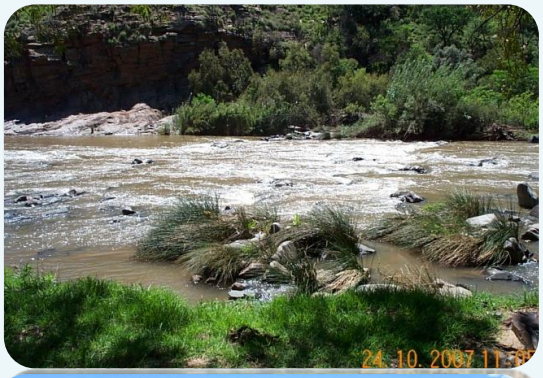

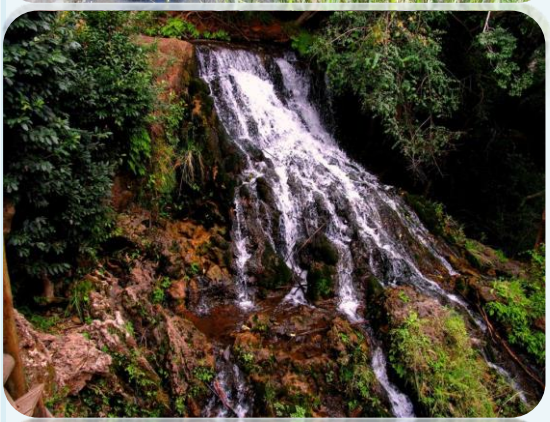

DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE MOKOLO, MATLABAS, CROCODILE (WEST) AND MARICO CATCHMENTS IN THE LIMPOPO NORTH WEST WATER MANAGEMENT AREA (WMA 01)

WP10992

IMPLEMENTATION/OPERATION PLAN REPORT

REPORT NO.: RDM/WMA01/00/CON/RQO/0117

FINAL

Chief Directorate: Water Ecosystems

AUGUST 2017

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Published by

Department of Water and Sanitation
Private Bag X313
Pretoria, 0001
Republic of South Africa

Tel: (012) 336 7500/ +27 12 336 7500
Fax: (012) 336 6731/ +27 12 336 6731

This report is to be cited as:

Department of Water and Sanitation, South Africa. August 2017. Determination of Resource Quality Objectives in the Mokolo, Matlabas, Crocodile West and Marico Catchments in the Limpopo North West Water Management Area (WMA01): Implementation/Operation Plan Report. Report No: RDM/WMA01/00/CON/RQO/0117

Prepared by:

Golder Associates Africa in association with Wetland Consulting Services and JMM Stassen

Title:	*Implementation/Operation Plan Report*
Authors:	*P Moodley, L Boyd, E van Wyk, JMM Stassen, T Coleman*
Project Name:	*Determination of Resource Quality Objectives in the Mokolo, Matlabas, Crocodile (West) and Marico Catchments in the Limpopo North West Water Management Area: WP 10992*
DWS Report No:	*RDM/WMA01/00/CON/RQO/0117*
Status of Report:	*Final*
First Issue:	*31 May 2017*
Final Issue:	*August 2017*

Professional Service Providers: Golder Associates Africa/ Wetland Consulting Services/ JMM Stassen and Hydrosol

Approved for the PSP by:

…… ……..

Trevor Coleman *Date*

Project Leader

DEPARTMENT OF WATER AND SANITATION

Chief Directorate: Water Ecosystems

Approved for DWS by:

……

Ndileka Mohapi

Chief Director: Water Ecosystems

DOCUMENT INDEX

Reports as part of this project:

Bold type indicates this report.

REPORT INDEX	REPORT NUMBER	REPORT TITLE
1.0	RDM/WMA01/00/CON/RQO/0116	Inception Report
2.0	RDM/WMA01/00/CON/RQO/0216	Information Analysis Report
3.0	RDM/WMA01/00/CON/RQO/0316	Preliminary Resource Units Report
4.0	RDM/WMA01/00/CON/RQO/0416	Resource Units Prioritisation, Sub-component Prioritisation and Indicator Selection Report
5.0	RDM/WMA01/00/CON/RQO/0516	Draft Resource Quality Objectives and Numerical Limits Report
6.0	**RDM/WMA01/00/CON/RQO/0117**	**Implementation/Operation Plan Report**

LIST OF ABBREVIATIONS

CD: WE	Chief Directorate: Water Ecosystems
CMS	Catchment Management Strategy
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
EC	Ecological Category
EWR	Ecological Water Requirements
FRAI	Fish Response Assessment Index
FIFHA	Flow, Invertebrate, Fish, Habitat Assessment
GMU	Groundwater Management Unit
HGM	Hydrogeopmorphic
IUA	Integrated Unit of Analysis
IUAs	Integrated Units of Analysis
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resources Management Plan
MIRAI	Macro-invertebrate Response Assessment Index
NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
NWA	National Water Act
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category
REMP	River Eco-status Monitoring Programme
RHAMM	Rapid Habitat Assessment Method and Model
RHP	River Health Programme
RQIS	Resource Quality Information Services

RQOs	Resource Quality Objectives
RPW	Resource Protection and Waste
RUs	Resource Units
SASS5	South African Scoring System Version 5
TDS	Total Dissolved Solids
VEGRAI	Vegetation Response Assessment Index
WMA	Water Management Area
WMS	Water Management System
WRCS	Water Resource Classification System
WUL	Water Use Licence
WWTW	Wastewater Treatment Works

EXECUTIVE SUMMARY

The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) in March 2016, commissioned the study "Determination of Resource Quality Objectives (RQOs) in Mokolo, Matlabas, Crocodile (West) and Marico catchments in the Limpopo North West Water Management Area (WMA)". Proposed water resource classes have been completed in these catchment areas and draft RQOs have been determined through this project. Establishment of RQOs is a mechanism through which the balance between sustainable and optimal water use and protection of the water resource can be achieved. RQOs are defined by the National Water Act (Act No. 36 of 1998) as "clear goals relating to the quality of the relevant water resources" (DWAF, 2006).

RQOs are descriptive or quantitative and are the goals defined to protect the water resource and the alignment to the catchment vision and class of the water resource. In determining the RQOs, it is important to recognise that different water resources will require different levels of protection.

With proposed water resource classes and RQOs in place the next step in the protection framework is to achieve its implementation. Implementation of the RQOs must function within the existing environment of water resource management as well as existing monitoring programmes and initiatives. This report therefore focuses on principles of an implementation plan, the actions required as well as a timeline for the implementation of the RQOs. Monitoring activities to measure whether the RQOs are being achieved is also provided.

The main objectives of this implementation plan framework are to:

- Outline the actions required to achieve the implementation of the RQOs;
- Assign roles and responsibilities to implement RQOs; and
- Describe a communication plan.

Successful implementation of the water resource classes and RQOs, will also require co-ordination among the responsible role players and relevant functional and operational Directorates/Offices in the Department. This may require the establishment of a management committee of national and regional personnel, to work out a co-ordinated plan of what must happen, when, how it is to be achieved and who is accountable. This process would also need to specify reporting requirements and reporting periods. Thus, it is important that the institutional roles and responsibilities be clearly understood and defined, and that the implementation be facilitated through co-ordinated approaches and activities. Implementation would be addressed through two 'legs': (1) Compliance monitoring and reporting, and (2) operationalisation of RQOs (actiions, activities and initiatives to achieve RQOs).

Determination of Resource Quality Objectives in the Mokolo, Matlabas, Crocodile (West) and Marico catchments

Implementation/Operation Plan Report

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 BACKGROUND

Resource Directed Measures (RDM) is enabled through Chapter 3 of the National Water Act (Act No.36 of 1998) (NWA) which provides for the protection of water resources through the classification of water resources, determination of RQOs and determination of the Reserve. These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources on one hand and the need to develop and use them on the other.

RQOs have to be determined for a significant water resource as the means to ensure a desired level of protection. The purpose of the RQOs is to provide limits or boundaries (biological, physical and chemical attributes, etc.) which should be met in the receiving water resource in order to ensure protection. In determining the RQOs, it is important to recognise that different water resources will require different levels of protection.

The Chief Directorate: Water Ecosystems of the Department of Water and Sanitation (DWS) has through a recently completed study, determined RQOs for the Mokolo, Matlabas, Crocodile (West) and Marico catchments. With the water resources in these catchment areas having been classified, RQOs form the next step of the protection framework.

RQOs are important management objectives against which resource monitoring information will be assessed. Compliance monitoring will provide an indication as to whether the water resource class is being maintained. RQOs form important sustainability indicators for water resource management.

1.2 STUDY OVERVIEW

The main objective of the study was to determine RQOs for all significant water resources in the Mokolo, Matlabas, Crocodile (West) and Marico catchments. The RQOs have been determined in accordance with the DWS's Procedure to Determine and Implement Resource Quality Objectives.

The determination of the RQOs have considered the requirements of meeting the water resource class, the desired protection level, current and future water use and the needs of water users. The RQO process has taken account of land based activities and considered anticipated potential impacts that these activities may have on water resources within the catchment areas. The study has been primarily of a technical nature being guided by stakeholder and specialists' involvement.

Through this study, the resource units (RU) for the water resources in Mokolo, Matlabas, Crocodile (West) and Marico catchments were delineated and prioritised. Following on from RU prioritisation, as part of the RQO development process, selection of components and the identification of sub-components and indicators were finalised. The selected sub-components and indicators prioritised per resource unit formed the basis for development of RQOs and associated numerical limits, which has been guided by stakeholder consultation.

Based on the components and sub-components that were prioritised for the RUs draft RQOs and numerical limits for these have been formulated. The RQOs relate to the components, sub-components and selected indicators of each RU in the Mokolo, Matlabas, Crocodile (West) and Marico catchments. RQOs were set for rivers, dams, wetlands and groundwater. Numerical limits translate the narrative RQOs into numerical values which can be monitored and assessed for compliance. Numerical limits have been proposed where applicable for the RQOs set. The draft

RQOs proposed have been taken through various stakeholder consultation processes to obtain comments, guidance and inputs.

1.3 TOWARDS IMPLEMENTATION

The report focuses on providing a context to and guidance on the implementation of the determined RQOs for the Mokolo, Matlabas, Crocodile (West) and Marico catchments and identifies the implementation actions that should be undertaken within the water resource management framework that exists.

It must be noted that the implementation actions outlined cannot be undertaken in isolation but would need to be integrated into parallel management, strategy and regulatory processes of the Department Water and Sanitation (DWS) to ensure that implementation is achieved. The water resource classes and the RQOs form an integral component of the integrated water resource management process and informs the current and future planning, use, development, management and control of the water resources in the catchment areas.

Some of the activities needed to fulfil the requirements of the RQO implementation relate to functions that are currently performed by different Directorates and offices in DWS or even other institutions. Coordination among these institutions is essential and the allocation of particular responsibilities relating to these actions need to be formalised and added to their respective business plans.

However the mandate of reporting on the compliance to the RQOs and the achievement of the Water Resource Class resides with the CD: Water Ecosystems (WE) of the DWS.

1.4 DESCRIPTION OF THE STUDY AREA

The study area for the RQO Determination study is the Mokolo, Matlabas, Crocodile (West) and Marico Catchments (Figure 1) in the Limpopo Water Management Area (WMA). The spatial extent of the area includes tertiary drainage regions A10, A21 to A24, A31, A32, A41, A42 and quaternary drainage region D41A. Much of the area has low rainfall with significant inter-dependencies for water resources between catchments and with neighbouring WMAs.

The catchment areas lie predominately within the North West Province and include the northern part of Gauteng as well as the south-western portion of the Limpopo Province. Towards the north west the area borders on Botswana. The main river systems within the catchment (Crocodile, Marico, Mokolo and Matlabas rivers) flow northwards to join the Limpopo River. Major tributary systems include the Pienaars, Apies, Moretele, Hennops, Jukskei, Magalies, Elands, Klein Marico, Molopo, and Ngotwane rivers.

The Pilanesburg Nature Reserve, the Cradle of Humankind Heritage Site, the Marakele Nature Reserve, the Bafokeng Tribal area, the dolomitic wetland or eye systems and large dams such as the Hartbeespoort, Vaalkop, Roodekopjes, Klipvoor, Roodeplaat, Molatedi and Mokolo Dams are all very important features in the catchment area. The Pilanesburg Nature Reserve, the Cradle of Humankind Heritage Site and Hartbeespoort Dam are key tourist attractions in South Africa.

The area is altered by catchment development, with economic activity dominated by urban areas and industrial complexes of northern Johannesburg and Tshwane, with platinum mining north-east of Rustenburg, and power generation and mining. In the Lephalale area, economic activity is mainly

centred on commercial agriculture, together with increasing mining operations, game and livestock farming and eco-tourism. The major land-use is irrigation farming, with private and provincial nature reserves as well as extensive coal mining and platinum mining. Parts of the catchment area are also largely rural in nature.

The water resources of the catchment area support major economic activities and a population of approximately 5.0 million people. The surface water potential of the area has largely been developed. Large dolomitic groundwater aquifers occur along the southern and north-western part of the area. The southern aquifers are utilised extensively for urban and irrigation purposes. Groundwater is therefore used extensively. However, over exploitation occurs in certain areas. Several inter-water management area transfers exist, all of which bring water into the catchment. A transfer from the Crocodile (West) catchment into the Mokolo catchment is being planned to support the power generation and expected growth in mining in the Lephalale area.

1.5 PURPOSE OF THE REPORT

This report focuses on providing information that can be used towards implementation of the water resource classes and RQOs in the Mokolo, Matlabas, Crocodile (West) and Marico Catchments. It provides high level guidance and information on implementation requirements, activities and actions necessary to achieve compliance, but however does not constitute a detailed implementation plan. The information provided here forms a framework which serves to guide the development of detailed business plans of the CD:WE, other relevant DWS directorates, regional offices and the Proto Catchment Management Agency (CMA), which would need to incorporate roles and responsibilities, the availability of budgetary and human resources; definition and schedule of activities; set implementation priorities and time lines; define institutional arrangements and reporting procedures.

