th percentile of the data is 0.2 - 0.25 mg/L.
PO_4-P	The 50th percentile of the data must be ≤0.015 mg/L.	The 50th percentile of the data is 0.012 - 0.015 mg/L.
Response variables#		
Chl-*a* phytoplankton	The 50th percentile of the data must be ≤15 mg/L.	The 50th percentile of the data is 12 - 15 µg/L.
Chl-*a* periphyton	The 50th percentile of the data must be ≤12 mg/m^2.	The 50th percentile of the data is 10 - 12 mg/m^2.
Toxics		
Ammonia (NH_3-N)	The 95th percentile of the data must be ≤0.043 mg/L.	The 95th percentile of the data is 0.034 - 0.043 mg/L.
Fe (#)	The Fe concentration should not vary more than 10% of the background dissolved Fe concentration (TWQR; DWAF, 1996a).	The Fe concentration is varying ≥8% of the background dissolved Fe concentration.
Al (#)	The 95th percentile of the data must be ≤0.055 mg/L (ANZ, 2000 - 2023).	The 95th percentile of the data is 0.044 - 0.055 mg/L.
Pb (#)	The 95th percentile of the data must be ≤0.003 mg/L (ANZ, 2000 - 2023).	The 95th percentile of the data is 0.002 - 0.003 mg/L.
Zn (#)	The 95th percentile of the data must be ≤0.008 mg/L (ANZ, 2000 - 2023).	The 95th percentile of the data is 0.006 - 0.008 mg/L.
Other variables (#)	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008a), or within the AEV as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the TWQR as stated in DWAF (1996a).

* Inorganic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.

** Information provided where available. Data could only be located for sulphate – see BC MOE (2013) guideline. This guideline is set in terms of the current state of sulphate, which is lower than the BC MOE (2013) guideline. Statistics used for the preparation of DWS (2020) also considered.

Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

8.4 RIPARIAN VEGETATION

EcoSpecs and TPCs for riparian vegetation are shown in **Table 8.6** and are based on an improvement from the PES which at this site requires removal of alien invasive plant species, predominantly perennial species, but does not require an improvement of vegetation removal for agriculture on the floodplain.

Table 8.6 Mkuze River (EWR MK 1): Riparian vegetation EcoSpecs and TPCs (TEC: C (PES 73% - to TEC 76.4%))

Assessed metric	EcoSpec	TPC
Marginal / Lower zones		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain a mixture of woody and non-woody vegetation, but also with open (unvegetated) sandy areas.	An absence of non-woody riparian vegetation or an increase in non-woody vegetation cover above 50%. An absence of woody riparian vegetation or an increase in woody vegetation cover above 70%.
Key Species	The presence of *Phragmites mauritianus, Arundinella napalensis, Ishaemum fasiculatum, Ficus sycomorus* and *F. caprefolia.*	The absence of *Phragmites mauritianus,* or *Arundinella napalensis,* or *Ishaemum fasiculatum,* or *Ficus sycomorus* or *F. caprefolia.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 5% in the zone.	An increase in perennial alien plant species cover above 5% in the zone.
Terrestrial woody species (% aerial cover)	Maintain an absence of terrestrial woody species in the zone.	An occurrence of terrestrial woody species in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover (including overhang) below 70% in the zone.	An absence of indigenous woody species or an increase in woody species cover (including overhang) above 70% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 20% in the zone.	An absence of non-woody riparian vegetation or an increase in non-woody vegetation cover above 50% in the zone.
Reed cover (% aerial)	Maintain reed cover below 50% in the zone.	An absence of reeds or an increase in reed cover above 50% in the zone.
Flood features / Upper zone		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain woody vegetation	Reduced proportion of aerial indigenous woody cover below 50% in the zone.
Key Species	The presence of *Phragmites mauritianus, Ficus sycomorus* and *Vachellia xanthophloea.*	The absence of *Phragmites mauritianus,* or *Ficus sycomorus* or *Vachellia xanthophloea.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 10% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 10% in the zone.	An increase in terrestrial woody species cover above 10% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover above 50% in the zone.	A decrease in indigenous woody species cover below 40% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 10% in the zone.	A decrease in non-woody vegetation cover below 10% in the zone.
Reed cover (% aerial)	Maintain reed cover below 20% in the zone.	An increase in reed cover above 20% in the zone.
MCB		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain woody vegetation	Reduced proportion of aerial indigenous woody cover below 50% in the zone.
Key species	The presence of F*icus sycomorus* and *Vachellia xanthophloea.*	The absence of *Ficus sycomorus* or *Vachellia xanthophloea.*

Assessed metric	EcoSpec	TPC
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 10% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 30% in the zone.	An increase in terrestrial woody species cover above 30% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover above 50% in the zone.	A decrease in indigenous woody species cover below 40% in the zone.
Floodplain		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain a mixture of woody and non-woody vegetation	Reduced proportion of aerial indigenous woody cover below 10% in the zone; Reduced proportion of aerial non-woody cover below 10% in the zone.
Key species	The presence of F*icus sycomorus, Vachellia xanthophloea, Trichilia emetica, Spirostachys africanus* and *Kigelia africana*.	The absence of F*icus sycomorus* or *Vachellia xanthophloea* or *Trichilia emetica* or *Spirostachys africanus or Kigelia africana*.
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 40% in the zone.	An increase in perennial alien plant species cover above 40% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 50% in the zone.	An increase in terrestrial woody species cover above 50% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover above 10% in the zone.	A decrease in indigenous woody species cover below 10% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain indigenous non-woody species cover above 10% in the zone.	A decrease in indigenous non-woody species cover below 10% in the zone.
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 70% for the riparian zone.	A decrease in PES score below 70% for the riparian zone.
Species richness	Maintain the presence of at least 27 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 20.
Threatened riparian species / ecosystems	The presence of *Balanites maughamii subsp. maughamii*, which has an IUCN threat status of LC but noted that population is in decline.	The absence of *Balanites maughamii subsp. maughamii.*

8.5 FISH

Table 8.7 outlines the spatial FROC of fish for the EWR reach and indicates the FROC under reference and PES (baseline conditions). Reach and EWR site specific EcoSpecs and TPCs based on the specific metrics or variables, as included in the FRAI (Kleynhans, 2007) are provided in **Table 8.8**. Should the TEC be achieved (primarily through improved water quality) over the long-term, some improvement in FROC can be expected for species with a requirement for unmodified water quality. These changes will have a limited impact on the overall RQO/EcoSpecs and TPCs described for the site and is indicated in brackets where applicable (**Table 8.8**).

Table 8.7 EWR MK1: Spatial FROC under reference, PES conditions and TPCs for baseline (PES C) conditions (estimated change in FROC under TEC: indicated in brackets)

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC (TEC: B/C)		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
BTRI	***Enteromius trimaculatus***	**5**	**4.5**	**FROC <4.5 (present at <50% of suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07.**
BVIV	***Enteromius viviparus***	**5**	**4.5**	**FROC <4.5 (present at <50% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
OMOS	***Oreochromis mossambicus***	**5**	**4.5**	**FROC <4.5 (present at <50% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
BPAU	***Enteromius paludinosus***	**4**	**3.5**	**FROC <3.5 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
CGAR	***Clarias gariepinus***	**3**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
LMOL	***Labeo molybdinus***	**2**	**1.5 (1.7)**	**FROC <1.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07. FROC may improve under TEC.**
AAEN	*Awaous aeneofuscus*	2	1.5	FROC <1.5 (present at <10% of suitable sites sampled in reach).	
AMOS	*Anguilla mossambica*	1	1	FROC <1 (absent from all suitable sites sampled in reach).	
PPHI	*Pseudocrenilabrus philander*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
ABER	*Acanthopagrus berda*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MKAT	*Micropanchax katangae*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
ALAB	*Anguilla bengalensis labiata*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
AMAR	*Anguilla marmorata*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
BANN	*Enteromius annectens*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
BANO	*Enteromius anoplus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
BARG	*Enteromius argenteus*	1	0.5 (0.8)	FROC <0.5 (absent from all suitable sites sampled in reach).	FROC may improve under TEC.
BLAT	*Brycinus lateralis*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
LNAT	*Labeobarbus natalensis*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
BTOP	*Enteromius toppini*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
BUNI	*Enteromius unitaeniatus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC (TEC: B/C)		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
CTHE	*Clarias theodorae*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
GCAL	*Glossogobius callidus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
GGIU	*Glossogobius giuris*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
LCYL	*Labeo cylindricus*	1	0.5 (0.7)	FROC <0.5 (absent from all suitable sites sampled in reach).	FROC may improve under TEC.
LROS	*Labeo rosae*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MACU	*Micralestes acutidens*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MBRE	*Mesobola brevianalis*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MMAC	*Marcusenius macrolepidotus*	1	0.5 (0.8)	FROC <0.5 (absent from all suitable sites sampled in reach).	FROC may improve under TEC.
RDEW	*Redigobius dewaali*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
SINT	*Schilbe intermedius*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
SZAM	*Synodontis zambezensis*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
TREN	*Tilapia rendalli*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
TSPA	*Tilapia sparrmanii*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

* Sampled at EWR site during previous surveys (2014 and 2022).

Table 8.8 EWR MK1: Fish EcoSpecs and TPCs (PEC: C and TEC: B/C)

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES / TEC	PES of fish is in a C (FRAI = 75.4%). TEC for fish is a B/C (FRAI = 80.7%).	PES: Decrease of PES towards a lower EC than PES (FRAI <70%). TEC: Decrease of PES towards a lower EC than PES (FRAI <78%).	Any deterioration in a habitat feature that results in decrease in FROC of species that lead to deterioration of PES.
Species richness	**Reach:** All indigenous species expected. **EWR site:** Indigenous species confirmed at site during EWR surveys.	**Reach:** All the expected indigenous fish species (19) estimated to be present in the reach under PES. **EWR site:** Six (6) indigenous fish species confirmed (sampled) previously at EWR site (2 surveys: 2014 and 2022).	**Reach:** Loss of any indigenous species from reach. **EWR site:** Less than four (4) indigenous fish species sampled at EWR site during any survey. Absence of range of life stages (juveniles to adults) of all species sampled at site during various surveys may also indicate deterioration.	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water	LMOL (LNAT)	**Reach:** LMOL estimated to be present at 10 to 25% of sites in reach (FROC = 1.5) while LNAT is estimated to occur at <5% of sites in reach (FROC = 0.5). **EWR site:** LMOL sampled at EWR site 50% of the surveys (2022/07) (LMAR not sampled previously at EWR site).	**Reach:** LMOL present at <10% of sites in reach (FROC<1) and LNAT absent from all sites in reach (FROC = 0). **EWR site:** LMOL absent from EWR site during two consecutive surveys.	Reduced suitability (abundance and quality) of flowing habitats (i.e., decreased flows, increased zero flows, altered seasonality).
Substrate				Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Water quality intolerance				Decreased water quality (especially flow related water quality variables such as oxygen).
Fast-Deep (FD) habitats				Reduced suitability (abundance and quality) of FD habitats (i.e., decreased flows, increased zero flows).
Fast-Shallow (FS) habitats				Reduced suitability (abundance and quality) of FS habitats (i.e., decreased flows, increased zero flows).
Overhanging vegetation	BVIV	**Reach:** BVIV estimated to be present at >50% of sites in reach (FROC = 4.5). **EWR site:** BVIV sampled at EWR site 100% of the surveys (2014 and 2022).	**Reach:** BVIV present at <50% of sites in reach (FROC<4). **EWR site:** BVIV absent from EWR site during two consecutive surveys.	Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).
Instream vegetation				Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes).
Slow-Shallow (SS) habitats				Significant change in SS habitat suitability (i.e., increased flows, altered seasonality, increased sedimentation of slow habitats).
Slow-Deep (SD) habitats	OMOS	**Reach:** OMOS estimated to be present at >50% of sites in reach (FROC = 4.5). **EWR**	**Reach:** OMOS present at <50% of sites in reach (FROC<4). **EWR site:** OMOS absent	Significant change in SD habitat suitability (i.e., increased or decreased flows, altered

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
		site: OMOS sampled at EWR site 100% of the surveys (2014 and 2022)	from EWR site during two consecutive surveys.	seasonality, increased sedimentation of slow habitats).
Alien fish species	Presence of any alien/introduced spp.	No alien fish species previously confirmed at site or known to be present in the SQ reach.	Presence of any additional alien/introduced species or increase in abundance and distribution of existing species.	N/A
Migratory success	AMOS, ALAB, AMAR, LMOL, BTRI	Three catadromous eel species (AMOS, ALAB and AMAR) and various potamodromous species expected and confirmed in reach. Various potamodromous species (including, LMOL, BTRI) sampled at EWR site and various other potamodromous species expected at EWR site.	**Reach:** Eels, LMOL, BTRI absent from all sites sampled in reach during two consecutive surveys. **EWR site:** Absence of LMOL during two consecutive surveys.	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

8.6 MACROINVERTEBRATES

Table 8.9 lists the macro-invertebrate indicator taxa (families) linked to preferred habitat attributes at the site or in the EWR reach. Site specific EcoSpecs and TPCs based on the specific metrics or variables, as established in the MIRAI (Thirion, 2016) during field surveys, are provided in **Table 8.10**. All the project sites were assigned to an ecoregion level 1 (Kleynhans *et al*., 2005).

According to the MIRAI compiled by C. Todd as part of the initial Reserve Study (2014), the reference condition for Site MK1 was established as: SASS 150 and ASPT 7, while a SASS 125 and ASPT 5 were recorded at the site at the time of the 2014 reserve survey (no recent data was available at the time of the current study).

Table 8.9 EWR MK1: Macro-invertebrate indicator taxa

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	Atyidae	<0.1	Vegetation	Moderate
2	Coenagrionidae	<0.1	Vegetation	Low
3	Gomphidae	<0.1	GSM	Low

Table 8.10 EWR MK1: Macro-invertebrate EcoSpecs and TPCs (PES C)

EcoSpecs	TPCs
Ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score range 120 to 160; ASPT value: >5.	ASPT below 5.1
Ensure that the MIRAI score is within the range of a B/C Category (>77.99 and <82) using the same reference data used in this study (DWS, 2022c).	A MIRAI score of 77% or less.
To maintain sufficient quantity and quality of inundated vegetation to support the Coenagrionidae and Atyidae.	Any one of Coenagrionidae and Atyidae missing in two consecutive surveys.
To maintain suitable coarse alluvial sediment and habitat conditions for Gomphidae	This taxon missing during a survey.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000) over more than two consecutive surveys.	Any taxon occurring in an abundance of >500 for two consecutive surveys.

Should the TEC be achieved (primarily through improved water quality) over the long-term, the MIRAI score can be expected to improve from 77.7% (B/C) to 79.1% (B/C) as more species with a requirement for unmodified water quality would possibly be recorded.

Table 8.11 EWR MK1: Macro-invertebrate EcoSpecs and TPCs (TEC: B/C)

EcoSpecs	TPCs
Ensure that the SASS5 scores and ASPT values occur in the following range (Lower NE Highlands): SASS5 score range 130 to 160; ASPT value: >5.	ASPT below 5.2.
Ensure that the MIRAI score is within the range of a B/C Category (>77.4 and <82.01) using the same reference data used in this study (DWS, 2022c).	A MIRAI score of 78% or less.

9 RQOs FOR EWR UP1 (PONGOLA RIVER)

EWR UP1: Pongola River

Coordinates	S27.36413 E30.96962
SQ code	W42E-02221
RU	RU W42-2
IUA	IUA W42-b
Level 2 EcoRegion	3.1
Geomorph Zone	lower/upper foothills

PRESENT ECOLOGICAL STATE: PES								
I IHI	**R IHI**	**PC**	**Geom**	**Rip Veg**	**Fish**	**Inverts**	**Instream**	**EcoStatus**
B (85.7%)	**B/C (77.8%)**	**A/B (88.3%)**	**A/B (89.8%)**	**C (70%)**	**C (73.9%)**	**B/C (79.5%)**	**C (77%)**	**C (73.5%)**
ECOLOGICAL IMPORTANCE AND SENSITIVITY								
MODERATE								
RECOMMENDED ECOLOGICAL CATEGORY (REC) = PES								
REC = C for ECOSTATUS								
TEC = REC = C for ECOSTATUS								

9.1 HYDROLOGICAL (FLOW) RQOs

The flow RQOs for EWR UP1 are provided in **Table 9.1.** The full EWR rule is provided as part of the electronic data for the project.

Table 9.1 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 9.1** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 9.1 Flow RQOs (EWRs) for EWR UP1

ECOLOGICAL WATER REQUIREMENTS (EWR)			
Natural MAR: 356.84 MCM		Present Day MAR: 299.39 MCM	
Low flow EWR		**Total flow EWR**	
MCM	% of nMAR	MCM	% of nMAR
54.84	15.4	97.31	27.3

Low Flow Assurance Rules (m³/s)										
m³/s	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**99%**
Oct	2.27	2.11	1.63	1.23	0.95	0.69	0.50	0.41	0.35	0.10
Nov	3.04	2.97	2.46	1.88	1.46	1.09	0.81	0.63	0.55	0.45
Dec	3.34	3.05	2.72	2.36	1.94	1.55	1.22	0.94	0.79	0.64
Jan	3.18	2.89	2.60	2.42	2.16	2.03	1.64	1.25	0.99	0.83
Feb[1]	2.58	2.50	2.42	2.30	2.16	1.98	1.76	1.49	1.19	0.92
Mar	5.04	5.04	3.37	3.14	3.08	2.53	2.01	1.72	1.57	1.21
Apr	3.12	2.94	2.57	2.57	2.56	2.27	1.85	1.65	1.47	1.22
May	3.33	3.15	2.72	2.39	2.03	1.74	1.45	1.22	0.96	0.70
Jun	2.99	2.89	2.40	1.97	1.54	1.17	0.84	0.70	0.60	0.38
Jul	2.38	2.26	1.75	1.22	0.96	0.70	0.52	0.43	0.31	0.11
Aug	1.60	1.51	1.21	0.98	0.64	0.48	0.35	0.25	0.14	0.05
Sep[1]	1.90	1.58	1.25	0.96	0.70	0.50	0.34	0.21	0.12	0.03
Total assurance rules (MCM)										
MCM	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	9.182	7.417	5.43	4.338	3.599	2.898	1.345	1.094	0.946	0.28
Nov	19.278	10.795	9.48	7.977	6.881	4.64	3.163	2.691	2.485	1.172
Dec	31.078	18.856	15.519	9.415	8.306	7.246	6.363	3.576	3.154	1.708
Jan	24.08	18.087	15.218	12.748	8.889	8.554	7.492	6.442	3.691	2.212
Feb	43.718	16.753	16.245	10.835	8.373	7.928	7.028	4.688	3.947	2.235
Mar	24.861	21.754	15.044	11.511	11.352	9.783	6.434	5.654	4.207	3.239
Apr	16.228	10.72	9.776	7.7	7.698	6.944	4.784	4.276	3.813	3.166
May	9.977	9.476	8.341	6.39	5.433	4.65	3.887	3.267	2.575	1.87
Jun	8.801	7.498	6.214	5.109	3.991	3.029	2.176	1.805	1.552	0.98
Jul	6.371	6.065	4.7	3.26	2.565	1.869	1.39	1.148	0.84	0.3
Aug	4.278	4.053	3.23	2.63	1.72	1.28	0.93	0.66	0.38	0.13
Sep	5.978	5.134	3.252	2.479	1.822	1.285	0.88	0.55	0.32	0.09

1 The low flows for the 60th and 90th percentiles for the wettest (February) and driest (September) month.

9.2 GEOMORPHOLOGY

Key concerns related to geomorphology at EWR UP1 were:

- Increased sediment deposition of fine sediment (sand) in fast flowing areas due to increased catchment erosion and/or reduced flow capacity.
- Loss of gravel habitat in marginal zone.
- Increased flood bench sediment leading to increased elevation and terrestrialisation of vegetation.
- Loss of secondary channels due to sedimentation.

EcoSpecs and TPCs are presented in **Table 9.2**, with the surveyed transect shown diagrammatically in **Figure 9.1**.

Table 9.2 EWR UP1: Geomorphology EcoSpecs and TPCs (PES and TEC: A/B)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Extent of sand in fast flowing habitat	Sand deposits should not exceed very low (<10%) in cobble and gravel patches in lee of boulders.	Sand deposits exceed 10% in cobble and gravel patches in lee of boulders.

Geomorphology metrics	EcoSpecs	TPC
Extent of fines in marginal low velocity habitat	Fines should not exceed moderate (<50%).	Fines exceed 45% of marginal low velocity habitat.
Channel cross-section		
Width of rapid/run at transect	Width between back of marginal zone (lower flood bench) should be stable at 33 m on transect line.	Visible erosion along either bank, width at transect line exceeds 34 m.
Lower flood bench (marginal zone)		
Present-absent	Lower flood bench should be present on both banks.	Lower flood bench actively eroding, absence of marginal vegetation.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent fine sediment deposits; excessive deposits leading to lower flood bench encroaching into channel.
Upper flood bench		
Present-absent	Upper flood bench should be present on both banks.	Upper flood bench actively eroding.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent sediment deposits linked to the last wet season; evidence of excessive deposition and terrestrialisation indicating elevated flood bench.
Channel pattern		
Channel type	Secondary channels should be maintained.	Loss of secondary channels due to reduced flow or sedimentation.

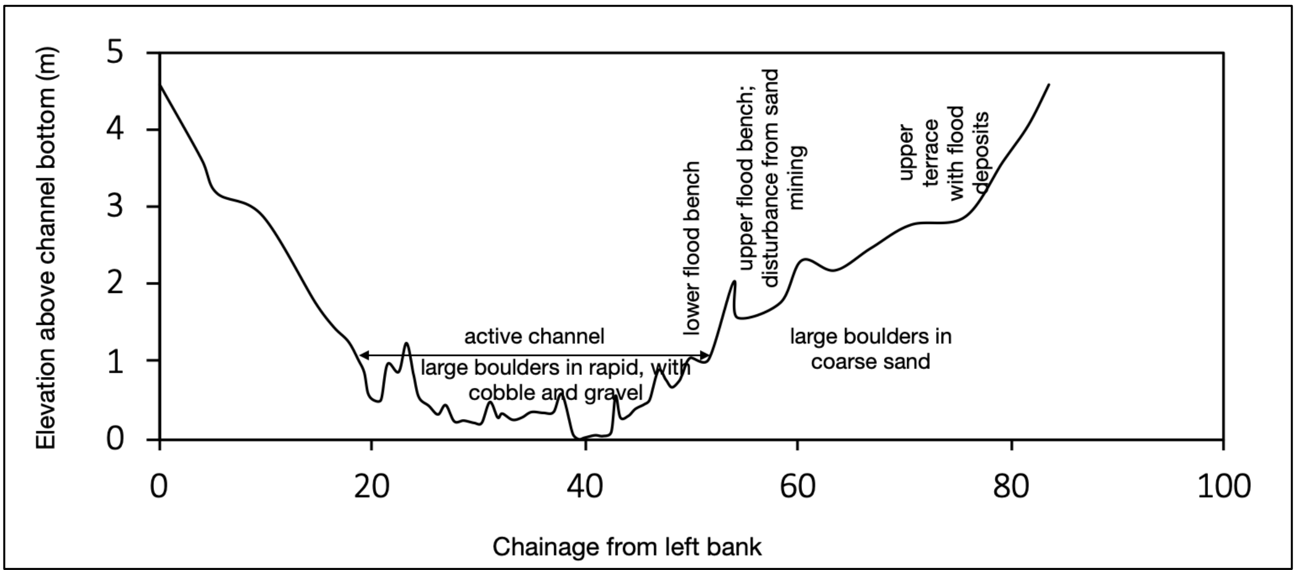

Figure 9.1 Surveyed transect line at EWR UP1

9.3 WATER QUALITY

EcoSpecs and TPCs are shown in **Table 9.3**.

Table 9.3 EWR UP1: Water quality EcoSpecs and TPCs (PES and TEC: A/B)

Water quality metrics	EcoSpecs	TPC
Inorganic salts*		
$MgSO_4$	The 95th percentile of the data must be ≤16 mg/L.	The 95th percentile of the data is 13-16 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤20 mg/L.	The 95th percentile of the data is 16 - 20 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤15 mg/L.	The 95th percentile of the data is 12 - 15 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤21 mg/L.	The 95th percentile of the data is 17 - 21 mg/L.
NaCl	The 95th percentile of the data must be ≤45 mg/L.	The 95th percentile of the data is 36 - 45 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤351 mg/L.	The 95th percentile of the data is 280 - 351 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤30 mS/m.	The 95th percentile of the data is 24 - 30 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.8.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.6.
Temperature	Largely natural temperature range is expected.	Abundance and frequency of occurrence of temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥7.5 mg/L.	The 5th percentile of the data is ≤7.7 mg/L.
Turbidity	Small changes expected.	Some localized gully erosion in the area.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be <0.25 mg/L.	The 50th percentile of the data is 0.2 - 0.25 mg/L
PO_4-P#	The 50th percentile of the data must be ≤0.01 mg/L.	The 50th percentile of the data is 0.008 - 0.01 mg/L
Response variables#		
Chl-*a* phytoplankton	The 50th percentile of the data must be <10 mg/L.	The 50th percentile of the data is 8 - 10 μg/L
Chl-*a* periphyton	The 50th percentile of the data must be <1.7 mg/m^2.	The 50th percentile of the data is 1.4 - 1.7 mg/m^2
Toxics#		
All variables	The 95th percentile of the data must be within the A (or 0) Category in DWAF (2008a), or within the AEV as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the TWQR as stated in DWAF (1996a).

* Inorganic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
# Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

9.4 RIPARIAN VEGETATION

EcoSpecs and TPCs for riparian vegetation are shown in **Table 9.4**.

