INKOMATI-USUTHU
CATCHMENT MANAGEMENT AGENCY

ANNUAL RESOURCE QUALITY STATUS REPORT

FOR THE INKOMATI-USUTHU CMA

2023/24 FINANCIAL YEAR

VISION

Sufficient, equitable and quality water resources for all in the Inkomati-Usuthu Water Management Area

MISSION

To efficiently manage water resources by empowering our stakeholders in our quest to contribute towards transformation by promoting equal access to water and protecting the environment

VALUES

Integrity
Batho Pele (Stakeholders Orientation)
Accountability
Diversity
Transparency

SLOGAN:

"INKOMATI-USUTHU CMA, YOUR PARTNER IN WATER MANAGEMENT"

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Authors:	: Dr B Maliba, Ms C Tlowana, Mr S Magagula, Dr T Shakhane
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INKOMATI USUTHU CATCHMENT MANAGEMENT AGENCY (IUCMA)
REVIEW FOR IUCMA BY:

Dr Tendai Sawunyama

Resource Planning and Operations

NKOMATI USUTHU CATCHMENT MANAGEMENT AGENCY (IUCMA)

APPROVAL FOR IUCMA BY:

Mr Marcus Selepe

Acting Executive: Water Resources Management

ACKNOWLEDGEMENTS FOR TECHNICAL CONTRIBUTIONS:

Dr Mthobisi Soko	(Scientist: Fish)
Dr Mahlodi Dikgale	(Scientist: Micro-invertebrate)
Mr Zipho Khoza	(Scientist: Vegetation)
Mr Thokozane Malibe	(Hydrologist)
Mr German Makwela	(Engineering Technician)
Mr Senzo Lukhele	(Engineering Technician)
Mr Jonathan Maenetja	(Scientific Technician)
Mr Sakhile Nkosi	(Scientific Technician)
Mrs Bongekile Mahlatsi	(Scientific Technician)
Ms Tebatso Chiloane	(Scientific Technician)
Ms Mbalenhle Dhlamini	(Scientific Technician)
Mr Nkululeko Nkala	(Scientific Technician)
Londeka Ntshangase	(Intern)
Maletele Nkadimeng	(Scientific Technician)

EXECUTIVE SUMMARY

Chapter 3 of the National Water Act (1998) prescribes the protection of water resources through resource-directed measures including the determination of the management classification, Resource Quality Objectives, and the Reserve of significant water resources. These are measures which together are intended to ensure the protection of the water resource whereas the Source Directed Control measures are intended to regulate and control the impacts of land-based activities by ensuring pollution prevention and remedying the effects of pollution on water resources. It is further required that the protection of water resources is balanced with the use of water as a factor of production to enable socio-economic growth and development.

All biophysical nodes and components (water quantity, water quality and aquatic biota) within the integrated Units of Analysis (IUA) of any catchments within Water Management Area (WMA) should comply with the set Targeted Ecological Category (TEC) in order to meet the management class. In this report only EWR sites were considered to ensure that the management class is met within the IUA. Assumption was made that if all components are met at an EWR site, then all biophysical nodes are met within the IUA. Ecological Water Requirements (EWR) compliance for flow and water quality is always poor during dry seasons in river systems where river flow levels are not supplemented by upstream dam release augmentations

El Niño event was predicted for the 2023/2024 hydrological year and below normal rainfall was received in the WMA. In addition, the cumulative rainfall received in the 2023/2024 hydrological year is lower than the cumulative rainfall received in the previous 2022/2023 hydrological year for all the catchments in the WMA. Despite below normal rainfall received in 2023/2024 financial year, a number of dams in the WMA started spilling earlier when compared to other years, while the river flows were lower than previous hydrological year. The compliance of river flows at ecological water requirements and international obligations sites were 100% including during the dry months except in the Sand River catchment where flows were below the ecological water requirement target due to no accruals.

During the 2023/24 financial year, the surface water quality in the Inkomati-Usuthu Water Management Area (WMA) complied with the Resource Quality Objectives (RQOs), South African Target Water Quality Guideline limits (SATWQG) and International Water Quality Guideline limits (IWQG) for most of the monitored points and this showed that the water quality within the WMA is in a relatively fair to good state. The challenges affecting water quality in the Inkomati-Usuthu WMA have always been mainly due to industrial and mining activities and the poor state of Water Services Authorities' sewage infrastructure. Pollution of the resource is caused due to sewage contamination (e.g., from overflows, spills and leakages or by discharge of untreated/partially treated sewage into the resource) and decanting of mining effluents or leachate as well as solid waste especially nappies. The microbial pollution remains a human health risk, especially to the vulnerable rural communities that at times use the river water for domestic, religious, cultural, and recreational purposes. Deteriorating water quality on certain Ecological Water Requirements sites especially microbiological quality has largely been attributed to inadequate compliance, monitoring and enforcement, weak co-operative governance, absence of regulation and delays in the implementation of the waste discharge charge.

The overall integrated eco-status (present ecological status) for each of the four catchments within the WMA was calculated as category C, which is consistent with the integrated eco-status calculated from previous results. This indicates that despite the site-specific issues, the overall biotic condition for each of the four catchments has remained constant at Category C (moderately modified), with loss and change of natural habitat and biota in terms of frequency of occurrence and abundance. The resilience of the system to recover from human impacts has not been lost and its ability to recover to a moderately modified state following disturbance has been maintained.

Hydrology and physicochemical indicators remain key drivers to ecosystem responses at ecological water requirements sites and the majority of the sites complied to required targets in the 2023/2024 financial year and thus the management classes were met in the WMA.

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ACRONYMS AND ABBREVIATIONS

NWA	National Water Act, Act 36 of 1998
IUCMA	Inkomati-Usuthu Catchment Management Agency.
IUWMA	Inkomati-Usuthu Water Management Area
RQOs	Resource Quality Objectives
RSA	Republic of South Africa
RDM	Resource Directed Measures
DWS	Department of Water and Sanitation.
WWTWs	Wastewater Treatment Works.
CFU	Colony-forming unit.
E. coli	*Escherichia coli*.
KNP	Kruger National Park.
EWR	Ecological Water Requirements
CME	Compliance Monitoring and Enforcement
SANAS	South African National Accreditation System
SDC	Source Directed Control
U/S	Up Stream
D/S	Down Stream
EC	Electrical Conductivity
mS/m	Milli Siemens per meter
µS/cm	Micro Siemens per centimetre
mg/l	milli-grams per liter
TWQG	Target Water Quality Guide
WMA	Water Management Area
SATWQG	South African Target Water Quality Guidelines
IWQG	International Water Quality Guidelines
PO_4	Phosphate
NO_3+NO_2	Nitrates and nitrites
pH	Acid base relation
SO_4	Sulphate
Sal	Salinity
NH_3	Ammonia
FRAI	Fish Response Assessment Index
IHI	Index of Habitat Integrity
m.a.s.l.	metres above sea level
PES	Present Ecological State
MIRAI	Macro-invertebrate Response Assessment
MTPA	Mpumalanga Tourism and Parks Agency
PAI	Physico-chemical driver Assessment Index
PES	Present Ecological State
RC	Reference Condition
REC	Recommended Ecological Category
REMP	River Ecostatus Monitoring Programme
RHP	River Health Programme

RIVDINT	River Data Integration
REC	Recommended Ecological Category
REMP	River Ecostatus Monitoring Programme
SASS5	South African Scoring System, Version 5
SQR	Sub-quaternary Reach
TEC	Target Ecological Category
VEGRAI	Riparian Vegetation Response Assessment Index

CHAPTER 1 INTRODUCTION AND BACKGROUND

1.1 Introduction

The Inkomati-Usuthu Catchment Management Agency (IUCMA) is the responsible authority within the jurisdiction of the Inkomati-Usuthu Water Management Area (WMA). The WMA is in the eastern part of the country and falls wholly within the Mpumalanga Provincial boundary depicted in Figure 1 below as WMA three (3) of the six (6) demarcated WMAs. The Inkomati-Usuthu WMA comprises of four catchments namely Sabie Sand, Crocodile, Komati and Usuthu and is also part of two international basins called the Incomati River Basin and Maputo River Basin. The water resources in the area are strategically important for international obligations as well as inter-basin transfers for power generation. As an authority, the IUCMA is responsible for managing, controlling, protecting, and monitoring water resources in its area of responsibility.

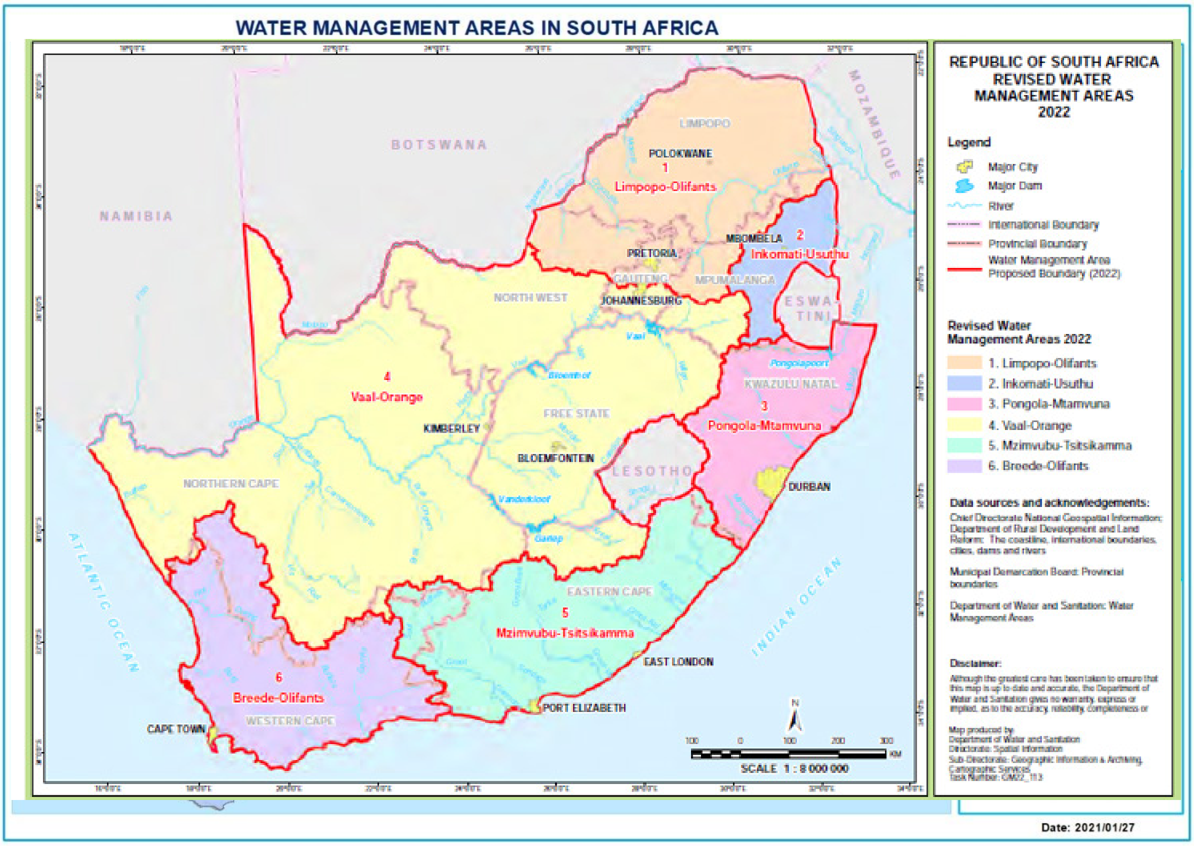


Figure 1: Map of South Africa indicating the nine WMAs.

1.2 Inkomati-Usuthu WMA

The resource quality monitoring takes place within the jurisdiction of the Inkomati-Usuthu WMA (IUWMA) which comprises of Sabie/Sand, Crocodile, Komati and Usuthu Catchments as illustrated in Figure 2 below. The IUWMA is situated in the north-eastern part of South Africa in the Mpumalanga Province, borders on Mozambique in the east and on eSwatini in the south-east. The WMA extends over several parallel river catchments that drain in a general easterly direction, and flow together at the border with Mozambique or within Mozambique, to form the Incomati River which discharges into the Indian Ocean immediately North of Maputo at Villa Laisa. The Usuthu River confluences with the Pongola River to form the Maputo River which discharges into the Indian Ocean south of Maputo and is called the Maputo Basin.

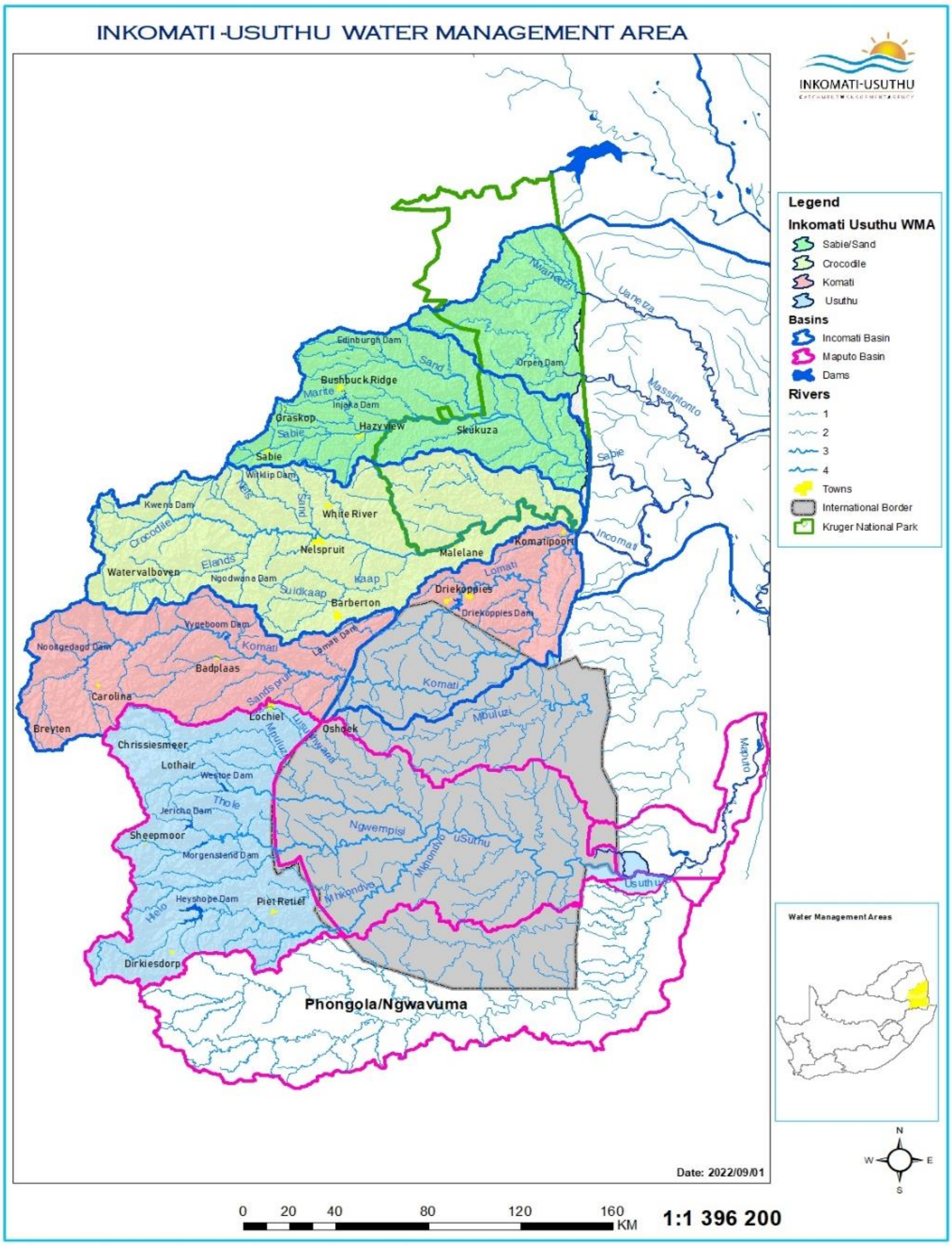


Figure 2: Inkomati-Usuthu Water Management Area.

1.3 Background

The National Water Act, Act 36 of 1998 (NWA) of South Africa Chapter 14 requires the Minister to establish national monitoring systems for the collection of appropriate data and information that is adequate and responsive to the present and future challenges of efficient management of the country's water resources. The Inkomati-Usuthu Catchment Management Agency (IUCMA) conducts resource quality monitoring in the Inkomati-Usuthu WMA which feeds into the national monitoring system.

The WMA is marked with seasonality of rainfall with wet summers and dry winters. This is also variable over longer periods with changes in rainfall seen from year to year and longer time scales. Most of the water demand is in the lower, drier, and hotter parts of the WMA where there is little rainfall and runoff. These factors create complexity and an unstable situation for the economy of the region, which is reliant on the availability of water and makes the proper management of the river flows very important. To adequately manage the high variable rainfall and scarce water resource in the WMA, the IUCMA has installed 25 near real-time rainfall gauges and 31 river flow gauges as well as 54 groundwater monitoring points.

Water quality is vital as it determines fitness for use, the protection of the health and integrity of aquatic ecosystems and is described as chemical, physical, and biological characteristics of water (DWS, 1996). Surface water quality within the Inkomati-Usuthu WMA is measured by means of physio-chemical, microbiological and eutrophication monitoring programme(s) conducted monthly through grab sampling, field measurements and continuous monitoring technique(s) respectively. The samples are then submitted to a South African National Accreditation System (SANAS) accredited laboratory for analysis. The variables of concern differ from catchment to catchment and are based on the types of activities occurring within a specific catchment. Eutrophication monitoring is conducted only in major dams within the WMA through National Eutrophication Monitoring Programme (NEMP). Eutrophication is the process of excessive nutrient enrichment of waters that typically results in problems associated with macrophyte, algal or cyanobacterial growth.

The health of the aquatic ecosystem is monitored through a programme called the River Eco-status Monitoring Programme (REMP). Approaches to water resource management that focus mainly on quantity and quality of the resource and do not consider aspects such as aquatic habitats and ecological integrity are not adequate to protect and maintain the aquatic ecosystems. The REMP complements the surface water chemical and bacteriological monitoring program and provides the state of the river's ecology, considering the various indices used to measure the community attributes of fish, aquatic macro-invertebrates and riparian vegetation and their response to changes in habitat, water quality and flow.

Water quality is linked with water quantity, instream and riparian habitat and aquatic biota integrity, which are collectively referred to as “resource quality” in terms of the NWA. Resource quality needs to be maintained within certain pre-determined parameters to enable continuous sustainable economic growth and social development. The pre-determined parameters are Resource Directed Measures (RDMs) represented by the Resource Management Class, Resources Quality Objectives (RQOs) and the Reserve.

The RDMs have been determined and gazetted for the Crocodile, Sabie-Sand and Komati Catchments within the Inkomati-Usuthu WMA, but not for the Usuthu Catchment. The comprehensive ecological Reserve determination study was completed in February 2006; however, it was gazetted into law only in July 2019 through government notice No. 998. The classification and setting of the RQOs studies were completed in April 2015 and gazetted into law in December 2016 by government notice No. 1616. The resource quality status and compliance within the WMA was evaluated against RQOs and where not available the Target Water Quality Guideline limits (TWQG) were used. RQOs are intended to give effect to the management class and the ecological needs determined in the reserve to assist resource managers in the protection of the resource.

The major watercourses within the Inkomati-Usuthu WMA form part of the Incomati and Maputo River Basins. Water quantity and quality conditions of the ten (10) major watercourses within Inkomati-Usuthu WMA were assessed as part of information and data sharing in terms of Interim Inco-Maputo Basin Agreement (IIMA) for co-operation on the protection and sustainable utilisation of these shared watercourses. Water quantity and quality compliance status of international obligation sites were evaluated against the water quality guidelines resolution of the Tripartite Permanent Technical Committee (TPTC) on exchange of information and water quality. The purpose of the report is to report on the resource quality status, trends and compliance with the set standards/objectives in the water resource, in a manner that supports balanced decision making and planning to support sustainable development within the Inkomati Usuthu WMA.

1.4 Objectives

The objective of this report is to achieve the following:

- To provide information on the status and trends in terms surface and groundwater resources quantity (river levels, groundwater levels and dams) within the Inkomati Usuthu WMA.
- To provide information on the status and trends in terms of the physio-chemical and microbial quality of surface water resources within the Inkomati Usuthu WMA.
- To provide information on the trophic status of major dams within the Inkomati Usuthu Water Management Area.
- To determine the present ecological status (PES) of the rivers within the Inkomati Usuthu WMA by using biological indicators (*i.e.*, macro-invertebrates, fish, and riparian vegetation) and Eco status Models.
- To determine compliance status of applicable variables at Ecological Water Requirements (EWR) sites and water quality priority Resource Units (RU) with Resource Quality Objectives (RQOs).
- To determine compliance to the Target Ecological Category (TEC) for water quantity, water quality and aquatic Biota at Ecological Water Requirements (EWR) sites within the Inkomati Water Management Area, and

- To determine water quantity and quality compliance status at International Obligation sites with the set limits in terms of the Interim Inco-Maputo Agreement (IIMA, 2002).

CHAPTER 2 MATERIALS AND METHODS

2.1 Materials and Methods

2.1.1 Surface Water

The water monitoring networks support a wide range of values and uses within the WMA. These entail the use of water from the rivers, streams, and dams for ensuring that the Reserve (Ecological and Basic Human Needs), International Obligations, strategic use (transfers out of the catchments) is guaranteed. The Inkomati Usuthu CMA monitoring network includes 31 riverflow gauging stations and 25 rainfall stations.

2.1.1.1 Rainfall

The rainfall gauges are automatic tipping buckets that transmit real time precipitation data. The rainfall gauge works by funnelling collected rain to land on the pivot-point of a two-sided "bucket." When one side fills, it pivots down - causing the "bucket-tip" to be recorded, emptying the bucket and bringing the empty side under the collection point. Each bucket - tip occurs when 0.2 mm of rain has been collected.

The IUCMA has two types of rainfall stations: 18 iMETOS eco d2 rain gauges supplied by iMetos-Pessl Instruments, and 7 Adcon's RG1 rain gauges. The iMETOS rain gauge measure rainfall permanently by iMetos ® rain and sent to the internet climate data base of Pessl Instruments GmbH.

The Adcon's RG1 rain gauge measures rainfall using sensors. Each tipping action triggers a pulse of a debounced reed switch with a lifetime of 1 million pulses. The body of the rain gauge, the funnel and the protective filter are made of aluminium, with a precision tipping bucket of plastic.

2.1.1.2 Riverflows

All the riverflow stations are real-time. Continuous flow monitoring involves using electronic equipment to measure and record the riverflow level. A programmable data logger operates a pressure sensor, measure the river level. The data logger is used to convert the pressure to recorded level values, which are recorded at set time intervals. Through ZEDNET software the water levels are converted to discharges and both the levels and discharges are published on ZEDNET and RiverOpWebsite (http://riverops.inkomaticma.co.za/).

The data loggers (Cello) are fully integrated with wireless using GSM (SMS/GPRS) for both network and environmental monitoring, having sophisticated profile alarm dial-out regimes. Cello has a variation of inputs such as pressure & flow variations, a universal eight channel recorder, offering optional dual 4-20mA self-powered version for remote level monitoring.

2.1.1.3 Dam Levels

The IUCMA does not have instrumentation installed in the dams located within the Inkomati Usuthu WMA. The IUCMA relies on the DWS data for dam monitoring, and uses the data provided by DWS to manage and implement operating rules for dams within Inkomati Usuthu WMA.

2.1.2 Groundwater

Inkomati-Usuthu Catchment Management Agency (IUCMA) oversees a groundwater monitoring program within the Inkomati-Usuthu Water Management Area (WMA). The programme comprises a monitoring network, data collection, data Quality control (QC), storage, data dissemination, and reporting.

2.1.2.1 Monitoring network.

The monitoring program is comprised of a network of fifty-seven (57) geo-sites (boreholes) with twelve (12), located within the Usuthu catchment, being monitored quarterly by IUCMA. Among these monitored boreholes, two are equipped with telemetric systems. The remaining boreholes are monitored monthly by the Department of Water and Sanitation (DWS) and the data is shared with the IUCMA for reporting.

2.1.2.2 Data collection

Groundwater monitoring is undertaken monthly predominately manually.; The IUCMA is piloting the telemetric systems for groundwater and currently, two boreholes are equipped with the water quality and level systems. Groundwater monitoring entails the measurement of groundwater levels and in-situ water quality indicators. Water quality grab sampling is undertaken biannually (dry and wet season) by the Department of Water and Sanitation (DWS).

2.1.2.3 Data storage and management

Following collection, the data undergo internal quality control before being uploaded into the Hydstra database and custom (developed internally by geohydrology subdivision) spreadsheets for specialised analyses. Moreover, the data is also updated into the custom spreadsheets linked to a groundwater webpage in the riverops.inkomaticma.co.za website. Telemetric data is published in the published live on ZEDNET.

2.1.2.4 Reporting

In-situ parameters are Water quality data are interpreted against the South African National Standard (SANS), 241 drinking water specification to flag any contamination prospects.

Groundwater levels, with streamflow and recharge data, are analyzed for groundwater resource status. Using baseflow separation and recession–curve displacement method (s), streamflow is analyzed for baseflow (groundwater contribution to stream flow) and groundwater recharge. Based on one and two–group standard statistics, drought (based on the deviation of the measurement from the long– term average) and performance (resilience referring to the ability of groundwater resources to withstand and quickly recover from natural and human–made impacts) are established.

2.1.3 Surface Water Quality

2.1.3.1 Grab sampling.

Monthly physio-chemical and microbiological samples were taken using the grab sample technique. Sampling bottles were marked with the site code, date and time of collection using a permanent marker. Some of the samples were taken on bridges using a bucket and bailer. The bucket was rinsed before collecting the sample and filling the sampling bottles.

One (1) litre physio-chemical sample bottles were rinsed three times before they were filled. The 300ml microbial sample collecting bottles were not rinsed since they were sterilized, ample air space was left in the sample bottle to facilitate mixing by shaking.

Both physio-chemical and microbial water quality samples were stored in two separate cooler boxes and preserved with ice packs or cubes. The samples were then submitted to a SANAS accredited laboratory for analysis and microbiological samples were delivered within 12 hours to the Laboratory.

Figure 3: Water quality samples taken at Komati River using the bailer and the bucket.

Figure 4: IUCMA official taking water quality chemical sample at tributary of Seekoeispruit.

2.1.3.2 Continuous monitoring

Six water quality probes are installed within the WMA for continuous water quality monitoring. The parameters measured in continuous monitoring stations are actual conductivity (µS/cm), temperature (˚C) and salinity (PSU) after every 3 hours. Actual conductivity data is transmitted to Zednet via network and other variables are downloaded through Win-Situ software.

Figure 5: IUCMA official downloading data from probe trough Win-Situ software.

2.1.3.3 Field measurements

These comprise measurements that are taken and recorded on site such as temperature and Dissolved Oxygen measured on a monthly basis. Field measurements were taken on 23 Ecological Water Requirements sites and 10 international Obligation site(s) using the handheld EcoSense DO200A Dissolved Oxygen Meter.

2.1.3.4 Eutrophication monitoring

Sampling protocol for eutrophication monitoring dated November 2004 was used for NEMP at major Dams within the WMA.

Macro samples were taken by decanting water from the integrated sample or subsurface grab sample into the blue-top bottle washed with phosphate free soap and the samples were stored in cooler box with ice cubes.

Figure 6: Filling of Macro sample.

Samples for **identification of algae** were taken by decanting water from the integrated sample or subsurface grab sample into a small glass bottle with 2-4 drops of lugol preservative.

Figure 7: Filling of Algae identification sample.

The **chlorophyll-*a*** samples were conducted using a filter unit, by unscrewing the top of the rinsed filter and carefully placing the filter paper inside the unit and screwing the top back. A volume of 250ml water from the integrated sample or subsurface grab sample was poured into the unit and water was drawn through the filter using a vacuum pump up to 500ml if possible. The total amount of water filtered was recorded. The filter was then opened gently, then the filter paper was carefully lifted and stored into a glass tube with ethanol.

Total suspended solids samples were taken using the same method as conducted for the Chlorophyll-a samples, but a weighed filter paper marked with a black dot was used and then stored in a petri dish.

Figure 8: Filtration of Suspended solids or chlorophyll-a sample(s).

All samples were clearly marked on a tag with the sample description, date, time, dam ID code, name of the resource and volume filtered. The samples were stored in a dark container. The samples and onsite monitoring report sheets were then submitted to the Department of Water and Sanitation laboratory at Resource Quality Information Services (RQIS) for analysis.

Figure 9: Clearly marked samples for Eutrophication taken at Injaka Dam.

<u>The following onsite visual monitoring and measurements were conducted:</u>

- Estimated visual area on the total surface area covered by algal blooms or invasive water plants.
- Other observation potentially related to eutrophication *i.e.*, Odour problems, fish kill, wind speed and direction.
- The secchi disc is used to determine the clarity by lowering the disc into the water until it is out of sight and record the depth reading on the marked rope.

Figure 10: Secchi disc used to measure clarity.

The HydroNet system and Microsoft Excel were used to display (average) and interpret the 12 months (January 2023- December 2023) water quality data for the sites monitored.

The PAI model of March 2008 was used to determine the present ecological category for water quality components. Five (5) years data from Jan 2018 to December 2022 was used to run the PAI model with number of samples ranging from 28-59. Therefore, the assessment was completed with a moderate confidence. TEACHA was not used to produce aggregated salts, instead the electrical conductivity was used as surrogate. The benchmark boundary tables were used for the PAI model analysis (DWAF, 2008) since the reference conditions were not determined. Water quality data below detection limits (denoted by a “<”) was statistically analysed by converting the data to half the detection limit value (Palmer et.al, 2005), for example, ammonia was <0.20 and replaced with 0.10, as a statistically approved method of manipulating water quality data below quantification levels.

The water quality status for compliance is represented by colour green while non-compliance is represented by colour red throughout the report unless indicated otherwise.

2.1.4 Aquatic Biota

2.1.4.1 Macro-invertebrates

Aquatic macro-invertebrates were sampled according to the South African Scoring System, Version 5 (SASS5) method. The method provides an assessment of the presence, diversity, and abundance of macroinvertebrates families at a site (Dickens and Graham 2002). The SASS 5 results are expressed as SASS score and ASPT. Each family of aquatic macroinvertebrates is allocated a value between 1 and 15 based on the perceived sensitivity to water quality changes (Murray 1999). The family's sensitivity is classified as having high tolerance (1–5), moderate tolerance (6–10) and very low tolerance (11–15) to water quality changes and pollution (Gerber and Gabriel 2002). Three biotopes were sampled at each site following the sampling method outlined by SASS 5 (Dickens and Graham 2002). The SASS 5 method identifies, and groups three biotopes inhabited by macroinvertebrates. The biotopes are stones (comprising of stones in and out of current and bedrock); vegetation (comprising of both instream and marginal vegetation) and GSM (comprising of gravel, sand, and mud). All the macro-invertebrate samples were collected using a kick-net of 30cm x 30cm and 1mm mesh size. The following time and length limitations were adhered to, as they are required by the SASS 5 method to ensure standardization:

- Stones (and bedrock)-in-current was sampled for 2 minutes.
- Stones (and bedrock)-out-of-current was sampled for 1 minute.
- Marginal vegetation (both in- and out-of-current) was swept with a net for a total length of 2m.
- Aquatic vegetation (where present) was swept with a net for an area of 1m^2.
- Gravel, sand, and mud was stirred and swept with a net for 1 minute.

The collected samples were placed in three trays for each biotope grouping (*i.e.*, stones, vegetation, and GSM). A total of 15 minutes was allowed for identification per tray. Macro-invertebrate field guides were used for correct identification of the macro-invertebrates sampled (Gerber and Gabriel 2002). The abundance of identified families was rated as 1 if only 1 specimen was found, A if between 2 and 10 specimens were found, B if between 10 and 100 were found, C if between 100 and 1000, and D if more than 1000, as outlined on the SASS 5 data sheet (Dickens and Graham 2002).

The Macro-Invertebrate Response Assessment Index (MIRAI) was used to interpret the Ecological State of the river (Thirion, 2008). The MIRAI is a rule-based model developed by DWS and it integrates the environmental requirements of the invertebrates in a community or assemblage to their response to modified habitat conditions, water quality and changes in the flow (Thirion, 2008). The MIRAI ratings considers both the abundance and frequency of occurrence of macroinvertebrates within a reach. In some reaches, only one site was monitored and as a result, only abundances were considered for comparison with the reference conditions.

2.1.4.2 Fish

Fish were sampled at each site using an electric shocker. The data was collected in different velocity depth classes, and for each flow depth class the presence of features that provide cover for fish were considered. Information on the general habitat and cover preferences of fish species was obtained from the available literature and personal experience. Fish data collected in different velocity depth was kept separate for analysis and the results were recorded as a number of fish caught per time unit.

A Fish Response Assessment Index (FRAI) was used to analyse the fish data to get the Present Ecological State of the river (Kleynhans, 2008). The FRAI is a rule-based model recently developed by DWS and is based on the environment intolerances and preference of the reference fish assemblage and the response of a constituent species of the assemblage to a group of environmental determinants or drivers (Kleynhans, 2008). These intolerance and preference attributes are categorized into metric groups with constituents' metric that relates to the environmental requirements and preferences of individual species.

2.1.4.3 Riparian Vegetation

The riparian vegetation was assessed in order to determine the present ecological state. The riparian vegetation was assessed using the Riparian Vegetation Response Assessment Index (VEGRAI), Level 3 technique (Kleynhans et al., 2007), along the 100m upstream and 100m downstream. When the vegetation species were different from either side of the riverbank, the riverbanks were treated as different sites and the two would be assessed separate from one another. The current data was obtained by recording all the important and dominant plant species in a riverine reach on a VEGRAI Level 3 data sheet. The VEGRAI technique comprises of many metrics (cover, abundance and species composition) and metric groups (marginal and non-marginal zones) that are considered in the in-situ assessment. The status of the indigenous vegetation species (woody and non-woody) for the present and reference states are described in each metric and the difference between the two states compared to measure the vegetation responses to the surrounding disturbances. The alien/exotic species are assessed separately from the indigenous species (Kleynhans et al., 2007). The VEGRAI was used to analyse the riparian vegetation data collected to get the Present Ecological State of the river (Kleynhans et al., 2007).

2.1.4.4 Present Ecological Status

The Present Ecological State (PES) of a river is expressed in terms of various abiotic and biotic factors which are then integrated to provide the Eco-status of the river. The biotic factors (*i.e.,* macro-invertebrates, fish, and riparian vegetation) provide an indication of biological responses to the changes in the abiotic factors (*i.e.,* physico-chemical, geomorphology, and hydrology), which serve as drivers. Figure 11 provides a simplified integration of influence of land use on physical driver determinants, habitats, and the associated biological responses. Data compilation was done according to models that were developed by DWS to determine the Eco-status (Kleynhans, 2008). The River Data Integration Application (RIVDINT) was also utilised during the data compilation and analysis process.

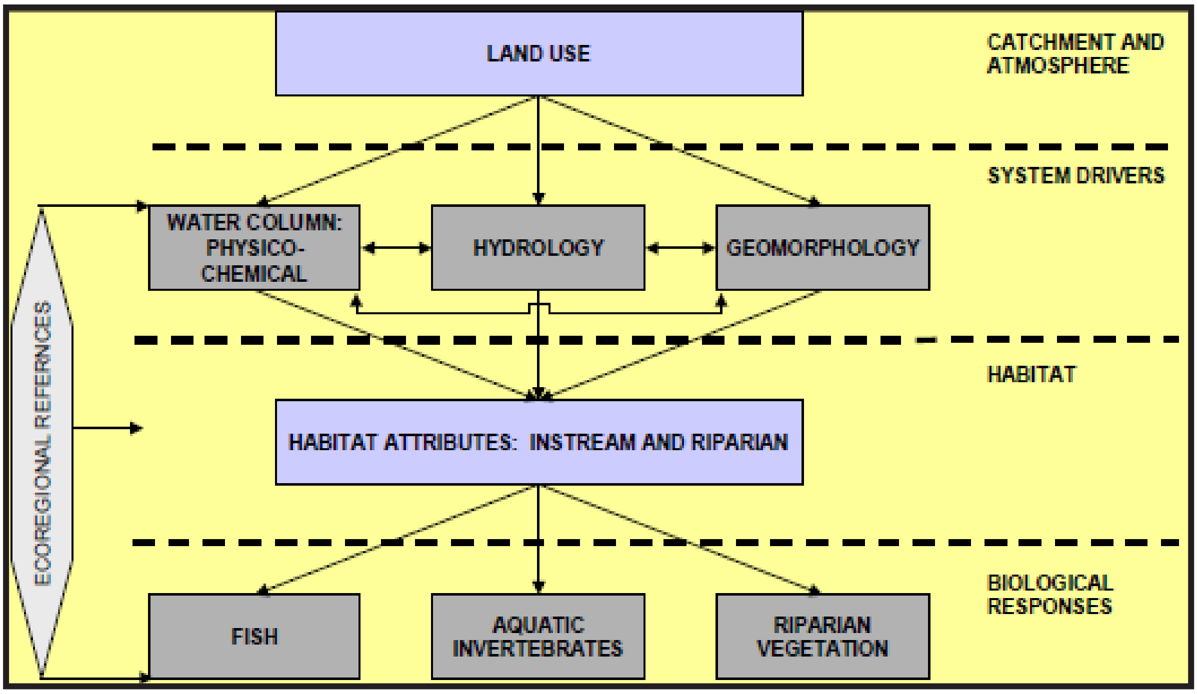


Figure 11: A simplified integration of influence of land use on physical driver determinants, habitats, and the associated biological responses (Kleynhans and Louw, 2008).

The Present Ecological State was determined per Sub-Quaternary Reach (SQR) using fish, macro-invertebrates, and vegetation as biological indicators. Table 1 provides a description of the main Ecological Categories (*i.e.,* A – F).

Table 1: The Generic ecological categories for Ecostatus components.

ECOLOGICAL CATEGORY	GENERIC DESCRIPTION OF ECOLOGICAL CONDITIONS	ARBITRARY GUIDELINE SCORE (% OF MAXIMUM THEORETICAL TOTAL)
A	The river is in a natural and undisturbed condition.	>92 – 100
AB	The system and its components are in a close to natural condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a B category.	>88 - <= 92
B	Largely natural with few modifications. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance.	>82 - <=88
BC	Close to largely natural most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a C category.	>78 - <=82
C	Moderately modified. Loss and change of natural habitat and biota have occurred in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged.	>62 - <=78
CD	The system is in a close to moderately modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a D category.	>58 - <=62
D	Largely modified. A large change or loss of natural habitat, biota and basic ecosystem functions have occurred.	>42 - <=58
DE	The system is in a close to largely modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of an E category.	>38 - <=42
E	Seriously modified. The change in the natural habitat template, biota and basic ecosystem functions are extensive.	20 - <=38
F	The river is in a critically or extremely modified state and ecosystem functions are completely lost. The natural habitat and biota are almost completely lost.	<20

CHAPTER 3 SURFACE AND GROUNDWATER QUANTITY STATUS

3.1 Introduction

Knowledge of hydrological patterns, trends, and water quality condition is critical for successful long-term water resource management. All the rivers in the Inkomati Usuthu WMA flow into the Indian Ocean via Mozambique. Because of the limited rainfall throughout the coastal plains east of the WMA, the southern portion of Mozambique relies heavily on water flowing from the South African territory. This has a substantial impact on the management of the Inkomati WMA's water resources, as South Africa is committed to meeting its international water requirement obligations.

The Sabie River and its main tributary, the Sand River, are located upstream of the Kruger National Park, which has high ecological flow requirements. This important factor, coupled with rural development and improved service delivery to the rural sector, necessitated the construction of the Inyaka Dam which was completed in 2000. The Sabie system is currently in balance.

The Crocodile catchment is dominated by irrigation and forestry, two activities that are also the primary users of water in the catchment. The catchment's industrial water consumption is limited to the Sappi paper mill in Ngodwana and the sugar mills in Malelane and Komatipoort. The catchment is not well developed in terms of water resources, with only one significant dam, the Kwena Dam, in the upper catchment. The catchment is considered highly stressed since the water requirements exceed the available resources.

There are two significant dams in the Upper Komati, the Nooitgedacht and Vygeboom dams. These dams account for the majority of the available yield in this sub-area, with transfers from these dams to the Olifants WMA constituting the dominant water usage of this sub-area's water resources. This sub-region has a huge, afforested area, which has a considerable impact on the available yield. Irrigation is another substantial water usage, and while domestic water use is now regulated, demand is fast increasing. The Driekoppies Dam is located in the Lower Komati while the Maguga Dam is in Eswatini. The Lower Komati sub-area is considered extremely stressed, with significant irrigation and domestic water demand.

The Usuthu catchment has a small surplus (based on current allocations and water usage), while domestic water demands are increasing due to population growth and expanding economic activity. This is offset by Eskom's declining water use, which transfers water out of the catchment to cool coal-fired power plants in the Olifants and Vaal catchments.

3.2 Rainfall status within the WMA

In general, rainfall has been below normal since the start of the 2023 hydrological year, but rainfall received in the Inkomati Usuthu Water Management Area (WMA) in December 2023 was above normal. The South African Weather Service (SAWS) seasonal climate watch in June 2023 indicated that El Niño-Southern Oscillation (ENSO) was transitioning into warm El Niño-like conditions and indicated that it will persist through most of the summer months October 2023 to March 2024.

The ENSO state slightly influences the rainfall distribution in the Inkomati Usuthu WMA. La Nina typically brings normal or above-normal rainfall, and El Niño typically brings below-average rainfall to the southern region of Africa, these trends cannot be considered as a 100% confirmation of seasonally weather prediction. There are various rainfall zones in Southern Africa, and each one has a unique relationship with ENSO. Additionally, ENSO only accounts for around 30% of the variability in rainfall, therefore additional factors should be considered when forecasting seasonal rainfall.

The 1997–98 El Niño was the strongest ever recorded, but not all of South Africa had rainfall that was below average, the amounts of rain were abundant in some areas due to the importation of humid air from the Indian Ocean. The relationship between the ENSO events and the Inkomati Usuthu WMA summer rainfall patterns is strong, but rainfall patterns in the WMA is also influenced by other events such the Indian Dipole hence the rainfall received in in this quarter is below historical average.

The well-below-average rainfall of 2015 and 2016 occurred during a strong El-Niño (Figure 12), and the storage volume of Kwena Dam dropped to 19% (Figure 13). On the other hand, during the strong El-Niño event of 1998-99, the storage volume of Kwena Dam slightly dropped below 70%, and this does not reflect the expected El-Niño-rainfall relationship. El- Niño event was predicted for the 2023/2024 hydrological year, but the impact was not high in the WMA for instance Kwena Dam started spilling earlier when compared to other years.

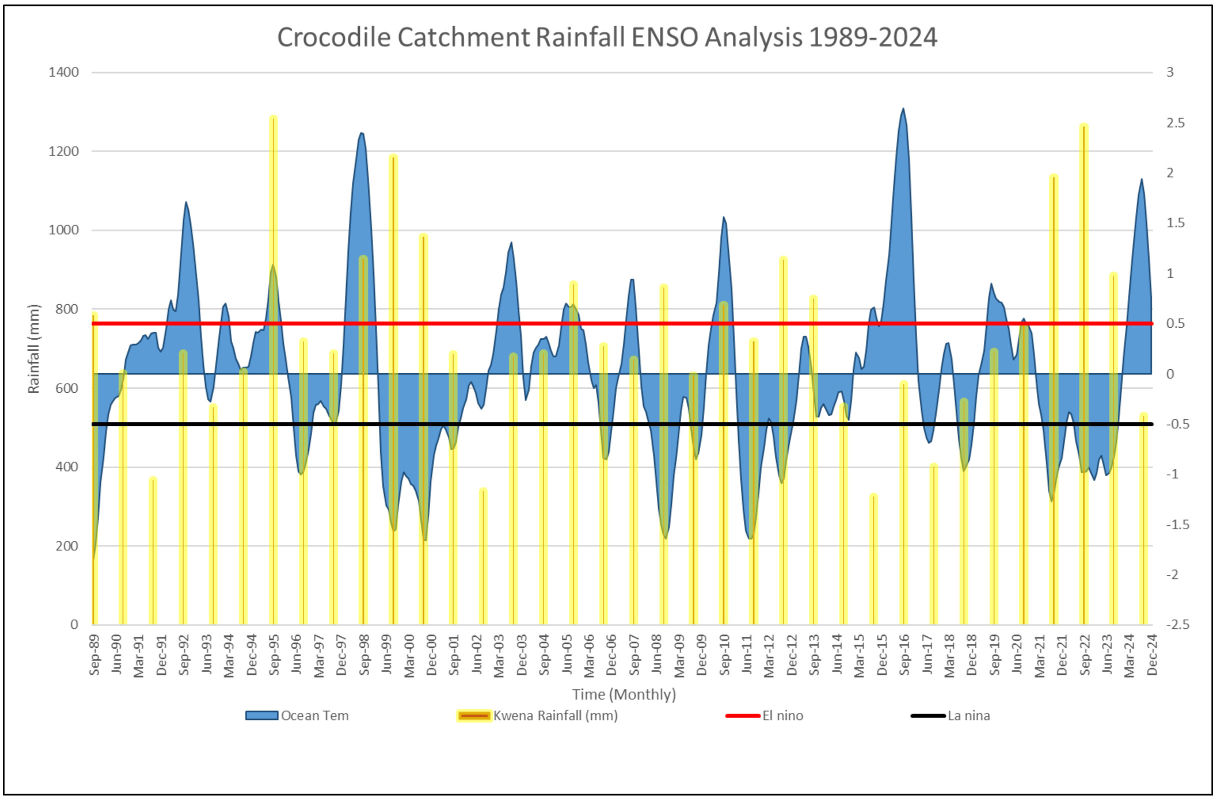


Figure 12: Crocodile catchment rainfall ENSO analysis.

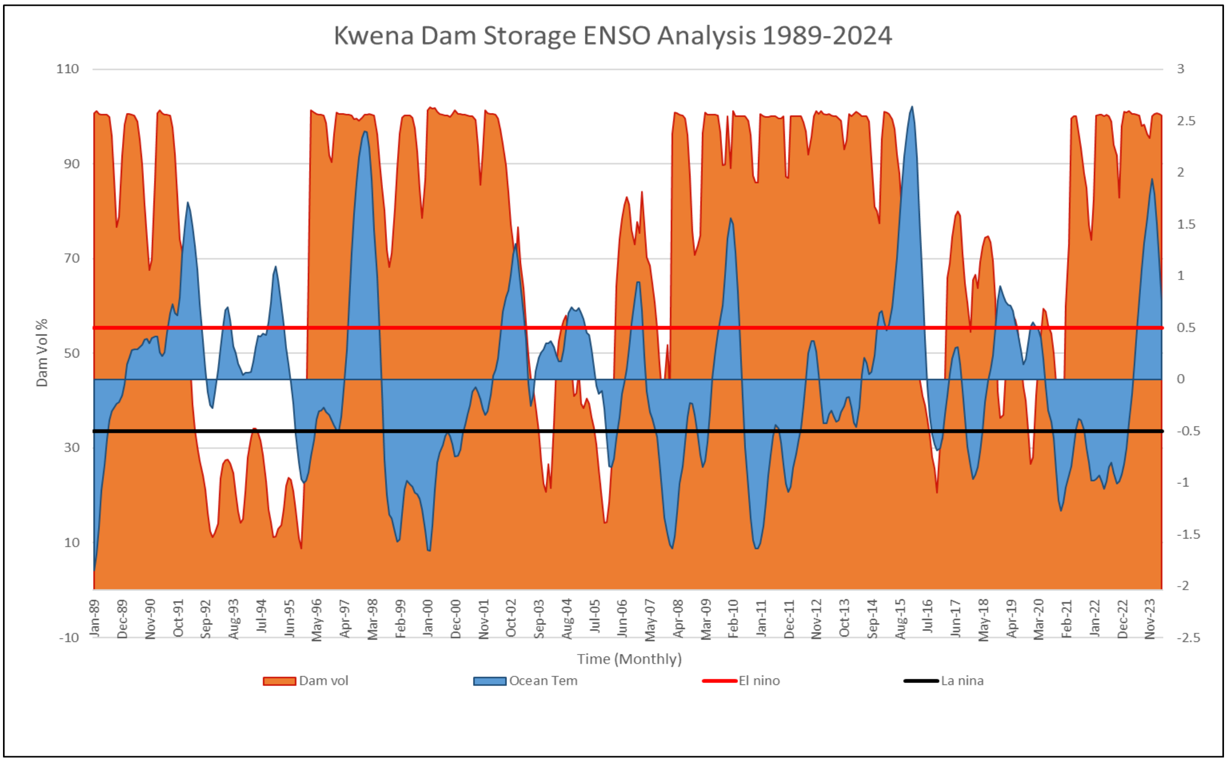


Figure 13: Kwena Dam storage ENSO analysis.

The catchment monthly rainfall statistics the water management area is presented. There are 25 rainfall stations monitored in the WMA and these stations have been optimised to provide catchment average rainfalls. The variability of rainfall is also very high as different catchments have different rainfall patterns for the different hydrological years and this affects the rainfall-runoff relationship.

This section also provides a brief statistical analysis, comprising the comparison of current rainfall figures with historical averages for these catchments. A comparison of the observations is made with the long-term statistics up to June 2024.

3.2.1 Crocodile Catchment Rainfall

The graph below represents the monthly rainfall received from this catchment in the current hydrological year starting October 2023. This data is compared with the historical average for the same catchment. The catchment has received lower cumulative annual rainfall up to June 2024 than the historical average. The cumulative rainfall for this hydrological year is also compared to previous hydrological year. It is lower than that of the previous hydrological year. It is currently at 698mm in June compared to 989.1mm in the previous hydrological year (Figure 14).

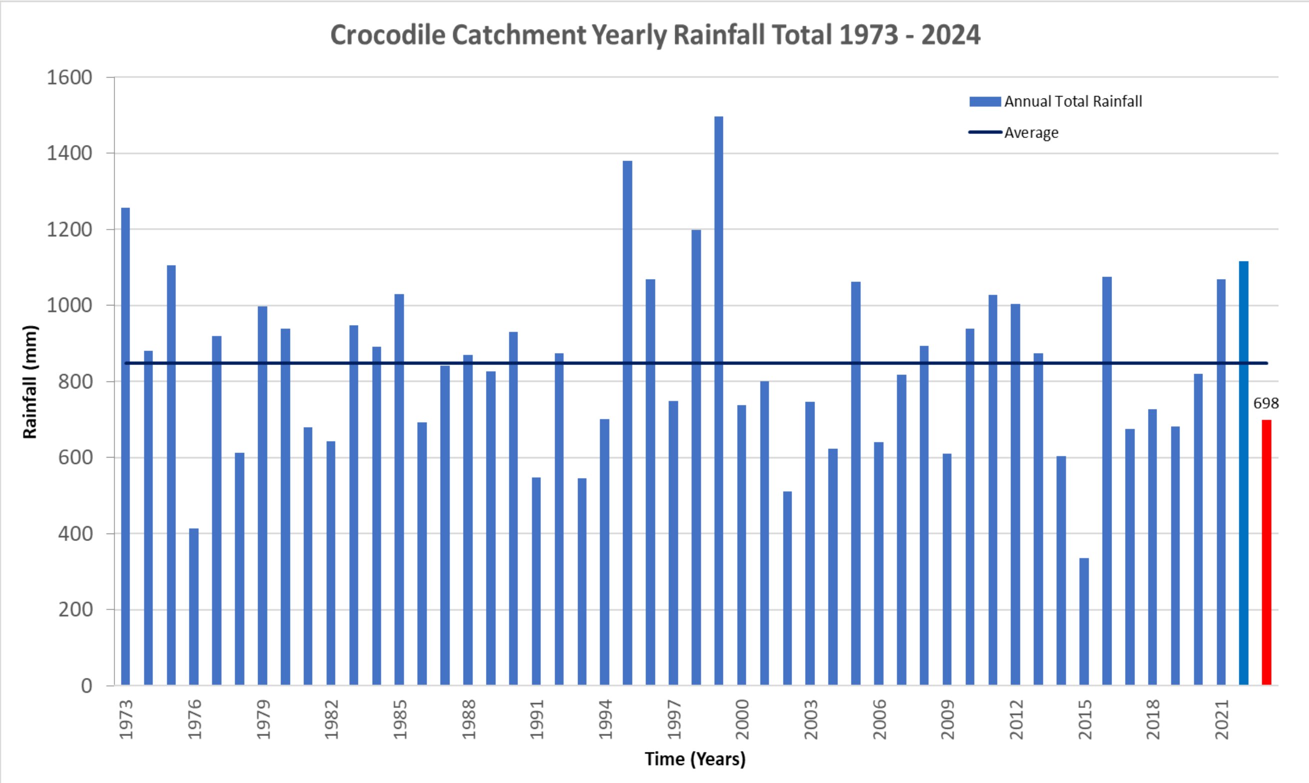


Figure 14: Graph showing the Rainfall Status for Crocodile Catchment.

3.2.2 Sabie-Sand Catchment Rainfall

The graph below represents the monthly rainfall received from this catchment in the current hydrological year starting October 2023. This data is compared with the historical average for the same catchment. The catchment has received lower cumulative annual rainfall up to June 2024 than the historical average. The cumulative rainfall for this hydrological year is also compared to previous years. It is lower than that of the previous hydrological year. It is currently at 643mm in June compared to 1190.6mm in the previous hydrological year (Figure 15*:*).

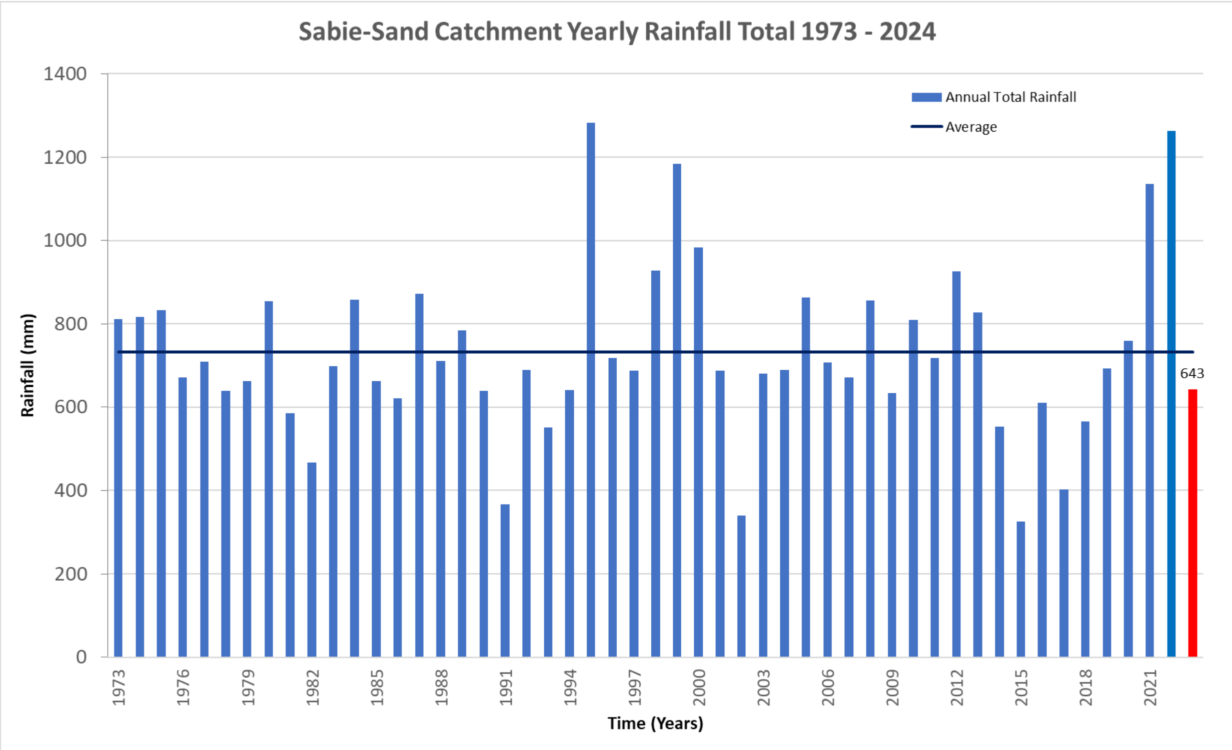


Figure 15: Graph showing the Rainfall status for Sabie-Sand Catchment.

3.2.3 Komati Catchment Rainfall

The graph below represents the monthly rainfall received from this catchment in the current hydrological year starting October 2023. This data is compared with the historical average for the same catchment. The catchment has received lower cumulative annual rainfall up to June 2024 than the historical average. The cumulative rainfall for this hydrological year is also compared to previous hydrological year. It is lower than that of the previous hydrological year. It is currently at 817mm in June compared to 886.0mm in the previous hydrological year (Figure 16:) but was higher for December 2023 and January 2024 months.

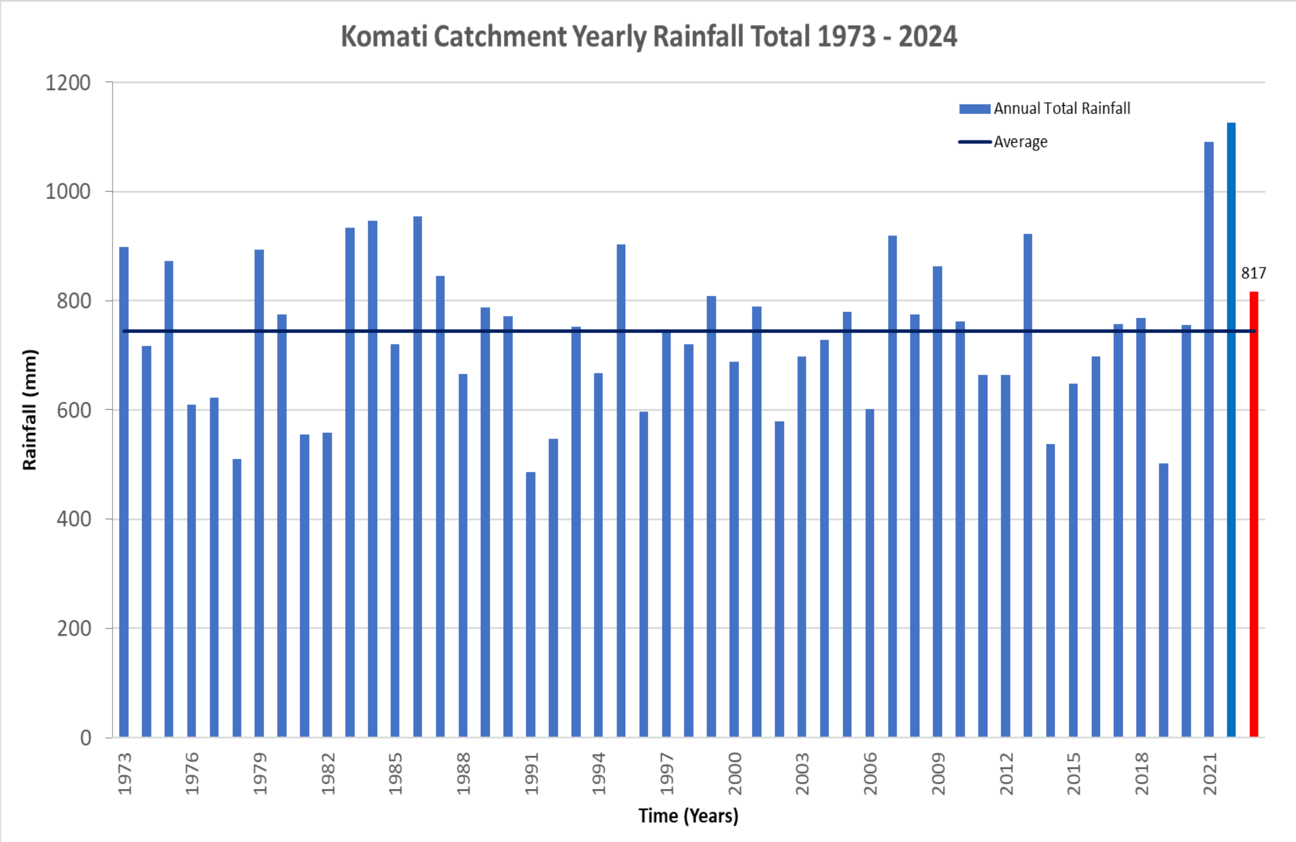


Figure 16: Graph showing the Rainfall Status for Komati Catchment.

3.2.4 Usuthu Catchment Rainfall

The graph below represents the monthly rainfall received from this catchment in the current hydrological year starting October 2023. This data is compared with the historical average for the same catchment. The catchment has received lower cumulative annual rainfall up to June 2024 than the historical average. The cumulative rainfall for this hydrological year is also compared to previous hydrological year. It is lower than that of the previous hydrological year. It is currently at 748mm in June compared to 862.2mm in the previous hydrological year (Figure 17), but it was higher in October and November months.

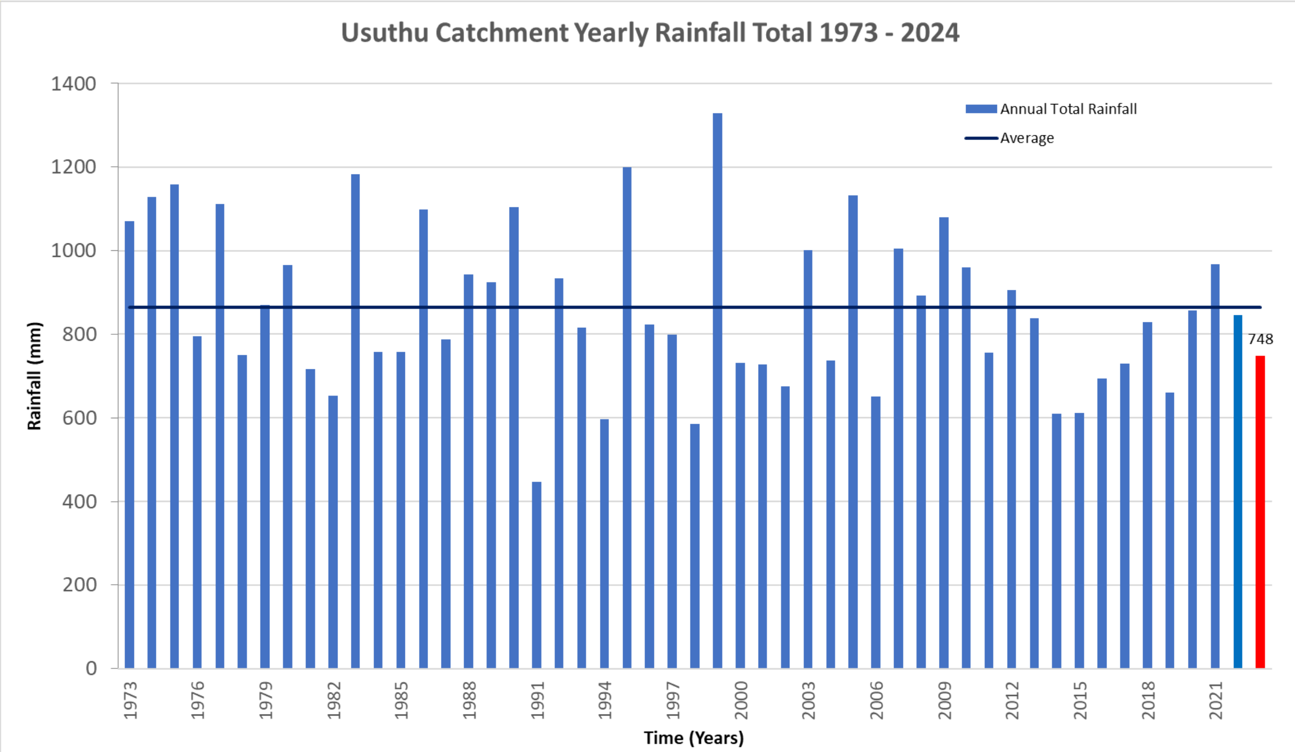


Figure 17: Graph showing the Rainfall status for Usuthu Catchment.