Successful implementation of the water resource classes and RQOs, will also require co-ordination among the responsible role players and relevant. This may require the establishment of management committees of national and regional personnel, to work out a co-ordinated plan of what must happen, when, how it is to be achieved and who is accountable. This process would also need to specify reporting requirements and reporting periods. Thus, it is important that the institutional roles and responsibilities be clearly understood and defined, and that the implementation be facilitated through co-ordinated approaches and activities.

The main objectives of this implementation plan framework are to:

- Outline the actions required to achieve the implementation of the RQOs;
- Assign roles and responsibilities to implement RQOs; and
- Describe a communication plan.

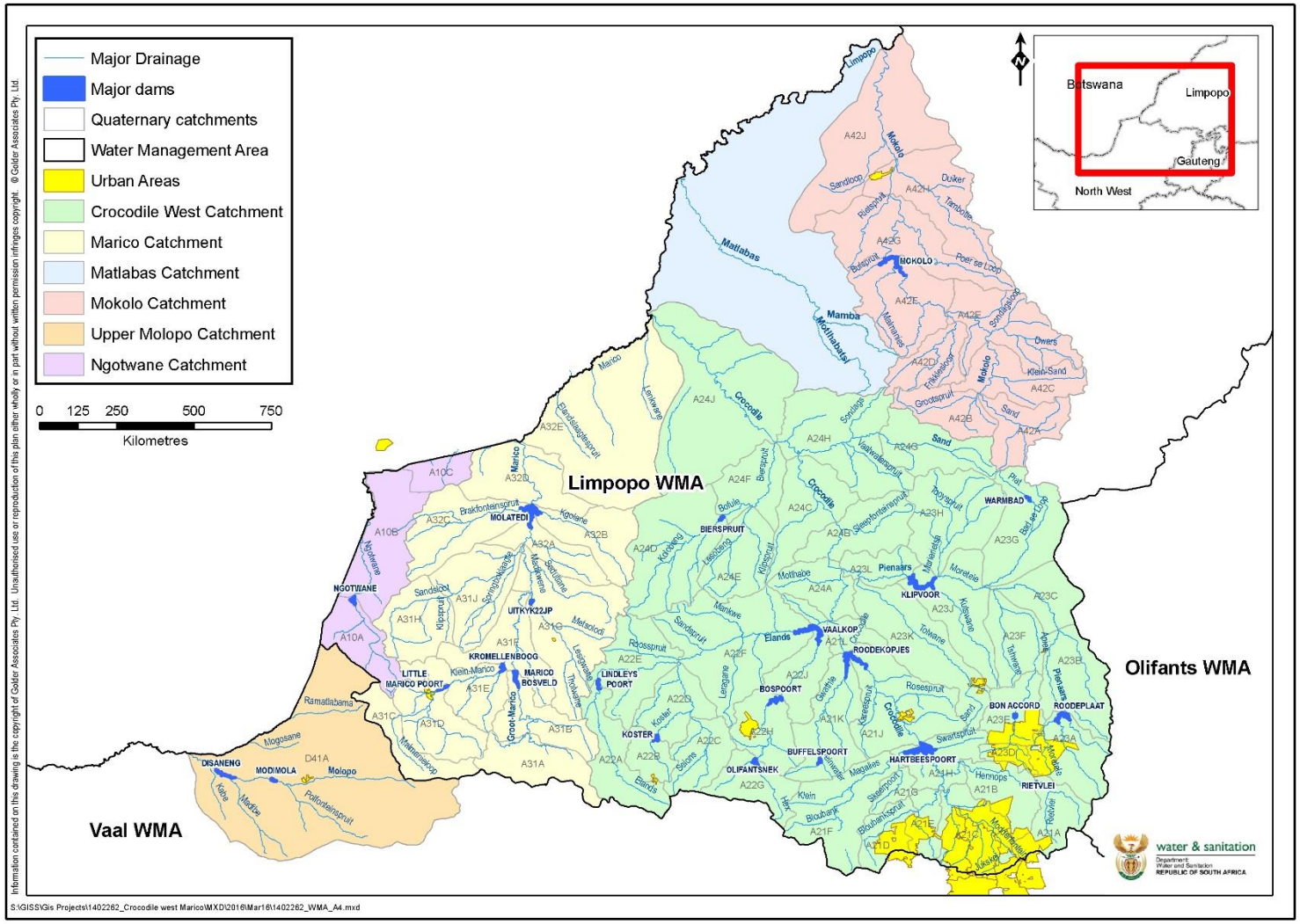

Figure 1: The Study Area - Mokolo, Matlabas, Crocodile (West) and Marico catchments

2 IMPLEMENTATION CONTEXT

The facilitation of RQO implementation will function within the current integrated water resource management (IWRM) and regulatory environment and therefore integration with existing processes is a requirement for developing an implementation plan. Actions are linked and dependent on a number of processes and role players.

RQO implementation would be facilitated through the context of the protection, use, development, conservation, management and control measures that exist for the water resources in the catchment, as follows:

- Water Resource Protection informed by the:
  - Water Resource Classes;
  - Preliminary Reserve, and
  - Pollution Prevention

  These protection measures are inherent to the RQOs and informed its development. The RQOs will give effect to the water resource class and Reserve. Linkages with and initiation of compliance monitoring and reporting is necessary to determine achievement of the class through RQO implementation.
  In terms of pollution prevention, RQO implementation may require that specific steps be taken to address current non-compliances to ensure that the RQOs are met.

- Water resource planning, development and use informed by:
  - Reconciliation Strategies (planning of interventions to increase availability and reduce water use through loss control and efficiency measures).
  - Feasibility studies and construction of infrastructure options;
  - Water quality management strategies;
  - Water conservation and demand management strategies; and
  - International agreements and treaties.

  RQO development has been guided by the Crocodile West River System Reconciliation Maintenance strategy interventions. Implementation of the planning, development and use measures will however have to adhere to the RQOs, by refining requirements, options and strategies to account for the flow and quality requirements (such as implementing EWR requirements, releases for dilution, or reduced availability of surface or groundwater for use). Update and refinement of reconciliation strategy would be necessary.
  The development of specific strategies, such as a water quality management strategy is required.

- Operational planning and implementation:
  - Operating Analysis providing decision support information;
  - The planning and execution of infrastructure maintenance activities influencing operational decisions and feeding into the above function; and
  - Integrated operation and control of infrastructure on a daily basis.

  RQO implementation requires operational and implementation activities (operation, control and maintenance) to be revised to meet the requirements. Implementing the operating rules in terms of the key driver (flow requirements) to ensure that the releases from infrastructure required by the ecology and users and are met at the EWR site. This may consist of the

operation of dams, abstractions and other infrastructure as well as management through water use authorisation and implementation of restrictions amongst other measures.
Water quality modelling and flow modelling is necessary to support the operation of the system.

- Regulatory and control functions:
  - Regulations governing water use and land based activities;
  - General authorisations;
  - Water use authorisations;
  - Compulsory licensing;
  - Validation and verification of water use; and
  - Discharge Standards

  The various instruments regulating water use may require revision or refinement or stricter enforcement to support RQO compliance. New regulations may be required to be developed to control land use activities. A water allocation strategy may be required. Implementing water quality source control measures is a necessity.
- Monitoring, Assessment and Information on:
  - quantity of water;
  - quality of water;
  - use of water resources;
  - rehabilitation of water resources;
  - health of aquatic ecosystems, and
  - compliance with resource quality objectives.

  The continued and co-ordinated monitoring of various aspects of water resources (as listed above) by collecting the relevant information and data to assess the compliance to RQOs is necessary. Reporting on RQO compliance would then be required. This has specific linkages to the various monitoring and assessment programmes of the DWS, as well as other institutions and municipalities.
- Maintenance (Execution) and Remedial Actions: Land based activities, pollution control, infrastructure management, operational decisions and activities related to operational functions may require remedial action measures or maintenance adjustments. (Monitoring feeds into this process and yields compliance information).

  Based on the RQO compliance results and non-conformances identified corrective action would need to be instituted. Management of programmes and initiatives such as clearing alien vegetation, pollution control measures (treatment plants/processes); protection zoning, water use control, etc. operation of dams, flow regulation may require adjustment.
- Institutional arrangements:
  - DWS national, regional and local level, and amongst government departments and authorities, municipalities and relevant water institutions.

  Linkages, integration, roles and responsibilities would need to be defined and allocated to the role players to facilitate RQO implementation.

As apparent from the context outlined above; RQO implementation extends across institutional, functional and operational levels of the DWS and would require a co-ordinated, integrated approach with clear roles, responsibilities and accountability assigned. The implementation will be required to integrate into these parallel water resource management processes and activities. The RQOs form the sustainability indicators of the water resource and compliance would reflect whether sustainable

water resource systems with a desired level of protection are being achieved.

The Limpopo/North West is a region where the CMA has not yet been established, however a proto CMA is in place. With support from the North West and Limpopo Regional and National DWS Offices, the Limpopo/North West proto CMA will continue to manage the water resources in the WMA.

3 IMPLEMENTATION COMPONENTS

There are a number of water resource processes that have been and are being undertaken in the Limpopo WMA that are needed to facilitate the implementation of the RQOs. Compliance with RQOs is not achieved through new mechanisms or processes but rather is facilitated through current and existing measures, processes, functions, activities and instruments that are governed by the NWA (Act No. 36 of 1998) and applied to water resource management in a catchment.

The key implementation components identified for the achievement of the RQOs and the water resource class include the following:

3.1 GAZETTING OF THE RESOURCE QUALITY OBJECTIVES

Classification of significant water resources for the Mokolo, Matlabas, Crocodile (West) and Marico Catchments was undertaken in 2013 and the proposed water resource classes were gazetted for comment in Government Gazette No 37999, 19 September 2014 (GN 818 of 2014).

The gazetting of the final water resource classes and RQOs is required to enable its implementation and operationalisation. The gazetted RQOs are legally binding and enforceable and must be integrated to all other processes, strategies and activities in the WMA.

3.2 OPERATION OF THE SYSTEM

Once gazetted, the quantity RQOs (flow requirements) must be met, and the water balance and reconciliation strategies for the Crocodile (West), Mokolo and Marico would have to be updated/developed to accommodate these. Interventions related to the water resources especially the stressed and over utilised and those in high conservation areas will require integrated operating rules to provide the necessary release plan for achieving and maintaining the EWRs. Improved operation of the system and management of the various impoundments and water uses will also be required, to ensure that all user requirements are met and to maintain the EWRs through the system

This will require implementation related to:

- Planning interventions;
- Operational analysis and control of infrastructure; and
- Maintenance and management operating rules.

3.3 WATER QUALITY MANAGEMENT

Implementing water quality management measures are necessary to ensure the achievement of the water quality RQOs. This component is integral to the sustainability and protection of the water resources. Water quality deterioration is occurring in many areas of the catchment (some areas are under threat) and improvement is necessary to ensure protection afforded through the Class and RQOs.

Currently a water quality management strategy and plans are absent for the Mokolo, Matlabas, Crocodile (West) and Marico catchments (so to an overarching plan for the Limpopo/North West WMA) which poses a challenge in terms of implementing the water quality RQOs.

3.4 MONITORING PROGRAMMES AND NETWORKS

Monitoring is an integral component of RQO implementation and compliance reporting. In order to support effective management actions ("you can only manage what you can measure"), the design and implementation of effective monitoring networks and repository databases is pivotal to RQO implementation.

Currently the DWS does have national monitoring programmes in place for hydrological monitoring, water quality monitoring and groundwater monitoring. These programmes would have to support the monitoring of the EWRs sites (quality and quantity), additional flow gauges, other key points and groundwater sites. However at present the flow gauges, water quality monitoring sites or boreholes are at locations/sites that are not necessarily linked to EWR sites, resource units or groundwater monitoring areas. In many instances, where they are present, the monitoring sites may be inactive or do not support the monitoring needs of the RQOs. There are also vast gaps in data as well as a lack of integration in the monitoring programmes to generate the information required.

Compliance geohydrological monitoring based on monitoring low flows and water levels at gauging weirs and boreholes is required. An integrated monitoring programme is also required to monitor the condition/health/state of the wetlands in the catchment area.

Thus, this is an integrated activity that needs co-ordination within and outside the DWS to support the implementation of the RQOs. Monitoring that forms a key component of RQO implementation.

3.5 ECOLOGICAL WATER RESOURCES MONITORING

The monitoring of the biota and habitat RQOs is undertaken through ecological water resource monitoring, at EWR and other key sites (response monitoring of the ecological status of the water resources). Ecological water resource monitoring is undertaken through the River Eco-status Monitoring Programme (REMP). The REMP evolved from the River Health Programme (RHP) and is a component of the DWS National Aquatic Ecosystem Health Monitoring Programme (NAEHMP). The REMP focuses on the monitoring of the ecological conditions in river ecosystems as it is reflected by the system drivers and biological responses (instream and riparian).

Ecological Water Resource Monitoring (EWRM) therefore measures whether the ecological RQOs are being met. A recent development in EWRM is the Rapid Habitat Assessment Method and Model (RHAMM). The RHAMM is a process to collate relevant habitat information in a cost-effective manner for EWRM monitoring.

Co-ordination and integration of the ecological monitoring of the Mokolo, Matlabas, Crocodile (West) and Marico catchments (habitat and biota) into existing programmes is required to optimize and ensure efficient utilization of resources and effort. In addition, it is important that all biomonitoring data is incorporated into the NAEHMP on a continuous basis to provide a solid and complete repository of information. The ecological water resource monitoring should establish linkages with other national, regional and local biomonitoring programmes in the catchment area to expand the database available. All the data should be made available through the NAEHMP for compliance reporting of the RQOs.

This is an implementation component that must be addressed through the Chief Directorates' Water Ecosystems and the Water Monitoring and Information and possibly the provincial Departments of Environment of the North West and Limpopo.

3.6 REGULATION AND CONTROL

Implementation and achievement of the RQOs, in addition to implementing basin wide operational and water quality interventions will require regulation and control of water use and development. This will require improvement of compliance and enforcement of existing water use authorisations. It will also necessitate improved and wider monitoring, auditing and control of the water resources and their use to understand the impacts and non-compliances in the system, as well as actions that prevent pollution. Based on the information provided from these measures, compulsory licensing, increased regulatory measures, incentives, management actions, prohibition of land based activities and other measures may be required to achieve compliance with the RQOs.