Table 9.4 EWR UP 1: Riparian vegetation EcoSpecs and TPCs (PES and TEC: C)

Assessed metric	EcoSpec	TPC
Marginal / Lower zones		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody vegetation, but with the presence of scattered woody riparian obligates.	A decrease in non-woody riparian vegetation cover below 60%.
Key Species	The presence of *Ischaemum fasciculatum, Cyperus longus,*	The absence of *Cyperus longus* or *Cyperus dives* or *Ischaemum fasciculatum,*

Assessed metric	EcoSpec	TPC
	Cyperus dives, Phragmites australis, Miscanthus junceus and *Salix mucronata.*	or *Phragmites australis* or *Salix mucronata* or *Miscanthus junceus*.
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 15% in the zone.	An increase in perennial alien plant species cover above 20% in the zone.
Terrestrial woody species (% aerial cover)	Maintain an absence of terrestrial woody species in the zone.	An occurrence of terrestrial woody species in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover below 20% in the zone.	An absence of indigenous woody species or an increase in woody species cover above 20% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 40% in the zone.	A decrease in non-woody vegetation cover below 40% in the zone.
Reed cover (% aerial)	Maintain the presence of reeds in the zone.	An increase in reed cover above 60% in the zone.
Flood features / Upper zone		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain non-woody vegetation, but with scattered woody individuals.	Reduced proportion of aerial non-woody cover below 50% in the zone.
Key Species	The presence of *Combretum erythrophyllum.*	The absence of *Combretum erythrophyllum.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 20% in the zone.	An increase in perennial alien plant species cover above 20% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 10% in the zone.	An increase in terrestrial woody species cover above 10% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover above 10% in the zone.	An absence of indigenous riparian woody species or an increase in woody species cover above 30% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 40% in the zone.	A decrease in non-woody vegetation cover below 40% in the zone.
Reed cover (% aerial)	Maintain reed cover below 30% in the zone.	An increase in reed cover above 30% in the zone.
MCB		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain mixed woody and non-woody vegetation.	Reduced proportion of indigenous woody aerial cover below 20% in the zone; reduced proportion of non-woody aerial cover below 50% in the zone.
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 20% in the zone.	An increase in perennial alien plant species cover above 20% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 30% in the zone.	An increase in terrestrial woody species cover above 30% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover of indigenous riparian woody species above 5% in the zone.	A decrease in woody species cover below 5% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 50% in the zone.	A decrease in non-woody vegetation cover below 40% in the zone.
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 65% for the riparian zone.	A decrease in PES score below 65% for the riparian zone.
Species richness	Maintain the presence of at least 25 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 20.

9.5 FISH

Table 9.5 outlines the spatial FROC of fish for the EWR site and indicates the FROC under reference and PES (baseline conditions). EcoSpecs and TPCs based on the FRAI (Kleynhans, 2007) data are provided in **Table 9.6** for the TEC.

Table 9.5 EWR UP1: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
CANO*	***Chiloglanis anoterus***	**5**	**4.5**	**FROC <4.5 (present at <50% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07 and 2022/07.**
CSWI*	***Chiloglanis swierstrai***	**2**	**1.5**	**FROC <1.5 (absent from all suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07.**
LMAR*	***Labeobarbus marequensis***	**3**	**2**	**FROC <2 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07.**
LPOL*	***Labeobarbus polylepis***	**3**	**2**	**FROC <2 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
LCYL*	***Labeo cylindricus***	**3**	**2**	**FROC <2 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07.**
LMOL*	***Labeo molybdinus***	**3**	**2**	**FROC <2 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
MMAC*	***Marcusenius pongolensis (Macrolepidotus)***	**2**	**1.5**	**FROC <1.5 (absent from all suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07.**
OPER*	***Opsaridium peringueyi***	**2**	**1.5**	**FROC <1.5 (absent from all suitable sites sampled in reach).**	**Sampled at EWR site in 2022/07.**
TSPA*	***Tilapia sparrmanii***	**3**	**2**	**FROC <2 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2014/07.**
CGAR	*Clarias gariepinus*	3	3	FROC <3 (present at <25% of suitable sites sampled in reach).	
AURA	*Amphilius uranoscopus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BTRI	*Enteromius trimaculatus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BUNI	*Enteromius unitaeniatus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
OMOS	*Oreochromis mossambicus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
VNEL	*Labeobarbus (Varicorhinus) nelspruitensis*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BANO	*Enteromius anoplus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
BARG	*Enteromius argenteus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
BPAU	*Enteromius paludinosus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
AMAR	*Anguilla marmorata*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
AMOS	*Anguilla mossambica*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
CEMA	*Chiloglanis emarginatus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
LROS	*Labeo rosae*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
MBRE	*Mesobola brevianalis*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
PCAT	*Petrocephalus wesselsi*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
PPHI	*Pseudocrenilabrus philander*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
TREN	*Tilapia rendalli*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

* Priority indicator species (previously confirmed/sampled in reach during EWR surveys).

Table 9.6 EWR UP1: Fish EcoSpecs and TPCs (PES and TEC: C)

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	PES of fish is in a C (FRAI = 73.9%).	Decrease of PES towards a lower EC than PES (FRAI <68%).	Any deterioration in a habitat feature that results in decrease in FROC of species that lead to deterioration of PES.
Species richness	**Reach:** All indigenous species expected. **EWR site:** Indigenous species confirmed at site during EWR surveys.	**Reach:** All of the expected indigenous fish species (26) estimated to be present in the reach under PES. **EWR site:** Nine (9) indigenous fish species confirmed (sampled) previously at EWR site (2014 and 2022).	**Reach:** Loss of any indigenous species from reach. **EWR site:** Less than four (4) indigenous fish species sampled at EWR site during any survey. Absence of range of life stages (juveniles to adults) of all species sampled at site during various surveys may also indicate deterioration.	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water	CANO / LMAR	**Reach:** CANO estimated to be present at 50 to 75% of sites in reach (FROC = 4.5) while LMAR is estimated to occur at 10 - 25% of sites in reach (FROC = 2). **EWR site:** CANO sampled at EWR site 100% of the surveys (2014 and 2022) while LMAR was sampled 50% of the surveys (2022/07).	**Reach:** CANO present at <50% of sites in reach (FROC<4) and LMAR sampled at <10% of sites (FROC<2). **EWR site:** CANO and/or LMAR absent from EWR site during two consecutive surveys.	Reduced suitability (abundance and quality) of flowing habitats (i.e., decreased flows, increased zero flows, altered seasonality).
Fast-Deep (FD) habitats				Reduced suitability (abundance and quality) of FD habitats (i.e., decreased flows, increased zero flows).
Fast-Shallow (FS) habitats				Reduced suitability (abundance and quality) of FS habitats (i.e., decreased flows, increased zero flows).
Substrate				Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Water quality intolerance	CANO/OPER	**Reach:** CANO estimated to be present at 50 to 75% of sites in reach (FROC = 4.5) while OPER is estimated to occur at <10% of sites in reach (FROC = 1.5). **EWR site:** CANO sampled at EWR site 100% of the surveys (2014 and 2022) while OPER was sampled 50% of the surveys (2022/07).	**Reach:** CANO present at <50% of sites in reach (FROC<4) and OPER absent from all sites (FROC = 0). **EWR site:** CANO and/or OPER absent from EWR site during two consecutive surveys.	Decreased water quality (especially flow related water quality variables such as oxygen).
Overhanging vegetation	BPAU/TSPA	**Reach:** BPAU and TSPA most applicable indicator in reach (BPAU scarce estimated to occur at <10% sites: FROC = 0.5 and TSPA more abundant, occurring at 10 to 25% of sites: FROC = 2). **EWR site:** TSPA sampled during 50% of surveys (2014) (BPAU not previous sampled at site).	**Reach:** BPAU absent from all sites sampled in reach (FROC = 0) and TSPA present at <10% of sites (FROC<2). **EWR site:** TSPA absent from site during two consecutive surveys.	Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).
Instream vegetation				Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes).

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Slow-Shallow (SS) habitats				Significant change in SS habitat suitability (i.e., increased flows, altered seasonality, increased sedimentation of slow habitats).
Undercut banks	MMAC	**Reach:** MMAC estimated to be present at <10% of sites in reach (FROC = 1.5). **EWR site:** MMAC sampled at EWR site 50% of surveys (2022/07).	**Reach:** MMAC absent from all sites in reach (FROC = 0). **EWR site:** MMAC absent from EWR site during two consecutive surveys.	Significant change in undercut bank and rootwads habitats (e.g., bank erosion, reduced flows).
Slow-Deep (SD) habitats	LMAR	**Reach**: LMAR is estimated to occur at 10 - 25% of sites in reach (FROC = 2). **EWR site:** LMAR was sampled 50% of the surveys (2022/07).	**Reach:** LMAR sampled at <10% of sites (FROC<2). **EWR site:** LMAR absent from EWR site during two consecutive surveys.	Significant change in SD habitat suitability (i.e., increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
Alien fish species	Presence of any alien/introduced spp.	No alien species previously sampled at EWR site or known from reach.	Presence of any alien/introduced species in reach or at EWR site during any survey.	N/A
Migratory success	Eels, LMAR, LPOL, LMOL	Two catadromous eel species (AMAR and AMOS) and various potamodromous species expected in reach. Various potamodromous species (including LMAR, LPOL, LMOL) sampled at EWR site and various other potamodromous species expected at EWR site.	**Reach:** Eels, LMAR, LPOL or LMOL absent from all sites sampled in reach during two consecutive surveys. **EWR site:** Absence of LMAR, LPOL or LMOL from site during two consecutive surveys.	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

9.6 MACROINVERTEBRATES

Table 9.7 lists the macro-invertebrate indicator taxa (families) linked to preferred habitat attributes at the site or in the EWR reach. Site specific EcoSpecs and TPCs based on the specific metrics or variables, as established in the MIRAI (Thirion, 2016) during field surveys, are provided in **Table 9.8**. All the project sites were assigned to an ecoregion level 1 (Kleynhans *et al.,* 2005).

According to the MIRAI compiled by C. Todd as part of the initial Reserve Study (2014), the reference condition for Site UP1 was established as: SASS 220 and ASPT 7, while SASS 204 and ASPT 7 were recorded at the site at the time of the 2014 reserve survey (no recent data was available at the time of the current study).

Table 9.7 EWR UP1: Macro-invertebrate indicator taxa

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	Elmidae	>0.6	Cobbles	High
2	Hydropsychidae >2spp			
3	Philopotamidae	>0.6	Cobbles	Moderate
4	Perlidae	0.3 - 0.6	Cobbles	High
5	Heptageniidae			
6	Psephenidae	0.3 - 0.6	Cobbles	Moderate
7	Leptophlebiidae			
8	Coenagrionidae	<0.1	Vegetation	Low
9	Gomphidae	<0.1	GSM	Low

Table 9.8 EWR UP1: Macro-invertebrate EcoSpecs and TPCs (PES and TEC: B/C)

EcoSpecs	TPCs
Ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score range 120 to 210; ASPT value: >6.4.	ASPT below 6.6 and SASS 180.
Ensure that the MIRAI score is within the range of a B/C category (>77.99 and <82) using the same reference data used in this study (DWS, 2022c).	A MIRAI score of 79% or less.
Maintain suitable flow velocity (maximum >0.6 m/s) and clean, unembedded surface area (cobbles) to support the Philopotamidae, Elmidae, Tricorythidae and Hydropsychidae (>2 species) assemblages in the VFCS biotope.	More than one of Psephenidae, Philopotamidae, Elmidae or Hydropsychidae (>2 species) assemblage missing in a survey.
To maintain suitable flow velocity (0.3 - 0.6 m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the FFCS biotope: ▫ Perlidae	Perlidae, missing in a survey.
Maintain suitable conditions in the SIC habitat regarding moderate velocity (0.3 - 0.6 m/s) and good water quality to support Psephenidae and Heptageniidae.	Any of Heptageniidae or Psephenidae missing in two consecutive surveys.
Maintain suitable conditions for the following flow-dependent species in the SIC biotope: ▫ Leptophlebiidae: Abundance B.	Leptophlebiidae missing in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the Coenagrionidae.	Coenagrionidae missing in two consecutive surveys.
To maintain suitable coarse alluvial sediment and habitat conditions for Gomphidae	This taxon missing during a survey.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000) over more than two consecutive surveys.	Any taxon occurring in an abundance of >500 for two consecutive surveys.

10 RQOs FOR EWR AS1 (ASSEGAAI RIVER)

EWR AS1: Assegaai River

Coordinates	S27.06230 E30.98880
SQ code	W51E-02049
RU	RU W51-3
IUA	IUA W52
Level 2 EcoRegion	4.06
Geomorph Zone	lower/upper foothills

PRESENT ECOLOGICAL STATE: PES								
I IHI	**R IHI**	**PC**	**Geom**	**Rip Veg**	**Fish**	**Inverts**	**Instream**	**EcoStatus**
C/D (59.1%)	**C/D (58.7%)**	**B/C (80.6%)**	**C (70.8%)**	**C (69.9)%**	**C (69.2%)**	**B/C (78.4%)**	**C (77.8%)**	**C (74.2%)**
ECOLOGICAL IMPORTANCE AND SENSITIVITY								
MODERATE								
RECOMMENDED ECOLOGICAL CATEGORY (REC) = PES								
REC = C for ECOSTATUS								
TEC = REC = C for ECOSTATUS								

10.1 HYDROLOGICAL (FLOW) RQOs

The flow RQOs for EWR AS1 are provided in **Table 10.1**. The full EWR rule is provided as part of the electronic data for the project.

Table 10.1 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 10.1** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 10.1 Flow RQOs (EWRs) for EWR AS1

ECOLOGICAL WATER REQUIREMENTS (EWR)			
Natural MAR: 328.61 MCM		Present Day MAR: 164.11 MCM	
Low flow EWR		**Total flow EWR**	
MCM	% of nMAR	MCM	% of nMAR
40.06	12.2	70.85	21.6

Low Flow Assurance Rules (m^3/s)										
m^3/s	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	2.81	1.60	0.92	0.57	0.42	0.35	0.31	0.27	0.23	0.20
Nov	3.58	2.22	1.40	0.84	0.58	0.48	0.41	0.36	0.32	0.24
Dec	3.58	3.31	1.82	1.31	0.92	0.69	0.62	0.54	0.45	0.30
Jan	4.16	2.70	2.30	1.59	1.25	1.04	0.92	0.76	0.61	0.51
Feb[1]	2.92	2.34	1.91	1.54	1.29	1.10	0.95	0.82	0.69	0.61
Mar	3.40	2.98	1.86	1.44	1.23	1.08	0.92	0.79	0.69	0.57
Apr	3.62	2.42	1.74	1.29	1.08	0.96	0.89	0.80	0.67	0.59
May	3.39	2.27	1.54	1.05	0.82	0.74	0.67	0.57	0.53	0.49
Jun	2.92	1.96	1.21	0.79	0.60	0.52	0.45	0.40	0.38	0.38
Jul	2.30	1.66	1.00	0.64	0.45	0.39	0.34	0.31	0.29	0.28
Aug	1.95	1.40	0.83	0.52	0.38	0.34	0.29	0.26	0.24	0.24
Sep[1]	1.99	1.24	0.76	0.48	0.36	0.30	0.26	0.23	0.20	0.18
Total assurance rules (MCM)										
MCM	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	10.506	5.555	3.721	1.526	1.116	0.938	0.822	0.711	0.605	0.546
Nov	23.873	10.156	7.797	6.344	3.869	2.497	2.337	0.943	0.828	0.632
Dec	27.461	18.949	10.908	8.92	6.624	6.014	5.253	2.72	2.434	0.811
Jan	28.256	21.292	14.582	10.28	7.515	6.933	6.614	4.55	2.91	1.379
Feb	22.981	14.28	10.684	7.916	7.295	6.674	3.761	3.258	1.696	1.49
Mar	18.419	14.02	9.139	8.021	4.546	4.168	2.462	2.119	1.838	1.536
Apr	13.539	10.423	5.77	4.618	2.807	2.489	2.315	2.063	1.744	1.518
May	10.351	6.068	4.12	2.802	2.194	1.993	1.785	1.534	1.417	1.315
Jun	7.559	5.071	3.125	2.042	1.544	1.343	1.172	1.043	0.982	0.98
Jul	6.152	4.437	2.689	1.706	1.199	1.054	0.92	0.84	0.78	0.758
Aug	5.234	3.759	2.217	1.381	1.018	0.905	0.773	0.696	0.642	0.631
Sep	5.148	3.222	1.978	1.233	0.924	0.782	0.685	0.606	0.524	0.464

1 The low flows for the 60th and 90th percentiles for the wettest (February) and driest (September) month.

10.2 GEOMORPHOLOGY

Key concerns related to geomorphology at EWR AS1 were related to the Heyshope Dam:

- Bed armouring in response to sediment trapping in dam.
- Reduced deposition of fines in lower flood benches / marginal zone.
- Reduced lateral connectivity with flood benches due to reduced flood magnitude.
- Increased sediment deposition of fine sediment (sand) in pools and backwaters due to reduced flow capacity.

EcoSpecs and TPCs are presented in **Table 10.2**, with the surveyed transect shown diagrammatically in **Figure 10.1**.

Table 10.2 EWR AS1: Geomorphology EcoSpecs and TPCs (PES and TEC: C)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Bed armouring in fast flowing habitat	Fine to medium gravels cover >40% of bed within run habitat; 50% of cobbles are mobile	Fine to medium gravels cover <40% of bed within run habitat; <50% of cobbles are mobile, >50% imbricated.
Increased sedimentation in	Deposition of fines (sand and silt) in pools is not extensive or visibly increasing (no available metric to evaluate this against).	Visible increase of fine sediment deposits in pools causing a discernible decrease in depth at low flows.

Geomorphology metrics	EcoSpecs	TPC
pools (including backwater pools)		
Channel cross-section		
Width of active channel at transect	No available metric to judge this.	No available metric to judge this.
Lower flood bench (marginal zone)		
Present-absent	Lower flood bench should be present on both banks.	Lower flood bench actively eroding, absence of marginal vegetation.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent fine sediment deposits or excessive deposits.
Upper flood bench		
Present-absent	Upper flood bench present on right bank.	Upper flood bench actively eroding.
Sediment deposits/ connectivity	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent sediment deposits linked to the last wet season. Terrestrialisation of riparian vegetation would indicate reduced lateral connectivity.
Channel pattern		
Channel type	Channel should not change from a single thread channel with pool-rapid morphology.	Change to a different channel type.

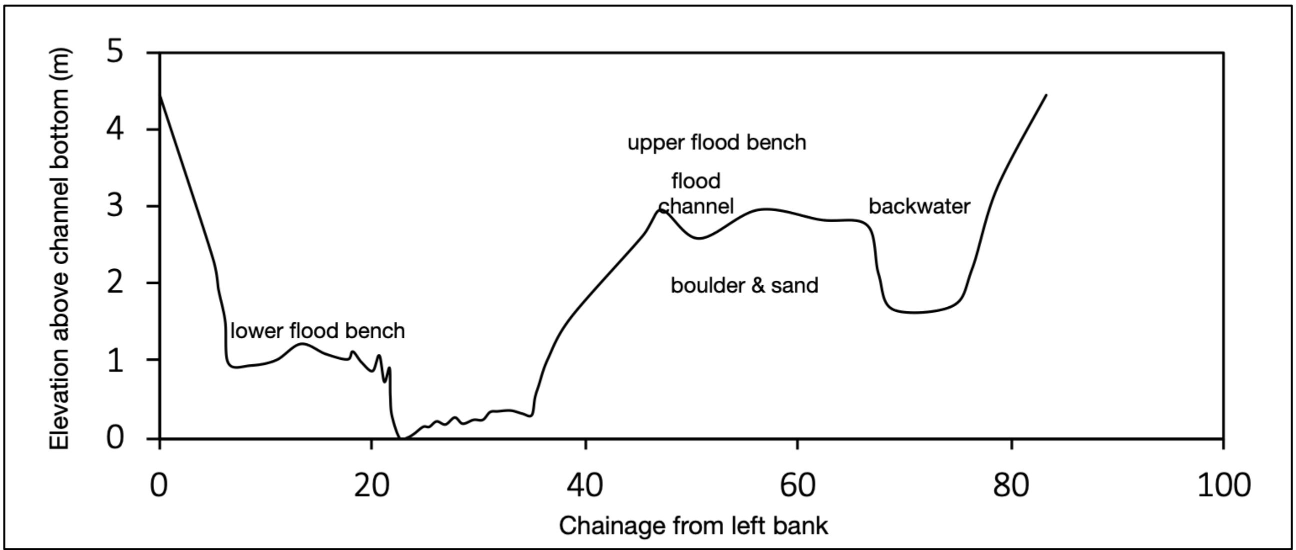

Figure 10.1 Surveyed transect line at EWR AS1

10.3 WATER QUALITY

EcoSpecs and TPCs are shown in **Table 10.3**.

Table 10.3 EWR AS1: Water quality EcoSpecs and TPCs (PES and TEC: B/C)

Water quality metrics	EcoSpecs	TPC
Inorganic salts*		
$MgSO_4$	The 95th percentile of the data must be ≤16 mg/L.	The 95th percentile of the data is 13 - 16 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤20 mg/L.	The 95th percentile of the data is 16 - 20 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤15 mg/L.	The 95th percentile of the data is 12 - 15 mg/L.

Water quality metrics	EcoSpecs	TPC
$CaCl_2$	The 95th percentile of the data must be ≤21 mg/L.	The 95th percentile of the data is 17 - 21 mg/L.
NaCl	The 95th percentile of the data must be ≤45 mg/L.	The 95th percentile of the data is 36 - 45 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤351 mg/L.	The 95th percentile of the data is 280 - 351 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤30 mS/m.	The 95th percentile of the data is 24 - 30 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.8.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.6.
Temperature	Largely natural temperature range is expected.	Some temperature sensitive species at lower abundance and frequency of occurrence than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be >7.0 mg/L.	The 5th percentile of the data is ≤7.2 mg/L.
Turbidity	Small changes expected.	Maintain within current range (median: 14.0 NTU).
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be ≤0.7 mg/L.	The 50th percentile of the data is 0.6 - 0.7 mg/L
PO_4-P	The 50th percentile of the data must be ≤0.075 mg/L.	The 50th percentile of the data is 0.06 - 0.075 mg/L.
Response variables#		
Chl-*a* phytoplankton	The 50th percentile of the data must be ≤20 mg/L.	The 50th percentile of the data is 16 - 20 μg/L
Chl-*a* periphyton	The 50th percentile of the data must be ≤21 mg/m^2.	The 50th percentile of the data is 17 - 21 mg/m^2
Toxics		
Other variables#	The 95th percentile of the data must be within the A (or 0) Category in DWAF (2008a), or within the AEV as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the TWQR as stated in DWAF (1996a).

* Inorganic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
# Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

10.4 RIPARIAN VEGETATION

EcoSpecs and TPCs for riparian vegetation are shown in **Table 10.4**.

Table 10.4 EWR AS1: Riparian vegetation EcoSpecs and TPCs (PES and TEC: C)

Assessed metric	EcoSpec	TPC
Marginal / Lower zones		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain a mixture of woody and non-woody vegetation.	A decrease in non-woody riparian vegetation cover below 60%; a decrease in woody riparian cover below 20% in the zone.
Key Species	The presence of *Ischaemum fasciculatum, Cyperus longus, Phragmites australis* and *Salix mucronata.*	The absence of *Cyperus longus* or *Ischaemum fasciculatum,* or *Phragmites australis* or *Salix mucronata.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 5% in the zone.	An increase in perennial alien plant species cover above 5% in the zone.
Terrestrial woody species (% aerial cover)	Maintain an absence of terrestrial woody species in the zone.	An occurrence of terrestrial woody species in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover below 40% in the zone.	An absence of indigenous woody species or an increase in woody species cover above 40% in the zone.

Assessed metric	EcoSpec	TPC
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 40% in the zone.	A decrease in non-woody vegetation cover below 40% in the zone.
Reed cover (% aerial)	Maintain the presence of reeds in the zone.	An increase in reed cover above 40% in the zone.
Flood features / Upper zone		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain a mixture of woody and non-woody vegetation.	A decrease in non-woody riparian vegetation cover below 40%; a decrease in woody riparian cover below 20% in the zone.
Key Species	The presence of *Combretum erythrophyllum* and *Nuxia oppositifolia*.	The absence of *Combretum erythrophyllum* or *Nuxia oppositifolia.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 10% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 10% in the zone.	An increase in terrestrial woody species cover above 10% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover above 10% in the zone.	An absence of indigenous riparian woody species or an increase in woody species cover above 40% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 30% in the zone.	A decrease in non-woody vegetation cover below 30% in the zone.
Reed cover (% aerial)	Maintain reed cover below 30% in the zone.	An increase in reed cover above 30% in the zone.
MCB		
Dominant vegetation type	The dominant vegetation type in the zone should remain woody vegetation.	Reduced proportion of indigenous woody aerial cover below 30% in the zone.
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 20% in the zone.	An increase in perennial alien plant species cover above 20% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 30% in the zone.	An increase in terrestrial woody species cover above 30% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover of indigenous riparian woody species above 10% in the zone.	A decrease in woody species cover below 10% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain the presence of non-woody cover in the zone.	An absence of non-woody vegetation cover in the zone.
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 60% for the riparian zone.	A decrease in PES score below 60% for the riparian zone.
Species richness	Maintain the presence of at least 20 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 15.

10.5 FISH

Table 10.5 outlines the spatial FROC of fish for the EWR reach and indicates the FROC under reference and PES (baseline conditions). Reach and EWR site specific EcoSpecs and TPCs based on the specific metrics or variables, as included in the FRAI (Kleynhans, 2007) are provided in **Table 10.6**.