The catchment rainfall characteristics varied throughout the WMA in the 2023-24 hydrological year.

3.3 Groundwater status within MWA

3.3.1 Sabie Sand Catchment

3.3.1.1 Sabie Subsystem

In the Sabie subsystem, the status of groundwater (recharge, baseflow, and storage/levels) is shown in Figure 18 against this dataset:

- Almost all the groundwater indicators were in the mild drought during the October (2023) to January (2024) months while the recharge was in the severe drought condition. Except for groundwater recharge which consistently maintained drought conditions (mild to moderate), these indicators predominantly recovered onwards (ranging between slightly wet to severely extreme wet conditions) until May 2024. Recharge being the source of groundwater replenishment, groundwater levels similarly started low (slightly wet condition) from October to December 2023) before responding to the high recharge and increasing to moderately wet conditions from January to May 2024). Both recharge and groundwater levels followed the same trajectory as the previous hydrological year which implies that they will both most likely end up in mild drought conditions by the end of the running hydrological year (2023/2024).

- Figure 19 shows that recharge starts from the mild drought conditions at the start of a hydrological year (October), improving into wet conditions. The peak of the recharge rising limb was in severe wet condition in January before the recharge receded to moderate condition from February to May 2024.

- Figure 20 shows that groundwater levels and recharge decreases are cyclically seasonal.

    - Water level and recharge are resilient (the ability of groundwater resources to withstand and quickly recover from natural and human-made impacts) as they exhibit full recoveries following dry spells.

    - The weak linear relationship between recharge and groundwater levels, in Figure 21, is indicative that groundwater storage is additionally constrained by draft (combined borehole abstraction and plant groundwater uptake).

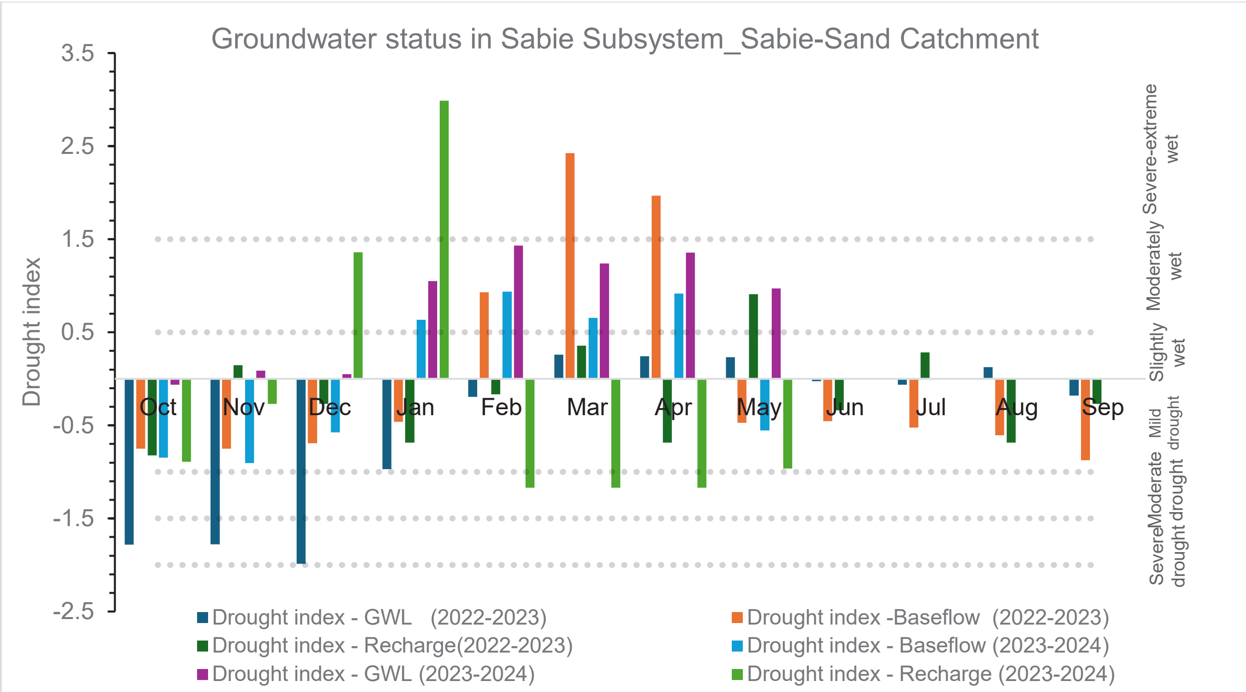


Figure 18: Groundwater status between consecutive hydrological years (2022/2023-2023/2024) Sabie subsystem, Sabie-Sand catchment.

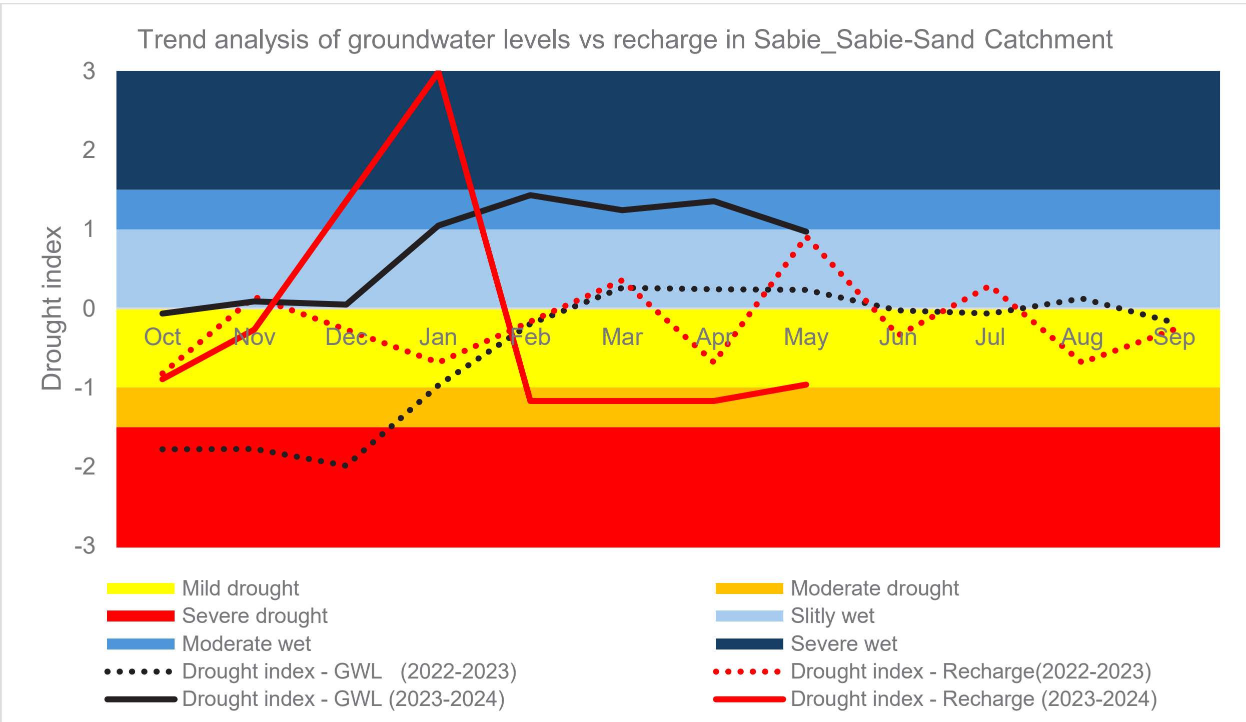


Figure 19: Analysis of groundwater levels and recharge trend for the 2022/2023 and 2023/2024 hydrological years in the Sabie subsystem of the Sabie-Sand catchment.

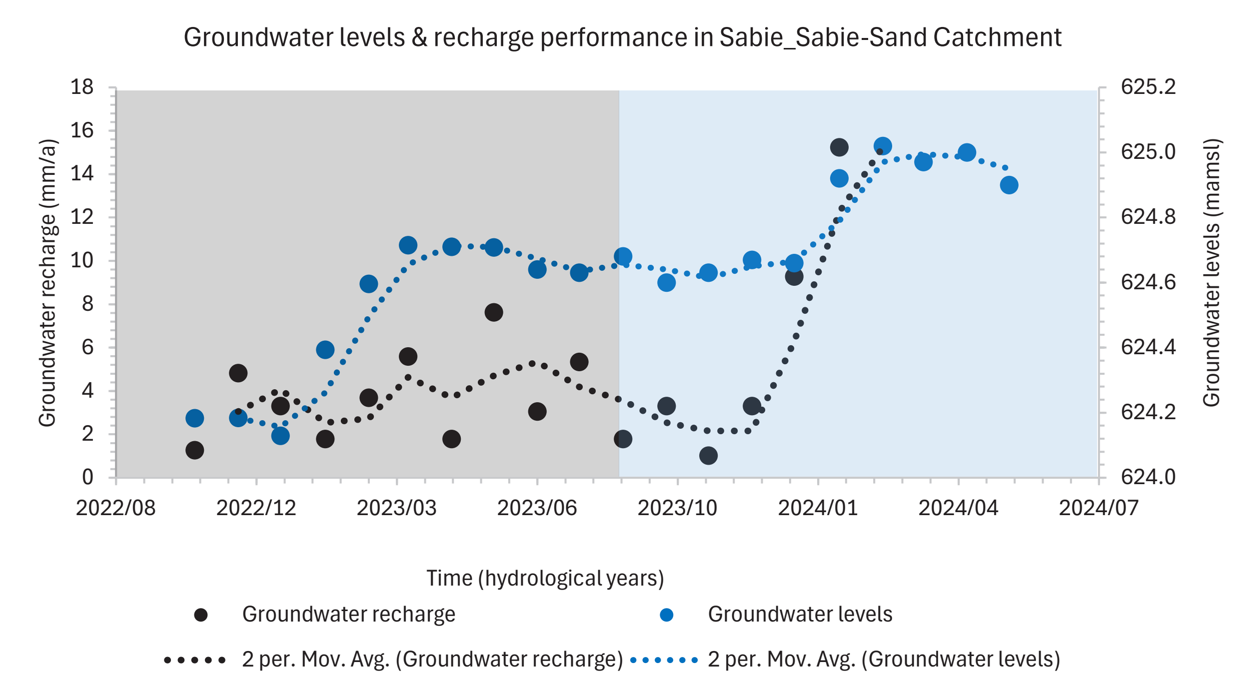


Figure 20: An analysis of groundwater resource performance for the Sabie subsystem in the Usuthu catchment based on the consecutive hydrological years (2022/2023 & 2023/2024).

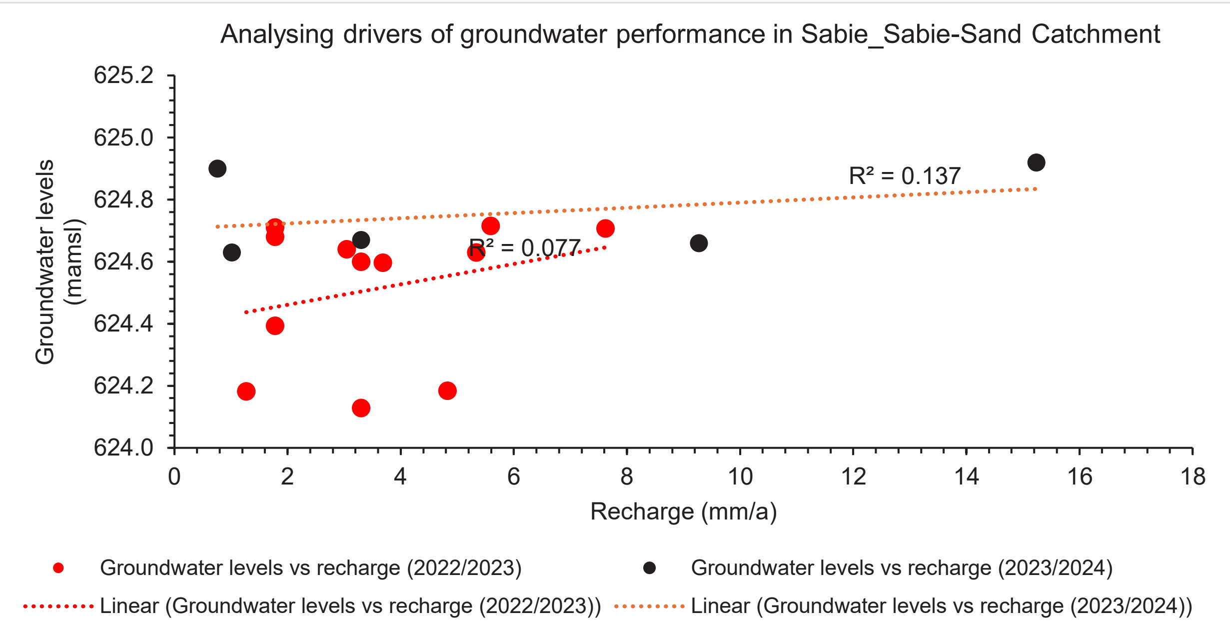


Figure 21: Analysing drivers of groundwater resource performance based on the strength of correlation between groundwater level and recharge data from the Sabie subsystem, Sabie-Sand catchment.

1.3.1.1. Sand Subsystem

In the Sans subsystem, the status of groundwater (recharge, baseflow, and storage/levels) is shown in Figure 22 against which the following notes were made against this dataset:

- Almost all the groundwater indicators were in the mild drought during the October (2023) to January (2024) months while the recharge was in the severe drought condition. These indicators predominantly recovered onwards (ranging between slightly wet to severely extreme wet conditions) until May 2024. Notably, this excludes baseflow and groundwater recharge, which began to experience mild drought in April 2024. Recharge being the source of groundwater replenishment, groundwater levels similarly started low (slightly wet condition) from October to December 2023) before responding to the high recharge and increasing to moderately wet conditions from January to May 2024). Both recharge and groundwater levels followed the same trajectory as the previous hydrological year which implies that recharge will end up in mild drought conditions while groundwater levels will end up in slightly wet conditions by the end of the running hydrological year (2023/2024).

- Figure 23 shows that recharge started in the drought conditions in October (2023) and responded to the wet season by improving into the wet conditions throughout December 2023) to March 2024). The peak of the rising recharge limp attained extreme wet conditions from December to January. It receded into slightly wet conditions in February to March before dropping into the mild drought conditions in April.

- Figure 24 shows that groundwater levels and recharge decreases are cyclically seasonal.
    - Groundwater recharge conventionally decreases during the dry season followed by an increase in the wet season; should the groundwater not be under stress (*i.e.*, groundwater use be less than the replenishment), the groundwater level would recover to the original status following the dry spell. Figure 25 shows that both groundwater level and recharge recover fully from a period of dry spell recoveries.
    - The above bullet point suggests that groundwater levels and recharge in the sand subsystem are resilient (the ability of groundwater resources to withstand and quickly recover from natural and human-made impacts); however, the weak and negative linear relationship (*i.e*., as one variable increases in its values, the other variable decreases in its values) between recharge and groundwater levels, in Figure 25, is indicative that the resilience (the ability of groundwater resources to withstand and quickly recover from natural and human-made impacts) is related to decreased abstraction.

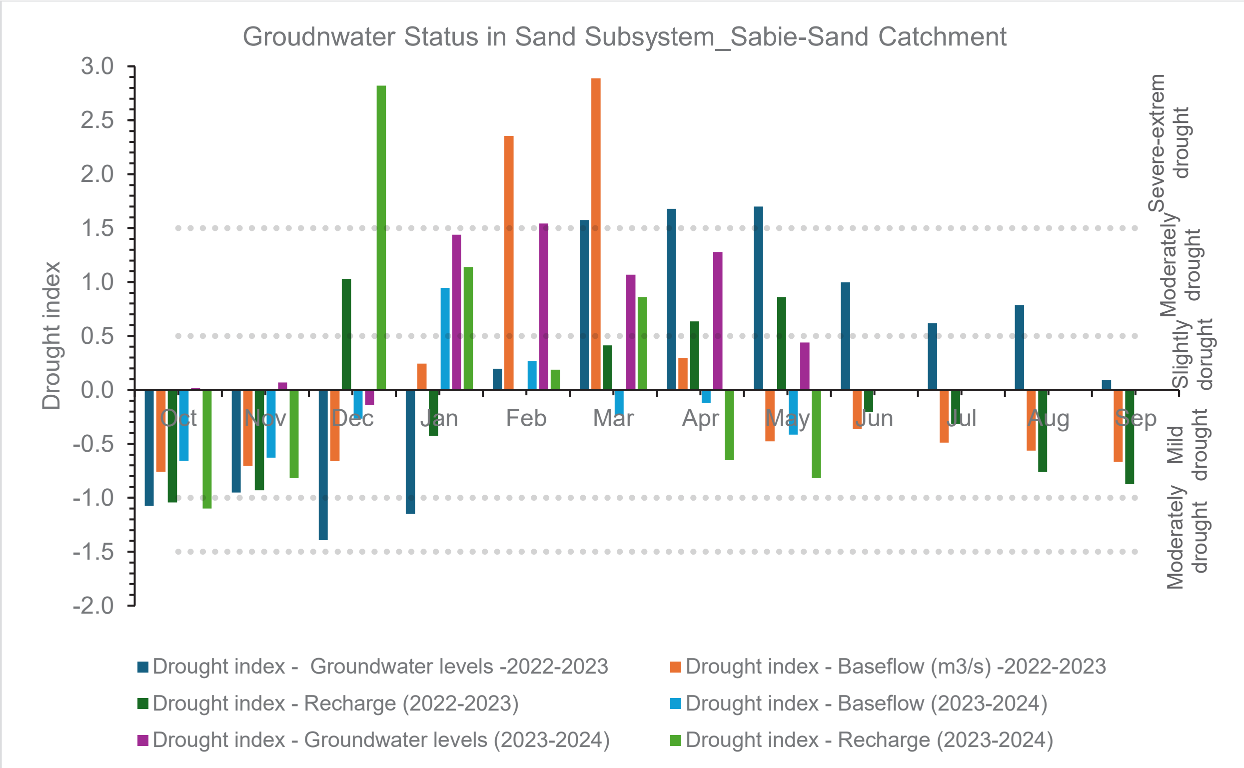


Figure 22: Groundwater status between consecutive hydrological years (2022/2023- 2023/2024) Sand subsystem of Sabie-Sand catchment.

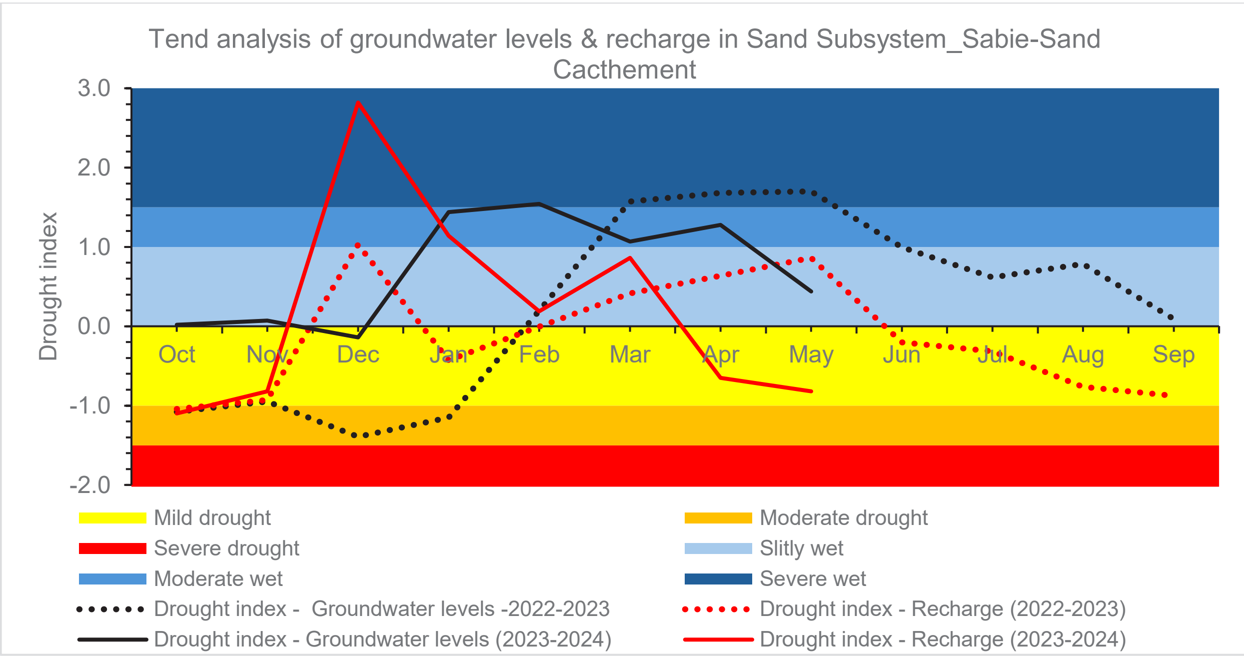


Figure 23: Analysis of groundwater levels and recharge trend for the 2022/2023 and 2023/2024 hydrological years in the Sand subsystem of Sabie-Sand catchment.

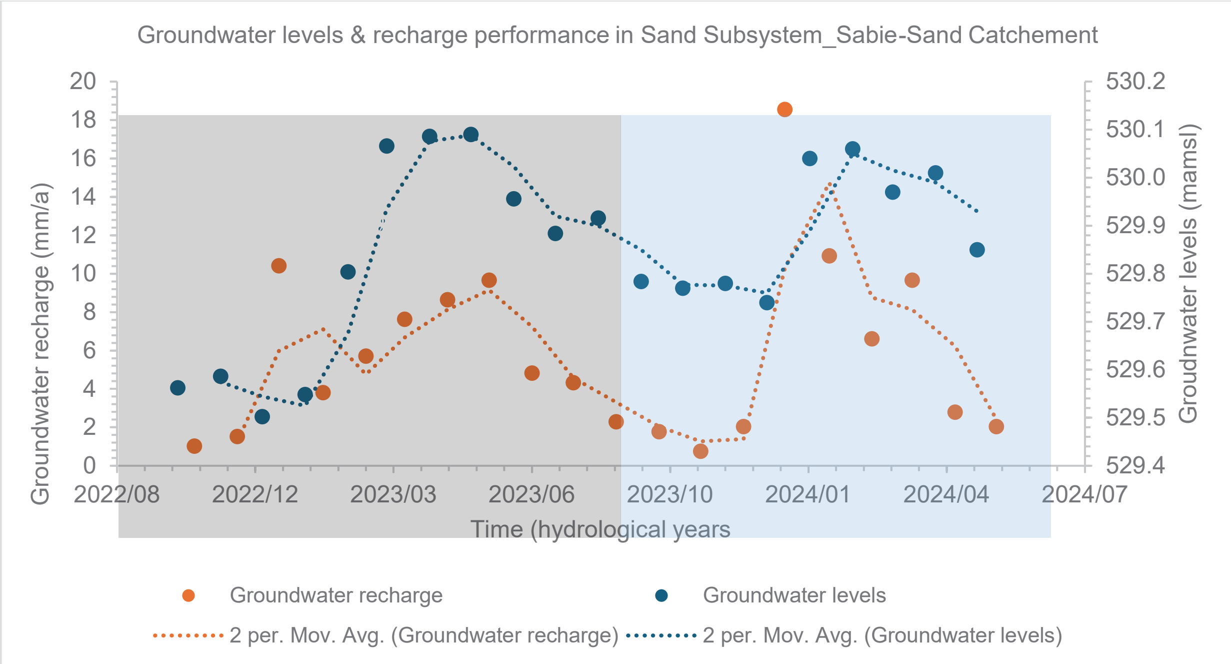


Figure 24: An analysis of groundwater resource performance for the Sand subsystem in the Sabie-Sand catchment based on the consecutive hydrological years (2022/2023 & 2023/2024).

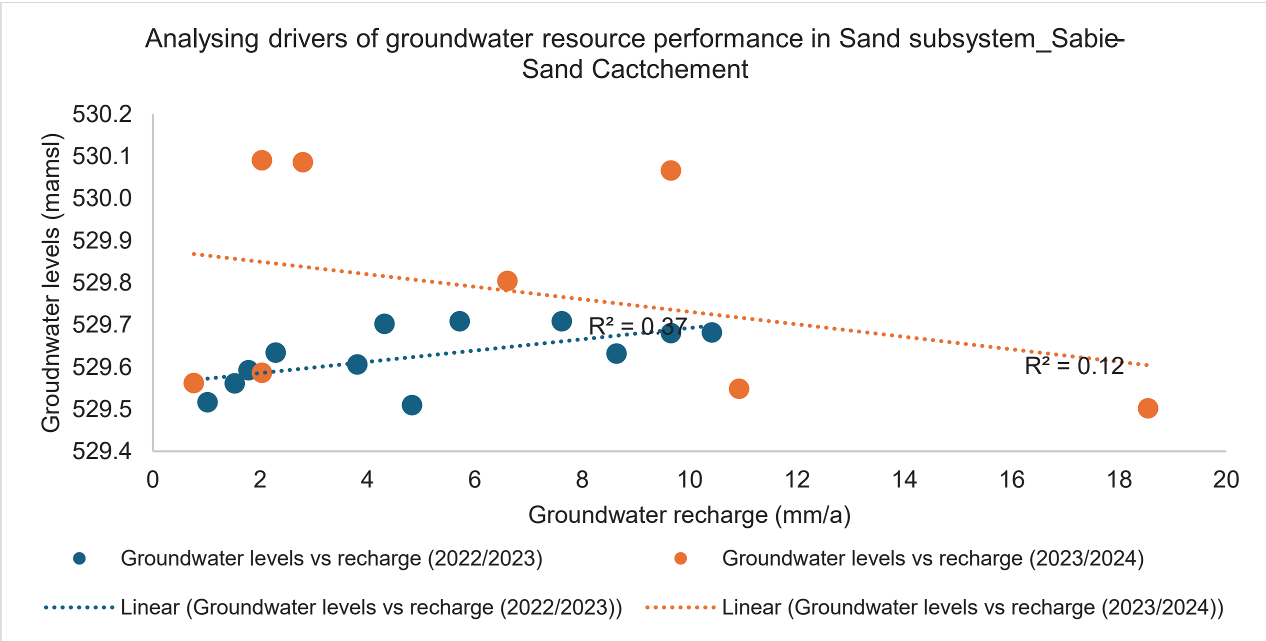


Figure 25: Analysing drivers of groundwater resource performance based on the strength of correlation between groundwater level and recharge data in the Sand subsystem, Sabie-Sand catchment.

3.3.2 Crocodile Catchment

In the Crocodile catchment, the status of groundwater (recharge, baseflow, and storage/levels) is shown in Figure 26 against which the following notes were made against this dataset:

- Except for groundwater levels, all the groundwater status indicators were in the wet condition ranging from slightly wet to severe-extreme wet conditions. Conversely, groundwater levels, just like the previous hydrological year (2022/2023) were in drought conditions. Nevertheless, they improved from mild-moderately drought conditions (in the 2022/2023 hydrological year) to mild drought conditions in the current hydrological year (2023/2024).

- Figure 27 shows that recharge began in the mild range during October 2023 and picked up to severe-extreme wet conditions in December before receding to slight wet conditions from January to April. In April, recharge began to drop, reaching mild drought conditions in May 2024. Following the same trajectory, groundwater levels started in the mild drought (from October 2023 to January 2024) before peaking up in January to be in the slightly wet condition; however, they dropped again reaching mild drought in May 2024).

- As shown in Figure 28, the decreasing groundwater levels and recharge are cyclically seasonal.
    - Seasonal changes play a role in regulating groundwater recharge and levels; wet seasons lead to high recharge while dry seasons lead to decreased recharge and levels. Although recharge exhibited resilience (*i.e.*, it recovered to the original amount following the dry spells), groundwater levels did not recover to the same level as those of the previous hydrological year (2022/2023). This is indicative that groundwater use was more than groundwater recharge, in which case groundwater levels decline progressively, indicative that groundwater levels are non-resilient.
    - The weak and negative linear relationship between recharge and groundwater levels, in Figure 29, is indicative that groundwater storage was predominantly constrained by abstraction. This point and the previous one collectively indicate the unsustainability of groundwater resources.

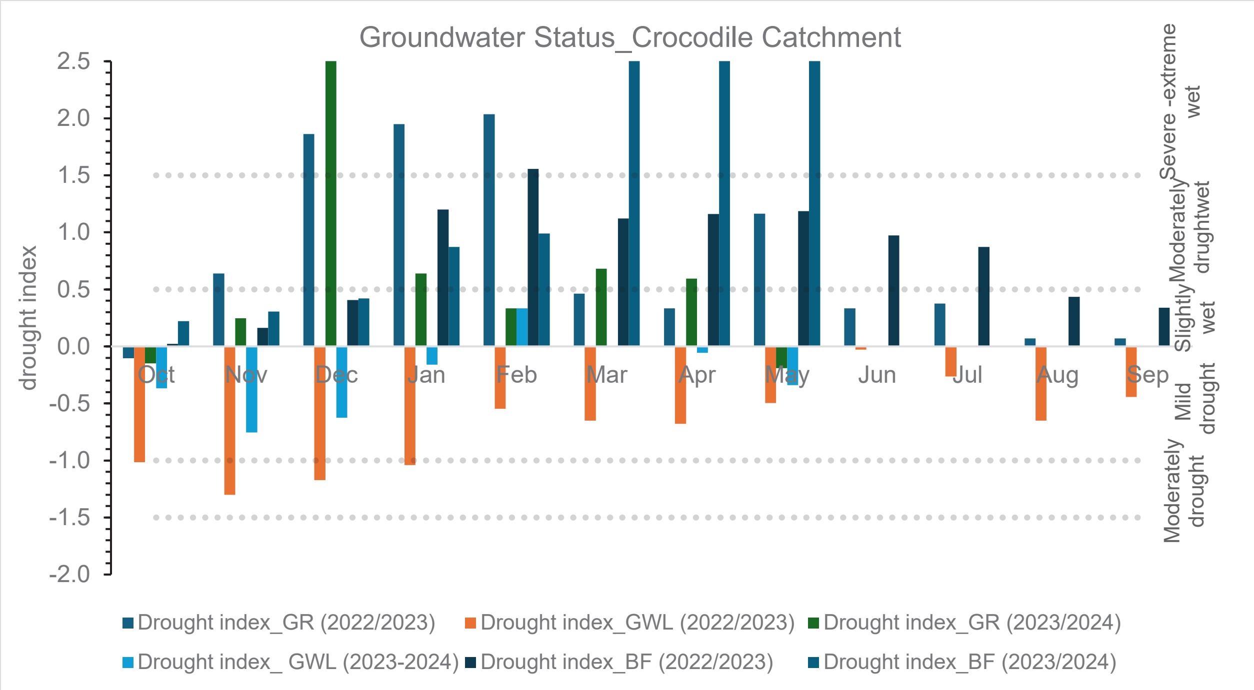


Figure 26: Groundwater status between consecutive hydrological years (2022/2023-2023/2024) Crocodile catchment

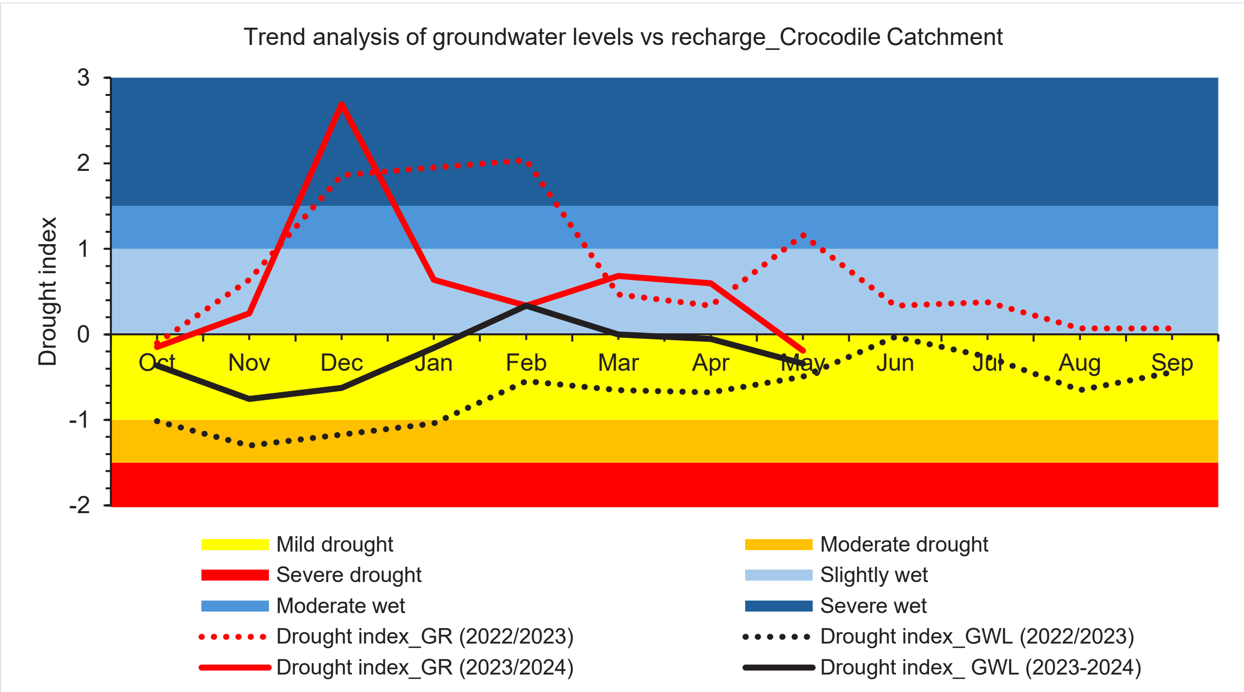


Figure 27: Analysis of groundwater levels and recharge trend for the 2022/2023 and 2023/2024 hydrological years in the Crocodile catchment.

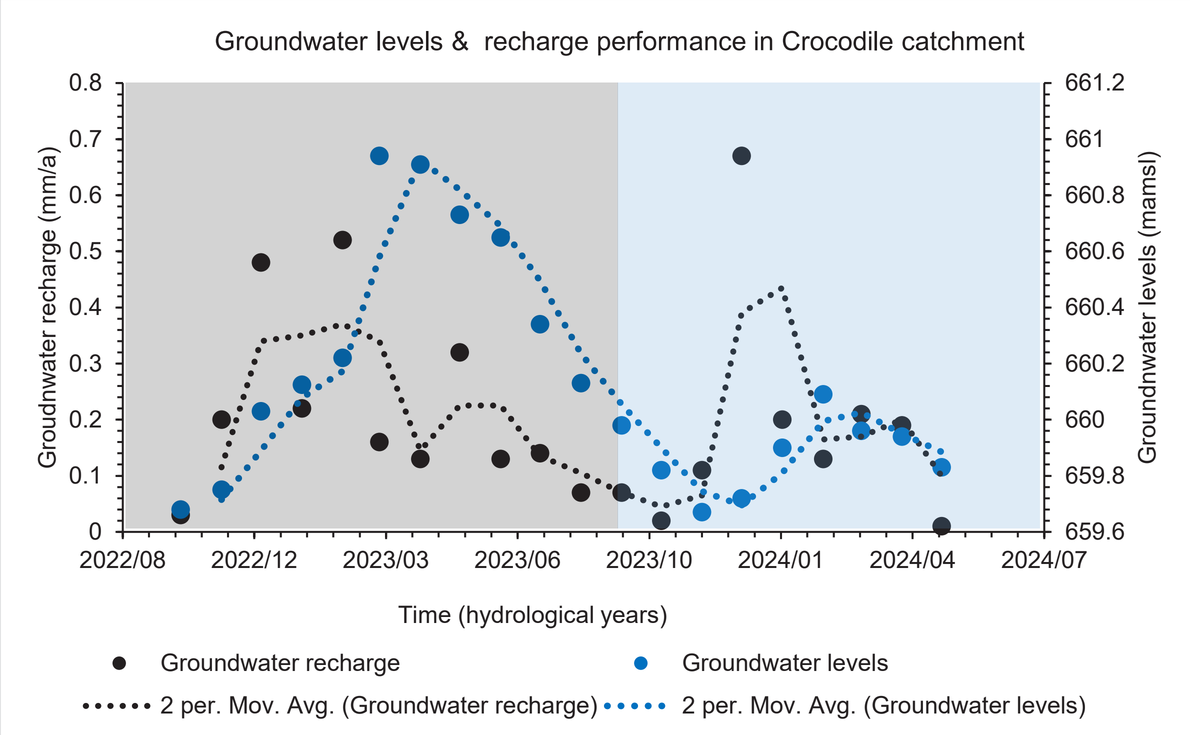


Figure 28: An analysis of groundwater resource performance for Crocodile catchment.

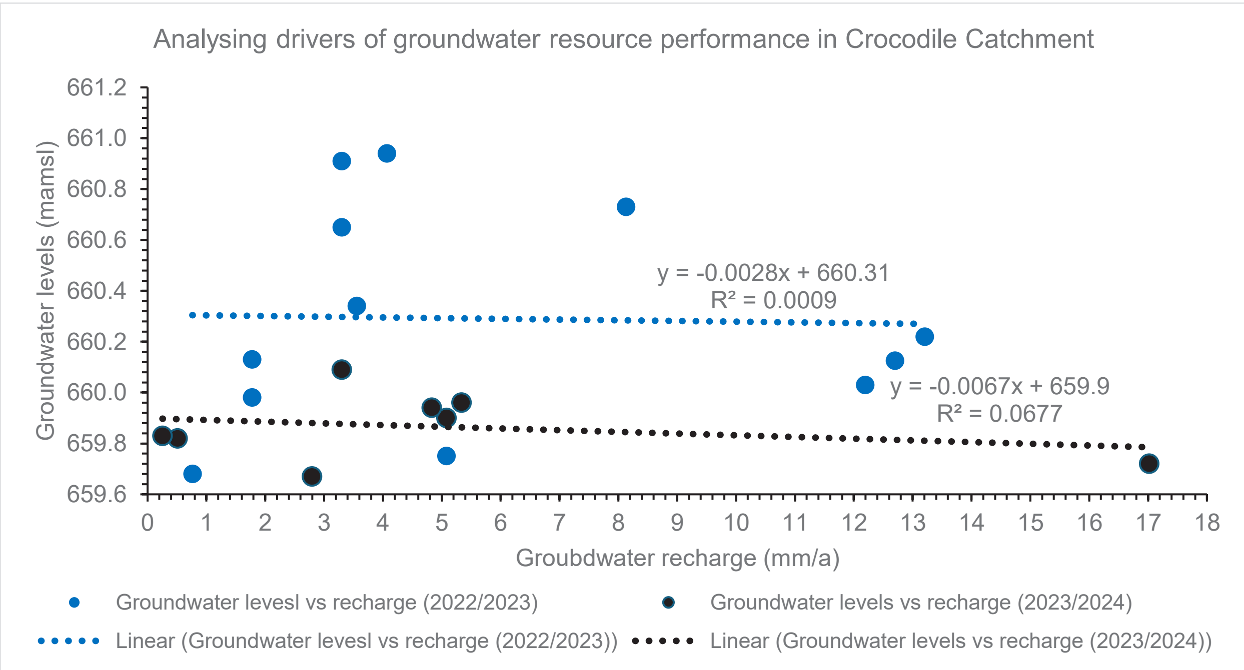


Figure 29: Analysing drivers of groundwater resource performance based on the strength of the correlation between groundwater level and recharge data in the Crocodile catchment

3.3.3 Komati Catchment

3.3.3.1 Upper Komati

The dataset in Figure 30 establishes the status of groundwater (recharge, baseflow and storage/levels) against which the following notes were made against this dataset:

- Groundwater status indicators were all in mild to moderate conditions from October to November 2023. In December 2023, groundwater recharge recovered to moderate conditions while the rest of the indicators maintained drought status. In January 2024, except for recharge which maintained mild drought conditions, all the other indicators were in slightly wet conditions before they downgraded to mild drought conditions to May 2024.

- Figure 31 shows recharge consistently maintained the mild drought status from October 2023 to May 2024. Recharge being the source of groundwater replenishment, groundwater levels predominantly maintained mild drought conditions. Contrarily, these two indicators attained extreme wet status between December (2023) and March 2023) which effectively points to the deterioration of the groundwater resource from the 2023/2023 hydrological to 2023/24 hydrological year.

- As shown in Figure 32, the decreasing groundwater levels and recharge are cyclically seasonal.
  - Seasonal changes play a role in regulating groundwater recharge and, therefore, levels; however, the significant difference in recoveries between the 2022/2023 hydrological year and the current hydrological year (2023/2024) is indicative that both groundwater levels and recharge never attain full recovery which implies that groundwater resources lacked resiliency (the ability of groundwater resource to withstand and quickly recover from natural and human-made impacts.
  - In general, levels decline due to increased groundwater withdrawal and/or reduced aquifer recharge. The weak and positive linear relationship between recharge and groundwater levels, in Figure 32, is indicative that groundwater storage was constrained by both draft (combined borehole abstraction and plants groundwater uptake) and recharge. This point and the previous one collectively indicate an unsustainability of groundwater resources between the 2022/2023 and so far in the 2023/2024 hydrological years.

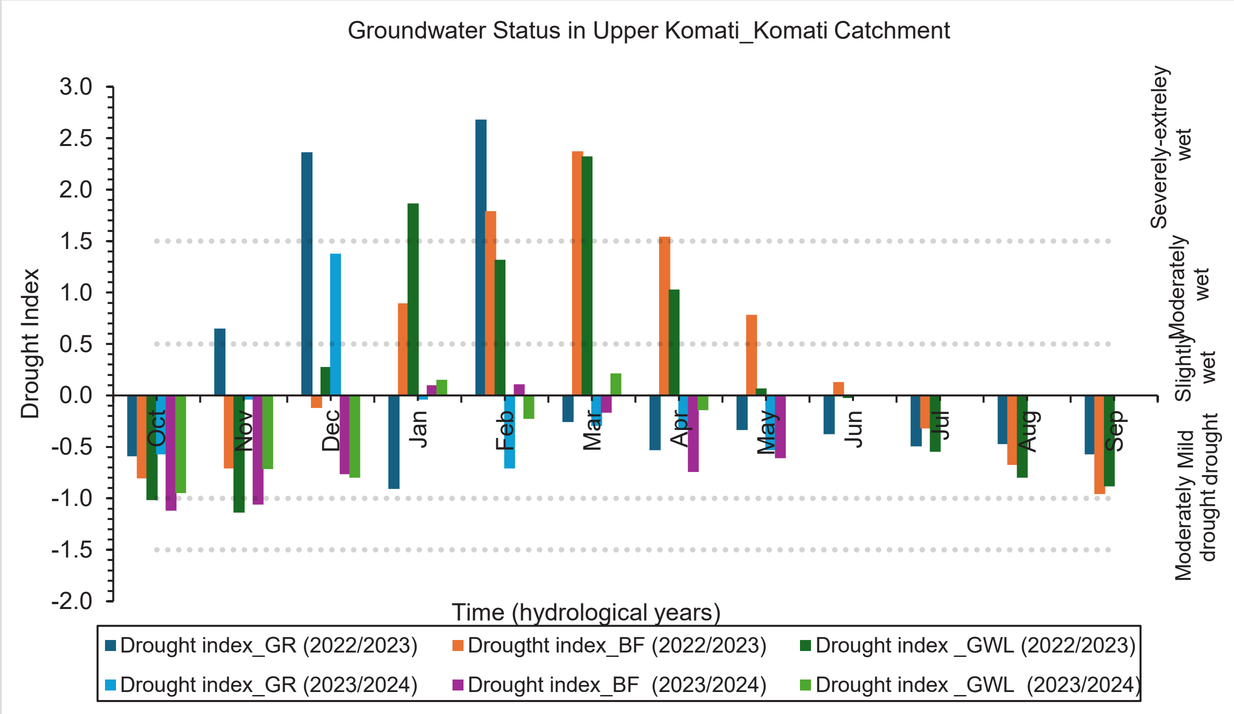


Figure 30: Groundwater status between consecutive hydrological years (2022/2023-2023/2024) in the Upper Komati of Komati Catchment.

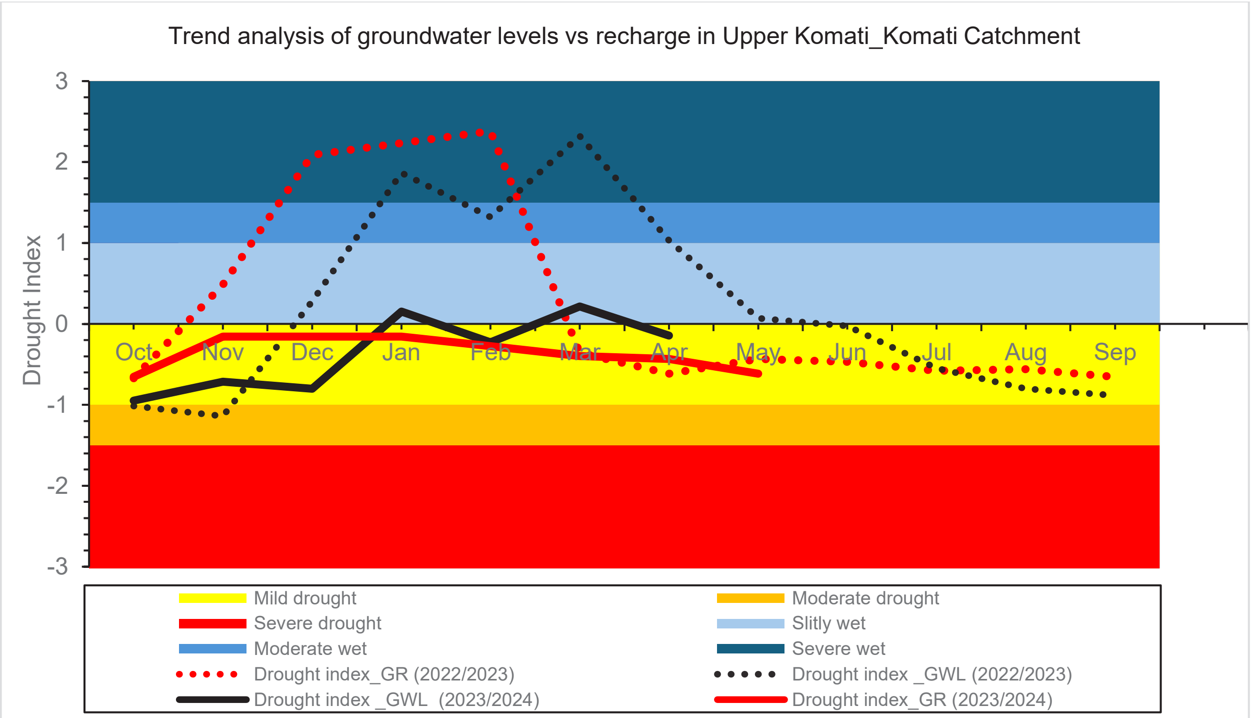


Figure 31: Analysis of groundwater levels and recharge trend for the 2022/2023 and 2023/2024 hydrological years in the Upper Komati of Komati catchment.

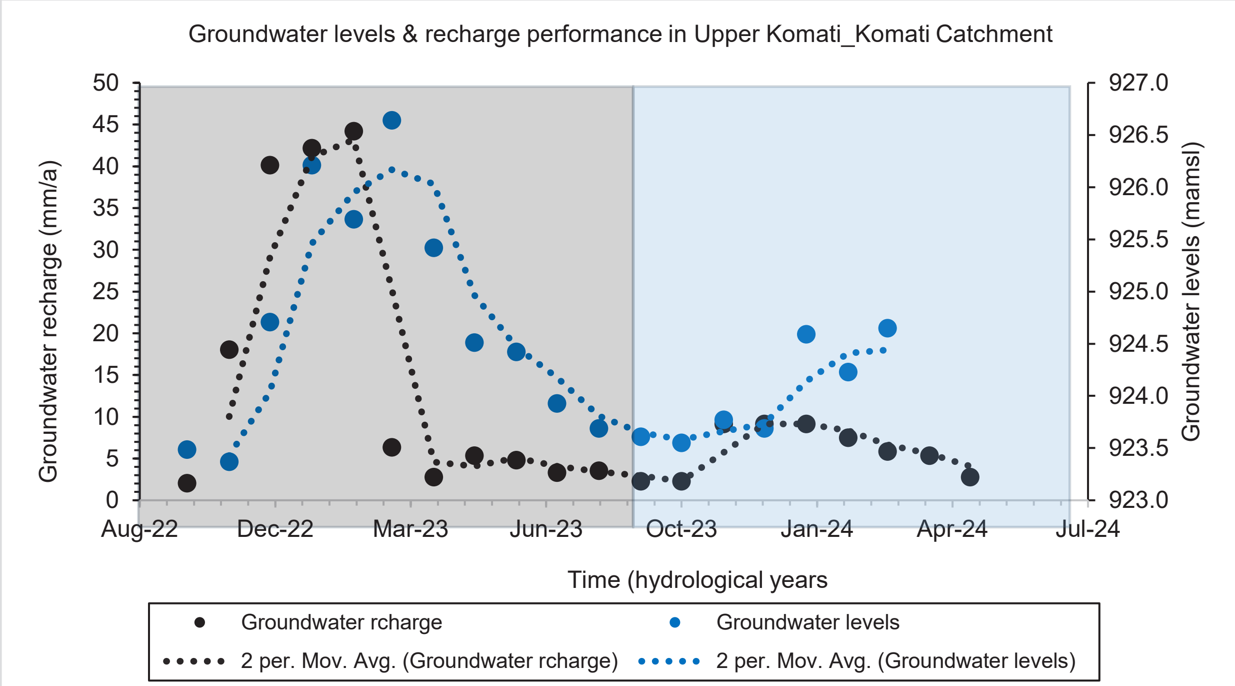


Figure 32: An analysis of groundwater resource performance for Upper Komati in the Komati catchment based on the consecutive hydrological years (2022/2023 & 2023/2024).

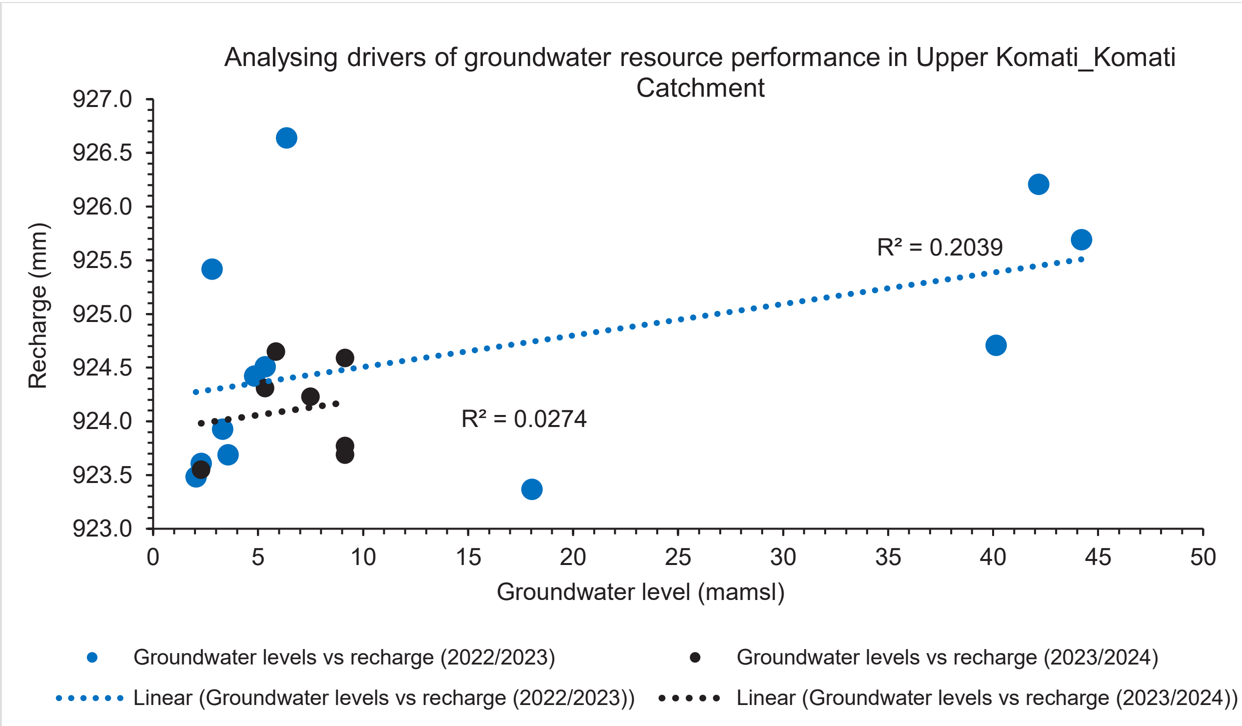


Figure 33: Analysing drivers of groundwater resource performance based on the strength of correlation between groundwater level and recharge data in the Upper Komati of Komati catchment.

3.3.3.2 Lower Komati

For lower Komati, the dataset in Figure 34 establishes the status of groundwater (recharge, baseflow and storage/levels) against which the following notes were made against this dataset:

- October to November 2023 were characterised by mild to moderate drought conditions. Whilst groundwater levels recovered to slightly wet conditions, both baseflow and groundwater recharge maintained mild drought conditions from December (2023) to January (2024). While baseflow maintained this status to May 2024, all other indicators improved to slightly wet and moderately wet.

- Figure 35 shows that recharge was in severe drought conditions when the 2023/2024 hydrological year started, improving to the peak of moderately wet conditions in March before declining in April to reach slightly wet conditions in May 2024. Contrarily, groundwater levels were not sure of pronounced fluctuations; they started in the mild drought improved to the interface of the mild drought and were slightly wet from December to April before reverting to mild drought in May 2024.

- As shown in Figure 36, the decreasing groundwater levels and recharge are cyclically seasonal.
    - Equal recoveries between 2022/2023 and the current hydrological year (2023/2024) were indicative that both groundwater levels and recharge attain a full recovery, which implies groundwater resiliency.
    - The strong (0.5) and positive linear relationship between recharge and groundwater levels, in Figure 37, is indicative that groundwater storage is predominantly constrained by recharge.

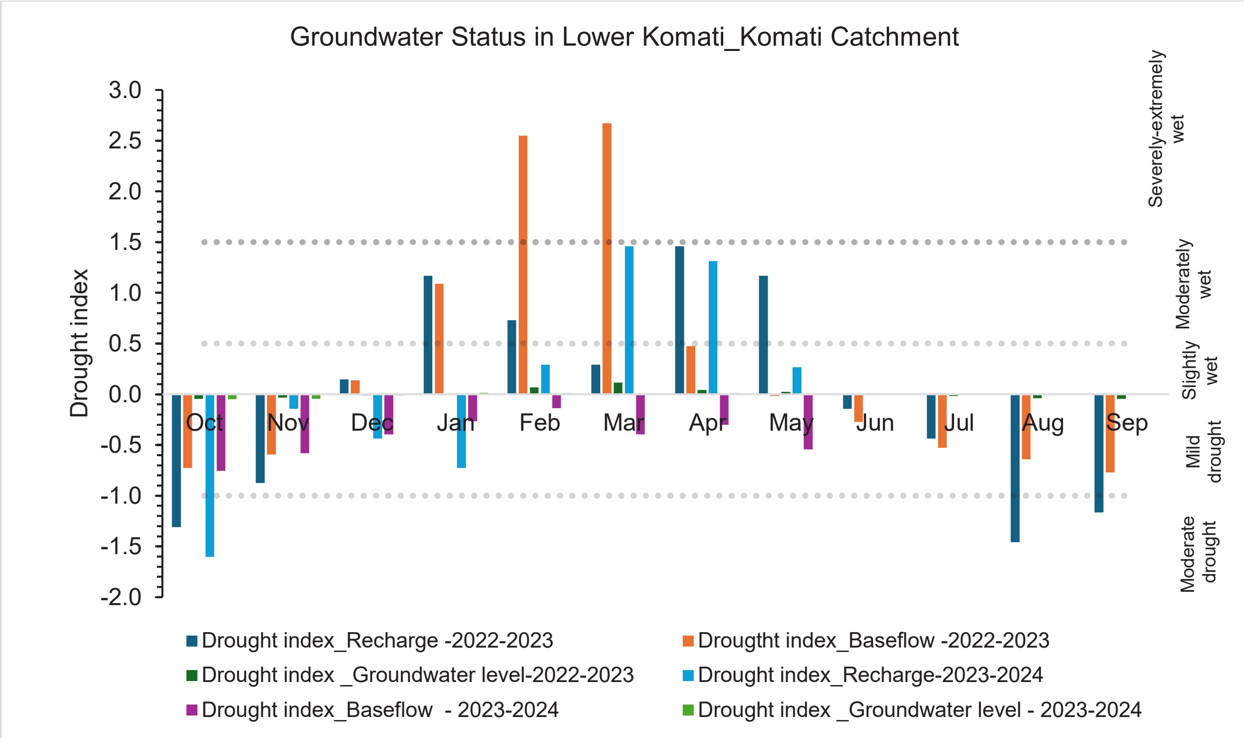


Figure 34: Groundwater status between consecutive hydrological years (2022/2023-2023/2024) Lower Komati of Komati catchment.

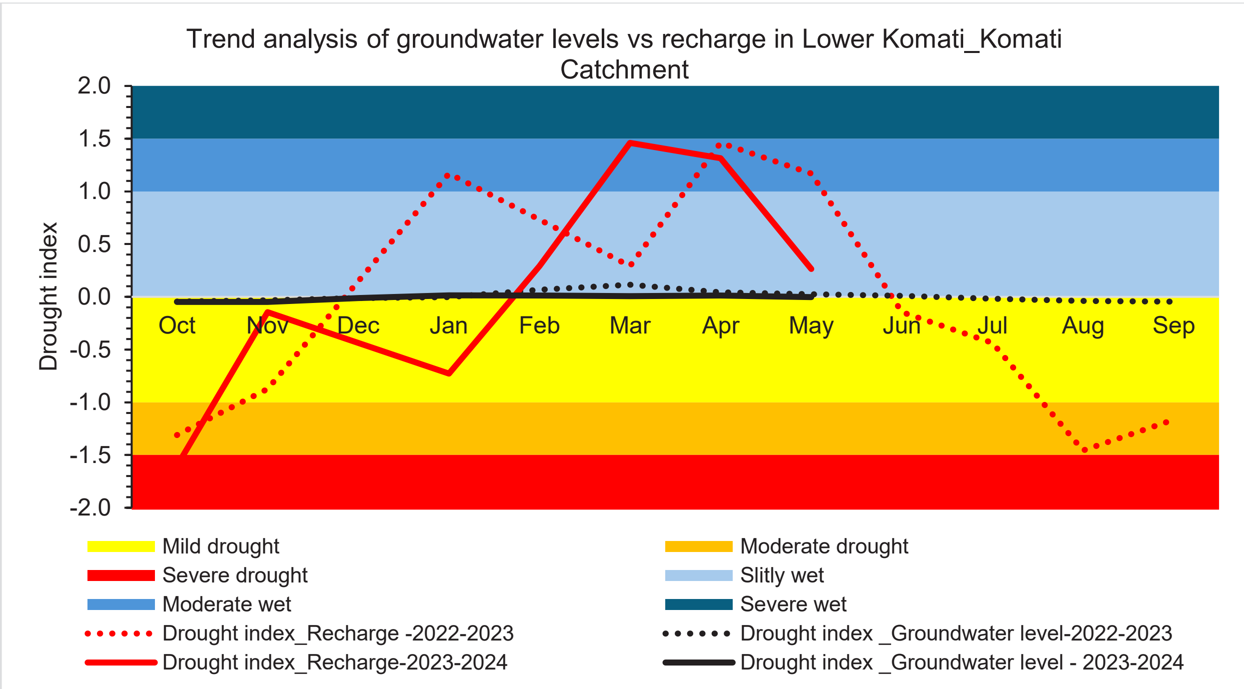


Figure 35: Analysis of groundwater levels and recharge trend for the 2022/2023 and 2023/2024 hydrological years in the Lower Komati of Komati catchment.

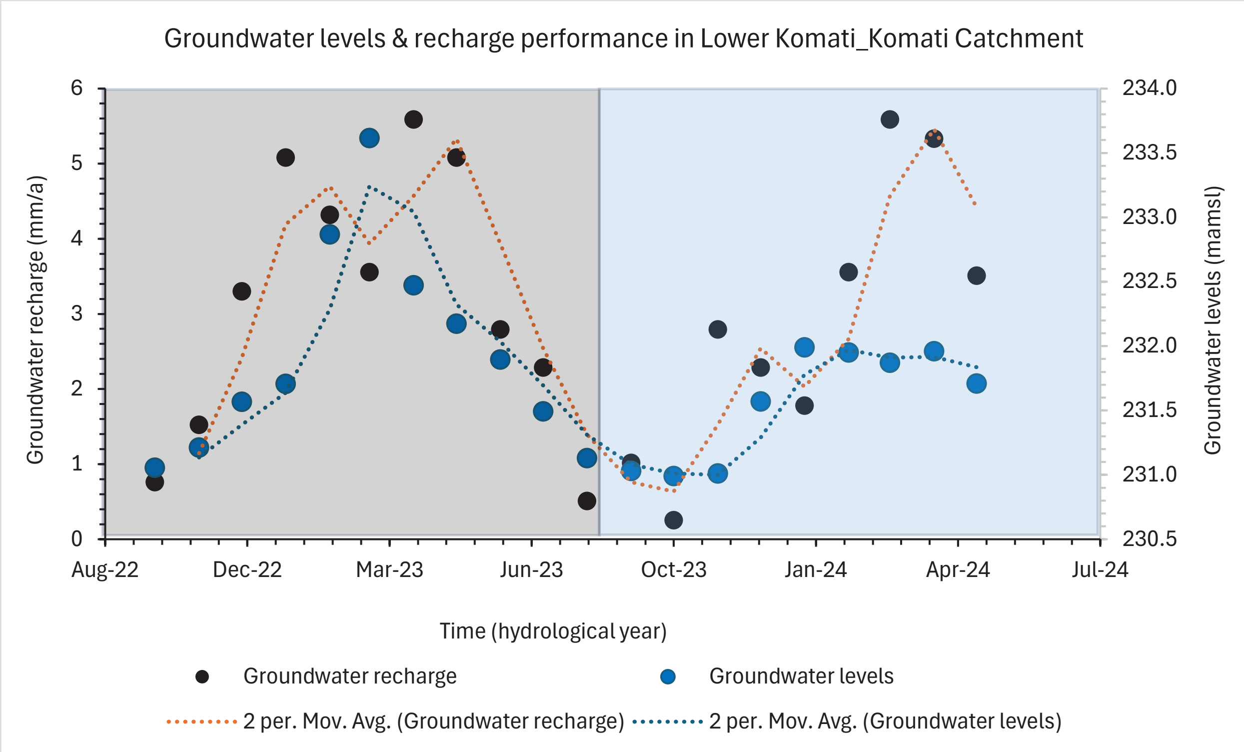


Figure 36: An analysis of groundwater resource performance for Lower Komati.