Operational requirements and management measures in place would also inform new water use authorisations applications and guide development on a catchment basis. Management tools to model system behaviour (quality and flow) based on the RQO requirements, are required to regulate and control water use.

This function and related activities are central to achieving compliance to the RQOs.

3.7 COMPLIANCE REPORTING

Reporting requirements are fundamental to informing adaptive management relating to whether the RQOs are being met or not. DWS would need to respond with appropriate action based on the monitoring and compliance reporting on the RQOs in the Mokolo, Matlabas, Crocodile (West) and Marico catchments.

Thus, the DWS monitoring programmes and other reporting mechanisms must account for RQO compliance information. This will require liaison and establishment of programmes amongst the Chief Directorates' Water Ecosystems, Compliance Monitoring and Water Monitoring and Information.

The various DWS Directorates and the Limpopo/North West Proto CMA will be the responsible authority to oversee the implementation of the RQOs. In the Mokolo, Matlabas, Crocodile (West) and Marico Catchments, the following comprise the strategies, process and activities that will need to be addressed at varying levels to facilitate the achievement of the RQOs:

Table 1: Strategies, Processes and Activities to facilitate achievement of the RQOs

No	Water Resource Management Strategies/Processes/Activities	Requirement for RQO implementation to be achieved
1	Final Gazetted Water Resource Classes and Resource Quality Objectives	Gazetted water resource classes and RQOs to be adopted as the legal binding protection framework for the Limpopo North West WMA (South) incorporated into the business plans of the DWS Chief Directorates and Limpopo North West Proto CMA/Regional Office. This will also require an establishment of a management committee to direct and oversee implementation.
2	Catchment Management Strategy	Must be incorporated into the CMS in terms of implementation actions required for the RQOs

No	Water Resource Management Strategies/Processes/Activities	Requirement for RQO implementation to be achieved
		that have to be met. Has linkages to a number of strategies and activities namely: water allocation, water regulation, source directed controls, water use authorisations, compliance and enforcement, monitoring, will require co-operation of all catchment based institutions and DWS National and Regional.
3	Maintenance of the Reconciliation Strategy: Crocodile West River System (2012) Limpopo Water Management Area North Draft Reconciliation Strategy (2016)	Revise/update the Crocodile West River and Limpopo Water Management Area North Reconciliation Strategies based on the Gazetted RQOs and account for implementation of the EWRs.
4	Reconciliation System Operation Strategy for the Marico River Catchment area	Develop a Reconciliation Strategy
5	Operating Analysis and system operation	Integrate into operational planning and control of infrastructure and maintenance and management of operating rules. Assessment of the flows is required in the respective catchment systems to inform the release plans and water quality in each area. Establish installed real time models to manage options and releases.
6	Institutional arrangements	Linked to a number of activities and programmes. Roles and responsibilities within and among National government, Regional and local structures must be specified in terms of business plans for each implementing agent so that actions can be carried out and there is accountability in terms of reporting.
7	Integrated Water Quality Management	An integrated water quality management strategy must be developed with sub-catchment strategies for each of the Mokolo, Matlabas, Crocodile (West) and Marico catchment areas. This is a priority in order to manage water quality impacts and deteriorating water quality specifically in the Crocodile (West), Marico and Molopo catchments.

No	Water Resource Management Strategies/Processes/Activities	Requirement for RQO implementation to be achieved
8	Regulation, Use, Control	Integration of RQO implementation requirements in regulation, use and control activities, programmes and measures for the Limpopo/North West WMA. RQO implementation will inform specific regulatory actions and new regulations may be required. Source controls/pollution prevention measures, water use authorisations, water allocation measures need to instituted or revised.
9	Monitoring	Revision of monitoring networks and programmes for surface water and groundwater is required. New sites and weirs, activation of inactive sites and monitoring boreholes must be evaluated to extend the monitoring networks. Additional resources are needed. Integration of national and regional programmes. Integration of programme and actions into the CMS. New monitoring networks to include wetlands are required. Integration with the SANBI progammes for wetlands should be undertaken. Hydrological monitoring must be undertaken. User, municipal, water boards and DWS monitoring programmes must be integrated.
10	Ecological Water Resource Monitoring	Co-ordination and integration of the ecological monitoring of the RQOs (habitat and biota) into existing programs is required to optimize and ensure efficient utilization of resources and effort. All biomonitoring data is incorporated into the DWS national database on a continuous basis to provide a solid and complete repository of information. This should be inclusive of wetland systems.
11	Transboundary Obligations	Currently a transboundary obligation exists with Botswana for releases from Twasa weir at Molatedi Dam. This should be reviewed and assessed based on the water resource classes and RQOs.
12	Groundwater Management	A Groundwater management plan for the catchment area must be developed that incorporates extent of groundwater use,

No	Water Resource Management Strategies/Processes/Activities	Requirement for RQO implementation to be achieved
		revision and development of a groundwater monitoring programme and network, groundwater protection zoning, groundwater surface water interaction and implementation of the groundwater RQOs.
13	Wetlands Component	A management plan for protection and monitoring of the wetlands in the catchment area must be must be developed.

4 ACTIONS/INTERVENTIONS TO ACHIEVE IMPLEMENTATION

The following section focuses on the recommended requirements, activities and actions that are required to achieve the RQOs.

Narrative RQOs with numerical limits have been developed for the RUs in the Mokolo, Matlabas, Crocodile (West) and Marico catchments. These relate to specifications set for water quantity (flow), water quality, habitat and biota of rivers and have been set based on Target Ecological Category (TEC) related to the water resource classes as well as guided by specific water users, land based activities/impacts or conservation/protection priorities identified in the resource units. The groundwater component of the Reserve and wetlands Reserve have also been specified and require additional specific implementation actions.

The activities/actions to achieve the implementation of the RQOs include:

- Management of the flow and operation of the system to achieve the desired flow at the related EWR site;
- Management of the integrated releases from the various dams in the system to achieve the EWRs;
- Integrated water quality management interventions to control and manage non-flow related impacts and associated monitoring activities;
- Actions to support habitat and biological integrity requirements of the water resources;
- Regulation, control and enforcement interventions to ensure that the RQOs determined are adhered to;
- Actions and interventions related to the implementation of the groundwater RQOs;
- Actions and interventions related to the protection and sustainable management of wetland and development in the wetlands;
- Monitoring of water resources to collate the required date, undertake the necessary assessment and provide the required information;
- Compliance reporting requirements; and
- Resourcing and Institutional requirements.

Table 2 describes the activities and actions related to the above required for RQO implementation.

Table 2: Proposed activities and actions required for RQO implementation

Requirement	Activity	Action	Completion	Responsibility
1) Flow Management				
The required temporal and spatial flow as specified by the RQOs must be achieved/implemented at the EWR sites and flow points in the system.	Integrate EWRs into the Reconciliation Strategy maintenance requirements.	Update and revise and water requirements and water balances for the Crocodile (West)	November 2018	CD: Integrated Water Resources Planning in collaboration with the CD: WE
		Update/develop the Reconciliation Strategies for the Marico and Mokolo catchments. Include EWR requirements.		
		Adjust water reconciliation in all catchments to cater for implementation of the EWRs.		
		Implement EWRs		
Flow management monitoring is required	Develop a flow monitoring programme order to ensure flows present in the system. This will provide information on whether RQOs are complied with.	What: Measure flow – compare to EWRs/flow requirements	November 2019 Monitoring should be ongoing – with quarterly reporting	CD: Water Monitoring and Information, CD: Integrated Water Resources Planning, CD: WE
		Where: Identify which flow gauges will form part of the monitoring programme (existing, and where required new weirs must be built. In addition, sites where *in situ* measurements are required must be confirmed). It is proposed that flow is measured at all EWR sites.		
		Frequency: Determine how often flow monitoring will be undertaken at the sites?		
		Who: Specify who will be responsible for the flow monitoring and data management.		

Requirement	Activity	Action	Completion	Responsibility
		Ensure that the flows at the weirs are measured so that releases can be made in order to meet the recommended EWRs. Confirm which weirs are to be included.		
		Compare flows with the recommended EWR flows and ensure that flows are released accordingly to meet the requirements.		
		Capacitate the necessary resources within DWS to undertake the flow monitoring and data management.		
	Base flow contributions to surface water flow must be determined	Base flow requirements of resources in close proximity of rivers with needs to be assessed in IUA 13 and IUA 16 (Lower Crocodile and Lower Mokolo).	December 2019	CD: Water Monitoring and Information, CD: WE, Directorate: Water Resource Planning Systems
		Status of contribution to base flow needs to be evaluated in IUAs 8 and 10		
2) Operation of the System				
Update of Operational analysis and control of infrastructure is required to meet RQOs for quantity	Ensure required updates to system operational analysis, operation and control are undertaken.	Update of the operational analysis of the system based on the reconciliation strategy.	March 2019	CD: Integrated Water Resources Planning (Directorate:Water Resource Planning Systems and Sub-Directorate: Systems Operation) to lead in collaboration with the CD: WE National Water Infrastructure Branch (Northern Operations) and area offices
		Update operating rules to cater for EWR releases at all the dams.		
		Develop an operational plan to identify flow releases, operate the system as an integrated system, to maintain the EWRs and to also maintain the supply to the end-users.		
		Develop an operational tool to manage the EWR release pattern, timing and measurements together with the releases for the other water users in the various catchments.		

Requirement	Activity	Action	Completion	Responsibility
		Use a combination of actual flow data and modelling results to direct operational flow management		
		Implement new operating rules.		
Management of releases from Dams	Required releases are made from dams at correct frequency, duration and release pattern	Update/develop dam operating rules. Dams must be operated as integrated and linked systems. This would be typically done using the WRPM and the dam operation is calculated annually. The operating rules should take into account the water quality aspects of operating the dams at low water levels.	March 2019	CD: Integrated Water Resources Planning, Directorate Water Resource Planning Systems, to lead in collaboration with the CD: WE. Limpopo North West Proto CMA/Regional office National Water Infrastructure Branch (Northern Operations) and area offices
		A real time operational model should be in place to manage discharges. Integrate with flow tool.	September 2019	
		Flow release management from the following major dams need to be implemented to meet the recommended EWRs: • Hartbeespoort • Roodekopjes Dam • Klipvoor Dam • Roodeplaat Dam • Bospoort Dam • Vaalkop Dam • Klein Maricopoort Dam • Marico Bosveld Dam • Molatedi Dam* • Mokolo Dam *The revision of the TSWASA agreement with Botswana indicated that there is already over allocation in most sub-systems including the use of Molatedi	June 2019	

Requirement	Activity	Action	Completion	Responsibility
		Dam by Gaborone, and that use of this dam needs to be reduced to allow for sustainable use of the dam, and for release of EWRs.		
3) Water Quality Management				
Water quality RQOs must be complied with.	Develop a water quality management strategy for the Limpopo North West WMA (South) and water quality management plans for the Mokolo, Matlabas, Crocodile (West), Marico and Ngotwane sub-catchments. Implement targeted interventions to address water quality impacts.	Develop water quality management plans for all the catchments in the study area, prioritizing the Crocodile (West), Marico and Lower Mokolo focussing specifically on: TDS reduction and non-compliant WWTW discharges in IUAs 1, 2, 6a, 9, 14 and 16.	June 2019	Sub-Directorate: Water Quality Planning Limpopo North West Proto CMA/Regional office Directorate: Resource Protection and Waste (D: RPW)
		Develop the water quality planning limits for the sub-catchments (based on the RQOs). This would inform discharge standards included in water use authorisations.	June 2019	Sub-Directorate: Water Quality Planning Limpopo North West Proto CMA/Regional Office D:RPW
		Develop a water quality model to determine the contaminant loads and behaviour through the system. This would inform load allocations and apportionment to specific land based sources and water use authorizations.	December 2019	Directorate: RPW Sub-Directorate: Water Quality Planning
		Develop a nutrient balance using the available instream flow and water quality data required to understand the system. The balance must include all the point sources and estimates of the wash-off loads from urban and agricultural areas. The monitoring of the return flows from the irrigation schemes will support the nutrient balance study.		Directorate: RPW Sub-Directorate: Water Quality Planning
		An assessment of discharge standards is required to address non-compliances (support compliance to water quality RQOs).	March 2019	Limpopo North West Proto CMA/Regional Office Directorate: RPW

Requirement	Activity	Action	Completion	Responsibility
		Develop monitoring and management measures for identified acid mine drainage impacts in the Crocodile catchment. Localised pollution impacts (especially from mine discharge and industries) on the aquifer systems in IUAs 1 and 2 to be investigated.	March 2019	Limpopo North West Proto CMA/Regional Office Chief Directorate: Compliance Monitoring Chief Directorate: Water Quality Management (CD: WQM
		Assess the impacts of the sand mining on the Lower Mokolo River and implement appropriate management measures	March 2019	Limpopo North West Proto CMA/Regional Office
		Address management of wastewater discharges and non-point source impacts in the catchment areas related to mining and urbanisation.	December 2019	Limpopo North West Proto CMA/Regional Office
		The numerous non-compliant wastewater treatment works (WWTW) discharges must be addressed throughout all the catchment areas. Continual and annual auditing of WWTWs within the catchment areas is required as a matter of priority to prevent any further water quality deterioration.	March 2019	Limpopo North West Proto CMA/Regional Office
		An integrated and revised water quality monitoring network and database management system should be developed and in place within a year of gazetting of the final RQOs.	December 2019	CD: Water Monitoring and Information, CD: WE, and Limpopo North West Proto CMA/Regional Office
	Implementation to be achieved through catchment institutional structures	Set up the necessary institutional structures to support the water quality management activities. Resourcing and institutional arrangements regarding the monitoring activities and information management must be specified.	December 2019	Limpopo North West Proto CMA/Regional Office Directorate: Resource Protection and Waste
4) Habitat and Biota				

Requirement	Activity	Action	Completion	Responsibility
RQOs for fish, macroinvertebrates and habitat integrity must be complied with.	Assess compliance to fish, macroinvertebrates and habitat ecological specifications at each EWR site (and additional sites specified)	Conduct the instream and riparian habitat integrity as this is a precursor of the assessment of biotic integrity.	December 2018	Directorate: Resource Quality Information Services (D: RQIS) CD: Water Monitoring and Information Limpopo North West Proto CMA/Regional Office In collaboration with Provincial Departments of Environment
		Set up biomonitoring programme		
		What: Measurement in terms of numerical limits and ecological specifications		
		Where: EWR sites and additional biomonitoring sites as specified (Identify which sites will form part of the biomonitoring programme. In addition, sites where specific species/data measurements are required must be confirmed).		
		Frequency: Determine how often biomonitoring will be undertaken at the sites?		
		Who: Specify who will be responsible for the biomonitoring and data management.		
		Undertake a general habitat assessment.	Ongoing – quarterly basis	
		Measure ecological category		
		Undertake following assessments as required: ○ Rapid Habitat Assessment Method and Model (RHAMM) ○ Integrated Habitat Assessment System (IHAS - version 2). ○ Aquatic Macroinvertebrates (SASS5) ○ Ichthyofauna (fish): focus on fish species diversity and abundance, fish health assessment and the presence of Red Data species.		