Table 10.5 EWR AS1: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: B EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
AURA*	***Amphilius uranoscopus***	**2**	**1.5**	**FROC <1.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2014, 2015, 2019, 2022**
LMAR*	***Labeobarbus marequensis***	**4**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2014, 2015, 2019, 2022.**
BTRI*	***Enteromius trimaculatus***	**2**	**1**	**FROC <1 (absent from all suitable sites sampled in reach).**	**Sampled at EWR site in 2014.**
CANO*	***Chiloglanis anoterus***	**5**	**4**	**FROC<4 (present at <50% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2015, 2019, 2022.**
CEMA*	***Chiloglanis emarginatus***	**2**	**1**	**FROC <1 (absent from all suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2014.**
PPHI*	***Pseudocrenilabrus philander***	**4**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2019,**
TSPA*	***Tilapia sparrmanii***	**4**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2022.**
VNEL*	***Varicorhinus nelspruitensis***	**2**	**1**	**FROC <1 (absent from all suitable sites sampled in reach).**	**Sampled at EWR site in 2010.**
BANO	*Enteromius anoplus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BARG	*Enteromius argenteus*	3	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
LPOL	*Labeobarbus polylepis*	4	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
CGAR	*Clarias gariepinus*	2	2	FROC <2 (present at <10% of suitable sites sampled in reach).	
BUNI	*Enteromius unitaeniatus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BVIV	*Enteromius viviparus*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
CSWI	*Chiloglanis swierstrai*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
LMOL	*Labeo molybdinus du*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
LCYL	*Labeo cylindricus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
AMOS	*Anguilla mossambica*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
OPER	*Opsaridium peringueyi*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

* Sampled previously at site.

Table 10.6 EWR AS1: Fish EcoSpecs and TPCs (PES and TEC: C)

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	Present Ecological State of fish is in a C (FRAI = 69.2%).	Decrease of PES towards a lower EC than PES (FRAI < 64%).	Any deterioration in a habitat feature that results in decrease in FROC of species that lead to deterioration of PES.
Species richness	**Reach:** All indigenous species expected. **EWR site:** Indigenous species confirmed at site during EWR surveys.	**Reach:** All of the expected indigenous fish species (19) estimated to be present in the reach under PES. **EWR site:** Eight (8) indigenous fish species confirmed (sampled) previously at EWR site (5 surveys: 2010 to 2022).	**Reach:** Loss of any indigenous species from reach. **EWR site:** Less than four (4) indigenous fish species sampled at EWR site during any survey. Absence of range of life stages (juveniles to adults) of all species sampled at site during various surveys may also indicate deterioration.	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water	CANO/LMAR	**Reach:** CANO estimated to be present at 50 to 75% of sites in reach (FROC = 4) while LMAR is estimated to occur at 25 to 50% of sites in reach (FROC = 3). **EWR site:** CANO sampled at EWR site 80% of the surveys while LMAR was sampled 100% of the surveys (2010 to 2022).	**Reach:** CANO present at <50% of sites in reach (FROC<4) and LMAR sampled at <25% of sites (FROC<3). **EWR site:** CANO and/or LMAR absent from EWR site during two consecutive surveys.	Reduced suitability (abundance and quality) of flowing habitats (i.e., decreased flows, increased zero flows, altered seasonality).
Fast-Deep (FD) habitats				Reduced suitability (abundance and quality) of FD habitats (i.e., decreased flows, increased zero flows)
Fast-Shallow (FS) habitats				Reduced suitability (abundance and quality) of FS habitats (i.e., decreased flows, increased zero flows).
Substrate	AURA/CANO	**Reach:** AURA estimated to be present at 10 to 25% of sites in reach (FROC = 1.5) while CANO is estimated to occur at 50 - 75% of sites in reach (FROC = 4). **EWR site:** AURA was sampled 100% of the surveys and CANO 80% of the surveys (2010 to 2022).	**Reach:** AURA sampled at <10% of sites (FROC<1) and/or CANO present at <50% of sites in reach (FROC<4). **EWR site:** CANO and/or LMAR absent from EWR site during two consecutive surveys.	Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Water quality intolerance				Decreased water quality (especially flow related water quality variables such as oxygen).
Overhanging vegetation	TSPA/PPHI	**Reach:** TSPA and/or PPHI estimated to be present at 25 to 50% of sites in reach (FROC = 3). **EWR site:** TSPA and PPHI sampled 40% of the surveys at site (2010 to 2022).	**Reach:** TSPA and/or PPHI present at <25% of sites in reach (FROC<3). **EWR site:** TSPA and/or PPHI absent from EWR site during three consecutive surveys.	Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).
Instream vegetation				Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes).
Undercut banks				Significant change in undercut bank and rootwads habitats (e.g., bank erosion, reduced flows).

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Slow-Shallow (SS) habitats				Significant change in SS habitat suitability (i.e., increased flows, altered seasonality, increased sedimentation of slow habitats).
Water column	LMAR	**Reach:** LMAR is estimated to occur at 25 to 50% of sites in reach (FROC = 3). **EWR site:** LMAR was sampled 100% of the surveys (2010 to 2022).	**Reach:** LMAR sampled at <25% of sites (FROC<3). **EWR site:** LMAR absent from EWR site during two consecutive surveys.	Reduction in suitability of water column (i.e., increased sedimentation of pools, reduced flows).
Slow-Deep (SD) habitats				Significant change in SD habitat suitability (i.e., increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
Alien fish species	Presence of any alien/introduced spp.	MSAL previously sampled at EWR site, confirmed in reach.	Presence of any additional alien/introduced species in reach or at EWR site during any survey.	N/A
Migratory success	AMOS, LMAR, VNEL, BTRI	One catadromous eel species (AMOS) and various potamodromous species expected and confirmed in reach. Various potamodromous species (including LMAR, VNEL, BTRI) sampled at EWR site and various other potamodromous species expected at EWR site.	**Reach:** AMOS, LMAR, VNEL absent from all sites sampled in reach during two consecutive surveys. **EWR site:** Absence of LMAR during two consecutive surveys.	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

10.6 MACROINVERTEBRATES

Table 10.7 lists the macro-invertebrate indicator taxa (families) linked to preferred habitat attributes at the site or in the EWR reach. Site specific EcoSpecs and TPCs based on the specific metrics or variables, as established in the MIRAI (Thirion, 2016) during field surveys, are provided in **Table 10.8**. All the project sites were assigned to an Ecoregion Level 1 (Kleynhans *et al*., 2005).

According to the MIRAI compiled by C. Todd as part of the initial Reserve Study (2014), the reference condition for Site AS1 was established as: SASS 200 and ASPT 6.4, while a SASS 207 and ASPT 6.6 were recorded at the site at the time of the 2014 reserve survey (no recent data was available at the time of the current study).

Table 10.7 EWR AS1: Macro-invertebrate indicator taxa

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	Hydropsychidae >2spp	>0.6	Cobbles	High
2	Philopotamidae	>0.6	Cobbles	Moderate
3	Elmidae			
4	Heptageniidae	0.3 - 0.6	Cobbles	High
5	Perlidae			
6	Leptophlebiidae	0.3 - 0.6	Cobbles	Moderate
7	Psephenidae			
8	Atyidae	<0.1	Vegetation	Moderate
9	Coenagrionidae	<0.1	Vegetation	Low
10	Gomphidae	<0.1	GSM	Low

Table 10.8 EWR AS1: Macro-invertebrate EcoSpecs and TPCs (PES and TEC: B/C)

EcoSpecs	TPCs
Ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score range 180 to 250; ASPT value: >6.3.	ASPT below 6.5 and SASS 190.
Ensure that the MIRAI score is within the range of a B/C category (>77.99 and <82.) using the same reference data used in this study (DWS, 2022c).	A MIRAI score of 78% or less.
Maintain suitable flow velocity (maximum >0.6 m/s) and clean, unembedded surface area (cobbles) to support the Philopotamidae, Elmidae and Hydropsychidae (>2 species) assemblages in the VFCS biotope).	More than one of Philopotamidae, Elmidae or Hydropsychidae (>2 species) assemblages missing in a survey.
To maintain suitable flow velocity (0.3 - 0.6 m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the FFCS biotope: ▫ Perlidae	Perlidae: This taxon missing in two consecutive surveys.
Maintain suitable conditions in the SIC habitat regarding moderate velocity (0.3 - 0.6 m/s) and good water quality to support Heptageniidae.	Heptageniidae: This taxon missing in two consecutive surveys.
Maintain suitable conditions for the following flow-dependent species in the SIC biotope: ▫ Leptophlebiidae: Abundance B. ▫ Psephenidae: Abundance A.	Any one of Psephenidae and Leptophlebiidae missing in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the Coenagrionidae and Atyidae.	Any one of Coenagrionidae and Atyidae missing in two consecutive surveys.
To maintain suitable coarse alluvial sediment and habitat conditions for Gomphidae	This taxon missing during a survey.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000) over more than two consecutive surveys.	Any taxon occurring in an abundance of >500 for two consecutive surveys.

11 RQOs FOR EWR NG1 (NGWEMPISI RIVER)

EWR NG1: Ngwempisi River

Coordinates	S26.679448 E30.70213
SQ code	W53E-01790
RU	RU W53-3
IUA	IUA W52
Level 2 EcoRegion	11.04/4.06
Geomorph Zone	Upper foothills/ Transitional

PRESENT ECOLOGICAL STATE: PES								
I IHI	**R IHI**	**PC**	**Geom**	**Rip Veg**	**Fish**	**Inverts**	**Instream**	**EcoStatus**
C (64.3%)	**C/D (61.8%)**	**B (85.5)**	**B (83.3%)**	**C (77.4%)**	**C (72.8%)**	**B (87.3%)**	**B/C (80.36%)**	**B/C (79.8%)**
ECOLOGICAL IMPORTANCE AND SENSITIVITY								
MODERATE								
RECOMMENDED ECOLOGICAL CATEGORY (REC) = PES								
REC = B/C for ECOSTATUS								
TEC = REC = B/C for ECOSTATUS								

11.1 HYDROLOGICAL (FLOW) RQOs

The flow RQOs for EWR NG1 are provided in **Table 11.1.** The full EWR rule is provided as part of the electronic data for the project.

Table 11.1 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 11.1** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 11.1 Flow RQOs (EWRs) for EWR NG1

ECOLOGICAL WATER REQUIREMENTS (EWR)			
Natural MAR: 156.33 MCM		Present Day MAR: 79.15 MCM	
Low flow EWR		**Total flow EWR**	
MCM	% of nMAR	MCM	% of nMAR
30.46	19.5	50.82	32.5

Low Flow Assurance Rules (m³/s)										
m³/s	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**99%**
Oct	1.27	1.06	0.65	0.52	0.37	0.28	0.22	0.17	0.12	0.09
Nov	2.10	1.59	1.27	0.85	0.60	0.43	0.30	0.23	0.19	0.14
Dec	2.81	2.45	1.84	1.32	0.97	0.71	0.55	0.38	0.29	0.21
Jan	3.49	2.89	2.47	1.56	1.19	0.97	0.80	0.64	0.51	0.50
Feb[1]	3.49	2.97	2.37	1.78	1.30	1.00	0.82	0.69	0.60	0.43
Mar	3.42	2.89	2.44	1.75	1.26	0.98	0.75	0.65	0.49	0.38
Apr	3.01	2.61	2.13	1.55	1.14	0.87	0.73	0.59	0.43	0.19
May	2.40	1.21	0.96	0.82	0.66	0.56	0.43	0.35	0.21	0.10
Jun	1.12	0.72	0.57	0.46	0.39	0.34	0.29	0.23	0.16	0.11
Jul	0.64	0.49	0.35	0.30	0.25	0.21	0.18	0.15	0.12	0.08
Aug	0.49	0.33	0.28	0.25	0.20	0.17	0.14	0.12	0.10	0.07
Sep[1]	0.50	0.37	0.30	0.24	0.22	0.19	0.15	0.13	0.09	0.06
Total assurance rules (MCM)										
MCM	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	5.245	3.208	1.738	1.524	1.09	0.742	0.579	0.444	0.321	0.228
Nov	10.718	6.047	5.128	4.044	2.379	1.527	1.192	0.606	0.485	0.351
Dec	23.177	12.227	8.893	5.789	4.438	3.743	3.218	1.438	1.181	0.569
Jan	31.087	16.305	11.82	8.16	5.445	4.444	3.996	3.305	1.784	1.327
Feb	22.288	12.465	9.413	6.589	5.015	4.288	3.838	2.104	1.885	1.06
Mar	13.944	11.411	8.365	6.532	5.21	3.274	2.43	1.729	1.324	1.023
Apr	9.646	6.884	5.922	4.44	3.29	2.558	1.882	1.531	1.104	0.498
May	6.674	3.248	2.568	2.196	1.77	1.508	1.152	0.94	0.552	0.265
Jun	2.914	1.856	1.478	1.184	1	0.876	0.744	0.608	0.418	0.284
Jul	1.716	1.314	0.948	0.804	0.68	0.55	0.482	0.4	0.332	0.227
Aug	1.304	0.88	0.748	0.678	0.53	0.45	0.382	0.33	0.27	0.189
Sep	1.294	0.962	0.768	0.634	0.58	0.48	0.4	0.348	0.224	0.159

1 The low flows for the 60th and 90th percentiles for the wettest (February) and driest (September) month.

11.2 GEOMORPHOLOGY

Key concerns related to geomorphology at EWR NG1 were related to the impact of the Morgenstond and Jerico dams:

- Bed armouring in response to sediment trapping in upstream dams.
- Reduced deposition of fines in lower flood benches / marginal zone.
- Reduced lateral connectivity with flood benches due to reduced flood magnitude.
- Increased sediment deposition of fine sediment in secondary channels due to reduced flow capacity

EcoSpecs and TPCs are presented in **Table 11.2**, with the surveyed transect shown diagrammatically in **Figure 11.1**.

Table 11.2 EWR NG1: Geomorphology EcoSpecs and TPCs (PES and TEC: B)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Bed armouring in fast flowing habitat	Fine to medium gravels cover >10% of bed within run or glide habitat; 50% of cobbles are mobile	Fine to medium gravels cover <10% of bed within run habitat; <50% of cobbles are mobile, >50% imbricated.
Channel cross-section		
Width of active channel at transect	No available metric to judge this.	No available metric to judge this.
Lower flood bench (marginal zone)		
Present-absent	Lower flood bench should be present on at least one bank.	Lower flood bench actively eroding, absence of marginal vegetation.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand).	No recent fine sediment deposits.
Upper flood bench		
Present-absent	Upper flood bench present on right bank.	Upper flood bench actively eroding.
Sediment deposits/ connectivity	Evidence of fine sediment deposits (silt to medium sand).	No recent sediment deposits linked to the last wet season. Terrestrialisation of riparian vegetation would indicate reduced lateral connectivity.
Channel pattern		
Channel type	Channel pattern should not change from an anastomosing channel with islands and multiple channels.	Loss of secondary channels; coalescence of islands.

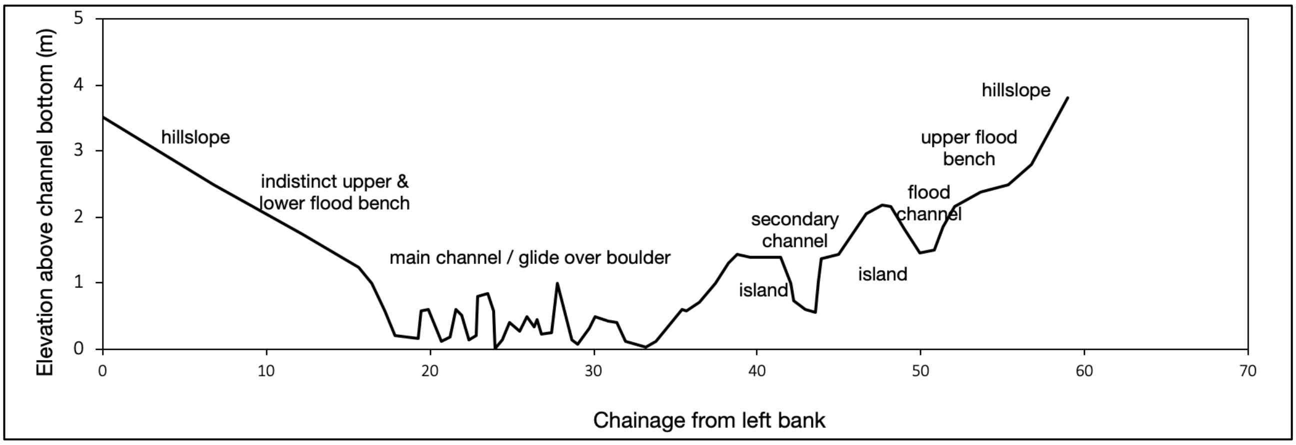

Figure 11.1 Surveyed transect line at EWR NG1

11.3 WATER QUALITY (ECOSPECS)

EcoSpecs and TPCs are shown in **Table 11.3**.

Table 11.3 EWR NG1: Water quality EcoSpecs and TPCs (PES and TEC: B)

Water quality metrics	EcoSpecs	TPC
Inorganic salts*		
$MgSO_4$	The 95th percentile of the data must be ≤16 mg/L.	The 95th percentile of the data is 13 - 16 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤20 mg/L.	The 95th percentile of the data is 16 - 20 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤15 mg/L.	The 95th percentile of the data is 12 - 15 mg/L.

Water quality metrics	EcoSpecs	TPC
$CaCl_2$	The 95th percentile of the data must be ≤21 mg/L.	The 95th percentile of the data is 17 - 21 mg/L.
NaCl	The 95th percentile of the data must be ≤45 mg/L.	The 95th percentile of the data is 36 - 45 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤351 mg/L.	The 95th percentile of the data is 280 - 351 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤30 mS/m.	The 95th percentile of the data is 24 - 30 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 6.5 to 8.4.	The 5th percentile of the data is <6.7 and >7.8, and the 95th percentile is <6.7 and >8.2.
Temperature	Largely natural temperature range is expected.	Some temperature sensitive species at lower abundance and frequency of occurrence than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be >7.0 mg/L.	The 5th percentile of the data is ≤7.2 mg/L.
Turbidity	Small changes expected.	Small increase in sediment supply from cultivated lands and forestry. Maintain within current range (median: 10.7 NTU).
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be ≤0.5 mg/L.	The 50th percentile of the data is 0.4 - 0.5 mg/L
PO_4-P	The 50th percentile of the data must be ≤0.075 mg/L.	The 50th percentile of the data is 0.06 - 0.075 mg/L.
Response variables#		
Chl-*a* phytoplankton	The 50th percentile of the data must be ≤20 mg/L.	The 50th percentile of the data is 16 - 20 μg/L
Chl-*a* periphyton	The 50th percentile of the data must be ≤21 mg/m^2.	The 50th percentile of the data is 17 - 21 mg/m^2
Toxics		
Other variables#	The 95th percentile of the data must be within the A (or 0) Category in DWAF (2008a), or within the AEV as stated in DWAF (1996a) for those variables not in DWAF (2008a).	An impact is expected if the 95th percentile of the data exceeds the A Category range in DWAF (2008a), or the TWQR as stated in DWAF (1996a).

* Inorganic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
# Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available.

11.4 RIPARIAN VEGETATION

EcoSpecs and TPCs for riparian vegetation are shown in **Table 11.4**.

Table 11.4 EWR NG 1: Riparian vegetation EcoSpecs and TPCs (PES and TEC:B/C)

Assessed metric	EcoSpec	TPC
Marginal / Lower zones		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain a mixture of woody and non-woody vegetation.	A decrease in non-woody riparian vegetation cover below 40%; a decrease in woody riparian cover below 20% in the zone.
Key Species	The presence of *Phragmites australis* and *Ciffortia strobilifera.*	The absence of *Phragmites australis* or *Cliffortia strobilifera.*
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 10% in the zone.	An increase in perennial alien plant species cover above 10% in the zone.
Terrestrial woody species (% aerial cover)	Maintain an absence of terrestrial woody species in the zone.	An occurrence of terrestrial woody species in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain indigenous riparian woody species cover above 20% in the zone.	An absence of indigenous woody species or an increase in woody species cover above 40% in the zone.

Assessed metric	EcoSpec	TPC
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain non-woody cover above 40% in the zone.	A decrease in non-woody vegetation cover below 40% in the zone.
Reed cover (% aerial)	Maintain the presence of reeds in the zone.	The absence of reeds in the zone.
MCB		
Dominant vegetation type	The dominant vegetation type in the zone was and should remain woody vegetation.	Reduced proportion of indigenous woody aerial cover below 30% in the zone.
Alien species invasion (% aerial cover)	Maintain perennial alien plant species cover below 20% in the zone.	An increase in perennial alien plant species cover above 20% in the zone.
Terrestrial woody species (% aerial cover)	Maintain indigenous terrestrial woody species cover below 30% in the zone.	An increase in terrestrial woody species cover above 30% in the zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover of indigenous riparian woody species above 10% in the zone.	A decrease in woody species cover below 10% in the zone.
Non-woody indigenous cover (grasses, sedges, and dicotyledonous forbs) (% aerial)	Maintain the presence of non-woody cover in the zone.	An absence of non-woody vegetation cover in the zone.
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 65% for the riparian zone.	A decrease in PES score below 65% for the riparian zone.
Species richness	Maintain the presence of at least 10 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 10.

11.5 FISH

Table 11.5 outlines the spatial FROC of fish for the EWR reach and indicates the FROC under reference and PES (baseline conditions). Reach and EWR site specific EcoSpecs and TPCs based on the specific metrics or variables, as included in the FRAI (Kleynhans, 2007) are provided in **Table 11.6**.

Table 11.5 EWR NG1: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
MMAC	***Marcusenius macrolepidotus***	**2**	**1.5**	**FROC <1.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2014, 2015, 2019, 2022**
AURA*	***Amphilius uranoscopus***	**4**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2015, 2019, 2022.**
CANO*	***Chiloglanis anoterus***	**5**	**4**	**FROC <4 (present at <50% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2015, 2019, 2022.**
LMAR*	***Labeobarbus marequensis***	**4**	**3**	**FROC <3 (present at <25% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2015, 2019, 2022.**
LPOL*	***Labeobarbus polylepis***	**4**	**2**	**FROC <2 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2015, 2022.**
BARG*	***Enteromius crocodilensis*** **(*Barbus argenteus*)**	**3**	**2.5**	**FROC <2.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2015, 2019, 2022.**

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC		Comment
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC	
MMAC*	***Marcusenius pongolensis* (*Macrolepidotus*)**	**2**	**1.5**	**FROC <1.5 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2010, 2015, 2019, 2022.**
TSPA*	***Tilapia sparrmanii***	**3**	**2**	**FROC <2 (present at <10% of suitable sites sampled in reach).**	**Sampled at EWR site in 2015, 2022.**
CGAR*	***Clarias gariepinus***	**5**	**4**	**FROC <4 (present at <50% of suitable sites sampled in reach).**	**Sampled at EWR site in 2022.**
PPHI	*Pseudocrenilabrus philander*	2	1	FROC <1 (absent from all suitable sites sampled in reach).	
BANO	*Barbus anoplus*	2	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
LCYL	*Labeo cylindricus*	2	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
LMOL	*Labeo molybdinus*	2	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
AMOS	*Anguilla mossambica*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	
CEMA	*Chiloglanis emarginatus*	1	0.5	FROC <0.5 (absent from all suitable sites sampled in reach).	

* Previously sampled/confirmed at EWR site.

Table 11.6 EWR NG1: Fish EcoSpecs and TPCs (PES and TEC: C)

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	Present Ecological State of fish is in a C (FRAI = 72.78%).	Decrease of PES towards a lower EC than PES (FRAI <67%).	Any deterioration in habitat that results in decrease in FROC* of species.
Species richness	**Reach:** All indigenous species expected. **EWR site:** Indigenous species confirmed at site during EWR surveys.	**Reach:** All the expected indigenous fish species (14 species) estimated to be present in the reach under PES. **EWR site:** Eight (8) indigenous fish species confirmed (sampled) previously at EWR site (4 surveys: 2010 to 2022).	**Reach:** Loss of any indigenous species from reach. **EWR site:** Less than five (5) indigenous fish species sampled at EWR site during any survey. Absence of range of life stages (juveniles to adults) of all species sampled at site during various surveys may also indicate deterioration.	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water	CANO/LMAR	**Reach:** CANO estimated to be present at 50 to 75% of sites in reach (FROC = 4) while LMAR is estimated to occur at 25 to 50% of sites in reach (FROC = 3). **EWR site:** CANO and LMAR was sampled 100% of the surveys (2010 to 2022).	**Reach:** CANO present at <50% of sites in reach (FROC<4) and LMAR sampled at <25% of sites (FROC<3). **EWR site:** CANO and/or LMAR absent from EWR site during two consecutive surveys.	Reduced suitability (abundance and quality) of flowing habitats (i.e., decreased flows, increased zero flows, altered seasonality).
Fast-Shallow (FS) habitats				Reduced suitability (abundance and quality) of FS habitats (i.e., decreased flows, increased zero flows).
Substrate	AURA/CANO	**Reach:** AURA estimated to be present at 25 to 50% of sites in reach (FROC = 3) while CANO is estimated to occur at 50 - 75% of sites in reach (FROC = 4). **EWR site:** AURA and CANO sampled 100% of the surveys (2010 to 2022).	**Reach:** AURA sampled at <25% of sites (FROC<3) and/or CANO present at <50% of sites in reach (FROC<4). **EWR site:** AURA & CANO absent from EWR site during two consecutive surveys.	Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Water quality intolerance				Decreased water quality (especially flow related water quality variables such as oxygen).
Fast-Deep (FD) habitats	AURA	**Reach:** AURA estimated to be present at 25 to 50% of sites in reach (FROC = 3). **EWR site:** AURA sampled 100% of the surveys (2010 to 2022).	**Reach:** AURA sampled at <25% of sites (FROC<3). **EWR site:** AURA absent from EWR site during two consecutive surveys.	Reduced suitability (abundance and quality) of FD habitats (i.e., decreased flows, increased zero flows).
Water column	LMAR	**Reach:** LMAR is estimated to occur at 25 to 50% of sites in reach (FROC =3). **EWR site:** LMAR was sampled 100% of the surveys (2010 to 2022).	**Reach:** LMAR sampled at <25% of sites (FROC<3). **EWR site:** LMAR absent from EWR site during two consecutive surveys.	Reduction in suitability of water column (i.e., increased sedimentation of pools, reduced flows).
Slow-Deep (SD) habitats				Significant change in SD habitat suitability (i.e., increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
Overhanging vegetation	TSPA	**Reach:** TSPA estimated to be present at 10 to 25% of sites in reach (FROC = 2). **EWR site:** TSPA sampled 50% of the surveys at site (2010 to 2022).	**Reach:** TSPA present at <10% of sites in reach (FROC<2). **EWR site:** TSPA absent from EWR site during three consecutive surveys.	Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Instream vegetation				Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes).
Slow-Shallow (SS) habitats				Significant change in SS habitat suitability (i.e., increased flows, altered seasonality, increased sedimentation of slow habitats).
Undercut banks	MMAC	**Reach:** MMAC estimated to be present at 10 to 25% of sites in reach (FROC = 1.5). **EWR site:** MMAC sampled 100% of the surveys at site (2010 to 2022).	**Reach:** TSPA present at <10% of sites in reach (FROC<1.5). **EWR site:** TSPA absent from EWR site during two consecutive surveys.	Significant change in undercut bank and rootwads habitats (e.g., bank erosion, reduced flows).
Alien fish species	Presence of any alien/introduced spp.	MSAL previously sampled at EWR site, confirmed in reach.	Presence of any additional alien/introduced species in reach or at EWR site during any survey.	N/A
Migratory success	AMOS, LMAR, LPOL	One catadromous eel species (AMOS) and various potamodromous species expected and confirmed in reach. Various potamodromous species (including LMAR, LPOL) sampled at EWR site and various other potamodromous species expected at EWR site.	**Reach:** AMOS, LMAR, LPOL absent from all sites sampled in reach during two consecutive surveys. **EWR site:** Absence of LMAR and/or LPOL during two consecutive surveys.	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

11.6 MACROINVERTEBRATES

Table 11.7 lists the macro-invertebrate indicator taxa (families) linked to preferred habitat attributes at the site or in the EWR reach. Site specific EcoSpecs and TPCs based on the specific metrics or variables, as established in the MIRAI (Thirion, 2016) during field surveys, are provided in **Table 11.8**.