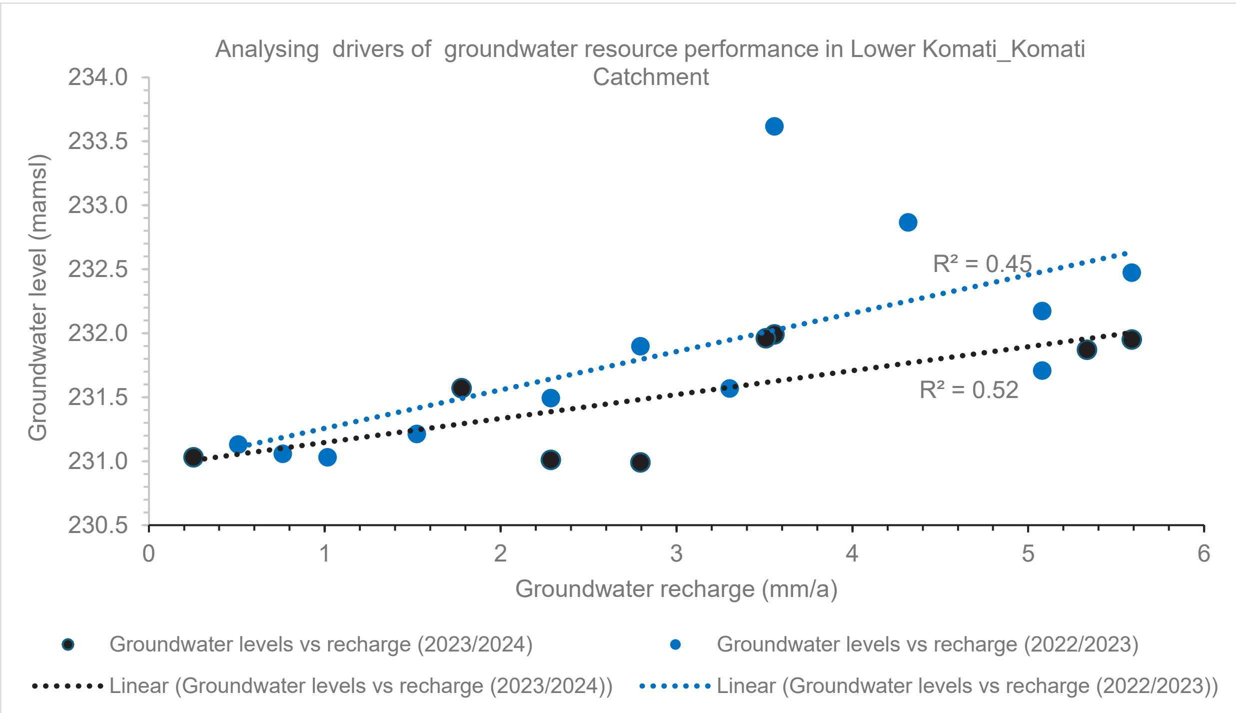


Figure 37: Analysing drivers of groundwater resource performance based on the strength of correlation between groundwater level and recharge data in the lower Komati of Komati catchment.

3.3.4 Usuthu Catchment

3.3.4.1 Ngwempisi Subsystem

In the Ngwempisi subsystem, the status of groundwater (recharge, baseflow and storage/levels) is shown in Figure 38 against which the following notes were made against this dataset:

- Between October and December 2023, all the groundwater status indicators were predominantly in mild to moderate drought conditions. However, recharge began to recover in December attaining a moderately wet status in December 2023. In January, except for groundwater levels, all the indicators declined to mild drought with recharge deteriorating farther into moderate drought in May.

- Figure 39 shows that recharge Improved from mild drought conditions, in October and November 2023, to moderately wet conditions in December. From December 2023, recharge linearly deteriorated until moderate drought conditions in May. Groundwater levels followed the same trend, but they only reached the maximum of slightly wet conditions that lasted until March 2024, before a similar downward decline took place.

- As shown in Figure 40, the decreasing groundwater levels and recharge are cyclically seasonal.
    - Since the primary source of groundwater recharge is rainfall which is seasonal in the Inkomati-Usuthu water Management Area (WMA), seasonal changes play a role in regulating groundwater recharge and levels; however, the notable difference in recoveries is indicative that both groundwater levels and recharge never attain full recovery following a dry spell.
    - The above point implies that groundwater resources lacked resiliency (the ability of groundwater resources to withstand and quickly recover from natural and human-made impacts).
    - In general, water levels decline due to increased groundwater withdrawal and/or reduced aquifer recharge. The weak and positive linear relationship between recharge and groundwater levels, in Figure 41, is indicative that groundwater storage is constrained by both draft (combined borehole abstraction and plants groundwater uptake) and recharge.

3.3.4 Usuthu Catchment

3.3.4.1 Ngwempisi Subsystem

In the Ngwempisi subsystem, the status of groundwater (recharge, baseflow and storage/levels) is shown in Figure 38 against which the following notes were made against this dataset:

- Between October and December 2023, all the groundwater status indicators were predominantly in mild to moderate drought conditions. However, recharge began to recover in December attaining a moderately wet status in December 2023. In January, except for groundwater levels, all the indicators declined to mild drought with recharge deteriorating farther into moderate drought in May.

- Figure 39 shows that recharge Improved from mild drought conditions, in October and November 2023, to moderately wet conditions in December. From December 2023, recharge linearly deteriorated until moderate drought conditions in May. Groundwater levels followed the same trend, but they only reached the maximum of slightly wet conditions that lasted until March 2024, before a similar downward decline took place.

- As shown in Figure 40, the decreasing groundwater levels and recharge are cyclically seasonal.
    - Since the primary source of groundwater recharge is rainfall which is seasonal in the Inkomati-Usuthu water Management Area (WMA), seasonal changes play a role in regulating groundwater recharge and levels; however, the notable difference in recoveries is indicative that both groundwater levels and recharge never attain full recovery following a dry spell.
    - The above point implies that groundwater resources lacked resiliency (the ability of groundwater resources to withstand and quickly recover from natural and human-made impacts).
    - In general, water levels decline due to increased groundwater withdrawal and/or reduced aquifer recharge. The weak and positive linear relationship between recharge and groundwater levels, in Figure 41, is indicative that groundwater storage is constrained by both draft (combined borehole abstraction and plants groundwater uptake) and recharge.

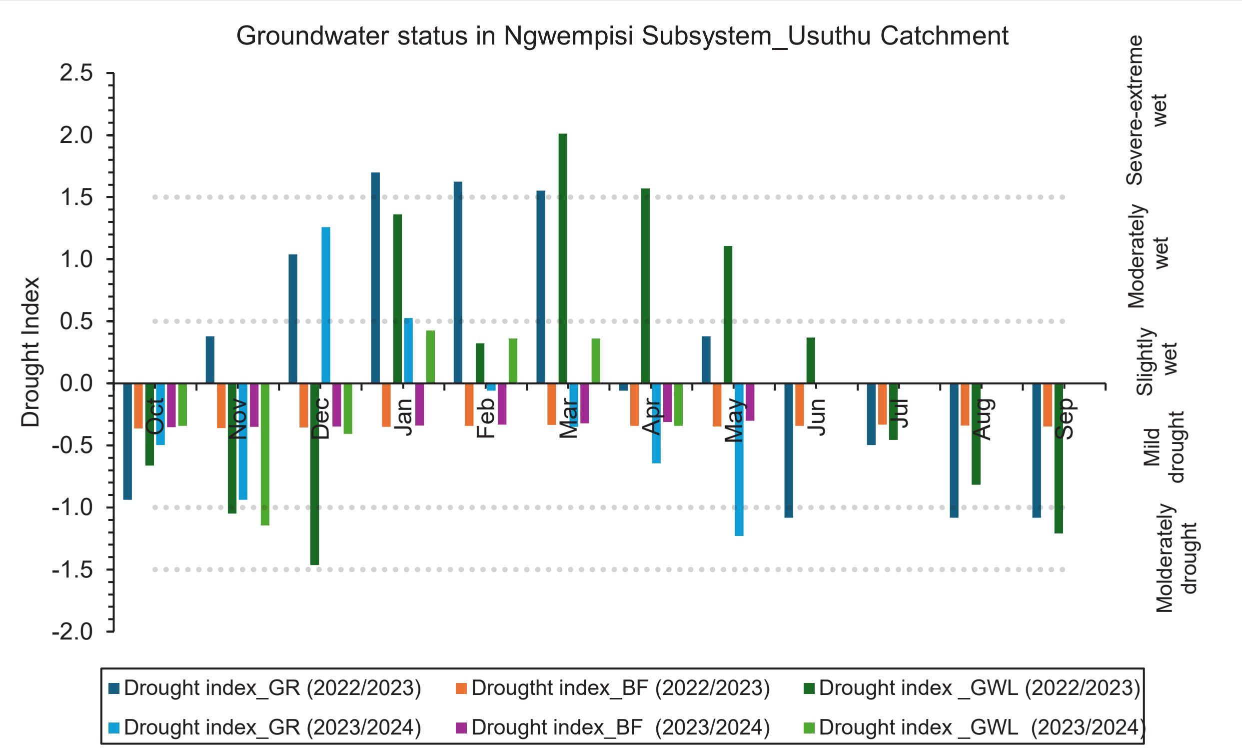


Figure 38: Groundwater status between consecutive hydrological years (2022/2023-2023/2024) in Nwempisi subsystem, Usuthu catchment.

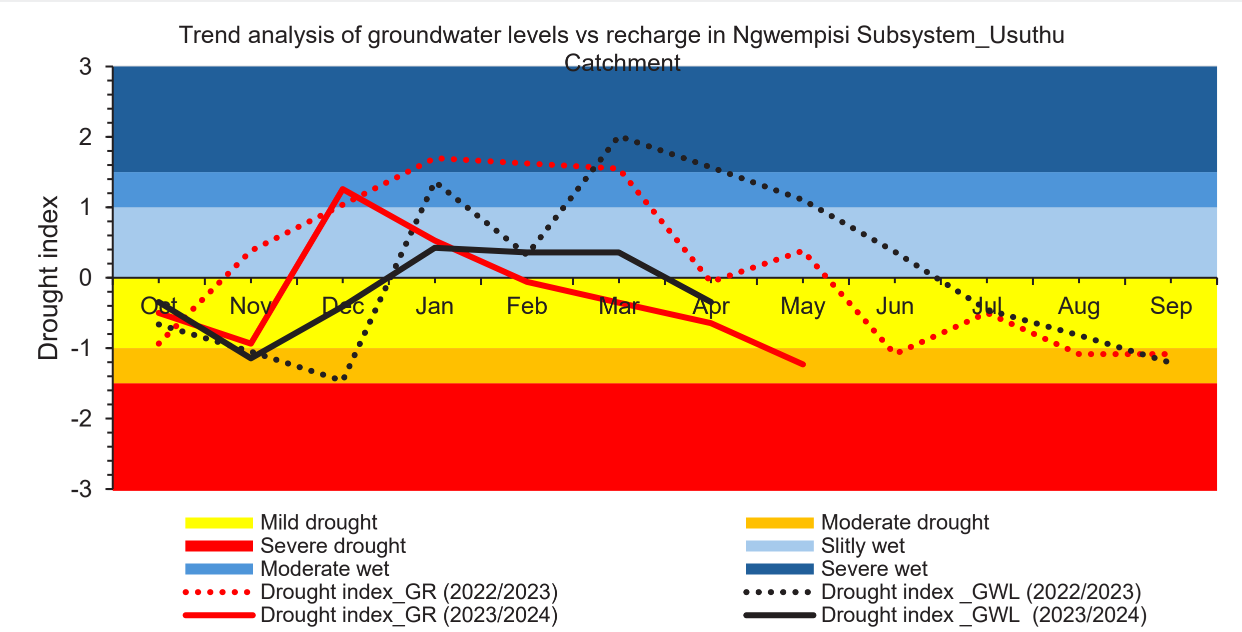


Figure 39: Analysis of groundwater levels and recharge trend from 2022/2023 to 2023/2024 hydrological years in the Ngwempisi subsystem, Usuthu subsystem of Usuthu catchment.

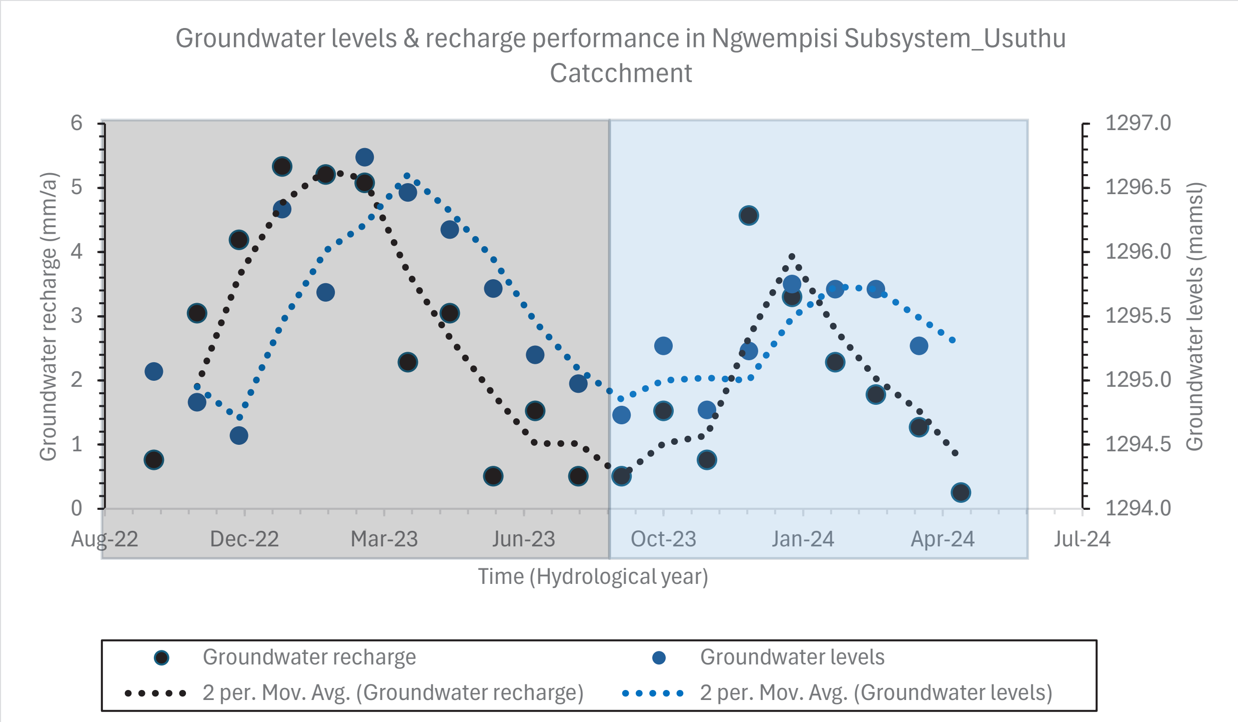


Figure 40: An analysis of groundwater resource performance for Ngwempisi subsystem in the Usuthu catchment.

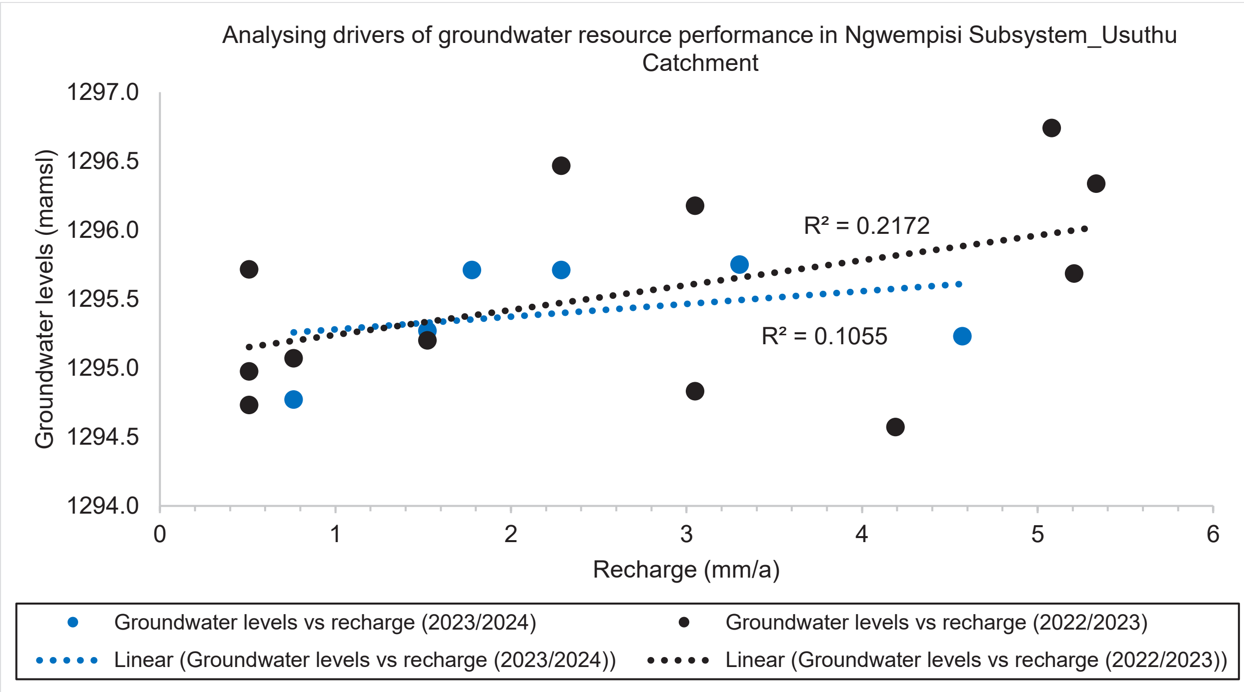


Figure 41: Analysing drivers of groundwater resource performance based on the strength of the correlation between groundwater level and recharge in the Ngwempisi subsystem.

3.3.4.2 Assegai Subsystem

In the Assegai subsystem, the status of groundwater (recharge, baseflow and storage/levels) is shown in Figure 42 against this dataset:

- In October and November 2023, all the groundwater status indicators were predominantly in mild drought conditions. In December, only groundwater recharge improved from mild drought to slightly wet whilst the rest of the indicators maintained mild drought conditions. In January 2024, all the indicators improved except for baseflow and groundwater levels (the decrease in groundwater leads to the decrease of groundwater discharge to stream) which were later joined by recharge in April and May.
- Figure 43 that recharge responded to seasonal changes where it improved from mild drought conditions into slightly wet conditions during the wet season before decreasing again to mild drought in March to Paril. Conversely, there has not been a pronounced response by groundwater levels as they consistently remained in the mild drought condition before improving momentarily slightly wet conditions in March.
- Figure 44 shows that groundwater levels and recharge fluctuations were cyclically seasonal.
    - Seasonal changes play a role in regulating groundwater recharge and levels; however, the notable difference in recoveries is indicative that both groundwater levels and recharge never attain full recovery which implies that groundwater resources lacked resiliency.
    - The weak and positive linear relationship between recharge and groundwater levels, in Figure 45, is indicative that groundwater storage was constrained by both draft (combined borehole abstraction and plants groundwater uptake) and recharge.
- Because an increase in groundwater abstraction causes both baseflow and water levels to decrease, baseflow is characterized by consistent mild drought conditions with no signs of recovery. This is substantiated by a negative slope which implies groundwater use controls the groundwater resource fluctuation.
- The above point suggests the unsustainability of groundwater use which reduces groundwater discharge into the river and vice versa. This effectively calls for groundwater management plans to be developed; the IUCMA is in the process of appointing service providers to address this recommendation.

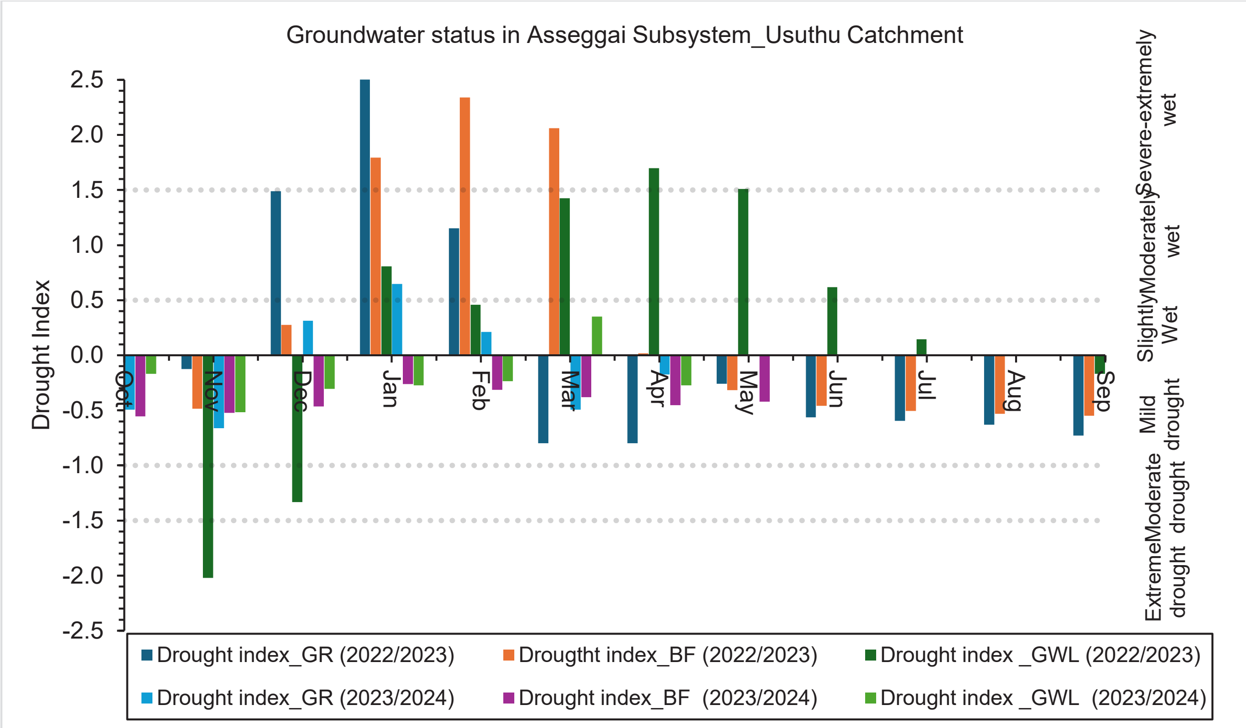


Figure 42: Groundwater status between consecutive hydrological years (2022/2023-2023/2024) in Assegai subsystem, Usuthu catchment.

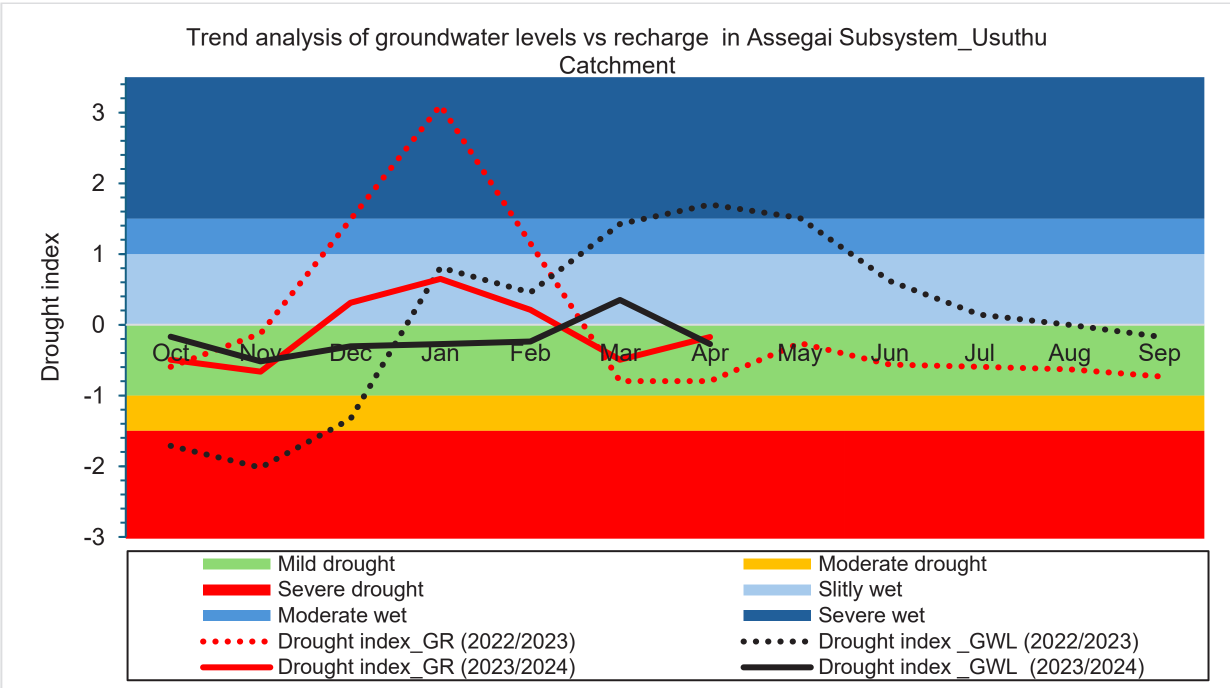


Figure 43: Analysis of groundwater levels and recharge trend from 2022/2023 to 2023/2024 hydrological years in the Assegai subsystem of Usuthu catchment.

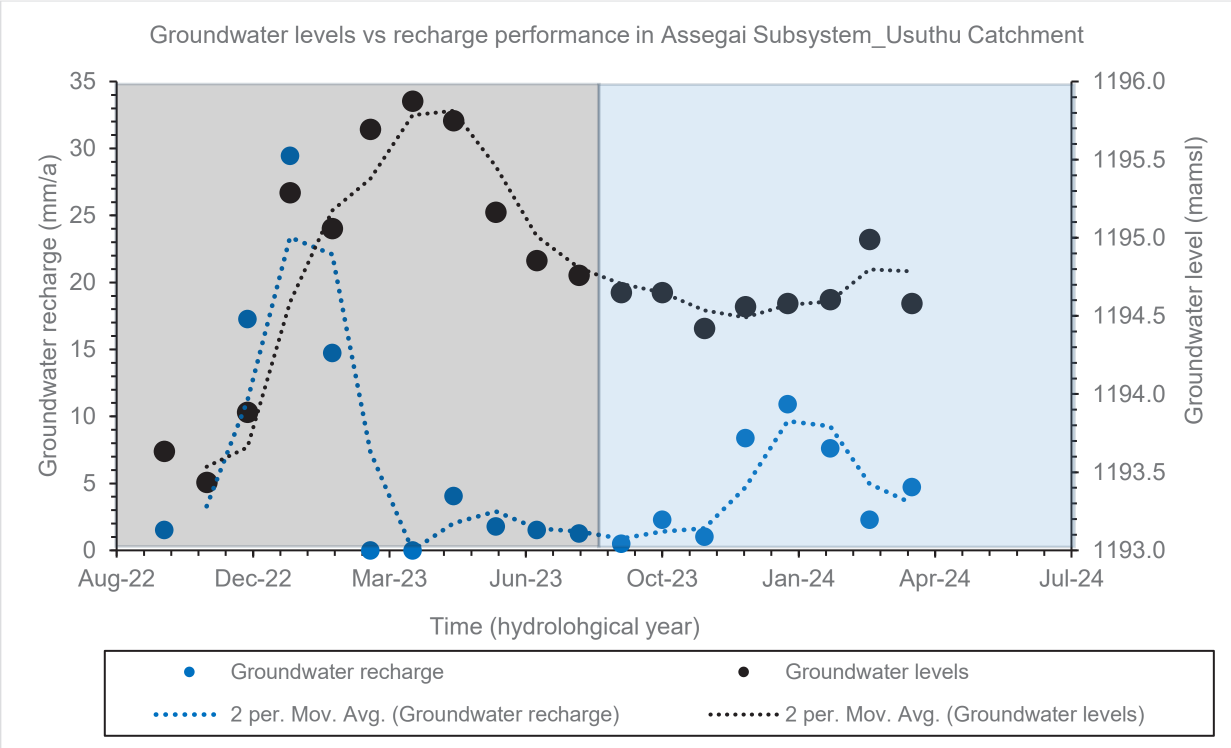


Figure 44: An analysis of groundwater resource performance for the Assegai subsystem in the Usuthu catchment.

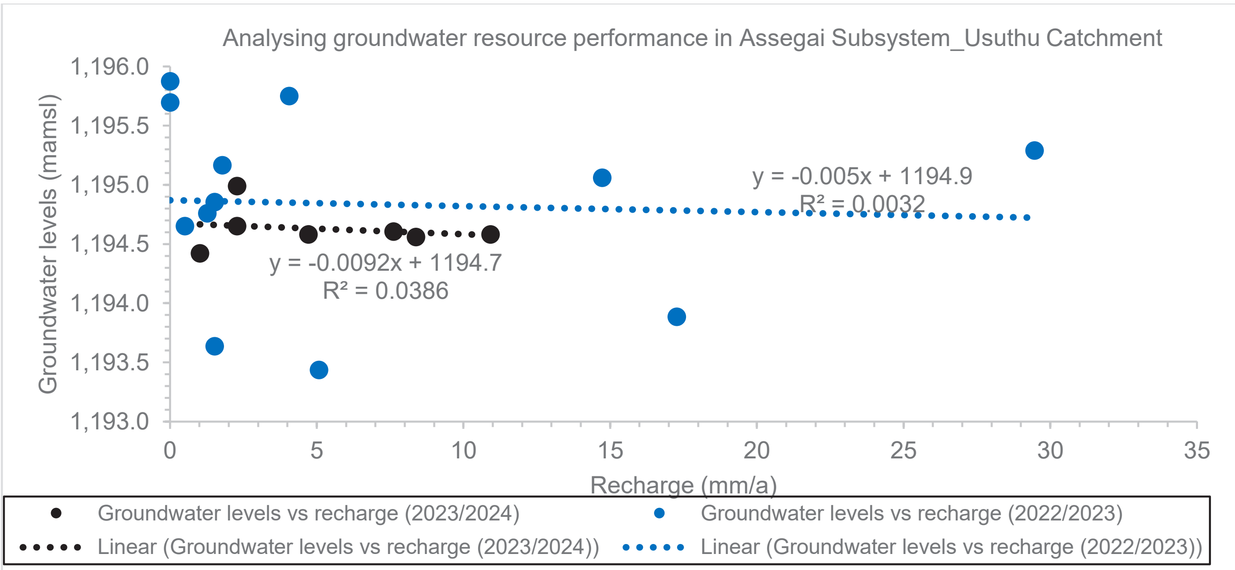


Figure 45: Analysing drivers of groundwater resource performance based on the strength of the correlation between groundwater levels and recharge.

3.3.5 Groundwater resource status summary

In addition to annual status, a comparison of two quarters is also presented for different financial years. The groundwater resource status, for the Inkomati-Usuthu Water Management Area, is summarised in Table 2 which shows that:

- Groundwater predominantly deteriorated from a period of wet condition in Q4 of the previous Groundwater deteriorated from a period of wet condition in Q4 of the previous financial year to the current reporting quarter (Q1 of the 2024/2025 year).

- From Q4 of the previous financial year to the current reporting quarter (Q1 of the 2024/2025 financial year, only groundwater levels and recharge, in the Sabie subsystem, improved from a drought period to a wet period while they maintained drought conditions in the Sand.

- In Usuthu and Crocodile, baseflow also maintained drought conditions from Q4 (2023/2024) to Q1 (2024/2025).

- In terms of performance, groundwater resources in the Lower Komati, Sabie and Sand Subsystems were (at the time of reporting) resilient (the ability of groundwater resources to withstand and quickly recover from natural and human-made impacts) while the rest were not.

The above summary results highlighted the need for adaptive water management whose effectiveness relies on predictive studies. Consequently, future models should be developed to capture the spatial and temporal dynamism of the natural groundwater budget due to climate change, water demands, and population growth predictions

Table 2: Summary of the groundwater status in the Inkomati-Usuthu Water Management Area between 2024/2025 and 2024/2025 (Q1) hydrological years respectively.

Catchment ID	Specific location	Recharge*		Groundwater level**		Baseflow***		Performance****
		Q4 (2023/2024)	Q1 (2024/2025)	Q4 (2023/2024)	Q1 (2024/2025)	Q4 (2023/2024)	Q1 (2024/2025)	
Usuthu	Ngwempisi	Severely-extremely wet	Moderately drought	Moderately wet	Mild drought	Mild drought	Mild drought	Non-resilient
	Assegai	Moderately wet	Mild drought	Moderately wet	Mild drought	Severely-extremely wet	Mild drought	Non-resilient
KOMATI	Upper Komati	Slightly wet	Mild drought	Severe-extremely wet	Mild drought	Severe-extreme wet	Mild drought	Non-resilient
	Lower Komati	Moderately wet	Moderately wet	Slightly wet	Moderately wet	Severely extreme wet	Mild drought	Resilient
CROCODILE	Crocodile	Moderately wet	Slightly wet	Slightly wet	Severe-extreme wet	Extreme drought	Mild drought	Non-resilient
SABIE-SAND	Sabie	Mild drought	Slightly wet	Mild drought	Slightly wet	Severely-extremely wet	Moderately wet	Resilient
	Sand	Slightly wet	Mild drought	Mild drought	Mild drought	Severely-extremely wet	Moderately wet	Resilient

**Addition of water into the groundwater storage either directly (diffuse/rainfall recharge) or indirectly (form streams, return flows and other surface water bodies)*
***Depth or height of the top of the groundwater volume and reflects the amount of water in storage; fluctuation of groundwater level is associated with draft (use by pumping and phreatophyte plants pumping) and natural processes such as recharge*
****Sustained low flow in a river predominantly contributed by groundwater which can be used as an indicator for the status of the groundwater reserve*
*****Ability of groundwater resource to withstand and quickly recover from natural (e.g., prolonged lack of recharge) and human-made impacts (e.g., over-pumping)*

3.4 Riverflow status within the WMA

The October to September 2024 River flow discharges has been generally a slightly lower than the historical average during the same period. Due to good summer rains received during the start 2023 hydrological year, all the rivers (Sabie, Crocodile, Komati and Usuthu) as in Figure 46 to Figure 52 have been flowing normal to high, but lower, compared to previous hydrological year 2022-23. The ecological water requirements and international obligations were met in the months October to June 2024 most of the time.

The riverflow stations listed below were chosen as indicator stations to offer information on the catchments' overall riverflow status levels. In the Sabie-Sand, two stations were chosen: Sand River @ Exeter and Sabie River @ Emmet; in the Crocodile, the station at Karino; in the Komati, the station at Hooggenoeg; and in the Usuthu, the station Assegaai River at Zandbank.

3.4.1 Sabie Sand Catchment

3.4.1.1 Sabie River at Lower Sabie

Water body: Sabie River
Drainage area: 5715 Km^2

The observed daily average flow at Lower Sabie was very high at the beginning of the quarter (month of January) but decreased in February and March 2024 (Table 3). The flow for the current hydrological year was only higher than the previous hydrological year in December, but generally lower for the rest of the period (Figure 46). These statistics can be seen in the figure below. The international obligation of 0.6 m^3/s has been met to Mozambique from Sabie River.

Table 3: Sabie River at Lower Sabie daily mean discharge (m^3/s).

Jan-24		Long-term January	
Mean	179.90	Mean	31.29
Minimum	17.45	Q5	70.68
Maximum	416.50	Q95	1.96
Feb-24		Long-term February	
Mean	23.92	Mean	49.22
Minimum	9.13	Q5	53.35
Maximum	61.42	Q95	2.72
Mar-24		Long-term March	
Mean	33.29	Mean	31.50
Minimum	6.50	Q5	41.31
Maximum	98.05	Q95	2.57

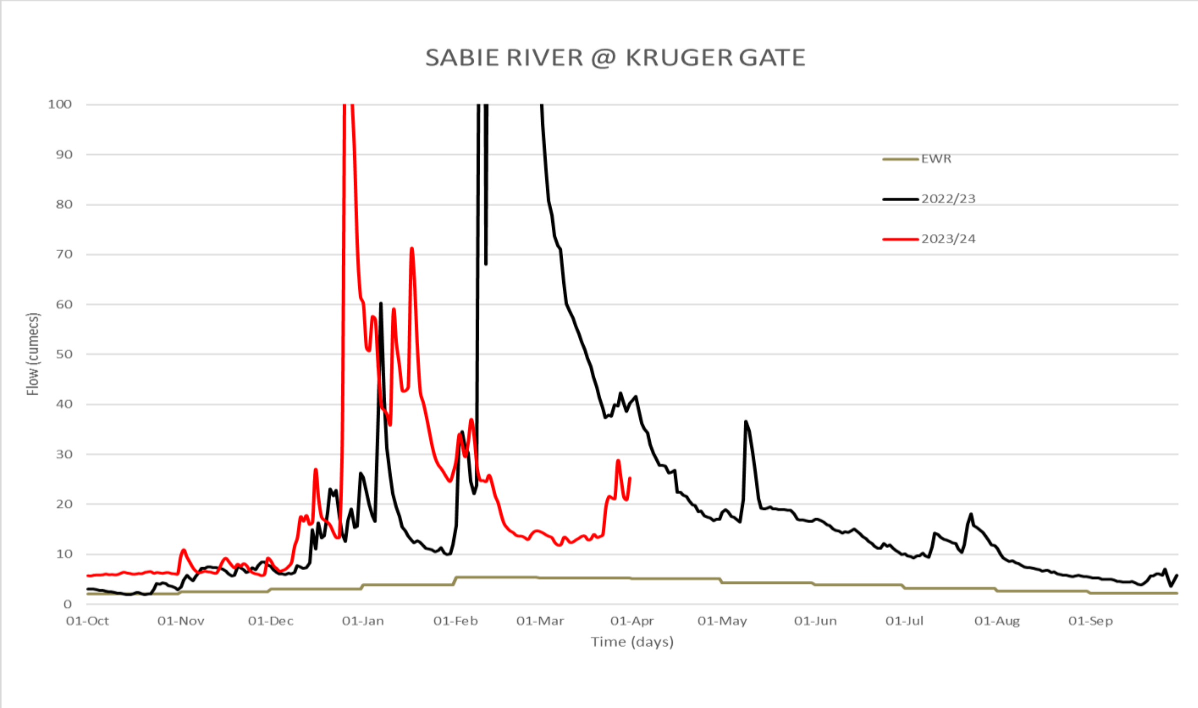


Figure 46: Sabie River level status and compliance to ecological requirements.

3.4.1.2 Sand River at Exeter

Water body: Sand River

Drainage area: 21481 Km^2

The observed mean discharge from Exeter is below the long term averages during the reporting period. The flows generally follow the same trend as the previous hydrological year until the end of December 2023 (Table 4). From January 2024, the flows have been decreasing and currently at normal levels. In comparison with the previous hydrological year, the flows for the reporting period are lower (Figure 47). The ecological water requirements were not met at the start of the hydrological year due to low flows experienced in October month but were met in the current reporting period.

Table 4: Sand River at Exeter daily mean discharge (m^3/s).

Jan-24		Long-term January	
Mean	136.17	Mean	66.96
Minimum	37.60	Q5	378.28
Maximum	550.99	Q95	0.27
Feb-24		Long-term February	
Mean	36.10	Mean	92.56
Minimum	18.30	Q5	208.30
Maximum	84.09	Q95	0.6
Mar-24		Long-term March	
Mean	33.29	Mean	65.72
Minimum	8.11	Q5	367.72
Maximum	79.77	Q95	3.54

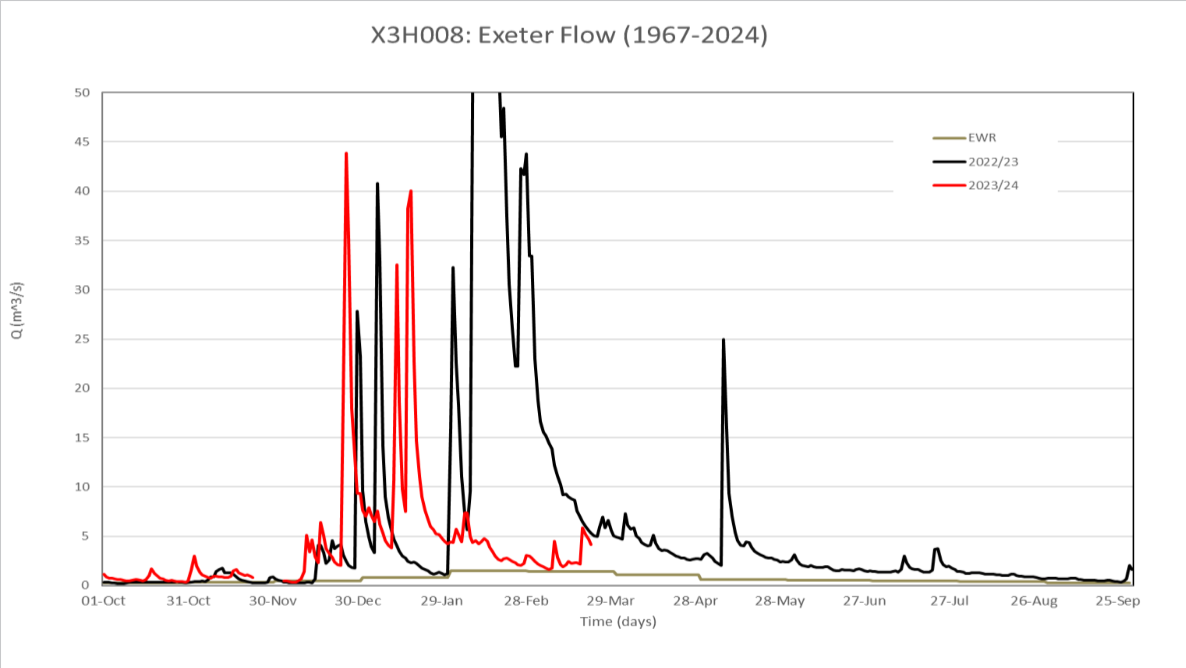


Figure 47: Sand River level status and compliance to ecological requirements.

3.4.1.1. Sabie River at Emmet

Water body: Sabie River

Drainage area: 771 Km^2

The observed mean discharge from Emmet was ranging between below normal and high for the entire reporting period. Flows have been lower than the previous hydrological year for most of the reporting period. The flows follow the same trend as the previous hydrological year until the end of December, after which the flow have been decreasing (Table 5). The ecological water requirements were met through the reporting period (Figure 48).

Table 5: Sabie River at Lower Sabie daily mean discharge (m^3/s).

Jan-24		Long-term January	
Mean	11.38	Mean	12.46
Minimum	6.96	Q5	57.28
Maximum	18.57	Q95	2.00
Feb-24		Long-term February	
Mean	7.62	Mean	14.28
Minimum	5.71	Q5	23.79
Maximum	11.12	Q95	1.84
Mar-24		Long-term March	
Mean	6.43	Mean	10.90
Minimum	5.17	Q5	25.62
Maximum	9.87	Q95	3.77

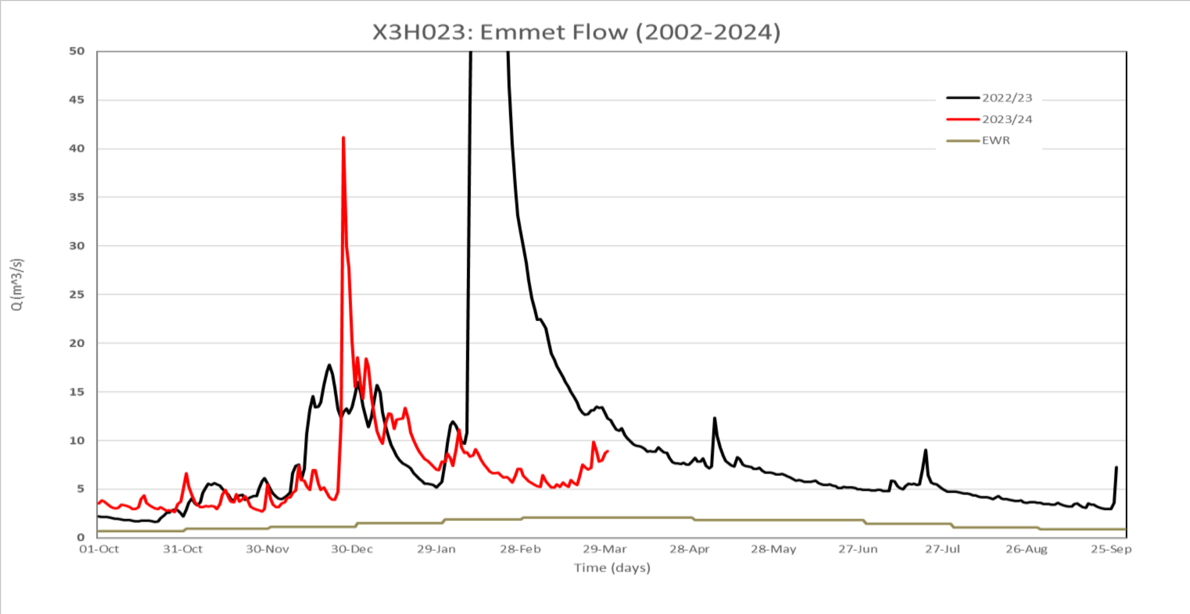


Figure 48: Sabie River level status and compliance to ecological requirements.

3.4.2 Crocodile Catchment

3.4.2.1 Crocodile River at Karino

Water body: Crocodile River
Drainage area: 5097 Km^2

The observed daily average flow at Karino are slightly below the long term averages for the quarter under review, except for January month (Table 6). The flow from the previous hydrological year were very high compared to the flows for the current hydrological year for the same period, owing to the above normal rainfall received in January and February 2024 (Figure 49). The ecological water requirements were met throughout the reporting period.

Table 6: Crocodile River at Karino daily mean discharge (m^3/s).

Jan-24		Long-term January	
Mean	39.36	Mean	27.42
Minimum	18.96	Q5	121.63
Maximum	62.86	Q95	3.64
Feb-24		Long-term February	
Mean	20.17	Mean	32.68
Minimum	13.86	Q5	78.88
Maximum	30.15	Q95	4.49
Mar-24		Long-term March	
Mean	16.94	Mean	28.60
Minimum	12.76	Q5	71.62
Maximum	24.76	Q95	4.63

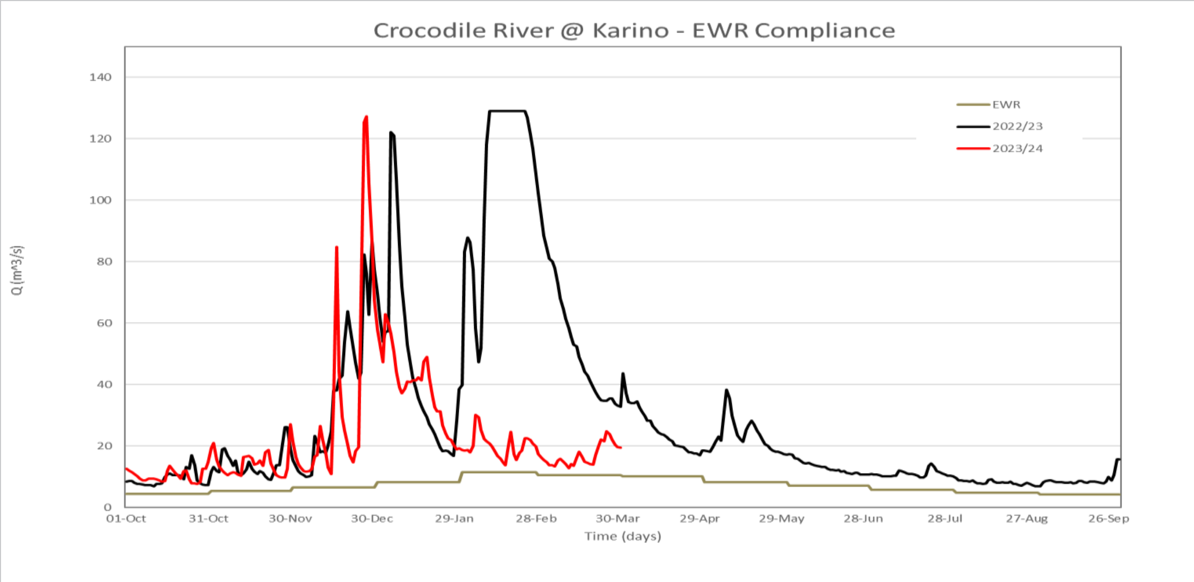


Figure 49: Crocodile River level status and compliance to ecological requirements.

3.4.2.2 Crocodile River at Tenbosch

Water body: Crocodile River

Drainage area: 5097 Km^2

The observed daily average flow at Tenbosch are well below the long term averages for the quarter under review, except for January month (Table 7). The flow from the previous hydrological year were very high compared to the flows for the current hydrological year for the same period, owing to the above normal rainfall received in January and February 2023 (Figure 50). The ecological water requirements were met throughout the reporting period.

Table 7: Crocodile River at Karino daily mean discharge (m^3/s).

Jan-24		Long-term January	
Mean	42.64	Mean	39.49
Minimum	21.92	Q5	285.45
Maximum	74.19	Q95	0.46
Feb-24		Long-term February	
Mean	19.16	Mean	55.84
Minimum	11.68	Q5	130.62
Maximum	29.52	Q95	0.51
Mar-24		Long-term March	
Mean	16.16	Mean	41.17
Minimum	9.38	Q5	204.13
Maximum	25.53	Q95	2.02

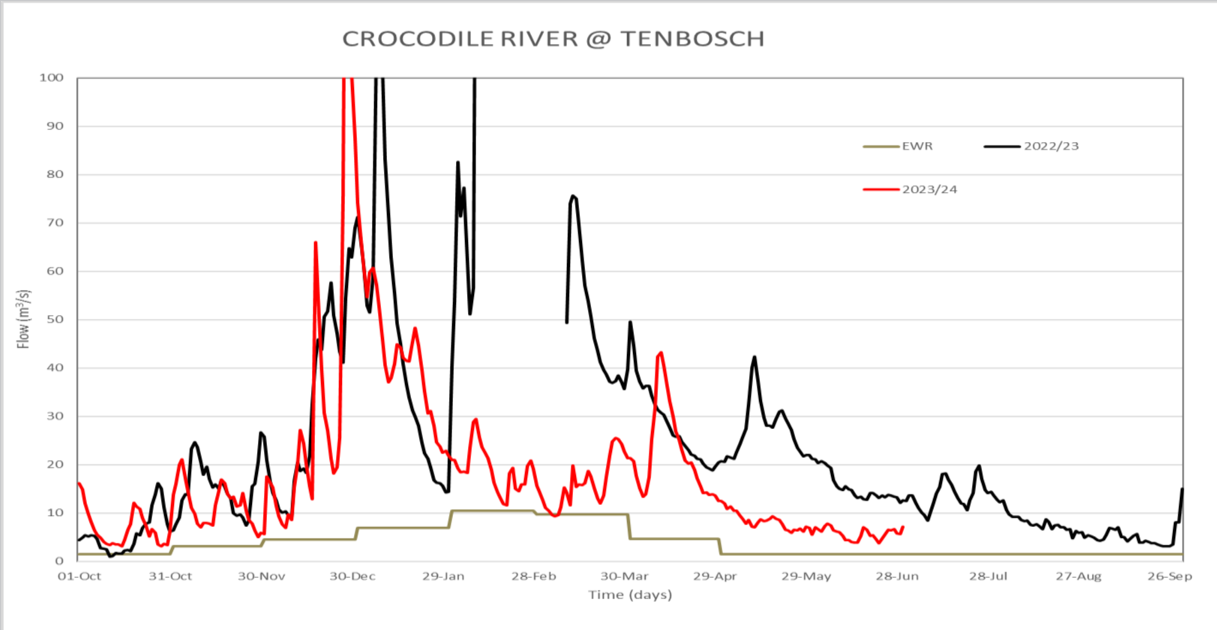


Figure 50: Crocodile River at Tenbosch level status and compliance to ecological requirements

3.4.3 Komati Catchment

3.4.3.1 Komati River at Hooggenoeg station

Water body: Komati River
Drainage area: 5503 Km^2

Observed average flow conditions are lower than long term averages for months of February and March in the Komati River at Hooggenoeg (Table 8). The same trend is being followed as the previous hydrological year until the end of January 2024 where the current flows dropped rapidly than the previous hydrological year due to below normal rainfall received (Figure 51). The international obligation flows were met throughout the reporting period.

Table 8: Komati River at Hooggenoeg daily mean discharge (m^3/s).

Jan-24		Long-term January	
Mean	33.51	Mean	28.42
Minimum	22.04	Q5	88.67
Maximum	49.55	Q95	3.62
Feb-24		Long-term February	
Mean	21.38	Mean	30.53
Minimum	13.54	Q5	52.40
Maximum	57.23	Q95	2.99
Mar-24		Long-term March	
Mean	12.72	Mean	23.07
Minimum	8.11	Q5	40.20
Maximum	24.78	Q95	3.85

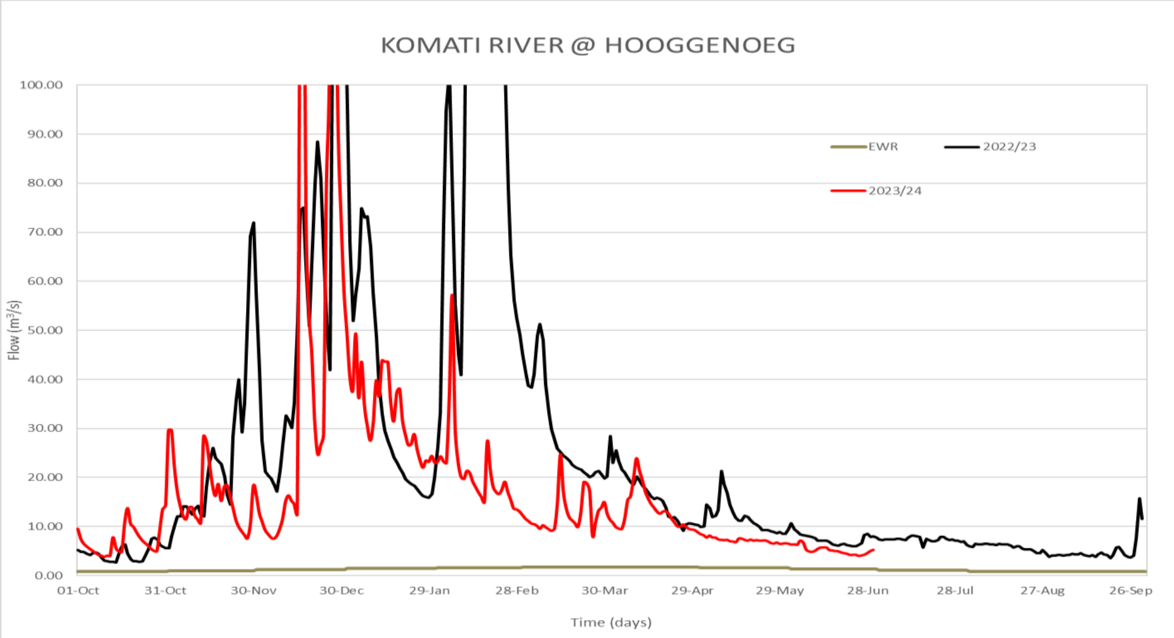


Figure 51: Komati River at Hooggenoeg level status and compliance to ecological requirements.

3.4.4 Usuthu Catchment

3.4.4.1 Assegaai River at Zandbank station

Water body: Assegaai River
Drainage area: 2313 Km^2

Observed average flow conditions are low than historical averages in the Assegaai River at Zandbank for the entire reporting period (Table 9). Flows have been generally lower than the previous hydrological year for the entire reporting period (Figure 52). The international obligation on 0.1m^3/s was met to eSwatini from Assegai River.

Table 9: Assegaai River at Zandbank daily mean discharge (m^3/s).

Jan-24		Long-term January	
Mean	15.03	Mean	16.19
Minimum	1.19	Q5	61.06
Maximum	47.39	Q95	0.74
Feb-24		Long-term February	
Mean	8.80	Mean	16.45
Minimum	0.89	Q5	26.81
Maximum	36.75	Q95	0.82
Mar-24		Long-term March	
Mean	2.24	Mean	12.16
Minimum	1.41	Q5	28.30
Maximum	4.30	Q95	1.39

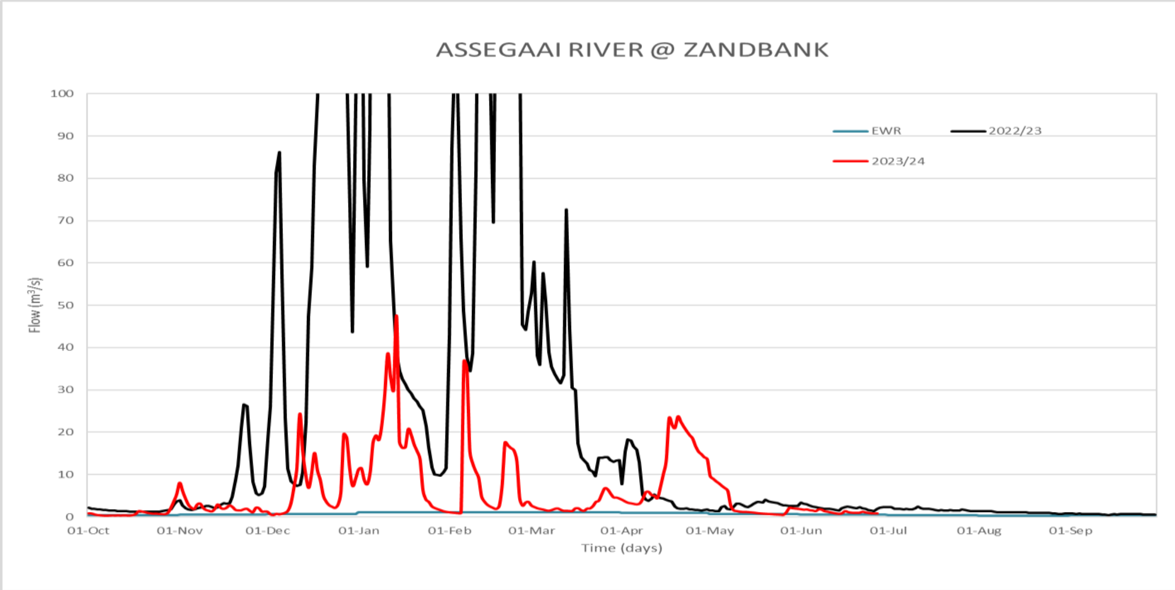


Figure 52: Assegaai River at Zandbank level status and compliance to ecological requirements

3.5 Dam Level Status with the WMA

The water level status in most dams within the WMA (which supply the major towns, irrigation, and strategic water users) since the start of the current hydrological year varied between moderately high to high. The total dams storage level in the WMA significantly increased from 90.0% to 100% in December 2023 because of the above normal rainfall received. The 2023/24 hydrological year dams storage trend has been below the 2022/23 hydrological year illustrated below (Figure 53).

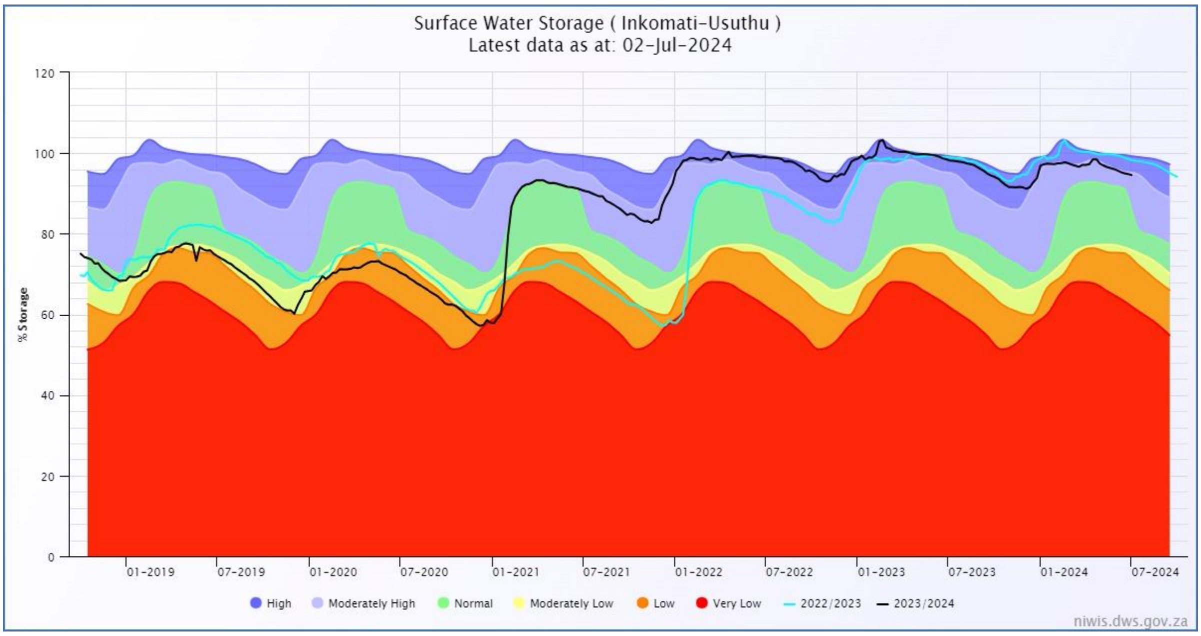


Figure 53: Inkomati – Usuthu WMA dams' storage historical analysis.

CHAPTER 4 SURFACE WATER QUALITY STATUS

4.1 Introduction

Much of the importance in water resource management has revolved around quantity ensuring that users have enough water, however, as water gets used and re-used, water quantity also becomes scarce and feedback loops become even tighter. As such, it is the quality aspect that begins to assume an even more important characteristic. Importantly, both quantity and quality need to be considered at the same level of detail, and this can mean that at times they should be considered with similar emphasis and expenditure of resources. Water quality describes the condition of the water, including chemical, physical, and biological characteristics, usually with respect to its fitness to use.