Requirement	Activity	Action	Completion	Responsibility
		○ Fish Response Assessment Index (FRAI) ○ Diatoms		
		Assess approved Reserve to see whether it needs to be updated.	March 2019	
		Generate required reporting and information on a periodic basis to assess meeting of the RQOs and check if the river health is responding as specified/expected. Implement interventions if and as required.	Ongoing – quarterly basis	CD:WE
	Restore habitat integrity and improve instream habitats.	Eradicate and control alien invasive species alien vegetation and especially in IUAs 6a and 6b	March 2021	Limpopo North West Proto CMA/Regional Office
		Assess the impacts on habitats due to increased return flows from WWTWs.	December 2019	Limpopo North West Proto CMA/Regional Office
		Assess the impacts of the sand mining on the instream habitat of the Lower Mokolo River and implement interventions to restore habitat.	December 2019	Limpopo North West Proto CMA/Regional Office
		Erosion control measures should be implemented.	March 2021	Limpopo North West Proto CMA/Regional Office
RQOs for dams must be implemented and monitored.	Improve dam habitats	Institute necessary programmes to remove nuisance plants identified in many of the dams in the Crocodile (West), Marico and Ngotwane catchments. Apply hyacinth management programmes. Many dams are under threat and require urgent intervention.	March 2020	Limpopo North West Proto CMA/Regional Office Other CDs in DWS D:RQIS Department of Environment Affairs (management of semi-aquatic ecosystem)
		Develop management plans for each of the dams to protect habitat and aquatic and semi-aquatic ecosystem diversity and support the users.		

Requirement	Activity	Action	Completion	Responsibility
	Determine presence of semi-aquatic species (birds and mammals) supported by each dam habitat	Undertake the necessary baseline assessments to determine the aquatic bird population and representative mammal species present in riparian zones ans artificial shorelines.		
5) Regulation and Control				
Improved regulation and control is required in the catchment area for RQO compliance.	Develop, revise or update instruments regulating water use and enforcement to support RQO compliance.	Develop new regulations required to control land use activities: specifically in the Magalies (IUA2); Upper Marico (IUA 6), Kaaloog se Loop (IUA7); Matlabas (IUA 17), Upper Mokolo (IUA 15) to ensure required protection and preserve conservation areas, and in the Upper Crocodile catchment to prevent further deterioration of water resources.	March 2021	CD:WE CD: Water Use Authorisation Branch: Regulation
		Develop a water allocation strategy based on water availability and in relation to load allocation (linked to reconciliation and water quality management strategies respectively).	December 2023	Limpopo North West Proto CMA/Regional Office CD: Water Use Authorisation
		Review trends of current discharge standards for WWTW and industries in the Crocodile (West) catchment.	December 2019	
		Implement necessary water quality source control measures all catchment areas.	December 2019	Limpopo North West Proto CMA/Regional Office CD: Water Use Authorisation
		Improve on the monitoring and enforcement of water use authorisation conditions. Review of water use authorisations may be required.	Ongoing –Annual auditing	
		Eradicate unlawful water use in all catchments.	December 2021	
6) Monitoring				

Requirement	Activity	Action	Completion	Responsibility
An integrated activity that needs co-ordination within and outside the DWS to support the implementation of the RQOs. Monitoring that forms a key component of RQO implementation.	Establish Ecological resource monitoring	The ecological water resource monitoring programme must be established as part of the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) and implemented for the Mokolo, Matlabas, Crocodile (West) and Marico catchments to assess compliance and determine if the target ecological categories are being achieved.	December 2018	Limpopo North West Proto CMA/Regional Office CD: Water Monitoring and Information
		Undertake surveys and monitoring to determine any changes in the ecological categories and the trajectory of change. Determine frequencies and establish networks. Integrate with the existing structures and programmes.	Ongoing – quarterly basis	
		Ensure the biomonitoring data is loaded on the central repository (NAEHMP database), updated regularly and maintained.	Ongoing	
	Flow and water quality monitoring	Update the temporal and spatial extent of the water quality and flow monitoring programmes to allow a higher level of confidence in the results for the EcoSpecs and desired RQOs.	December 2019	CD: Water Monitoring and Information Limpopo North West Proto CMA/Regional Office
		New sites and weirs, activation of inactive sites must be evaluated to extend the monitoring networks.		
	Flow monitoring	Implement flow monitoring programme.	January 2020	
		Maintain flow gauges.	Ongoing	
	Water quality monitoring	Implement water quality monitoring programme for RQOs.	December 2019	CD: Water Monitoring and Information

Requirement	Activity	Action	Completion	Responsibility
		What: Sample/measure RQOs sub-components and indicators as specified. *Where*: Water quality monitoring sites through the system (at least a site within each RU) and at EWR sites. In addition, sites where specific water quality issues or problems are known to occur or data is required. *Frequency*: Monthly, for review after two years		CD: Water Monitoring and Information Limpopo North West Proto CMA/Regional Office
		All existing monitoring points (not only those linked to the DWS chemical monitoring programme) should be identified before new monitoring points are set up, as existing points, e.g. linked to compliance monitoring for an industry or municipality, could be used as long-term points.	December 2019	CD: Water Monitoring and Information Limpopo North West Proto CMA/Regional Office
		The suite of water quality parameters to be monitored per catchment must be extended to include the water quality RQOs, if required.		Limpopo North West Proto CMA/Regional Office CD: Water Monitoring and Information
		Initiate and maintain additional water quality monitoring points as specified as part of water quality monitoring programme developed for the catchment area.		
		Consolidate water quality data collected from the different water quality databases and assessments to provide a consolidated view of the water quality trends within the catchments.	Ongoing	
		An important aspect of water quality monitoring is methods and data quality, including the length of data records used for compliance monitoring. Although the use of percentiles of water quality data is acceptable practice for statistically		

Requirement	Activity	Action	Completion	Responsibility
		summarizing data, it is necessary to define data quality and length of an acceptable data record when calculating percentiles.		
	Dam monitoring	Based on the RQOs per Dam unit, undertake monitoring related to o Fish surveys, bird counts o Sediment surveys o Water quality parameters as per components.		
Financial and human resources	Specify resourcing and institutional arrangements regarding the monitoring activities and information management.	Develop a business plan for the monitoring activities and information management. Specify the manpower and budgetary requirements.	March 2020	CD:WE CD: Water Monitoring and Information Limpopo North West Proto CMA/Regional Office
		Secure the required funding.		
		Build and resource the necessary capacity required.		
7) Groundwater				
Aquifer related management options are required in terms of the different aquifer types identified for the for the Mokolo, Matlabas, Crocodile (West) and Marico catchments (See Appendix A for types and prioritized groundwater areas)	Update GRA II dataset including verification of the WARMS database (water use figures) - in order to update water user locations and water use figures to current values for all catchments.	Apply to all prioritized groundwater resource units in the study area.	December 2019 Ongoing	CD: Water Use Authorisation CD: Water Monitoring and Information (Groundwater functions) Directorate: Surface and Groundwater Information Sub-Directorate: Integrated Hydrological Planning Limpopo North West Proto CMA/Regional Office
		Verify groundwater use in terms of the topocadastral property name/number. The application of the Stress Index requires a representative value for groundwater use of the RU in question. Due to the volumes of groundwater use being unreliable and stress indices can't be based as is on the WARMS dataset. The WARMS dataset is not correct in terms of the actual coordinates- needs urgent attention.		

Requirement	Activity	Action	Completion	Responsibility
		The Stress Index algorithm requires the recharge value, *viz,* the actual recharged rainwater reaching the saturated zone (aquifer system) based on approved methodologies, *i.e*. the Chloride Mass Balance (CMB) methodology, proves to be the simplest. Obtain a good understanding of the mass balance of the atmospheric, and groundwater chloride input. Apply long-term datasets to produce results to correlate recharge values for the aquifer systems.		
	Groundwater quality and aquifer level assessment To support estimation of groundwater recharge and calculations of more accurate and point source Stress Index values.	Applicable to all prioritized groundwater resource units in the study area and specifically to the dolomite water areas due to their high yields (significant abstractions) and high pollution risks (direct recharge path ways).	December 2019 Ongoing	CD: Water Monitoring and Information (Groundwater functions) Directorate: Surface and Groundwater Information Sub-Directorate: Integrated Hydrological Planning CD: Water Use Authorisation Limpopo North West Proto CMA/Regional Office
		Reference water quality status for RUs, quaternary catchment and IUAs must be generated on timely assessment of bulk groundwater chemistry datasets to obtain a reference water quality status (see discussion on the 3-Tier protection zoning below). Currently long-term groundwater quality data is scarce and does not provide a representative history of the long-term trends in groundwater quality which is an indicator of aquifer health and land use impacts. Water quality monitoring by water users, specifically mines and industries are significant, but can't be used as indicators for– it gives a false indication of the reference water quality which required.		
		Apply a limit on the annual groundwater recession rate (a time series of water		

Requirement	Activity	Action	Completion	Responsibility
		levels/trend analysis) to address groundwater levels. A recession rate is not applicable to the activity area due to cases where aquifer dewatering is required for safe mining conditions, however, in cases where abstractions for irrigation and bulk water supplies occur, a limit and the annual water level recession per aquifer system is proposed, i.e. 0.5 or 1.0 m/a for dolomite and non-dolomite aquifer systems respectively. The surrounding area's water level trends should, however, be monitored and reference water level trends obtained and used as a guideline.		
		An annual water level recession limit in the case of dolomite water areas should be applied to dolomite compartment units, which are mapped and demarcated already, *viz*, groundwater resource units. If required, the DWS should request a finer demarcation into sub-compartment units to control the impacts of recession on private and national infrastructures, *i.e*. private homes and national roads for example.	March 2020	CD: Water Monitoring and Information (Groundwater functions) Directorate: Surface and Groundwater Information Sub-Directorate: Integrated Hydrological Planning Limpopo North West Proto CMA/Regional Office CD:Water Use Authorisation (to apply limits)
		Establish groundwater quality and saturation level status and trends which should be applied as an "Early Warning" management system to prevent for example the depletion and drying-up of dolomite eyes as the case of the Bodibe and Grootfontein Eyes in RU 9_1 and 9_2 (IUA 9);	March 2020	
		Applicable to all prioritized groundwater resource units.		

Requirement	Activity	Action	Completion	Responsibility
		Physical boundaries need to be specified in areas where high-impact activities are taking place and should be based on the actual hydraulic parameters of the aquifer system(s) on the site.		
	Groundwater resource protection zoning for water quality management. Collate data and apply the Tier Zoning approach for the protection of Far Field water resources – this application are applicable to groundwater quality and aquifer saturation levels.	Generate water quality trend analyses for groundwater RUs in order to set limits for RQOs specifications. A 3-Tier water quality zoning approach should be applied for large mining/industrial activities, *i.e.*: Tier 1: "Impacted" water quality limits inside the site activity area *(viz*. a mined area, power station, industrial process area which should also include high-impact areas such as stock feedlots and waste/sewer water treatment facilities), Tier 2: Defining a "decline" buffer zone around the activity where prescribed water quality criteria are set based on a water quality investigation supported by a water quality impact assessment which could also require a transient (water flow)-transport (contaminant flow) modelling exercise, and Tier 3: A "reference" buffer zone representing the "natural" water quality criteria of the area and has a quaternary catchment *viz*.an infinite boundary. Undertake a statistical/hydrogeological assessment of the water quality criteria in a section (large quaternary catchment), or the whole quaternary, in order to set a typical water quality criteria for the catchment.	Ongoing Per water use authorisation (existing and new applications)	Sub-Directorate: Integrated Hydrological Planning Limpopo North West Proto CMA/Regional Office CD: Water Use Authorisation (to apply limits)
		Develop a dedicated groundwater monitoring programme/network where detail trend analyses (in time and space) can be implemented and sustained.	December 2019	

Requirement	Activity	Action	Completion	Responsibility
	Protection of water resource quantities and qualities where surface water to groundwater interaction are taking place	Undertake a study to determine the linkages between dolomite water areas and intergranular (*viz.* alluvium) aquifers (which normally hydraulically linked to surface water resources) in the catchment area. The study should also identify the impacts on surface water resources where large volumes are abstracted from these aquifers.	December 2020	Directorate: Surface and Groundwater Information Sub-directorate: Integrated Hydrological Planning CD:WE (Groundwater Reserve Requirements)
		Groundwater – surface water interaction must be managed as follows: • Based on the actual hydraulic nature of the aquifer systems; • Through a zoning system where certain activities should not be allowed, or • Managed strictly through monitoring programmes.		
Groundwater RQOs must be complied with.	Implement RQOs in the priority resource units (RU's)	Prioritize RUs in terms of level of impact. (*i.e*. RU's from highly impacted to less impacted).	December 2019	Directorate: Surface and Groundwater Information Sub-directorate: Integrated Hydrological Planning CD:WE (Groundwater Reserve requirements) Limpopo North West Proto CMA/Regional Office
		Undertake local-scale aquifer mapping (in terms of Aquifer Types of South Africa)		
		Undertake follow-up assessments of the aquifer systems, recharge values, actual water uses, land use activities, status of groundwater monitoring, and surface water-groundwater interaction.		
	Identify responsible regulator/agency for implementation of RQO specifications and monitoring/information maintenance	Create a body with regulatory status and effective logistical abilities to manage and maintain the groundwater information management in the study area.	December 2018	CD: WE Directorate: Surface and Groundwater Information Sub-directorate: Integrated Hydrological Planning
		Expand collaboration/support/advisory support between National/Regional DWS and the CMA in support of expanding the		