According to the MIRAI compiled for this site, the reference condition for Site NG1 was established as: SASS 220 and ASPT 6.7, while a SASS 203 - 245 and ASPT 6.6 were recorded during recent surveys at the sites (2015 and 2019).

Table 11.7 EWR NG1: Macro-invertebrate indicator taxa

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	Hydropsychidae >2spp	>0.6	Cobbles	High
2	Tricorythidae	>0.6	Cobbles	Moderate
3	Philopotamidae			
4	Heptageniidae	0.3 - 0.6	Cobbles	High
5	Perlidae			
6	Psephenidae	0.3 - 0.6	Cobbles	Moderate
7	Leptophlebiidae			
8	Coenagrionidae	<0.1	Vegetation	Low

Table 11.8 EWR NG1: Macro-invertebrate EcoSpecs and TPCs (PES and TEC: B)

EcoSpecs	TPCs
Ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score range 200 to 250; ASPT value: >6.5.	ASPT below 6.6 and SASS 205
Ensure that the MIRAI score is within the range of a B category (82.01 – 87.4) using the same reference data used in this study (DWS, 2022c).	A MIRAI score of 84% or less.
Maintain suitable flow velocity (maximum >0.6 m/s) and clean, unembedded surface area (cobbles) to support the Hydropsychidae (>2 species) assemblages in the VFCS biotope.	Hydropsychidae (>2 species) missing in a survey.
To maintain suitable flow velocity (0.6 m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the FFCS biotope: ▫ Tricorythidae ▫ Philopotamidae	Any one of Tricorythidae and Philopotamidae missing in two consecutive surveys.
Maintain suitable conditions in the SIC habitat regarding moderate velocity (0.3 - 0.6 m/s) and good water quality to support Heptageniidae and Perlidae.	Heptageniidae and Perlidae: Any one of these taxa missing in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support Coenagrionidae.	Coenagrionidae: This taxon missing in two consecutive surveys.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000) over more than two consecutive surveys.	Any taxon occurring in an abundance of >500 for two consecutive surveys.

12 RQOs FOR HIGH PRIORITY RUs WITHOUT EWR SITES

12.1 RU W53-2 (MPAMPA RIVER): B/C TEC

12.1.1 Water quality

The stretch of the Mpama River upstream of Jericho Dam (W53B-01710) was assessed as representative of RU W53-2. The water quality impact rating is 1.0, so very small, and related to roads, old lands and limited forestry upstream of the dam. The only EcoSpec and TPC considered relevant to the site would be for turbidity as provided in **Table 12.1**.

Table 12.1 Mpama River (RU W53-2): Water quality EcoSpecs and TPCs

Water quality metric	EcoSpecs	TPC
Turbidity	Small changes expected.	Small increase in sediment supply from old lands and forestry. Maintain within current range. Check biotic response for habitat-related changes.

12.1.2 Riparian vegetation

Data from the 2014 PES/EIS study (DWS, 2014; updates from this project) were used to develop broad EcoSpecs and TPCs for RUs without an EWR site (see **Table 12.2** and **Table 12.6**). Where more than a single SQ was included in the RU, data from an SQ with a better EC was used to represent the RU. The following indicators are described below and were used:

- Dominant vegetation cover: Different types of riparian ecosystems are characterised by different dominant riparian vegetation e.g. grass-dominated Highveld/mountainous streams, tree and shrub-dominated Lowveld/lowland rivers flowing through Bushveld, tall tree-dominated (forest) streams through forested /kloof areas, or mixed vegetation e.g. reed and tree/shrub dominated rivers which are common in the Inkomati and Mhlathuze to Usutu catchment. The dominant vegetation type (riparian) is a key component of the structure and function of the riparian zone as a whole.
- Presence of alien plant species: Invasion of riparian zones by alien plant species is a major concern and determinant of EC deterioration along almost all South African rivers. As such, its consideration and measurement are imperative for effective management. The consideration here makes no distinction of species but does focus on perennial aliens rather than including annuals as well. Alien invasion is expressed as the percentage aerial cover (% of total riparian zone area) of all perennial aliens within the riparian zone area.
- Longitudinal riparian zone continuity: Longitudinal riparian zone continuity was an integral factor in the PES/EIS project (DWS, 2014 and updates in this project) and since it is another important measure of riparian condition within a reach, it was additionally used to define certain riparian RQOs for each reach. Riparian zone continuity is also a characteristic of the riparian zone which lends itself to assessment from satellite imagery and hence is easier and quicker to measure, while remaining meaningful. Its measurement remains the same as the metrics used within the Present Ecological State, Ecological Importance and Ecological Sensitivity (PES/EI/ES) assessments (0 - 5, none – critical).
- Riparian zone fragmentation: The ability of the riparian zone to function as such depends largely on the level of longitudinal and lateral fragmentation. Where fragmentation is high functionality is lost. As such RQOs were developed that relate to fragmentation but make specific reference to agricultural and forestry activities as these are the most common and

dominant reasons for an increase in fragmentation. Since both agricultural and forestry activities were rated in the PES/EIS project (DWS, 2014 and updates within this project) fact sheets, it is possible to monitor changes over time. Its measurement remains the same as the metrics used within the PES/EI/ES assessments (0 - 5, none – critical).

Table 12.2 Mpama River (RU W53-2): Riparian vegetation EcoSpecs and TPCs

Indicators	EcoSpecs	TPCs
Dominant vegetation cover (% aerial)	The SQs within this RU are natural grassland (Eastern Highveld Grassland) and should remain dominated by grassland. Maintain grassland cover above 40% in the riparian zone and 60% in the wetlands.	A decrease in grassland cover below 40% in the riparian zone and 60% in the wetlands.
Presence of alien plant species	The extent of perennial alien plant species (mainly Wattles and Willow) within the riparian zone and wetlands should remain low or decrease.	An increase in extent of perennial alien plant species above 20% (aerial cover) in the riparian zone and wetlands.
Riparian zone continuity	Modification of riparian zone continuity should remain small or improve.	Modification of riparian zone continuity becomes moderate or worse.
Riparian zone fragmentation	Riparian zone fragmentation should remain moderate or improve. There shall be no expansion of forestry into the riparian zone or wetlands, and existing forestry shall not expand or intensify towards or within the riparian zone. Buffer zone protocol should be adhered to.	Riparian zone fragmentation becomes large; Forestry encroachment into the riparian zone or wetlands.

12.1.3 Fish

The approach is described in **Section 12.1.3** and the results are provided in **Table 12.3**.

Table 12.3 Mpama River (RU W53-2): Fish EcoSpecs and TPCs

Indicators	Narrative RQO	Numerical RQO
Species richness	Indigenous fish species richness is low to moderate, with an estimated eight species expected to occur in this RU under present condition (to be confirmed with monitoring programme). Flows should be adequate to ensure suitable habitats for primary (flow dependant) indicator species (AURA/CANO/BMAR/BPOL). Flood regime, catchment management and water quality should also be optimised to maintain adequate substrate quality (limit erosion that result in sedimentation). Maintain adequate vegetation as cover for some fish species and do not allow an increase in migration barriers (Westoe Dam complete migration barrier) to fish or spread of alien fish species (especially from Westoe Dam).	Maintain estimated indigenous species (AURA, BANO, BARG, BMAR, BPOL, CANO, PPHI, and TSPA) (to be confirmed with monitoring programme). Maintain current habitat diversity to meet the requirements of these species.
Primary indicator species: Flow and flow related water quality, substrate, migration: AURA/CANO/BMAR/ BPOL		Maintain suitable flows and velocities (>0.3 m/s) (all seasons) to sustain the rheophilic species, adequate velocities (>0.3 m/s) and depth (>0.3 m) during wet season for large semi-rheophilic species in the reach where they occur (if confirmed to be present). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be maintained to facilitate migration (especially wet season).
Secondary indicator species: Vegetation: BANO, PPHI, TSPA		Ensure the habitat requirements of the secondary indicator species are maintained. These include adequate vegetative and substrate cover and prevent the construction of any further migration barriers to fish movement.

12.1.4 Macroinvertebrates

The approach is described in **Section 12.1.4** and the results are provided in **Table 12.4**.

Table 12.4 Mpama River (RU W53-2): Macroinvertebrate EcoSpecs and TPCs

Indicators	Narrative RQO	Numerical RQO
Hydropsychidae	Flows and water quality should be adequate to ensure suitable habitats for this flow dependant taxon.	Maintain suitable flow velocity (maximum >0.6 m/s) and clean, unembedded surface area (cobbles) to support this high water quality taxon in the Very fast flow over coarse sediment biotope (VFCS).
Philopotamidae	Flows should be adequate to ensure suitable habitats for these flow dependant taxa.	Maintain suitable conditions for this flow dependent taxa (high velocity: >0.6 m/s) and moderate water quality in the SIC biotope (15 cm depth).
Heptageniidae	Habitat and water quality should be adequate to ensure suitable habitats for this sensitive taxon.	Maintain suitable conditions in the SIC habitat regarding moderate velocity (0.3 - 0.6 m/s) and good water quality for this taxon.
Leptophlebiidae Elmidae	Habitat and medium flows should be adequate to ensure suitable habitats for these sensitive taxa.	Maintain suitable conditions for this flow dependent taxa (moderate velocity: 0.3 - 0.6 m/s) and moderate water quality in the SIC biotope (15 cm depth).
Coenagrionidae Atyidae	Marginal vegetation habitat should be adequate to accommodate these key taxa.	Maintain suitable conditions in the marginal vegetation (MV) in moderate velocity (0.3 - 0.6 m/s) for these key taxa.
Gomphidae	To maintain suitable coarse alluvial sediment and habitat conditions for this key taxon.	Coarse sand habitat should be adequate to accommodate this key taxon. Maintain suitable conditions in the sediment in moderate velocity (0.3 - 0.6 m/s) for this key taxon.

12.2 RU W54-1 (USUTU RIVER): B TEC

12.2.1 Water quality

The stretch of the Usutu River upstream of Westoe Dam (W54B-01569) was assessed as representative of RU W54-1. The water quality impact rating is 1.0, so very small, and related to forestry upstream of the dam. The only EcoSpec and TPC considered relevant to the site would be for turbidity as provided in **Table 12.5**.

Table 12.5 Usutu River (RU W54-1): Water quality EcoSpecs and TPCs

Water quality metric	EcoSpecs	TPC
Turbidity	Small changes expected.	Small increase in sediment supply from forestry. Maintain within current range. Check biotic response for habitat-related changes.

12.2.2 Riparian vegetation

The approach is described in **Section 12.1.2** and the results are provided in **Table 12.6**.

Table 12.6 Usutu River (RU W54-1): Riparian vegetation EcoSpecs and TPCs

Indicators	EcoSpecs	TPCs
Dominant vegetation cover (% aerial)	The SQs within this RU are natural grassland (Eastern Highveld Grassland) and should remain dominated by grassland. Maintain grassland cover	A decrease in grassland cover below 40% in the riparian zone and 60% in the wetlands.

Indicators	EcoSpecs	TPCs
	above 40% in the riparian zone and 60% in the wetlands.	
Presence of alien plant species	The extent of perennial alien plant species (mainly Wattles) within the riparian zone and wetlands should remain low or decrease.	An increase in extent of perennial alien plant species above 20% (aerial cover) in the riparian zone and wetlands.
Riparian zone continuity	Modification of riparian zone continuity should remain moderate or improve.	Modification of riparian zone continuity becomes large.
Riparian zone fragmentation	Riparian zone fragmentation should remain moderate or improve. There shall be no expansion of forestry into the riparian zone or wetlands, and existing forestry shall not expand or intensify towards or within the riparian zone. Buffer zone protocol should be adhered to.	Riparian zone fragmentation becomes large; Forestry encroachment into the riparian zone or wetlands.

12.2.3 Fish

The approach is described in **Section 12.1.3** and the results are provided in **Table 12.7**.

Table 12.7 Usutu River (RU W54-1): Fish EcoSpecs and TPCs

Indicators	Narrative RQO	Numerical RQO
Species richness	Indigenous fish species richness is low (three expected species) in both SQ reaches in this RU (upstream of Jericho Dam) (no data available for confirmation). Flows should be adequate to ensure suitable habitats for all these species (SS and SD with adequate vegetation as cover). Do not allow a further increase in migration barriers (Jericho Dam complete migration barrier) or spread of alien fish species (especially from Jericho Dam).	Maintain indigenous species (BANO, PPHI and TSPA) richness of approximately three fish species in the two SQ reaches of concern. Maintain current habitat diversity to meet the requirements of these species.
Indicator species: Water quality: BANO Vegetation: BANO, PPHI, TSPA		Ensure the habitat requirements of the indicator species are maintained. These include adequate vegetative and substrate cover and prevent the construction of any further migration barriers to fish movement.

12.2.4 Macroinvertebrates

The approach is described in **Section 12.1.4** and the results are provided in **Table 12.8**.

Table 12.8 Usutu River (RU W54-1): Macroinvertebrate EcoSpecs and TPCs

Indicators	Narrative RQO	Numerical RQO
Tricorythidae, Philopotamidae	Flows should be adequate to ensure suitable habitats for these flow dependant taxa.	Maintain suitable conditions for this flow dependent species (high velocity: >0.6 m/s) and moderate water quality in the SIC biotope (15 cm depth).
Leptophlebiidae	Habitat and medium flows should be adequate to ensure suitable habitats for this sensitive taxon.	Maintain suitable conditions for this flow dependent taxon (moderate velocity: 0.3 - 0.6 m/s) and moderate water quality in the SIC biotope (15 cm depth).
Coenagrionidae Atyidae	Marginal vegetation habitat should be adequate to accommodate these key taxa.	Maintain suitable conditions in the marginal vegetation (MV) in moderate velocity (0.3 - 0.6 m/s) for these key taxa.
Gomphidae	To maintain suitable coarse alluvial sediment and habitat conditions for this key taxon.	Coarse sand habitat should be adequate to accommodate this key taxon. Maintain suitable conditions in the sediment in moderate velocity (0.3 - 0.6 m/s) for this key taxon.

13 USER WATER QUALITY RQOs FOR HIGH PRIORITY RUs WITHOUT EWR SITES

13.1 INTRODUCTION

Water quality RQOs (UserSpecs) are provided for the following RUs **(Table 13.1)**, with specific areas of interest, e.g. the rivers where specific WQ impacts are evident, or areas to be protected have been identified, listed per RU. The variables for which RQOs will be set, are also listed. Note that 'salts' on **Table 13.1** refer to electrical conductivity measurements in mS/m.

Table 13.1 High priority water quality RUs (excluding EWR sites) and component RQOs

RU	Priority areas	WQ role players	WQ variables for which RQOs will be set
W11-2	Nyezane	Dryland cultivation; Gingindlovu oxidation ponds (High Risk)	*E. coli* / coliforms. As the same RU as EWR MA1, RQOs exist for all other variables.
W12-5	Mfulazane	Melmoth oxidation ponds. Sewage pumpstation overflows.	Nutrients, salts, *E. coli* / coliforms
W12-6	Mhlathuze	Dryland cultivation	Turbidity
W12-8	Okula	Dryland cultivation; erosion; Tronox	Turbidity, nutrients, *E. coli* / coliforms. Tronox: Fe, sulphate and metals, i.e. toxics.
W12-10	Mpisini	Smelter	Toxics
W21-1	White Mfolozi iShoba	Waste Water Treatment Works (WWTW); Hlobane Mine; erosion	Nutrients, salts, sulphate, *E. coli* / coliforms, turbidity, toxics
W21-4	Mvunyane Vumankala Jojosi Nondweni	Urban impacts, incl. WWTW; erosion; over-grazing	Toxics, salts, nutrients, turbidity, *E. coli* / coliforms
W21-7	Mbilane Nhlungwane White Mfolozi	Ulundi WWTW; urban impacts; anthracite mine; forestry; irrigation; erosion; over-grazing	Nutrients, salts, toxics, turbidity, *E. coli* / coliforms
W22-5	Mvalo	Coal mining impact; over-grazing	Nutrients, salts, toxics, turbidity
W23-1	Mbukwini Mfolozi	Erosion; over-grazing; mining	Turbidity, toxics, salts
W23-3	Msunduzi Mfolozi	Cultivation; fertilizers/ biocides; sugar mill discharge point (Mfolozi); urban impacts	Nutrients, salts, toxics, *E. coli* / coliforms
W31-1	Nkongolwana Mkuze	Mining; cultivation; erosion	Toxics, salts, sulphate; nutrients, turbidity
W31-4	Mkuze	WWTW	Nutrients, salts, toxics, *E. coli* / coliforms
W42-1	Bazangoma	Cultivation; coal discard dumps	Nutrients, salts, toxics, sulphate, pH
W42-2	Gode	Urban impacts; cultivation	Nutrients, salts, toxics, *E. coli* / coliforms
W43-1	Ngwavuma	Erosion; extensive cultivation	Turbidity, toxics, nutrients, salts
W44-1	Manzawakho Phongola	Erosion; feedlots; WWTW; extensive cultivation; mill discharges	Turbidity, toxics, nutrients, salts, *E. coli* / coliforms
W45-1	Phongolo	WWTW; extensive cultivation; settlements; erosion	Toxics, nutrients, salts, *E. coli* / coliforms, turbidity
W51-1	Assegaai Ngulane Tributaries flowing into Heyshope Dam (Northern part of the Dam) within W51B	Mine decant; erosion; cultivation; Driefontein settlements; WWTWs; coal mines	Nutrients, salts, toxics, *E. coli* /coliforms
	Heyshope Dam	Water source for Eskom	Salts
W51-3	Assegaai	Urban impacts; Piet Retief WWTW	Nutrients, salts, toxics, *E. coli* / coliforms
W51-4	Blesbokspruit	Cultivation; wood-processing; Industries (Woodchem and PG	Toxics, nutrients, salts, *E. coli* / coliforms

RU	Priority areas	WQ role players	WQ variables for which RQOs will be set
		Bison and Mpact); saw mills; residential settlements	
W53-3	Thole	Urban impacts; WWTW; cultivation	Toxics, nutrients, salts, *E. coli* / coliforms
W55-1	Mpuluzi Chrissiesmeer Lake are within W55A	Erosion (sand-mining); residential settlements; WWTW oxidation ponds in lower reaches.	Turbidity, toxics, nutrients, salts, *E. coli* / coliforms
W70-3	Wetland/groundwater-driven	Effluent discharge points; oxidation ponds; cultivation	Toxics, nutrients, salts, *E. coli* / coliforms

RQOs are listed per identified RU, with information provided on the source of data for the assessment, primary users and water quality issues. Comments are also made on confidence and the applicability of RQOs. **Appendix B** provides numerical limits for toxic substances as sourced from aquatic ecosystem water quality guidelines (DWAF, 1996a) and methods for assessing the water quality part of the Ecological Reserve for rivers (DWAF, 2008a).

13.2 RU W11-2: WATER QUALITY RQOs

Sources: PAI model used for the assessment for EWR MA1. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Dryland cultivation; Gingindlovu oxidation ponds (High Risk).
WQ driving variables: Turbidity, nutrients, salts, *E. coli* / coliforms. As the same RU as EWR MA1, RQOs exist for all other variables, and only *E. coli / coliforms* and turbidity listed.
Confidence and applicability of RQOs: Low confidence for all variables, as poor dataset for analysis. Provisional RQO for turbidity.

Narrative and numerical details are provided in **Table 13.2**.

Table 13.2 RU W11-2: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	Unnaturally high sediment loads and turbidity during runoff events. Impacts are mostly temporary, but some sediment deposits are evident. Check biotic response for habitat-related changes (Aquatic ecosystems: driver).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.3 RU W12-5: WATER QUALITY RQOs

Sources: Monitoring points:
1) Point source discharge, WMS monitoring point W12_192457;
2) W12_102807 Mfulazane River at Golden Reef (n = 661; 1971 - 2018). PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG,

literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Melmoth oxidation ponds. Sewage pumpstation overflows.
WQ driving variables: Nutrients, salts, *E. coli* / coliforms.
Confidence and applicability of RQOs: Moderate confidence. Immediately applicable RQOs.

Narrative and numerical details are provided in **Table 13.3**.

Table 13.3 RU W12-5: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

* The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.4 RU W12-6: WATER QUALITY RQOs

Source: No detailed water quality assessment conducted. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Dryland cultivation.
WQ driving variables: Turbidity.
Confidence and applicability of RQOs: Low confidence. Provisional RQO.

Narrative and numerical details are provided in **Table 13.4**.

Table 13.4 RU W12-6: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).

13.5 RU W12-8: WATER QUALITY RQOs

Sources: PAI model used for the assessment for EWR NS1. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Dryland cultivation; erosion; Tronox; WWTWs (Owen Sithole Agricultural College ponds); piggery.
WQ driving variables: Turbidity, nutrients, salts, toxics, *E. coli* / coliforms. As the same RU as EWR NS1, RQOs exist for all other variables, and only *E. coli / coliforms* and turbidity are listed.
Confidence and applicability of RQOs: Low confidence for all variables, as poor dataset for analysis. Provisional RQO for turbidity.

Narrative and numerical details are provided in **Table 13.5**.

Table 13.5 RU W12-8: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	See specified biota requirements.		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.6 RU W12-10: WATER QUALITY RQOs

Source: No detailed water quality assessment conducted. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: RBM smelter.
WQ driving variables: Toxics.
Confidence and applicability of RQOs: Low confidence. Provisional RQOs.

Narrative and numerical details are provided in **Table 13.6**.

Table 13.6 RU W12-10: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).

13.7 RU W21-1: WATER QUALITY RQOs

Source: Monitoring point data considered:
1) WMS monitoring points 189005, 188385 and 188378 iShoba River;
2) WMS W21_102858 White Mfolozi at Klipfontein Dam d/s weir (1982 - 2018);
3) WMS W21_188970 White Mfolozi d/s Vryheid. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: WWTW; Hlobane Mine; erosion.
WQ driving variables: Turbidity, nutrients, salts, sulphate, toxics, *E. coli* / coliforms.
Confidence and applicability of RQOs: Moderate confidence, so immediately applicable RQOs for variables other than toxics and turbidity.

Narrative and numerical details are provided in **Table 13.7** and **Table 13.8**. **Table 13.8** shows proposed RQOs for salt and sulphate levels specifically for the iShoba River, W21B-02539.

Table 13.7 RU W21-1, excluding iShoba River: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).		
Ensure that sulphate levels are within Ideal limits.#	95th percentile of the data must be less than or equal to 80 mg/L (Aquatic ecosystems: driver).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.
#According to boundaries used for DWS (2020).

Table 13.8 RU W21-1, iShoba River W21B-02539: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Ensure that electrical conductivity (salt) levels are within Tolerable limits.	95th percentile of the data must be less than or equal to 85 mS/m (Aquatic ecosystems: driver).		
Ensure that sulphate levels are within Tolerable limits.#	95th percentile of the data must be less than or equal to 250 mg/L (Aquatic ecosystems: driver).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.
#According to boundaries used for DWS (2020).

13.8 RU W21-4: WATER QUALITY RQOs

Source: No detailed water quality assessment conducted. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Urban impacts including WWTW; erosion and over-grazing.
WQ driving variables: Turbidity, nutrients, salts, toxics, *E. coli* / coliforms.
Confidence and applicability of RQOs: Low confidence. Provisional RQOs.

Narrative and numerical details are provided in **Table 13.9**.

Table 13.9 RU W21-4: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.9 RU W21-7: WATER QUALITY RQOs

Source: Monitoring point data considered:
1) WMS monitoring point W21_102834 @ W2H005Q01, 1971-2018, n = 1254;
2) WMS W21_192483, 2011-2017; n = 16. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Urban impacts including Ulundi WWTW; anthracite mining (ZAC); forestry; irrigation; erosion and over-grazing.
WQ driving variables: Turbidity, nutrients, salts, toxics, *E. coli* / coliforms.
Confidence and applicability of RQOs: Moderate confidence for conductivity and orthophosphate, so Immediately applicable RQOs. Provisional RQOs for other variables.