Surface water quality within the WMA is affected mainly by land use activities including sediment and erosion. Water quality impacts of the resource is due to contamination from sewage (e.g., from overflows, spills, and leakages or by discharge of untreated/partially treated sewage into the resource), agricultural activities and decanting of mining effluents or leachate into the water resources as well as landfill sites and illegal solid waste dumping. Industrial waste and sewage discharges are the easiest to authorise and control, but this does not mean that this is problem-free. There is a problem of compliance regarding the local authorities and private operators responsible for waste management systems. The IUCMA has found that the quality of sewage discharges often far exceeded the standards and conditions demanded by authorisation.

Poor water quality impacts negatively on human health, threatens downstream water users, increases /industrial costs and raw water treatment costs arising from removing pollutants, reduces income generated from recreation and ecotourism, destroys ecosystems, and affects biodiversity. IUCMA is moving towards the integrated reporting of quantity and quality and its impact on the aquatic biota. To ensure that the quality of water resources remains fit for recognised water uses and that the viability of aquatic ecosystems is maintained and protected. The water quality compliance status will be presented by maps and trends chart per Catchment using the HydroNet application or Microsoft Excel. Maps indicate an average water quality status from January –December 2023 and trends chart indicate data ranging from January 2017 to December 2023.

4.2 Water Quality Status within WMA

4.2.1 Sabie Sand Catchment

The Sabie River originates in the upper reaches of the Sabie Town and passes through industries such as York Timber Sawmill and the defunct underground gold mines of the Transvaal Gold Mine Estate (TGME) are situated. The Sabie River further flows through Hazyview and Mkhuhlu and other residential areas before it enters the Kruger National Park, Mozambique, and the Indian Ocean respectively. The main tributaries of the Sabie River are Mac-Mac River, Klein Sabie River, Noord-Sand River, Bega River, Sand River and Marite River. The Sand River confluences with the Sabie River inside the Kruger National Park. There are four main dams in the Sabie Sand Catchment, namely: Inyaka Dam, Da-Gama Dam, Eidenburg Dam and Mahleve Dam. The catchment is dominated by trout farming, forestry at the upper reaches of the catchment and housing development such as guest houses, lodges and hotels. There are several wastewater treatments works, the majority of which are operated by municipalities. The middle reaches from Hazyview to the Kruger National Park are affected mostly by agriculture, eco-adventure tourism, irrigation, water abstraction and urban development while the lower reaches of the catchment are located within the Kruger National Park which is a protected area as shown in Figure 54.

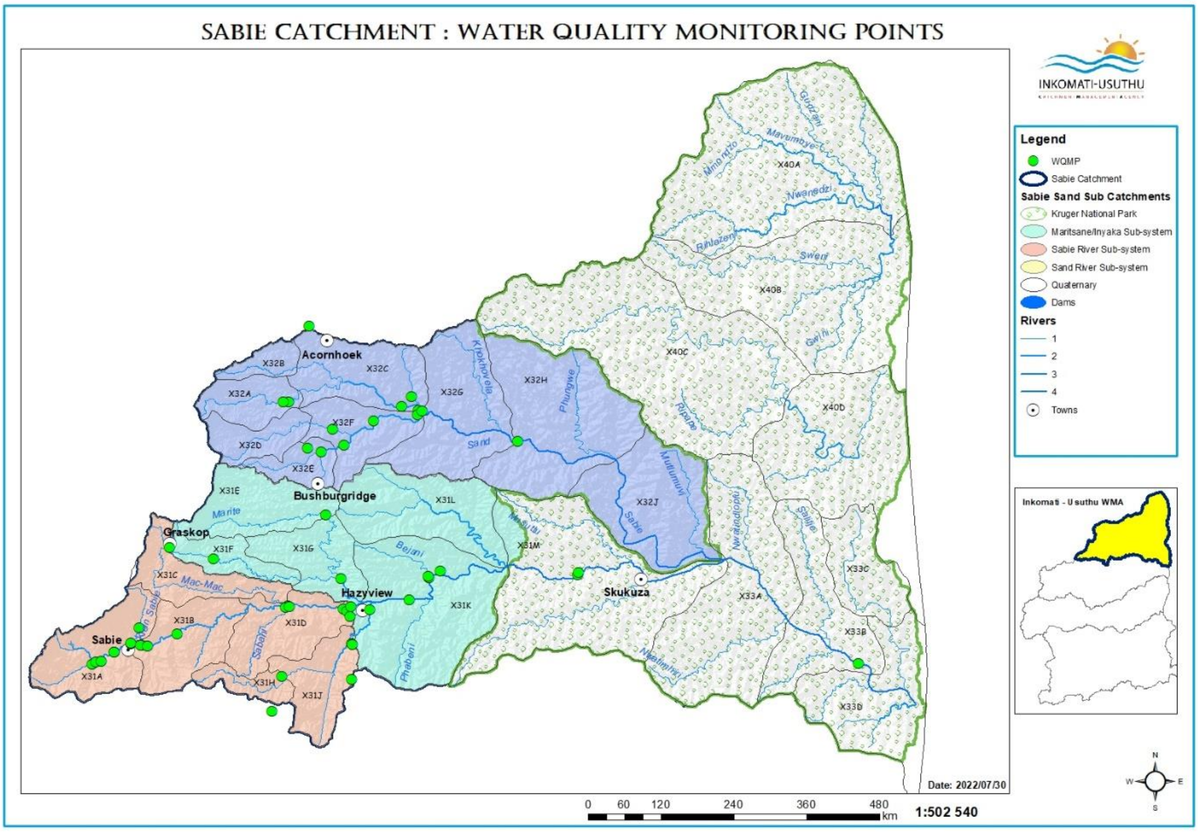


Figure 54: Water quality monitoring points in the Sabie Catchment.

The water quality status and trends of the indicator parameters is compared with the Resource Quality Objectives (RQOs) published in a Government Gazette dated 30 December 2016 or the Target Water Quality Guideline limits (TWQG) where the RQOs were not available or set as tabulated below (Table 10).

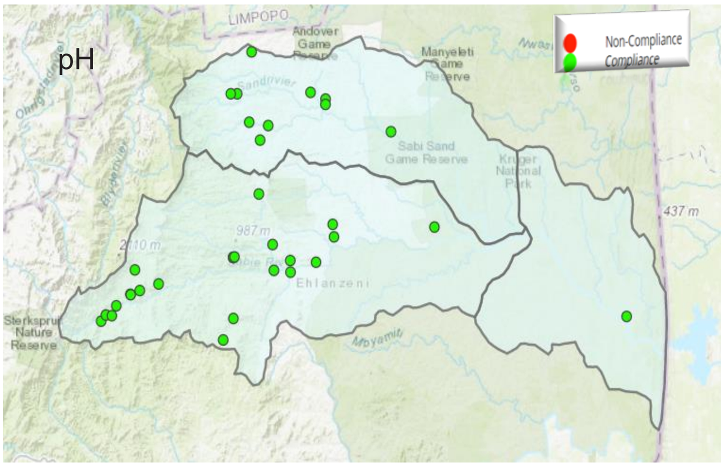
Table 10: TWQG and RQOs within Sabie/Sand Catchment.

Variables/Parameters	Resource Quality Objectives		TWQG
	Sabie System	Sand System	
pH	6.5 - 8.0	6.5 – 8.8	6.5-8.5 (Recreation)
Electrical Conductivity (EC) in mS/m	30	55	40
Phosphate (PO_4) in mg/l	0.015	0.125	N/A
Nitrates/Nitrites (NO_3 + NO_2) in mg/l)	N/A	N/A	6 (Domestic)
(E. coli) in cfu/100ml	130	130	0
Total ammonia (NH_3+ NH_4^+) in mg/l	-	-	1 (Domestic)

N/A=Not available

System Variable and Salts

pH is a vital indicator of water that is changing chemically and measures how acidic/or basic the water is, ranging from 0 to 14. **pH** levels complied with the TWQG throughout the Sabie Sand catchment.



Electrical Conductivity (EC) complied with RQOs except Langspruit (Hazyview), the Bega River and Ngwenyameni River (Mkhuhlu).

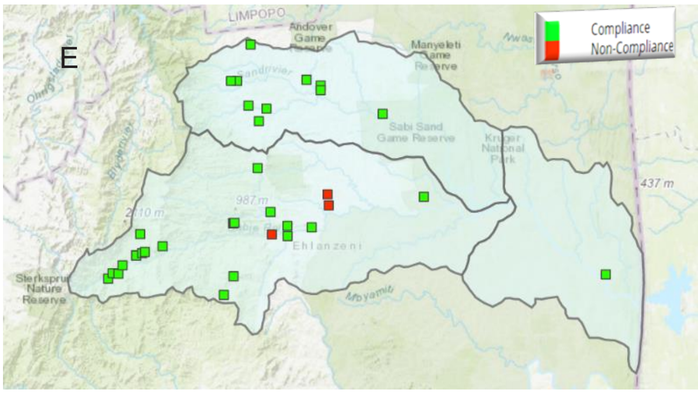


Figure 55: Water quality status within Sabie/Sand Catchment showing pH and EC concentrations.

Electrical Conductivity

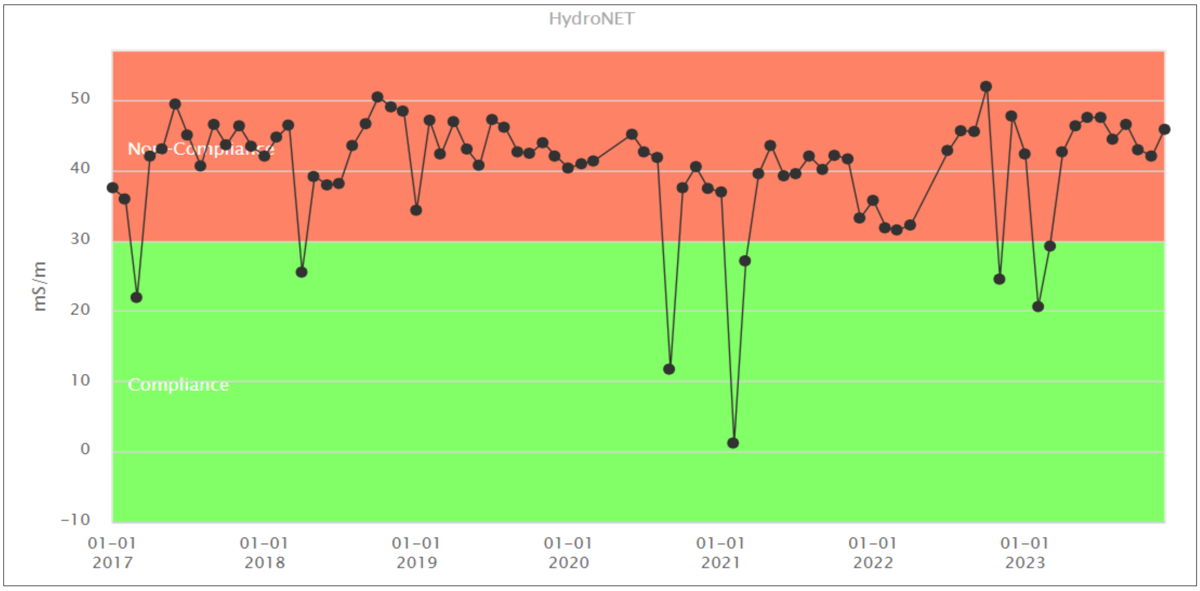
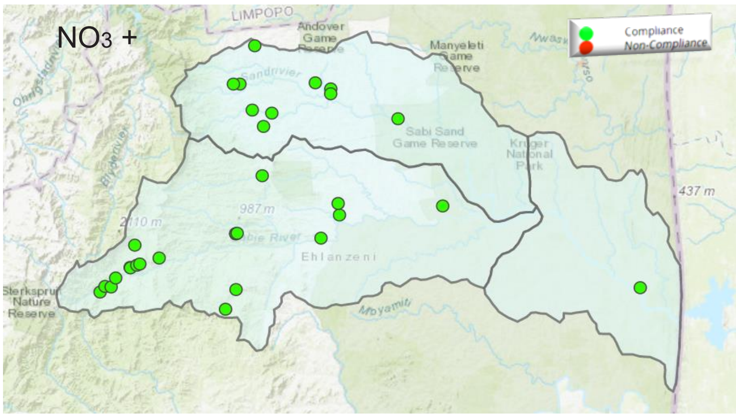


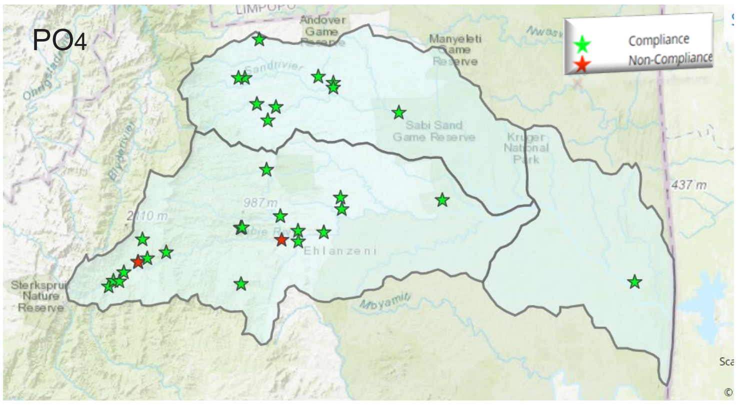
Figure 56: Chart indicating Electrical conductivity concentrations trends at Bega River (Mkhuhlu Area).

Nutrients



Nitrates/Nitrites concentrations complied with the TWQG throughout the sites monitored in the catchment.

Phosphate indicated compliance with the RQOs for most sites within the Catchment except for Klein Sabie (Sabie Town) and Langspruit River (Hazyview) which indicated non-compliance.



Nutrients are required in water resource; however excessive amount can lead to eutrophication process which is harmful to fish and other aquatic life.

Figure 57: Water quality status within Sabie/Sand Catchment NO_3+NO_2 and PO_4) concentrations.

Phosphate

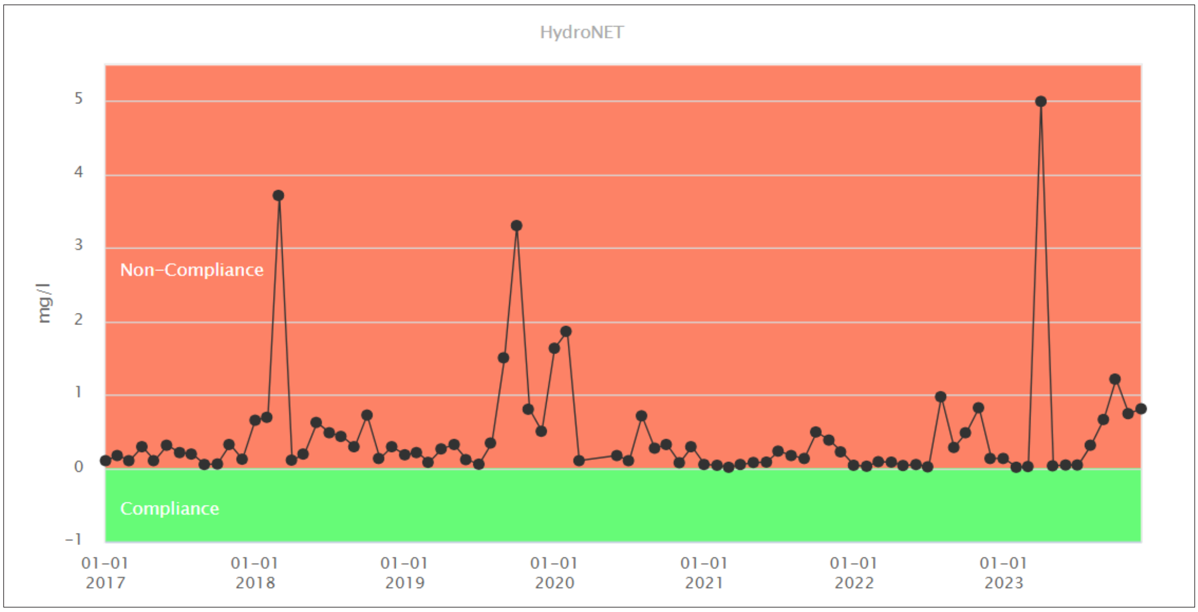
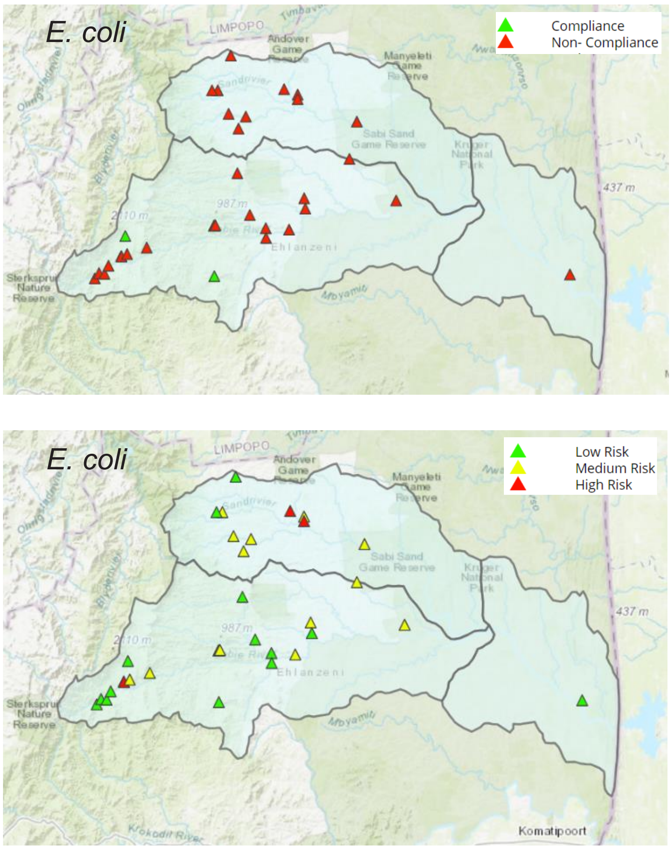


Figure 58: Chart indicating Phosphate concentrations trends at Langspruit D/S of Hazyview WWTW.

Microbial

E. coli



E. coli counts in the Sabie/Sand Catchment indicated noncompliance with the set RQOs of 130 (cfu/100ml) except for head waters of Klein Sabie River and Da-Gama Dam which showed compliance with the set RQOs. **The second map shows** potential health risk based on National Microbial Monitoring Programme (NMMP), the E coli below 600 counts per 100 ml is considered as low risk, between 600- 2000 counts per 100 ml is medium risk while above 2000 counts per 100 ml is considered high risk. The medium to high risk in the catchment was observed within residential areas due to intensive residential runoff pollution including effluent discharges from WWTWs and its associated infrastructure.

Figure 59: Water quality status within Sabie/Sand Catchment showing E coli concentrations.

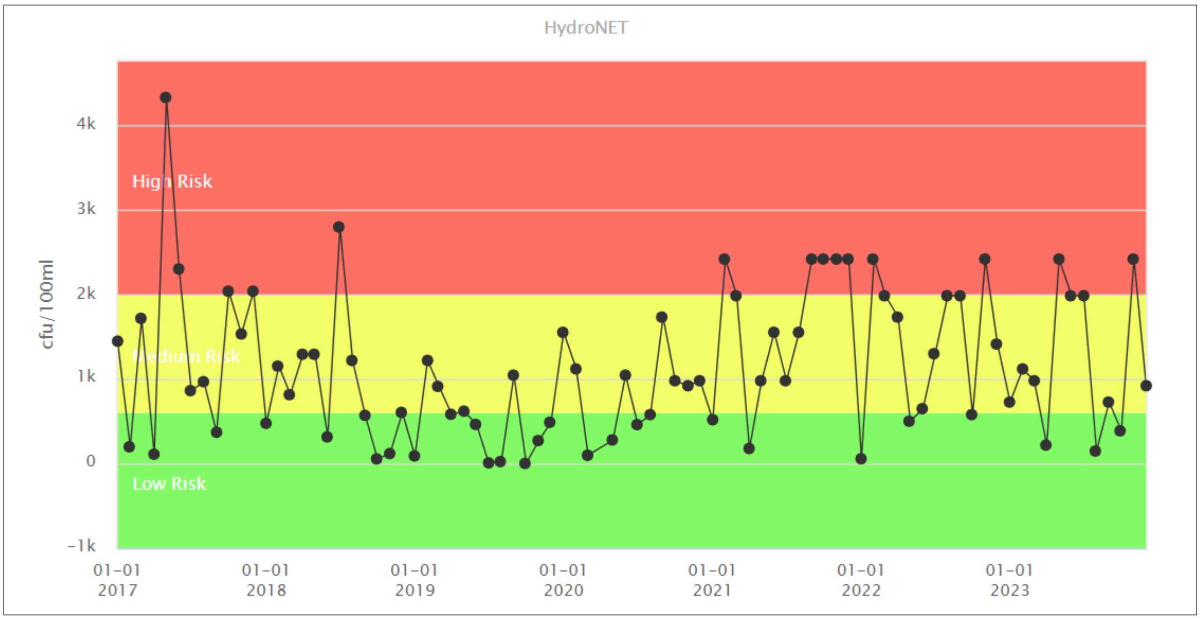
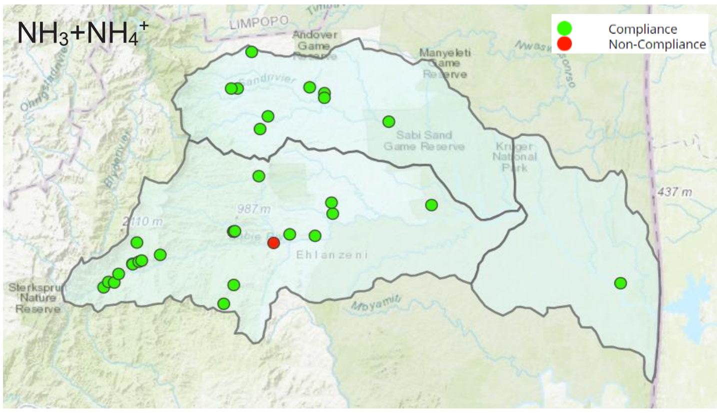


Figure 60: Chart indicating E. coli concentrations trends at Sabie River downstream of Sabie WWTWs.

Toxic Substances



Total ammonia ($NH_3+NH_4^+$) within the Sabie Sand Catchment indicated compliance with TWQG (Domestic) of 1 (mg/l), except the Langsruit downstream of Hazyview WWTWs and sewer pump station as illustrated in Figure 29.

Figure 61: Water quality status within Sabie/Sand Catchment showing total ammonia concentrations.

Ammonia is a common toxicant derived from domestic, industrial, or agricultural pollution (fertilizers, organic matter) and natural processes. Total ammonia ($NH_3 + NH_4^+$ as N) occurs in equilibrium with the ammonium ion and the position of equilibrium is governed by pH and temperature. The un-ionized form ammonia (NH_3) is more toxic than the ionized form ammonium (NH_4^+). As pH and temperature increase, NH_4^+ is converted to NH_3, and the toxicity increases. NH_3 is highly toxic to fish and other aquatic life. The chart (Figure 30) below indicates total ammonia concentrations which indicated non-compliance to TWQG from August to December 2023 in the Langspruit, in August 2023 a fish kill was reported in the Langspruit. Based on the temperature and pH the estimated concentration of un-ionized form ammonia (NH_3) contribution was above the set TWQG for aquatic ecosystem of 0.007 mg/l.

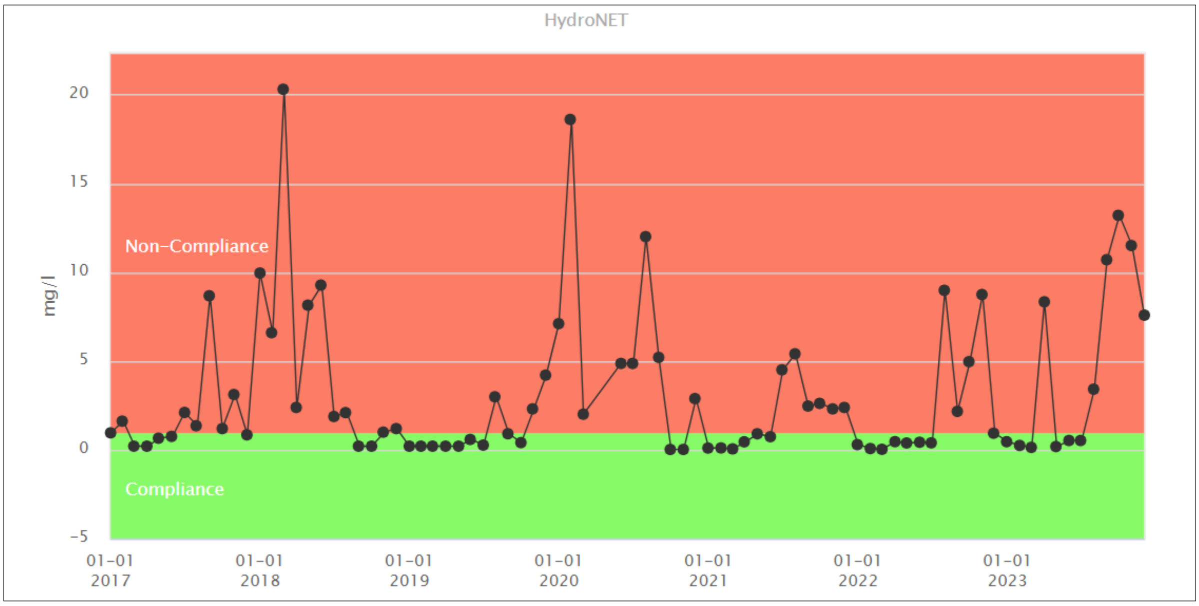


Figure 62: Chart indicating Ammonia concentrations trends at Langspruit D/S of Hazyview WWTWs.

4.2.2 Crocodile Catchment

The Crocodile River catchment originates near Dullstroom as illustrated in Figure 63, where it flows into the Kwena Dam and eastwards through Mbombela and confluences with the Komati River before entering Mozambique at the Lebombo Border Gate. The Elands River and Kaap River are two large tributaries of the Crocodile River system. The other smaller tributaries of the Crocodile River include the Lunsklip River, Nels River, Houtbosloop, Gladdespruit, White River and Bestersspruit. The Significant Dams include the Kwena Dam, Ngodwana Dam, Witklip Dam, Klipkoppie Dam, Longmere Dam & Primkop Dam. The Crocodile River Catchment is dominated by agricultural activities (dry land, and irrigated cultivation), forestry, rural and urban settlements. The middle region of the Crocodile River is characterized by increased urbanization. The river flows through the major towns of Mbombela, Kaapmuiden and Malelane as well as commercial farming activities (sugar cane, fruit orchards, and vegetables) which are important characteristics of this catchment. There are also mining activities in the Kaap River and the Sappi Mill in the Elands River sub-catchment. Other activities that existed in the catchment but have since closed are, Manganese Metal Corporation, Papas Quarry and Assmang Chrome. Illegal sand mining is posing a severe water quality problem in the middle regions of the Crocodile River catchment area around Ka-Nyamazane area.

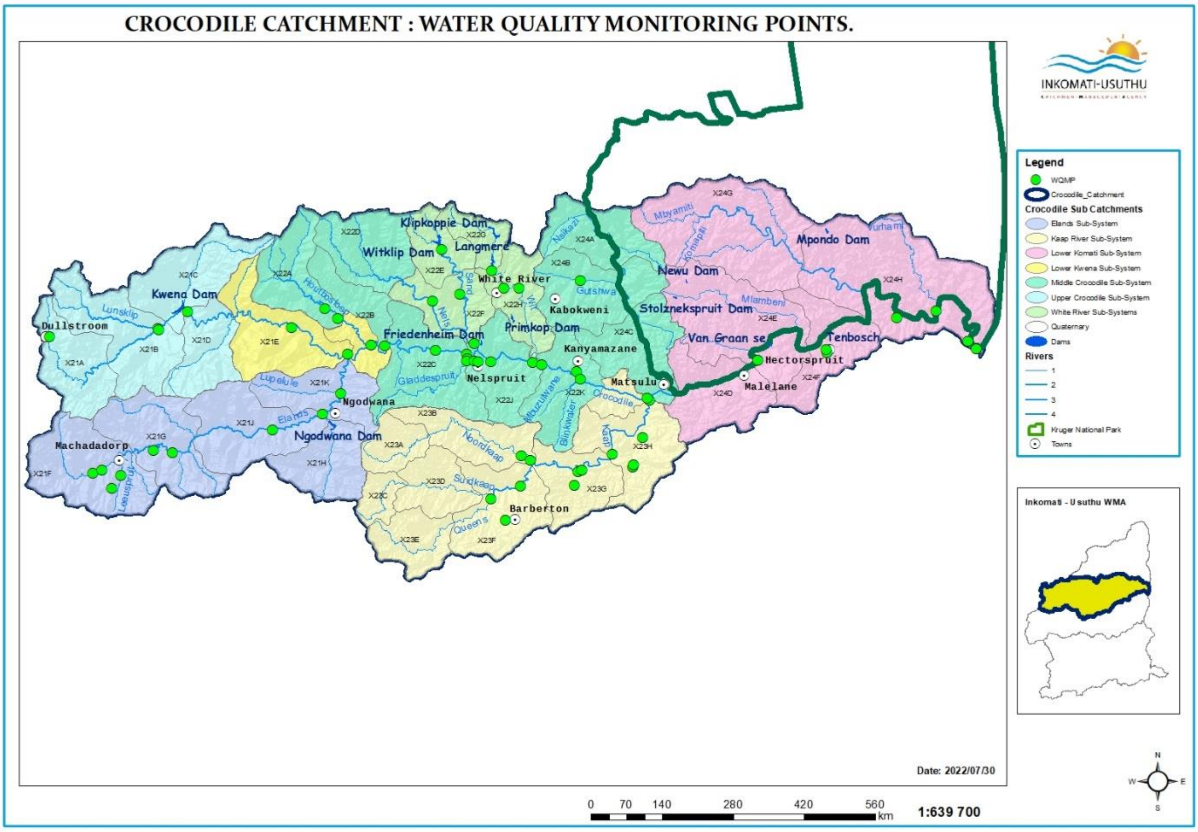


Figure 63: Water quality monitoring points in the Crocodile Catchment.

The compliance of the indicator parameters is compared with the Resource Quality Objectives published in a Government Gazette dated 30 December 2016 or the Target Water Quality Guideline limits (TWQG) where the RQOs were not available or set as tabulated below.

Table 11: TWQG and RQOs within Crocodile Catchment.

Variables/Parameters	RQOS	TWQG
Dissolved Oxygen (DO) in % Saturation		80 - 120
pH	6.5 – 8.0	6.5 - 8.5
Electrical Conductivity (EC) in mS/m	30, 70 & 200	40
Sulphate (SO_4) in mg/l	-	30 (Industry)
Phosphate (PO_4) in mg/l	0.015, 0.025, 0.075 & 0.125	0.025
Nitrates/Nitrites (NO_3 + NO_2) in mg/l)	-	6 (Domestic)
E. coli in (cfu/100ml)	120 and 130	130
Total ammonia (NH_3+ NH_4^+) in mg/l	-	1 (Domestic)
Chromium (Cr) VI in mg/l	0.014	-
Arsenic (As) in mg/l	0.02	-
Cyanide (Cn) in mg/l	0.004	-
Iron (Fe) in mg/l	-	0.1 (Domestic)
Manganese (Mn) in mg/l	0.18	-

N/A=Not available

System Variable(s) and Salt(s)

Dissolved oxygen (DO) is a measure of how much oxygen is dissolved in the water, the amount of oxygen available to fish, invertebrates, and other aquatic organisms. Figure 64 indicates that dissolved oxygen is above 80 % saturation in the catchment at ecological water requirements sites from 01 January 2023 to 31 December 2023.

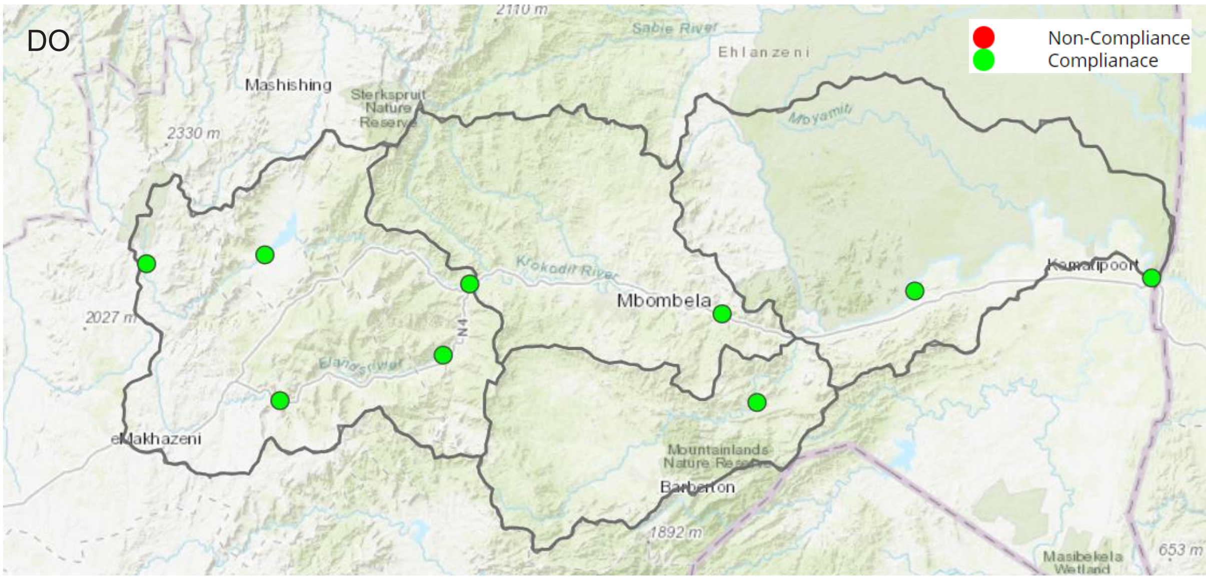


Figure 64: Water quality status within Crocodile Catchment showing Dissolve Oxygen concentrations.

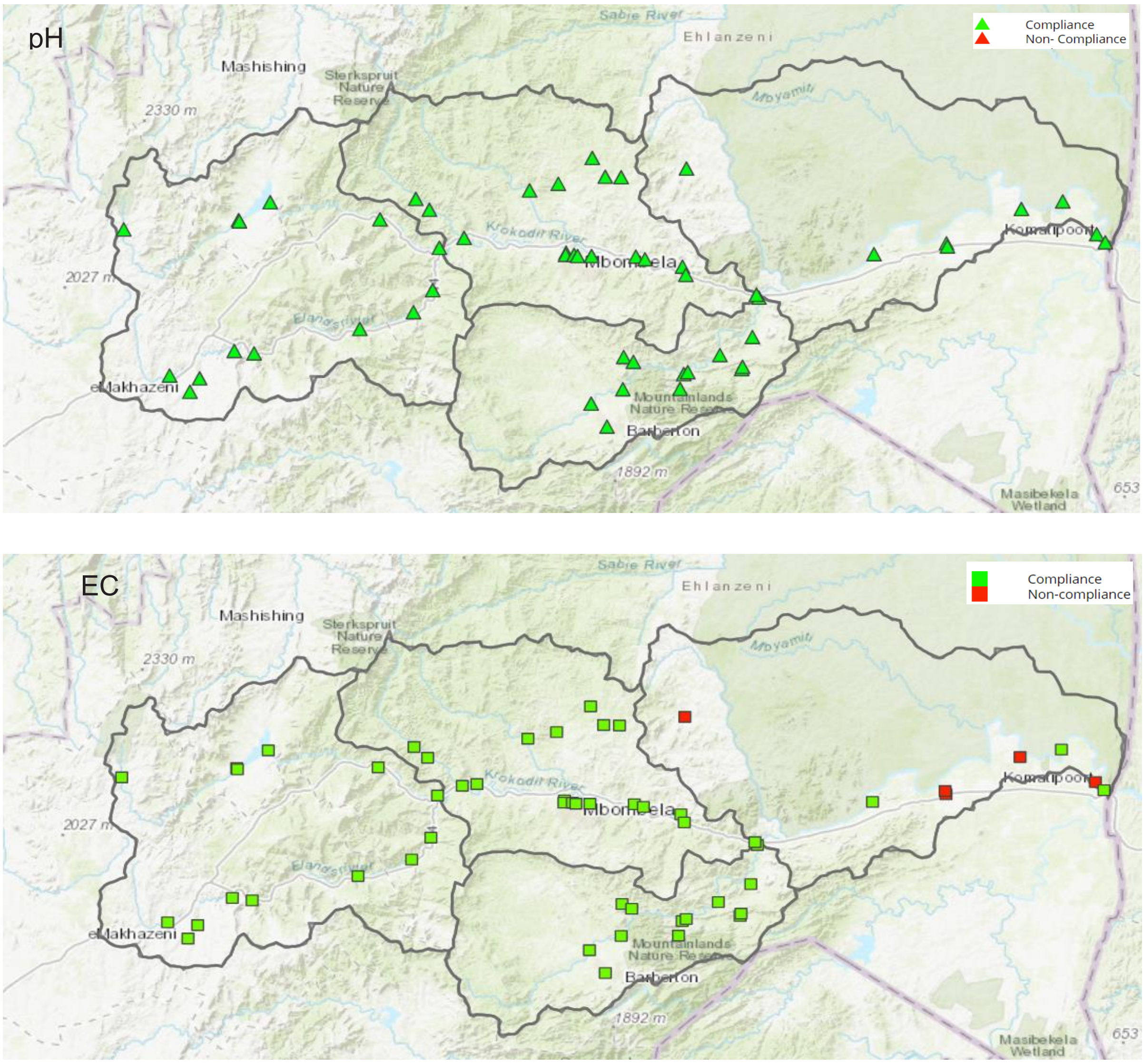


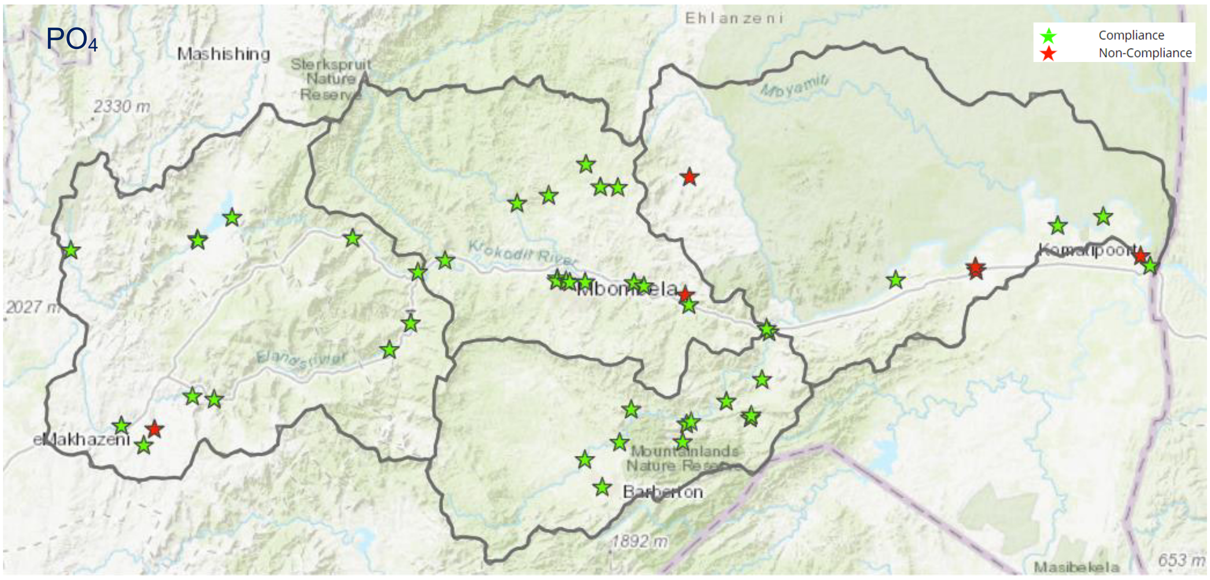
Figure 65: Water quality status within Crocodile Catchment showing pH and EC concentrations.

System Variable(s) and Salts

The pH levels complied with the TWQG throughout the Crocodile Catchment. The electrical conductivity is an indicator of the estimated levels of dissolved salts in water. Electrical Conductivity within the Crocodile Catchment complied with the RQOs (Aquatic Ecosystem drivers), except Gutshwa River downstream of Kabokweni WWTW, Hectorspruit (upstream and downstream of Hectorspruit WWTWs) and tributary of Crocodile River at Tenbosch and Komatipoort.

The high level of EC may be due to presence of dissolved inorganic solids such as chloride, phosphate, and nitrate arising from industrial effluent, WWTWs, stormwater runoff from formal /informal settlements and agricultural runoff. There are also challenges with sulphate concentration within the Crocodile Catchment indicating non-compliance with TWQG (Industry: category one) of 30 (mg/l) in the Elands River downstream of Sappi's Ngodwana Mill, tributary of Suidkaap River, Kaap River and Low’s Creek due to industrial activities (Mill and Mines).

Nutrients



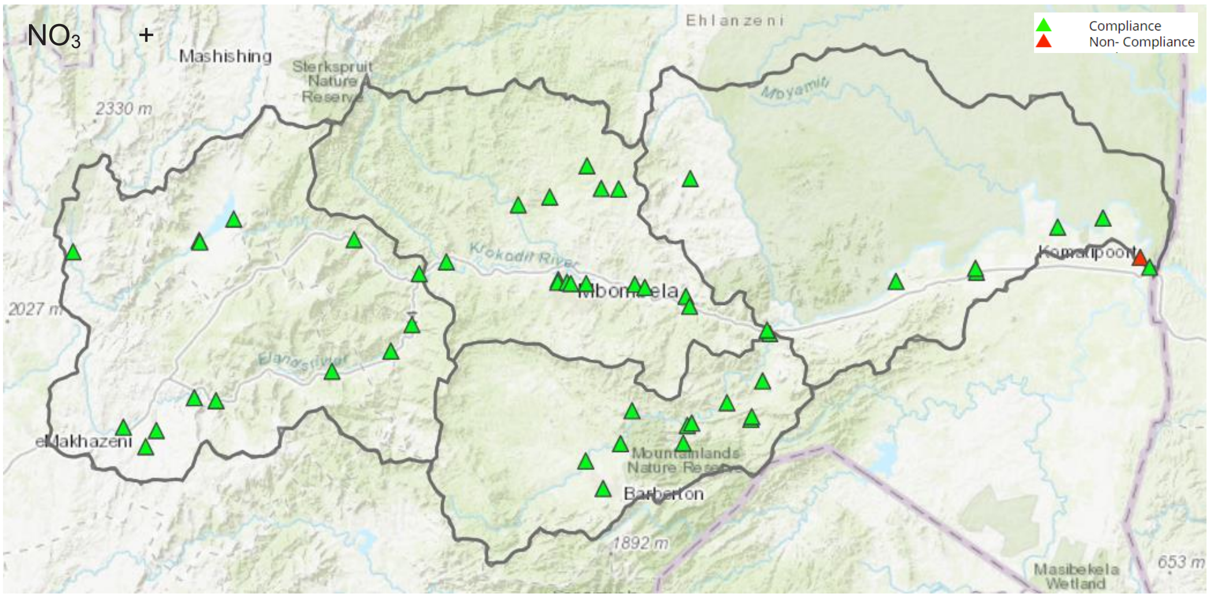


Figure 66: Water quality status within Crocodile Catchment showing PO_4 *and* $NO_3 + NO_2$ *concentrations.*

Phosphates enter surface water from human and animal feacal waste, effluent discharges and fertilizer runoff. Phosphate concentrations in the Crocodile Catchment complied with the RQOs for most of the time except for points downstream of Emthonjeni, Komatipoort and Kabokweni WWTWs, downstream & upstream of Hectorspruit WWTWs as well as the Kanyamazane stream. The impacts are attributed to effluent discharges from WWTWs and illegal dumping of solid waste. The nitrate and nitrite levels complied with the TWQG throughout the Crocodile Catchment, except in the tributaty of Crocodle River downstream of Kimatipoort WWTWs.

Microbial

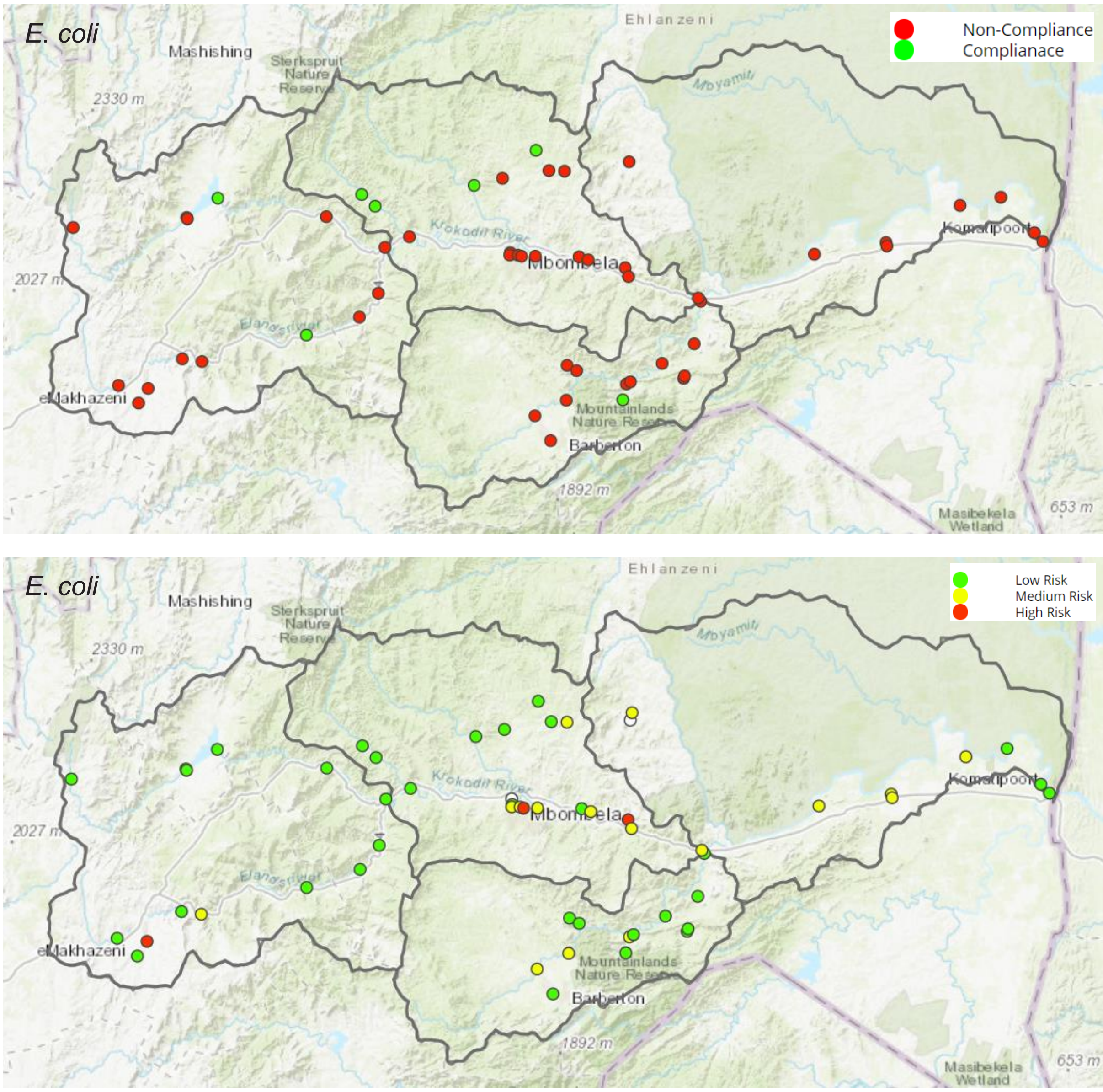


Figure 67: Water quality status within Crocodile Catchment showing E. coli concentrations.

The first map shows *E. coli* counts in the Crocodile Catchment with elevated counts which from time to time exceeded the set RQOs of 130 (cfu/100ml). The non-compliance from the upper, middle and lower parts of the Crocodile River and its tributaries are due to contamination from human faecal material and/or animals. Only seven (7) points in the catchments complied with the RQO of 130 (cfu/100ml) Kwena Dam, Elands River at Hemlock, Houtbosloop River, Langmere Dam , Nels River and tribitaty of suidkaap Crocodile River at Sheba.

The second map shows pontential health risk in terms of NMMP guidelines. Most of the points in the catchment are low risk with *E. coli* counts below 600 per 100ml. The areas with medium to high risk in the catchment were observed within residential areas due to intensive residential runoff pollution (stormwater runoff from rural and urban settlements, including direct disposal of domestic refuse, grey water, seepage from latrines, human and animal excrement, as well as sewer overflows) including effluent discharges from WWTWs and its associated infrastructure.

Toxic substances

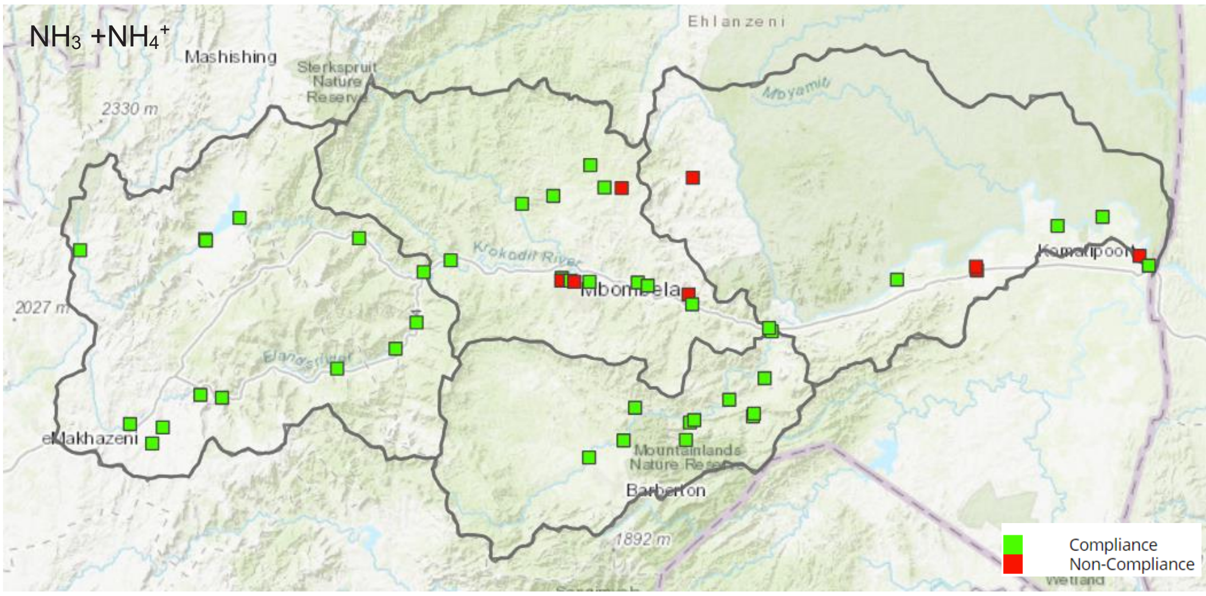


Figure 68: Water quality status within Crocodile Catchment showing total ammonia concentrations.

Total ammonia (NH_3+NH_4^+) within the Crocodile Catchment indicated compliance with TWQG (Domestic) of 1 (mg/l), except the tributaries of Crocodile River, namely the Gladdespruit, Bestersprruit, white River downstream of WWTWs, KaNyamazane Stream downstream of intensive resisential area, tributary of Gutshwa River downstream of Kabokweni WWTW, Hectorspruit (downstream of WWTWs and residential settlement) and unnamed tributary of Crocoile River downstream of Komatipoort WWTWs .

Cr (VI) is monitored at Leeuspruit to assess the impact from Assmang Chrome on the water resource. Cr (VI) complied with the RQOs of 0.014 (mg/l) throughout the reporting period (Jan-Dec 2023) with a concentration of <0.010 (mg/l), except in February which recorded a concentration of 0.35 (mg/l) as illustrated below in Figure 69.

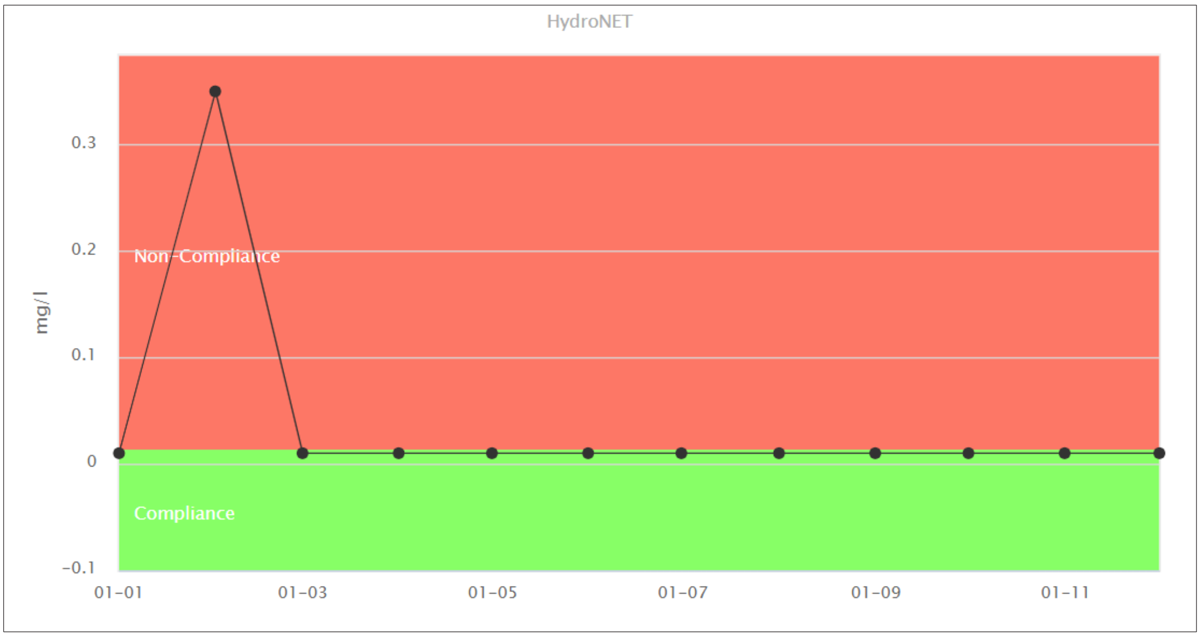


Figure 69: Chromium (VI) trend chart for the Leeuspruit.

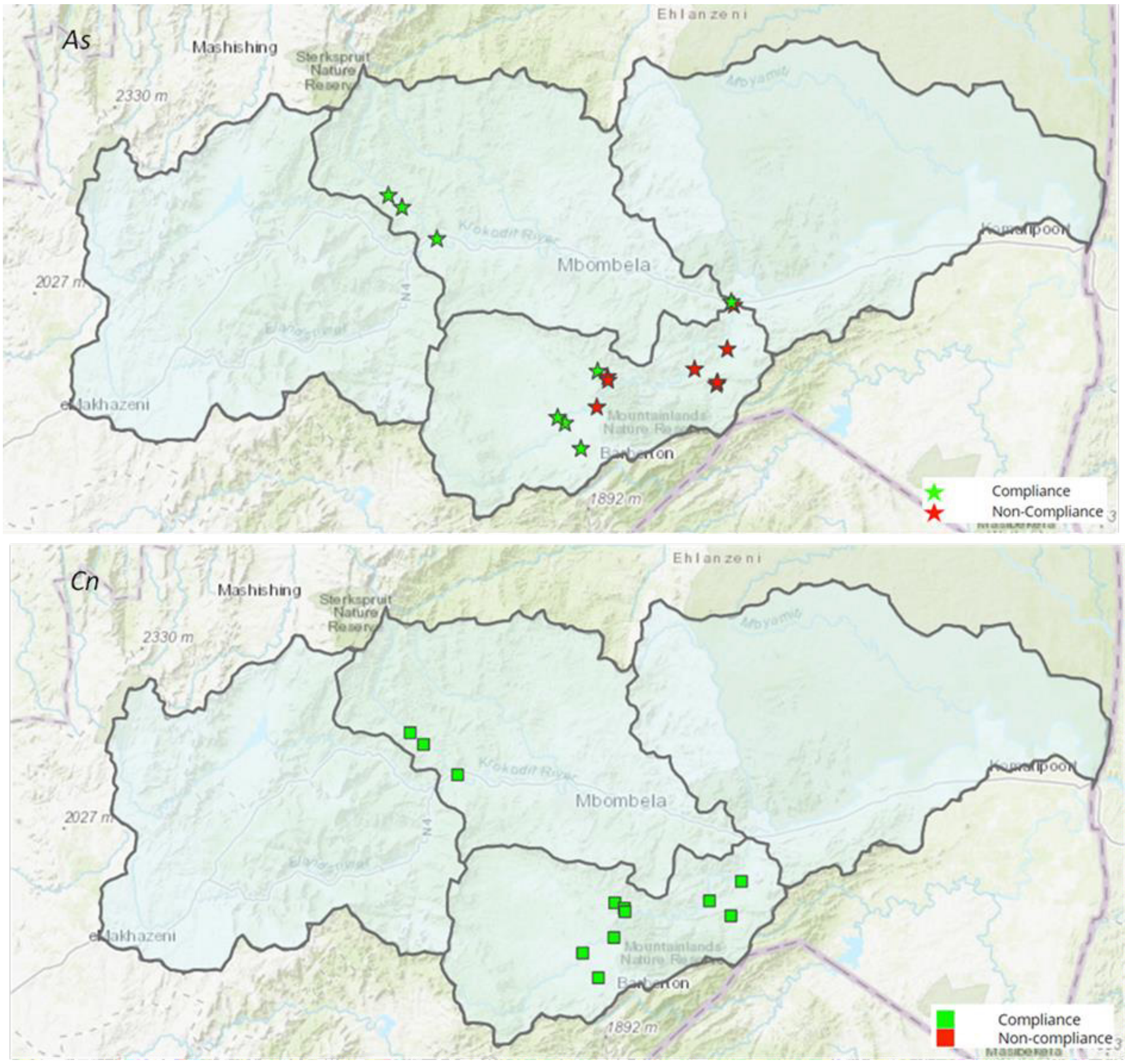


Figure 70: Water quality status within Crocodile Catchment showing As and Cn concentrations.

Arsenic is a toxic metalloid mainly found in gold mining areas and also a naturally occurring element. Arsenic complied with the RQOs of 0.02 (mg/l) within the Houtbosloop, Noordkaap, tributary of Queens, however indicated non-compliance in Suidkaap and Noordkaap downstream of Fairview and Consort Mine, respectively including Louw's Creek and its tributaries as well as Kaap River after confluence with Louws Creek . The impact is attributed to gold mine activities within the Kaap River system.

The cyanide concentrations within the Crocodile Catchment were <0.07 mg/l through out the reporting period, the RQO is 0.004 mg/l and there is no intruments that can detects below the 0.07 mg/l. Therefore, it will be regarded as compliant due to the detection limit that makes it impossibe to measure the concentration of cyanide in the water resources. The World Health Organisation recommends that people should not consume water with a cyanide concentration above 0.5 mg/l. The cynaide concenrations in the middle Crocodile Catchment and the Kaap River system is below 0.07 mg/l, however communities should drink treated water provided by water service authorities not directly from the resource.

Metals

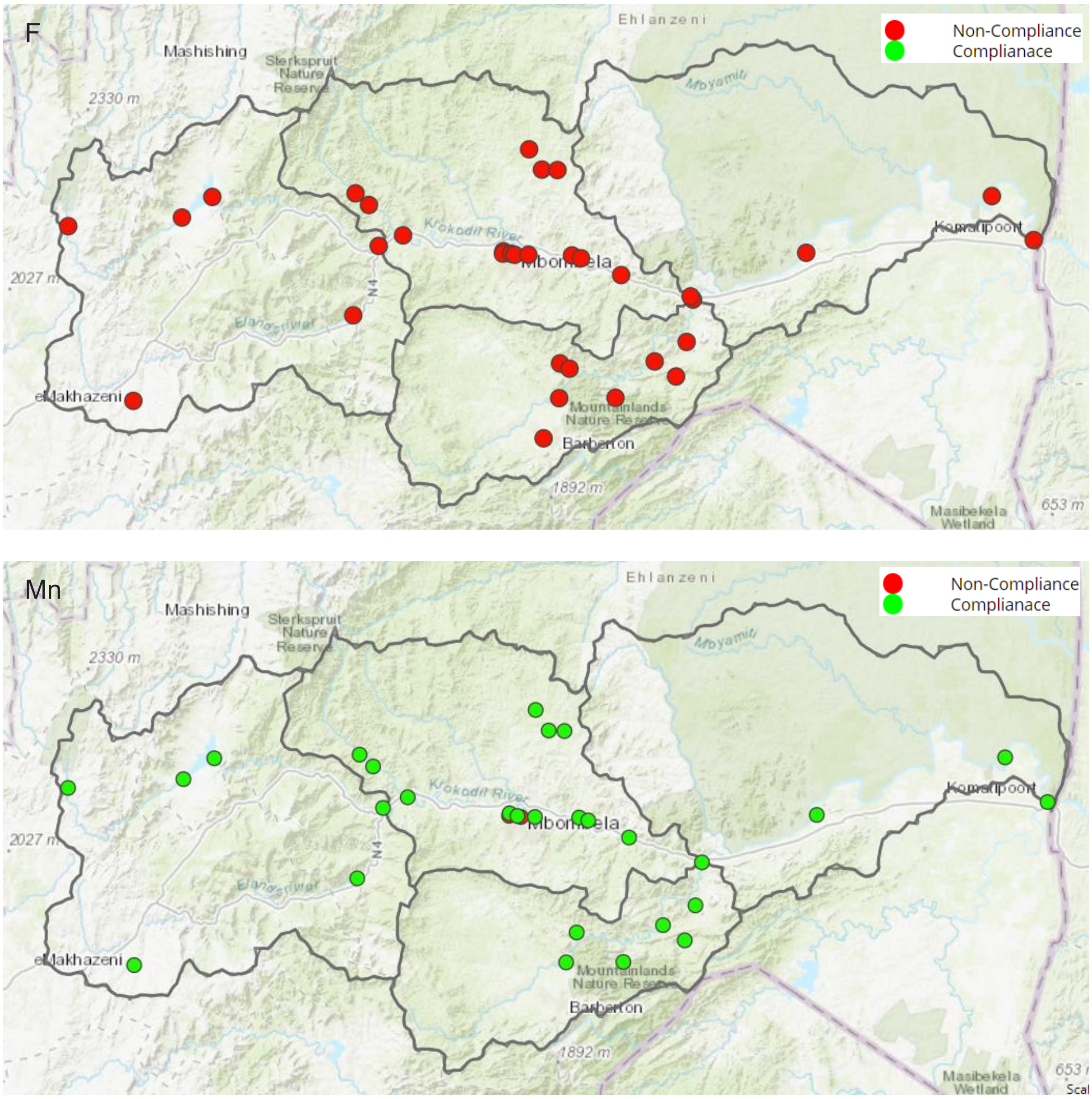


Figure 71: Water quality status within Crocodile Catchment showing Mn and Fe concentrations.