Requirement	Activity	Action	Completion	Responsibility
		groundwater information database needs to address the priority areas. Obtain support from water users in terms of local water use monitoring for supporting assessment of the aquifer Stress Index (this is critical).		Groundwater Reserve requirements Limpopo North West Proto CMA/Regional Office
	Groundwater quality and aquifer level monitoring	Update groundwater monitoring networks in prioritized groundwater resource units. This aspect needs urgent attention as it has been noted that monitoring networks (*i.e*. infrastructure and coverage) has deteriorated and is not maintained, *i.e.* local networks maintained by water users and regional/national networks maintained by the regulator, or it's representative (i.e. catchment management agency).	March 2020	CD: Water Monitoring and Information Directorate: Surface and Groundwater Information Sub-directorate: Integrated Hydrological Planning Limpopo North West Proto CMA/Regional Office CD: WE
		The following hydrological parameters must be monitored: • Water use figures (*i.e.* weekly/monthly/quarterly); • Water levels in boreholes (monthly intervals) and well field control points (continuous data logging); • Water quality indicators reporting water quality deterioration status (at least quarterly intervals); and • Monitoring of RQO protection zoning, e.g. the water use zoning application in the case of rivers/streams, wetlands and dolomite eyes.		
		It should be noted that due to the natural weathering of a number of rock formations in the study area, certain salts are released (viz. dissolved) to the local groundwater and could cause elevated		

Requirement	Activity	Action	Completion	Responsibility
		concentration levels not related to land use activities. Specific cases are, Na-Cl (salinity), metals such as aluminum, iron, and chrome, and toxins such a fluoride and nitrate. Baseline information on the groundwater quality criteria of areas where developments are foreseen should be obtained long before any physical developments are commenced.		
Immediate management interventions	Groundwater conditions noted in the study area that must be urgently addressed/managed	Address the management and control of groundwater resources, and specifically the dolomite water areas on the southern boundary of the WMA catchment area that are vulnerable in terms of land use impacts such as over-utilization of dolomite compartment units and bulk water abstractions at /in the pool areas of dolomite eye. Address the uncontrolled abstractions from dolomite catchments and dolomite eye pools that are directly impacting on downstream surface water users, (specifically referring to cases where dolomite eyes have stopped flowing); Manage uncontrolled storage of waste in the catchment area(s) of dolomite water areas (i.e. the case of the Rhenosterfontein Eye in RU 6_1); Apply the 50 Day (dying-off time limit for microbes in groundwater environment) and 365 Day (effective dilution decay time line) in the case of alluvial aquifer systems along perennial drainages; Manage/control abstractions from alluvial aquifers systems that could interact with surface water flows through application of the Stream Depletion Factor principle.	March 2021	Directorate: Surface and Groundwater Information Sub-directorate: Integrated Hydrological Planning CD: Water Use Authorisation Limpopo North West Proto CMA/Regional Office
8) Wetlands				

Requirement	Activity	Action	Completion	Responsibility
Wetland RQOs must be complied with.	Wetland priorities, coverage and ecological categorization must be confirmed	Undertake field verification, and confirm the wetland coverage (and priority wetlands/wetland complexes)	December 2020	D:RQIS CD: WE
		Compile accurate desktops base maps for the all priority wetlands/ wetland complexes prior to start of monitoring		
		Undertake desktop Present Ecological State (PES) assessments of (using method of Kotze (2016). Repeat every 3 to 5 years to assess changes in state.		
	Reserve Determination Studies	Undertake Wetland Reserve determination studies in RUs: • 6_1and 8_1 for the Buffelshoek and Paardenvlei and Malmaniesloop Wetland Complexes. • 7_1 Kaaloog se Loop (Marico Eye Wetland) • 9_2 Upper and Middle Molopo River wetland complex To determine ecological flow requirements.		
	Wetland monitoring to be addressed	Presence of the Blue Cranes within the pentads must be confirmed in RUs 15_1, 15_2 and 15_5: (Reporting rate higher than 5% must be maintained) (based on the South African Bird Atlas project)	December 2019	CD: Water Information Management
		Develop new monitoring networks in the catchment area to include wetlands. Integrate with the SANBI progammes for wetlands.		
		Develop and institute a wetland monitoring programme. Undertake monitoring every 3 to 5 years as per RQOs components and indicators		
		Water quality monitoring must be undertaken in accordance with the Water Quality RQOs where these specified. Mitigation measures will also need to be indicated in order to remedy the situation		

Requirement	Activity	Action	Completion	Responsibility
		in the case of exceedance or non-compliance.		
		Undertake biannual water quality monitoring at Tufa waterfall in RU 7_1.		
		Verify monitoring records against record sightings for avifaunal reporting data in terms of Biota RQOs in RUs 16_5_2, 16_1; 14_1, 14_2, 14_3, 14_4 and 1_3.		
	Protection of wetlands and wetland complexes	Undertake more detailed studies of individual wetland systems as required to support Water Use Licensing (WUL), Environmental Impact Assessments (EIAs) or other such related legislative or other requirements where the priority wetlands may be affected. Detailed wetland studies must remain a requirement for proposed developments in the study area where wetlands may be affected and the findings from such detailed wetland assessments will always replace any of the more general RQOs developed here.	Ongoing Per water use authorisation (existing and new applications)	Limpopo North West Proto CMA/Regional Office CD: Water Use Authorisation CD: Compliance Monitoring
		No abstraction of water from wetlands, streams and rivers should be allowed, unless specifically authorized in terms of the water use authorization.		
9) Compliance Reporting				
Compliance to RQOs must be reported on periodically	Determine reporting requirements, develop procedures, allocate responsibilities and report on RQO compliance	Confirm the frequency of the reporting period.	June 2018	CD:WE
		Develop a compliance reporting template aligned to RQOs gazette template.	December 2018	CD:WE

Requirement	Activity	Action	Completion	Responsibility
		Identify the responsible agents for collating and presenting the information.	June 2019	
		Undertake the assessment based on the monitoring information from the various monitoring programmes.	As per reporting period	Limpopo North West Proto CMA CD: Water Monitoring and Information
		Prepare the information and populate report template	As per reporting period	Limpopo North West Proto CMA/Regional Office
		Publish the report	To be determined	CD:WE
Institute adaptive management or interventions based on compliance reporting	Determine if RQOs are being achieved	Identify non-compliances to the RQOs in the Mokolo, Matlabas, Crocodile (West) and Marico catchments	Following each compliance reporting cycle (to be determined)	CD:WE Limpopo North West Proto CMA/Regional Office CD: Compliance Monitoring
		Instruct responsible agents/institutions to investigate and institute adaptive management measures or interventions		
		Follow up on progress of adaptive management implemented.	Quarterly after issuing instruction	
10) Institutional and Resourcing				
Facilitation of implementation of the RQOs	Establish RQO implementation structures (committee)	Design and establish the institutional structures. This could be in the form of a standalone committee (a management committee) or may be linked to other initiatives.	July 2018	CD:WE (Management committee)
	Assign roles and responsibilities	Assign accountability of functions, actions and timeframes in business plans of DWS Chief Directorates, Directorates and the Limpopo North West Proto CMA		

Requirement	Activity	Action	Completion	Responsibility
Reporting	Generate monitoring information that is concise and focused on reporting compliance with RQOs.	Develop reporting procedures, method and communication products	March 2019	CD:WE (Management committee)
	Meetings / compliance reports / adaptive measures.	Undertake regularly meetings with responsible role players during compliance monitoring cycle to review compliance report and progress on adaptive management measures	Ongoing linked to the reporting cycle	CD:WE (Management committee)
Programme and Resourcing	Determine the requirements for achieving implementation	Assess the budgetary associated with implementing the above.	December 2018	Limpopo North West Proto CMA/Regional Office
		Prioritize programme of implementation and necessary resourcing		CD:WE (Management committee)

5 ROLES AND RESPONSIBILITIES TO IMPLEMENT RQOS

While proposed responsible implementation agents are included in the actions list in the section above, the CD: WE (in the interim until the lead agent for implementation is confirmed) would need to lead a process to form a management committee that would include members from each of the responsible functional and operational Directorates and Offices. The management committee led by the CD: WE comprising national, proto-CMA and regional personnel will then be required, to work out an implementation strategy and co-ordinated plan of what must happen, when, how it is to be achieved and who is accountable for what.

5.1 MANAGEMENT COMMITTEE

Members of the management committee would include:

- Directorate Water Resource Classification
- Directorate Hydrological Services
- Directorate Surface and Groundwater Information
- Directorate Water Resource Planning Systems, including:
    - Sub-Directorate Water Quality Planning
    - Sub-Directorate Systems Operations
    - Sub-Directorate Integrated Hydrological Planning
- Directorate Resource Protection and Waste
- Directorate Resource Quality Information Services
- Directorate National Water Resources Planning
- Directorate: System Analysis
- Chief Directorate: Water Use Authorisation
- Chief Directorate Compliance and Monitoring
- Chief Directorate Infrastructure including:
    - Area Offices
- Limpopo North West Proto CMA
- Limpopo North West Regional Office
- And additional components as identified.

The management committee, led by the CD: WE would become the accountable body responsible for the implementation of the RQOs. While the committee will not necessarily undertake the specific actions required, it will have to oversee, manage, control, co-ordinate and facilitate them. The committee's governance structure, the functions and composition of the various parties involved will have to be confirmed.

It is anticipated that the majority of the communication amongst the committee members take place electronically, with a meeting held twice a year. However, in year 1 and 2 of its constitution, it is envisaged that the committee would need to meet on a quarterly basis to address reporting functions and monitor progress on RQO compliance and of the specific supporting water resource management actions that must be undertaken.

5.2 IMPLEMENTING ROLES

The Implementation of the RQOs consists of two 'legs', viz:

(1) compliance monitoring and compliance reporting and,

(2) operationalisation, which requires a number of catchment management actions to achieve the RQOs.

- **Monitoring and Reporting on RQO Compliance**

The immediate ongoing function of the management committee in terms of implementation of the RQOs are the compliance monitoring and compliance reporting. This is would be a direct responsibility and accountability of the management committee. The committee's activities will entail development of the detailed plan of action and implementation programme for the compliance monitoring and reporting. This will amongst others include coordination of monitoring activities among institutions and evaluation of monitoring information against RQO specifications. The necessary monitoring network, monitoring activities, data and information management, assessment for compliance and reporting must be undertaken periodically as determined by the committee.

In terms of compliance reporting the committee would have to:

- Develop a reporting system to assess compliance.
- Assess the reporting and monitoring information generated through the various monitoring networks and compare to RQO for the RUs.
- Check compliance and report differences.
- Assess against the water resource class and determine if the gazetted water resource class is achieved.
- Determine how to deal with non-compliances; and
- Develop an action plan for adaptive management to address non-compliance.

The format for reporting and the reporting period must be confirmed. The results would need to be published for public review. The responsibility of the compliance reporting will lie with the management committee and specifically the:

- Directorate Hydrological Services, Directorate Resource Quality Information Services (monitoring networks, monitoring, data acquisition)
- CD: Information Management and Limpopo North West Proto CMA/Regional Office – collation and maintenance of databases)
- Limpopo North West Proto CMA/Regional Office – (monitoring, assessment of the data and compliance assessment of status against RQOs)
- CD: WE (Compliance report; determination on the non-compliances and obtaining feedback and making recommendation on the required adaptive management measures where noncompliance occurs; reporting to the Director-General).
  (for surface, groundwater and wetland components).

The specific non-compliances reported will have to be addressed through the management committee with the responsible functional and operational components within the Department required to address the issue and implement the necessary corrective action to work towards

achieving compliance.

Operationalisation to Achieve RQOs

In terms of the operationalisation of the RQOs to achieve them, the management committee would serve as the vehicle to direct action and allocate the tasks to the responsible agents and serve as the 'watchdog' overseeing of the water resource management activities listed in Section 4. These activities and actions are to a large extent the building blocks and components of the Catchment Management Strategy. The accountability must be included into business plans of each Directorate, Sub-Directorate, Regional Office or the Proto CMA. This process would need to specify timeframes for achievement, reporting requirements and reporting periods. The implementing/responsible functional and operational components of the Department for the above must provide report back on progress at the management committee meetings.

The short term actions as listed in Section 6 must be addressed within the first two years of the gazetting of the RQOs. While water use enforcement and control, is ongoing it must be intensified immediately to get the water resources to achieve the targeted ecological categories (class and RQOs) as well as ensure that other water resources are maintained at their current status (no further deterioration that could compromise the water resource class). This is largely the role of the Limpopo North West Proto CMA/Regional Office. Key short term actions include the implementation of the EWRs, removal of alien vegetation, removal of hyacinth, management of wastewater discharges and control and management of the dolomitic groundwater areas. The management committee must oversee that the key short term actions are undertaken and in place over a two year timeframe. Once underway/achieved the key medium term actions outlined in Section 6 must be initiated.

Beyond year 1 to 3, once the facilitation actions are in place and complete, the management committee would meet bi-annually to discuss monitoring results obtained in the previous year, determine goals and actions to achieve the RQOs for the upcoming year, allocate the responsibility, and confirm the requirements related to the compliance reporting.

It is necessary to keep record of the implemented actions, monitoring and adaptive management and it is suggested that this take place on an annual basis. The annual implementation plan document will typically include a summary of the previous years' monitoring results. System changes that took place in the previous year should also be documented, as well as specific system operational aspects. The management committee would need to appoint a secretariat to manage and deliver on these aspects.

5.3 RESOURCING REQUIREMENTS

The committee would also need to address the capacity requirements of implementing the RQOs. This will have to take place (1) in terms of the compliance monitoring and reporting, and (2) in order to operationalise the water resource management actions.

Compliance monitoring and reporting will require training programmes, workshops and courses so that implementers know what to do, in terms of developing the monitoring programmes, monitoring, measuring, data and information management, data assessment and report generation.

Actions related to water resource management (surface, groundwater, wetlands – water quantity and quality) to ensure that the RQOs are achieved as detailed in the implementation actions above will require training and capacity building within the individual functional structures of the Department related to specific activity/function. This will form part of the general training programmes and capacity building initiatives of the individual functional components.