Narrative and numerical details are provided in **Table 13.10**.

Table 13.10 RU W21-7: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95th percentile of the data must be less than or equal to 55 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.10 RU W22-5: WATER QUALITY RQOs

Source: No detailed water quality assessment conducted. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Coal mining (ZAC mine); over-grazing.
WQ driving variables: Turbidity, nutrients, salts, toxics.
Confidence and applicability of RQOs: Low confidence. Provisional RQOs for all variables.

Narrative and numerical details are provided in **Table 13.11**.

Table 13.11 RU W22-5: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95th percentile of the data must be less than or equal to 55 mS/m (Aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	See specified biota requirements using information extrapolated from EWR BM1 (see **Table 2.1**).

13.11 RU W23-1: WATER QUALITY RQOs

Source: No detailed water quality assessment conducted. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Tendele mining area; erosion and over-grazing.
WQ driving variables: Turbidity, salts, toxics.

Confidence and applicability of RQOs: Low confidence. Provisional RQOs for all variables.

Narrative and numerical details are provided in **Table 13.12**.

Table 13.12 RU W23-1: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95^{th} percentile of the data must be less than or equal to 55 mS/m (Aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).
Ensure that toxics are within Ideal limits or A categories.	95^{th} percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).

13.12 RU W23-3: WATER QUALITY RQOs

Source: Monitoring point data considered: WMS monitoring point W23_102839, Mfolozi River @ W2H010Q01, 1973 - 2017, n = 1141. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Cultivation; fertilizers/biocides; urban impacts incl. WWTWs; sugar mill discharges into W23D-03108 (Mfolozi River).
WQ driving variables: Nutrients, salts, toxics, *E. coli* / coliforms.
Confidence and applicability of RQOs: Moderate confidence for conductivity and orthophosphate, so Immediately applicable RQOs. Provisional RQOs for other variables.

Narrative and numerical details are provided in **Table 13.13**.

Table 13.13 RU W23-3: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that electrical conductivity (salt) levels are within Tolerable limits.	95^{th} percentile of the data must be less than or equal to 85 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95^{th} percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	Use biological monitoring data or institute biological monitoring to set an objective for biota requirements, as a proxy for monitoring biocides/fertilizers. Alternatively, institute instream toxicity testing.		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.13 RU W31-1: WATER QUALITY RQOs

Source: Monitoring point data considered:
1) WMS monitoring point W31_102877, Nkongolwana River at Veelsgeluk @ W3H023Q01, 1995 - 2010, n = 274;
2) WMS W31_102878, Mkuze River d/s Nkongolwana confluence @ W3H024Q01, 1995 - 2010, n = 269;
3) WMS W31_188963, Rustplaats u/s dam on the Nkongolwana, 2004 - 2015, n = 62. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Mining; cultivation; erosion.
WQ driving variables: Turbidity, nutrients, salts, toxics.
Confidence and applicability of RQOs: Low-moderate confidence for conductivity, sulphate and orthophosphate, but data not recent so confirmation required before RQOs become Immediately applicable. Note that current levels for salts (sulphate and sodium) and conductivity are so elevated, a phased approach to reaching objectives is anticipated. Provisional RQOs for other variables.

Narrative and numerical details are provided in **Table 13.14**.

Table 13.14 RU W31-1: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
Ensure that electrical conductivity (salt) levels are within Tolerable limits.	95^{th} percentile of the data must be less than or equal to 85 mS/m (Aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).
Ensure that toxics are within Ideal limits or A categories.	95^{th} percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	Use biological monitoring data or institute biological monitoring to set an objective for biota requirements. *In situ* water quality testing should be conducted with biomonitoring, particularly for pH and dissolved oxygen. Alternatively, institute instream toxicity testing.

13.14 RU W31-4: WATER QUALITY RQOs

Source: PAI model used for the assessment for EWR MK1, as the High Priority WQ RU is in the upstream reach. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Mkuze WWTW.
WQ driving variables: Nutrients, salts, toxics, *E. coli*/ coliforms.
Confidence and applicability of RQOs: See EWR MK1, **Section 8.3**, of this report.

Narrative and numerical details are provided in **Table 13.15** for *E. coli* / coliforms only, as the progressive improvement in water quality recommended for EWR MK1 also applies to the upstream reach.

Table 13.15 RU W31-4: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.15 RU W42-1: WATER QUALITY RQOs

Source: Monitoring point data considered:
1) WMS monitoring point W42_89062 Z421802, Headwaters of Bazangoma, 1993 - 1995, n = 46;
2) WMS monitoring point W42_101121, downstream point, 1992 - 2014, n = 18;
3) WMS W42_18174, Makateeskop tributary, 2008 - 2009, n = 10;
4) Additional points on Makateeskop: WMS W42_189391, 189183 and 189193. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Cultivation; coal discard dumps, particularly on Makateeskop tributary.
WQ driving variables: Nutrients, salts, toxics, sulphate, pH.
Confidence and applicability of RQOs: Poor data set so low confidence and Provisional RQOs.

Narrative and numerical details are provided in **Table 13.16**.

Table 13.16 RU W42-1: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that electrical conductivity (salt) levels are within Tolerable limits.	95th percentile of the data must be less than or equal to 85 mS/m (Aquatic ecosystems: driver).
Ensure that sulphate levels are within Tolerable limits#.	95th percentile of the data must be less than or equal to 250 mg/L (Aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).
Ensure pH levels are within Acceptable limits	A small change from the Ideal range is allowed, i.e. a 5th percentile of 5.9 - 6.5, and a 95th percentile of 6.5 - 8.8 (aquatic ecosystems: driver).
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	*Makateeskop tributary and mainstem downstream:* Use biological monitoring data or institute biological monitoring to set an objective for biota requirements. *In situ* water quality testing should be conducted with biomonitoring, particularly for pH and dissolved oxygen. Alternatively, institute instream toxicity testing.

According to boundaries used for DWS (2020).

13.16 RU W42-2: WATER QUALITY RQOs

Source: Monitoring point data considered: WMS monitoring point W42_189172, downstream of discharge from sewage unit, 2008 - 2016, n = 28. PES/EI/ES data (DWS, 2014) updated for the

study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Urban impacts incl. eDumbe oxidation ponds at Paulpietersburg; cultivation.
WQ driving variables: Nutrients, salts, toxics, *E. coli* / coliforms.
Confidence and applicability of RQOs: Poor data set so low confidence and Provisional RQOs.

Narrative and numerical details are provided in **Table 13.17**.

Table 13.17 RU W42-2: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Tolerable limits.	50th percentile of the data must be less than 0.1 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.17 RU W43-1: WATER QUALITY RQOs

Source: No detailed water quality assessment conducted. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Erosion; extensive cultivation.
WQ driving variables: Turbidity, nutrients, salts, toxics.
Confidence and applicability of RQOs: Low confidence. Provisional RQOs for all variables.

Narrative and numerical details are provided in **Table 13.18**.

Table 13.18 RU W43-1: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	Institute biological monitoring data as a check on biotic state, considering possible extensive use of biocides/fertilizers. Alternatively, institute instream toxicity testing.

13.18 RU W44-1: WATER QUALITY RQOs

Source: Monitoring point data considered:
1) WMS monitoring point W44_102898, Phongola River @ W4H006Q01, 1971 - 2018, n = 1077;
2) W44_188864, 2005-2015, n = 100;
3) W44_188863, u/s final effluent discharge, 2005 - 2016, n = 101;
4) W44_188857, u/s canal discharge point, 2005-2015, n = 102; 5) W44_188865, Phongola d/s Illovo discharge point, 2005 - 2015, n = 94.
PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Extensive cultivation; erosion; feedlots; mill discharges; Pongola WWTW.
WQ driving variables: Turbidity, nutrients, salts, toxics, *E. coli* / coliforms.
Confidence and applicability of RQOs: Moderate confidence for conductivity and nutrients, so Immediately applicable. Provisional RQOs for other variables.

Narrative and numerical details are provided in **Table 13.19**.

Table 13.19 RU W44-1: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that electrical conductivity (salt) levels are within Tolerable limits.	95^{th} percentile of the data must be less than or equal to 85 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels – PO_4-P (orthophosphate) - are within Tolerable limits.	50th percentile of the data must be less than 0.075 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that nutrient levels – TIN (NO_2+NO_3-N plus NH_4-N)) are within Acceptable limits.	50^{th} percentile of the data must be less than 1.0 mg/L TIN (aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95^{th} percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	Institute biological monitoring data as a check on biotic state, considering probable extensive use of biocides/fertilizers. A highly impacted RU, where analysis of Persistent Organic Pollutants (POPs) is highly recommended. Alternatively, institute instream toxicity testing.		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.19 RU W45-1: WATER QUALITY RQOs

Source: Monitoring point data considered:
1) WMS monitoring point W45_102905, Pongolapoort Dam downstream weir @ W4H013Q01, 1983 - 2018, n = 825;

2) W45_102902 @ W4H010Q01, 1985 - 2017, n = 972. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Extensive cultivation; erosion; settlements; WWTW.
WQ driving variables: Turbidity, nutrients, salts, toxics, *E. coli* / coliforms.
Confidence and applicability of RQOs: Moderate confidence for conductivity and nutrients, so Immediately applicable. Provisional RQOs for other variables.

Narrative and numerical details are provided in **Table 13.20**.

Table 13.20 RU W45-1: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural due to land-use with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95th percentile of the data must be less than or equal to 55 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	Institute biological monitoring data as a check on biotic state, considering probable extensive use of biocides/fertilizers. A highly impacted RU, where analysis of Persistent Organic Pollutants (POPs) is highly recommended. Alternatively, institute instream toxicity testing.		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.20 RU W51-1: WATER QUALITY RQOs

Source: Monitoring point data considered:
1) WMS monitoring point W51_100001184, Assegaai River u/s Heyshope Dam, 2006 - 2019, n = 105;
2) IUCMA monitoring points U-5 (W51_102924), d/s Heyshope Dam at weir; U-6 (W51_102924), u/s Heyshope Dam on the Siloyane River; U-9 (W51_189059) u/s Heyshope Dam on the Egude River. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Coal mine decant; erosion; cultivation; Driefontein settlements; WWTWs.
WQ driving variables: Nutrients, salts, toxics, *E. coli / coliforms*.
Confidence and applicability of RQOs: Data collected by the IUCMA for phosphate and conductivity support Immediately applicable RQOs. Provisional RQOs for toxics.

Narrative and numerical details are provided in **Table 13.21**.

Table 13.21 RU W51-1: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95th percentile of the data must be less than or equal to 15 mS/m (Eskom abstraction from Heyshope Dam for cooling of coal-powered power stations: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.21 RU W51-3: WATER QUALITY RQOs

Sources: PAI model used for the assessment for EWR AS1. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Urban impacts, including Piet Retief WWTW.
WQ driving variables: Nutrients, salts, toxics, *E. coli* / coliforms. As the same RU as EWR AS1, RQOs exist for all other variables, and only *E. coli / coliforms* are listed.
Confidence and applicability of RQOs: RQOs for salts and nutrients Immediately applicable.

Narrative and numerical details are provided in **Table 13.22**.

Table 13.22 RU W51-3: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	See specified biota requirements.		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.22 RU W51-4: WATER QUALITY RQOs

Source: No detailed water quality assessment conducted. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).
WQ role players: Cultivation; settlements; wood-processing and saw mills.
WQ driving variables: Nutrients, salts, toxics, *E. coli / coliforms*.

Confidence and applicability of RQOs: No date so all Provisional RQOs.

Narrative and numerical details are provided in **Table 13.23**.

Table 13.23 RU W51-4: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95th percentile of the data must be less than or equal to 55 mS/m (Aquatic ecosystem: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1-10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.23 RU W53-3: WATER QUALITY RQOs

Source: Monitoring point data considered:

1) WMS monitoring point W53_188563, u/s Amsterdam effluent discharge point, 2006 - 2019, n = 160;

2) W53_188561, d/s Amsterdam effluent discharge point, 2006 - 2019, n = 166. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).

WQ role players: Urban impacts; cultivation; Amsterdam WWTW.

WQ driving variables: Nutrients, salts, toxics, *E. coli / coliforms*.

Confidence and applicability of RQOs: Immediately applicable RQOs for nutrients and salts. Provisional RQOs for toxics.

Narrative and numerical details are provided in **Table 13.24**.

Table 13.24 RU W53-3: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels – PO_4-P (orthophosphate) - are within Tolerable limits.	50th percentile of the data must be less than 0.125 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that nutrient levels – TIN (NO_2+NO_3-N plus NH_4-N) are within Acceptable limits.	50th percentile of the data must be less than 1.0 mg/L TIN (aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.24 RU W55-1: WATER QUALITY RQOs

Source: Monitoring point data considered:

1) IUCMA monitoring points on the Mpuluzi, i.e. U-58, oxidation ponds discharge to river; U-59 (W55_194553) u/s of ponds; U-60 (W55_194554) d/s Mpuluzi WWTW; U-63 (W55_194719) and U-64 (W55_194720);

2) W55_196012 u/s Chrissiesmeer oxidation ponds, 2017 - 2019, n = 60; W55_194718 Chrissiesmeer lake, 2015-2019, n = 94. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).

WQ role players: Erosion; residential settlements; Mpuluzi WWTW.

WQ driving variables: Turbidity, nutrients, salts, toxics, *E. coli / coliforms*.

Confidence and applicability of RQOs: Phosphate and conductivity RQOs are Immediately applicable. RQOs are Provisional for toxics and turbidity.

Narrative and numerical details are provided in **Table 13.25** and **13.26**. As Chrissiesmeer water quality state is significantly deteriorated compared to other monitoring points in the RU, objectives for the lake are shown separately in **Table 13.26**.

Table 13.25 RU W55-1, excluding Chrissiesmeer: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

Table 13.26 RU W55-1, Chrissiesmeer: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that electrical conductivity (salt) levels are within Tolerable limits.	95th percentile of the data must be less than or equal to 85 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Tolerable limits.	50th percentile of the data must be less than 0.125 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

13.25 RU W70-3: WATER QUALITY RQOs

Source: Swamanzi River flows into Lake Sibayi, so monitoring point data considered included the lake:

1) WMS monitoring point W60_192485, final discharge from Mseleni Hospital ponds to Mseleni River (flowing into Lake Sibayi), 2011 - 2015, n = 11;

2) W70_178830 at W7R1.3 Lake Sibayi, 1999 - 2017, n = 158. PES/EI/ES data (DWS, 2014) updated for the study, specialist input and associated data provided at Nov. 2022 TTG, and literature sources and method/guideline documents (e.g. DWAF, 1996a - e; DWAF, 2002; DWAF, 2008a; DWS, 2020).

WQ role players: Effluent discharge points, e.g. Mseleni Hospital oxidation ponds; cultivation.

WQ driving variables: Nutrients, salts, toxics, *E. coli / coliforms*.

Confidence and applicability of RQOs: As this section of the RU is groundwater (Lake Sibayi) and wetland-driven, proposed RQOs should be used as input information only. Groundwater/wetland information should be consulted.

Narrative and numerical details are provided in **Table 13.27**.

Table 13.27 RU W70-3: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that electrical conductivity (salt) levels are within Tolerable limits.	95^{th} percentile of the data must be less than or equal to 85 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels – PO_4-P (orthophosphate) - are within Tolerable limits.	50th percentile of the data must be less than 0.125 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95^{th} percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008a).		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	Institute biological monitoring data as a check on biotic state, considering probable extensive use of biocides/fertilizers. A highly impacted RU, where analysis of Persistent Organic Pollutants (POPs) is highly recommended. Alternatively, institute instream toxicity testing.		
Meet the following faecal coliform and *E. coli* targets, as applicable:	Potential Health Risk		
	Low	Medium	High
	Faecal coliform or *E. coli* counts/100 ml		
▪ Drinking untreated water	0	1 - 10	>10
▪ Drinking water after limited treatment*	<2 000	2 000 – 20 000	>20 000
▪ Full or partial contact	<600	600 – 2 000	>2 000
▪ Irrigation of crops to be eaten raw	<1 000	1 000 – 4 000	>4 000

*The guideline value refers to raw water; although water should only be used for drinking only AFTER limited treatment has taken place. Limited treatment refers to treatment that is NOT conventional. Conventional treatment includes all flocculation, sedimentation, filtration and disinfection.

14 HYDROLOGICAL RQOs FOR ADDITIONAL LOW AND MODERATE PRIORITY RUs

Source: Reports from the study; DWS (2022b), DWS (2022d).
Model: Revised Desktop Reserve Model (RDRMv2) (WRC, 2018), Water Resource Yield Model (WRYM) (DWS, 2022e), Water Resource Planning Model (WRPM) (DWS, 2022e).

A summary of the flow RQOs for the RUs with Low and Moderate Priorities and which do not have an EWR site in is provided in **Table 14.1**. The full EWR rule is provided as part of the electronic data for the project. Flows provided in **Table 14.1** are in MCM/a.

Table 14.1 Flow RQOs for Low and Moderate Priority RUs

IUA	RU	River	MAR			PES	TEC	EWR long-term requirements			
			10^6 m^3		PD			MAR low flows		MAR total flows	
			Nat	PD	(% Nat)			10^6 m^3	% Nat	10^6 m^3	% Nat
Secondary catchment W1											
W11	W11-1	Matigulu	22.78	13.06	57.3	B	B	4.68	20.6	7.16	31.4
W12-a	W12-1	Mhlathuze	32.15	23.32	72.5	B	B	8.21	25.5	12.79	39.8
W12-a	W12-2	Mhlathuze	95.13	28.48	29.9	B	B	22.83	24	37.9	N/A[1]
W12-a	W12-4	KwaMazula	12.87	9.89	76.8	C	B/C	4.4	34.2	6.12	47.6
W12-b	W12-5	Mfule	50.8	37.84	74.5	C	C	16.12	31.7	20.54	40.4
W12-b	W12-7	Mhtatuzana	23.13	21.76	94.1	B	B	6.86	29.6	8.76	37.9
W13	W13-1	Mlalazi	107.19	97.34	90.8	C	C	31.46	29.4	41.2	38.4
W13	W13-2	Manzamnyama	42.57	3.72	8.7	B/C	B/C	3.7	8.7	8.02	N/A[1]
Secondary catchment W2											
W21	W21-1	White Mfolozi	53.41	33.38	62.5	C	B/C	17.74	33.2	25.01	46.8
W21	W21-2	White Mfolozi	63.55	41.59	65.4	B	B	17.88	28.1	29.52	46.4
W21	W21-3	White Mfolozi	103.29	79.16	76.6	C	C	24.47	23.7	40.8	39.5
W21	W21-4	Mvunyane	66	60.51	91.7	D	D	10.85	16.4	19.85	30.1
W22	W22-3	Sikwebezi	69.08	60.58	87.7	C	C	15.61	22.6	26.18	37.9
W23	W23-1	Mfolozi	808.98	533.98	66	B	B	219.47	27.1	353.7	43.7
W23	W23-2	Ntobozi	19.38	16.49	85.1	B	B	6.12	31.6	8.36	43.2
Secondary catchment W3											
W31-b	W31-6	Msunduzi	20.16	19.28	95.6	B	B	8.64	42.9	11.96	59.3
W32-a	W32-2	Hluhluwe	23.9	23.67	99	B	B	3.69	15.5	7.21	30.2
W32-b	W32-3	Nyalazi	11.8	11.78	99.9	B	B	2.4	20.3	3.89	32.9
W32-b	W32-4	Nyalazi	25.92	25.92	100	C	C	3.83	14.8	7.68	29.6
W32-b	W32-5	Mzinene	20.8	16.82	80.9	C	C	3.82	18.4	7.23	34.8
Secondary catchment W4											
W41	W41-1	Bivane	221.53	190.28	85.9	C	B/C	55.34	25	85.73	38.7
W41	W41-2	Manzana	45.09	43.56	96.6	B	B	10.57	23.4	16.68	37
W42-a	W42-1	Phongolo	264.38	237.4	89.8	C	B/C	52.03	19.7	102.96	38.9
W42-b	W42-4	Mozana	52.7	46.5	88.2	B	B	14.4	27.3	22.37	42.4
W42-b	W42-5	Phongolo	901.99	784.54	87	B	B	180.04	20	335.16	37.2
W45	W43-1	Ngwavuma	26.95	26.86	99.7	C	C	3.74	13.9	9	33.4
W44	W44-1	Phongolo	942.03	654.62	69.5	D	D	124.76	13.2	251.62	26.7
Secondary catchment W5											
W51	W51-1	Assegaai	99.61	89.91	90.3	C/D	C	27.31	27.4	40.96	41.1
W52	W51-4	Blesbokspruit	43.36	40.5	93.4	C	C	12.59	29	17.98	41.5
W52	W52-1	Hlelo	97.06	78.34	80.7	B/C	B/C	26.96	27.8	42.77	44.1
W51	W53-1	Ngwempisi	38.66	28.14	72.8	D	D	8.03	20.8	12.8	33.1

IUA	RU	River	MAR			PES	TEC	EWR long-term requirements			
			10^6 m^3		PD			MAR low flows		MAR total flows	
			Nat	PD	(% Nat)			10^6 m^3	% Nat	10^6 m^3	% Nat
W51	W53-2		5.05	4	79.1	B/C	B/C	1.53	30.3	2.14	42.4
W52	W53-3	Ngwempisi	181.14	100.52	55.5	C	C	39.32	21.7	66	36.4
W51	W54-1	Usutu	32.77	24.22	73.9	B	B	9.05	27.6	15.07	46
W52	W54-2	Usutu	79.46	32.29	40.6	C	C	17.82	22.4	27.84	35
W55	W55-1	Mpuluzi	128.96	110.43	85.6	B/C	B/C	48.05	37.3	64.37	49.9
W55	W55-2	Lusushwana	39.48	36.19	91.7	C	C	14.09	35.7	18.19	46.1
W57	W57-1	Usutu	2289.46	1434.03	62.6	B/C	B	487.89	21.3	922.46	40.3

1 The Revised Desktop Reserve Model only constrains the Flow-Duration Curve to PD. Therefore, the long term % of nMAR will still reflect a higher than natural percentage and it is therefore not applicable.

15 CONCLUSION

In conclusion, the proposed Classes and Catchment Configuration have been documented, which concludes the National Water Resource Classification phase of this study.

That information leads to the final phase, i.e., the determination of Resource Quality Objectives, as shown in the RQO series of reports. All Target Ecological Categories (TECs) of high priority Resource Units (RUs) are defined in terms of flow, water quality, riparian and instream habitat and biota. In addition to this quantitative information, a suggested monitoring programme with ecological specifications to achieve and maintain the RQOs (and TEC) will be provided in the next report for the study, i.e. the Implementation and Monitoring Report. This will also form part of information that will/can be input into an implementation plan.