Iron and manganese can affect the colour and taste of water. These minerals can be found naturally in the environment (surface water) or because of land use activities such as mining and industrial discharges. Iron did not comply with the TWQG of 0.1 mg/l (Domestic) through-out the Catchment. However, there are no known sources of iron and furthermore, noncompliance is recorded in the head waters. It is apparent from the results that the noncompliance is because of the background geology.

Manganese complied with the RQOs of 0.18 (mg/l) within Crocodile Catchment, except for Gladdespruit (downstream of papa's quarry) and Bestерspruit. The targeted domestic limit for iron in water is 0.1 mg/l, and is based on taste and appearance rather than on any detrimental health effect. However, communities should drink treated water provided by water service authorities not directly from the resource.

4.2.3 Komati Catchment

The Komati River originates from the outflow of the Nooitgedacht dam next to Carolina, Mpumalanga province. The catchment of the Nooitgedacht dam includes the Boesmanspruit, Vaalwaterspruit and the Witkloofspruit tributaries that feed directly into the dam. The most unique feature of the Komati River is that it starts in South Africa and flows through Eswatini in a North-easterly direction and comes back to South Africa at the Mananga Border Gate. It then confluences with the Crocodile River (one of its main tributaries) at Komatipoort before it enters Mozambique where its confluences with the Sabie River which is another one of its main tributaries. After entering Mozambique, the Komati River is referred to as the Incomati River and flows into the Indian Ocean at Maputo Bay. From the source to the mouth, the length of the Inkomati River is 480 kilometers. The catchment is dominated by coal mining in the upper reaches of the catchment and irrigation agriculture in the lower reaches of the catchment. There are also WWTWs the majority of which are operated by municipalities. For the purposes of this report the Komati River upstream of eSwatini will be referred to as Upper Komati and downstream of Eswatini, will be referred to as Lower Komati as illustrated in Figure 72.

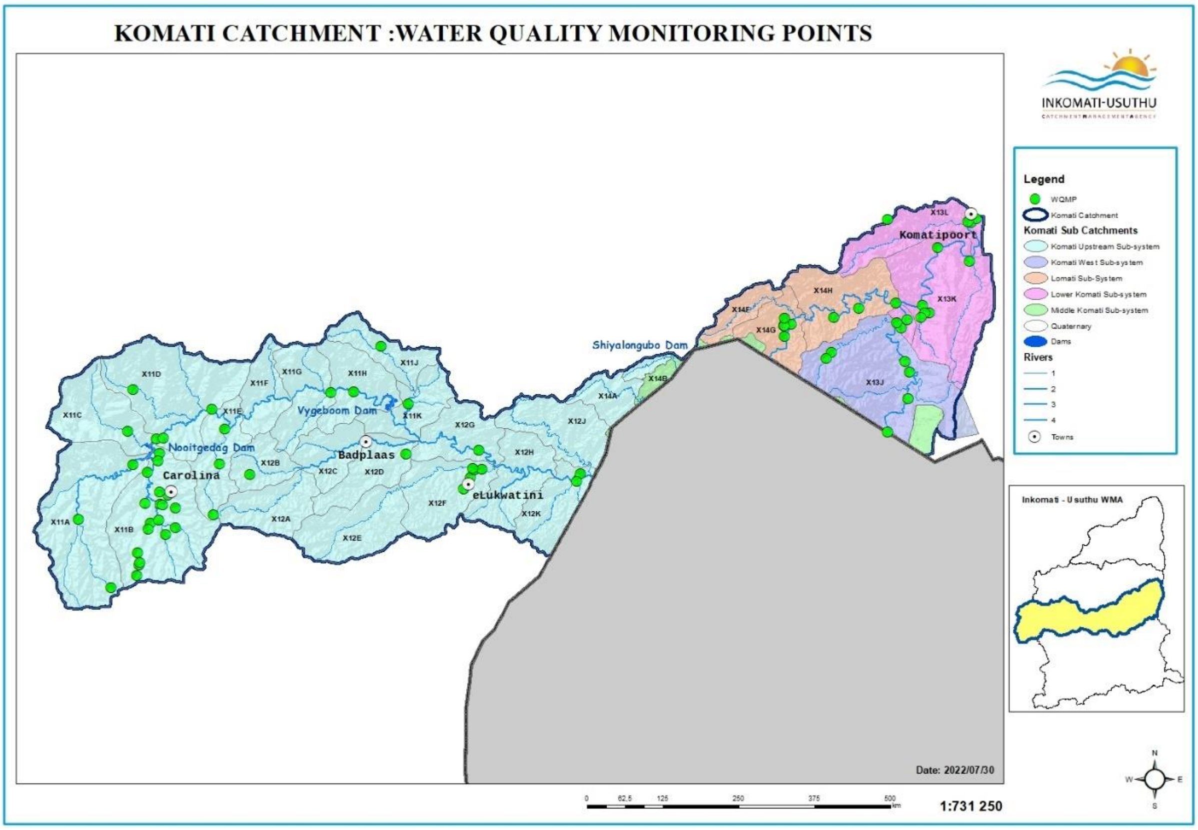


Figure 72: Water quality Monitoring points in the Komati Catchment.

The compliance of the indicator parameters is compared with the Resource Quality Objectives published in a Government Gazette dated 30 December 2016 or the Target Water Quality Guideline limits (TWQG) where the RQOs were not available or set as tabulated below.

Table 12: TWQG and RQOs within Komati Catchment.

Variables/Parameters	RQOs	TWQG
pH	6.5 - 8.0	6.5 - 8.5
Electrical Conductivity (EC) in mS/m	30, 40, 50, 55 & 85	40
Sulphate (SO_4) in mg/l	30 and 80	30 (Industry category 1)
Phosphate (PO_4) in mg/l	0.02	0.025
Nitrates/Nitrites ($NO_3 + NO_2$) in mg/l)	N/A	6 (Domestic)
E coli (cfu/100ml)	130	130
Total ammonia (NH_3+NH_4^+) in mg/l	-	1 (Domestic)
Nickel (Ni) in mg/l	-	0.2 (Agriculture-irrigation)
Alunimun (Al) in mg/l	-	0.02 (Aquatic ecosystem)
Manganese (Mn) in mg/l	-	0.18 (Aquatic ecosytem)

N/A=Not available

System Variable(s)

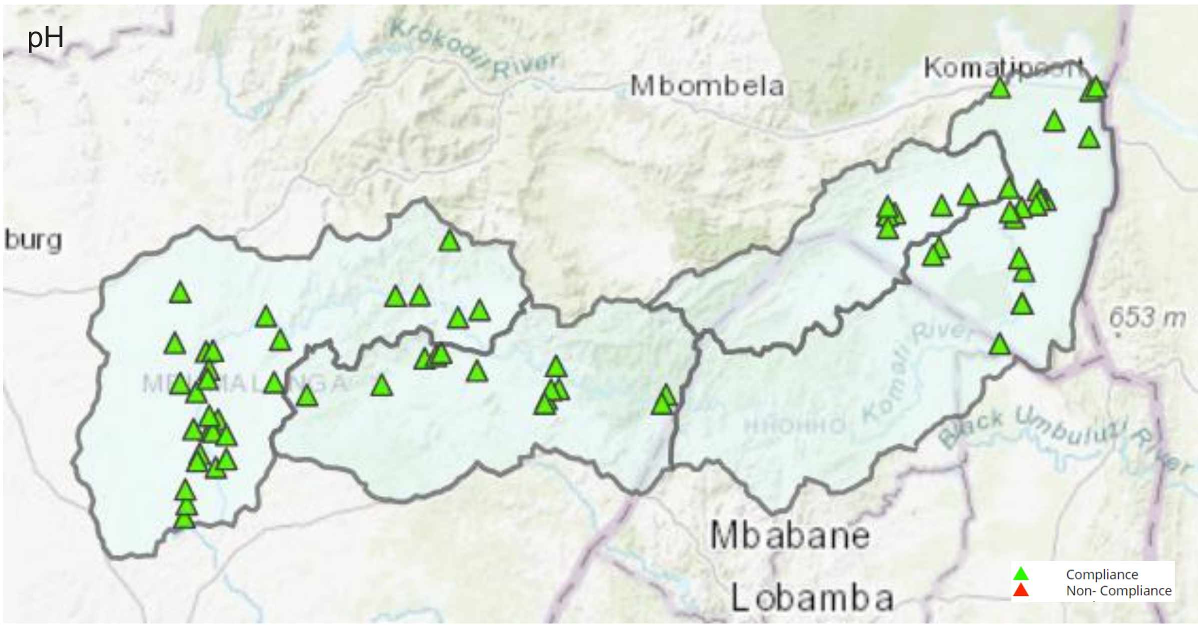


Figure 73: Water quality status within Komati Catchment showing pH concentrations.

pH is a vital indicator of water that is changing chemically and measures how acidic or basic the water is, ranging from 0 to 14. pH levels complied with the RQOs, Eco spec, TWQG throughout the catchment.

Salts

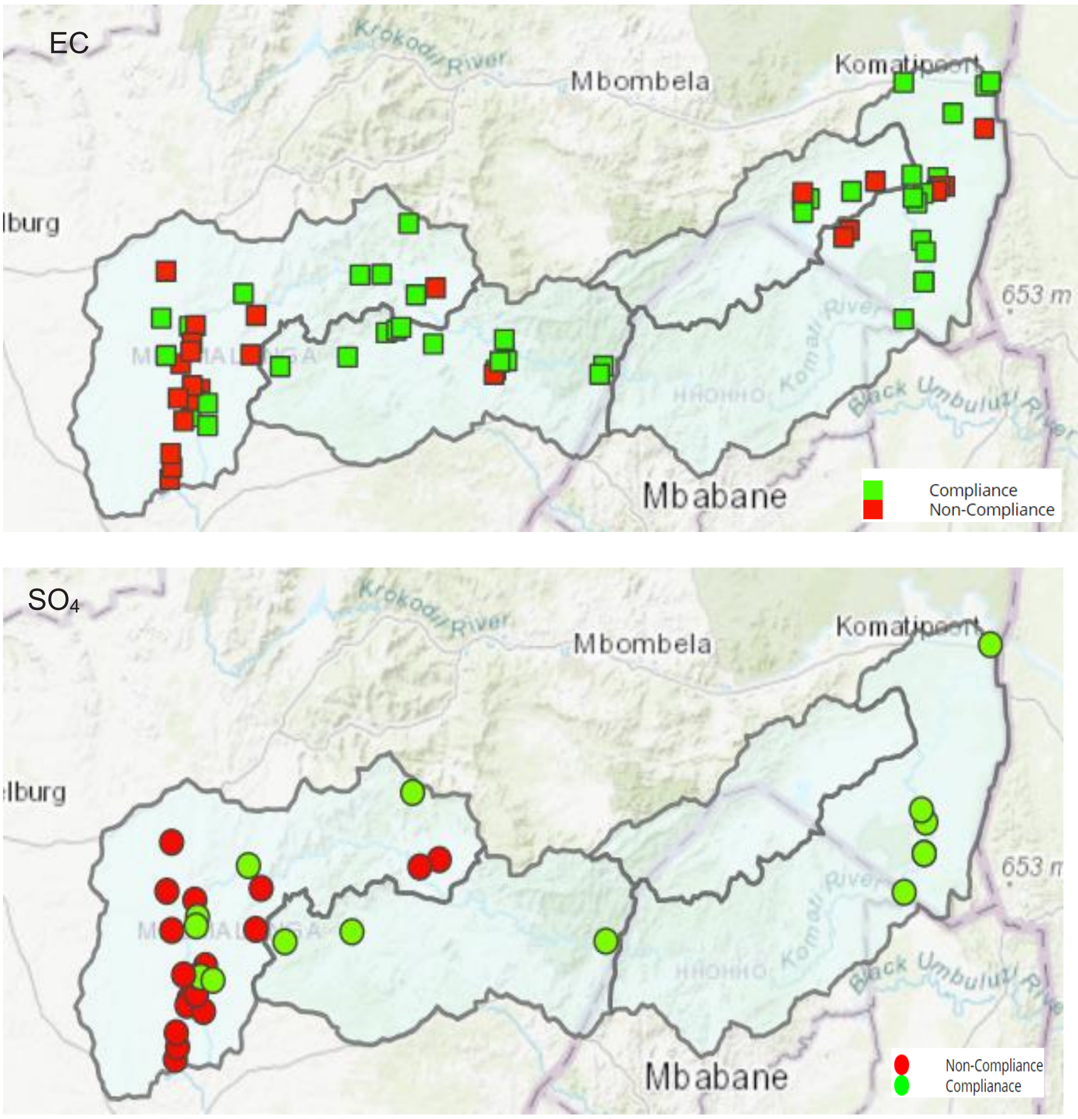


Figure 74: Water quality status within Komati Catchment showing EC and SO_4 concentrations.

Electrical Conductivity was compliant at most monitoring points with the RQOs (Aquatic Ecosystem drivers) set within the Komati Catchment. There were a few points where the EC did not comply with the set RQOs in the Upper Komati sub-catchment, especially on the Boesmanspruit, Swartpruit, Klein Komati and Gladdespruit which is dominated by mining mines. In the Lower Komati sub catchment mainly dominated by agricultural activities, there were also a few monitoring points where EC did not comply with the set RQOs. The high level of EC is due to the presence of dissolved solids arising from mining activities, effluent from WWTWs, stormwater runoff from formal /informal settlement areas and agricultural runoff within the Catchment.

Sulphate concentration showed non-compliance with the RQOs limit within priority resource units or the TWQG limits in the Vaalwaterspruit, Boesmanspruit, Witkloofspruit, Klien Komati, Swartspruit and Gladdespruit. These priority resource units are dominated by coal mines and the high levels of sulphates are mostly attributed to active mines and defunct mines some of which are decanting.

Nutrients

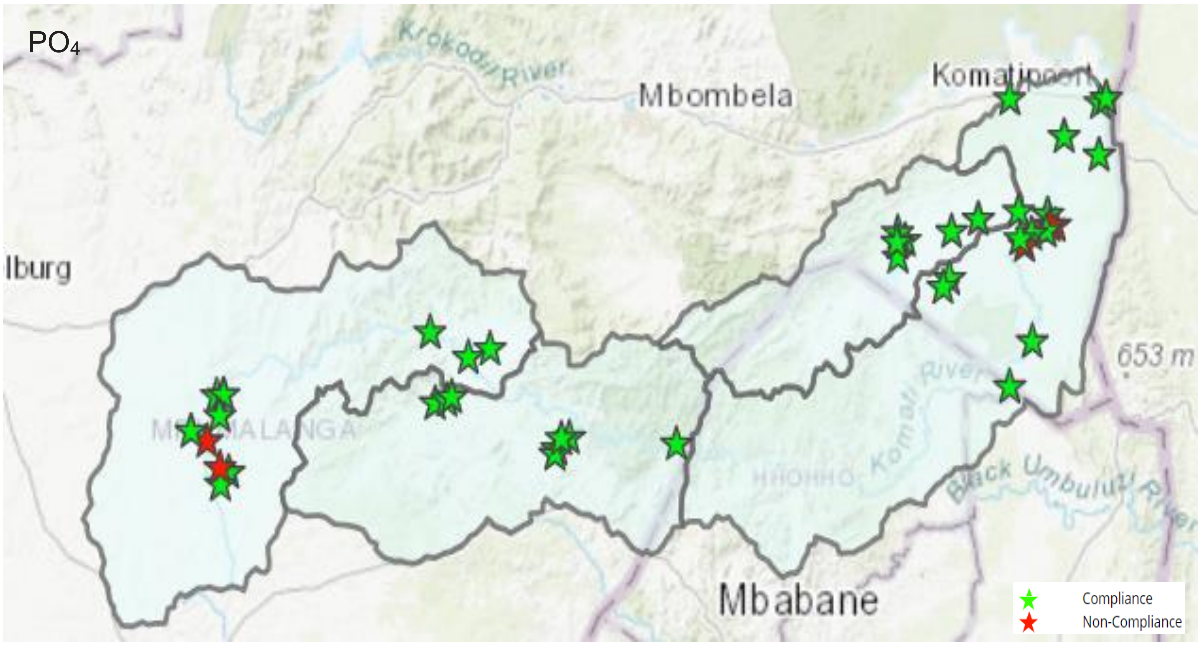
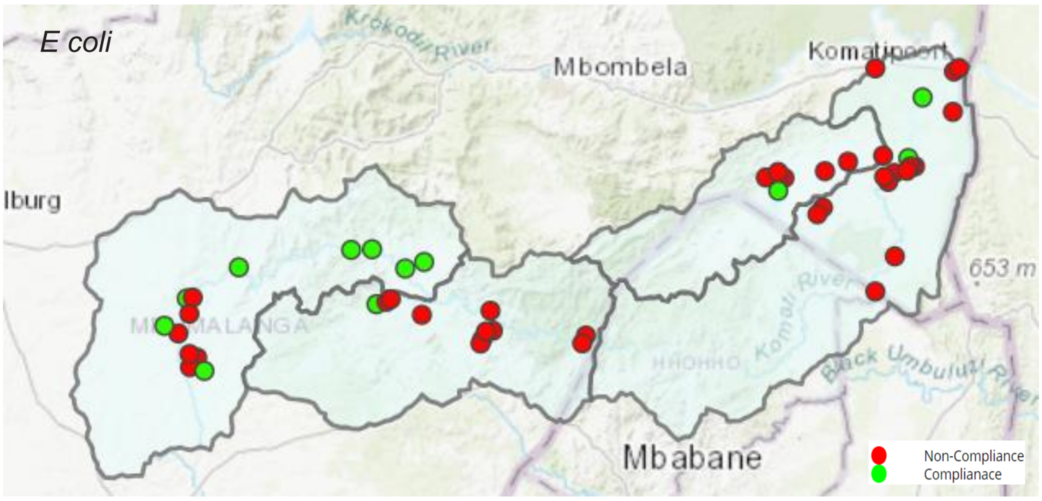


Figure 75: Water quality status within Komati Catchment showing PO_4 and NO_2+NO_3 concentrations.

Phosphate showed compliance with the RQOs for most of the points within Komati Catchment, except for five points. Two points are in upper Komati sub catchment on the tributary of Boesmanspruit downstream of Carolina WWTWs and sewer pump station, whereas the other three points are in the lower Komati sub catchment on the tributary of the Komati River downstream of Tonga Hospital WWTWs and Mahorwane stream and its tributary. The impacts are attributed to effluent discharges from WWTWs and illegal dumping of solid waste materials. Nitrates/Nitrites concentrations complied with the TWQG throughout the sites monitored in the Komati Catchment except the Mahorwane stream, which is highly impacted by extensive settlements (KaMaqhekeza).

Microbial



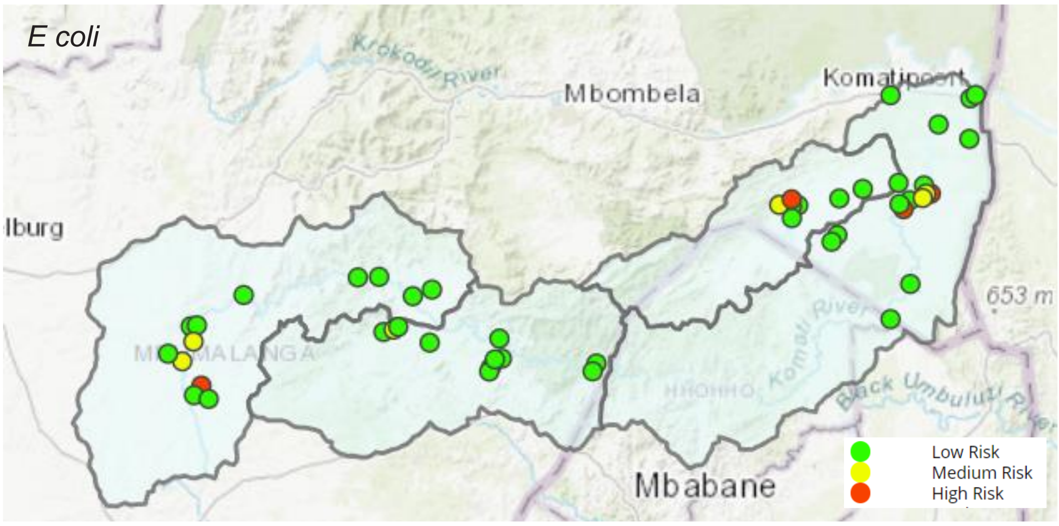


Figure 76: Water quality status within Komati Catchment showing E. coli concentrations.

The. *E. coli* counts in the Komati Catchment complied with the RQO of 130 (cfu/100ml) for few points mostly the major dams (Nooitgedacht, Vygeboom and Driekoppies); Vaalwaterspruit; Gladerspruit Komati River upstream of Vygeboom Dam, Komati River after confluence with Lomati River and at Cooperdale as illustrated in the first map of Figure 76. The other sites in Carolina, Badplaas and Elukwatini areas within the upper Komati sub catchment and Matsamo, Tonga, Skoonplaas, KaMaqhekeza and Buffelspruit settlements within the lower Komati sub catchment showed elevated *E. coli* counts that did not comply with the set RQOs due to contamination by human faecal material and/or other animals.

The second map shows pontential health risk in terms of NMMP guidelines. Most of the points in the catchment are low risk with *E. coli* counts below 600 per 100ml. The areas with high risk in the catchment were observed within residential areas (Carolina, Tonga, KaMaqhekeza and Schoemansdal) due to intensive residential runoff pollution (stormwater runoff from rural and urban settlements, including direct disposal of domestic refuse, grey water, seepage from latrines, human and animal excrement, as well as sewer overflows) including effluent discharges from WWTWs and its associated infrastructure.

Toxic

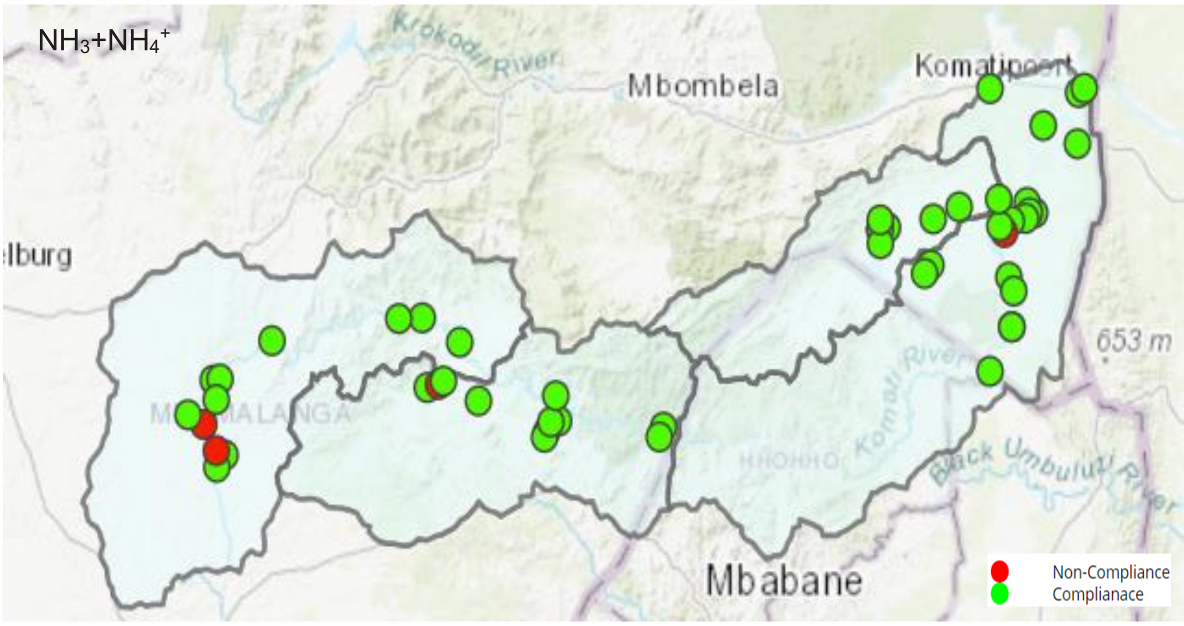


Figure 77: Water quality status within Komati Catchment showing total ammonia concentrations.

Total ammonia within the Komati Catchment indicated compliance with TWQG (Domestic) of 1 (mg/l), except Boesmanspruit and its tributary downstream of Carolina WWTWs, tributary of Seekoeispruit downstream of sewer pumpstation, tributary of Komati downstream of Tonga WWTWs.

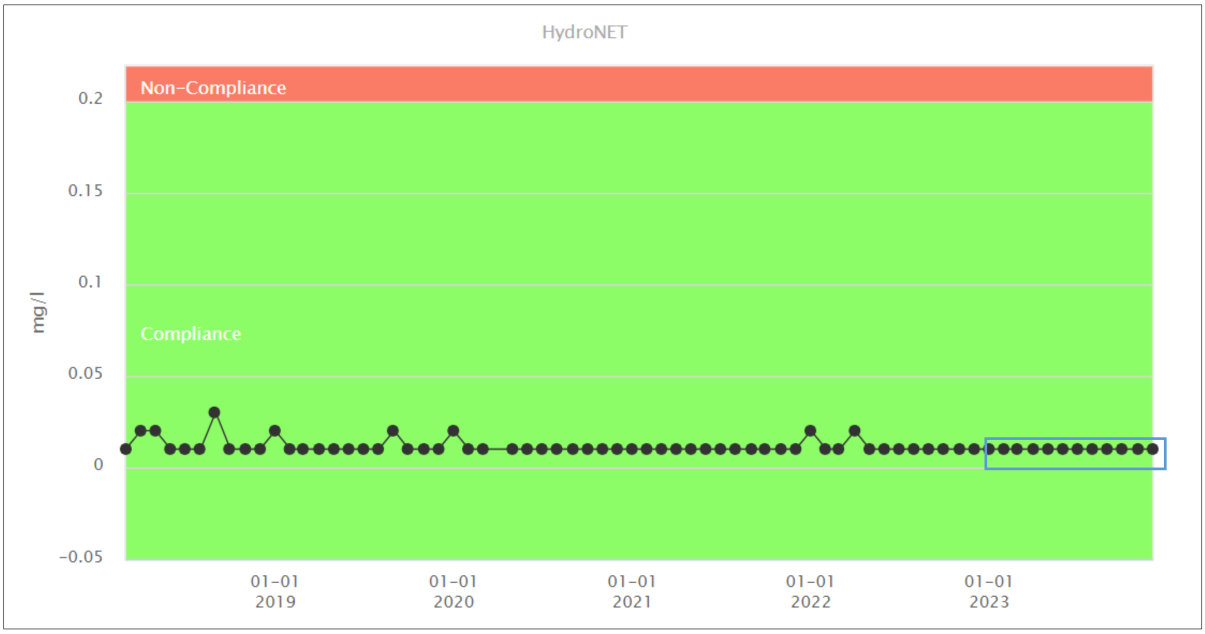
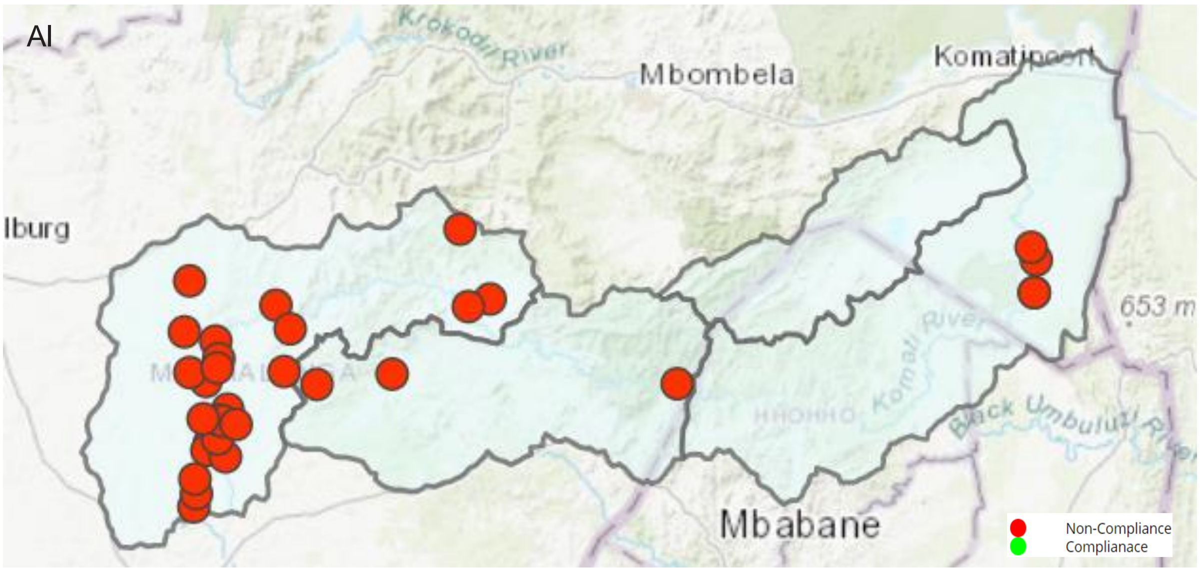


Figure 78: Nickel (Ni) trend chart in the Gladderspruit.

Nickel (Ni) is monitored in the Gladderspruit to assess the impact from the Nkomati Mine a joint venture between African Rainbow Minerals (Pty) Ltd and Norilsk Nickel that produces mainly nickel. Ni complied with the RQOs of 0.2 (mg/l) in the water resource throughout the reporting period (Jan-Dec 2023) as illustrated in Figure 78.

Metals



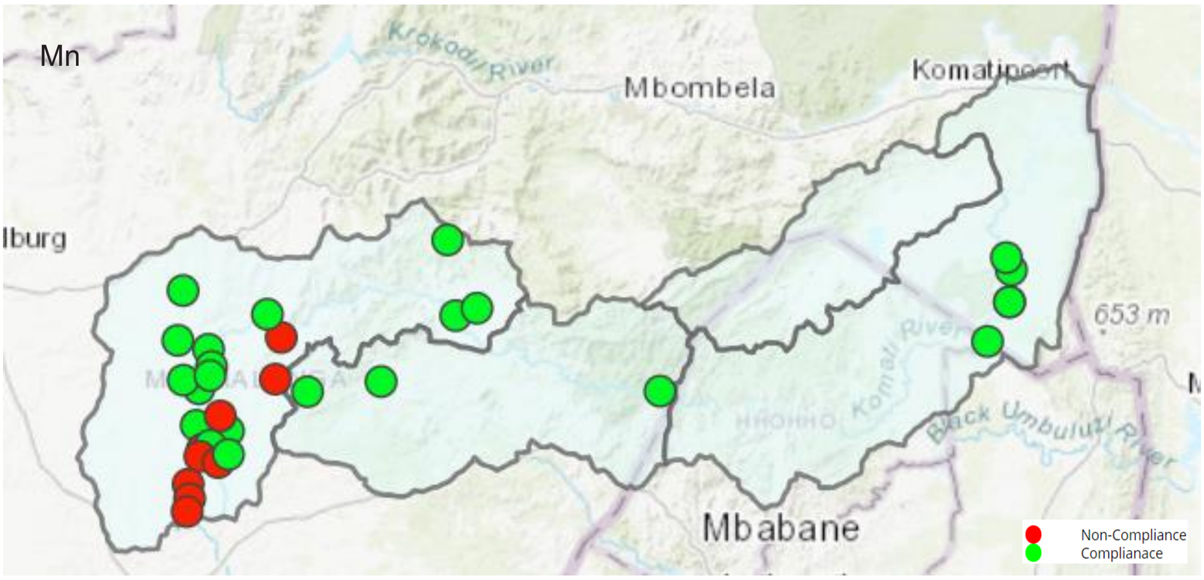


Figure 79: Water quality status within Komati Catchment showing Aluminium and Manganese concentrations.

Aluminium (Al) is a common chemical element released into the water resources from the earth's crust and many anthropogenic activities (mainly coal mining). Aluminium ions in river water have a significant negative correlation with pH, and the greater the acidity of river water, the higher the content of aluminium ions in river water. All points in the Komati catchment indicated non-compliance with the TWQR of 0.02 (mg/l) due to coal mining activities and background geology since noncompliance is also recorded in the head waters.

Manganese can affect the colour and taste of water. This mineral can be found naturally in the environment (surface water) or because of land use activities such as mining and industrial discharges. Manganese complied with the TWQG of 0.18 mg/l (Domestic) through-out the catchment, except Boesmans spruit and Swartspruit due to impacts from coal mining activities.

4.2.4 Usuthu Catchment

The headwaters of the Usuthu River emerge from the highlands of Amsterdam, Mpumalanga province, flow through the Kingdom of Eswatini and into the Republic of Mozambique before entering the Indian Ocean. The Usuthu Catchment is unique from the other three catchments due to the short distance from the headwaters to the border with Eswatini as illustrated in Figure 80.

The major activities in the catchment include forestry, mining, agricultural activities and municipal wastewater treatment works. The Usuthu Catchment is characterised by large transfers out of the catchment (and out of the WMA) to the Vaal and Olifants Water Management Areas mainly for cooling purposes at ESKOM power stations but also for other economically important activities. Four large dams in the Usuthu support these transfers, namely, Heyshope, Morgenstond, Westoe and Jericho Dams. Pollution of these strategic water resources will significantly impact on power generation and the economy of the country at large.

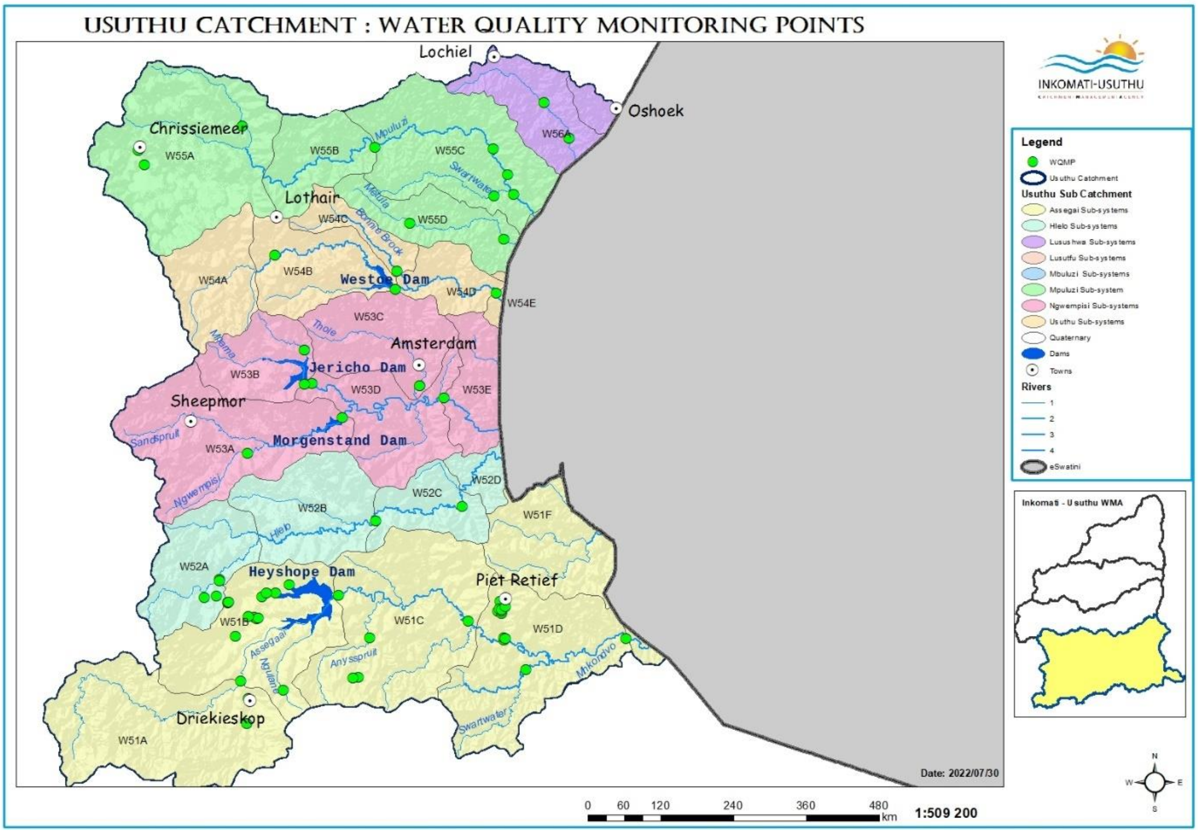


Figure 80: Water quality monitoring points in the Usuthu Catchment.

The RQO are currently not determined for the Usuthu Catchment. Thus, the South African Target Water Quality Guidelines (SATWQG) were used to benchmark the water quality data for all variables. The compliance of the indicator parameters was compared with the Target Water Quality Guideline Limits (TWQG) as indicated in Table 13.

Table 13: Target Water Quality Guideline.

Variables/Parameters	TWQG
pH	6.5-8.5
Dissolve Oxygen (DO) in % Saturation	>80
Electrical Conductivity (EC) in mS/m	40
Sulphate (SO_4) in mg/l	30 (Industry Category 1)
Phosphate (PO_4) in mg/l	0.025
Nitrates/Nitrites (NO_3 + NO_2) in mg/l	6 (Domestic)
E.coli in cfu/100ml	130 (recreation)
Total ammonia (NH_3+NH_4^+) in (mg/l)	1 (Domestic)
Aluminium (Al) in mg/l	0.02 (Aquatic ecosystem)

System Variables

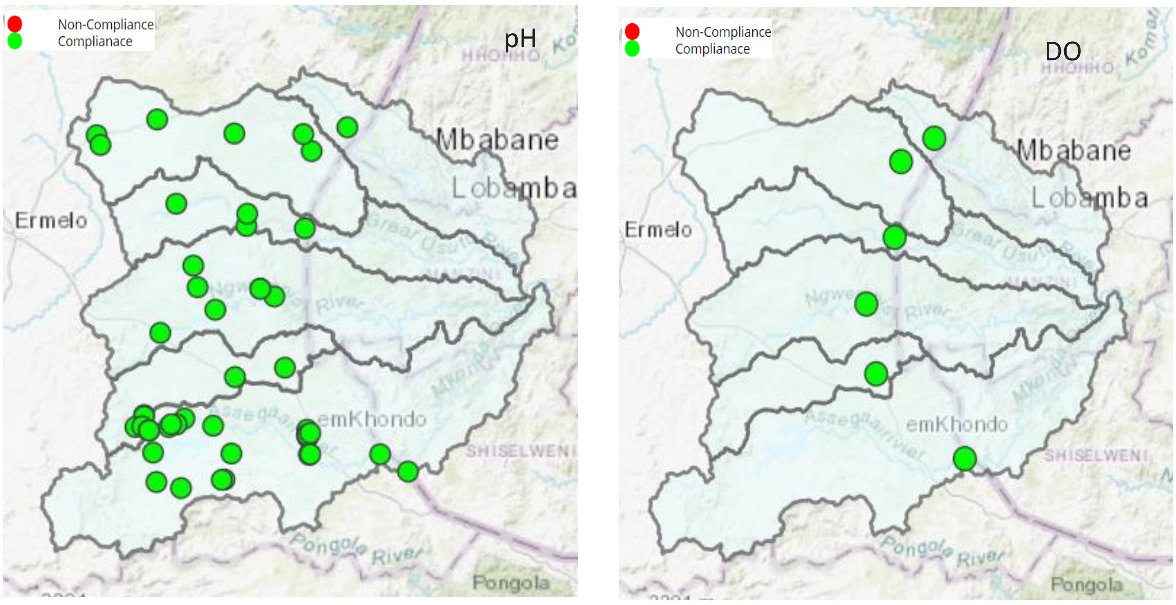


Figure 81: Water quality status within Usuthu Catchment showing pH and DO concentrations.

As shown in Figure 81 the system variables using pH and DO comply with the TWQR limit throughout the reporting period in the catchment.

Salts

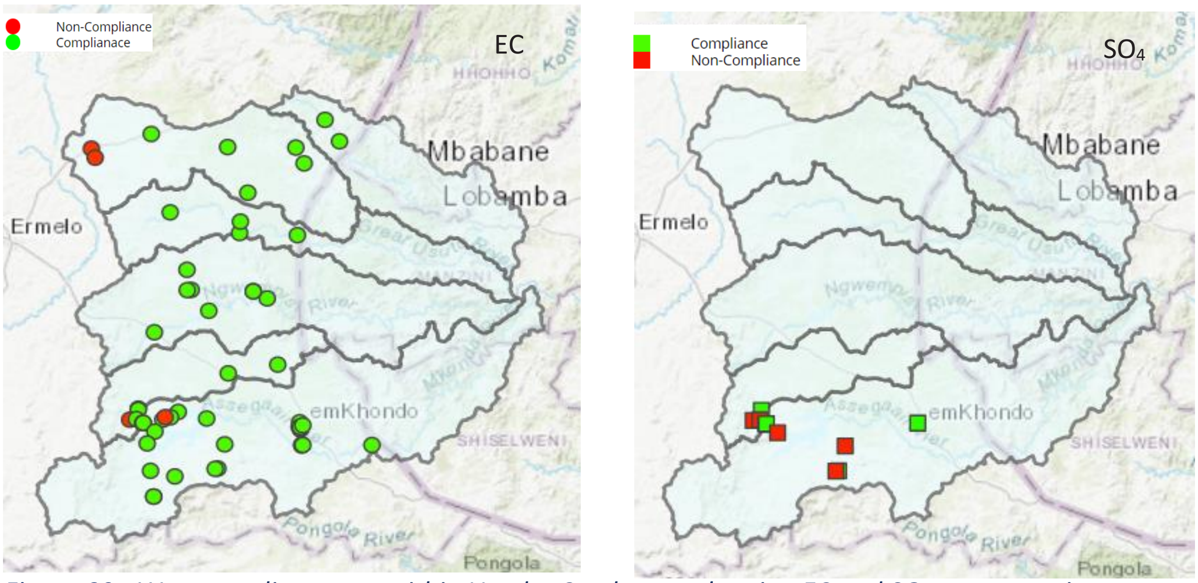


Figure 82 : Water quality status within Usuthu Catchment showing EC and SO_4 concentrations.

EC complied with the TWQG limits within the Usuthu Catchment except for upstream of Chrissiesmeer WWTWs, Chrissiesmeer lake, Ntanta stream, Tributary of Egude River, Klipmisselspruit and its tributary downstream of WWTW and industrial area (Umkhonto). Sulphate is monitored to assess the impact of coal mining activities in the upper Assegai River, Annysspruit and Hlelo River sub-systems in the Usuthu Catchment. SO4 indicated noncompliance with the TWQG for Industry of 30 (mg/l) except for 5 sites that indicated compliance as shown in Figure 82 due to impacts from coal mining activties.

Nutrients

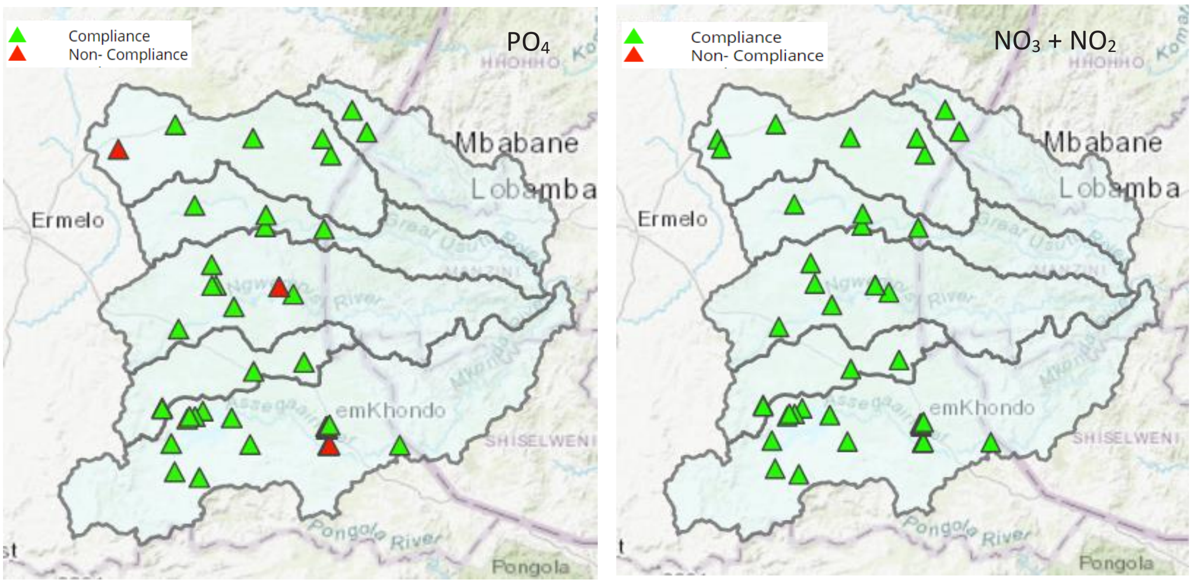


Figure 83 : Water quality status in Usuthu Catchment showing PO_4 and $NO_2 + NO_3$ concentrations.

As Figure 83 shows, Phosphate and Nitrates/Nitrite concentrations complied with the TWQG throughout the reporting period in the catchment, except for seven (7) points that indicated non-compliance for phosphate which are downstream of the WWTW as well as, Chrissiesmeer lake, Klipmisselspruit and its tributaries.

Microbial

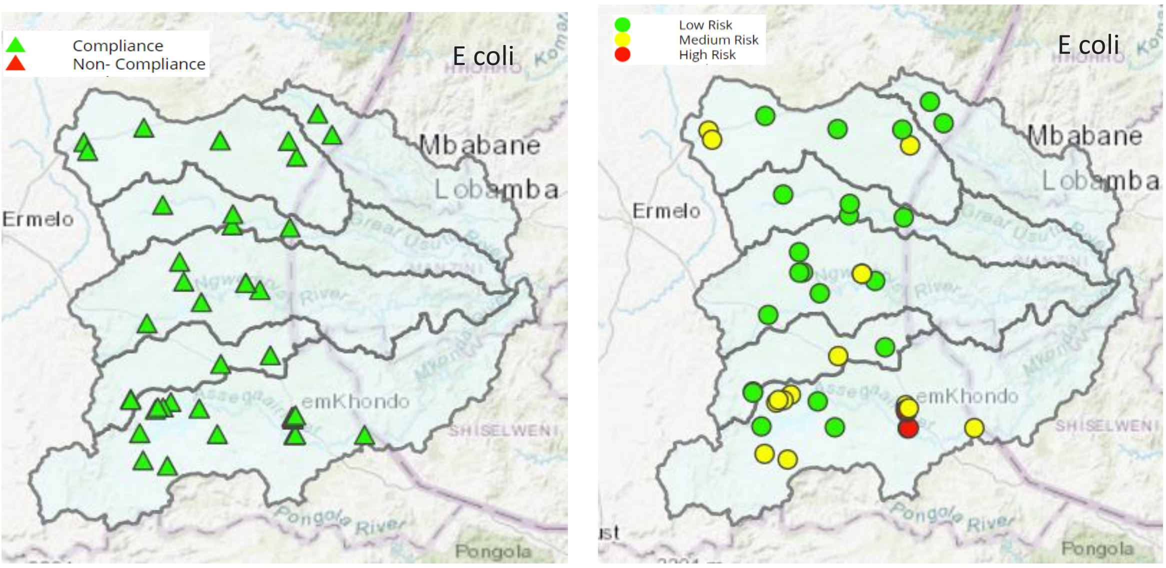


Figure 84 : Water quality status within Usuthu Catchment showing microbial (E coli) concentrations.

The map (left) shows elevated *E. coli* counts which from time to time exceeded the TWQG limits of 130 (cfu/100ml) as illustrated in Figure 84. The non-compliance can mostly be attributed to the WWTWs that discharge untreated or partially treated wastewater into the streams, overflowing sewer pump stations, non-point sources such as illegal waste dumping. The second map shows potential health risk in terms of NMMP guidelines. Most of the points in the catchment are low risk with *E. coli* counts below 600 per 100ml. The areas with medium to high risk in the catchment were observed within residential areas (Chrissiesmeer, Empuluzi, eMvelo, Driefontein and eMKhondo) due to intensive residential runoff pollution (stormwater runoff from rural and urban settlements, including direct disposal of domestic refuse, grey water, seepage from latrines, human and animal excrement, as well as sewer overflows) including effluent discharges from WWTWs and its associated infrastructure.

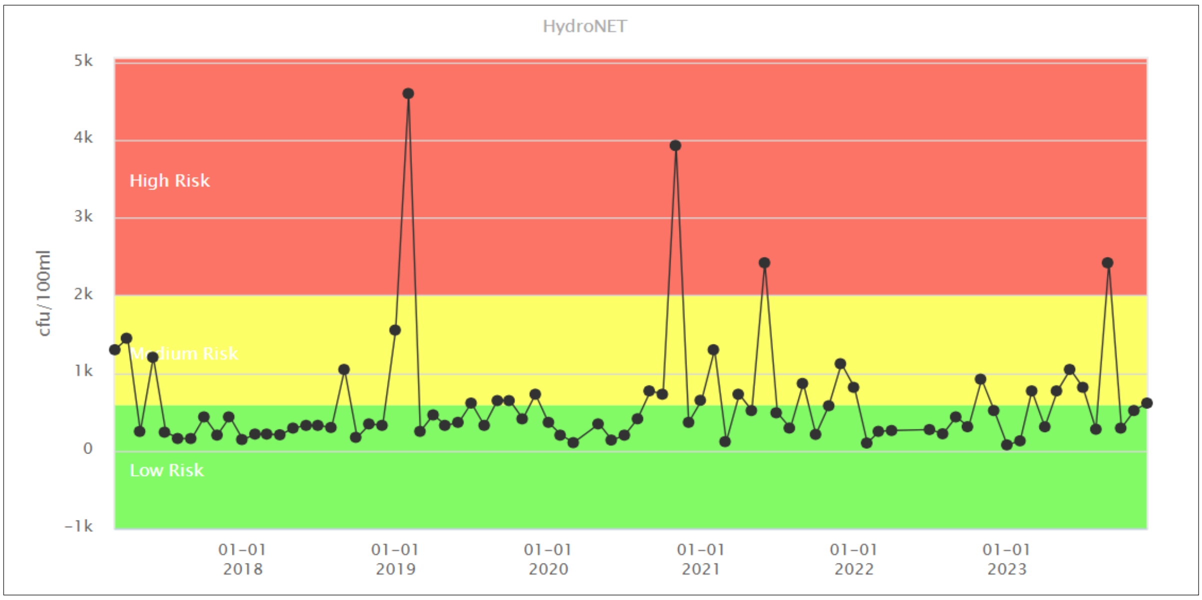


Figure 85: Chart indicating microbial (E coli) concentration trends (Marc 2017-Dec 2023) in the Assegai River.

Toxic Substances

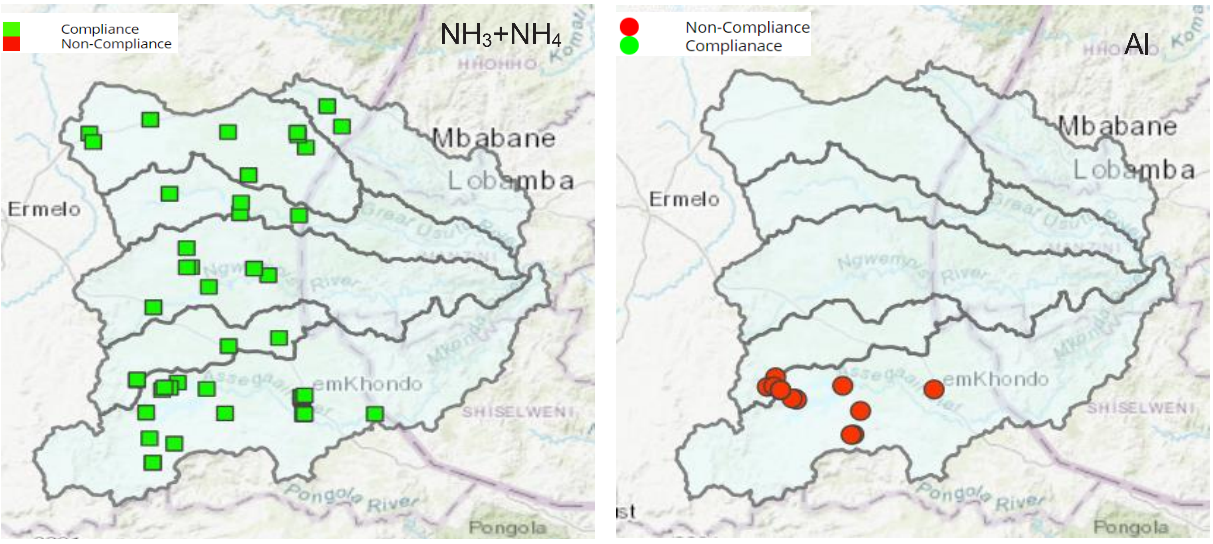


Figure 86 : Water quality status in Usuthu Catchment showing total NH_3 and Al concentrations.

Average concentration of total ammonia within the Usuthu Catchment indicated compliance with domestic targeted water qulity guideline of 1 (mg/l) throughout the catchment. Aluminium is found in soluble forms mainly in acid mine drainage waters. Aluminium indicated non compliance with targeted water quality guideline of 0.02 in ml/g within the Hlelo and Assegai River systems. The impacts arise from mining activities within this systems. The chart below shows aluminium trends at Annysspruit downstream of mining activities, and may have pontential risk of mining drainage within the system.

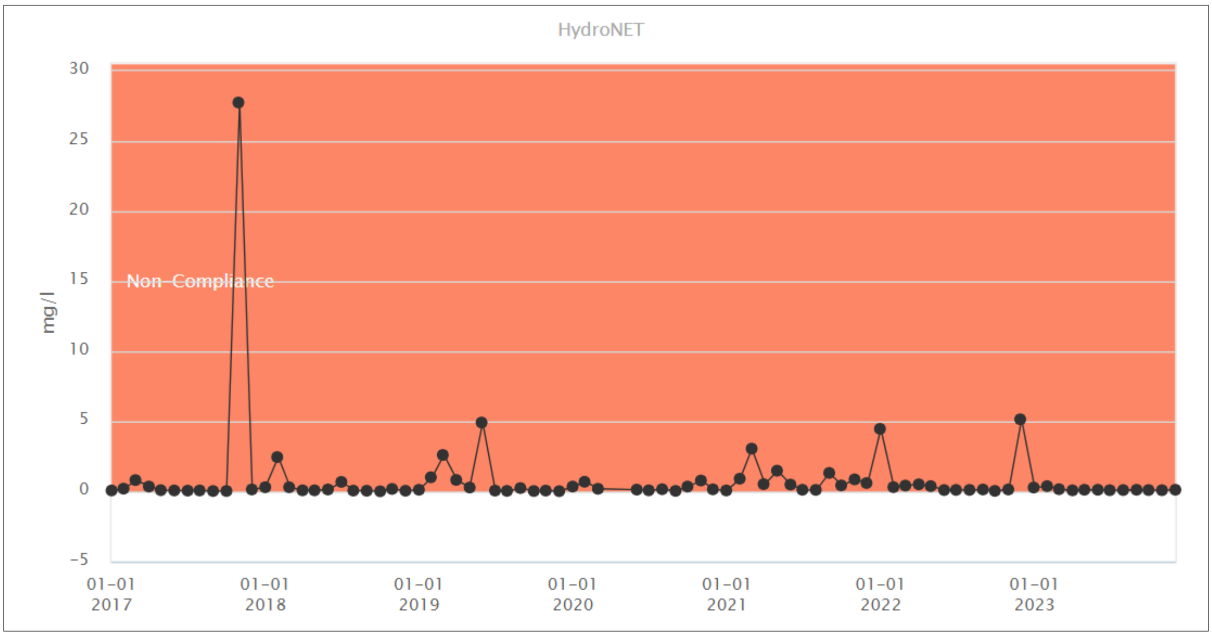


Figure 87 :Chart indicating Aluminium concentration trends (March 2017-Dec 2023) in the Annysspruі

4.3 Water Quality Areas of Concern

Below are the areas of concern in relation to water quality within the WMA per Catchment including the intervention implemented or to be implemented.

Catchment	Water Resource and Area	Parameters of concern	Intervention implemented and /or Solution
Sabie/Sand	Klein Sabie at Sabie area (Simile), Langspruit at Hazyview and Bega River and Ngwenyameni River at Mkhuhlu.	EC (Salts) and PO_4 (Nutrients)	i. Continuous implementation of water quality improvement strategy/plan by IUCMA. ii. Continuous implementation of RDM and SCM by IUCMA. iii. Continuous engagement (inter-governmental relations) with other spheres of government especially Local Municipalities due to sanitation and waste management services impacting on resource quality especially *E. coli* and ammonia (poor maintenance and operation of WWTWs and it's associated in infrastructure including waste management and services). iv. To expand the water quality improvement strategy and include external stakeholder. v. Implementation of waste discharge charge. vi. Review of water quality standards for wastewater effluent discharges by DWS. vii. Develop decision support (DSS) Tools to determine WUL condition for effluent discharge taking into consideration the RDM.
Crocodile	Tributary of Crocodile River at Hectorspruit, Komatipoort and Tenbosch and tributary of Gutshwa River at Kabokweni	EC (Salts)	
	Leeuspruit, KaNyamazane stream, tributary of Gutshwa River and tributary of Crocodile River at Hectorspruit and Komatipoort most of these points are down stream of WWTWs. Kaap River system (SuidKaap, NoordKaap and Louw's Creek). Gladder spruit and Bester spruit (Mbombela area)	PO_4 (Nutrients) Arsenic (Toxic) Manganese (Metal)	
Upper Komati	Boesmanspruit and its tributaries, Vaalwaterspruit, Witkloofspruit (Carolina area Upstream of Nooitgedacht Dam) and Gladdespruit (Badplaas area Downstream of Vygeboom Dam)	Sulphates, EC (Salts)	
	Tributary of Boesmaspruit at Carolina and tributary of Komati River downstream of Tonga Hospital WWTWs.	PO_4 (Nutrients)	
Lower Komati	Ntulane River, tributary of Mahorwane stream at Block B, Mahorwane Stream and Sikwakwa River	EC (Salts) PO_4 (Nutrients)	
Usuthu	Chrissiessmeer lake, Egude River and Klipmisselspruit and its tributaries. Nutrients mostly on downstream of the of the WWTWs.	EC (Salts) PO_4 (Nutrients)	
Inkomati-Usuthu WMA	Some of the EWRs indicated non-compliance to the set RQOs with un Unionized- Ammonia. Most of the downstream points of WWTWs indicated high levels concentration of total ammonia above (1 mg/l).	Unionised- Ammonia (Toxic) Total Ammonia	
	All EWRs indicated non-compliance to the set RQOs except for Crocodile at Dullstroom (Headwaters). The presence of *E coli* and *Feacal Coliforms* in water resource is a huge challenge throughout the entire water management area.	*E. coli* (Microbial)	

4.4 Eutrophication status within the WMA

Eutrophication is the process of nutrient enrichment of waters which results in the stimulation of an array of symptomatic changes, amongst which increased production of algae and aquatic macrophytes, deterioration of water quality and other symptomatic changes found to be undesirable and to interfere with water users (DWAF, 2002).

Eutrophication is a natural process resulting from the accumulation or overabundance of nutrients in bodies of water, particularly nitrogen and phosphorus compounds (Van Ginkel, 2011; Bol et al., 2018). However, human activities and related water pollution impacts such leaching from fertilized agricultural regions, erosion, nitrogen deposits from atmospheric pollution, sewage and industrial waste have been reported to accelerate the extent of eutrophication (Van Ginkel, 2011). This results in the intense development of eutrophication symptoms including blooms of blue-green algae (*i.e.* Cyanobacteria), which causes the reduction of water quality and clarity, an outbreak of alien aquatic plants such as water hyacinth (Moran, 2006), degradation of recreational opportunities, health risks to people and animals and thus, an increase in water treatment expenses.

Ten (10) major dams within the WMA were monitored as part of the National Eutrophication Monitoring Programme (NEMP) from April 2021 to December 2023. The list of trophic status classes and criterion used to assign the trophic status are given in Table 14 and Table 15 below.

Table 14: Trophic status classes used for assessment of dams in South Africa.

1. **Oligotrophic**	low in nutrients and not productive in terms of aquatic and animal plant life;
2. **Mesotrophic**	intermediate levels of nutrients, fairly productive in terms of aquatic animal and plant life and showing emerging signs of water quality problems;
3. **Eutrophic**	rich in nutrients, very productive in terms of aquatic animal and plant life and showing increasing signs of water quality problems; and
4. **Hypertrophic**	Very high nutrient concentrations where plant growth is determined by physical factors. Water quality problems are serious and can be continuous.

Table 15: Criterion used to assign trophic status for the dams and lakes in South Africa.

Statistic	Unit	Current trophic status			
Median annual Chl *a*	µg/l	0<x<10	10<x<20	20<x<30	>30
		Oligotrophic (low)	Mesotrophic (Moderate)	Eutrophic (significant)	Hypertrophic (serious)
		Potential for algal and plant productivity			
Median annual Total Phosphorus (TP)	mg/l	x<0.015	0.015<x<0.047	0.047<x<0.130	>0.130
		Negligible	Moderate	Significant	Serious

4.4.1 Trophic Status and Nutrients Level of Major Dams

The trophic status is the level of eutrophication within the water resource. The trophic status helps us in determining the level of plant and algal growth within the specific resource. Shown below in Table 16 are annual median concentrations of each impoundment monitored through the NEMP from January 2023 to December 2023. All 10 major impoundments monitored fall under the Oligotrophic status based on median annual Chlorophyll-a and Total Phosphorus (TP), thus meaning they are low in nutrients with negligible potential for plant and algal productivity as illustrated in Figure 88 and Figure 89. In 2023 compared to 2022 Chlorophyll-a concentrations improved in four major dams, whereas other six dams indicated decline as illustrated in Figure 88. Whereas total phosphorus remains constant at 0.01 (mg/l) compared to 2022 as illustrated in Figure 89. Eutrophication status of all major dams within the WMA were in an ideal condition.

Table 16 : The trophic status of the impoundments within the Inkomati Usuthu WMA.