Further to the capacity, the budgetary requirements must be adequately allocated to serve the required functions of implementation. This would need to be built into the business plans of the responsible Directorates, Sub-Directorate, Regional Office or the Proto CMA when the responsibilities are being allocated.

The management committee is the critical role player in the implementation of the RQOs. It must be a body created with the necessary regulatory status and effective logistical abilities (budget and manpower) to oversee, manage, control and maintain the RQO implementation programme, facilitate required activities and undertake the compliance reporting.

6 SUMMARY OF KEY ACTIONS

Table 3 lists the key actions that must be implemented over the short, medium and long term for achievement of the RQOs in the Mokolo, Matlabas, Crocodile (West) and Marico catchments.

Table 3: Summary of key actions over the short, medium and long term period

No.	Activity/Action	Period to be completed (Year)	Duration of activity within time period	Responsibility
Critical short term (1 – 3 years) Actions to be addressed				
1	Develop programme for implementation. Prioritise, action, resource (allocate and train) and budget	2018- 2020	3 months after RQO gazetting	RQO Management Committee led by CD:WE
2	Update of the Reconciliation strategies to incorporate and include the EWRs (quantity - flow RQOs) Develop a Reconciliation strategy for the Marico catchment.		10 months	CD: IWRP (Directorates National Water Resource Planning) to lead with the oversight by CD:WE (management committee)
3	Update and develop operating rules, and manage dam releases to achieve EWRs (release plans).		6 months	CD: IWRP (Directorate Water Resource Planning Systems) to lead. National Water Infrastructure Branch (Northern Operations) and area offices CD: Water Monitoring and Information and the Limpopo Proto-CMA/Regional office with the oversight by CD:WE (management committee)
4	Develop the operation plan and flow monitoring programme.			
5	Revise/optimise or develop the various monitoring programmes and networks for monitoring of: • Flow (quantity), • water quality, • groundwater, • biomonitoring (aquatic habitat and biota), • wetlands. to support the RQO reporting (as per sub-components, indicators and numerical limits).		6 months	CD: Water Monitoring and Information and the Limpopo Proto-CMA/Regional Office to lead with direction from CD:WE oversight by management committee
6	Implement the monitoring (as per spatial and temporal specifications) for biota, habitat, flow, quality, groundwater and wetlands.		Inititite within a year of RQO gazetting.	
7	Institute management and control measures specifically for the dolomite water areas on the southern boundary of the WMA catchment area that are vulnerable in terms of land use impacts.		12 months	CD: Water Use Authorisation and the Limpopo Proto-CMA/Regional Office (Groundwater functions)
	Undertake aquifer level and groundwater quality assessments to support estimation of groundwater recharge and calculations of more accurate and point source Stress Index values.		24 months	Directorate: Surface and Groundwater Information Sub-Directorate: Integrated Hydrological Planning

No.	Activity/Action	Period to be completed (Year)	Duration of activity within time period	Responsibility
8	Institute specific immediate interventions to deal with the many non-compliant WWTWs in the catchment, and acid mine drainage pollution		12 months	CD: Water Use Authorisation and the Limpopo Proto-CMA/Regional Office oversight by management committee
9	Allocate, resource, co-ordinate and manage activities related to the data management, assessment and information management of the monitoring data to meet the needs of the RQO compliance measurement and reporting.		6 months	RQO Management Committee led by CD:WE
10	Initiate the development of a water quality management strategy for the catchment area (Limpopo WMA (south)).		24 months	CD: IWRP (Sub: Directorate Water Quality Planning to lead). Limpopo North West Proto CMA/Regional Office
11	Intensify water use authorisation enforcement and control (source control and regulation). The Proto CMA must allocate more resources (budget and manpower) to this function as this fundamental to addressing impacts related to achieving the RQOs.		Address immediately and ongoing within period	Limpopo North West Proto CMA/Regional Office: Enforcement and regulation and monitoring to address the flow and non-flow impacts
12	Implement specific operational actions related to alien vegetation removal and control of activities that impact on instream and riparian habitats.		Address immediately and ongoing within period	Limpopo North West Proto CMA/Regional Office, Working for Water oversight by management committee
	Implement programmes for hyacinth removal in dams (a serious threat)			
13	Develop a programme and reporting requirements (legal and functional) related to compliance reporting on the RQOs.		12 months	RQO Management Committee led by CD:WE
14	Develop of a communication plan and roll out.		12 months	RQO Management Committee led by CD:WE
No.	**Medium term (3 to 5 years) Actions**			
1	Generate RQO compliance report (periodic per reporting cycle)	2021- 2023	3 months	RQO Management Committee led by CD:WE
2	Communicate as required.		Ongoing within period as required	RQO Management Committee led by CD:WE
3	Complete the development of the integrated water quality management strategy for the area and individual catchment water quality management plans		12 months (continued fron short term progress)	CD: IWRP (Sub: Directorate Water Quality Planning to lead). Limpopo North West Proto CMA/Regional Office
4	Develop a real time operational model for flow management		12 months	CD: IWRP (Directorate Water Resource Planning Systems) to lead
5	Update the WQT model for salts and develop a model for nutrients to understand the loads and support the allocation.		12 months	
6	Implement groundwater measures to achieve RQOs : • Delineate protection zones as specficied in terms of RQOs (collate data and apply tier zoning)		24 months	Sub-Directorate: Integrated Hydrological Planning Limpopo North West Proto CMA/Regional Office

No.	Activity/Action	Period to be completed (Year)	Duration of activity within time period	Responsibility
	• Confirm and manage the surface-groundwater linkages (determine stream depletion factors)			
7	Confirm wetland coverages and implement monitoring programme		12 months, monitoring is ongoing over period	CD:WE to lead D:RQIS (Linkages with external programmes to be established)
9	Develop dam management strategies for each major dam to ensure the aquatic and semi aquatic ecosystems associated with them and users needs are met.		24 months	Limpopo North West Proto CMA/Regional Office Other CDs in DWS D: RQIS Infrastructure Branch
10	Verify and validate water use (surface and groundwater)		24 months	CD: Water Use Authorisation Limpopo North West Proto CMA/Regional Office Directorate: Legal Services oversight by management committe
11	Revise General Authorisations;		6 months	
12	Update Discharge Standards		6 months	
13	Initiate Compulsory licensing		6 months	
14	Update and refine water resource monitoring programmes per component		6 months	RQO Management Committee led by CD:WE
No.	**Long term (5 to 10 years) Actions**			
1	Allocate waste loads based on water quality modelling and apportion. Develop a water allocation strategy (quality and quantity)	2024 -2028	24 months	CD: Water Use Authorisation Limpopo North West Proto CMA/Regional Office
2	Implement wetland RQOs		12 months (ongoing compliance reporting)	Limpopo North West Proto CMA/Regional Office CD:WE
3	Undertake the required baseline semi-aquatic species assessments in collaboration with the Department of Environment Affairs to confirm numerical indicators		24 months	Limpopo North West Proto CMA/Regional Office CD:WE
4	Develop regulations with respect to prohibition of land uses		12 months	RQO Management Committee led by CD:WE Directorate Legal Services Limpopo North West Proto CMA/Regional Office
5	Implement the waste discharge charge system		36 months	CD: Water Use Authorisation Limpopo North West Proto CMA/Regional Office

7 COMMUNICATION PLAN

The programme of RQO implementation will require dedicated and ongoing communication with internal DWS stakeholders and, ongoing, targeted communication with identified directly affected stakeholders, influencers, decision-makers and water managers, as well as the broader public in the catchment area. RQO implementation and roll out has a number of components and there is a lack of a holistic understanding of the implications and requirements and their strategic importance.

Achievement of the RQOs would require a short, medium and long term strategy of implementation, requiring collaboration and integration of a number of activities and action within and outside the Department. Once the detailed programme of implementation is developed, a communication action plan detailing the approach, types and modes of communication to the various DWS role players, implementing agents, collaborating institutions, stakeholders and the public should be developed. It is always important to know *who, what, why, when and where* to communicate to stakeholders.

Current experience and understanding of the context within which stakeholder engagement takes place, indicates that there is a need for consistent and well-coordinated, meaningful communication with role players, key stakeholders and the broader public. People seem to have different versions of messages and lack understanding of the overall, strategic drivers for RQO implementation as well as the consequences should the RQOs not be implemented against the set timeframes. Confusion seems to create collective misperceptions and feed negative expectations, all of which need to be managed through carefully structured communication.

Today, stakeholders are well versed with their environmental rights, and perceptions exist about water availability, allocation, use, quality, distribution, service provision and, although not all of these perceptions are necessarily accurate, to the public these perceptions are reality. There is a need to create a platform for constructive multi-party dialogue to equip people with knowledge of, and information to obtain buy-in from the key stakeholders (these are the directly affected parties, influencers, decision-makers and thought leaders representing various sectors of society) towards the implementation of the RQOs in the Mokolo, Matlabas, Crocodile (West) and Marico catchments.

Communication Action Plan

The Communication Action Plan is intended as an internal, living document that will be updated during the course of the implementation. Given the context of communication, this plan seeks to:

- Inform the DWS implementing agents, collaborating institutions and responsible role players of the RQO programme, requirements, targets and actions.
- Engage key stakeholders and targeted group/sectors as and when required to achieve specific outcomes related to achieving RQOs ; and
- Inform the broader public of the RQO implementation (process to achieving compliance) and its connection to con-current and new project-related aspects;
- Through sound relationships with key stakeholders and satisfactory process communication, build trust and create understanding, as well as collaborative action to ensure the work towards the facilitation of achieving the RQOs.

The key objectives of the Communication Action Plan are to:

- Conduct focussed consultation/meetings with key DWS implementers, Limpopo North West Proto CMA, collaborating institutions groups to obtain an understanding of what they need to enable effective implementation of the RQOs and to communicate to them what is required/expected of them in terms of implementation;
- Communicate on actions and activities and progress underway to achieve the RQO implementation internal and external to DWS;
- Engage key targeted groups and stakeholders (.e.g. mining, agricultural, local municipalities) representing various sectors of society on actions and activities that must be undertaken by the sector to contribute to meeting the RQOs for the IUAs;
- Assist the DWS to maintain a high level of information sharing with the broader group of stakeholders as the implementation programme progresses;
- Sharing information in an open and transparent manner with the broader public to correct misunderstandings, to reduce and manage expectations by providing information within the right context and helping public understand the progress to achieving the RQOs;
- Record and accommodate feedback, input and guidance from stakeholders for use towards improved and successful implementation.
- Communicate requirements related to the compliance reporting.

The Communication Action can include the following components undertaken in a phased manner:

- Announcement of the final gazetted RQOs and steps towards implementation.
- Communication on resource requirements, activities and support required.
- Distribution of the implementation programme (short, medium and long term – with envisaged timeframes).
- Communication of the activities underway.
- Compliance Reports
- Communication on follow up actions based on non-compliances.

Once the first round of compliance reporting is completed, the communication can be limited to the compliance reporting cycles and progress on implementation programme progress.

The Communication Action Plan must identify and comprise communication activities targeted at the specific audiences internal and external to DWS. Internal to DWS could include:

- Focus group meetings
- Workshops
- Presentations
- Roadshows.

External to DWS could include:

- Targeted sector, authority or organisational group meetings

- Newsletters
- News Flashes
- Media releases
- Public meetings.

The communication plan will need to be developed by the management committee and actioned through the CD:WE and collaborating Chief Directorates of DWS.

8 CONCLUSION

As apparent from the sections above the implementation actions outlined cannot be undertaken in isolation but would need to be integrated into other management, strategy and regulatory processes within the water management area to ensure that implementation is achieved. Many of the actions related to the 'implementation' and achievement of the RQOs relate to functions that are currently performed by different Directorates in the Department of Water and Sanitation (DWS), other institutions and are also dependent water users and stakeholders. Coordination among these institutions is essential and the uptake of particular responsibilities relating to these actions need to be formalised and added to their respective business plans. Alignment with the activities with those of the Proto CMA in the Limpopo WMA and integration into the CMS must also be achieved. A management committee is the mechanism to facilitate the implementation and be accountable for the compliance reporting.

The achievement of all implementation actions over the short, medium and long term outlined above would culminate in the compliance to the RQOs and achievement of the water resource classes in the Mokolo, Matlabas, Crocodile (West) and Marico catchments.

9 REFERENCES

Department of Water Affairs (2011). Procedures to develop and implement Resource Quality Objectives. Department of Water Affairs, Pretoria, South Africa.

Department of Water Affairs (2013). Directorate Water Resource Classification. November 2013. *Classification of Significant Water Resources in the* Crocodile (West) *Marico, Mokolo and Matlabas Catchments:* Management Classes Report. Report No: RDM/WMA1_3/00/CON/CLA/0612. Pretoria. South Africa.

Department of Water and Sanitation, South Africa. April 2017. Determination of Resource Quality Objectives in the Mokolo, Matlabas, Crocodile West and Marico Catchments in the Limpopo North West Water Management Area (WMA01): Draft Resource Quality Objectives and Numerical Limits Report. Report No: RDM/WMA01/00/CON/RQO/0516

Kotze, D. 2016a. *A method to assess wetland ecological condition based on land-cover type. Part 1: The user manual.* A simple Citizen Science tool to assess the ecological condition of a wetland. Version 1.4. Water Research Commission: Project No.K5/2350.

Kotze, D. 2016b. *A method to assess wetland ecological condition based on land-cover type. Part 2: Technical Background.* A simple Citizen Science tool to assess the ecological condition of a wetland. Version 1.4. Water Research Commission: Project No.K5/2350.

WCS, Wetland Consulting Services (2013). *Wetland Component: Classification of significant water resources in the Mokolo and Matlabas Catchments (Limpopo WMA) and Crocodile West and Marico WMA.*

APPENDIX A

Aquifer Types and Prioritized Groundwater units

Hydrogeological background

Important Geological Groupings

The geology as published by the Council for Geoscience on 1:250 000 scale maps for the study area is shown in Figure A1, in relation to delineated IUAs. Major fault zones are also indicated as increased groundwater yield potential is generally present in these features; therefore these features could play an important role enhancing migration of poor, impacted water towards low-lying areas, i.e. drainage channels/discharge pans/lakes.