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17 APPENDIX A: RUs AND ASSOCIATED SUB QUATERNARY REACHES

A1 W1 CATCHMENT

IUA	RU number	SQ number	Quaternary catchment
W11	W11-1	W11A-03597, W11A-03748, W11A-03776	W11A
	W11-2	W11A-03599, **W11A-03612 (EWR MA1)**, W11C-03713	W11A, W11C
	W11-3	W11C-03917	W11C
W12-a	W12-1	W12A-03086, W12A-03104, W12A-03153, W12A-03226	W11A
	W12-2	W12B-03334, W12B-03356, W12B-03398	W12B
	W12-3	W12B-03471, W12B-03479	W12B
	W12-4	W12B-03336	W12B
W12-b	W12-5	W12C-03189, W12C-03225, W12C-03232, W12C-03263, W12C-03303	W12C
W12-c	W12-6	W12D-03346, W12D-03375, W12D-03388, W12E-03475	W12D, W12E
W12-b	W12-7	W12E-03526, W12E-03530, W12E-03558	W12E
	W12-8	**W12G-03229 (EWR NS1)**, W12H-03289, W12H-03316, W12H-03401, W12H-03418, W12H-03428, W12H-03459	W12G, W12H
W12-d	W12-9	W12J-03290, W12J-03411	W12J
W12-e	W12-10	W12J-03392, W12J-03403, W12J-03450	W12J
W13	W13-1	W13A-03583, W13A-03609, W13A-03641, W13B-03593	W13A, W13B
	W13-2	W13B-03774	W13B

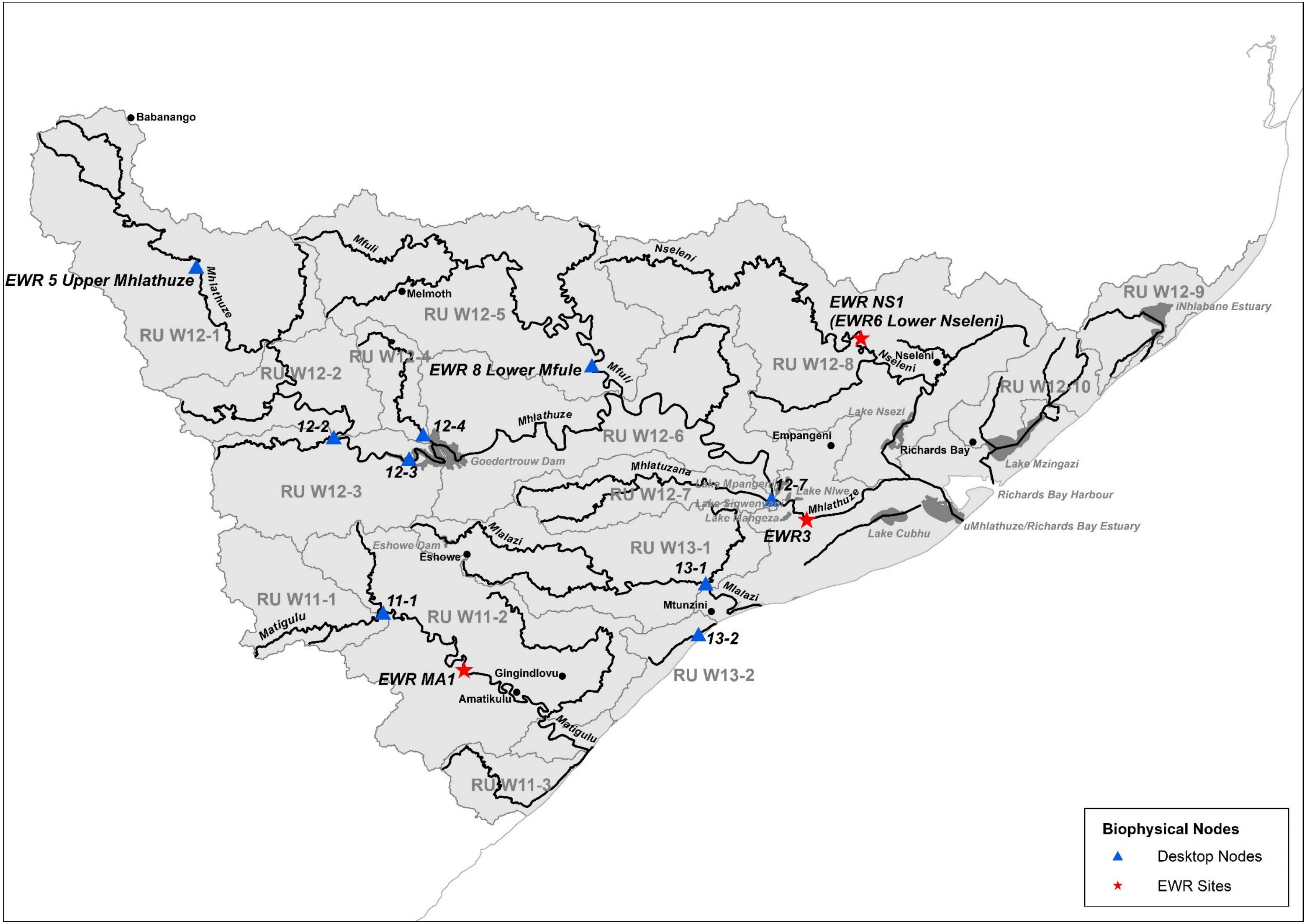

Figure A1 Resource Units located within secondary catchment W1

A2 W2 CATCHMENT

IUA	RU number	SQR number	Quaternary catchment
W22	W21-1	W21A-02527, W21A-02512, W21B-02539, W21B-02546	W21A, W21B
	W21-2	W21B-02603, W21B-02652, W21B-02670	W21B
	W21-3	W21C-02599, W21F-02727	W21C, W21F
	W21-4	W21D-02676, W21D-02788, W21D-02832, W21D-02848, W21D-02815, W21E-02934, W21E-02963, W21E-02953, W21E-02912, W21E-02873	W21D, W21E
	W21-5	W21F-02840, W21G-03085, W21G-03067, W21G-02929, W21G-02914, W21G-02885, W21G-02851, W21H-02889, **W21H-02897 (EWR WM1),** W21H-03004	W21F, W21G, W21H
	W21-6	W21J-03112, W21J-03036, W21J-03018, W21J-03075, W21J-03066, W21J-03050, W21J-03030	W21J
	W21-7	W21K-02976, W21K-03019, W21K-02981, W21K-03080	W21K
	W22-1	W22A-02587, W22A-02591, W22A-02586, W22A-02596, **W22A-02610 (EWR BM1)**, W22B-02662, W22B-02773, W22B-02661, W22B-02728, W22B-02706	W22A, W22B
	W22-2	W22C-02688, W22D-02795, W22F-02722	W22C, W22D, W22F
	W22-3	W22E-02601, W22E-02605, W22E-02595, W22E-02702, W22F-02726	W22E, W22F
	W22-4	W22F-02748, W22G-02624, W22H-02846	W22F, W22G, W22H
W23	W21-8	W21L-03161, W21L-03176, W21L-03163, W21L-03059, W21L-03041	W21L
	W22-5	W22H-02844, W22J-02942, W22J-02918, W22J-02807, W22J-02910, W22J-02817, W22K-02761, W22K-02636, W22K-02629, W22K-02783, W22L-02916	W22H, W22J, W22K, W22L
	W23-1	W23A-03098, W23A-03160, W23A-03058, W23A-03083, W23A-03149, W23A-03113	W23A
	W23-2	W23B-03250, W23B-03222	W23B
St Lucia	W23-3	W23B-03231, W23C-03287, W23C-03272, W23C-03254, W23C-03180, W23D-03108	W23B, W23C, W23D

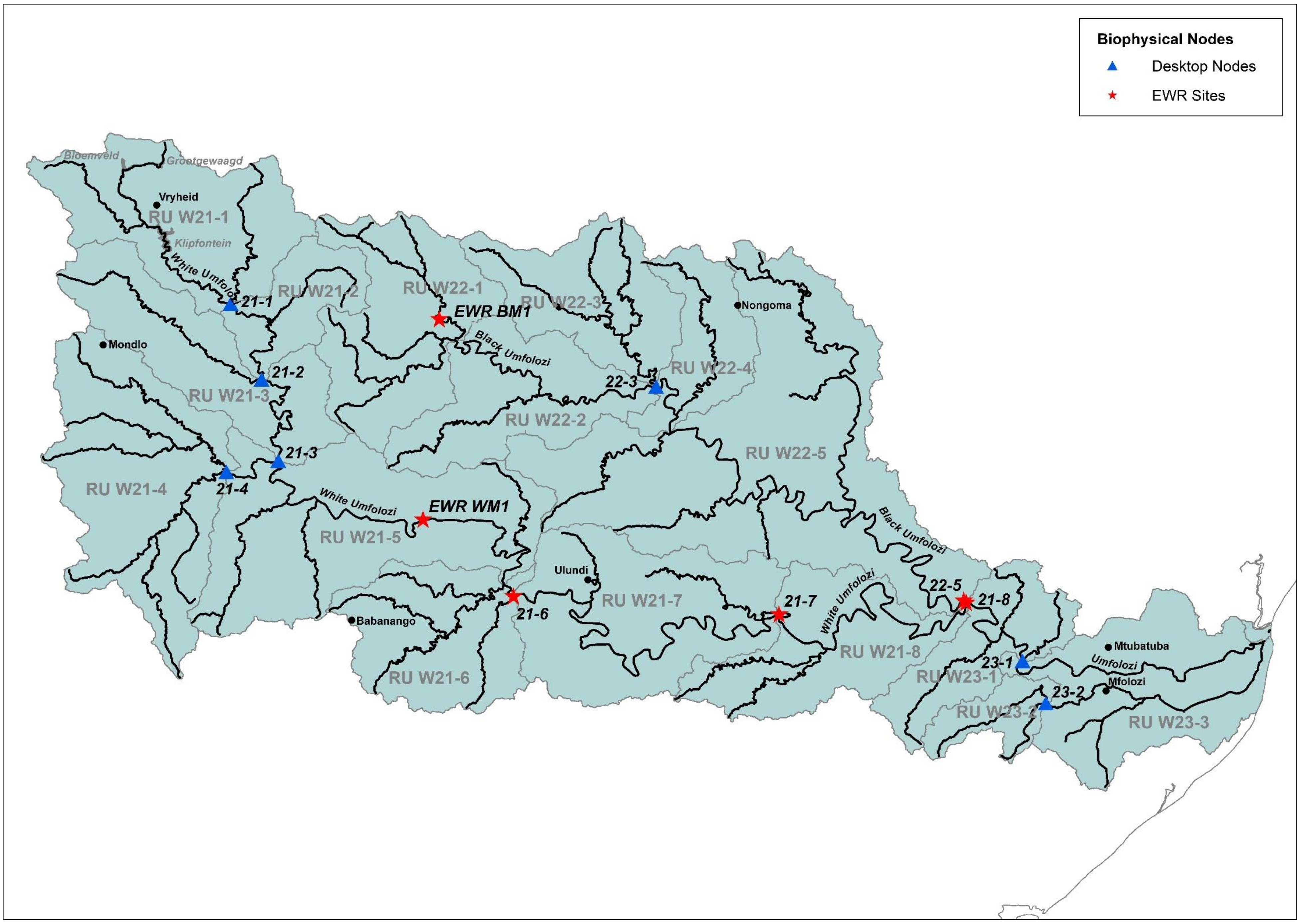

Figure A2 Resource Units located within secondary catchment W2

A3 W3 CATCHMENT

IUA	RU number	SQR number	Quaternary catchment
W31-a	W31-1	W31A-02494, W31A-02534, W31B-02477	W31A
	W31-2	W31C-02556, W31D-02436, W31D-02450, W31D-02495, W31D-02500	W31C, W31D
	W31-3	W31E-02456, W31F-02573, W31F-02555, W31F-02530, W31G-02455, W31G-02506	W31E, W31F, W31G
W31-b	W31-4	W31G-02425, W31H-02514, W31J-02501, W31J-02469	W31G, W31H, W31J
	W31-5	W31J-02343, W31J-02406, **W31J-02480 (EWR MK1)**, W31J-02509	W31J
	W31-6	W31K-02617, W31K-02611, W31K-02582, W31K-02568, W31L-02553, W31L-02525, W31L-02528, W31L-02551, W31L-02563, W31L-02569	W31K, W31L
	W32_1	W32A-02345, W32A-02557, W32B-02476, W32B-02547	W32A, W32B
W32-a	W32-2	W32D-02811, W32D-02720, W32E-02887, W32E-02797, W32E-02765, W32E-02779, W32E-02859, W32E-02865	W32D, W32E
W32-b	W32-3	W32G-02946, W32G-02973	W32G
	W32-4	W32G-03102, W32G-02943, W32G-02980, W32G-03006, W32G-03055, W32G-02986	W32G
	W32-5	W32C-02684, W32C-02749, W32C-02721, W32C-02671	W32C
	W32-6	W32C-02634, W32C-02612	W32C
St Lucia	W33-7	W32F-02835, W32H-02998, W32H-02854	W32F, W32H

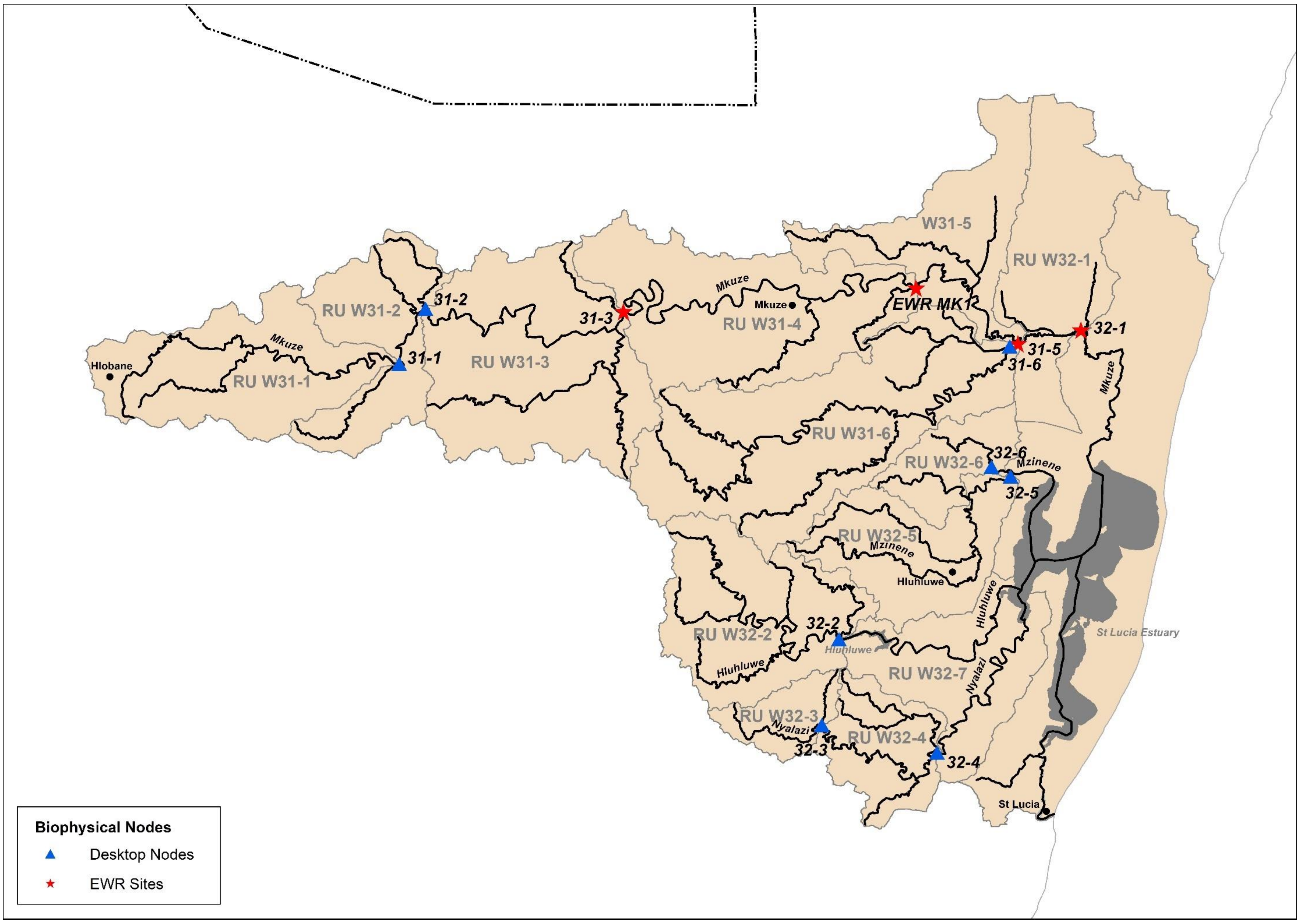

Figure A3 **Resource Units located within secondary catchment W3**

A4 W4 CATCHMENT

IUA	RU number	SQR number	Quaternary catchment
W41	W41-1	W41A-02372, W41B-02401, W41B-02427, W41B-02431, W41B-02434, W41C-02437, W41D-02373, W41D-02435, W41E-02359	W41A, W41B, W41C, W41D, W41E
	W41-2	W41F-02433, W41F-02454, W41F-02461, W41F-02481, W41F-02502	W41F
	W42-1	W42A-02261, W42A-02328, W42B-02268, W42B-02271, W42B-02315, W42B-02325, W42B-02331, W42C-02205	W42A, W42B, W42C
	W42-2	W42D-02251, W42D-02327, **W42E-02221 (EWR UP1)**, W42F-02185, W42G-02317	W42D, W42E, W42F, W42G
W42-b	W41-3	W41G-02379	W41G
	W42-3	W42H-02382, W42H-02394, W42H-02411, W42H-02428, W42J-02353, W42J-02378, W42J-02397	W42H, W42J
	W42-4	W42K-02148, W42K-02242, W42K-02272, W42L-02270	W42K, W42L
	W42-5	W42M-02269, W42M-02294, W42M-02352	W42M
W44	W44-1	W44A-02332, W44A-02386, W44A-02389, W44A-02410, W44B-02248, W44B-02351, W44C-02338, W44D-02304	W44A, W44B, W44C, W44D
W45	W43-1	W43F-02013, W43F-02053, W43F-02072, W43F-02076, W43F-02089, W43F-02099, W43F-02104, W43F-02107, W43F-02113, W43F-02142, W43F-02159	W43F
W45	W45-1	W45A-02216, W45A-02245, W45A-02246, W45A-02256, W45A-02275, W45A-02282, W45A-02285, W45A-02310, W45A-02316, W45A-02356, W45A-02367, W45A-02368, W45B-02029, W45B-02105	W45A, W45B
W45-Pongola Floodplain	Pongola Floodplain	W45A, W45B	W45-Pongola Floodplain

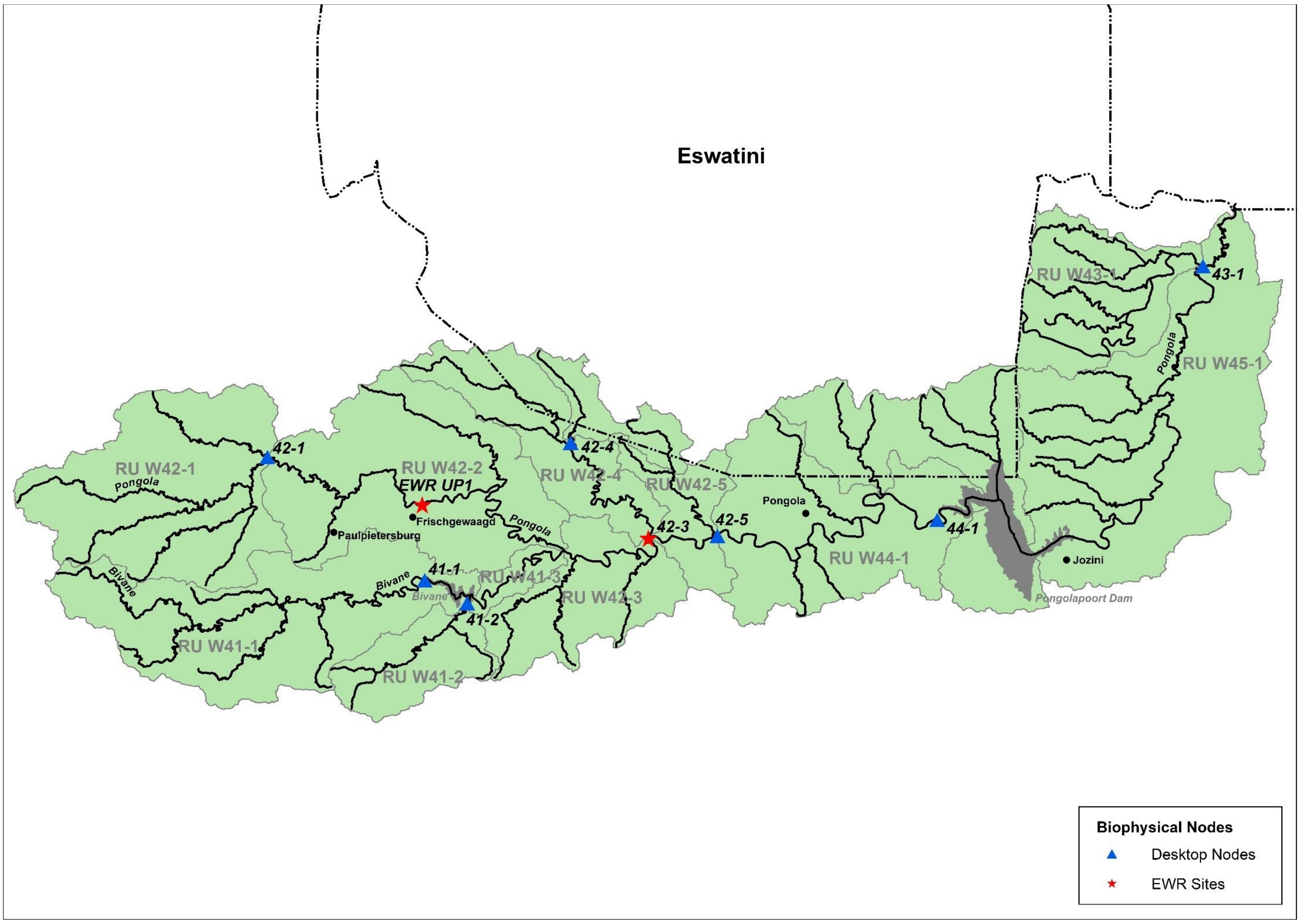

Figure A4 Resource Units located within secondary catchment W4

A5 W5 CATCHMENT

IUA	RU number	SQR number	Quaternary catchment
W51-a	W51-1	W51A-02082	W51A
W51-b	W53-1	W53A-01804	W53A
W51-b	W53-2	W53B-01694	W53B
W51-b	W54-1	W54B-01569	W54B
W52	W51-2	W51C-01981	W51C
	W51-3	**W51E-02049 (EWR AS1)**	**W51E**
	W51-4	W51F-01986	W51F
	W53-3	**W53E-01790 (EWR NG1)**	**W53E**
	W54-2	W54D-01593	W54D
W55	W55-1	W55E-01477	W55E
	W55-2	W56A-01372	W56A
	W55-pans incl. Chrissiesmeer		W55A
W57	W57-1	W57K-01929	W57K
	W57-Ndumo Pans		W57K

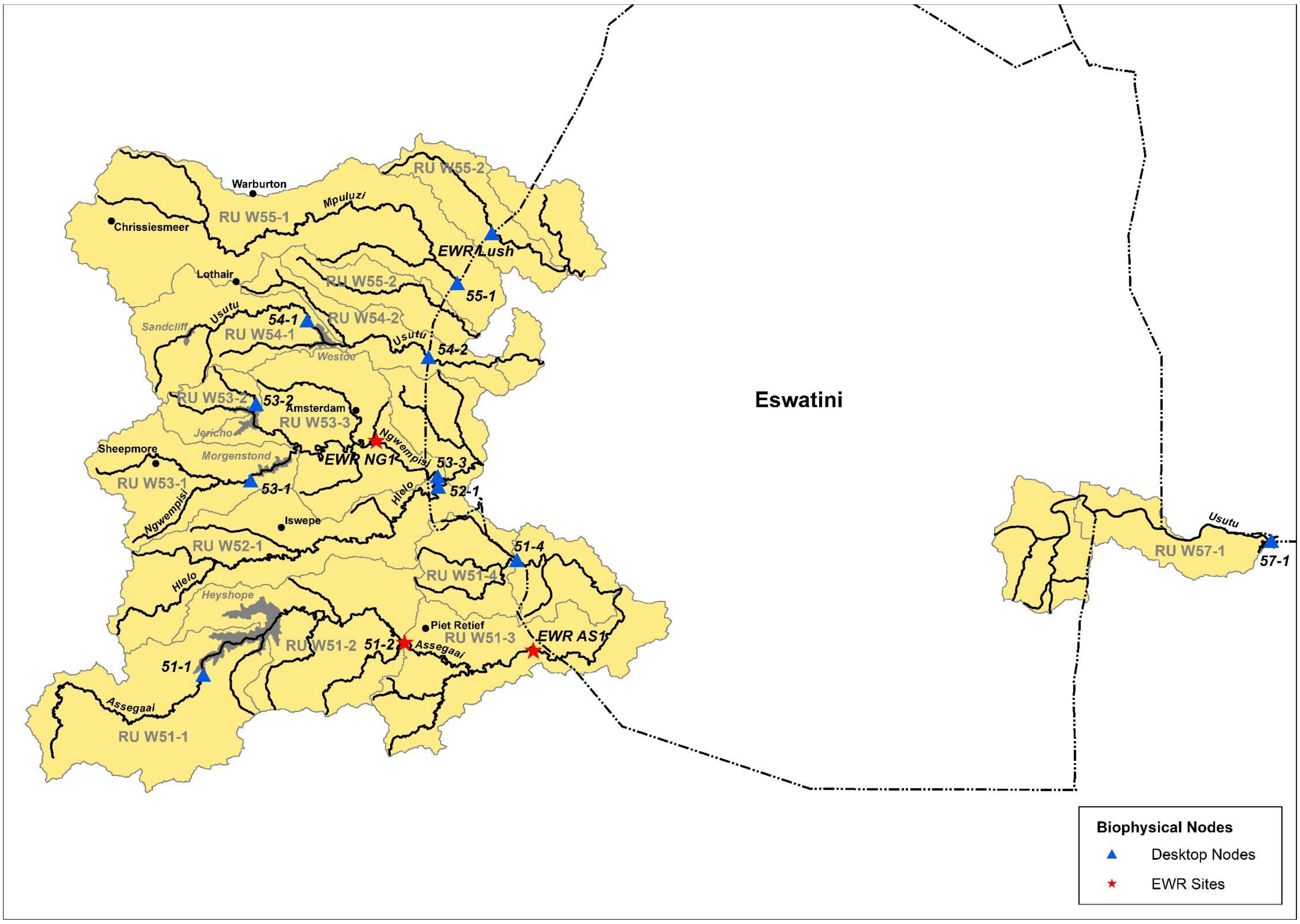

Figure A5 Resource Units located within secondary catchment W5

A6 W7 CATCHMENT

IUA	RU number	SQR number	Quaternary catchment
W70-a	W70-1	W70A-02079	W70A
	W70-Lake Sibaya	Lake Sibaya	W70A
	W70-Kosi Lakes & Estuary	Kosi Lakes & Estuary	W70A
W70-Muzi Swamps	W70-Muzi Swamps	Muzi Swamps	W70A
W70-b	W70-3	W70A-02301, W70A-02381	W70A
	W70-Lake Sibaya	W70A-02112	W70A
	W70-uMgobezeleni Estuary	uMgobezeleni Estuary	W70A