Dam Name	**Parameters**	
	Chlorophyll-a in (µg/l)	**Total Phosphorus in (mg/l)**
Inyaka Dam	4.0	0.01
Kwena Dam	3.2	0.01
Nooitgedacht Dam	4.1	0.01
Vygeboom Dam	1.6	0.01
Boesmanspruit Dam	2.5	0.01
Driekoppies Dam	4.7	0.01
Westoe Dam	3.4	0.01
Jericho Dam	8.1	0.01
Morgenstond Dam	3.7	0.01
Heyshope Dam	2.0	0.01

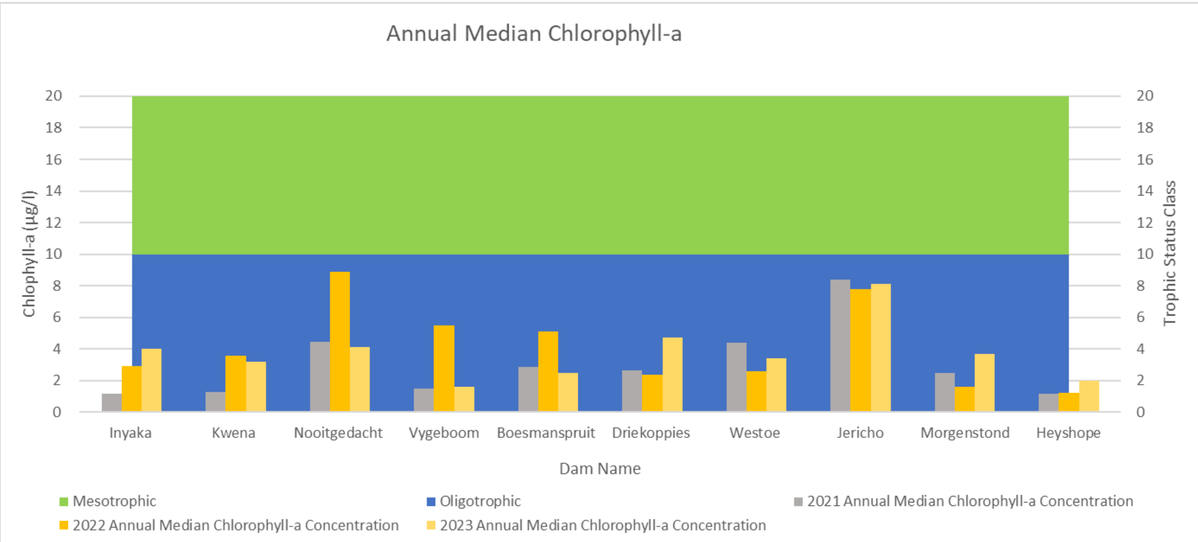


Figure 88: Annual Median Chlorophyll-a Concentration of major dams within WMA.

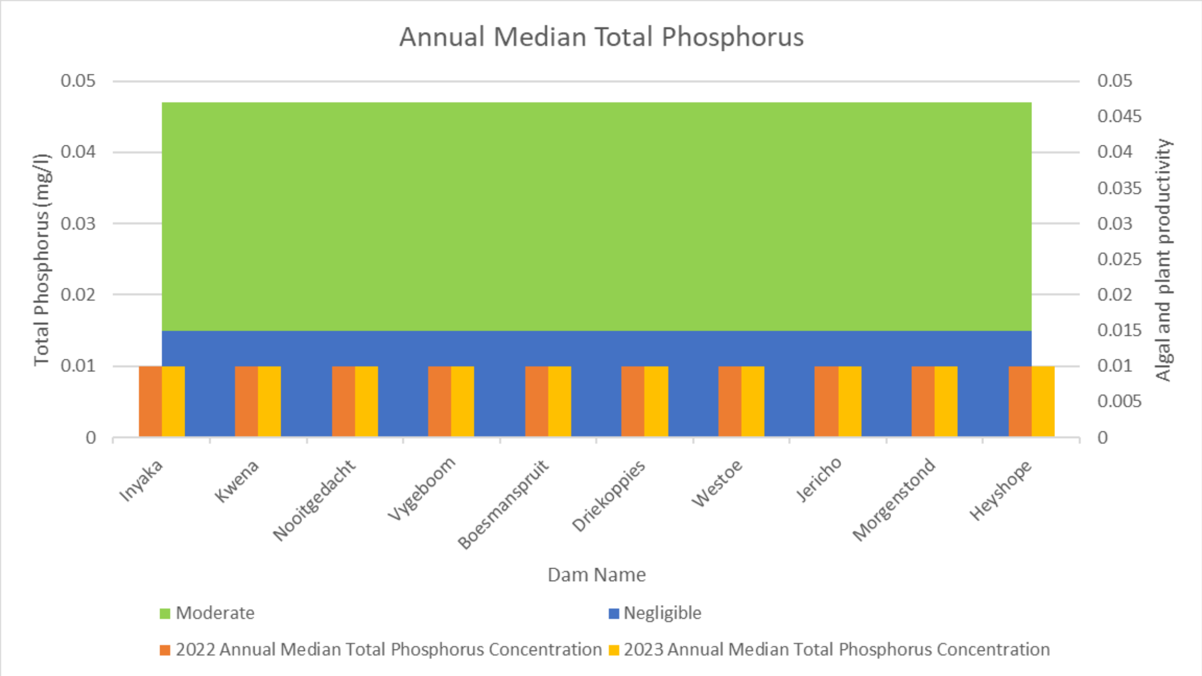


Figure 89: Annual Median Total Phosphorus Concentration of major dams within WMA.

Below is the photo of Kwena Dam as an example in Crocodile Catchment indicating trophic status and nutrients level of the dam which implies low or no productivity in terms of plants (Water hyacinth) and algal growth.

Figure 90: A photo of *Kwena* Dam with low to no algal growth *and* macrophyte *(*Water hyacinth*).*

CHAPTER 5 BIOTA

5.1 Introduction

Aquatic biomonitoring is the science of gathering information of the ecological condition of rivers and streams by examining the types of organisms that live there, such as invertebrates, algae, aquatic vegetation, and fish. The method is based on the principle that different aquatic organisms have different tolerances to pollutants, and that certain organisms will appear under conditions of pollution, while others will disappear. The assessment of biota in freshwater ecosystems is a widely recognized means of determining the condition, or 'health' of the ecosystem.

The health of the aquatic ecosystem is monitored through a programme called the River Eco-status Monitoring Programme (REMP). The REMP complements the surface water chemical and bacteriological monitoring program and provides the state of the river's ecology, considering the various indices used to measure the community attributes of fish, aquatic invertebrates and riparian vegetation and their response to changes in water quality and flow.

The full ecostatus includes combined analysis of vegetation, fish, and macro-invertebrate communities. This provides an integrated and sensitive measurement of environmental problems and represent progress in the assessment of ecological impacts and in the management of aquatic ecosystems.

5.2 Present Ecological Status within the WMA

The present ecological status was determined for the four catchments within the WMA and is presented in the following sections for each catchment.

5.2.1 Sabie Sand Catchment

The survey was conducted on a total of 34 monitoring sites (Figure 91), representative of the Sabie-Sand catchment from the source of the river in the upper reaches to the lower reaches and ending in the lower reaches mainly located in the Kruger National Park and other protected areas.

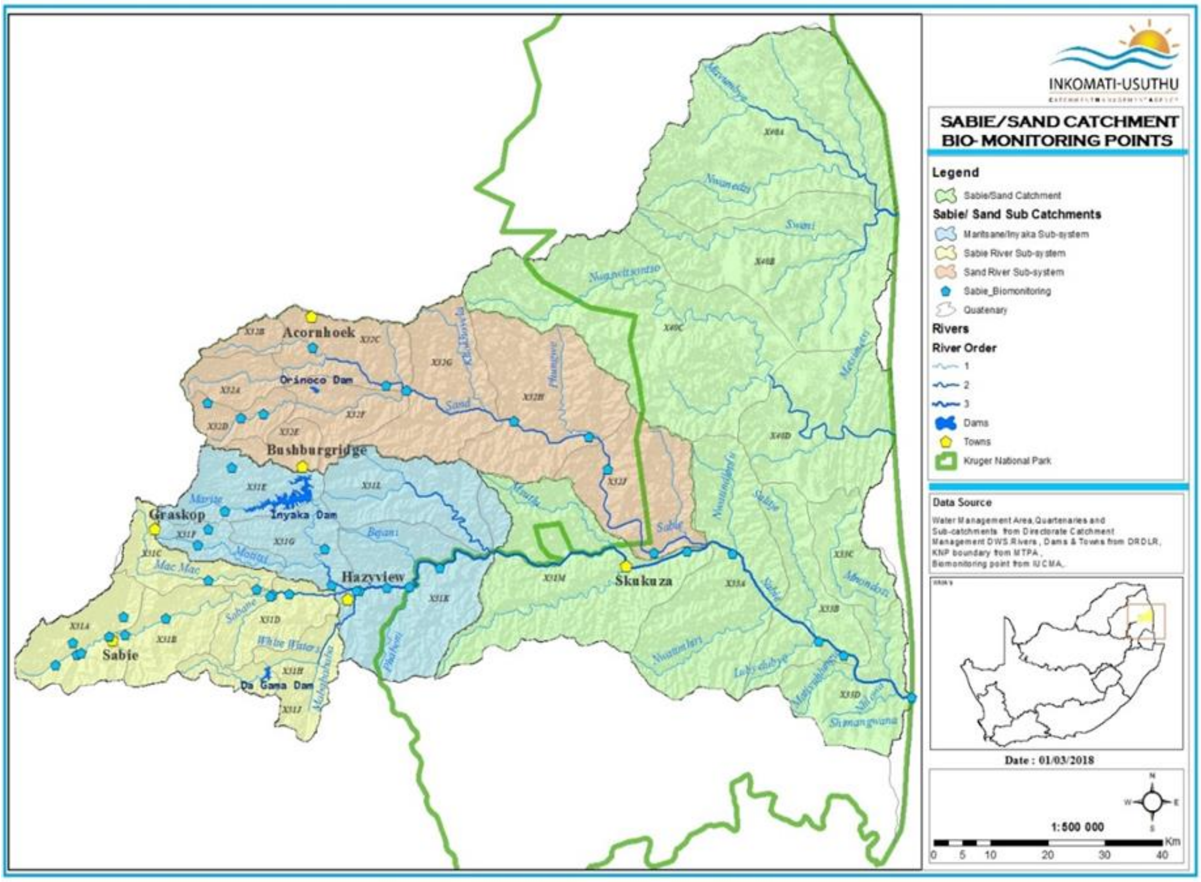


Figure 91: A map showing the sub-catchments in the Sabie-Sand Catchment.

5.2.1.1 Aquatic macro-invertebrates

The results indicate the catchment is generally in an ecological category C indicating the catchment is moderately impacted by anthropogenic activities occurring within the catchment (Figure 92). The catchment remained in a similar ecological category C that was obtained in the previous surveys but with changes in the MIRAI scores at some reaches indicating either improvements or deteriorations in the ecological health of specific reaches in the catchment. There were reaches that were in an ecological category CD (*i.e.,* X3Sand-Thula) and D (*i.e.,* X3Saba-Brand and X3Sand-Rolle). Sand mining, alien invasive species, eutrophication and waste disposal are some of the emerging environmental issues identified during this study.

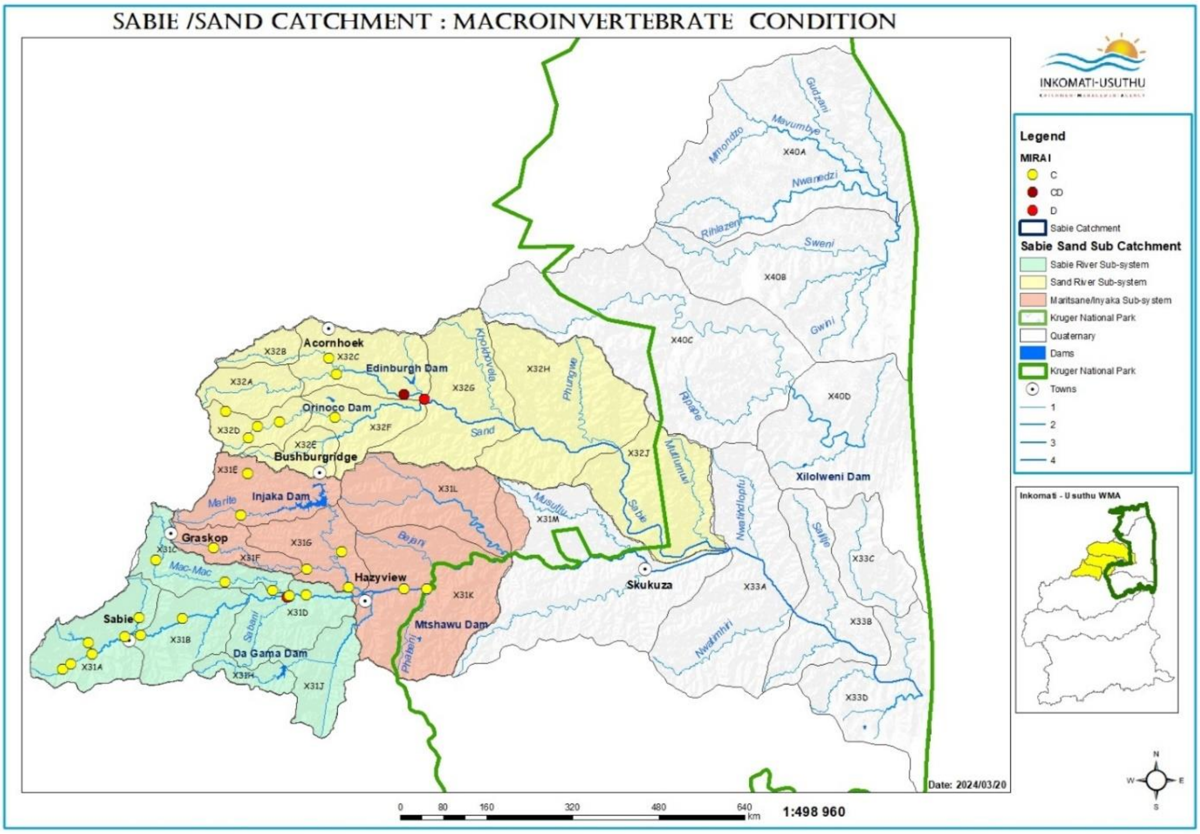


Figure 92: Ecological Categories in the Sabie-Sand catchment reflecting macroinvertebrates condition for sites monitored in July 2023 survey.

5.2.1.2 Fish

Fish condition in the Sabie-Sand catchment is shown in Figure 93. The present ecological state of the Sabie-Sand Catchment was mostly in ecological category C (moderately modified). The PES of the river remained unchanged from the previous survey but with changes in the FRAI scores at some reaches indicating either improvements or deteriorations in the ecological conditions of the specific reaches in the catchment. Reach X31C-00683 (Mac Mac) deteriorated from the previous survey, resulting in non-compliance with the set RQO of BC for fish in the reach. The presence of alien fish species (*Oncorhynchus mykiss*), flow modification due to weirs and dams, and limited habitat cover for certain fish species contributed to the absence of other fish species in the catchment.

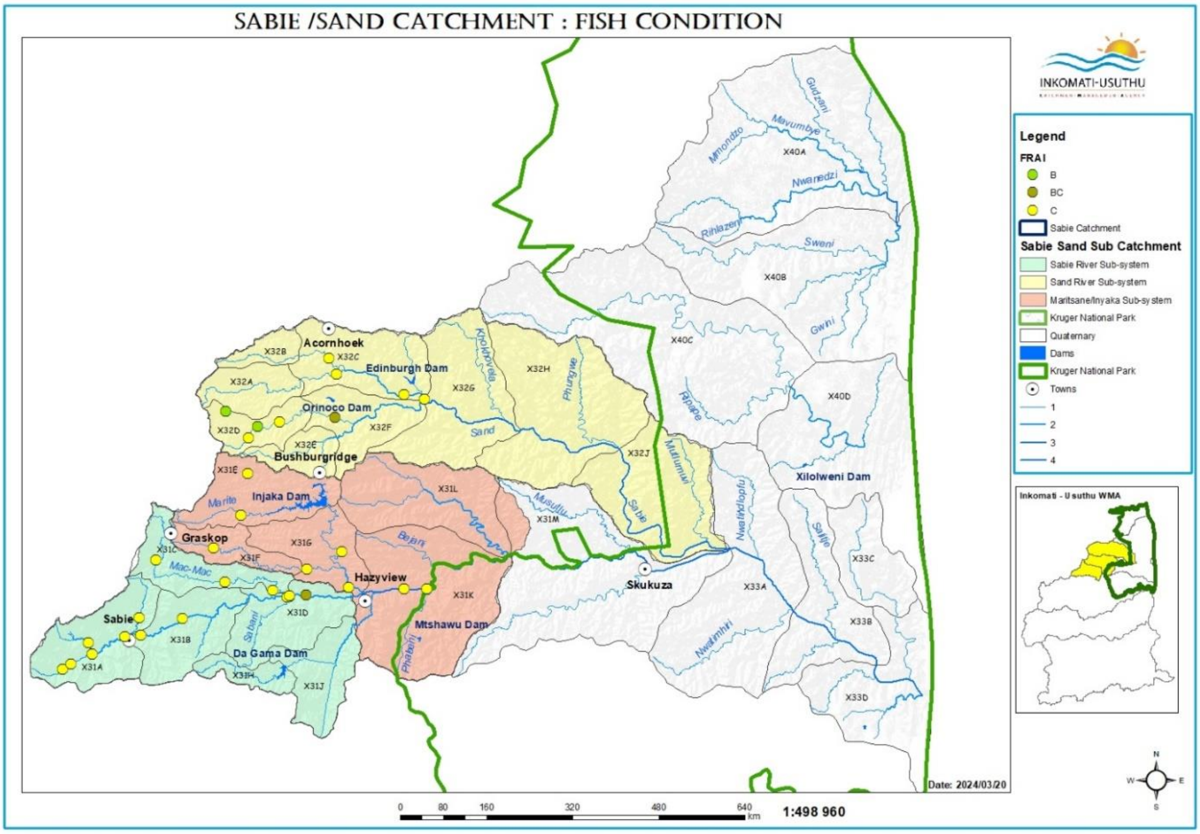


Figure 93: Ecological Categories in the Sabie-Sand catchment reflecting fish condition for sites monitored in July 2023 survey.

5.2.1.3 Riparian vegetation

The results of the riparian vegetation assessment are shown in Figure 94. Monitoring sites that resulted in a B Ecological Category (largely natural with few modifications), such as sites X3MACM-PICNI, X3MACM-BRAND, and X3MOHL-WELGE, are situated high in the mountainous slopes of the catchment, where anthropogenic activities and impacts tend to be minimal. Site X3Sabi-HFall was the only site indicating a BC Ecological category, located in an undisturbed reserved forest (Figure 94). The VEGRAI scores from the current survey revealed that most reaches were in a moderately modified condition (C) except for reach X31C-00683 (MAC MAC), which indicated a BC Ecological category (Figure 94).

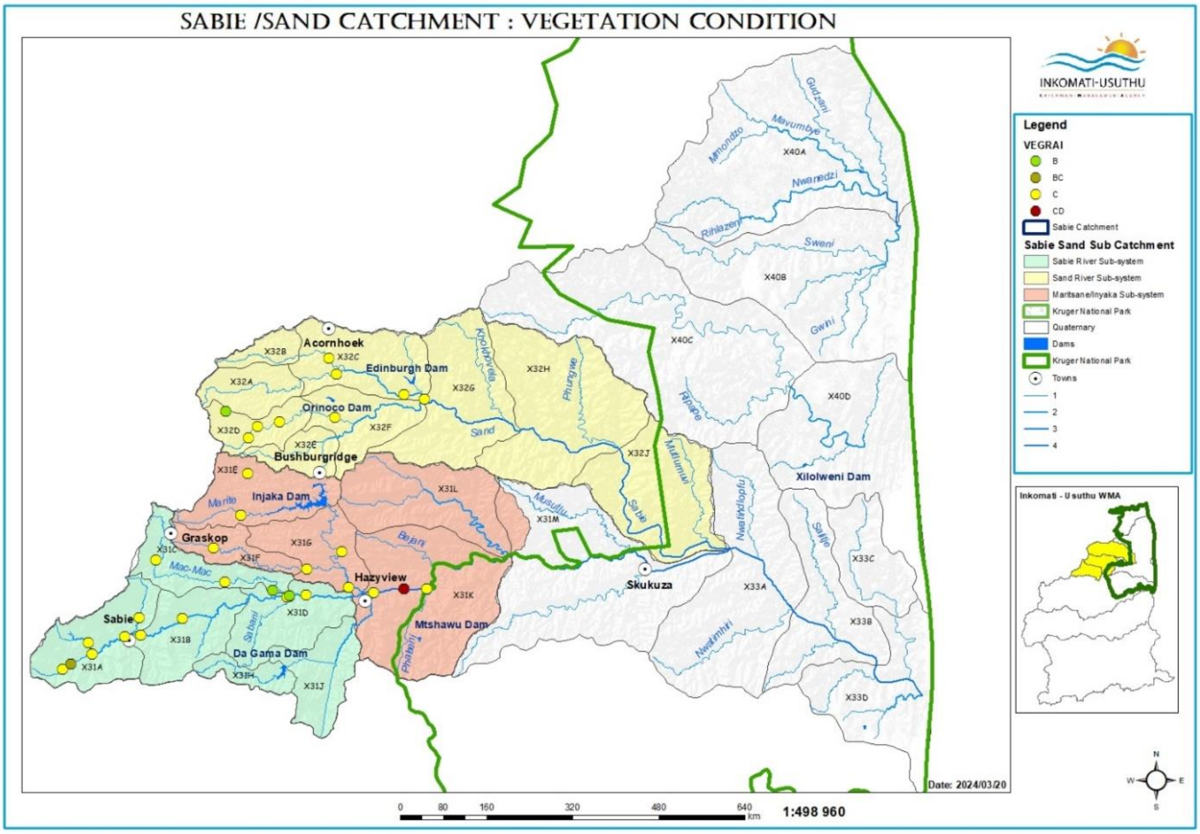


Figure 94: Ecological Categories in the Sabie-Sand catchment reflecting riparian vegetation condition for sites monitored in July 2023 survey.

Based on the macroinvertebrates, fish and riparian vegetation results, the ecological condition in the catchment ranged from largely natural condition with few modifications (B) to a largely modified (D) condition (Figure 95). About 91% of the sites were in a moderately modified (C) condition, 6% in a largely modified condition (D) and 3% in a close to moderately modified (CD) condition for macroinvertebrates (Figure 95). For fish, 84% of the sites were in a moderately modified (C) condition, 9% were in a close to largely natural (BC) condition and 6% were in a largely natural condition (B) with few modifications.

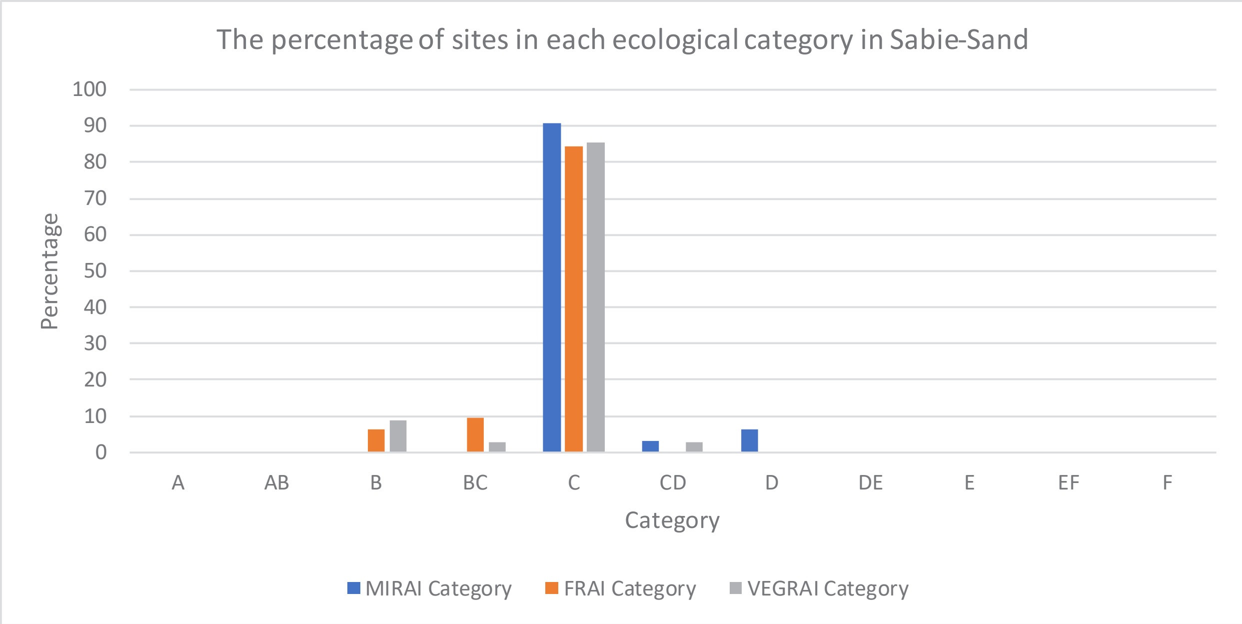


Figure 95:The percentage of sites in each ecological category in the Sabie-Sand catchment for macroinvertebrates (MIRAI), fish (FRAI) and riparian vegetation (VEGRAI) at all sites monitored during the July 2023 survey.

Most sites (85%) were in a moderately modified (C) condition for riparian vegetation, with 16% in a largely natural condition (B) with few modifications. In addition, 3% of the sites were in a close to moderately modified (CD) condition and in a close to largely natural (BC) condition for riparian vegetation. The ecostatus for macroinvertebrates, fish and riparian vegetation is also discussed further in the next sections.

5.2.2 Crocodile Catchment

The survey was conducted in the Crocodile Catchment, one of the four catchments within the IUWMA. The current survey was conducted at a total of 41 monitoring sites. Figure 96 shows a map of the Crocodile Catchment, on which the locations of the monitoring sites are marked. The Elands and Kaap Rivers are the two major tributaries of the Crocodile River which were monitored. In addition to the two tributaries, a total of six relatively smaller tributaries were monitored. The tributaries are Lunsklip River, Houtbosloop, Visspruit, Nels River, and Gladdespruit. The following tributaries of the Elands River were monitored: Leeuspruit, Swartkoppiespruit and Ngodwana. Noord Kaap, Suid Kaap and Queens Rivers are relatively large tributaries of the Kaap River and were also monitored.

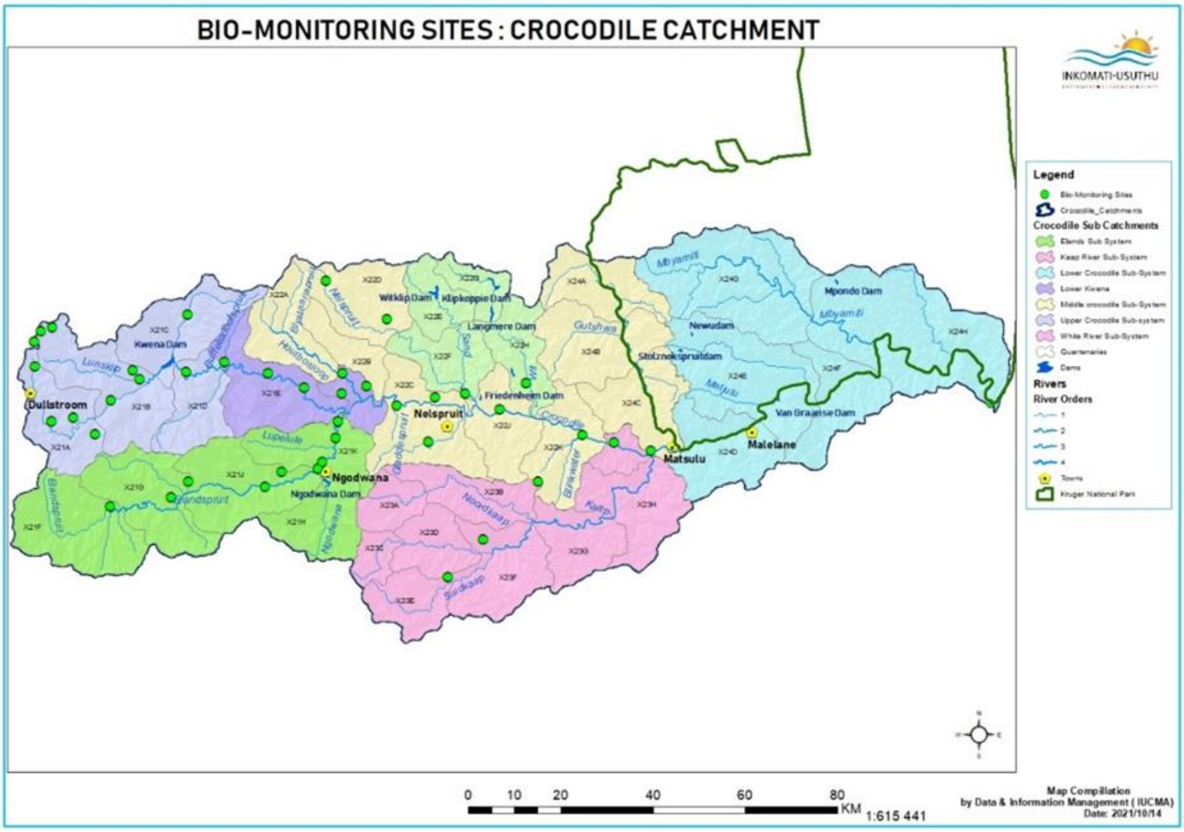


Figure 96: A map showing the biomonitoring sites in the Crocodile Catchment.

5.2.2.1 Aquatic macro-invertebrates

Figure 97 indicates that the Crocodile catchment is currently in a moderately modified condition (C), which is similar to the ecological condition found in previous surveys. However, some reaches of the catchment were in a close to moderately modified (CD) condition (*i.e.,* X21E-00943, X22K-01018, X21F-01100, X21H-01060 and X23E-01154) and in a largely modified (D) condition (*i.e.,* X22C-00990 and X22C-01004). This shows that the catchment is moderately modified, and the modifications can be attributed to the anthropogenic activities such as agriculture, forestry, residential areas, and industrial activities, occurring in the catchment.

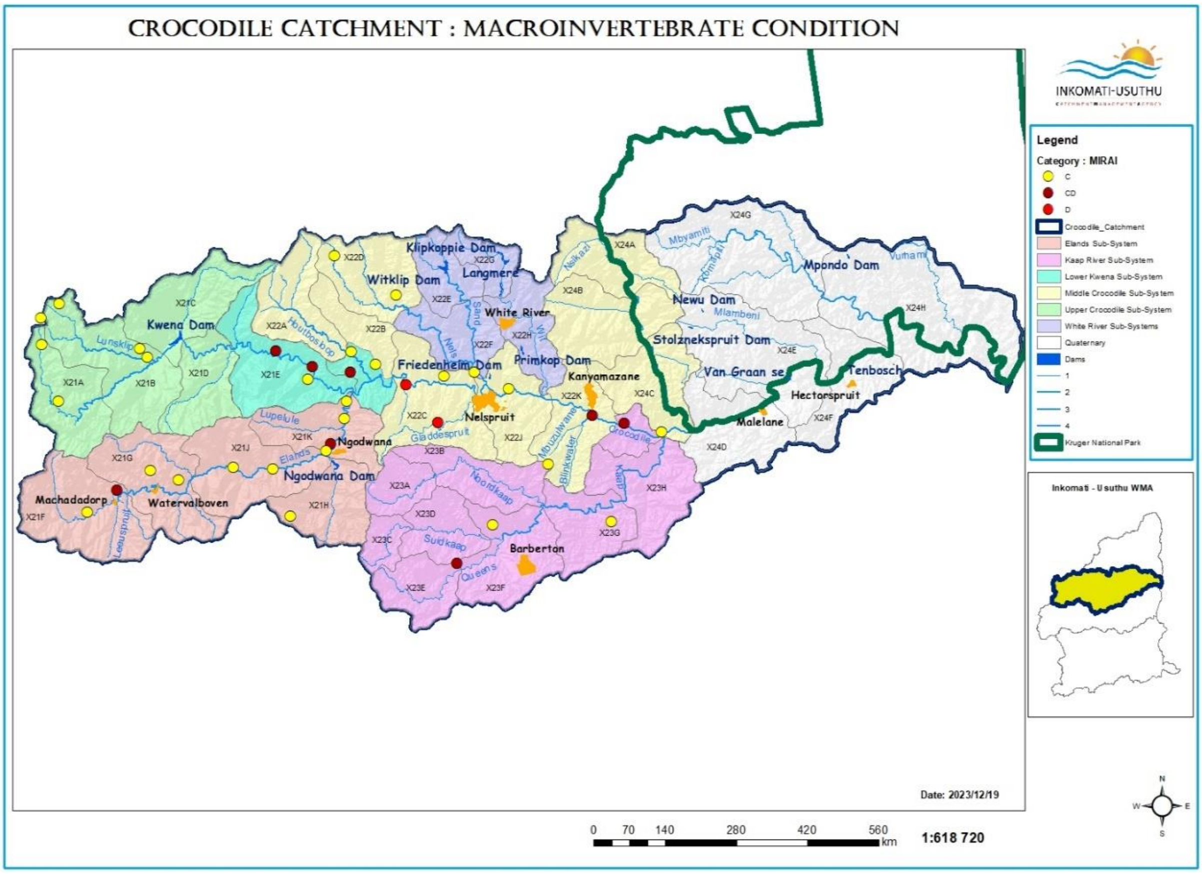


Figure 97: Ecological Categories in the Crocodile Catchment reflecting macro-invertebrates condition for sites monitored in June 2023 survey.

5.2.2.2 Fish

Figure 98 shows the condition of the fish in the Crocodile Catchment. According to the results, the X22C-00990 reach was found to be of concern and was in a close to moderately modified condition (CD). The sites located in the main tributary of the Crocodile River, the Elands River, were determined to be in a moderately modified (C) condition, reflecting limited impact. Other ecological categories in the Crocodile Catchment remained unchanged from the previous surveys. The Crocodile River downstream of Kwena Dam is heavily influenced by unseasonal dam releases for irrigation. Commercial forestry, agriculture activities, as well as rural and urban settlement, all have an impact on the Crocodile River catchment.

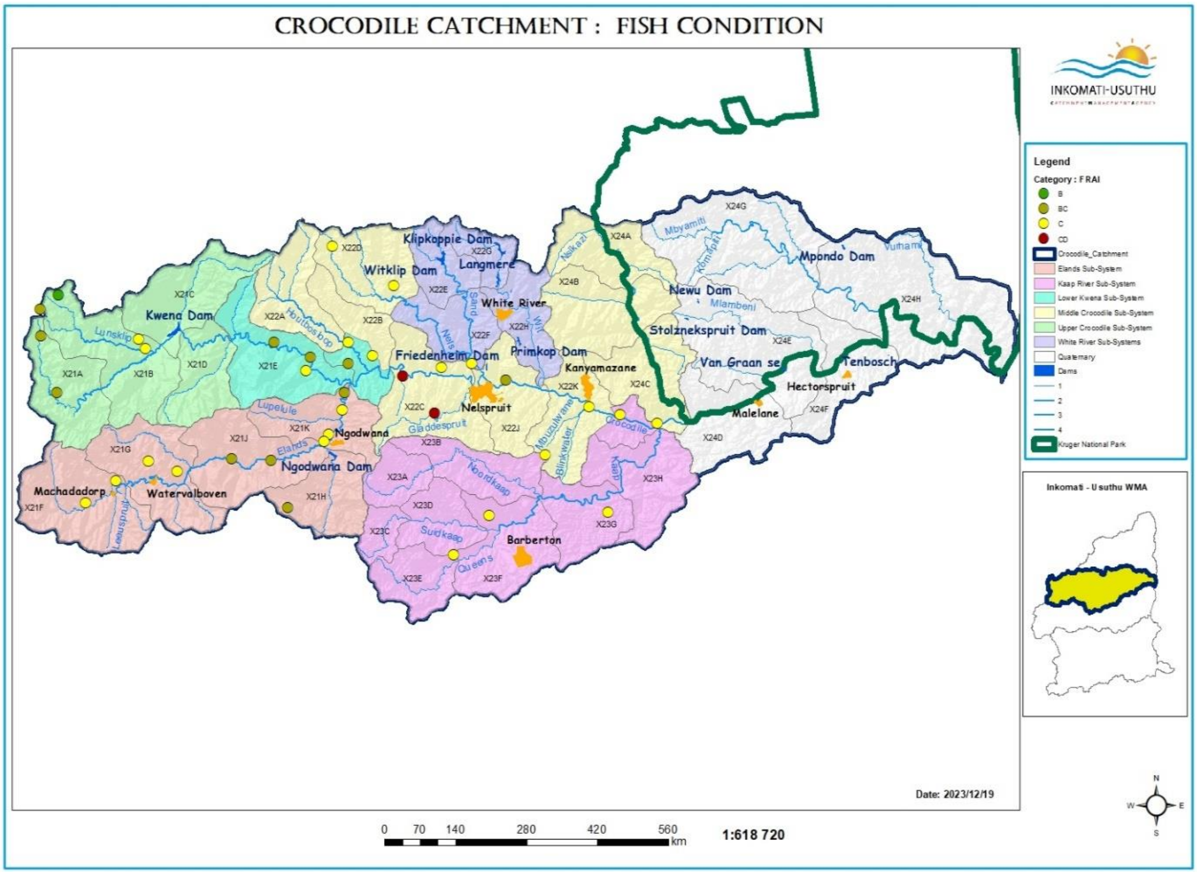


Figure 98: Ecological Categories in the Crocodile catchment reflecting fish condition for sites monitored in June 2023 survey.

5.2.2.3 Riparian vegetation

Based on the riparian vegetation assessment, the Crocodile Catchment is currently in an ecological category C (Figure 99). The riparian condition ranged from natural condition (A) to a largely modified (D) condition. The ecological categories from the upper-most reaches (*i.e.*, X21A-0030 and X221B-00962 resulted in a vast improvement, where a B ecological category for both reaches was achieved when compared with results from the previous survey. An ecological category A (Natural condition) was also achieved at site X2Croc-Kwena, which is stand-alone site on the reach X21D-00938 and was not assessed during the previous survey of 2022 sampling period.

Apart from the mainstem of the Crocodile River, the assessments on the tributaries revealed a general improvement in ecological condition. This improvement could be ascribed to the fact that there were fewer visible impacts related to the removal of riparian vegetation on most of the sampled sites during the current survey. However, some deterioration was found on reach X21K-01035 which has been degraded from a moderately modified (C) to a largely modified (D) condition when compared to the previous survey (Figure 10). This site is located downstream of the Ngodwana industrial area, where the primary impact is the loss of riparian vegetation and the disposal of solid waste debris.

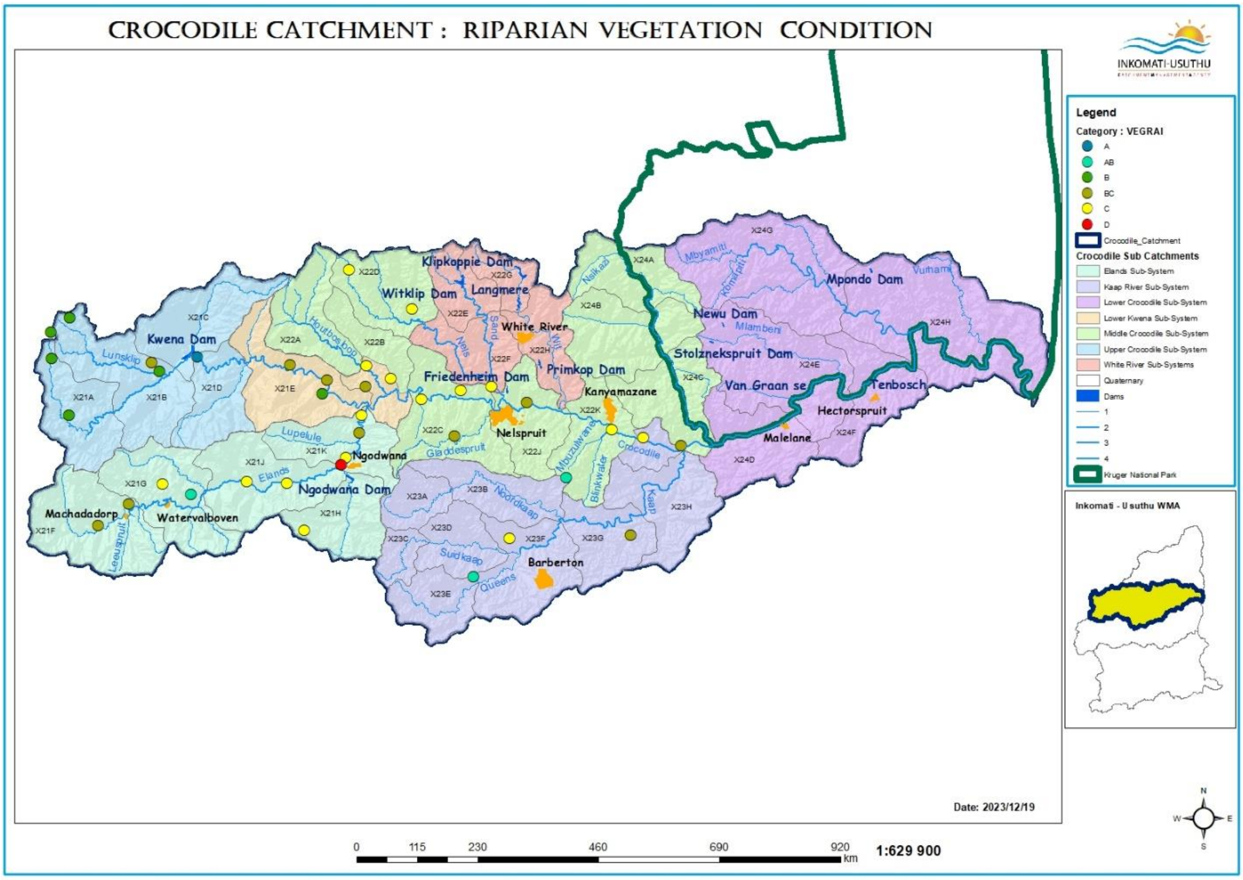


Figure 99: Ecological Categories in the Crocodile catchment reflecting riparian vegetation condition for sites monitored in June 2023 survey.

Based on the macroinvertebrates, fish and riparian vegetation results, the ecological condition in the catchment ranged from natural condition (A) to a largely modified (D) condition (Figure 100). About 73% of the sites were in a moderately modified (C) condition, 22% in a close to moderately modified (CD) condition and 5% in a largely modified condition (D) for macroinvertebrates (Figure 3). For fish, 62% of the sites were in a moderately modified (C) condition, 30% were in a close to largely natural (BC) condition and 11% were in a largely natural condition (B) with few modifications. Only 5% were in a close to moderately modified (CD) condition while 3% were close to natural condition (AB).

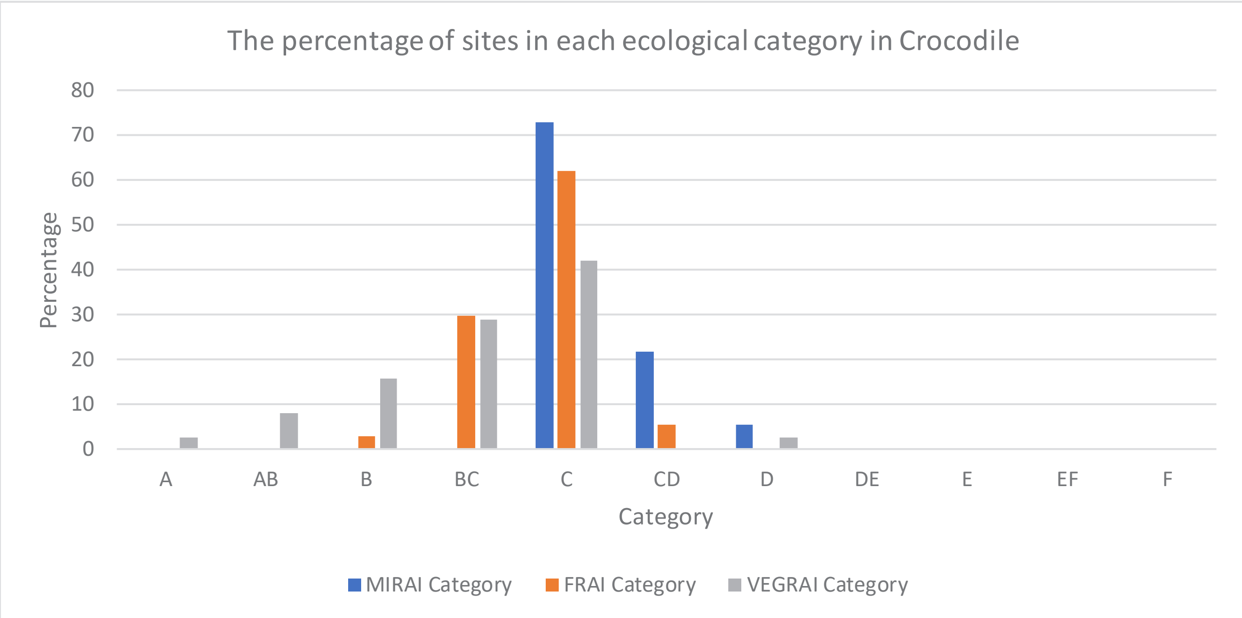


Figure 100: The percentage of sites in each ecological category in the Crocodile catchment for macroinvertebrates (MIRAI), fish (FRAI) and riparian vegetation (VEGRAI) at all sites monitored during the June 2023 survey.

Most sites (42%) were in a moderately modified (C) condition for riparian vegetation, with 29% in a close to largely natural (BC) condition and 16% were in a largely natural condition (B) with few modifications. Only 8% were close to natural condition (AB) and 3% for largely modified (D). The ecostatus for macro-invertebrates, fish and riparian vegetation is also discussed further in the next sections.

5.2.3 Komati Catchment

The survey was conducted in the Komati Catchment, one of the four catchments within the IUWMA. The current survey was conducted at the 36 selected monitoring sites sourced from the 2015 Komati Catchment Eco-status Report. A total of 13 sites are located on the mainstream of the Komati River, while the remaining 23 sites are located on tributaries. Figure 101 shows a map of biomonitoring sites in the Komati Catchment and the assigned reach codes. The following tributaries were monitored during the current survey: Vaalwaterspruit, Mtsoli, Lomati, Boesmanspruit, Klein Komati, Swartspruit, Ndubazi, Gladdespruit, Buffelspruit, Seekoeispruit, Teespruit, Sandspruit, Mhlangampepa, Mlondolozi, Ngweti, Mzinti, Ugutugulo and Mhlambanyatsi.

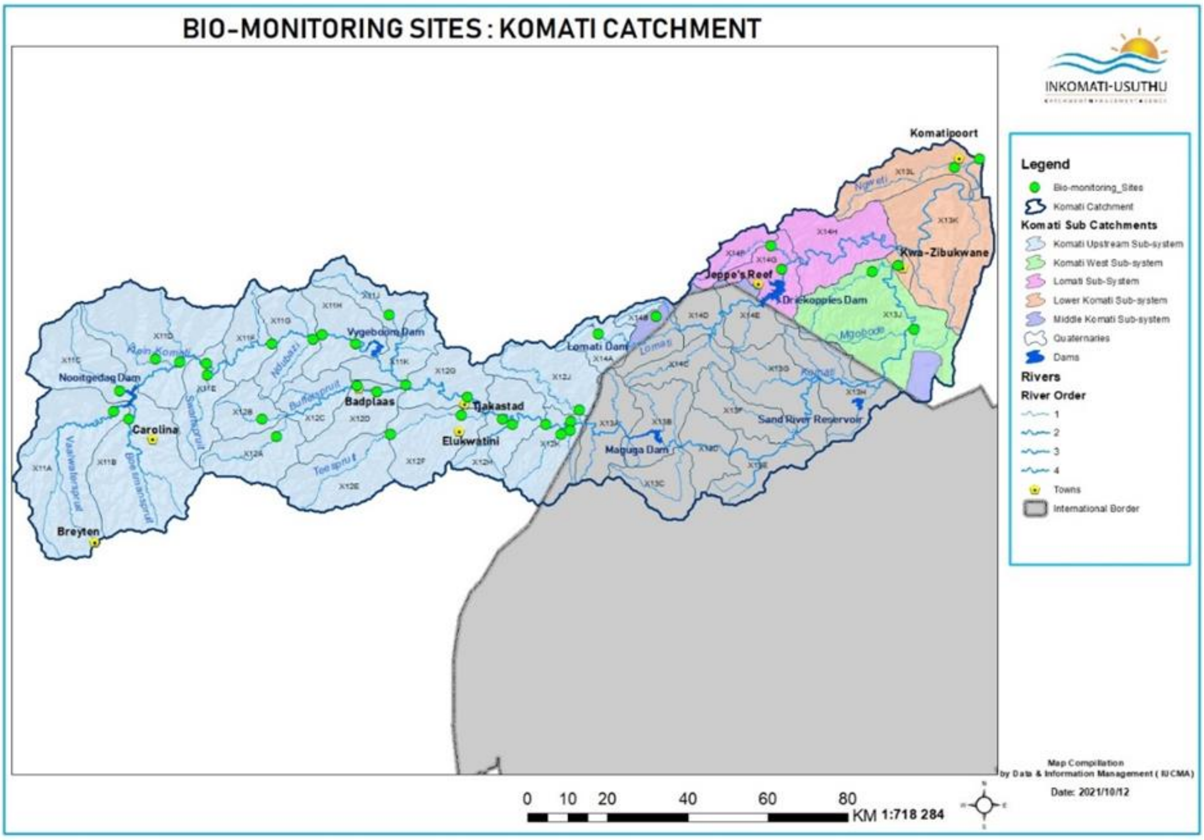


Figure 101: A map showing the biomonitoring sites in the Komati Catchment.

5.2.3.1 Aquatic macro-invertebrates

The current study shows that the Komati Catchment largely falls into an ecological category C, with all reaches of the Komati River being in an ecological category C, as determined by the MIRAI analysis (Figure 102). The reaches of the tributaries were also in a moderately modified condition (C) category. However, four reaches X11E-01237, X11K-01194, X13J-01141 and X14F-01085 were in an ecological category CD. The tributaries represented by the reaches are Swartspruit, Gladdespruit, Mzinti and Mhlambanyatsi. The results, therefore, show that the catchment is in a moderately modified (C) condition while the four reaches were in a close to moderately modified (CD) condition. Reach X12H-01318 on the Sandspruit was in an ecological category BC indicating that the reach is in a close to largely natural condition CD. In general, the macro-invertebrate condition of the Komati catchment remained relatively unchanged when compared to the eco-status obtained in 2022. But there were deteriorations in the ecological condition of the Swartspruit, Gladdespruit and Mhlambanyatsi River as they were in an ecological category C in 2022 but in an ecological category CD in the current survey. This suggest that there are anthropogenic activities occurring in the catchment that have negative impact on the ecological condition of macroinvertebrates.

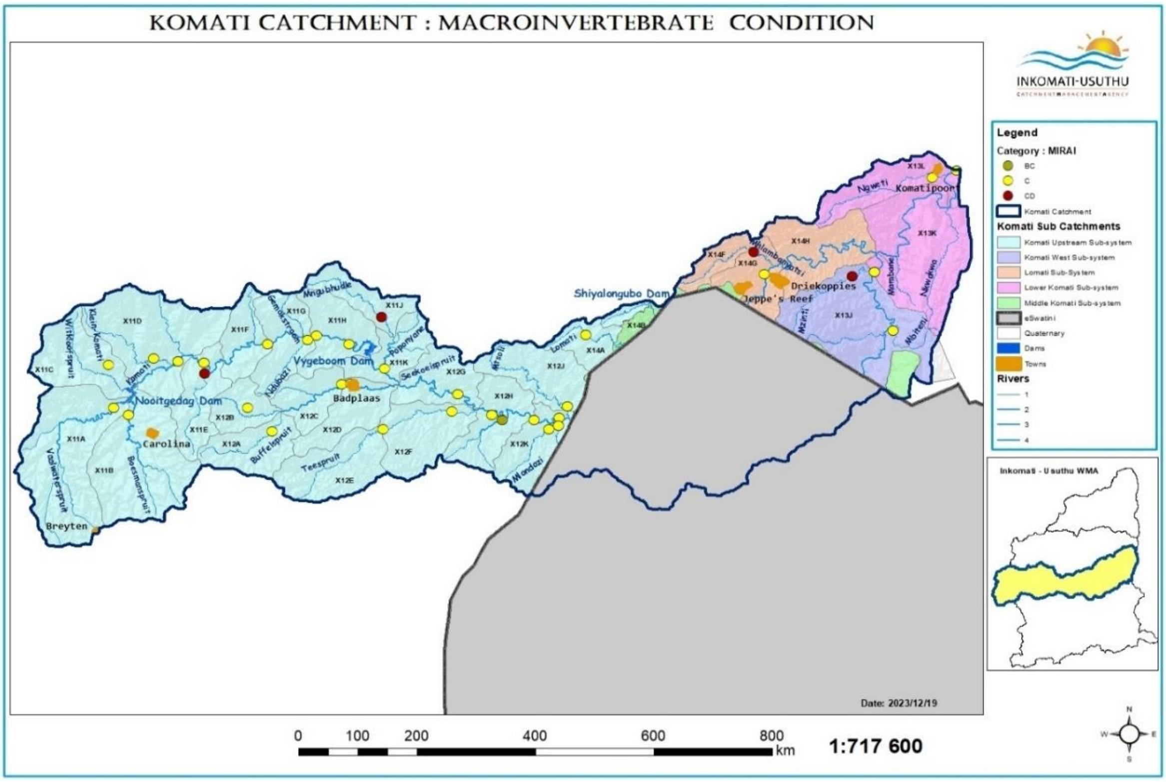


Figure 102: Ecological Categories in the Komati catchment reflecting macroinvertebrate condition for sites monitored in May 2023 survey.

Impoundments, including large dams, farm dams and weirs in the catchment, have a negative impact on the migration of taxa and thereby change the river habitat from flowing to standing water. The catchment is also affected by domestic waste disposal, which has been observed at sites such as X1KKom-Welge, X1Koma-Tjaka and X1Tees-Heuni, while sand mining activities have been observed at X1Koma-IFR04.

5.2.3.2 Fish

Figure 103 shows the ecological condition of fish in the Komati Catchment. The current ecological condition of fish is mainly in an ecological category C (Moderately modified) and only a few reaches were in a close to largely natural (BC) condition. Reaches of concern in the catchment included X11B-01272, which lies in the Boesmanspruit, and X11K-01194, which lies in the Gladdespruit. Both reaches have mining activities upstream and their fish eco-status falls into an ecological category D (Largely modified).

Other reaches such as X13J-01141 and X13J-01210 were also in a largely modified (D) condition due to poor habitat and poor velocity depth classes. The catchment is highly stressed due to water demands, with Eskom and agriculture (mainly irrigation in the lower reaches) being the major water users. The numerous weirs and dams in the system alter the natural flow regime and impede fish migration.

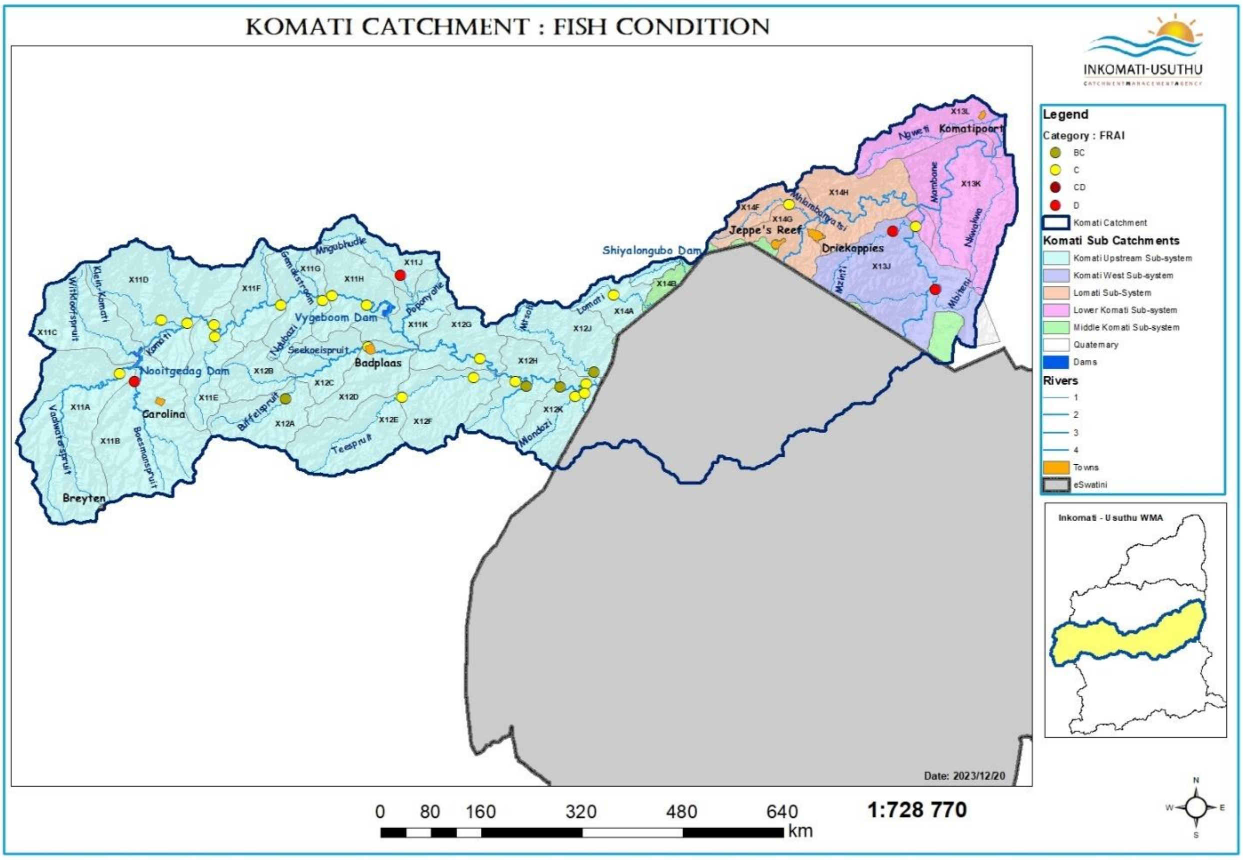


Figure 103: Komati catchment reflecting fish condition for sites monitored in May 2023 survey.

5.2.3.3 Riparian Vegetation

The results of the riparian vegetation assessment showed that none of the rivers in the catchment are still in a pristine condition (Figure 104). The ecological condition based on the riparian vegetation in the catchment was mostly in an ecological category C (moderately modified) and few reaches were in an ecological category BC (Close to largely natural condition most of the time). This result indicates that the ecological conditions have been moderately modified from its historical reference condition and represent a fair condition. However, there were deteriorations in the ecological condition of reaches X13J-01130 and X13J-01141 as they were in a moderately modified (C) condition in 2022 but in a close to moderately modified (CD) condition in the current survey. This suggests that anthropogenic activities in the catchment are having a negative impact on the ecological condition of riparian vegetation. Afforestation, sand mining, and alien vegetation invasion have deteriorated most of the catchment's riparian zone areas, particularly in the lower reaches. This necessitates the implementation of effective management interventions in order to protect the water resources.

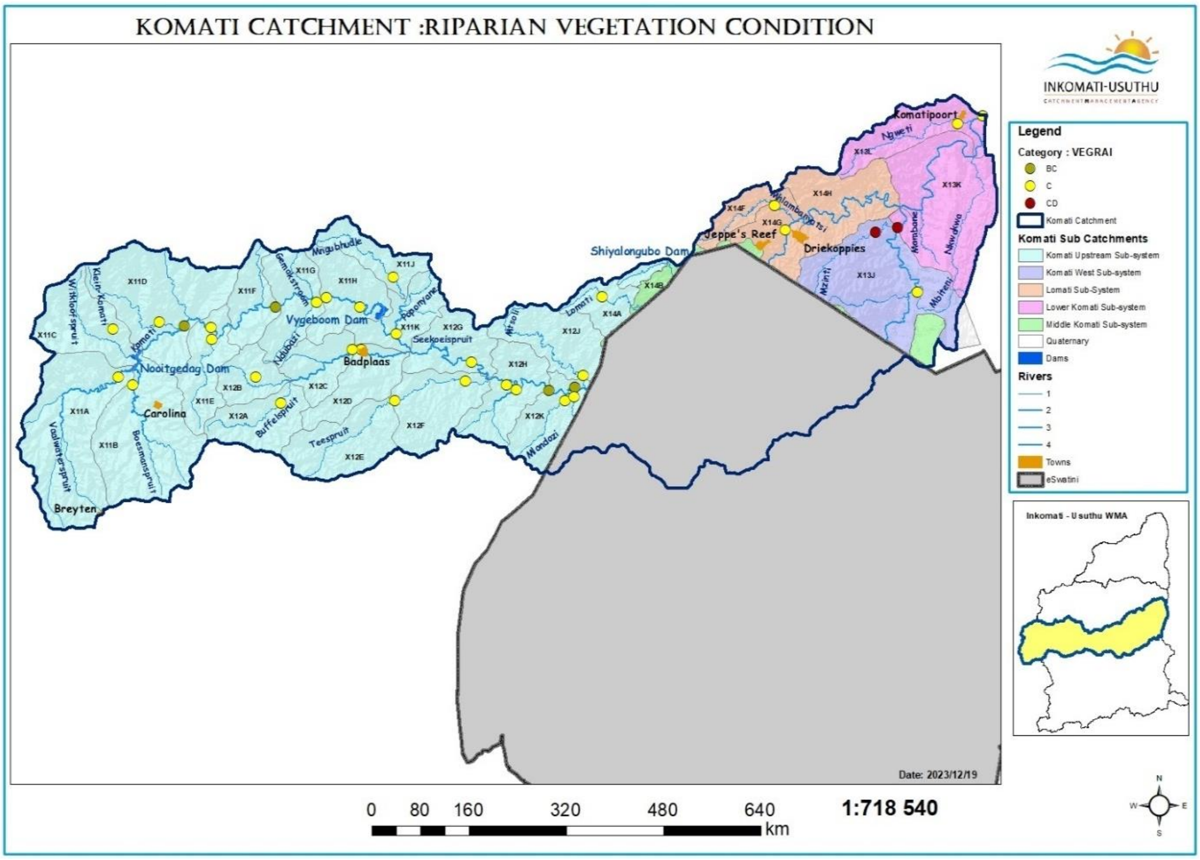


Figure 104: Ecological Categories in the Komati catchment reflecting riparian vegetation condition for sites monitored in May 2023 survey.

Based on the macroinvertebrates, fish and riparian vegetation results, the ecological condition in the catchment ranged from close to largely natural (BC) condition to largely modified (D) condition (Figure 105). Ecological category BC represents relatively good conditions, while ecological category D reflects relatively poor conditions. About 82% of the sites were in a moderately modified (C) condition, 14% in a close to moderately modified (CD) condition and 4% in a close to largely natural (BC) condition for macroinvertebrates (Figure 105).