The following major geological groups with regard to RQO implementation are present in the study area:

- Limpopo Mobile Belt:
  - The Limpopo Mobile Belt is present in the upper-northern sections of IUA 16 and IUA 17b and comprise of high grade metamorphosed gneissic formations of the Beit Bridge Complex rock formation (viz. the Alldays Gneiss). No significant RQO implementation required in this grouping.
  - A pre-Karoo Age graben structure, filled with typical Karoo SPGRP sediments (tillite-mudrock, sandstone, mudrock-coal seams, mudstone-sandstone, and aeolian sandstone sequence) covers >½ of QC's A41E and A42J (IUA's. Significant RQO implementation (mainly water quality driven issues) are required in this grouping due to current and future coal mining activities, as well as power station developments. Zonderwater and Grootegeluk coal mining with future mining in the Springbokpan area is to be noted.
  - The interaction between the alluvial aquifer and the adjacent/underlying hard rock aquifers along the lower Mokolo River are important for RQO implementation in terms of water quality and stream flow depletion.
- Waterberg Group Sandstones, Transvaal Supergroup and secondary intrusions of concern:
  - To the south of the Limpopo Mobile Belt the area is underlain by Waterberg Group which cover IUA 15, most of the southern ½ of IUA 16, IUA 17a (complete), and IUA 17b (towards the west), consisting of a wide variety of different lithologies (i.e. feldspathic sandstones, sandstones and subordinate mudrocks). The southern ¼ of IUA15 consists of the Kwaggasnek Felsite Formation of the Transvaal SPGRP. This is not a priority RQO implementation region, except for wetlands that occurs in the headwater areas of the Tambotie and Poer se Loop river systems (see wetlands section).
  - A Carbonatite Intrusion (Glenover Carbonatite) occurs in IUA17b a ~10 km's from the Matlabas River channel (in QC A41D) which could generate fluoride pollution when mined (Glenover Phosphate Mine).
- Basement Granite Complex:

  Makoppa Dome:

  Potassium rich granite-gneiss of the Makoppa Dome covers eastern ½ of IUA 11b (QC A32E) and the lower part (QC A24J) of IUA 13. No relevant RQO implementation is foreseen in this geological grouping, however, RQO implementation is required for the alluvium aquifer systems in the lower Crocodile River (viz. below Thabazimbi– QC A24J).

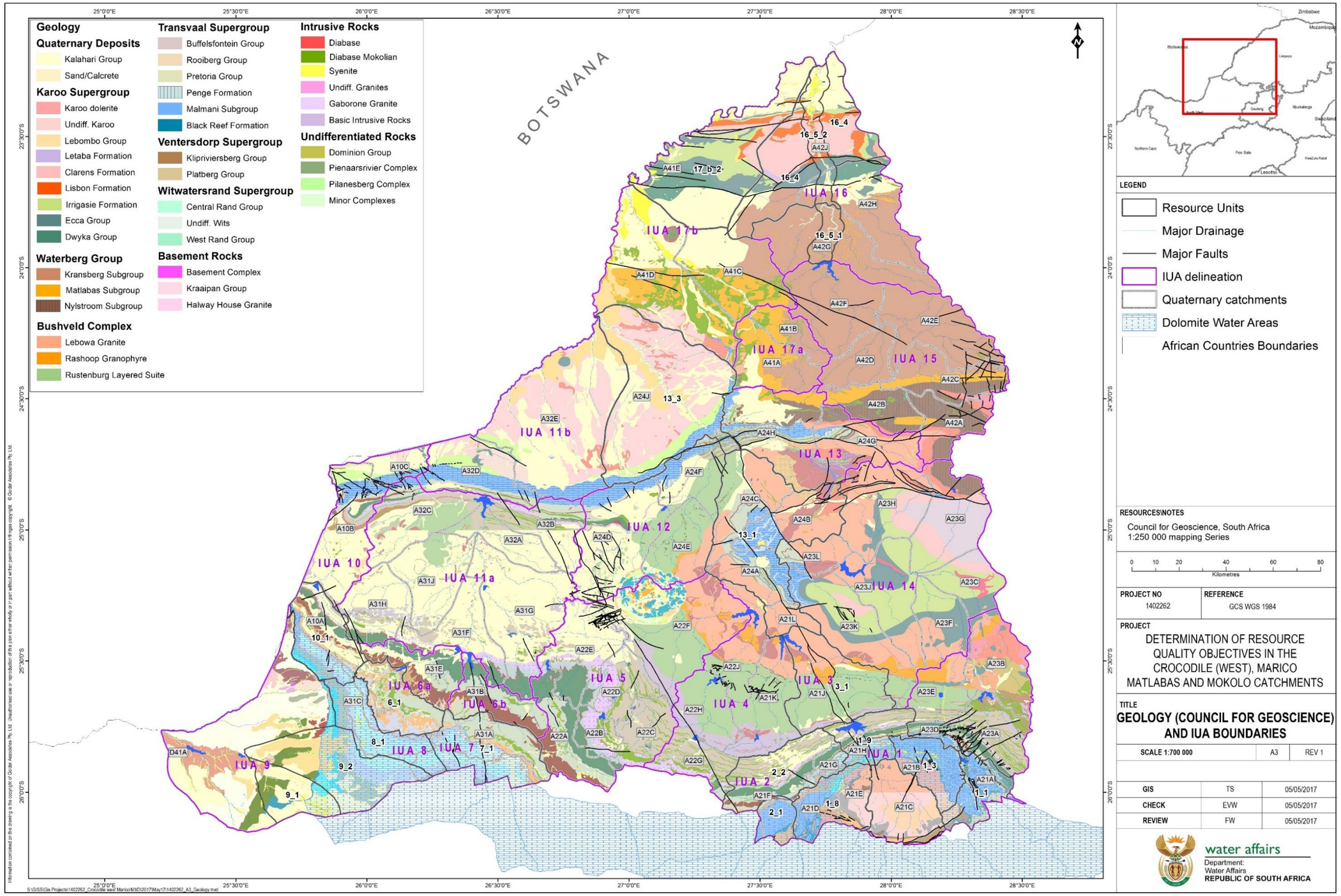

Figure A1: Illustrating IUA's and RU's related to the geological units in the study area

The valley of the Crocodile River, upstream of Thabazimbi in catchments A24H, A24C, and A24B, contains extensive alluvial deposits for approximate 80 km in length - termed the Crocodile River Valley Aquifer. The area is known for intensive irrigation which relies heavily on both surface and groundwater resources. The total reach of the river is some 92 km. Hobbs (1986) reports that the alluvial aquifer is in hydraulic connection with the river, which recharges the aquifer during flow events. The alluvial aquifer is partially underlain by highly productive secondary aquifers, associated with highly fractured granite bedrock.

Specific management options in terms of water quality impacts and streamflow depletion factorization is required for the Lower Crocodile River Valley Aquifer System.

Halway House Granite:

A Swazian granite-gneiss dome occurs in the southern part of IUA 1 and represent the headwater area of the Jukskei and Crocodile-West Rivers (viz. QC A21C and –E). Aquifers in the Halway House Granite are regarded as insignificant, however, water quality impacts on the surface water systems are significant – these drainages flows over large areas consisting of Malmani Dolomites where surface water to groundwater interaction is possible, i.e. QC A21H.

- Bushveld Igneous Complex (BIC), younger cover rocks and secondary intrusions of concern:

North of the Magaliesberg Ranges in the south the geology is largely dominated by the Bushveld Complex, a massive layered igneous complex with Karoo SPGRP cover and the massive Pilanesberg intrusive Complex consisting of several “cones” of syenite/foyaite, and lava.

The lower portion of the intrusive complex comprises of ultramafic rocks known as the Rustenburg Layered Suite (RLS), which is overlain by acidic rocks that form the Rashoop Granophyre Suite and Nebo Granite. The Rustenburg Layered Suite is rich in minerals and a number of mines have been developed. Platinum, chrome, and vanadium mining in particular are taking place at a large scale. Implementation of RQO’s for those areas underlain by the RLS should address water quality management options due to impacts of platinum and chromite mining and processing on site. Waste rock dumps and tailings dams poses a serious impact on local surface and groundwater quality. However, it should be noted that elevated values for rare earth metals could occur under natural conditions in certain groundwater systems in this grouping.

- Important IUA’s in this geological grouping are:
  - IUA 3 – QC A21J (100%);
  - IUA 4 – Northern section (¾’s) including QC’s A22J, A22H, A21K;
  - IUA 5 – Northeastern sector including QC A22F (100%),
  - IUA 11a – Isolated complex in northern part incl. QC’s A31J (north ½)), A32C (central), and A32A (west 1/4); and
  - IUA 12 – Eastern part including A24A, A24F (east ½), A24C (eastern ¼);

The Rashoop Granophyre and Nebo Granite represent weathered and fractured aquifers which often contain excessive fluoride in groundwater from geological origin, rendering the water unsuitable for human consumption. Implementing RQO’s for groundwater quality will have to acknowledge this natural source of a chemical constituent that is at risk for human water

consumption. Limited mining activity present in this geological grouping.

- Important IUA's in this geological grouping are:

IUA 1 – Northern part of QC's A23B

  - IUA 3 – Northern part of QC A21J;
  - IUA 4 – Northern parts of QC's A21K and A22J;
  - IUA 5 – Northeastern ½ of QC A22F;
  - IUA 13 – Southeastern sector with QC's A24H (south ½), and A24B;
  - IUA 14 – Northwestern and northern boundary with IUA 13 and 15;
  - IUA 14 – Southern parts of QC's A23F, A23J, and A23K

  Karoo SPGRP sediments consist of the basal Ecca Shales, followed by the Irrigasie Mudstones, Clarens Sandstones and capped by the Letaba Basalts. Poor water qualities occurs in the Irrigasie Formation (salinity), and Letaba Basalts (elevated nitrates). These are related to natural rock decomposition and cannot be addressed in any RQO specification(s) within specific investigation. Implementation thereof will have to be based on specific research/investigations.

- Important IUA's in this geological grouping are:

  - IUA 14 – Central ¾'s of area incl. QC's A23G, A23F (north ¾'s), A23J (central part), and A23K (northeast ½).

- The Pilanesberg Complex (~28 km's diameter) falls on the northern boundary of IUA 5. Previous groundwater investigations have noted significant problems with fluoride in groundwater and could be related to the rock type present in this area. No specific RQO specifications were established for this geological grouping.

- Transvaal SPGRP

Sedimentary formations of the Pretoria GRP (i.e Transvaal SPGRP) forms the southern boundary of the BIC and is clearly visible on the southern boundary of the study area consisting mainly of Pretoria GRP and Chuniespoort GRP sediments. A thinner grouping of these formations forms the northern boundary of the BIC and runs along a line from Thabazimbi (east) to just south of Lobatsi (Botswana) in the west.

- Pretoria GRP:

  Not considered significant groundwater resources, however, many of the upstream dolomite water area's discharge runs through this grouping. RQO implementation focussing merely on the dolomite water areas, however, surface water RQO's are important for protection of the water resources supporting downstream users. Interaction between surface and groundwater along the head water sections of the major drainages are important and RQO implementation for these specific cases are noted.

  Southern limb of BIC: IUA's in this geological grouping and relevant issues:

  - IUA 1 – Central arch area incl. QC's A23A (central part), A23E (south ¼), A21J (south boundary) and A21H (north ½);

- IUA 2 – QC A21F, receiving water from dolomite aquifer system in headwaters part of QC A21F (Steenkoppies DCU) and A21G;
- IUA 4 – Southern ¼ incl. parts of QC's A22G
- IUA 5 – Southwestern ½ incl. parts of QC's A22A, A22B, A22C, A22D,, and A22E;
- IUA 6a – Receiving flows from IUA 8 (dolomite eyes and underlying dolomite aquifer system)
- IUA 6b – Receiving flows from IUA 7 (dolomite eyes and underlying dolomite aquifer system)
- IUA 10 – Central part incl. QC's A10A and B;

Central part of BIC area:

- IUA 11a – Total area included (consisting of insignificant aquifer with natural elevated salinity);

Northern limb of BIC: IUA's in this geological grouping:

- IUA 10 – Northern ½ of QC A10B, and southern ¼ of QC A10C;
- IUA 11b – Southern boundary of QC A32E, northern
- IUA 12 – Northwestern ¼ incl. QC's A24D (north ¼) and A24F (northwest ½); and
- IUA 13 – Central part incl. central ¼'s of QC's A24H and A24G

- Chuniespoort GRP

The most important groundwater aquifer systems occurs in the Chuniespoort GRP consisting of significant dolomite water areas driving dolomite eyes and several headwater streams of the major river systems in the Northwest Province. High level RQO's have been specified for these aquifer systems based on water quantities and water qualities. Over-utilisation of groundwater is the most threatening risk for these aquifer systems and several cases of high water level depletions have been noted –to such a level that dolomite eyes have dried up, or are in the process of dropping to below long-term baseflow levels.

Dolomite formations of the Malmanie Subgroup occur in four UIA's situated on the southern boundary of the study area. In the Upper Crocodile sub-catchment, dolomite formations are found in the Rietvlei Dam catchment at the confluence of the Tolwane and Pienaars rivers as well as the origin of the Apies River (Pretoria Fountains) in the Apies/Pienaars sub-catchment. Further west to the (north and west of Mogale City) large dolomite compartments occurs and is used for irrigation, i.e. the Tarlton area towards the Maloney's Eye, viz. the Steenkoppies Compartment). Dolomite formations also occur in the south-western parts of the Marico catchment in the Lichtenburg-Itsoseng area and further north towards Lobatsi (Botswana).

The dolomite formations are compartmentalised by intrusive dykes and represent dolomite compartment units with unique water bearing characteristic, i.e. good quality and significant yield potential, however, vulnerable to pollution and over utilization (e.g. ground stability risks).

Important IUA's in this geological grouping are:

- IUA 1 – Dolomite arch north of the Halway House Granite dome with portions of QC's A21A (north ¾'s), A21B (north ¾'s), A21H (south ¼), and A21D (west ¾'s);
- IUA 2 – southern ¼ of QC A21D (Steenkoppies DCU);
- IUA 7 – QC A31B (south ¼) and the northern ¼ of QC C31A and a small portion of QC C24F up north[1],
- IUA 8 – southern ⅓ of QC A31D and A31C (100%);
- IUA 9 – eastern ⅓ of QC D41A (Lower Vaal WMA); and
- IUA 10 – northeastern portion of QC D41A (dolomite water area only).