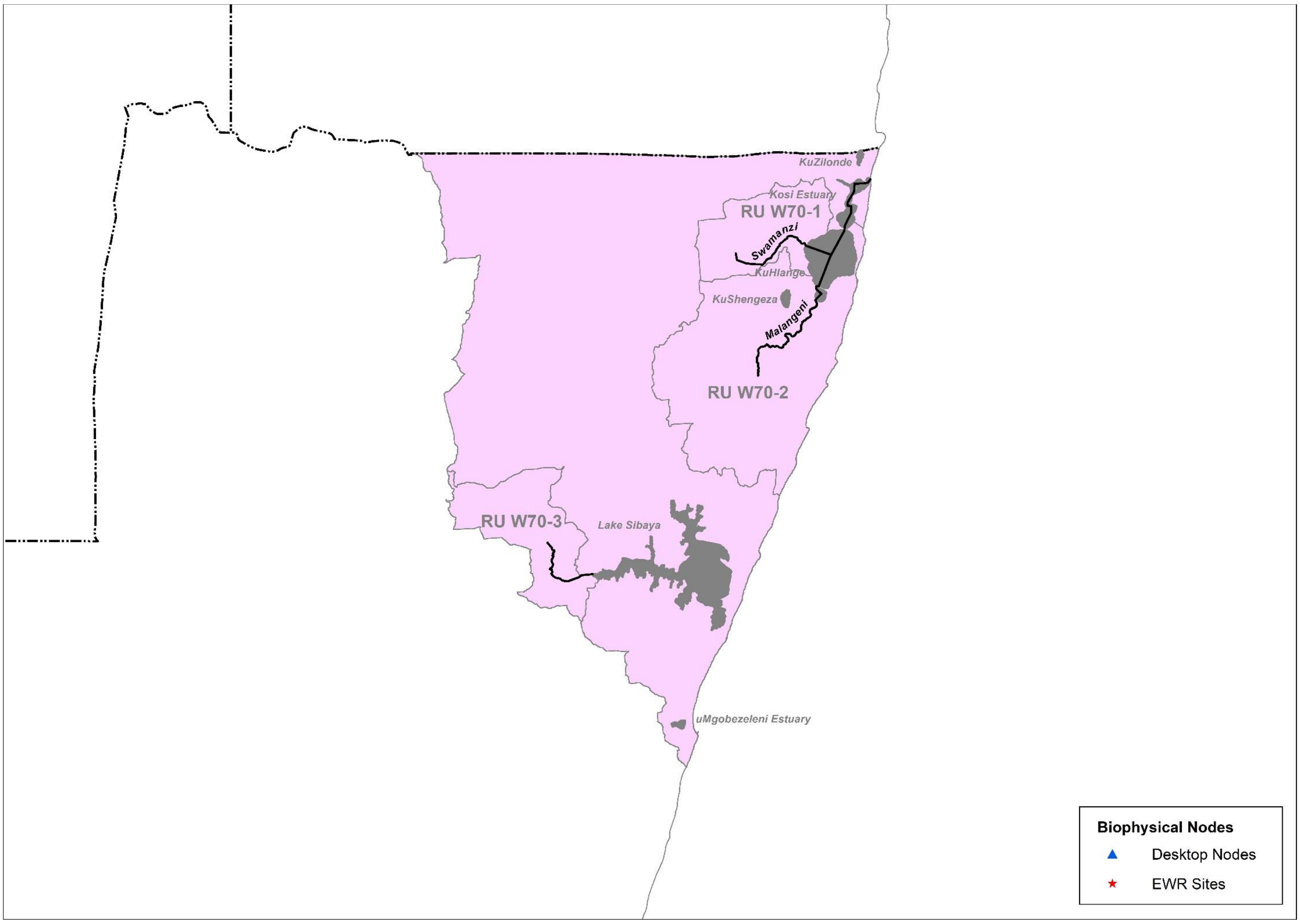

Figure A6 Resource Units located within secondary catchment W7

18 APPENDIX B: NUMERICAL LIMITS FOR TOXICS

Table B1 Water quality guidelines for aquatic ecosystems and toxic substances (DWAF, 1996a)

Toxic substance	Unit	TWQR		CEV		AEV	
		pH < 6.5	pH > 6.5	pH < 6.5	pH > 6.5	pH < 6.5	pH > 6.5
Aluminium	µg/L	≤ 5	≤ 10	10	20	100	150
Ammonia (NH_3)	µg N/L	≤ 7		15		100	
Arsenic	µg/L	≤ 10		20		130	
Atrazine	µg/L	≤ 10		19		100; 20 for the protection of aquatic plants	
Chromium (VI)	µg/L	≤ 7		14		200	
Chromium (III)	µg/L	≤ 12		24		340	
Cyanide (free)	µg/L	≤ 1		4		110	
Endosulfan	µg/L	≤ 0.01		0.02		0.2	
Fluoride	µg/L	≤ 750		1 500		2 540	
Manganese	µg/L	180		370		1 300	
Mercury (total)	µg/L	≤ 0.04		0.08		1.7	
Phenol (total)	µg/L	≤ 30		60		500	
Selenium	µg/L	≤ 2		5		30	
Zinc	µg/L	≤ 2		3.6		36	

Copper (µg/L)

Criteria	Water hardness (mg $CaCO_3$/L)			
	< 60 (soft)	60-119 (medium)	120-180 (hard)	> 180 (very hard)
TWQR	≤ 0.3	≤ 0.8	≤ 1.2	≤ 1.4
CEV	0.53	1.5	2.4	2.8
AEV	1.6	4.6	7.5	12

Lead (µg/L)

Criteria	Water hardness (mg $CaCO_3$/L)			
	< 60 (soft)	60-120 (medium)	120-180 (hard)	> 180 (very hard)
TWQR[1]	≤ 0.2	≤ 0.5	≤ 1.0	≤ 1.2
CEV[2]	0.5	1.0	2.0	2.4
AEV[3]	4	7.0	13	16

1 TWQR: Target Water Quality Range.
2 CEV: Chronic Effect Value.
3 AEV: Acute Effect Value.

Table B2 Present state rating values for toxic substances (DWAF, 2008a)

Toxic substance (µg/L)	Rating					
	0	1	2	3	4	5
Al	20	62.5	105	150	192.5	>192.5
Ammonia	15	43.75	72.5	100	128.75	>128.75
As	20	57.5	95	130	167.5	>167.5
Atrazine	19	48.75	78.5	100	129.75	>129.75
Cd soft*	0.2	0.7	1.2	1.8	2.3	>2.3
Cd mod**	0.2	0.95	1.7	2.8	3.55	>3.55
Cd hard***	0.3	1.625	2.95	5	6.325	>6.325
Chlorine (free)	0.4	1.75	3.1	5	6.35	>6.35
Cr (III)	24	115	206	340	431	>431
Cr (VI)	14	67.5	121	200	253.5	>253.5
Cu soft*	0.5	1.025	1.55	1.6	2.125	>2.125
Cu mod**	1.5	3.025	4.55	4.6	6.125	>6.125
Cu hard***	2.4	4.875	7.35	7.5	9.975	>9.975
Cyanide (free)	4	32.5	61	110	138.5	>138.5
Endosulfan	0.02	0.075	0.13	0.2	0.255	>0.255
Fluoride	1500	2510	3520	2540	3550	>3550
Pb soft*	0.5	1.625	2.75	4	5.125	>5.125
Pb mod**	1	3	5	7	9	>9
Pb hard***	2	5.75	9.5	13	16.75	>16.75
Hg	0.08	0.525	0.97	1.7	2.145	>2.145
Phenol	60	200	340	500	640	>640

*For use in soft water (Hardness less than 60mg $CaCO_3$/L).
** For use in moderately hard water (Hardness between 60 – 119 mg $CaCO_3$/L).
***For use in hard water (Hardness greater than 120 mg $CaCO_3$/L).

Note the relationship between rating and A-F categories below (DWAF, 2008a):

Rating	Deviation from reference conditions	A- F Categories	Score
0	No change	A	≥ 92.01
		A/B	>87.4 and <92.01
1	Small change	B	82.01 – 87.4
		B/C	>77.4 and <82.01
2	Moderate change	C	62.01 – 77.4
		C/D	>57.4 and <62.01
3	Large change	D	42.01 – 57.4
		D/E	>37.4 and <42.01
4	Serious change	E	22.01 – 37.4
		E/F	>17.4 and <22.01
5	Extreme change	F	0 - 17.4

19 APPENDIX C: COMMENTS AND RESPONSE REGISTER

No.	Section	Comment	From	Addressed?
WQ Comments				
1.	Section 3.1.4 Pg 3-3	Under the heading *"a) Dams"* - Are the required dam releases to support EWRs included as part of this study? And if not, it is recommended that these are included for completeness of the report.	M Singh M Maharaj R Pillay	Any flow scenarios that are routed past or through a dam using the yield/planning model will include dam releases if the scenario requires this.
2.	Pg 3-5	Table should be given a heading. According to NMMP it is the "Guidelines for assessing the potential health risk for the four water uses" – The note as per the NMMP document states *"these guidelines were developed specifically for use in the NMMP and were not tested in other contexts"*. With regard to item 2 of the table (Drinking water after limited treatment) – The explanation provided at the bottom of the table is confusing. It should be unpacked for the reader in terms of what it actually means. Based on what Geert Grobler (DWS: Head Office) had said at one of the PMC meetings, if the resource quality is within these limits, it will require some limited treatment. However, if people are utilizing the river, they are not privy to the actual *E. coli*/Faecal coliform levels on the day so they are unable to determine if the water is within those limits. Further to this, no information is provided on what "limited treatment" means. Additionally, unpack what is meant by partial or full contact so that anyone reading document understands this.	M Singh M Maharaj R Pillay	Addressed with more information provided in the text. Note it was the final decision of the meeting that the guidelines be presented as used by the NMMP.
3.	Table 13.2 Pg 13-2	RU W11-2: Narrative and numerical water quality RQOs – *"Ensure that turbidity or clarity levels stay within Acceptable limits"* - is there any background information on sediment loads or turbidity levels? Is there an understanding on the distribution of particular soil types, noting some soil types are more erodible than others. In addition, please refer to the comments made above under *point no. 2.*	M Singh M Maharaj R Pillay	Limited information is available for turbidity or clarity guidelines. Guideline development has encountered difficulties due to the high biological response variability to suspended solids exposure, suggesting that organisms are responding not only to exposure concentration and duration but also to other factors associated with suspended particles e.g., size, shape, and geochemical composition. Soil types or erodibility was therefore not considered for turbidity RQOs, with the RQO referring specifically to the suspended loads in the water and not their source. Due to the dearth of turbidity data, the approach to be followed in assessments is to understand the catchment context and consider changes in turbidity levels in relation to the known reference state or condition. Qualitative clues, rather than quantitative information, would become important in this instance.

No.	Section	Comment	From	Addressed?
4.	Table 13.3 Pg 13-3	RU W12-5: Narrative and numerical water quality RQOs ▪ *"50th percentile of the data must be less than 0.015 mg/L PO4-P (Aquatic ecosystems: driver)"* – Is it only orthophosphate where a limit is being set and not for nitrates/nitrites? ▪ In addition, please refer to the comments made above under point no. 2.	M Singh M Maharaj R Pillay	That is correct. Where nitrates/nitrites are considered the driver, RQOs will be set accordingly.
5.	Table 13.3 Pg 13-4	RU W12-6: Narrative and numerical water quality RQOs: ▪ Is there any background sediment load information available or would this involve baseline monitoring to establish a trend.	M Singh M Maharaj R Pillay	Correct. Turbidity is one of the RQOs that can only be provisional until a database has been developed and acceptable and other levels quantitatively defined.
6.	Table 13.5 Pg 13-4	RU W12-8: Narrative and numerical water quality RQOs: ▪ *"95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b)."* - Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report. ▪ Additionally, please refer to the comments made above under point no. 2.	M Singh M Maharaj R Pillay	Addressed.
7.	Table 13.6 Pg 13-4	RU W12-10: Narrative and numerical water quality RQOs: ▪ "*95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b).* - Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report.	M Singh M Maharaj R Pillay	Addressed.
8.	Table 13.7 Pg 13-5	RU W21-1, excl. iShoba River: Narrative and numerical water quality RQOs: ▪ *"50th percentile of the data must be less than 0.015 mg/L PO4-P (Aquatic ecosystems: driver)"* – Is it only orthophosphate where a limit is being set and not for nitrates/nitrites? ▪ *"95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b)."* - Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report. ▪ Additionally, please refer to the comments made above under point no. 2.	M Singh M Maharaj R Pillay	Where nitrates/nitrites are considered the driver, RQOs will be set accordingly. Addressed.
	Table 13.8 Pg 13-5	RU W21-1, iShoba River W21B-02539 – As Above.	M Singh M Maharaj R Pillay	As above.
9.	Table 13.9 Pg 13-6	Narrative and numerical water quality RQOs: ▪ *"50th percentile of the data must be less than 0.025 mg/L PO4-P (Aquatic ecosystems: driver)"* - Is it only orthophosphate where a limit is being set and not for nitrates/nitrites. ▪ *"95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b)."* - Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report. ▪ Additionally, please refer to the comments made above under point no. 2.	M Singh M Maharaj R Pillay	As above.
	Table 13.10 Pg 13-7	RU W21-7: Narrative and numerical water quality RQOs – As above.	M Singh M Maharaj	As above.

No.	Section	Comment	From	Addressed?
			R Pillay	
10.	Table 13.11 Pg 13-8	RU W22-5: Narrative and numerical water quality RQOs: ▪ *"50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver)"* - Is it only orthophosphate where a limit is being set and not for nitrates/nitrites. ▪ *"95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b)."* - Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report.	M Singh M Maharaj R Pillay	As above.
	Table 13.12 Pg 13-8	RU W23-1: Narrative and numerical water quality RQOs – As above.	M Singh M Maharaj R Pillay	As above.
11.	Table 13.13 Pg 13-9	RU W23-3: Narrative and numerical water quality RQOs: ▪ *"50th percentile of the data must be less than 0.015 mg/L PO4-P (Aquatic ecosystems: driver)"* – Is it only orthophosphate where a limit is being set and not for nitrates/nitrites? ▪ *"95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b)."* - Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report. ▪ *"Use biological monitoring data or institute biological monitoring to set an objective for biota requirements, as a proxy for monitoring biocides/fertilizers. Alternatively, institute instream toxicity testing."* – What type of toxicity testing should be used. Please elaborate on the method.	M Singh M Maharaj R Pillay	Where nitrates/nitrites are considered the driver, RQOs will be set accordingly. Addressed. Addressed in Section 3.1.
12.	Table 13.14 Pg 13-10	RU W31-1: Narrative and numerical water quality RQOs: ▪ *"50th percentile of the data must be less than 0.015 mg/L PO4-P (Aquatic ecosystems: driver)"* – Is it only orthophosphate where a limit is being set and not for nitrates/nitrites? ▪ *"95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b)."* - Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report. ▪ *"Use biological monitoring data or institute biological monitoring to set an objective for biota requirements. In situ water quality testing should be conducted with biomonitoring, particularly for pH and dissolved oxygen. Alternatively, institute instream toxicity testing"* - What type of toxicity testing should be used. Please elaborate on the method.	M Singh M Maharaj R Pillay	As above.
	Table 13.15 Pg 13-11	RU W31-4: Narrative and numerical water quality RQOs – As above.	M Singh M Maharaj R Pillay	As above.
	Table 13.16 Pg 13-11	RU W42-1: Narrative and numerical water quality RQOs – As above.	M Singh M Maharaj R Pillay	As above.

<table>
<tr><th>No.</th><th>Section</th><th>Comment</th><th>From</th><th>Addressed?</th></tr>
<tr><td>13.</td><td>Table 13.17
Pg 13-12</td><td>RU W42-2: Narrative and numerical water quality RQOs:
▪ "50th percentile of the data must be less than 0.1 mg/L PO4-P (Aquatic ecosystems: driver)" – Is it only orthophosphate where a limit is being set and not for nitrates/nitrites?
▪ "95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b)." -- Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report.
▪ Additionally, please refer to point no. 2.</td><td>M Singh
M Maharaj
R Pillay</td><td>Where nitrates/nitrites are considered the driver, RQOs will be set accordingly.

Addressed.</td></tr>
<tr><td>14.</td><td>Table 13.18
Pg 13-13</td><td>RU W43-1: Narrative and numerical water quality RQOs:
▪ "50th percentile of the data must be less than 0.025 mg/L PO4-P (Aquatic ecosystems: driver)" - Is it only orthophosphate where a limit is being set and not for nitrates/nitrites.
▪ "95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b)." - Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report.
▪ "Institute biological monitoring data as a check on biotic state, considering possible extensive use of biocides/fertilizers. Alternatively, institute instream toxicity testing." - What type of toxicity testing should be used. Please elaborate on the method.</td><td>M Singh
M Maharaj
R Pillay</td><td>Where nitrates/nitrites are considered the driver, RQOs will be set accordingly.

Addressed.

Addressed in Section 3.1.</td></tr>
<tr><td rowspan="3">15.</td><td>Table 13.19
Pg 13-13</td><td>RU W44-1: Narrative and numerical water quality RQOs:
▪ "Institute biological monitoring data as a check on biotic state, considering probable extensive use of biocides/fertilizers. A highly impacted RU, where analysis of Persistent Organic Pollutants (POPs) is highly recommended. Alternatively, institute instream toxicity testing" - What type of toxicity testing should be used. Please elaborate on the method.
▪ "95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b)." - Please include the TWQR for toxics as per DWAF (1996a) and DWAF (2008b) as an appendix in the report for ease of reference and completeness of the RQO report.
▪ Additionally, please refer to point no. 2.</td><td>M Singh
M Maharaj
R Pillay</td><td>Addressed in Section 3.1.

Addressed.</td></tr>
<tr><td>Table 13.20
Pg 13-13</td><td>RU W45-1: Narrative and numerical water quality RQOs – As above.</td><td>M Singh
M Maharaj
R Pillay</td><td>As above.</td></tr>
<tr><td>Table 13.27
Pg 13-19</td><td>RU W70-3: Narrative and numerical water quality RQOs – As above.</td><td>M Singh
M Maharaj
R Pillay</td><td>As above.</td></tr>
<tr><td>16.</td><td>Whole report</td><td>This is applicable to all the Tables for the water quality RQOs: Section on Toxics – "other variables" – Please stipulate the variables and include the TPC for the A Category range in DWAF (2008b), or the Target Water Quality Range (TWQR) as stated in DWAF (1996a) as an appendix in the report for ease of reference and completeness of the RQO report. Often those who read this document will prefer to have all the relevant information within the body of one document to prevent errors and limit confusion and uncertainty as to what limits/values need to be adhered to.</td><td>M Singh
M Maharaj
R Pillay</td><td>Addressed.</td></tr>
</table>

No.	Section	Comment	From	Addressed?
17.	Whole report	This is applicable to all the Tables with the water quality RQOs: at the bottom of the table, it states [#] *Low confidence. EcoSpec and TPC boundaries may need adjusting as data becomes available."* – Whose responsibility is it to adjust the EcoSpecs and TPC boundaries as more data becomes available. The Region views this as a function of DWS: Head office as it has implications for the gazetted RQOs.	M Singh M Maharaj R Pillay	Note that the recommendation from the PSP would be that Low confidence RQOs not be gazetted. EcoSpec and TPC boundaries can only be adjusted based on additional data.
18.	Table 8.3 - 8.5 Pg 8-4 – 8-6	These Tables provide EcoSpecs and TPCs for the immediate, short term and long-term horizon. Please define these horizons – what time scale is applicable to each?	M Singh M Maharaj R Pillay	Time horizons are defined in the text above Table 8.3, with short-term being 5 years and long-term being 10 years.
19.	Table 12.1 Pg	All Tables in Chapter 12: EcoSpecs and TPCs - RQOs are linked to a category, but I see no indication of a category for any of these sites without EWRs.	C Thirion	TECs for the relevant RUs added.
Riparian vegetation				
20.	Table 4.5 Pg 4-5	Riparian vegetation EcoSpecs and TPCs: There are references made to a zone and/or sub-zone in a zone – Please map/geolocate the zone or sub-zone being referred to. Has this been demarcated in a Google Earth KML file to show the locations of the marginal/lower zone, flood features/upper zone, MCB, floodplain and riparian zone? Please advise further.	M Singh M Maharaj R Pillay	It would not be useful or meaningful to try show these zones on a satellite image. The resolution will likely just cause confusion. The assessor needs to determine these on site according to the channel morphology, vegetation distribution and profile of the site. The zones should be easily identifiable to anyone who is confident with the use of VEGRAI.
	Table 5.4 Pg 5-4			
	Table 6.4 Pg 6-4			
21.	Table 7.5 Pg 7-4			
22.	Table 8.6 Pg 8-8			
23.	Table 9.4 Pg 9-4			
24.	Section 12.1.2 Pg 12-1	Dominant vegetation cover - Are they also common in the Usutu Catchment?	M Sekoele	Yes, this has been added to the report.
25.	Table 4.4 Pg 4-5	An increase in woody species cover above 20% in the zone. A decrease in non-woody cover (% aerial) below 40% in the zone. If your RQO is <10% your TPC cannot be >20%. The TPC is a value while it is still in the REC but moving towards a lower EC. The same comment applies to non-woody species.	C. Thirion	Yes, exactly. This zone is dominated by non-woody vegetation but should still have a non-dominant woody component. The quality objective is to keep it low i.e., less than 10% but if it should go above the REC will not have changed yet. The level of probable concern, however, i.e., the point at which the REC is in jeopardy of deterioration is if it continues to increase above 20% i.e., it's not a strict line in the "sand" but allows for oscillation within a range.
26.		I am in support of the TPC vs. RQO/EcoSpec comments by Christa. The TPC needs to be a warning bell before the change that will affect the category change occurs. I had a look at the riparian vegetation, the TPCs actually sound like the narrative in some instances but also	N Jafta	Refer to comment 25 response.

<table>
<tr><th>No.</th><th>Section</th><th>Comment</th><th>From</th><th>Addressed?</th></tr>
<tr><td></td><td></td><td>TPC that would be too late to be warning in other instances. Below are some random examples.

<table>
<tr><th>Assessed metric</th><th>EcoSpec</th><th>TPC</th></tr>
<tr><td>Reed cover (% aerial)</td><td>Maintain reed cover (% aerial) below 10% in the zone.</td><td>An increase in reed cover above 10% in the zone (it would be too late)</td></tr>
<tr><td>Dominant vegetation type</td><td>The dominant vegetation type in the zone was and should remain a mixture of woody and non-woody vegetation, but also with open (unvegetated) sandy areas.</td><td>An absence of non-woody riparian vegetation or an increase in non-woody vegetation cover above 50%. An absence of woody riparian vegetation or an increase in woody vegetation cover above 70%.</td></tr>
<tr><td>Indigenous riparian woody species cover (% aerial)</td><td>Maintain indigenous riparian woody species cover above 50% in the zone.</td><td>A decrease in indigenous woody species cover below 40% in the zone (it sounds too late)</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td colspan="5">GENERAL</td></tr>
<tr><td>27.</td><td>Table 2-1
Pg IX and 2-2</td><td>The Report states that this is “Linked to EWR BM2 and WM1” – The Report does not include any EWR requirements and EcoSpecs and TPCs for EWR BM2. Please clarify if this was omitted or if BM2 should refer to BM1 instead.</td><td>M Singh
M Maharaj
R Pillay</td><td>Addressed.</td></tr>
<tr><td>28.</td><td></td><td>The draft Reconciliation report for the Umfolozi catchment has been completed. The information in the text box below is an extract from the said Report. Please elaborate how the proposed EWRs impact on the proposed dam/s developments in the catchment and the subsequent water supply security for water users?

“Proposed Lake Nkata Off Channel Storage Dam

A number of proposed dams have previously been considered in the Umfolozi catchment. These are summarised in the Screening of Dam Options Report, prepared as part of this study. After completion of the water balances, the indication is that there are deficits in the lower Umfolozi catchment resulting from increasing domestic requirements, as well as the environmental requirement to maintain an open river mouth.

Based on the requirements, and the proposed dam yields, the preferred option appears to be the Lake Nkata off channel storage dam. Previous assessments were undertaken on four dam sizes ranging from 30 million m^3 to 78 million m^3 and diversion capacities of 2 m^3/s and 2.5 m^3/s. Updated analyses were undertaken to determine whether the</td><td>M Singh
M Maharaj
R Pillay</td><td>The feasibility investigations of the proposed dams is supposed to take into consideration the provision of the set EWR.</td></tr>
</table>

No.	Section	Comment	From	Addressed?
		proposed dam would be able to supply the growing requirements of Matubatuba and Mpukunyoni WSSs as well as the minimum flows at the mouth."		
29.		Please include co-ordinates of all sites where monitoring needs to be undertaken (EWRs, high priority RUs, etc.). This can be included in the Implementation Plan being prepared as part of the study. The monitoring plan indicating frequency, what needs to be monitored and locations must be addressed in the Implementation Plan.	M Singh M Maharaj R Pillay	Noted.
30.		It is indicated in the report that "The full EWR rule is provided as part of the electronic data for the project." – it is requested that this information is sent to the Region as soon as the study has been finalised. Is there a reason why this is not included in the Report.	M Singh M Maharaj R Pillay	The reason is that this will consist of a large number of pages with just numbers on – has never been included in these reports. Regarding the data to be sent through to the Region – this should be requested from the DWS project manager as it forms part of the project deliverables.
31.	Exec sum Pg x	Not sure why the text here is in red.	R Cedras	This is to indicate that information forms part of Volume 2. Text adjusted.
32.	Spelling Pg xxiii	Various spellings of Estuaries.	R Cedras	No. As stated below the table the names adopted in the estuaries report are the official names assigned to the systems in the 'South African National Ecosystem Classification System' (and the *KwaZulu-Natal Department of Economic Development* and *Environmental Affairs) (*Dayaram *et al.*, 2021).
33.	Sec 3.1.2	Please make sure that the categories A-F mentioned here are matching those listed below, i.e. A-D.	R Cedras	Addressed.
34.	Table 2.1 Pg 2-3	W53-3: What about RU W53-3, Ngwempisi River, EWR NG1?	M Sekoele	Addressed.
35.	Chapter 4-12	An IUA map showing the RUs catchments within the IUA and the EWR site would be useful for visualisation.	M Sekoele	Addressed. Maps added as Appendix A.
36.	Exec Sum Pg x	It is difficult to relate this table to actual site localities unless you are very familiar with the catchment and RUs. I would suggest that you add a column indicating the SQ Reach to make it easier for those of us who are not that familiar with the numbering system used. The next table includes the SQ reach numbers and it is much easier to follow.	C Thirion	An appendix has been included that provides the SQs that make up the RUs. The EWR sites as well as relevant historical EWR sites have been included in brackets behind the SQ within which they are situated in. Note that the next table (water quality; also Table 2.2 in the document) is different in that it refers to the specific SQ within the RU that has a water quality issue or is a hotspot. This is different than the table in question where the PES and priority score is a weighted average of all the SQs in the RU, except where there are EWR sites.