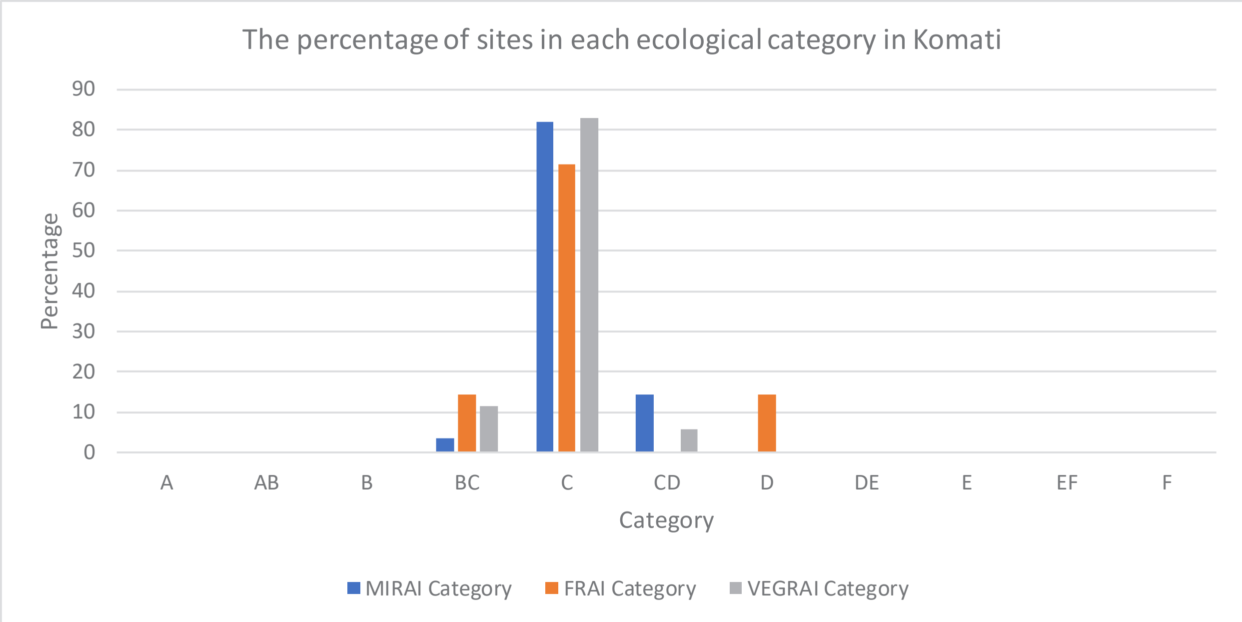


Figure 105: The percentage of sites in each ecological category in the Komati catchment for macroinvertebrates (MIRAI), fish (FRAI) and riparian vegetation (VEGRAI) at all sites monitored during the May 2023 survey.

In terms of FRAI analysis, 71% of the sites were in a moderately modified (C) condition, 14% were in a close to largely natural (BC) condition and 14% were in a largely modified (D) condition (Figure 105). Only 4% were in a close to moderately modified (CD) condition. For riparian vegetation, most of sites (83%) were in a moderately modified (C) condition, 11% were in a close to largely natural (BC) condition and 6% were in a largely modified (D) condition (Figure 3). The eco-status of macroinvertebrates, fish, and riparian vegetation is also explored in greater detail in the next sections.

5.2.4 Usuthu catchment

The current survey was conducted on a total of 38 monitoring sites. Figure 106 shows a map of the six sub-catchments within the Usuthu Catchment as well as the allocated reach codes.

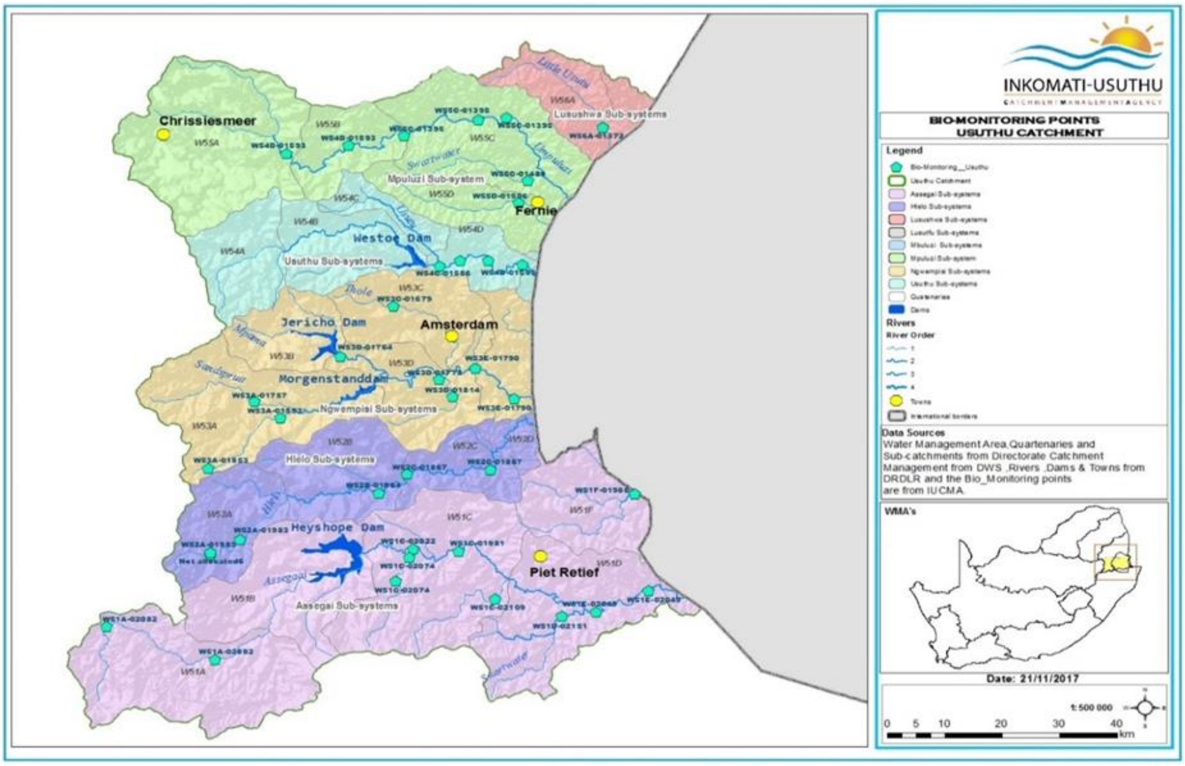


Figure 106: A map showing the six sub-catchments in the Usuthu Catchment.

The current ecological status of macro-invertebrates, fish and riparian vegetation was determined for the Usuthu catchment and is presented in the next sections.

5.2.4.1 Aquatic macro-invertebrates

The current survey shows the Usuthu Catchment was generally in an ecological category C, showing that the catchment is in a moderately modified ecological condition in response to anthropogenic activities (Figure 107). These activities introduce pollutants in the river indirectly through diffuse pollution (*i.e.* agriculture through run-off) or directly through the wastewater treatment works discharging partially treated effluent into rivers. There were eight reaches (W51A-02082, W51C-02022, W51C-01981, W51C-02109, W51F-01986, W51C-02074 and W51D-02151) sampled in the Assegai Sub-catchment and seven of them were in an ecological category C. Only reach W51F-01986 with site W5Bles-Weeho was in an ecological category CD showing the reach is in a close to moderately modified condition. Three reaches (W52A-01983, W52B-01964 and W52D-01867) were sampled in the Hlelo Sub-catchment and all of them were in an ecological category C. There were seven reaches (W53A-01853, W53D-01773, W53E-01790, W53D-01814, W53A-01757, W53D-01764, W53C-01679) sampled in the Ngwempisi Sub-catchment, and four of them were in an ecological category C.

The remaining three reaches, namely, W53D-01814, W53D-01764 and W34A-01757, were in an ecological category CD. The Usuthu Sub-catchment was also in an ecological category C but reach W54C-01556 on the Bonnie Brook was in an ecological category CD. There were three reaches (W55C-01395, W55C-01489 and W55D-01506) sampled in the Mpuluzi Sub-catchment, and all of them were in an ecological category CD. There was one reach (W5Lusu-Robin) that was sampled in the Lusushwane sub-catchment, and it was in an ecological category CD.

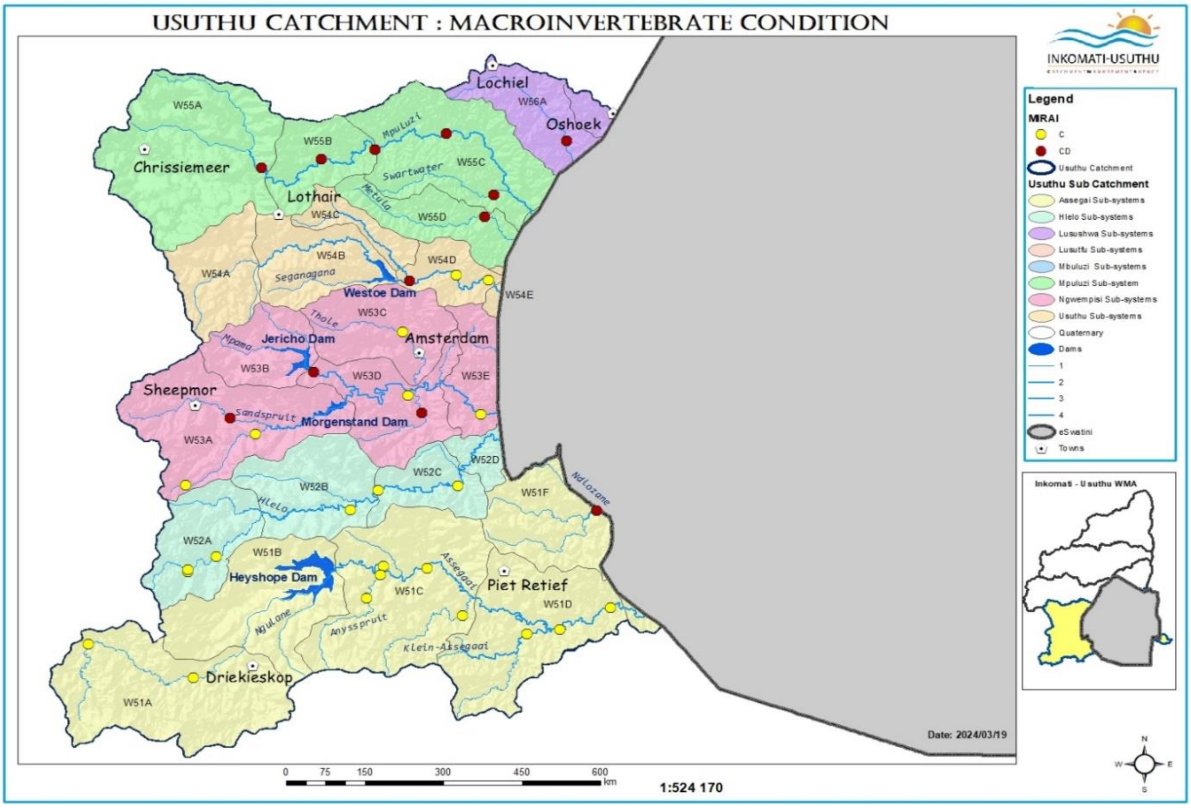


Figure 107: Ecological Categories in the Usuthu catchment reflecting macroinvertebrates condition for sites monitored in September 2023 survey.

5.2.4.2 Fish

The present ecological state of the catchment was mostly in an ecological category C (moderately modified), indicating that the catchment is in a moderately modified ecological condition (Figure 108). This status remained unchanged from the previous surveys. A deterioration of the PES was observed at reach W54D-01593 from a C to a CD ecological category. Exotic fish species such as *Micropterus Salmoides* were caught at reaches W52D-01867, W53D-01773, W54D-01593, and W53D-01764, contributing to the low abundance of fish species at the river catchment due to the presence of exotic or predatory fish species during the survey.

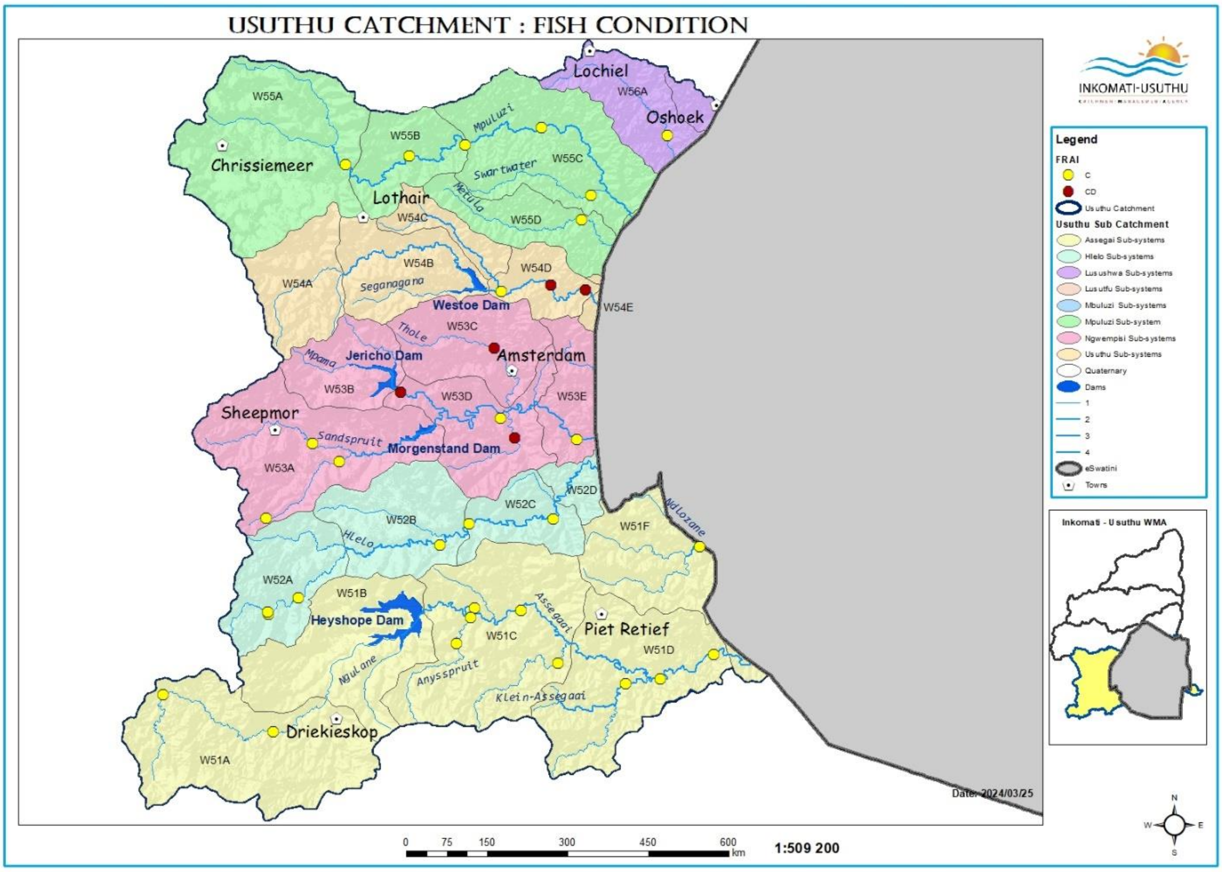


Figure 108: Ecological Categories in the Usuthu catchment reflecting fish condition for sites monitored in September 2023 survey.

5.2.4.3 Riparian vegetation

The riparian condition ranged from close to largely natural to natural condition (BC) to a largely modified (D) condition (Figure 109). The riparian vegetation survey indicates that the Usuthu Catchment was generally in an ecological category C, indicating moderately modified condition. Only four sites were determined to be in an ecological category BC. The W5MPUL-BORDE and W5HLEL-THOEK sites are consistently in the lower categories considering that they also recorded a D and a CD ecological category in the previous survey, respectively. Impacts associated with the degradation of riparian areas status in the Usuthu Catchment included invasion by alien vegetation, removal of vegetation along the riparian zones, water abstraction, sand mining, agriculture (overgrazing and irrigation) and dumping of waste material and rubble. The main alien invasive riparian vegetation species in the Usuthu Catchment remains the *Acacia mearnsii* (black wattle).

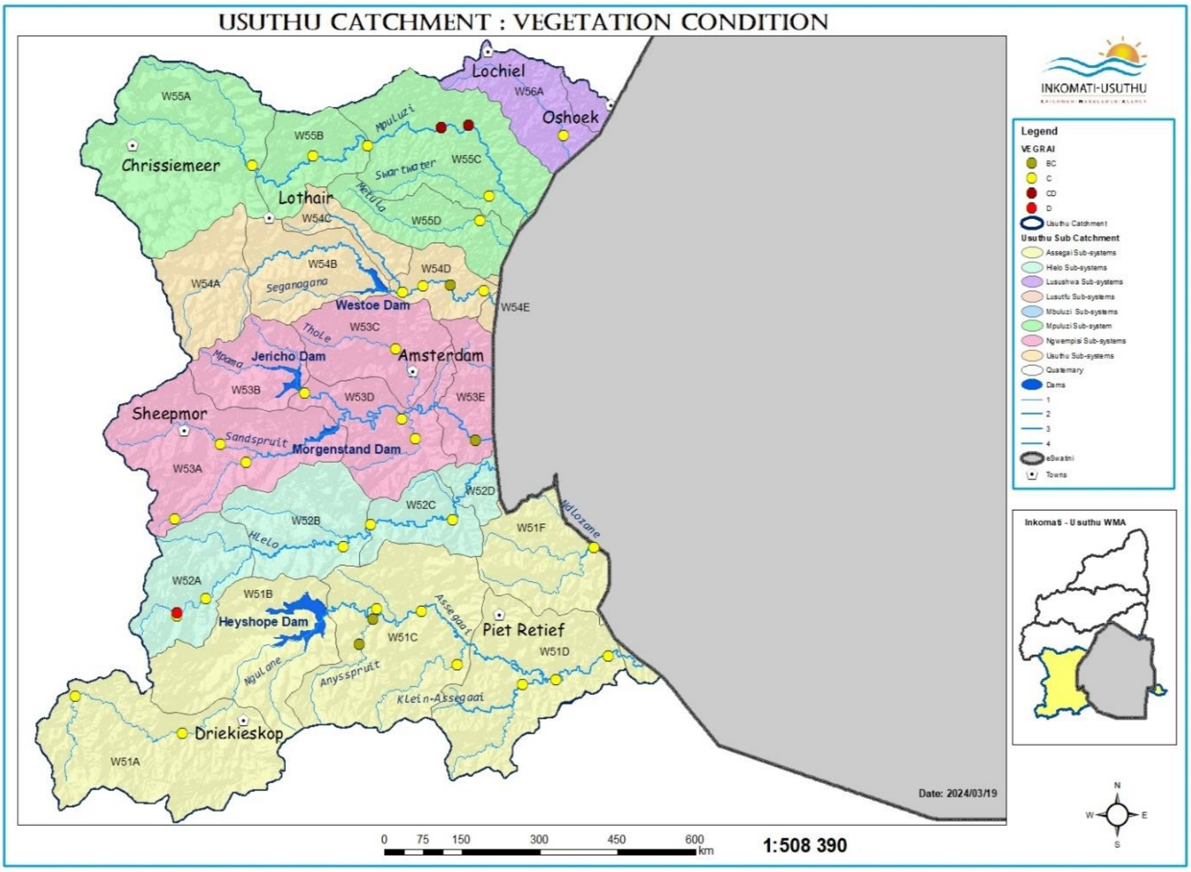


Figure 109: Ecological Categories in the Usuthu catchment reflecting riparian vegetation condition for sites monitored in September 2023 survey.

Based on the macroinvertebrates, fish and riparian vegetation results, the ecological condition in the catchment ranged from close to largely natural (BC) to a largely modified (D) condition (Figure 110). About 67% of the sites were in a moderately modified (C) condition and 33% in a close to moderately modified (CD) condition for macroinvertebrates (Figure 3). For fish, 86% of the sites were in a moderately modified (C) condition and 14% were in a close to moderately modified (CD) condition.

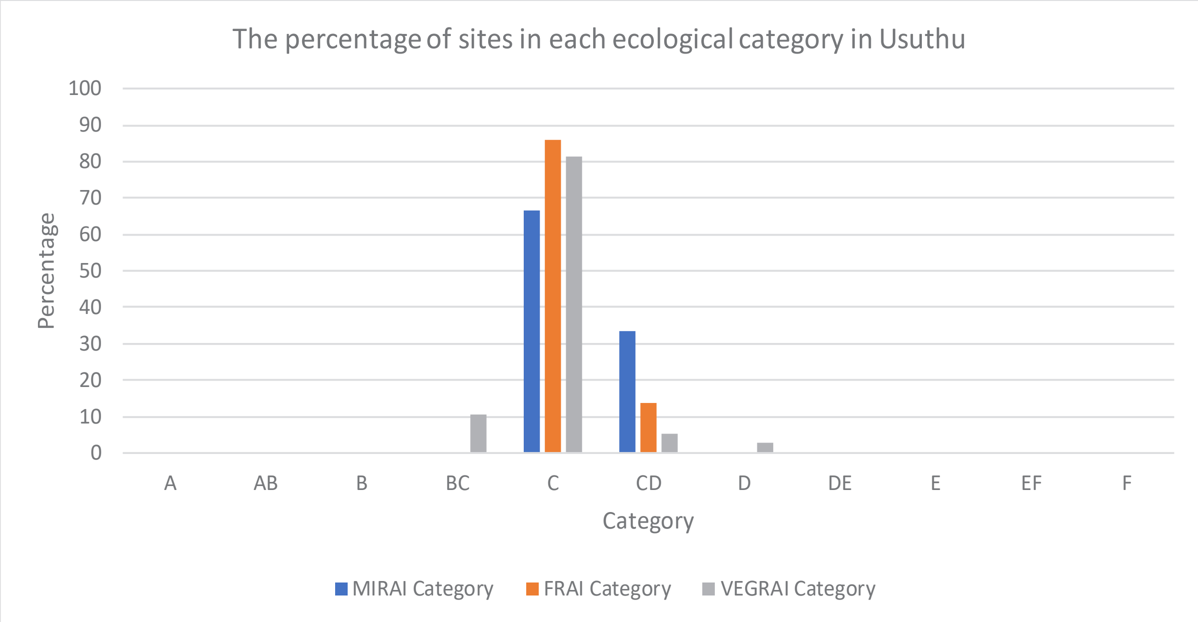


Figure 110: The percentage of sites in each ecological category in the Usuthu catchment for macroinvertebrates (MIRAI), fish (FRAI) and riparian vegetation (VEGRAI) at all sites monitored during the September 2023 survey.

Most sites (82%) were in a moderately modified (C) condition for riparian vegetation, with 11% in a close to largely natural (BC) condition. Only 5% and 3% of the sites were in a close to moderately modified (CD) condition and in a largely modified condition (D) for riparian vegetation, respectively (Figure 110).

CHAPTER 6 RESOURCE DIRECTED MEASURES

6.1 Introduction

This chapter focuses on the Resource Directed Measures (RDM). RDM are tools developed to manage water quality, water quantity and aquatic ecosystems for the protection of water resources by setting objectives for the desired condition of resources. The ecological Reserve is one of the components of Reserve within the framework of resource directed measures which also consist of the Management Class (MC) and Resource Quality Objectives (RQOs) for protection of water resources to ensure sustainable development and use of water resource. RQOs provide descriptive and numerical goals for the state of the resource, while the Source Directed Controls (SDC) specify the criteria for controlling impacts.

Classification process sets a class in which the water resource must be managed (DWS, 2011), while Reserve and RQOs are prescribed based on the management class set. RQOs capture the ecological Reserve into measurable conditions which should be adhered to in the receiving water resource in terms of resource quality. In the Inkomati Usuthu WMA, Classes and RQOs are determined within the X primary drainage region of Komati (X1), Crocodile (X2), Sabie-Sand (X3) and (X4) and gazetted were into law in December 2016 through government notice No. 1616. The comprehensive ecological Reserve determination study was also completed in February 2006, however gazetted into law in July 2019 by government notice No. 998.

Resource quality objectives (RQOs) are numerical or narrative descriptors of quality, quantity, habitat, and aquatic biotic conditions that need to be met to achieve the required management scenario and are defined for each resource units (RU) for every integrated Units of Analysis (IUA). RU are the portrayal of catchments using units which are relatively homogenous on an ecological basis and IUAs represent a homogenous catchment area of similar impacts. Every IUA is classed in terms of the extent of permissible utilisation and protection and constitutes respective catchment configuration. The catchment configuration consists of several biophysical nodes representing river reaches. Within these river reaches Ecological water requirements (EWR) sites are established.

The RQOs have four key components of aquatic ecosystem (quality, quantity, habitat, and biota) to ensure that the structure and the function is protected. Monitoring of RQOs is required to determine compliance/or achievement of the numerical or narrative descriptors of resource quality set to achieve the required management class.

Resource quality monitoring is conducted within the WMA, and the purpose of this chapter is to assess compliance/or achievement of RQOs at specified Ecological Water Requirements site(s) and water quality priority resource units within the specified reaches. Note that where there is more than one monitoring site on the same river reach within the water quality (WQ) priority resource units the downstream monitoring site is used for reporting. It should be noted that it is not a single water user responsibility for the achievement/or compliance of the RQO in a resource unit but rather an aggregate impact of all water users within the RU. Consequently, the RQOs do not form part of the licence conditions.

Non-compliance to RQO should not only be seen as a failure to achieve Key Performance Area when moving towards the direction of the RQO and certainly not away from it, then it should still be seen as effective management of water resource. In situations where the RQO is persistently not achieved, it needs to be addressed progressively over realistic period, to allow users to adjust their activities, to allow water resource managers to apply successful SDC that are guided by RDM which may require amendment of regulation(s)/condition(s). For example, attaching appropriate conditions of use to licenses.

6.2 EWR Sites and WQ Priority Resources Units Compliance Status

The data reported was collected over a period of a year from January 2023- December 2023 for water quality and aquatic biota while water quantity data was collected from April 2023 to March 2024 and was analysed as tabulated below in Table 17.

Table 17:Variables analysed and assessed.

Resource Quality Variable	Indicator Variables	Statistical analysis of data/Ecostatus models
System variable(s)	pH, Turbidity (TUR), Temperature (Temp),	5 and 95 percentiles Mean 10 and 90 percentiles
Salt(s)	Electrical Conductivity (EC), Sulphate (SO_4)	95 percentiles
Nutrient(s)	Phosphate (PO_4), Total inorganic nitrogen (TIN)	50 percentiles
Microbial	*Escherichia coli (E. coli) and Faecal Coliforms (FC)*	Average
Toxic(s)	Copper (Cu), Arsenic (As), Cyanide (Cn), Manganese (Mn), Chromium IV (Cr IV), Nickel (Ni)	95 percentiles
Water quantity	Flow	90% or 60% 90% or 70%
Aquatic biota	Fish	FRAI
	Macro-invertebrate	MIRAI
	Riparian vegetation	VEGRAI

The hydrological RQOs for Komati and Crocodile River systems were calculated on 90% below normal rainfall and 60% above normal rainfall whereas, Sabie Sand River system was calculated on 90% and 70%, respectively. The hydrological RQOs compliance were implemented using the above normal rainfall percentiles of 60% and 70 %. Table 18 shows the models/methods used to determine Targeted Ecological Categories for each component (water quantity, water quality, habitat and aquatic biota).

Table 18: Models/methods used to determine Targeted Ecological Categories.

Characteristics of the resource	Models /Methods
Water Quantity	Actual measured values against 90% or 60% and 90% or 70% of RQOs
Water Quality	Physio-chemical driver Assessment Index (PAI)
Aquatic biota	River Data Integration (RIVDINT)

6.2.1 Sabie-Sand Catchment

The Sabie-Sand catchment comprises of eight (8) Ecological Water Requirements (EWR) sites across the catchment as presented in Figure 111.

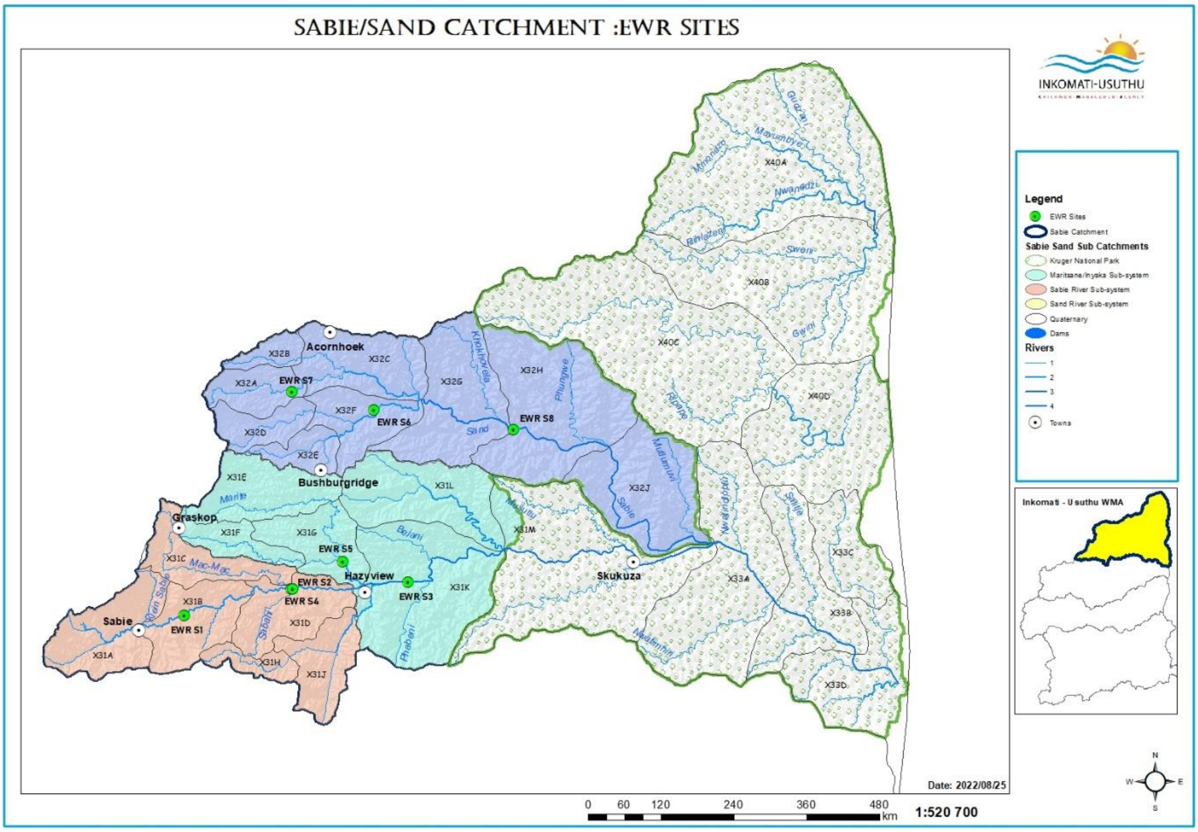


Figure 111 : Map showing Ecological Water Requirement sites within Sabie-Sand Catchment.

The compliance status of each EWR site is indicated by colours: Compliance (Green) or non-compliance (Red) as shown in Table 19 - Table 21 below.

Table 19: EWR Sites compliance status in the Sabie-Sand Catchment.

EWR Site	Turbidity (NTU)		EC (mS/m)		PO_4 (mg/l)		*E. coli* (cfu/100ml)		Un-ionized Ammonia (mg/l)		Flow (m^3/s)		Fish		*Macro-invertebrates*		*Riparian vegetation*	
	RQO	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQO	Compliance %	RQOs	Results	RQOs	Results	RQOs	Results
EWR S-1	NR	9	30	12.9	0.015	0	130	1084	0.007	0.002	1.00	91.25%	B	BC	B	C	B	C
EWR S-2	NR	7	30	11.3	0.015	0	130	407	0.007	0.002	0.93	100%	B	BC	B	C	B	C
EWR S-3	NA	16	30	11.7	0.015	0	130	450	0.007	0.002	3.20	100%	B	VA	B	VA	A/B	C
EWR S-4	NA	4	40*	11.7	0.025*	0	130*	293	*0.007	0.002		VA	B/C	C	A/B	C	A/B	BC
EWR S-5	NR	7	30	11.4	0.015	0	130	481	0.007	0.002		VA	B/C	C	B/C	C	B/C	C
EWR S-6	NR	41	55	17.1	0.015	0.013	130	507	0.007	0.004		VA	C	BC	B/C	C	C	C
EWR S-7	NA	13	42	9.8	0.125	0	130	627	0.007	0.002		VA	C	C	C	C	C	C
EWR S-8	NR	19	30*	20.1	0.125	0.029	130	958	*0.007	0.002	0.35	99.75%	B	VA	B	VA	B	VA

NA: Not available NR: Not Required VA: Variable Not Analysed TWQR*: Strictest limit from Targeted Water Quality Guidelines

Table 20: Water Resource Classes and Targeted Ecological Categories in the Sabie-Sand Catchment.

IUAs	Class for IUAs	Resource Name	EWR Site	Water Quantity			Water Quality			Aquatic Biota		
				TEC	PEC	Target Met	TEC	PEC	Target Met	TEC	PEC	Target Met
X3-2	I	Sabie River	EWR S-1	**B**	**B (91.3%**	X	**A/B**	**A/B**	√	**B**	**C**	X
		Sabie River	EWR S-2	**B**	**B**	√	**B**	**B**	√	**B**	**C**	X
		Mac Mac River	EWR S-4	**B**	**VA**		**A/B**	**A/B**	√	**B**	**C**	X
X3-3	I	Sabie River	EWR S-3	**A/B**	**B (100%)**	√	**B**	**A/B**	√	**A/B**	**VA**	
		Marite River	EWR S-5	**B/C**	**VA**		**B**	**A/B**	√	**B/C**	**C**	X
X3-7	II	Mutlumuvi River	EWR S-6	**C**	**VA**		**B**	**B**	√	**C**	**C**	√
X3-8	II	Tlulandziteka	EWR S-7	**C**	**VA**		**C**	**B**	√	**C**	**C**	√
X3-9	I	Sand River	EWR S-8	**B**	**B (99.8%)**	X	**B**	**B/C**	X	**B**	**VA**	

NA: Not available VA: Variable Not Analysed

Table 21: Compliance status of monitoring sites per reach within WQ Priority Resources Units: Compliance (Green) or non-compliance (Red).

WQ Priority RU	River reach and Resource Name	Turbidity (NTU)		EC (mS/m)		PO_4 (mg/l)		*E. coli* (cfu/100ml)	
		RQO	Results	RQOs	Results	RQOs	Results	RQOs	Results
RU S6	X31J-00774 (Noorsand)	NA	**9**	30	**28.3**	0.025	**0**	130	**415**
RU S9	X31K-00713 (Bejani)	NA	**23**	30	**69.2**	0.025	**0**	130	**1190**
MRU Sabie C	X33B-00804 (Sabie River)	NA	**19**	42	**19.1**	0.125	**0.012**	130	**418**
RU S13	X32E-00639 (Ndlobesuthu)	NA	**39**	42	**28.5**	0.125	**0**	130	**1125**
RU S14	X32B-00551 (Motlamogatsana)	NA	**12**	30*	**12.1**	0.025	**0.010**	130	**866**

NA: Not available NR: Not Required TWQR*: Strictest limit from Targeted Water Quality Guidelines

6.2.1.1 Discussion of results within Sabie Sand Catchment

IUA X3-2

This IUA consists of the headwaters of the Sabie River down to the confluence with the Klein Sabie River and Mac-Mac River. The Sabie River rises on the escarpment and drops off steeply through mountainous terrain. There are three (3) EWR sites and no significant dams within the IUA. Land use in this IUA is mostly forestry with some wilderness areas and urban areas. EWR sites S1, S2 and S4 did not meet the Target Ecological Category (TEC) as shown in Table 20 in terms of aquatic biota, whereas water quantity and water quality complied with the set TEC except at EWRS1 where quantity did not comply with TEC. The sites in this IUA ranged between slightly modified (B to B/C PES) to moderately modified (C PES).

The primary impact in this IUA is non-flow related as the RQO for all EWR sites is met within the IUA with exception of EWRS1. *E. c*oli did not comply with the set RQO due to residential runoff in the lower Sabie reach of the IUA due to urban runoff, effluent discharge from municipal and private WWTW and Sawmill industries (Table 19). The macroinvertebrates, fish and riparian vegetation did not meet the RQO due to the loss of habitat as contributing factors. The variable of concern related to water quality are microbial (*E. coli*) which did not comply with the set RQOs. However, *E. coli* has no impact on aquatic biota.

IUA X3-3

This IUA consists of the upper reaches of the Marite River down to the Inyaka Dam, Motitsi River and Middle Sabie River. The terrain is mostly steep and mountainous. There are two EWR sites and includes the Inyaka Dam, the largest dam in the Sabie Sand Catchment within the IUA. Land use in the IUA consists mostly of forestry although there are significant wilderness areas, irrigation, but were not met for aquatic biota as shown in Table 20. The sites in this IUA ranged between slightly modified (B to B/C PES) to moderately modified (C PES).

The primary impact in this IUA is non-flow related, while *E. coli* did not comply with the set RQO due to residential runoff (Graskop, Marite and parts of Bushbuckridge), effluent discharge from municipal and private WWTWs. The macroinvertebrates, fish and riparian vegetation did not meet the RQO due to the loss of habitat as contributing factors at EWR S- 5. The variable of concern related to water quality is *E. coli* which did not comply with the set RQOs but has no impact on aquatic (Table 19).

IUA X3-7

This IUA consists of the Mutlumuvi River, a major tributary of the Sand River. The Mutlumuvi River rises on escarpment and drops rapidly to the Lowveld plains. There is one EWR site and no significant dams within the IUA. Land use consists of forestry on the mountain slopes, numerous villages, grazing, limited irrigation, and subsistence dry-land agriculture. The set targets were met for water quality and aquatic biota at EWR S-6, when comparing with the TEC as shown in Table 20.

Table 19 shows that *E. coli* and macroinvertebrates did not comply with the set RQO due to residential runoff, effluent discharge from WWTWs and loss of instream habitat as contributing factors, respectively. This IUA is situated in an area dominated by rural agriculture and urbanizations such as agricultural fields, vegetation removal, overgrazing and trampling, sedimentation, bed and channel disturbance.

IUA X3-8

This IUA consists of the northern tributaries of the Sand River, *i.e.*, the Klein-sand and Thulandziteka Rivers. The terrain is the same as the IUA X3-7 with the rivers rising on the escarpment and falling rapidly to the Lowveld plains. There is one EWR site and no significant dams within the IUA. Land use is grazing, villages, irrigation, and dry-land subsistence agriculture. The set targets ecological category of C for water quantity, water quality and aquatic biota were met at EWR S-7 with PES of B (Slightly modified) and this indicates an improvement in water quality status from C (moderately modified) in 2014.

The primary impact in this IUA is non-flow related, while *E. coli* did not comply with the set RQO due residential runoff (Mmoleleng and Mathoshe villages) effluent discharge or seepage from septic tanks and disposal of waste solid waste especially nappies. The macroinvertebrates, fish and riparian vegetation did meet the set RQO as shown in Table 19.

IUA X3-9

This IUA consists of the lower Sand River Catchment. The terrain is flat, and the area falls entirely within wilderness area, either the Sabi Sand Park or the KNP. There is one EWR site and no significant dams within the IUA. Land use includes the settlement of Phungwe and Utlha and tourism and recreational activities. The set targets ecological category for water quantity and quality were not met at EWR S-8, when comparing with the TEC as shown in Table 20. Aquatic biota water was not sampled, due to no access.

The flows in the Sand sub-catchment are not controlled, because of the lack of infrastructure to implement the sub-catchment operating rules. Water quality variable of concern related to deterioration of the PES from category B (largely natural with few modifications) in 2014 to C (moderate modification) in 2024 is phosphate and water quantity as mentioned that flows in the sub-catchment are not controlled. However, the site within this IUA is situated in conservation areas and thus fairly well protected.

6.2.1.2 WQ Priority Resources Units

Compliance status on water quality priority resource units of analysis presented in Table 21 show that microbial pollution is a major concern as reflected by the non-compliance to the set RQOs of *E. coli*. Electrical conductivity (EC) was non-compliant at Bejani River (Mkhuhlu) while nutrients complied with the set RQOs for water quality priority resource units of analysis sites.

6.2.1.3 Management Class

All biophysical nodes (reaches) and components (water quantity, water quality and aquatic biota) within the IUA should comply with the set TEC in order to meet the management class (Table 19). In this report only EWR sites were considered to ensure that the management class is met within the IUA. Assumption was made that if all components are met at an EWR site, then all biophysical nodes are met within the IUA. It was not possible to conclude on all IUAs (X3-2, X3-3 and X3-7 to X3-9) because not all components were assessed.

6.2.1.4 WQ Priority Resources Units

Compliance status on water quality priority resource units of analysis in Table 21 shows that microbial and salt are a major concern as shown by the non-compliance to the set RQOs.

6.2.2 Crocodile Catchment

The Crocodile catchment comprises of nine (9) Ecological Water Requirements (EWR) sites across the catchment as presented in Figure 112.

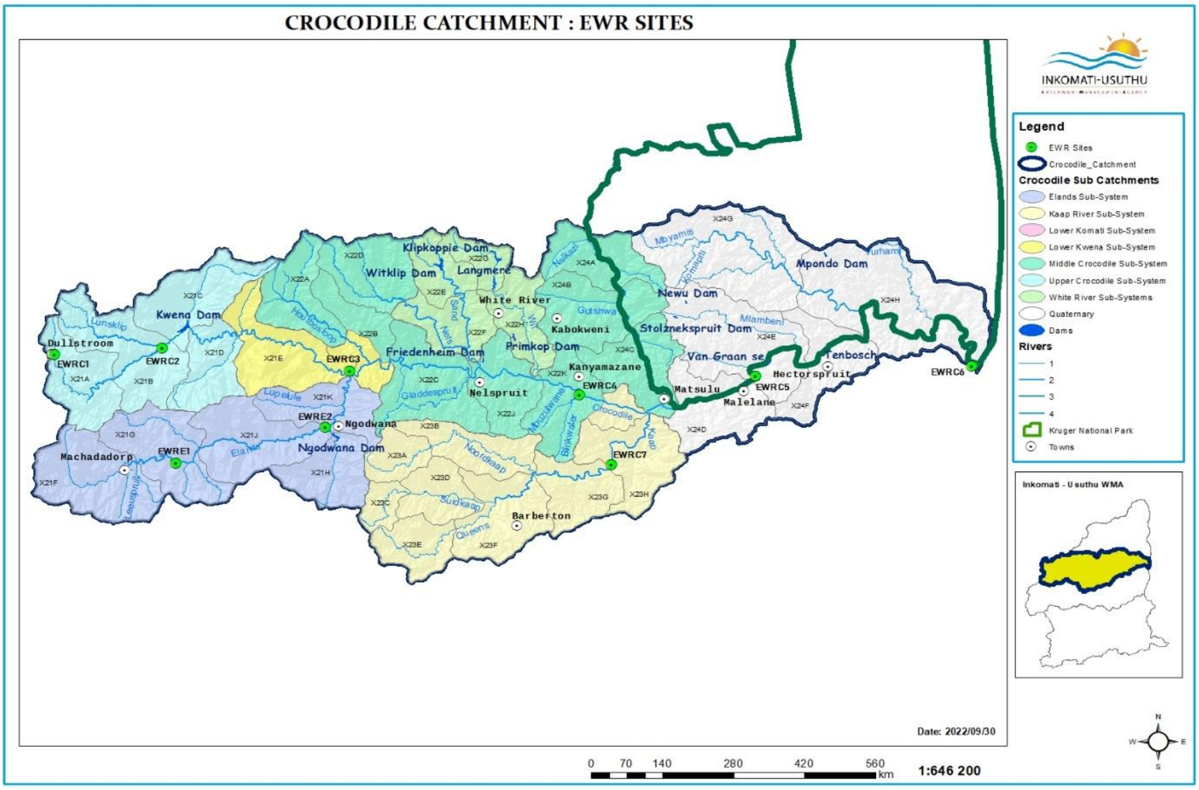


Figure 112: Map showing Ecological Water Requirement sites within Crocodile Catchment.

The compliance status of each EWR site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in Table 22 - Table 24 below.

Table 22: EWR Sites compliance status in the Crocodile Catchment.

Variable	Results ROQs Ecospecs	Resources Units								
		MRU CROC A Crocodile River		MRU CROC B Crocodile River	MRU ELAN A Elands River	MRU ELAN B Elands River	MRU CROC D Crocodile River	MRU CROC E Crocodile River		MRU KAAP A Kaap River
		EWR-C1	EWR-C2	EWR-C3	EWR-E1	EWR-E2	EWR-C4	EWR-C5	EWR-C6	EWR-C7
Temp (°C)	RQO	Not more than 2 °C from baseline (Aquatic Ecosystem driver)								
	Results	11 - 21.6	10.3 – 20.6	16.6 – 24.1	13.8 - 24.6	15.9 - 23.6	15.3 - 24.8	16.6 - 25.6	21.7 - 28.3	16.7 - 25.4
Turbidity (NTU)	RQO	NA (Aquatic Ecosystems driver)								
	Results	3	9	14	18	18	22	15	11	11
EC (mS/m)	RQO	30	30	30	30	55	70	70	70	200
	Results	5.8	12.9	13.3	17.3	64.3	29.8	45.1	60.2	51.2
PO_4 (mg/l)	RQO	0.015	0.025	0.015	0.025	0.015	0.125	0.075	0.125	0.125
	Results	<0.010	<0.010	<0.010	<0.014	<0.010	0.075	0.042	0.014	0.043
TIN (mg/l)	RQO	NR	NR	NR	NR	NR	NR	NR	NR	< 4
	Results	NR	NR	NR	NR	NR	NR	NR	NR	0.83
E-coli (cfu/100 ml)	RQO	120	130	130	130	130	130	130	130	130
	Results	369	517	299	540	304	1459	1172	118	273
Un-ionized Ammonia (mg/l)	RQO	*0.007	*0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Results	0.001	0.001	0.001	0.020	0.005	0.002	0.002	0.025	0.008
Cn(mg/l)	RQO	NR	NR	NR	NR	NR	NR	NR	NR	0.004
	Results	NR	NR	NR	NR	NR	NR	NR	VA	<0.07
As (mg/l)	RQO	NR	NR	NR	NR	NR	NR	NR	NR	0.020
	Results	NR	NR	NR	NR	NR	NR	NR	VA	0.050
Flow (m^3/s)	RQO			2.43		0.58	5.47	6.71	3.5	0.67
	Results	VA	VA	100%	VA	100%	100%	100%	100%	88%

Variable	Results ROQs Ecospecs	Resources Units								
		MRU CROC A Crocodile River		MRU CROC B Crocodile River	MRU ELAN A Elands River	MRU ELAN B Elands River	MRU CROC D Crocodile River	MRU CROC E Crocodile River		MRU KAAP A Kaap River
		EWR-C1	EWR-C2	EWR-C3	EWR-E1	EWR-E2	EWR-C4	EWR-C5	EWR-C6	EWR-C7
Fish	RQO	A	B	B	B	B	B	C	C	C
	Results	BC	C	BC	C	C	C	VA	C	C
Macro-invertebrates	RQO	B	B	C	B	B	C	C	C	B
	Results	C	C	CD	C	C	CD	VA	C	C
Riparian Vegetation	RQO	A	A/B	C	C	C	C	C	C	C/D
	Results	B	B	BC	C	D	C	VA	VA	C

NA: Not available NR: Not Required VA: Variable Not Analysed **Detection limit TWQR*: Strictest limit from TWQG

Table 23: Water Resource Classes and Targeted Ecological Categories in the Crocodile Catchment.

IUAs	Class for IUAs	Resource Name	EWR Site	Water Quantity			Water Quality			Aquatic Biota		
				TEC	PEC	Target Met	TEC	PEC	Target Met	TEC	PEC	Target Met
X2-1	II	Crocodile River	EWR C-1	**A/B**	**VA**		**A**	**A/B**	X	**A/B**	**C**	X
		Crocodile River	EWR C-2	**B**	**VA**		**C**	**A/B**	√	**B**	**B/C**	X
X2-2	II	Crocodile River	EWR C-3	**B/C**	**B/C**	√	**C**	**A/B**	√	**B/C**	**B/C**	√
X2-3	I	Elands River	EWR E-1	**B**	**B (100%)**	√	**NA**	**B**	√	**B**	**C**	X
X2-5	I	Elands River	EWR E-2	**C**	**C (100%)**	√	**NA**	**C**	√	**B**	**C**	X
X2-9	II	Crocodile River	EWR C-4	**C**	**C (100%)**	√	**C**	**B/C**	√	**C**	**C**	√
X2-11	II	Crocodile River	EWR C-5	**C**	**C (100%)**	√	**C**	**B/C**	√	**C**	**VA**	
		Crocodile River	EWR C-6	**C**	**C (100%)**	√	**C**	**C**	√	**C**	**VA**	
X2-10	II	Kaap River	EWR C-7	**C**	**C (88%)**	X	**B**	**C**	X	**C**	**C**	√

NA: Not Available VA: Variable Not Analysed

Table 24: Compliance status of monitoring sites per reach within WQ Priority Resources Units: Compliance (Green) or non-compliance (Red).

WQ Priority RU: River reach (Resource Name)	Turbidity		pH		EC (mS/m)		PO_4 (mg/l)		*E. coli* (cfu/100ml)		*Mn(mg/l)*		As(mg/l)		Cn (mg/l)		Cr VI (mg/l)	
	RQO	Results	RQO	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results
MRU Elan A: X21F-01046 (Elands River)	NR		6.5 – 8	7.1-7.6	30	14.9	0.025	<0.010	130	512	0.18	<0.010	NR		NR		0.014	<0.010
RU C7: X21F-01100 (Leeuspruit)	NR		6.5 – 8	7.3-7.7	30	25.1	0.025	0.090	130	1941	0.18	0.019	NR		NR		0.014	<0.010
MRU Elan B: X21J-01013 (Elands River)	NA	5	6.5-8.5*	7.5-7.8	55	16.9	0.025	<0.010	130*	65	0.18	<0.010	NR		NR		0.014	<0.010
MRU Elan B: X21K-00997 (Elands River)	NA	8	6.5-8.5*	7.3-8.1	55	56.3	0.025	<0.010	130*	182	0.18	0.015	NR		NR		NR	
MRU Croc C: X22B-00888 (Crocodile River)	NA	10	6.5-8.5*	7.0-7.8	55	29.4	0.025	<0.010	130	167	0.18	<0.010	0.020	<0.010	0.004	0.070**	NR	
MRU Croc C: X22J-00993 (Crocodile River)	NA	15	6.5-8.5*	7.0-7.8	55	28.6	0.025	<0.010	130	616	0.18	<0.010	NR		NR		NR	
MRU Croc C: X22J-00958 (Crocodile River)	NA	18	6.5-8.5*	7.0-7.7	55	25.6	0.025	<0.010	130	1509	0.18	0.187	NR		NR		NR	
MRU Croc C: X22K-00981 (Crocodile River)	NA	17	6.5-8.5*	7.0-7.8	55	28.9	0.025	0.043	130	1227	0.18	0.030	NR		NR		NR	
RU C12: X22C-01004 (Gladdespruit)	NA	26	6.5-8.5*	6.9-7.6	30*	42.7	0.02*	<0.010	130*	1490	0.18	3.170	NR		NR		NR	
RU C14: X22H-00836 (White River)	NR		6.5-8.5*	7.1-7.9	55	30.0	0.125	0.017	130	133	0.18	0.210	NR		NR		NR	
RU C13 X22F-00886 (Sand River)	NA	2	6.5-8.5*	6.8-7.0	30	3.3	0.025	<0.010	130*	12	0.18*	<0.010	NR		NR		NR	

WQ Priority RU: River reach (Resource Name)	Turbidity		pH		EC (mS/m)		PO_4 (mg/l)		*E. coli* (cfu/100ml)		*Mn(mg/l)*		As(mg/l)		Cn (mg/l)		Cr VI (mg/l)	
	RQO	Results	RQO	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results
RU C13 **X22F-00977** (Nels River)	NA	21	6.5-8.5*	6.9-7.7	30	20.5	0.025	<0.010	130*	416	0.18*	0.025	NR		NR		NR	
RU C17: X23C-01098 Suidkaap River)	NR		6.5-8.5*	7.1-7.3	30	16.8	0.075	0.013	130	154	NR		0.02	<0.010	0.004	0.07**	NR	
RU C17: X23E-01154 (Queens River)	NR		6.5-8.5*	7.5-7.9	30	41.7	0.075	0.019	130	1512	0.18	0.030	0.02	<0.010	0.004	0.07**	NR	
RU C17: X23F-01120 (Suidkaap River)	NR		6.5-8.5*	7.4-7.8	30	51.0	0.075	0.098	130	660	0.18	0.128	0.02	0.099	0.004	0.07**	NR	
MRU Croc D: X24C-01033 (Crocodile River)	NA	24	6.5-8.5*	7.4-8.1	85	34.7	0.125	0.051	130	396	0.18*	0.025	0.01*	<0.010	NR		NR	
RU C19: X24B-00903 (Gutshwa River)	NA	15	6.5-8.5*	6.9-7.9	55	151.8	0.125	1.670	130	1575	NR		NR		NR		NR	

NA: Not available NR: Not Required VA: Variable Not Analysed **Detection limit TWQR*: Strictest limit from TWQG

6.2.2.1 Discussion of results within Crocodile Catchment

IUA X2-1

This IUA consists of the headwater of the Crocodile River down to the confluence with Lunsklip River and Alexanderspruit. This IUA rises over 2000m on the escarpment and forms increasingly deep valleys moving downstream towards Kwena Dam. There are two (2) EWR sites and Kwena Dam is the largest and most important dam in the Crocodile River System. The Kwena Dam is located at the outlet to this this IUA. Land use consists of forestry, grazing, irrigation and dry-land crops, trout farming.

The set targets were not met for water quality and aquatic biota at EWR C-1. The target for biota was also not met at EWR C-2 but was met for water quality which indicated compliance with the set TEC (Table 23). Water quantity was not measured, due to no measuring station. The EWR sites in this IUA ranged between slightly modified (A/B PES) to moderately modified (C PES). The aquatic biota did not meet the Target Ecological Category due to loss of instream habitat as contributing factors. The variable of concern related to water quality which did not comply with the set RQOs is *E. coli* due to *Feacal* contamination from sewer infrastructure spillages. The macroinvertebrates, fish and riparian vegetation did not meet the RQO due to loss of habitat as contributing factors (Table 22).

IUA X2-2

This IUA consists of the Crocodile River and tributaries from the Kwena Dam to the confluence of the Elands River. The terrain consists of a deeply incised valley although the valley bottom is sufficiently wide for extensive agricultural lands. There is one (1) EWR site and few small farm dams in the IUA. Land use consists mostly of forestry and agricultural activities (grazing and irrigation) in lower lying areas of this IUA.

The set targets were met for water quantity, water quality and aquatic biota at EWR C-3 when comparing with the TEC as shown in Table 23. The variable of concern related to water quality is *E. coli* which did not comply with the set RQOs. The macroinvertebrates and fish did not meet the RQO due to loss of instream habitat (construction/upgrading of the N4) as contributing factor (Table 22).

IUA X2-3

This IUA consists of the upper reaches of the Elands River catchment. The catchment rises on the escarpment and is generally undulating although becoming increasingly mountainous as the river drops down the escarpment near Waterval Boven. There is one (1) EWR site and few farm dams and trout dams in the catchment and a small dam which supplies water to Machadodorp. Land uses consist of settlement, forestry, grazing and dry-land crops.

The set targets were met for water quantity and quality at EWR E-1 when comparing with the TEC as per the classification technical report, except for aquatic biota which indicated non-compliance with the set TEC (Table 23). For water quantity, measured values were estimated using results of EWR E-2 because it is the outlet of EWR E-1. The TEC for water quality is not available (has not been set) and therefore the PES will be regarded as compliant.

The macroinvertebrate and fish did not meet the RQO due to the loss of instream habitat as contributing factors. *E. coli* related impacts are associated residential runoff and effluent discharge from WWTWs of Machadodorp and Waterfall Boven towns (Table 22)

IUA X2-5

This IUA consists of the Elands River and tributaries downstream of Waterval Boven and ending at the confluence with the Ngodwana River and Lupelele River. The landscape consists of a deeply incised but wide-bottom valley. There is one (1) EWR site and small farm dams and Ngodwana dam which supplies water to the SAPPI paper mill. The land use consists of extensive forestry, industrial and agricultural activities (grazing and irrigation with raw water and water containing waste from SAPPI Paper Mill).

The set targets were met for water quantity and quality at EWR E-2 when comparing with the TEC as per the classification technical report, but not met for aquatic biota which indicated non-compliance with the set TEC (Table 23). In case of water quality, TEC is not available and therefore the PES will be regarded as compliant. The macroinvertebrate, fish and riparian vegetation did not meet the RQO due to the loss of habitat as contributing factors (Table 22). *E. coli* and EC indicated non-compliance due to issues associated with these land-uses (irrigation return from Ngodwana Mill, residential runoff and WWTWs).

IUA X2-9

This IUA consists of the main stem of the Crocodile River from Nelspruit down to the confluence with the Kaap River, including the Blinkwater River. The landscape is undulating and flat although the Blinkwater River flows through a mountainous area. There is one (1) EWR site and no significant dams within the IUA. The land use consists of extensive settlements (KaNyamazane and Thekwane) and agricultural activities including effluent discharge from WWTWs.

The set targets were met for water quantity, water quality and aquatic biota at EWR C-4 when comparing with the TEC as shown in Table 23. The water quantity TEC was estimated using the measured flow values from Karino station. The macroinvertebrate and fish did not meet the RQO due to the loss of instream habitat as contributing factors with the exception of riparian vegetation (Table 22). *E. coli* indicated non-compliance due to *Feacal* contamination arising from intensive residential runoff and effluent discharges from WWTWs.

IUA X2-11

This IUA consists of the Crocodile River from the confluence with the Kaap River down to the confluence with the Komati River. The landscape in this IUA is very flat. There are two (2) EWR sites and no significant dams within the IUA. The land use consists of extensive irrigation (sugarcane), grazing and game farming as well as settlements (Malelane, Hectorspruit and Komatipoort).

The set targets were not met for water quantity at EWR C-7 when comparing with the TEC as per the gazette. However, the target for water quality at EWR C-5 and C-6 indicated compliance with the set

TEC. The aquatic biota was not sampled as the sites are located within KNP and is not safe to sample without the rangers. In future the sites will be sampled with the team from KNP accompanied by the rangers.

The macroinvertebrate and fish did not meet the RQO due to the loss of instream habitat as contributing factors (Table 22). *E. coli* and ammonia indicated non-compliance due to sewer contamination arising from intensive residential runoff and effluent discharges from WWTWs

IUA X2-10

This IUA consists of the Kaap River catchment, a major tributary of the Crocodile River. The Kaap River rises on the escarpment and drops off steeply to a wide valley floor. There is one (1) EWR site and no significant dams within the IUA but there are several farm dams present. Land use in this IUA consists of gold mining, forestry, rural and urban settlement, and agricultural activities (grazing and irrigation).

The set targets were not met for water quantity and quality at EWR C-7 when comparing with the TEC as shown in Table 23. However, the target for aquatic biota indicated compliance with the set TEC of C. The PES of C (moderately modified) was attained for both water quantity and quality, with the primary impact being attributed to upstream flow modification and land use activities.

The macroinvertebrate did not meet the RQO due to the loss of instream habitat as contributing factors with the exception of fish and riparian vegetation (Table 22). *E. coli* and ammonia indicated non-compliance due to sewer contamination arising from intensive residential runoff and effluent discharges from WWTWs. The variables of concern related to water quality deterioration at EWR site C-7 are arsenic which did not comply with the set RQOs. Illegal gold mining is likely contributing to higher levels arsenic within the Kaap sub-catchment.

6.2.2.2 Management Class

All biophysical nodes and components (water quantity, water quality and aquatic biota) within the IUA should comply with the set TEC in order to meet the management class. In this report only EWR sites were considered to ensure that the management class is met within the IUA. Assumption was made that if all components are met at an EWR site, then all biophysical nodes are met within the IUA.

EWR E-1 and EWR E-2 represents all biophysical nodes within IUA X2-3 and X2-5 respectively and have not met the management Class I due to aquatic biota not complying to the TEC.

EWR C3 represents all biophysical nodes of X2-2 and has met the Management Class II. EWR C7 represents all biophysical nodes of X2-10 and has not met the management Class II due to water quantity and quality not complying to the TEC. It was not possible to conclude on other IUAs because not all components were assessed.

6.2.2.3 WQ Priority Resources Units

Compliance status on water quality priority resource units of analysis in Table 24 shows that microbial pollution as a major concern as shown by the non-compliance to the set RQOs of *E. coli*. Salts and nutrients were non-compliant at selected sites using EC and PO_4 as indicator variables. The levels of arsenic exceeded the set RQOs in Suid-Kaap River.

6.2.3 Komati Catchment

The Komati catchment comprises of six (6) Ecological Water Requirements (EWR) sites across the catchment as presented in Figure 113.

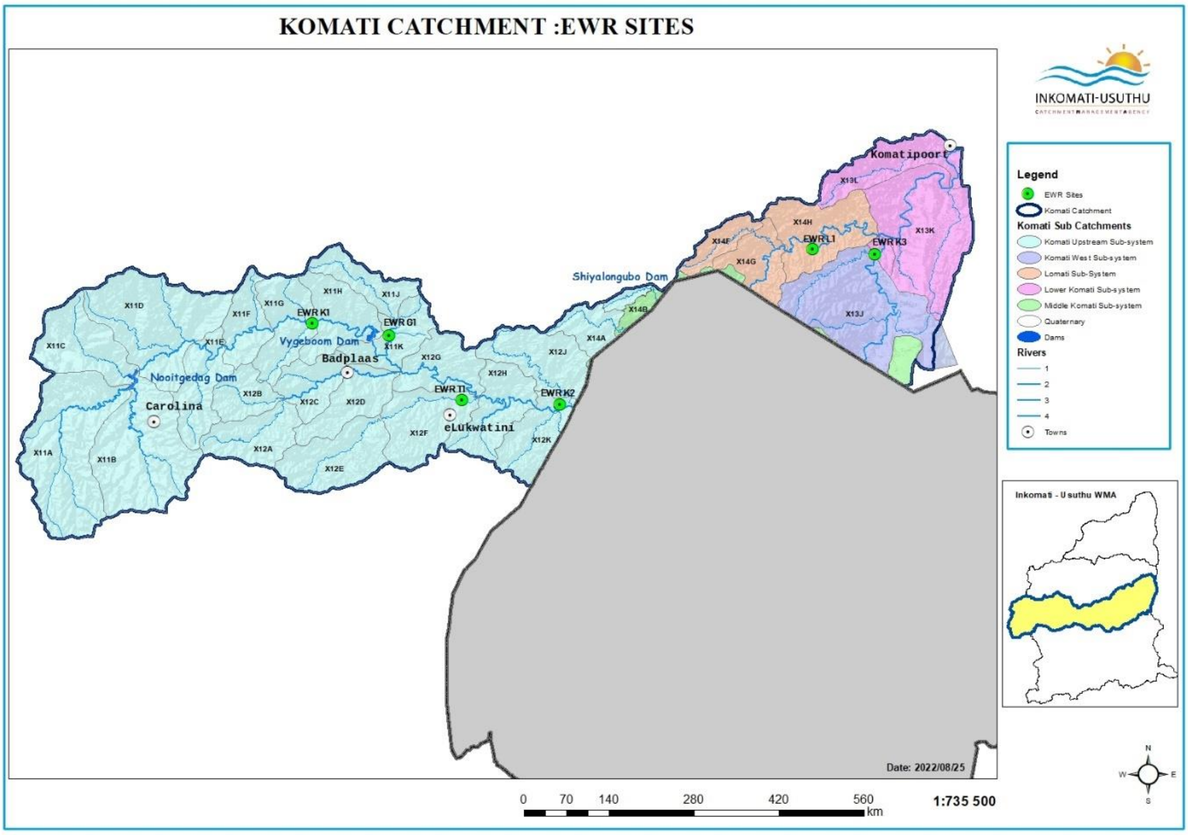


Figure 113 : Map showing Ecological Water Requirement sites within Komati Catchment.