- Alluvial Formation Grouping

  Alluvial aquifer systems are classified under Intergranular Aquifer Type in South Africa. These will be discussed under the different aquifer groupings below.

Aquifer types

Aquifer systems in South Africa are described in terms of their hydrogeological characteristics (rock types), i.e.:

Intergranular aquifer types (referenced as primary aquifers, or alluvial aquifers) are limited to the main river stems. Interaction occurs on various levels between the surface water component (river channel stream) and the groundwater occurring in the alluvial beds adjacent to the river channel. RQO implementation with regard to intergranular aquifer systems has three specific parameters of importance, i.e.

- A 50 Day travel period for microbial based leachate/pollution to "die-off" 100%, which specifies a protection zone of a number of metres between a perennial river channel and any land use activity (waste water treatment facility, septic tanks, or waste sludge) should be established based on tested hydraulic characteristics of the underlying intergranular aquifer system(s) on site; and/or
- A 350 Day travel period which would result in dilution of any threatening hydrochemical constituent to a level fit for domestic water use application, which specifies a protection zone of a number of metres between a perennial river and any land use activity (mining, industrial and agricultural based injections/discharges) should be established based on tested hydraulic characteristics of the underlying intergranular aquifer system(s) on site; and/or
- A Stream Depletion Factor (SDF) for the particular intergranular aquifer system adjacent to the perennial surface water resource should be established through testing of the hydraulic properties of the aquifer system and demarcation of a protection zone where the impact of surface water resource capturing during long-term abstraction from the intergranular aquifer system.
- For the Crocodile West – Marico and the Mokolo-Matlabas UIA's, a SDF factor of <5% has been proposed – thus indication that not more than 5% of the abstraction yield of an

[1] Important note: Due to the flow boundaries formed by the dolerite dykes in the dolomite water areas, certain dolomite compartment units of the southern water management area, viz. Lower Vaal are included in IUA 7 of the Crocodile West-Marico WMA. This is based on a detailed survey of the water level piezometric elevations of the DCU's in the Northwest Province.

intergranular well field should be drawn from the surface water resource.

The following intergranular aquifer systems are specifically listed where a set of management options should be implemented to protect and secure the surface resources where applicable (i.e. large perennial river systems as mentioned above).

- Crocodile River Valley Aquifer, specific IUA 3 (viz. RU 3_1, viz. patches between Hartbeespoort and Roodekopjes Dams) and IUA 13 (RU 13_3);
- Matlabas River Alluvium, specific IUA 17b (RU 17_b_1); and
- Mokolo River Alluvium, specific in IUA 16 (viz. RU 16_5_2).

The water quality status of intergranular aquifers are highly influenced by the local land use activities, the quality in the adjacent river channel (could be impacted by upstream water uses), and the water quality of the underlying/adjacent regional aquifer systems. The overall groundwater quality in the intergranular aquifer systems in the water management area are towards the upper Marginal water quality class (70 to 300 mS/m). The result of anthropogenic pollution (probably poor water treatment and heavy fertilizer feeding) has resulted in elevated nitrate (NO3 as N) concentration (>10 mg/l) along the lower reaches of the Crocodile West (Thabazimbi to Limpopo River confluence) and the Matlabas (UIA13 and –17b).

Fractured (hard rock) Aquifer Type (referenced as secondary aquifers, typical fractured (broken) hard rock granitoids/gneissoids, banded ironstone, quartzitic sandstones; massive basalt/andesitic lava's, rhyolite/felsite extrusive rocks, competent metamorphic rocks such as quartzites, granulite and marble and intrusive rocks such as dolerite, diabase, norite and gabbro). A large percentage (~85%) of the water bearing rock formations discussed in section 0 above are related to this aquifer type.

These aquifer systems are the most typical systems in the region and consist of rock formations from a wide grouping of sedimentary, igneous, and metamorphic origin, i.e.:

- The deep Waterberg Group (mainly in the Matlabas and Mokolo catchments): aquifer is typical a hard rock aquifer type, but rather an insignificant system in the study area.
- The Bushveld Igneous Complex represents a large part of the study area and consists of a large variation of crystalline rock formations of which the Nebo Granites, Rooiberg Felsites and the Rustenberg Layered Suite represents typical fracture type aquifers, but with low yields and poor water quality.
- The Transvaal Supergroup: (partly, predominantly meta-arenaceous quartzitic aquifers of the Timeball Hill and Magaliesburg formations with limited weathered zones, but significant deep fracturing due to the younger BIC emplacement)
- The Witwatersrand Supergroup (limited exposure in IUA_1 only, mostly subequal shale and quartzite in QC's A21D and –E).
- The Basement Rock Formations granitoids of the Makoppa Dome (IUA_11b) and Halfway House Granite complexes (A21C and A21C); and
- Intrusive Rock Formations (complexes): Glenover Carbonatite (A41D) with Ideal to Marginal water quality (<300 mS/m) and Minor yield rating (<2.0 l/s). The Rashoop granophyre in the southern part of QC A24H is part of the BIC. Severaql large diabase sills/dykes are present on the Transvaal SPGRP formations, but do not represent a significant water resource in

terms of this study.

No specific RQO's have been specified for these aquifer types as they are not regarded as prioritised systems, except where interaction with surface water systems are important, i.e. the Crocodile River Valley Aquifer and the Mokolo and Matlabas drainage channel alluvium with potential links to underlying hard rock aquifer systems. However, where open cast and underground mining and large dewatering takes place the impacts on the water resources are quite significant and RQO's specifications were applied and need quite strick implementation measures. For example, the long-term impacts on the Tarlton Dolomite Water Area (viz. IUA 1) where a large DCU has been impacted in the A21D quaternary catchment.

Intergranular and Fractured Aquifers, (a more descriptive classification is fractured and shallow weathered aquifers) and represent a combination of an upper horizon of weathered/broken rock overlain by a deeper, underlying zone of jointed/fractured rocks – in most cases the same formation composition. In drainage channels, these aquifer systems are highly productive and a unique surface-groundwater interaction systems exists Rock formations classified under this aquifer type are moderate hard rocks such as granite/granite-gneiss complexes, sandstone, and soft rocks such as shales, mudrock and tillite, and incompetent metamorphic rocks such as phyllite and slate).

Occasionally, so-called deep weathered basins in crystalline rock formations such as granite and gneiss complexes occurs, but were not prioritised for RQO specifications due to their isolated occurrence.

The shallower Waterberg Group water bearing formations are predominantly of a fractured and weathered type potentially connected to alluvial deposits occurring along the lower Matlabas and Mokolo River. In the upper reaches of the Mokolo, interaction between interflow from the Waterberg and wetlands occur due to the limited aquifer storativity of the Waterberg sandstone. Groundwater RQO's for the Waterberg have not been specified.

In the study area, the Karoo Supergroup: aquifer is predominantly of a fractured and weathered nature comprising of fractured rocks with a spasmodic porous matrix at shallow depths. These aquifer systems occur on the eastern side of the study area, A23H, –J, and –K, but the major impact are in the central parts of IUA 16 and 17b (A42J and A41E respectively) due to extensive coal mining operations and power stations. RQO specifications have been developed and management options will be required for these activities. A special approach has been followed for highly impacted areas where a 3 Tier Zoning of RQO water quality specifications were proposed.

Dolomite (Karst) Aquifer Systems, classified as significant aquifer systems characterised in terms of hydrogeological properties including significantly higher recharge rates, hydraulic parameters and subsequently, it's potential as a sustainable aquifer system. In most cases, dolomite aquifer systems supports several large dolomite eyes, and subsequently surface water resources. Contributions from large dolomite eyes to the Crocodile West (Pretoria Eye), Magalies River (Maloney's Eye), Groot Marico River (several eyes in QC A31A, IUA 7), Klein Marico River (several eyes in QC A31D, IUA 6a), Malmani se Loop (several eyes along the Malmani se Loop in QC A31C, IUA 8), and the headwater streams of the Ngotwane River (i.e. the Dinokana Eye in QC D41A, IUA 10).

The high yielding dolomite compartments are used extensively for domestic (Pretoria, Centurion, Tarlton, Mafikeng and Zeerust areas) and irrigation water supplies. Spring flows from dolomite compartments have mainly been secured for bulk municipal supply purposes. These flows have

been diverted into pipelines, thereby limiting or curtailing their contribution to the original receiving surface water catchments. Due to high water supply demands, natural flows (dolomite eyes, or springs) from these dolomite compartments have been augmented by abstraction boreholes in the vicinity of the eyes, which subsequently lowered the water table resulting in total capturing of the natural spring flows, i.e. the Grootfontein Eye supplying Mahikeng in IUA9 (D41A).

The parameters applicable to intergranular aquifer systems, as discussed above, are equally applicable to dolomite aquifer systems and should be seen as important management options. Specific zoning (i.e. numerical limits) in terms of water sources (i.e. river/drainage, wetland and dolomite eye) have been specified for these systems.

Geological Contact Aquifers occur on a wide scale in the study area (viz. criss-crossed) formed by secondary geological features consisting of dykes (diabase, syenite, and pre/post Karoo Dolerite), folding/jointing (larger tectonic movements in the crust), and faults/fractures (brecciated zones formed due to relative movement along fault line).

Although not specifically classified under the national geohydrological aquifer classification system, geological contacts (i.e. fracture zones, fault zones, and various dyke intrusions), plays a significant role in the occurrences of groundwater (specifically the actual borehole yield status) and may act as preferential path ways between aquifers and low lying water resources such as drainage channels and pans. Borehole yields of these contact type aquifers, are normally an order of magnitude higher than the surrounding aquifer system (intergranular & fractured and fractured types). Dolerite dykes, and specifically the Jurassic Karoo dolerite dykes play an important role in local borehole yields due to the high permeabilities of the dyke/host rock contact zone. These high yields, however, is still depends on the storativity of the adjacent host rock formation, i.e. a dolerite-shale contact aquifer might not have a similar sustainable yield classification than a dolerite-sandstone type combination. In many cases, dyke/sill-like intrusives may act as groundwater flow boundary systems – which in the case of the dolomite water areas, forms the compartment boundaries where the dolomite eyes occur.

Prioritised Groundwater Resource Units

In terms of RQO requirements for the study area, the following groundwater resource units have been prioritised in terms of water quantity and quality resource quality objectives:

- Intergranular (Alluvial) Aquifers: Crocodile River (RU 3_1 and RU 13_1 and RU 13_3), and Mokolo River (main stem) (RU's 16_5_1 and 16_5_2) – RQO's specifically for managing the impact on adjacent surface water resources in terms of quality and quantity;
- Intergranular and Fractured Aquifer: Karoo Aquifers in the lower Mokolo River Catchment (RU 16_4, Grootegeluk and Zonderwater coal mining related) and RU 17_b_2, Steenbokpan future coal mining developments);
- Dolomite (Karst) Aquifer Systems:
    - Eastern headwater catchments of the Crocodile River (IUA 1): RU 1_1, and RU 1_3 (significantly impacted – due to bulk groundwater abstractions);
    - Western headwater catchment of the Crocodile River (IUA 1): RU 1_8, , and RU 1_9 (moderately impacted – due to upstream treated mine and waste water releases);

- Magalies River (IUA 2): RU 2_1 and RU 2_2 (Steenkoppies DCU, Maloney's Eye impacted due to abstractions, and Skeerpoort River as representative pristine groundwater environment);
- Groot Marico River (IUA 7): RU 7_1 (almost pristine conditions, but moderate to high risk to downstream EWR's due to high abstractions in headwaters areas);
- Malmani se Loop (IUA 8): RU 8_1 (almost pristine conditions, but risk of high abstractions of downstream surface water and impact on eyes feeding into the Klein Marico River (IUA 6a, RU 6_1, not prioritised in terms of Gwater RQO's due to absence of significant groundwater resources);
- Upper Molopo River (IUA 9): RU 9_1 and RU 9_2 (highly impacted groundwater resources due to municipal and agricultural uses from dolomite compartment units). Two large dolomite eyes, i.e. Bodibe and Grootfontein have dried up due to continued water level depletions – currently Molopo(-os) Eye is threatened by over abstraction for bulk water supplies; and
- Dinokana Eye Catchment (IUA 10): RU (10_1), potential agricultural impact (local irrigation and stock farming) in the western catchment area. Long-term droughts could affect the sustainability of the Eye significantly.

Recommendations

Groundwater monitoring programmes and networks needs to be upgraded. Utilising the RQO Indicators/Measures for groundwater as indicators for updating the current level of monitoring (programmes and networks) and assessing the status of the resource, is therefore required.

Protection Zoning has been added to the RQO specifications in the study area and should be used as an indicator of potential impacts on the groundwater resources.

In terms of the implementation of the management options, the support of local institutions (i.e. catchment management agencies) and non-governmental (environmental) organisations needs to be address based on an implementation strategy.

Such a strategy should focus on the water users and local regulating organisations and need to address the current high-level concerns which have been included as Indicators/Measures and Numerical Limits proposed as the water resources quality objectives (RQO's). Immediate implementations actions should address:

- Bulk water abstractions (municipal, industrial, and irrigation supplies) from dolomite compartment units needs to be strictly controlled in terms of annual recharge values and abstractions. Long-term trend analyses are recommended with strict control on area of development, i.e. irrigated land sizes;
- Investigate and classify the status (used/not used) and extend (sizes and hydraulic links with surface water stream) of the Intergranular (viz. alluvial) Aquifer Systems along the Crocodile West and Mokolo Rivers;
- Updating of current groundwater resource information (i.e. GRA II, current dataset from pre-2005 surveys). This is, however, a comprehensive work load to address, but at least the prioritised IUA's should be addressed immediately; and

- Groundwater monitoring programmes and networks in the prioritised IUA's should be updated and where possible extended to address the RQO Indicators/Measures and status in terms of the Numerical Limits.

To conclude, the success of applying the groundwater resource quality objectives to manage and guide an aquifer, will be significantly limited if no reference conditions/status are available to timely compare the impact of water use and local land use activities. Specific monitoring programmes and networks will have to be available to conduct these RQO checks and expand/refine management of the groundwater resources and there relation to surface water resources.