No.	Section	Comment	From	Addressed?
37.	Exec Sum Pg x	W54-1: Considering the Drainage region, this RU is very far downstream of the EWR site high up in the catchment. Is it realistic for it to be the same PES? I am not sure what "linked to EWR UP1" means.	C Thirion	This does not imply that it is the same PES. Linked to EWR site is in terms of the hydrological regime in that the EWRs is extrapolated from the high confidence EWR sites. So relevant for hydrological RQOs. Explanation is now provided in report.
38.	Table 2-1 Pg 2-2	You have to at least give some description of the RUs in this report as well. It is unfair to expect the reviewer to refer back to another report just to figure out which area to look at. The map shows the EWR sites but not the RUs linked to the EWR sites e.g. W12-3 linked to historical EWR3. How is the reviewer supposed to know where historical EWR 3 is.	C Thirion	EWR 3 is now plotted on the study area map and in the appendix.
39.		It is difficult to figure out where the RUs are without a description in the table. Figure 1.1 only indicated the drainage regions not the RUs.	C Thirion	Addressed. Maps and SQs associated with RUs are provided in Appendix A.
40.	Section 3.4.1 Pg 3-3	Note that monitoring data to be collected for measurement against RQOs that are immediately applicable and to be gazetted, should be collected from **the monitoring sites as identified in the water quality Reserve documentation, if possible** - Although I agree with this in principle, when EWR sites are selected, the routine monitoring to be conducted at these sites should also be considered. If an EWR site is located in an area that is logistically difficult and time consuming to reach, the monitoring becomes problematic.	C Thirion	Text updated. Note that data used for present state analyses, and subsequently RQO development, are from routine water quality monitoring points.
41.	Chapter 3 Pg 3-1	The RQOs will be broader and less detailed and this is inherently the case as fieldwork has not been undertaken - But there may be recent information available from other sources such as REMP surveys. You have to source and use all available information not just the results from your own surveys.	C Thirion	Project leaders requested supporting information from all relevant institutions (IUCMA, Regional DWS office, etc.) at the onset of the study. All information available to the team at the time of the study was incorporated in the report.
EWRS				
42.	Table 7.1 Pg 7-1	Flow RQOs (EWRs) for EWR BM1: Please recheck the % of nMAR under the Total Flow EWR. It is recorded as 26.1% but it appears that it should be 27.3%. Please verify.	M Singh M Maharaj R Pillay	Data was checked and % nMAR is correct.
FISH				
43.	Section 3.3.1 Pg 3-8	The FROC under the PES is used as the RQO/EcoSpecs for the reach and any **deviation (decrease) by one FROC category of the PES can be seen as a Threshold of Potential Concern (TPC)** - The TPC should be within the REC range as it indicates a danger of the EC deteriorating to a worse condition. What about the TPCs for the FRAI category?	C Thirion	Changed as requested.
44.		1 = Present at very few sites (<10%) - This should be less than or equal.	C Thirion	Changed as requested.
45.		The second approach (second table) of RQOs/EcoSpecs and TPCs were aimed to be metric specific and can be applied on both EWR reach and EWR site levels - Is there a reference for this approach?	C Thirion	No, it is an approach that was developed over the years doing Reserve studies.
46.	Section 3.3.2 Pg 3-8	IUCMA EcoStatus monitoring report (IUCMA, 2020) - Did you also use the later information from the IUCMA? They are conducting annual monitoring at a reduced number of sites.	C Thirion	All information that was available at the time of this study was utilised.

<table>
<tr><th>No.</th><th>Section</th><th>Comment</th><th>From</th><th>Addressed?</th></tr>
<tr><td>47.</td><td>Table 4.5
Pg 4-5</td><td>FROC<4 (present at <50% of suitable sites sampled in reach) - If the REC is 4.5, then your TPC should be close to but >4.5 maybe 4.6.</td><td>C Thirion</td><td>The conventional FRAI uses only full numbers, 0,1,2,3,4,5) for FROC values, but decimals were included for finer scale evaluation purposes. Due to the variability of FROC values by users (since it is based on actual data and habitat derived interpretation), it is not sensitive enough to consider small decimal changes (such as 4.6). Furthermore, a change of FROC by one unit (say from 5 to 4) for one species should not result in a decrease of EC to a lower category. Therefore, the current approach and scoring will be retained in the report.</td></tr>
<tr><td>48.</td><td>Table 4.6
Pg 4-8</td><td>Decrease of PES into a lower EC than PES (<B) - The TPC should still be in a B but in the lower end of the B maybe 83 or 82.5%</td><td>C Thirion</td><td>Not changed. Report information correct.</td></tr>
<tr><td colspan="5">INVERTEBRATES</td></tr>
<tr><td>49.</td><td rowspan="3">Table 3.2
Pg 3-10</td><td>The information is not correct. You need to use the preferences in MIRAIv2.
<table>
<tr><th></th><th>Velocity metrics</th><th></th><th></th><th></th><th>Habitat metrics</th><th></th><th></th><th>Water Qaulity</th><th></th></tr>
<tr><th>Taxon</th><th><0.1</th><th>0.1-0.3</th><th>0.3-0.6</th><th>>0.6</th><th>COBBLES</th><th>VEG</th><th>GSM</th><th>SENSITIVITY</th><th>SASS QV</th></tr>
<tr><td>Atyidae</td><td>4</td><td>3.5</td><td>0.5</td><td>0</td><td>1</td><td>4.5</td><td>0.5</td><td>MODERATE</td><td>8</td></tr>
<tr><td>Paleomonidae</td><td>0.5</td><td>2</td><td>2</td><td>3</td><td>3</td><td>3</td><td>1</td><td>MODERATE</td><td>10</td></tr>
<tr><td>Perlidae</td><td>0.5</td><td>3</td><td>4</td><td>3.5</td><td>4</td><td>0.5</td><td>1.5</td><td>HIGH</td><td>12</td></tr>
<tr><td>Heptageniidae</td><td>1</td><td>4</td><td>4.5</td><td>3</td><td>4.5</td><td>0.5</td><td>1.5</td><td>HIGH</td><td>13</td></tr>
<tr><td>Leptophlebiidae</td><td>2</td><td>3.5</td><td>4.5</td><td>3.5</td><td>4</td><td>1</td><td>3.5</td><td>MODERATE</td><td>9</td></tr>
<tr><td>Prosopistomatidae</td><td>0.5</td><td>1</td><td>2</td><td>4</td><td>4</td><td>0</td><td>3.5</td><td>HIGH</td><td>15</td></tr>
<tr><td>Trichorythidae</td><td>0.5</td><td>2</td><td>3.5</td><td>4.5</td><td>4.5</td><td>1</td><td>0.5</td><td>MODERATE</td><td>9</td></tr>
<tr><td>Coenagrionidae</td><td>4.5</td><td>3.5</td><td>2</td><td>2</td><td>0.5</td><td>4.5</td><td>0.5</td><td>LOW</td><td>4</td></tr>
<tr><td>Gomphidae</td><td>4.5</td><td>4</td><td>3</td><td>2.5</td><td>2.5</td><td>1</td><td>4.5</td><td>LOW</td><td>6</td></tr>
<tr><td>Pyralidae</td><td>1</td><td>1</td><td>3.5</td><td>3.5</td><td>3</td><td>3</td><td>0</td><td>HIGH</td><td>12</td></tr>
<tr><td>Hydropsychidae >2</td><td>1</td><td>2.5</td><td>4</td><td>4.5</td><td>4.5</td><td>1</td><td>1.5</td><td>HIGH</td><td>12</td></tr>
<tr><td>Philopotamidae</td><td>0.5</td><td>1.5</td><td>3.5</td><td>4.5</td><td>4.5</td><td>1</td><td>0.5</td><td>MODERATE</td><td>10</td></tr>
<tr><td>Elmidae</td><td>1.5</td><td>3</td><td>4</td><td>4.5</td><td>4</td><td>1</td><td>3.5</td><td>MODERATE</td><td>8</td></tr>
<tr><td>Psephenidae</td><td>2.5</td><td>3.5</td><td>4.5</td><td>4</td><td>4.5</td><td>0.5</td><td>1</td><td>MODERATE</td><td>10</td></tr>
</table></td><td>C Thirion</td><td>Values updated and corrected in the report according to Thirion comment.</td></tr>
<tr><td>50.</td><td>Paleomonidae – Please remove.</td><td>C Thirion</td><td>Paleomonidae was included to address the aspect of invertebrate movement/migration and migration barriers in the system. However, it was removed as suggested by Thirion.</td></tr>
<tr><td>51.</td><td>Pyralidae - Please use the latest family name “Crambidae” not the old name as was used in the MIRAI. The MIRAI needs some updating to account for the latest taxonomic changes.</td><td>C Thirion</td><td>Crambidae is not a good indicator, and was removed from the indicator list.</td></tr>
<tr><td>52.</td><td>Section 3.4.1
Pg 3-11</td><td>Relevant historic data and observations from surveys in the catchment - Did you also use the latest REMP data from the IUCMA and DWS KZN region? I have the information, but nobody requested it.</td><td>C Thirion</td><td>Project leaders requested supporting information from all relevant institutions (IUCMA, Regional DWS office, etc.) at the onset of the study. All</td></tr>
</table>

No.	Section	Comment	From	Addressed?
				information available to the team at the time of the study was incorporated in the report.
53.		SASS Data Interpretation Guidelines (Dallas, 2007) - DWS does not support this method.	C Thirion	Guidelines were used to aid understanding but have now been removed. Only SASS and MIRAI scores have been used.
54.	Section 4.6	Please include your reference conditions as an appendix if need be. Also provide some kind of indication of the present SASS scores and ASPT to allow the reviewer to assess the RQOs and TPS sensibly.	C Thirion	As stated in the inception report, the MIRAI, as compiled by Ms C Todd during the Reserve study would be used as part of the current study (no budget allocated to repeat invertebrate sampling). The reference conditions and observed SASS and ASPT scores were included in the EcoClassification report. Reference and present conditions will now be included in this report. The information regarding the reference conditions and present SASS information are included in the second paragraph at all the site discussions.
55.	Table 4.7 Pg 4-10	Perlidae: Single individual sampled in summer 2015. Not a good indicator for this site.	C Thirion	Perlidae was also sampled during the 2014 reserve survey, however, Thirion comment accepted and Perlidae removed here as an indicator.
56.		Hydropsychidae >2spp: Only found once in September 2019; 2spp Hydropsychidae occurred more frequently.	C Thirion	Hydropsychidae >2spp was sampled during the 2014 reserve survey, however, Thirion comment accepted and Hydropsychidae >2spp is replaced by Hydropsychidae 1 or 2spp as an indicator.
57.		Philopotamidae: Velocity preference>0.6, see comments in table 3.2, Only occurred in 3 of the 17 sampled.	C Thirion	Velocity preferences all rectified in report. Philopotamidae was sampled during the 2014

No.	Section	Comment	From	Addressed?
				reserve survey (Abundance = A) and identified as an indicator.
58.		Elmidae: Never been recorded.	C Thirion	Elmidae was sampled during the 2014 reserve survey (Abundance = A), however, Thirion comment accepted and Elmidae removed as an indicator.
59.		Leptophlebiidae: Only occurred in 4 of the 17 samples but was recorded in the last 2 samples June and September 2023).	C Thirion	Leptophlebiidae was sampled during the 2014 reserve survey (Abundance = B) and identified as an indicator.
60.		Atyidae: Recorded in all 17 samples.	C Thirion	Atyidae was sampled during the 2014 reserve survey (Abundance = B) and identified as an indicator.
61.		Coenagrionidae: Recorded in all 17 samples.	C Thirion	Coenagrionidae was sampled during the 2014 reserve survey (Abundance = A) and identified as an indicator.
62.		Gomphidae: Recorded in 8 of the 17 samples but not in September 2023.	C Thirion	Gomphidae was sampled during the 2014 reserve survey (Abundance = B) and identified as an indicator.
63.	Table 4.8 Pg 4-10	These SASS scores seem very high for a B/C and I think the ASPTs may be a bit low. What is your reference SASS and ASPT? The REMP site located in the next SQR just downstream of the Nyezane River is also in a B/C condition and the highest SASS score recorded there is 160. I have 17 data sets from Autumn 2015 to September 2023 ranging from 24 to 160 and ASPT ranging from 4.5-6.7).	C Thirion	SASS level set to 180 t0 204 (2014 level) and ASPT increased to 6.7 (see Thirion comment).
64.		Not correct, a B/C is >77.99 <82.	C Thirion	Corrected throughout the report.
65.		Paleomonidae: This is not a good indicator and would only be expected sporadically. The reference FROC is very low. Rather use another indicator such as Psephenidae or Aeshnidae.	C Thirion	Paleomonidae removed as an indicator and Philopotamidae moved to correct velocity. Psephenidae and Aeshnidae absent during Reserve Study (2014).
66.	Section 5.6 Table 5.8	DWS does not support the use of the biological bands. Use the SASS data and your MIRAI results to link the SASS and ASPT ranges to the relevant category.	C Thirion	Removed info regarding biological bands.
67.		I only have 1 data set for the Nseleni for July 2014. The SASS was 140 and the ASPT 5.4. I think the ASPT RQO of >5 is too low for a B/C.	C Thirion	Values according to Todd (2014 reserve survey); values inserted

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				in second paragraph of Section 5.6. ASPT RQO of below 5.5.
68.		See earlier comment re the correct range.	C Thirion	All the values in the report corrected as proposed.
69.		Why not Atyidae as well? Did you collect it?	C Thirion	Atyidae (abundance B) was sampled during the 2014 reserve survey and listed above - thus included as proposed by Thirion.
70.	Section 6.6 Table 6.7	Hydropsychidae >2spp: Not recorded in any of my 4 data sets, only 1 sp and 2 spp.	C Thirion	Hydropsychidae 2 spp was sampled during the 2014 reserve survey and replaces Hydropsychidae >2 spp.
71.		Paleomonidae: Not recorded in my 4 data sets.	C Thirion	Paleomonidae removed as an indicator species in the report.
72.		Tricorythidae: Only recorded in May 2018.	C Thirion	Tricorythidae was sampled during the 2014 reserve survey. (Abundance = A) and identified as an indicator.
73.		Heptageniidae: Not recorded in my 4 data sets.	C Thirion	Heptageniidae (A) was sampled during the 2014 reserve survey. Will be removed since not recorded any other time (Thirion).
74.		Elmidae: Single individual recorded in Nov 2017.	C Thirion	Elmidae (A) was sampled during the 2014 reserve survey. Will be removed due to low recording rate any other time (Thirion).
75.		Leptophlebiidae: Present in all 4 samples.	C Thirion	Leptophlebiidae was sampled during the 2014 reserve survey (Abundance = A) and identified as an indicator.
76.		Atyidae: Only resent in 2 of the 4 samples.	C Thirion	Atyidae was sampled during the 2014 reserve survey (Abundance = A) and identified as an indicator.
77.		Coenagrionidae: Present in all 4 samples.	C Thirion	Coenagrionidae was sampled during the 2014 reserve survey (Abundance = A) and identified as an indicator.

No.	Section	Comment	From	Addressed?
78.	Table 6.8 Pg 6-9	DWS does not support the use of the biological bands.	C Thirion	Removed as requested.
79.		What was your SASS score and ASPT? The SASS scores seem high for a B/C. I have 4 data sets for this site (May 2017-May 2018) and the highest SASS score was 127. I got a C category for 2017/2018 Hydrological year.	C Thirion	See info just before Table 6.7: According to the MIRAI compiled by C. Todd as part of the initial Reserve Study (2014), the reference condition for Site WM1 was established as: SASS 220 and ASPT 7, while a SASS 152 and ASPT 6.08 were recorded at the site at the time of the 2014 reserve survey (no recent data was available at the time of the current study). TPC adapted: ASPT below 6.1 and SASS 155 as proposed by Thirion.
80.	Section 7.6 Table 7.7	I only have 2 data sets from July 2014 & May 2017. Of this list of indicator taxa only Atyidae, Coenagrionidae & Gomphidae were present in both samples. >2spp Hydropsychidae, Tricorythidae & Crambidae were not recorded. Psephenidae, Perlidae, Palaemonidae, Philopotamidae, Heptageniidae, Elmidae & Leptophlebiidae were only recorded in 2014.	C Thirion	Making use of the info supplied by Thition, the following indicator taxa were removed: Paleomonidae, Tricorythidae and Crambidae. All the other listed taxa were recorded at least 2 out of 3 surveys.
81.	Table 7.8	This is a very broad range. The only data I have for this site is SASS5 of 210 & 100 and ASPT of 6.8 & 5.3. What were your scores?	C Thirion	See info just before Table 7.7. Thirion mentioned SASS scores of 100 and 210, which are not far removed from the 120-200 range suggested.
82.	Section 8.6 Table 8.9	Atyidae: Present in last 3 samples.	C Thirion	Atyidae was sampled during the 2014 reserve survey (Abundance = B) and identified as an indicator.
83.		Coenagrionidae: Present in all 4 samples.	C Thirion	Coenagrionidae was sampled during the 2014 reserve survey (Abundance = B) and identified as an indicator.
84.		Gomphidae: Only present in 2011 7 2014.	C Thirion	Gomphidae was sampled during the 2014 reserve survey (Abundance = B) and identified as an indicator.

No.	Section	Comment	From	Addressed?
85.	Table 8.10 Pg 8-14	I have 4 data sets for this site Feb 2004 to July 2014. SASS scores range from 27 to 131 in 2014 with ASPTs ranging from 4.8-6.8 (5.7 in 2014).	C Thirion	Noted.
86.		This is below the lower end of your EcoSpec (>5).	C Thirion	Amended to ASPT 5.1.
87.		This does not make sense. The EC is determined for the whole assemblage not for "species with a requirement for unmodified water quality.	C Thirion	Addressed.
88.		Why 2 difference tables for the same category TEC?	C Thirion	Addressed.
89.	Table 9.7 Pg 9-10	Only dataset I have is from July 2014.	C Thirion	The initial Reserve Study (2014) was used.
90.		Palaemonidae: You cannot use them as indicators they cannot get over the Pongolapoort Dam.	C Thirion	Removed as an indicator.
91.		Tricorythidae: Not present in 2014.	C Thirion	Removed as an indicator due to absence (Thirion).
92.		Atyidae: Not present in 2014.	C Thirion	Removed as an indicator due to absence (Thirion).
93.	Table 10.7 Pg 10-9	Psephenidae: Only found in 2014 and 2019.	C Thirion	Moved to correct velocity group; found during 2014 Reserve Study (Abundance = A).
94.		Hydropsychidae >2spp: Found 4 times, last found in 2020.	C Thirion	Found during 2014 Reserve Study (Abundance = B)
95.		Tricorythidae: Never recorded.	C Thirion	Not found during 2014 Reserve, removed as an indicator
96.		Heptageniidae: Occurred in all 6 samples.	C Thirion	Found during 2014 Reserve Study (Abundance = 1).
97.		Elmidae: Occurred in all 6 samples.	C Thirion	Moved to correct velocity group; found during 2014 Reserve Study (Abundance = A).
98.		Leptophlebiidae: Occurred in all 6 samples.	C Thirion	Found during 2014 Reserve Study (Abundance = A).
99.		Psephenidae: Only found in 2014 and 2019.	C Thirion	Found during 2014 Reserve Study (Abundance = A).
100.		Atyidae: Found 3 times, last occurred in 2019.	C Thirion	Found during 2014 Reserve Study (Abundance = A).
101.		Gomphidae: Not present in 2019.	C Thirion	Found during 2014 Reserve Study (Abundance = A).
102.	Table 10.8 Pg 10-9	REMP site approximately 3km upstream. MIRAI ranged from B/C (78.2%) in 2018/19 to a C category (71.6-76.8) in 2019/20 to 2021/22). I have 6 data sets from July 2014 to Aug 2022.	C Thirion	Thirion information noted and used.

No.	Section	Comment	From	Addressed?
103.		At an ASPT of 6, the siter will no longer be in a B/C category. If your EcoSpec is >6.3 for a B/C the TPC should be higher than 6.3 as it is supposed to indicate a likelihood of the site changing from a B/C to a C. You should also provide TPCs for SASS scores not just ASPT.	C Thirion	Adjusted TPC accordingly.
104.		The Ref SASS score for the REMP site is 240 and the SASS scores ranged from 158-214. Ref ASPT is 7 with recorded ASPT ranging from 6.1-6.9. the EcoSpec values do not match a B/C. The recorded SASS scores range from 158-214 and the ASPTs from 6.1-6.9.	C Thirion	The project brief was to use the EWR 2014 data for the current review. See reference conditions in paragraph before Table 10.7.
105.	Table 11.7 Pg 11-9	Psephenidae: Always present.	C Thirion	Psephenidae – were found during the 2022 project survey (Abundance 1).
106.		Hydropsychidae >2spp: Found in 8 samples, not present since 2019.	C Thirion	Hydropsychidae >2spp – were found during the 2022 project survey (Abundance A).
107.		Tricorythidae: Always present.	C Thirion	Tricorythidae – were found during the 2022 project survey (Abundance B).
108.		Philopotamidae: Found in 10 samples. Always present since 2015.	C Thirion	Philopotamidae – were found during the 2022 project survey (Abundance A).
109.		Heptageniidae: Always present.	C Thirion	Heptageniidae – were found during the 2022 project survey (Abundance A).
110.		Leptophlebiidae: Always present.	C Thirion	Leptophlebiidae were found during the 2022 project survey (Abundance B).
111.		Crambidae: Only present in Sept 2001 7 March 2015.	C Thirion	Crambidae – Removed as an indicator.
112.		Coenagrionidae: Always present.	C Thirion	Coenagrionidae – were found during the 2022 project survey (Abundance A).
113.	Table 11.8 Pg 11-9	The % seems very high although I do not dispute that it might be in a B condition. The REMP site is approximately 230m downstream and has been in a B/C condition since 2019/20. The last time it was in a B category was in 2018/19 and the MIRAI % was only 82.01.	C Thirion	IUCMA (2020) used as a guideline for the PES. Site was sampled in 2022 and the MIRAI resulted in a B.
114.		This seems low. The REMP site has 12 data sets from Aug 1999 to Aug 2022 with SASS scores ranging from 160-278 and ASPT from 6.2 to 6.9. I would expect the B values to be in the higher ranges.	C Thirion	Increased it to 200 to 250. ASPT below 6.6 and SASS 205. IUCMA (2020) used as a guideline for PES.

No.	Section	Comment	From	Addressed?
115.		It this is your EcoSpec you have to also provide the reference conditions in the report.	C Thirion	Added in the introduction above (Section 11.6).
116.		This is already a B/C so it cannot be a TPC for a B category.	C Thirion	Changed the MIRAI TPC to 84% or less.
117.	Section 12.1.4	Do you have any data for this section to allow you to identify indicator taxa? Do you have any idea of the PES for this section of the river? The IUCMA samples the Usuthu annually so you should be able to get some background information.	C Thirion	IUCMA (2020) used as a guideline for PES.
118.	Table 12.8 Pg 12-3	Mpama river just downstream of Jericho Dam fluctuates between a C/D and a C category. 11 data sets from Aug 1999 to Aug 2022. Aug 2021 had poor results (SASS 60 ASPT 4.3) otherwise the SASS scores ranged from 109-181 and the ASPT from 5.2-6.1).	C Thirion	Noted.
119.		Hydropsychidae >2spp: Never recorded (1sp Hydropsychidae recorded 7 times every sample since 2019.	C Thirion	Adjusted to 1- 2 spp Hydropsychidae.
120.		Tricorythidae: Never recorded.	C Thirion	Tricorythidae removed.
121.		Heptageniidae: Only recorded 4 times; last recorded in 2011.	C Thirion	Noted, used Heptageniidae as indicator.
122.		Leptophlebiidae: Recorded 7 times last recorded in2022. Recorded in 3 of the last 4 samples.	C Thirion	Noted, used Leptophlebiidae as indicator.
123.		Elmidae: A single individual was recorded in 2005. Not prior to then or since.	C Thirion	Removed Elmidae as indicator.
124.		Coenagrionidae: Always recorded.	C Thirion	Noted, used Coenagrionidae as indicator.
125.		Atyidae: Recorded 5 times, recorded in 3 of the last 4 samples.	C Thirion	Noted, used Atyidae as indicator.
126.	Chapter 12	The RQOs for other high priority RUs (rated 3 and 4) that do not have EWR site were only done for 2 RUs. What happened to the other RUs?	N Jafta	Refer to Table 2.1. These were the only two RUs with high priority rating where there is data available from the IUMCA and that could not be linked (in terms of hydrological RQOs) to areas where RQOs are available. Also note that as per the contract and TOR we are dealing with existing EWR sites only, although an additional site was surveyed.
127.	Chapter 15	The conclusion (Chapter 15) indicates that generic RQOs were done for sites with moderate importance, whereas only the flows are presented.	N Jafta	Flow RQOs are available as well as the PES which is the surrogate for biota and habitat RQOs. Conclusion rewritten.

No.	Section	Comment	From	Addressed?
128.	Table 14.1 Pg 14-1	May the flows RQO table (Table 14.1) be checked and may the RUs where the EWR is higher than present be double checked. And especially situations like RU W12-2, that are still recommending a B category when there is already large reduction in flows. I know flows are not the only driver for PES, REC, TEC but please check.	N Jafta	Addressed.
129.		On this table may the RUs where the EWR is higher than present please be highlighted, for management purposes.	N Jafta	Addressed.
130.		It also looks like there are no RQOs for habitat integrity (instream and riparian), may you add them please.	N Jafta	Habitat Integrity was only undertaken at EWR sites. RQOs are not set for Habitat Integrity as it is a much broader indicator than the biotic responses, geomorphology and riparian vegetation. Those indicators override the IHI.