The compliance status of each EWR site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in Table 25 - Table 27 below.

Table 25: EWR Sites compliance status in the Komati Catchment.

EWR Site	Turbidity (NTU)		EC (mS/m)		PO_4 (mg/l)		TIN		*E. coli* (cfu/100ml)		Un-ionised Ammonia (mg/l)		Flow (m^3/s)		Fish		Macro-invertebrates		Riparian Vegetation	
	RQO	Results	RQOs	Results	RQOs	Results	RQO	Results	RQOs	Results	RQOs	Results	RQOs	Compliance %	RQOs	Results	RQOs	Results	RQOs	Results
EWR K-1	NR	14	50	19	0.02	<0.010	NR		130*	362	0.007	0.005	0.7	100	C	C	B/C	C	C	BC
EWR G-1	NA	7	30*	44	0.02	<0.010	NR		130*	109	0.007	0.002		VA	D	D	D	C	D	C
EWR K-2	NA	8	55	22	0.02	<0.010	NR		130	79	*0.007	0.001	1.02	100	C	BC	C	C	C	BC
EWR T-1	NA	8	30*	27	0.125	0.007	NR		130	409	*0.007	0.006		VA	C	C	C	C	C	C
EWR L-1	NA	9	30	30	0.015	<0.010	1	0.77	130	414	0.007	0.003	0.97	100	C	VA	C	VA	B/C	VA
EWR K-3	NR	10	85	64	0.125	<0.010	1	0.54	130	376	0.007	0.012	1.84	100	C/D	C	D	C	D	CD

NA: Not available NR: Not Required VA: Variable Not Analysed TWQR*: Strictest limit from Targeted Water Quality Guideline

Table 26: Water Resource Classes and Targeted Ecological Categories in the Komati Catchment.

IUAs	Class for IUAs	Resource Name	EWR Site	Water Quantity			Water Quality			Aquatic Biota		
				TEC	PEC	Target Met	TEC	PEC	Target Met	TEC	PEC	Target Met
X1- 2	II	Komati	EWR K-1	C	C (100%)	√	B	B	√	C	C	√
X1- 4	III	Mngubhudle	EWR G-1	D	VA		C	C	√	D	C	√
X1- 5	II	Komati	EWR K-2	C	C (100%)	√	B/C	B/C	√	C	C	√
X1- 6	I	Teespruit	EWR T-1	C	VA		B/C	C	X	C	C	√
X1- 8	III	Lomati River	EWR L-1	C	C (100%)	√	B/C	B/C	√	C	VA	VA
X1- 9	III	Komati River	EWR K-3	D	D (100%)	√	D	C	√	D	C	√

NA: Not Available VA: Variable Not Analysed

Table 27: Compliance status of monitoring sites per reach within WQ Priority Resources Units: Compliance (Green) or non-compliance (Red).

WQ Priority RU	River reach and Resource Name	pH		Temperature		Turbidity (NTU)		Sulphate (mg/l)		EC (mS/m)		PO_4 (mg/l)		*E-coli* (cfu/100ml)	
		RQO	Results	RQO	Results	RQOs	Results	RQOS	Results	RQOs	Results	RQOs	Results	RQOs	Results
RU K1	X11A-01248 (Vaalwaterspruit)	8.0-8.8	7.4-7.8	NR		NR		30	79	30	34	0.025	<0.010	130	229
	X11A-01295 (Vaalwaterspruit)	8.0-8.8	7.4-7.8	NR		NR		30	350	30	94	0.025		130	384
RU K2	X11B-01370 (Boesmanspruit)	8.0-8.8	6.1-7.0	NR		NR		80	415	30	86	0.025		130	327
	X11B-01361 (Tributory of Boesmanspruit)	8.0-8.8	6.8-7.5	NR		NR		80	53	30	20	0.025		130	181
	X11B-01272 (Boesmanspruit)	8.0-8.8	7.0-7.6	NR		NR		80	243	30	66	0.025	0.120	130	662
RU-K3	X11C-00147 (Witkloofspruit)	8.0-8.8	6.8-7.7	NR		NR		30	215	30	56	NR		NR	
	X11D-01129 (Klein Komati River)	8.0-8.8	6.7-7.8	NR		NR		30	118	30	50	NR		NR	
RU-K4	X11E-01237 (Swartspruit)	6.5-8.5*	6.6-8.0	NR		NA	5	30	396	40*	92	NR		NR	
RU K13	X13L-01000 (Ngweti River)	6.5-8.5*	7.4-7.8	NR		NR		NR		85	132	0.125	6.225	130	40
MRU Komati E	X13K-01038 (Komati River)	6.5-8.5*	7.4-8.1	Not more than 2 °C from baseline.	23.6-27.4	NA	9	NR		85	63	0.125	0.685	130	181
	X13L-00995 (Komati River)	6.5-8.5*	7.6-8.1		20.3-27.4	NA	7	30*	27.3	85	85	0.125	1.065	130	40

NA: Not available NR: Not Required VA: Variable Not Analysed TWQR*: Limit from Targeted Water Quality Guideline

6.2.3.1 Discussion of results within Komati Catchment

IUA X1-2

This IUA consists of the main stem of the Komati River commencing immediately downstream of the Nooitgedacht dam and ending with the Vygeboom Dam. This IUA is relatively flat in the upper reaches but becomes increasingly incised progressing downstream, although the catchment flattens out again in the vicinity of the Vygeboom Dam. There is one (1) EWR site and the Vygeboom Dam. Land use is forestry and agricultural activities (grazing, dry land crops and limited irrigation).

The set targets were met for water quantity, water quality and aquatic biota at EWR K-1 when compared with the TEC as shown (Table 26). The PES ranges between B (slightly modified) to C (moderately modified). The Komati River is dominated by changes in flow largely due to the operation of Nooitgedacht Dam. There is a weir located in the river between the two dams from which water is pumped by Eskom for transfer to the Olifants system. The other significant abstraction is from the Vygeboom Dam, also for transfer to the Olifants.

The primary impact in this IUA is non-flow related, while *E. coli* did not comply with the set RQO due residential runoff and effluent discharge from WWTWs. The macroinvertebrates did not meet the RQO due to the loss of instream habitat as contributing factors on EWR K-1 while the fish and riparian vegetation complied with the set RQO (Table 25).

IUA X1-4

This IUA consists of the Gladdespruit tributary. The catchment is mountainous with the river rising on the Highveld escarpment and descending over 800 m to the low-lying plateau on which the Vygeboom Dam is located. There is one (1) EWR site and no significant dams. Land use is forestry, nickel mining, and agricultural activities (grazing, dry land crops and limited irrigation).

The set targets were met for water quality and aquatic biota at EWR G-1 when comparing with the TEC as shown (Table 26). The PES for both water quality and aquatic biota is B/C to C (slightly to moderately modified). The TEC for biota was exceeded at EWR G-1, indicating that improvement of the target is possible with appropriate management. It also shows that the ecological category for these reaches can be managed as ecological category C. Water quantity was not measured, due to the lack of a measuring station.

E. coli did not comply with the set RQO due residential runoff and effluent discharge from WWTWs (Table 25). The macroinvertebrates, fish and riparian vegetation complied with the set RQO on EWR G-1.

IUA X1-5

This IUA consists of the main stem of the Komati River from the outlet of the Vygeboom Dam down to the Eswatini border. This stretch of river is relatively flat but flows through a deeply incised valley. There is one (1) EWR site and no significant dams. Land use in this IUA is mainly agricultural activities (grazing with limited dryland crops), settlement and conservation areas.

The set targets were met for water quantity, water quality and aquatic biota at EWR K-2 when comparing with the TEC as shown in (Table 26). The PES ranged between B (slightly modified) to C (moderately modified). The river was still in a reasonable condition, mostly as it is situated in some protected areas such as Songimvelo Nature Reserve.

E coli did not comply with the set RQO due residential runoff and effluent discharge from WWTWs (Table 25). The water quantity (flow), macroinvertebrates, fish and riparian vegetation complied with the set RQO on EWR K-2.

IUA X1-6

This IUA consists of three tributaries flowing into the Komati River, mainly the Seekoeispruit, Sandspruit and Mlondolozi River. The terrain is flat, high-lying escarpment area with tributaries flowing steeply to the Komati through deeply incised valleys. There is one (1) EWR site and no significant dams in this IUA. Land use consists mostly of forestry, settlement, and agriculture activities (grazing with limited dryland crops).

The set targets were met for aquatic biota at EWR T-1 when comparing with the TEC as shown in Table 26. The PES is category C (moderately modified) for both water quality and aquatic biota. However, the water quality exceeded the set TEC of category B/C due the overflow of effluent from the Elukwatini oxidation ponds and storm water impacts from Elukwatini. The water quality variables of concern identified are nutrients. Water quantity was not measured, due to no measuring station.

E coli did not comply with the set RQO due residential runoff and effluent discharge from WWTWs (Table 25). The macroinvertebrates, fish and riparian vegetation complied with the set RQO on EWR T-1.

IUA X1-8

This IUA consists of the Lomati River downstream of the eSwatini border and down to the confluence with the Komati River. The area is mostly very flat although bordered by mountains in the Northwest. There is one (1) EWR site and a large dam (Driekoppies Dam) in this IUA although there are also numerous farm dams. Land use consists mostly of numerous settlements, and agriculture activities (extensive irrigated crops and some livestock grazing).

The set target was met for water quantity at EWR L-1 when compared with the TEC as shown in Table 26. The PES is category B (slightly modified) for water quality. Aquatic biota was not sampled due to no access an alternative site will be established in the same sub-quaternary reach. *E. coli* did not comply with the set RQO due residential runoff and effluent discharge from WWTWs (Table 25).

IUA X1-9

This IUA consists of the Lower Komati River from the Swaziland border to the confluence with the Lomati River. The area is flat. There is one (1) EWR site and two small dams in this IUA, the Mbambiso and Masibikela dams. Land use consist of settlements, and dominated by irrigated crops, mostly sugar cane although there is also extensive stock grazing taking place.

The set targets were met for water quantity, water quality and aquatic biota at EWR K-3 when comparing with the TEC as shown in Table 26. The PES was category C (moderately modified) for water quality and aquatic biota. EWR K-3 exceeded the TEC for water quality and aquatic biota, indicating that improvement of the target is possible with appropriate management. It also shows that the ecological category for these reaches can be managed as ecological category C.

The primary impact in this IUA is non-flow related, while *E. coli*, ammonia and EC did not comply with the set RQO due residential runoff and effluent discharge from WWTWs. The macroinvertebrates, fish and riparian vegetation met the set RQO (Table 25).

6.2.3.2 Management Class

All biophysical nodes and components (water quantity, water quality and aquatic biota) within the IUA should comply with the set TEC in order to meet the management class. In this report only EWR sites were considered to ensure that the management class is met within the IUA. Assumption was made that if all components are met at an EWR site, then all biophysical nodes are met within the IUA.

EWR K-1- and K-2 are the only biophysical nodes where all components within IUA X1-2 and X1-5 have met Management Class II. This means the IUA X1-2 and X1-5 are moderately used. EWR K-3 is representing all biophysical nodes within IUA X1-9 and has met the management Class III, indicating that the IUA heavily used. It was not possible to conclude on other IUAs because not all components were assessed.

6.2.3.3 WQ Priority Resources Units

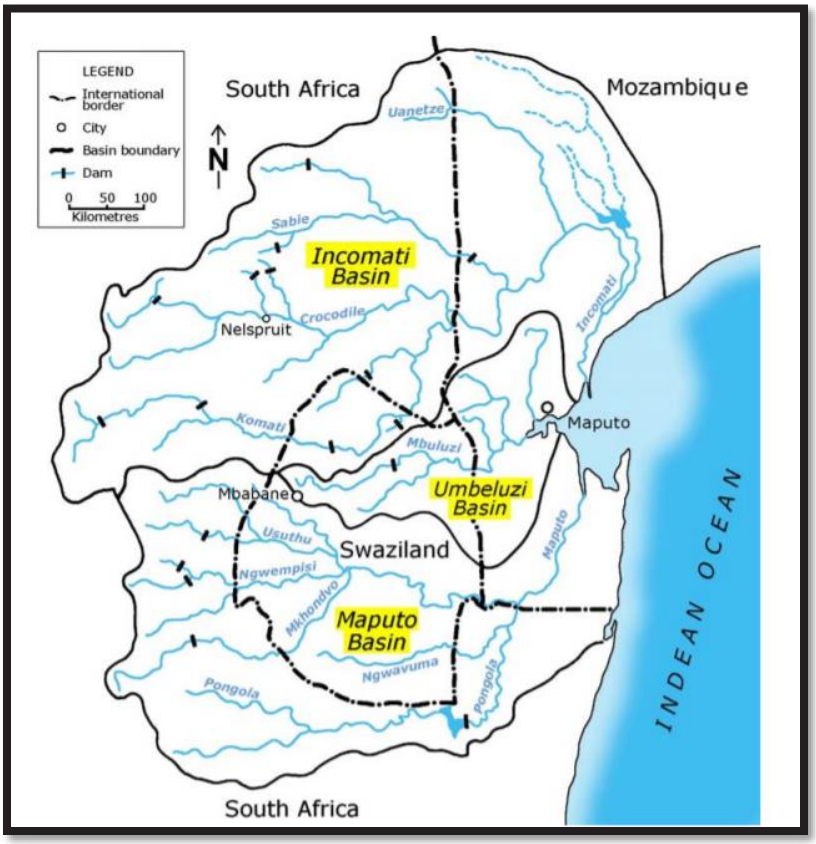
Compliance status on water quality priority resource units of analysis in Table 27 shows that microbial pollution is a major concern as shown by the non-compliance to the set RQOs of *E. coli*. System variable and nutrients complied at all sites using pH and PO_4 as indicator variables. There are challenges with salts, the levels of EC and sulphate exceeded the set RQOs due to coal mines within the Upper Komati Catchment and return flow from irrigation in the lower Komati.

CHAPTER 7: COMPLIANCE TO INTERNATIONAL OBLIGATIONS FOR WATER QUALITY AND FLOW REQUIREMENTS

7.1 Introduction

The governments of the Republic of Moçambique, the Republic of South Africa (RSA) and the Kingdom of Eswatini have been collaborating in the exchange of information, agreements on sharing of water, and in joint studies that are of mutual interest and benefit. These initiatives have been done through the Tripartite Permanent Technical Committee (TPTC), which was formally established on 17 February 1983. The TPTC is responsible for providing advice to the shared watercourse States on equitable utilisation and management of the shared waters. It was identified in the Interim IncoMaputo Agreement (IIMA), (August 2002) that a "Comprehensive Agreement" is required for the watercourse states to participate more effectively in the utilisation, development and protection of the shared waters.

The Incomati River Basin is located in the eastern region of southern Africa and is shared by South Africa, Eswatini and Mozambique. The basin is 480 kilometres long, with drainage basin 50,000 square kilometres in size. The headwaters of Maputo River Basin originates in South Africa, Usuthu River in Mpumalanga province, and flow easterly through eSwatini and the River is called Great Usuthu or Lusutfu, where it enters the Republic of Mozambique after confluence with Pongola River and it is called Maputo River flowing into the estuary in Maputo Bay. The 13 km gorge (Valley) forms the boundary between Kingdom of eSwatini and Republic of South Africa and approximately twenty kilometres forms the border between South Africa (province of KwaZulu-Natal) and the Republic of Mozambique. The land area of the Maputo River basin is about 30 000 km^2.



The purpose of this chapter is to share water quality compliance status and flow of the major watercourses within the basins which fall within the Inkomati Usuthu WMA, South Africa.

7.2 International Water Quality Monitoring Points

There are ten (10) international obligation (IO) sites across the WMA as presented in Figure 114.

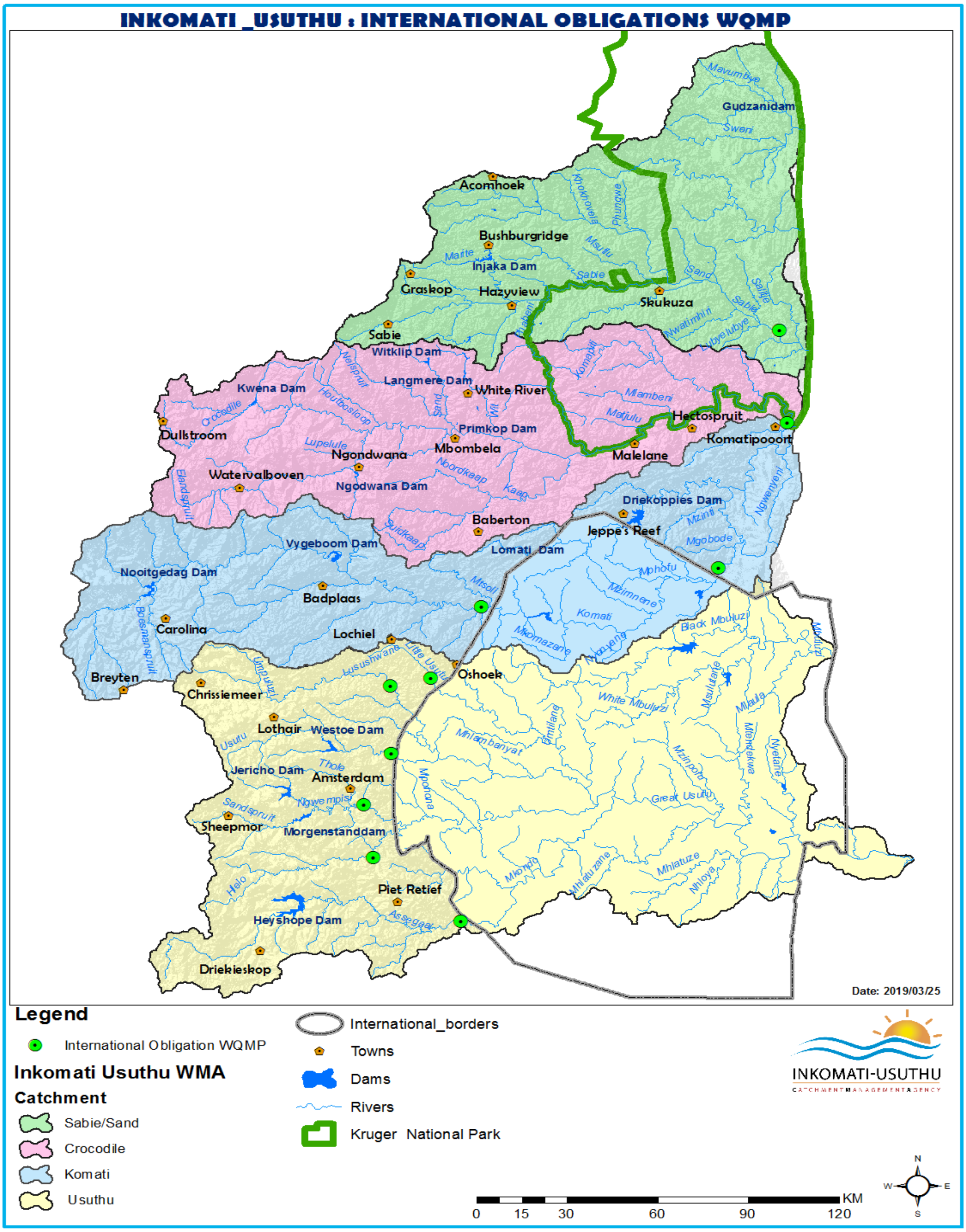


Figure 114 : International Obligation water quality monitoring points in the Inkomati-Usuthu WMA.

7.3 International Water Quantity Limits

The compliance of the flow is compared with the minimum requirement as per the Interim IncoMaputo Agreement (IIMA), tabulated below (Table 28).

Table 28: International Flow minimum requirement.

Flow measurement station	Flow minimum requirement (m^3/s)
Sabie river at lower sabie rest camp	0.6
Crocodile River at Tenbosch	1.17
Komati River at Komatipoort	2.6
Komati River at Hooggenoeg	0.6
Assegaai River at Zandbank	0.1
Hlelo River at Merrieskloof	0.1

7.4 International Water Quantity Compliance Status

The average data reported was collected over a period of three hydrological years from 2020/21 to 2023/24. The compliance percentage status per station was calculated using an average data over 3-day period and was compared against the minimum required flow. All the stations in 2023/24 complied with the minimum flow requirements except Crocodile River at Tenbosch and Komati River at Komatipoort which may be attributed to transmission losses as illustrated in Table 29 and Figures 115 - 118).

Table 29: Water quantity status for Internatinal obligations site(s).

Station	Flow minimum requirement (m^3/s)	2021/22	2022/23	2023/24	Compliance status
Sabie river at lower Sabie rest camp	0.6	0%	0%	0%	Non-compliance
		100%	100%	100%	Compliance
Crocodile River at Tenbosch	1.17	2%	1%	0%	Non-compliance
		98%	99%	100%	Compliance
Komati River at Komatipoort	2.6	4%	2%	2%	Non-compliance
		96%	98%	98%	Compliance
Komati River at Hooggenoeg	0.6	0%	0%	0%	Non-compliance
		100%	100%	100%	Compliance
Assegaai River at Zandbank	0.1	0%	0%	0%	Non-compliance
		100%	100%	100%	Compliance
Hlelo River at Merrieskloof	0.1	0%	0%	0%	Non-compliance
		100%	100%	100%	Compliance

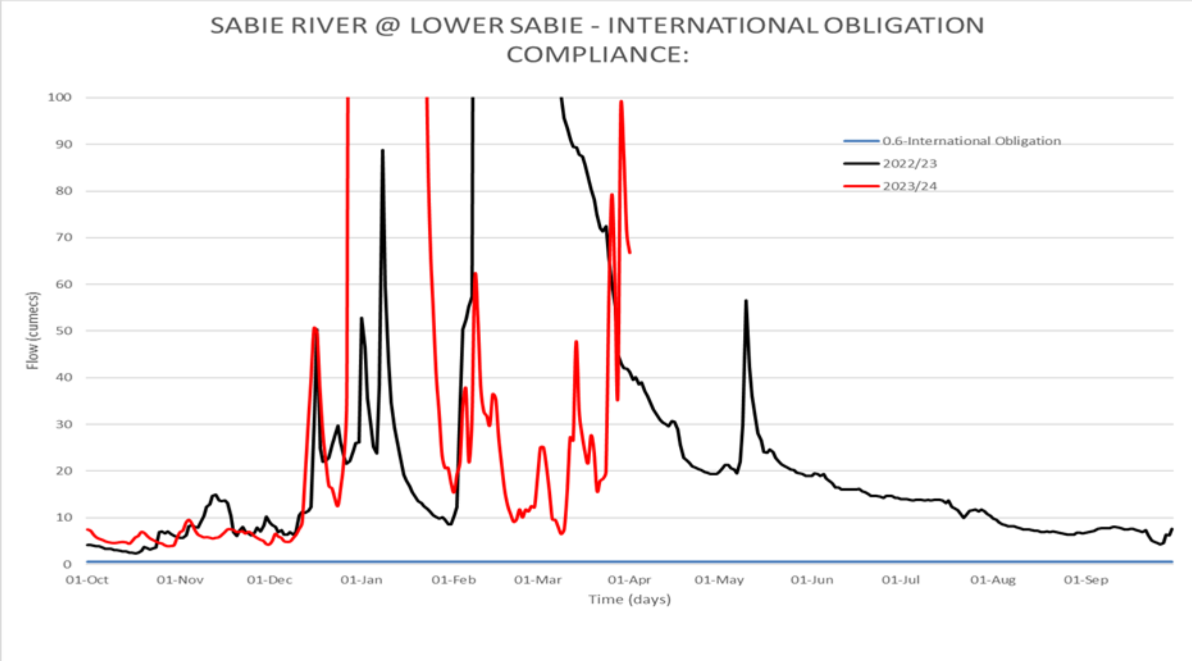


Figure 115 : Sabie River level status and compliance to international l requirements.

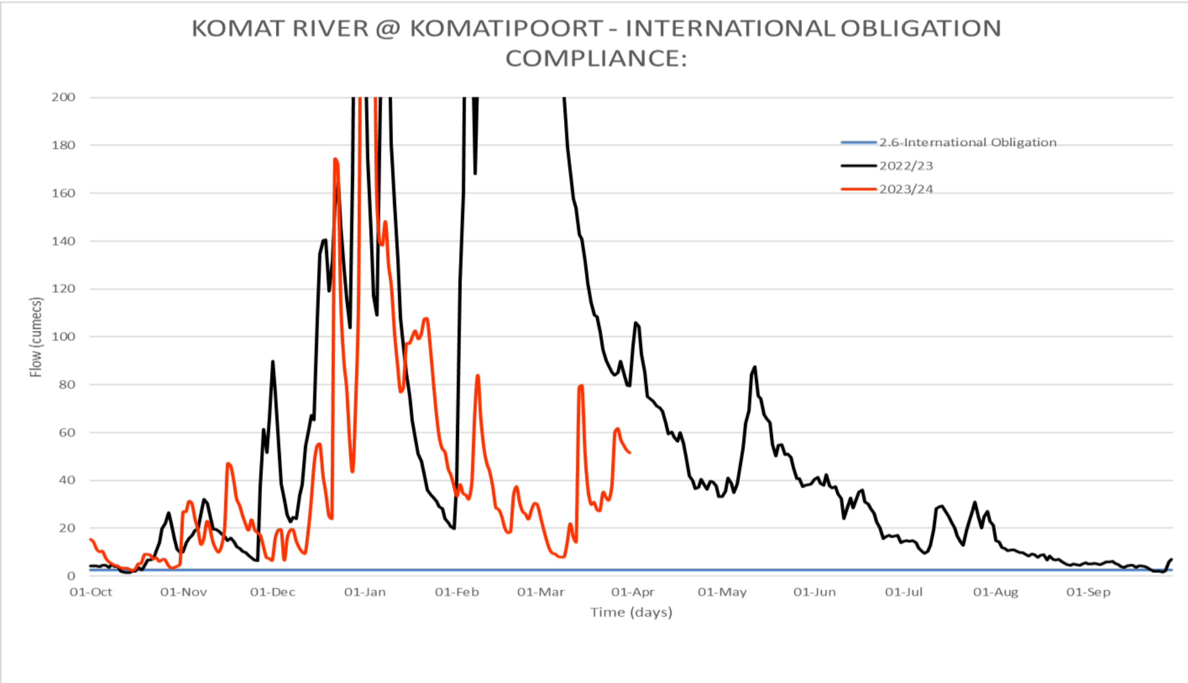


Figure 116 : Komati River at Komatipoort level status and compliance to international l requirements.

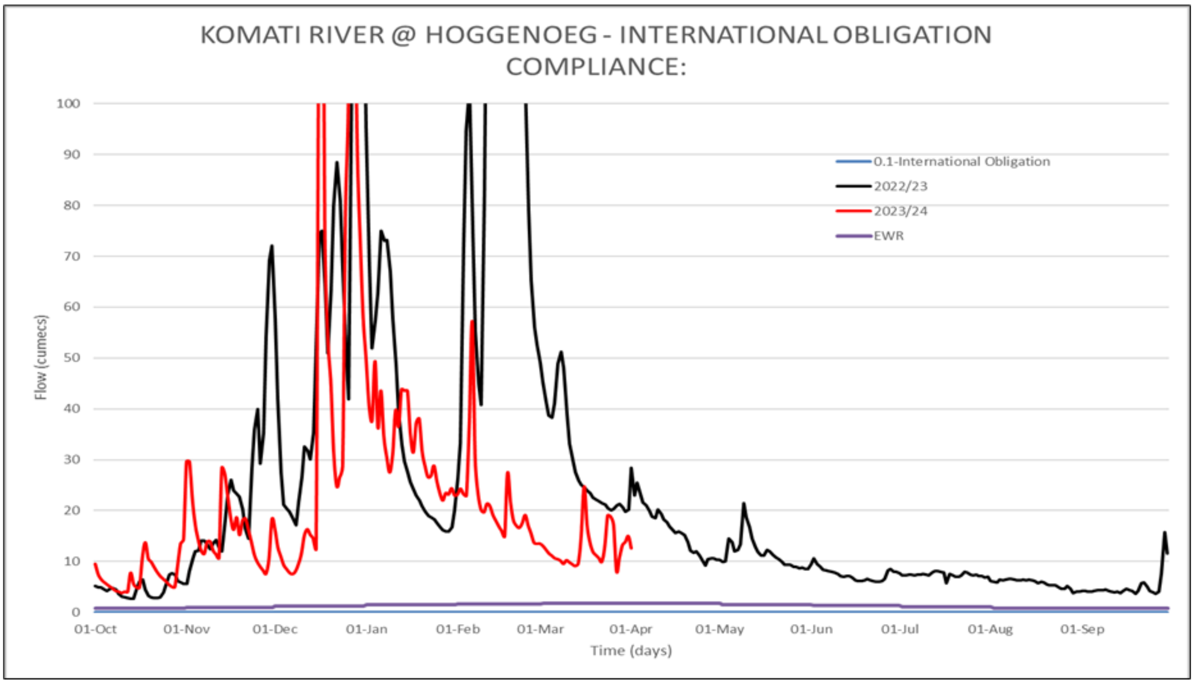


Figure 117 : Komati River at Hoggenoeg level status and compliance to international l requirements

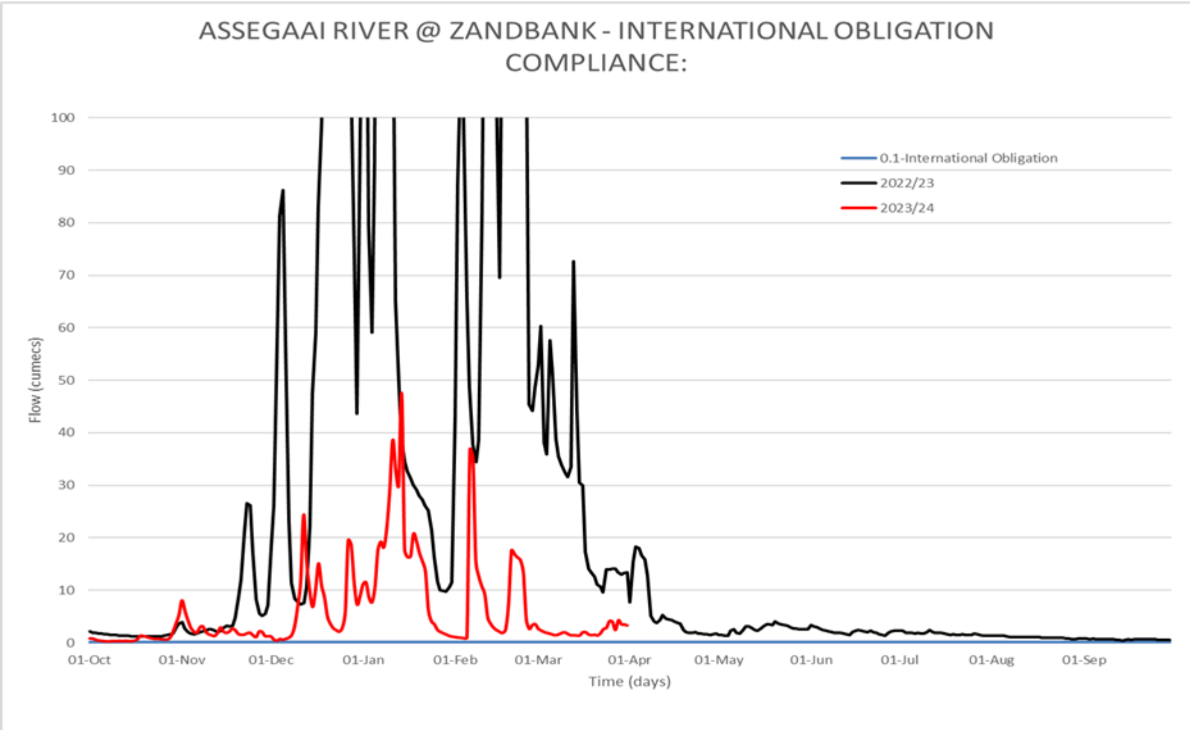


Figure 118 : Assegai River level status and compliance to international l requirements

7.5 International Water Quality Guideline limits

The average data reported was collected over a period of a year from January 2023 to December 2023. The compliance of the indicator parameters is compared with the water quality guidelines as per the Interim IncoMaputo Agreement (IIMA), tabulated below (Table 30).

Table 30: International Water Quality Guideline limits.

Variables/Parameters	International Water Quality Guidelines Limits
Total Coliforms (TC) in cfu/100ml	10 000
Faecal coliforms (FC) in cfu/100ml)	2 000
Faecal Streptococci (FS) in cfu/100ml)	1 000
Electrical Conductivity (EC) in mS/m)	150
Sulphate (SO_4) in mg/l)	250
Phosphate (PO_4) in (mg/l)	2
pH	6.5-8.5
Nitrates (NO_3) in mg/l	50
Ammonia (NH_3) in mg/l	1
Copper (Cu) in mg/l	0.02
Iron (Fe) in mg/l	N/A
Manganese (Mn) in mg/l	0.3
Biological Oxygen Demand (BOD) in mg/l	<5
Chemical Oxygen Demand (COD) in mg/l	10
Chloride (Cl) in mg/l	250
Fluoride (F) in mg/l	0.75
Potassium (K) mg/l	50
Sodium (Na) in mg/l	200
Turbidity (TUR) in NTU	5
Dissolved Oxygen (DO) in %	>75

7.6 International Water Quality Compliance Status

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

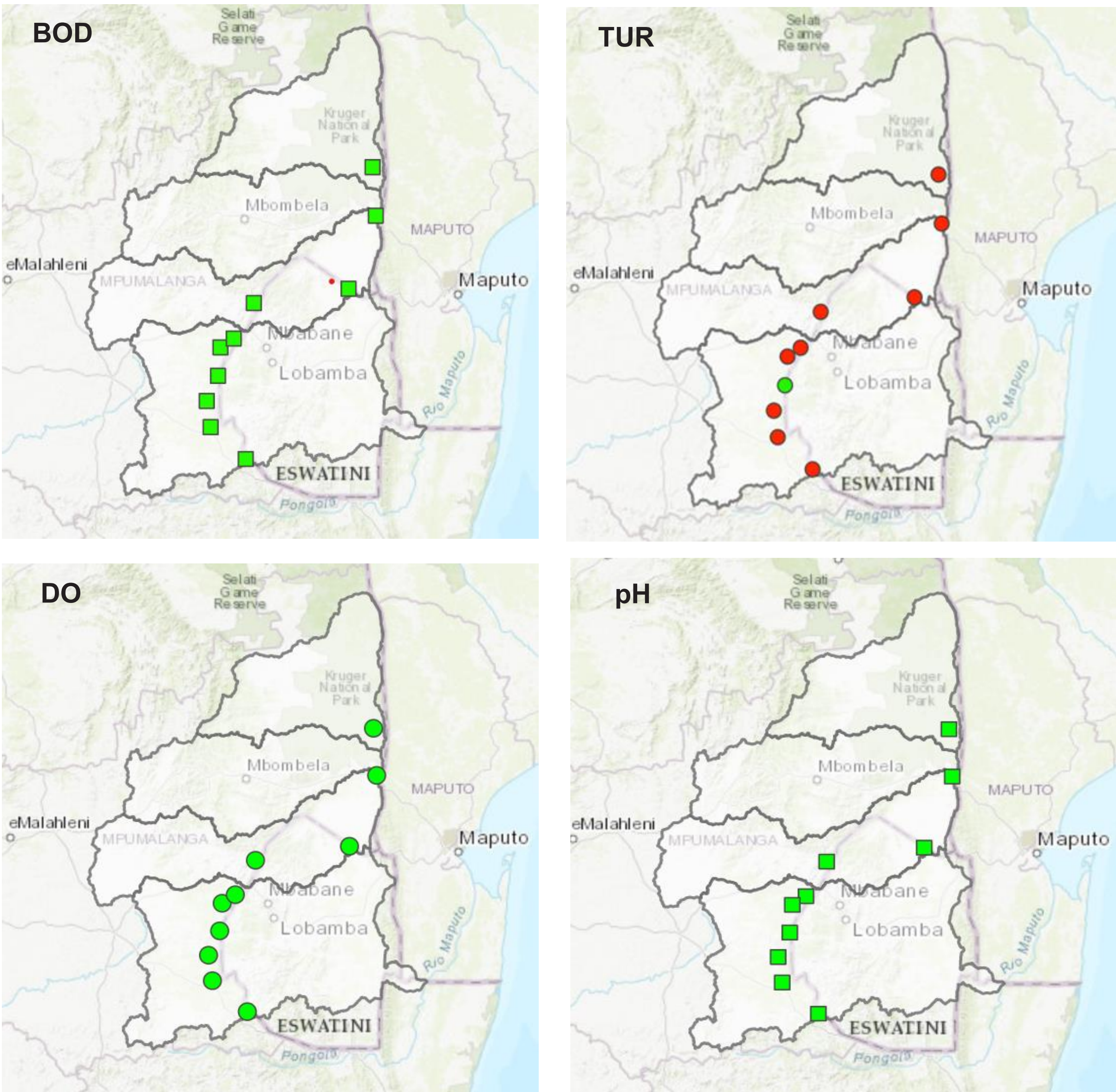


Figure 119 : Maps showing water quality status (BOD, TUR, DO, and pH) for international obligation site (s).

Almost all variables as shown in Figure 119 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of Eswatini as per the international obligation agreement throughout the reporting period, except for turbidity which indicated non-compliance at all international Obligation sites, except Usuthu River within the basin due to the stringent turbidity limit and the high flows that result in soil erosion as well as illegal sand mining.

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

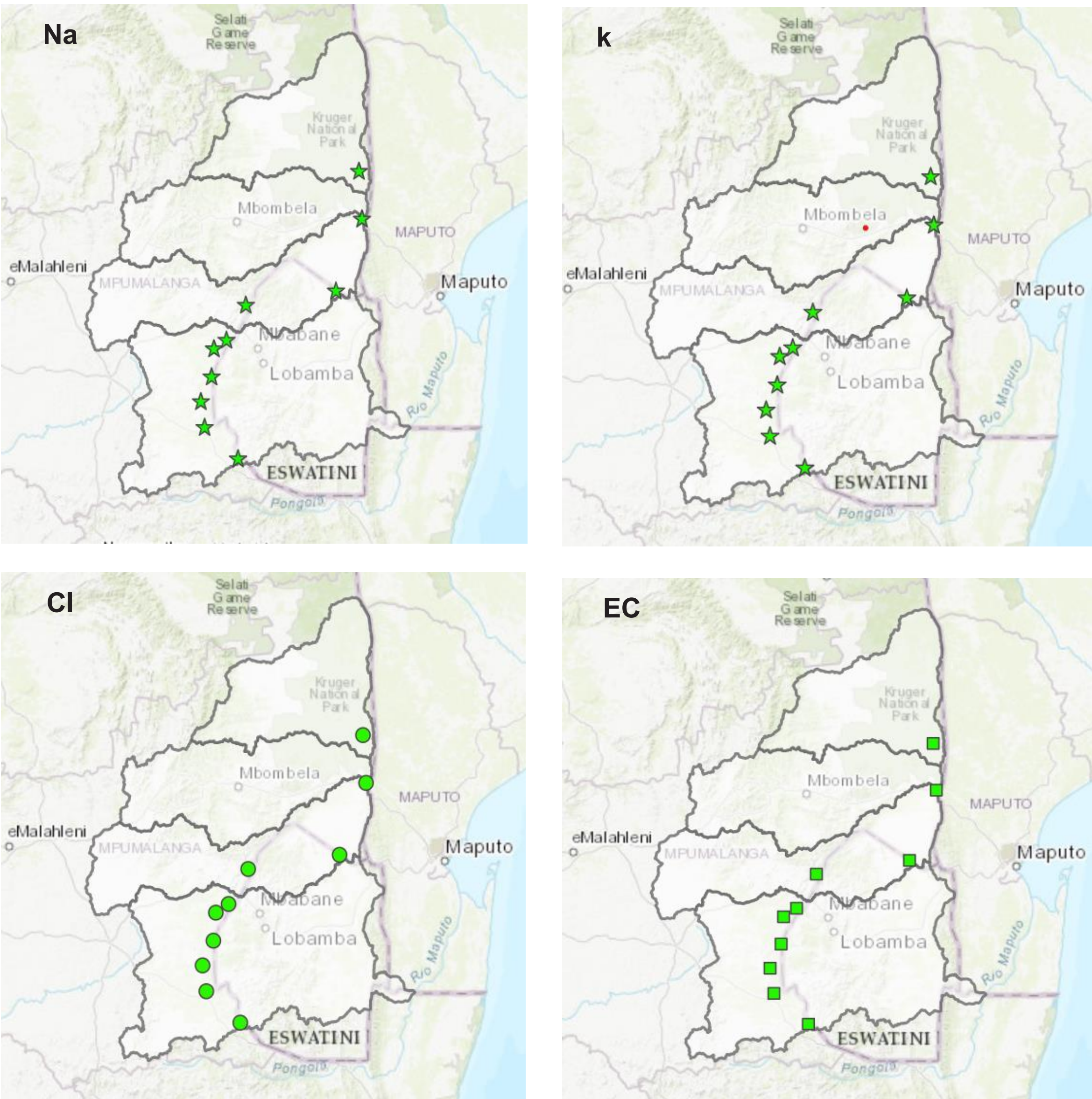


Figure 120: Maps showing water quality status (Na, K, Cl, and EC) for international obligation site(s).

All variables as shown in Figure 120 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of eSwatini as per the international obligation agreement throughout the reporting period.

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

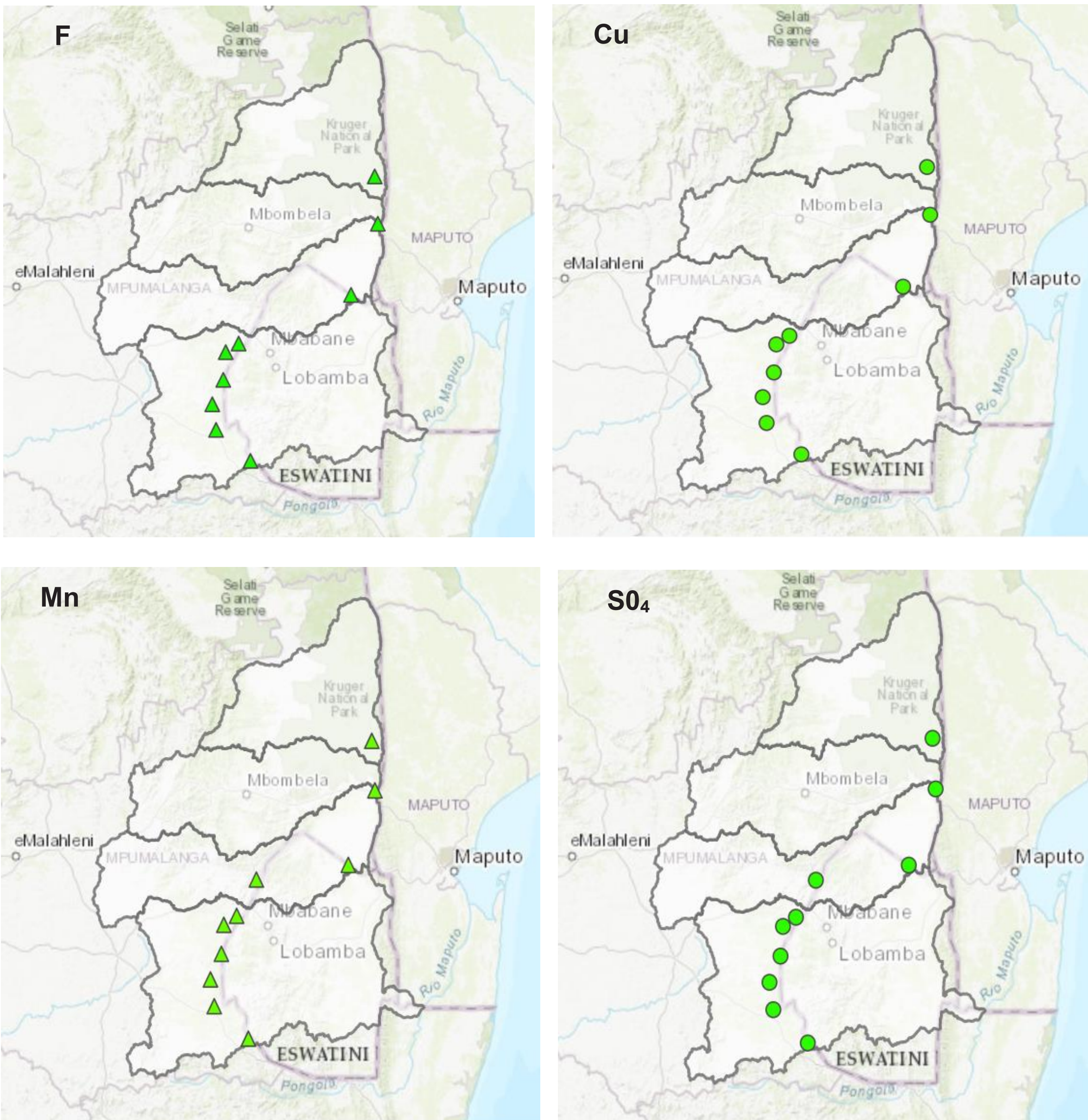


Figure 121: Maps showing water quality status for international obligation site(s).

All variables as shown in Figure 121 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of Eswatini as per the international obligation agreement throughout the reporting period.

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

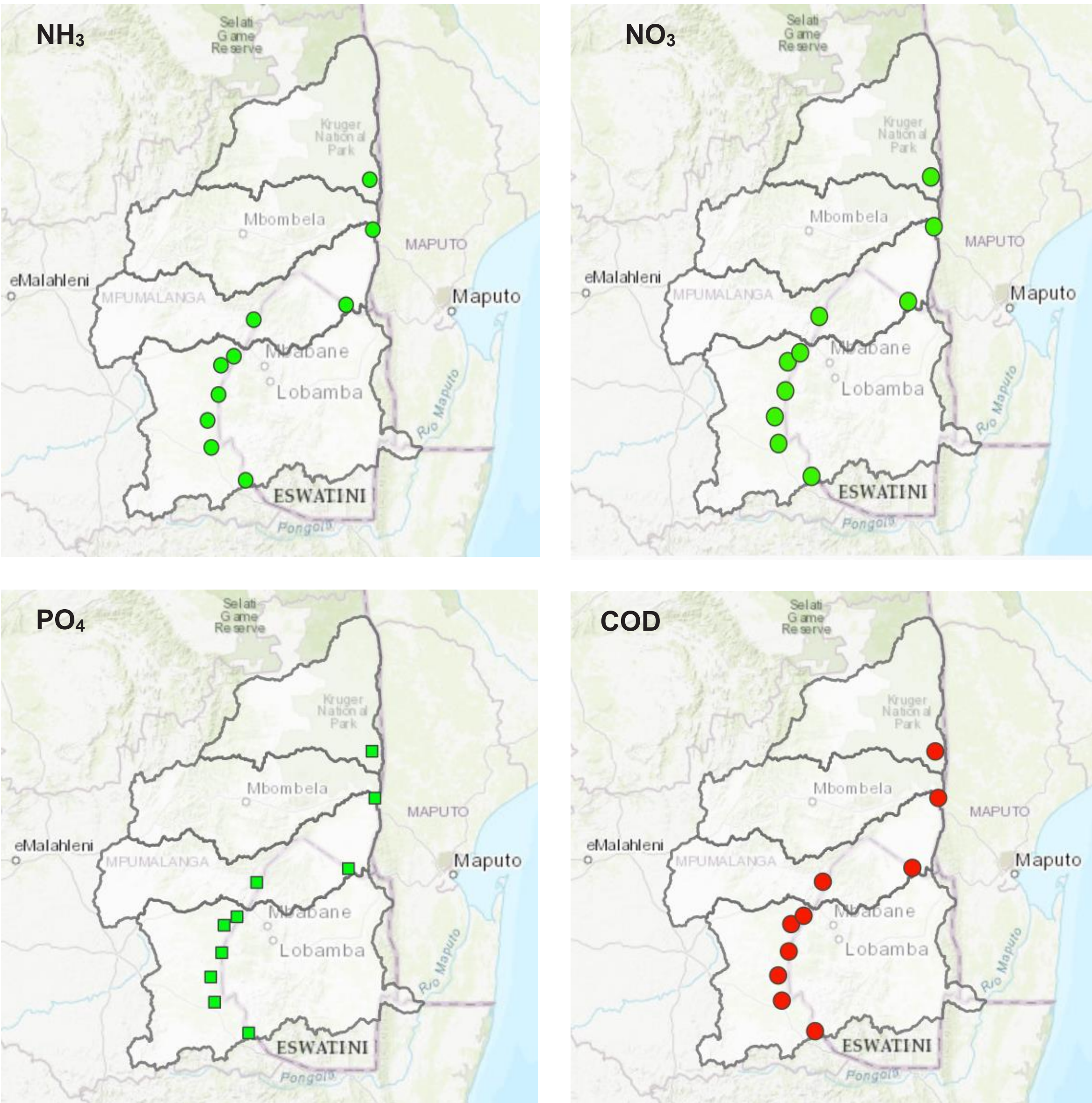


Figure 122: Maps showing water quality status for international obligation site(s).

Almost all variables as shown in Figure 122 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of eSwatini as per the international obligation agreement throughout the reporting period, except for chemical oxygen demand which indicated non-compliance for at all international Obligation sites within the basin.

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

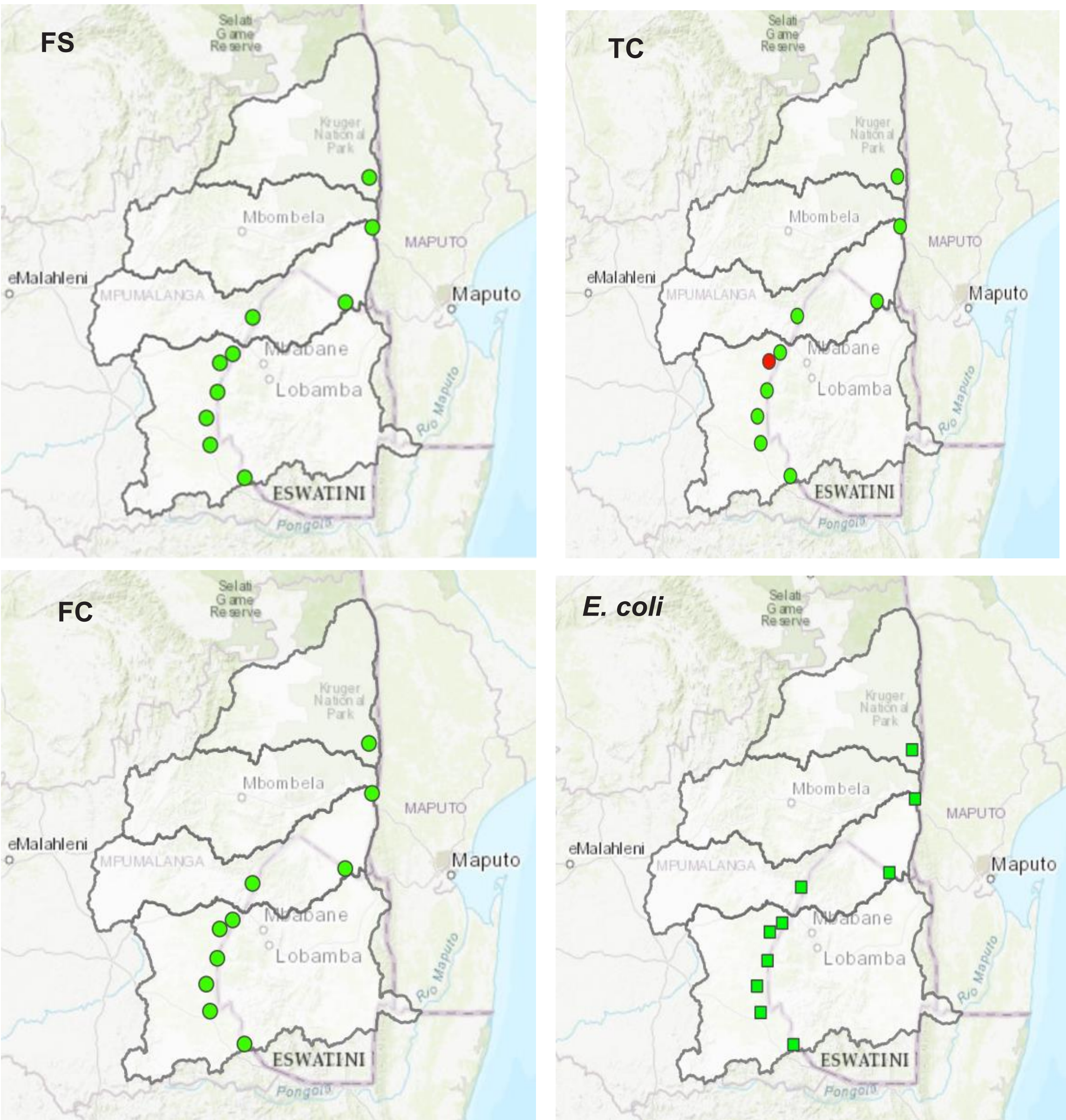


Figure 123: Maps showing water quality status (FS, TC, FC, E. coli) for international obligation site(s).

Almost all variables as shown in Figure 123 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of Eswatini as per the international obligation agreement throughout the reporting period, except for *Total coliform* which indicated non-compliance at Mpuluzi River due partially treated effluent from WWTWs. Note that *E. coli* does not form part of the IIMA however reported for information purposes using 2 000 (cfu/100ml) as a limit.

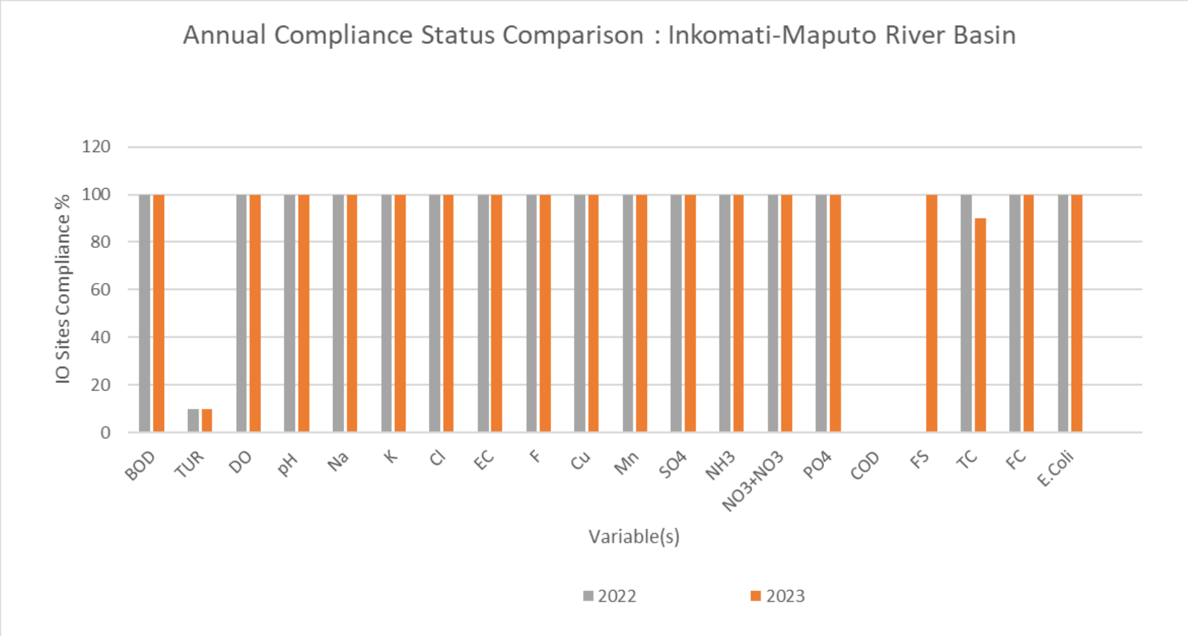


Figure 124: Water quality compliance status for international obligation site(s).

The RSA complied with the international water quality limits discharged (allowed to flow) into Kingdom of eSwatini as well as Republic of Mozambique as per the international agreement from January to December 2023. Yearly compliance percentage of international Obligation sites within Inkomati-Usuthu WMA with international water quality guideline were 100% compliance with all variables except TUR (10%), COD (0%) and TC (90%). The percentage compliance remained constant at 100% for all variable, TUR at 10% and COD at 0% compared to 2022. Whereas FS showed improvement from 0% to 100% and TC showed deterioration from 100% to 90% as compared to 2022 as illustrated in Figure 124.

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

All biophysical nodes and components (water quantity, water quality and aquatic biota) within the integrated Units of Analysis (IUA) of any catchments within Water Management Area (WMA) should comply with the set Targeted Ecological Category (TEC) in order to meet the management class. In this report only EWR sites were considered to ensure that the management class is met within the IUA. Assumption was made that if all components are met at an EWR site, then all biophysical nodes are met within the IUA. Ecological Water Requirements (EWR) compliance for flow and water quality is always poor during dry seasons in river systems where river flow levels are not supplemented by upstream dam release augmentations

Water quantity (surface and groundwater) and water quality are key drivers to ecosystem responses at ecological water requirements sites. The hydrological analysis spans two hydrological years, 2022-23 and 2023-24, with the latter ending on March 31, 2023. The summer rainfall received since the start of the 2021 hydrological year has resulted in normal to above normal river flow levels in the Inkomati-Usuthu WMA. The rainfall received in the 2023-24 hydrological year has been below normal, with most of the rainfall falling in December 2023. While the river flow levels in the 2023-24 hydrological has been normal to above normal during the summers, the overall status is that the rivers have been below compared to the previous two hydrological years (2021-22 and 2022-23), but the ecological reserve requirements were met 90-100% at all EWR sites.

The EWR compliance for flow and water quality is always poor during dry seasons in river systems where riverflow levels are not supplemented by upstream dam releases augmentations. However, surface water quality in the Inkomati-Usuthu WMA complied with the RQOs, TWQG and IWQG limits for most of the monitored points and this showed that the water quality within the WMA is in a relatively good state. Furthermore, there are challenges with other variables in the water resources. The presence of *E. coli* in water resource indicates that the water has been contaminated with human or animal faecal material and this is a challenge in the entire WMA. *E coli* contamination has a potential health risk for individuals who use water directly from the resource which may also lead to waterborne diseases for those people and is a threat for crop production, especially those crops eaten raw.

Salts and Nutrients (Electrical conductivity and phosphate) are not a major cause for concern in the catchment. It is only in selected areas where the water quality status related to these parameters are punctuated by non-compliance. The Boesmanspruit, Gladdespruit, and Kaap River systems are threatened by metal and toxic substance contamination especially manganese and arsenic arising from mining activities (active mines, defunct mines and decanting mines).

Eutrophication status of the dams within the WMA were mostly oligotrophic (low levels of nutrients, with an average chlorophyll-*a* concentration of less than 10 ug/L). Based on the trophic status it was safe to undertake recreational activities within the water bodies during the period reported.

The overall integrated ecostatus for each of the four catchments within the WMA was calculated as category C, which is consistent with the integrated ecostatus calculated from previous results. This indicates that despite the site-specific issues, the overall biotic condition for each of the four catchments has remained constant at Category C (moderately modified), with loss and change of natural habitat and biota in terms of frequency of occurrence and abundance. The resilience of the system to recover from human impacts has not been lost and its ability to recover to a moderately modified state following disturbance has been maintained.

All biophysical nodes (reaches) and components (water quantity, water quality and aquatic biota) within the IUA should comply with the set TEC to meet the management class. It was not possible to conclude on most of IUAs (Sabie-Sand, Crocodile, and Komati) because not all components were assessed.

Hydrology and physicochemical indicators remain key drivers to ecosystem responses at ecological water requirements sites and the majority of the sites complied with the required targets in the 2023/2024 financial year and thus the management classes were met in the WMA.

The Republic of South Africa complied with the international water quantity and water quality limits discharged (allowed to flow) into Kingdom of Eswatini as well as Republic of Mozambique per the international agreement throughout the reporting period, except few variables and sites that indicated non-compliance.

8.2 Recommendations

It is recommended that the land use activities impacting on water resources quality be efficiently controlled through Source Directed Controls (SDC) as per the provision(s) of the National Water Act No 36 of 1998. SDC focus on managing the quantity and quality of water entering water resource with the primary purpose of ensuring that the water quantity and water quality RQOs that have been set for the water resource are achieved. The aquatic species are sensitive to changes in physical drivers such as water quality, hydrology, and geomorphology and when these drivers are within the set TEC the integrity of the aquatic ecosystems is protected and maintained.

SDC include regulatory mechanisms such as water quality discharge standards for wastewater, conditions in water use authorisations, pollution prevention, control of emergency incidents, best waste management practices and waste minimisation technologies. Additionally, progressive implementation of self-regulation is encouraged.

The authorisation of a water use related to water quality is an important tool for SDC and must consider Resources Directed Measures (RDM) such as the Class, Reserve and RQOs before issuance of an authorisation. The purpose of water use authorisation is to ensure that water is used for the purpose(s) authorised only and enable water manager(s) to achieve their resource quality objectives (RQOs), and hence contribute to sustainable development. It is therefore critically important to implement the SDC and RDM in an integrated and structured manner to achieve a balance between protecting and utilising of water resources for the current and future generation.

The RQO implementation plan is in place, which involves various stakeholders such as all spheres of government, water users, researchers and civil society. However, there is no formal implementation structure or committee. It is recommended that the Implementation Plan Management Committee (IPMC) be established to roll out the implementation plan.

It is also recommended that EWR and IO sites which were not sampled or measured be measured going forward by ensuring that alternative sites are established, or data sourced from other spheres of government or institutions (DWS, KPN, KOBWA, MTPA).

For integrated water quality management, it is recommended that the authorisation process be aligned with other environmental authorisation especially sensitive, vulnerable and important water resource areas or alternatively regulate or prohibit any activities in order to protect water resource or instream or riparian habitat within these areas in terms of section 26(1)(g).

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INKOMATI-USUTHU

CATCHMENT MANAGEMENT AGENCY

Postal Address:

Private bag X11214,

Mbombela, 1200

Physical Address:

2nd Floor,ABSA Square Building,

20 Paul Kruger Street, Mbombela,

1200

www.iucma.co.za