


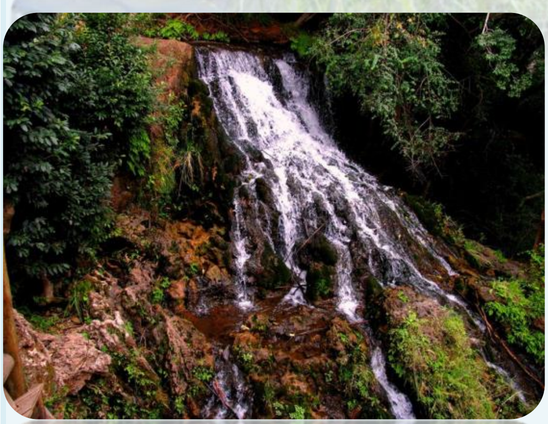


DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE MOKOLO, MATLABAS, CROCODILE (WEST) AND MARICO CATCHMENTS IN THE LIMPOPO NORTH WEST WATER MANAGEMENT AREA (WMA 01)

WP10992

RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS REPORT

REPORT NO.: RDM/WMA01/00/CON/RQO/0516

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LIST OF ABBREVIATIONS

ASPT	Average Score per Taxon
BAS	Best Attainable State
CD: WE	Chief Directorate: Water Ecosystems
DCU	Dolomite compartment unit
DLMT	Dolomite
DRM	Desktop Reserve Method
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
E. coli	*Escherichia coli*
EIS	Ecological importance and sensitivity
EWR	Ecological Water Requirements
FEPAs	Freshwater Ecosystem Priority Areas
FRAI	Fish Response Assessment Index
GMU	Groundwater Management Unit
ha	hectares
GRAII	Groundwater Resource Assessment Phase II
HGM	Hydrogeopmorphic
IHI	Index of habitat integrity
IUA	Integrated Unit of Analysis
IUAs	Integrated Units of Analysis
IWRM	Integrated Water Resource Management
NLC	National land cover
NMAR	Natural Mean Annual Runoff
MIRAI	Macroinvertebrate Response Assessment Index
NL	Numerical Limit
NWA	National Water Act
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category
REMP	River EcoStatus Monitoring Programme
RHAMM	Rapid Habitat Assessment Method and Model
RHP	River Health Programme
RQOs	Resource Quality Objectives
RUs	Resource Units
Userspec	User specification

SASS5	South African Scoring System version 5
SAWQGs	South African Water Quality Guidelines
SPI	Specific Pollution sensitivity Index
TCTA	Trans Caledon Transfer Authority
TDS	Total Dissolved Solids
TWQR	Target Water Quality Range
VEGRAI	Vegetation Response Assessment Index
VMAR	Virgin Mean Annual Runoff
WARMS	Water Use Authorisation and Registration Management System
WMA	Water Management Area
WMS	Water Management System
WQ	Water Quality
WRC	Water Resource Class
WRCS	Water Resource Classification System
WfWetlands	Working for Wetlands
WWTWs	Wastewater Treatment Works

TABLE OF SCIENTIFIC UNITS AND SYMBOLS

As	Arsenic
Al	Aluminium
NH_3	Ammonia
Cd	Cadmium
Chl-*a*	Chlorophyll *a*
Cl	Chloride
CN	Cyanide (free)
Cu	Copper
DIN	Dissolved Inorganic Nitrogen
F	Fluoride
Fe	Iron
EC	Electrical Conductivity
Hg	Mercury
ug/l	Micrograms per litre
Q	Abstraction Volume/Rate
l/s	litres per second
mg/l	milligrams per litre
m^3/s	cubic metres/second
ml	millilitres

Mg	Magnesium
Mn	Manganese
mS/m	milliSiemens per metre
Mm^3/a	million cubic metres per annum
Na	Sodium
NO_2	Nitrite
NO_3	Nitrate
Pb	Lead
pH	power of hydrogen
PO_4	Orthophosphate
SO_4	Sulphate
U	Uranium
Zn	Zinc
AKAT	*Aplocheilichthys katagae* (striped topminnow)
AURA	*Amphilius uranoscopes* (Stargazer mountain catfish)
AJOH	*Aplocheilichthys johnstoni* (Johnston's topminnow)
BANO	*Enteromius anoplus* (Chubbyhead barb)
BMAR	*Labeobarbus marequensis* (Largescale yellow fish)
BMAT	*Enteromius mattozi (Papermouth)*
BPOL	*Labeobarbus polylepis (small scale yellow fish)*
CFLA	*Chetia flaviventris (*canary curper)
CPRE	*Chiloglanis pretoriae* (Shortspine suckermouth (rock catlet))
CTHE	*Clarius theodorae* (Snale catfish)
LCYL	*Labeo cylindricus* (Redeye labeo)
LMOL	*Labeo molybdinus* (Leaden labeo)
MBRE	*Mesobola brevianalis* (River sardine)
PPHI	*Pseudocrenilabrus philander* (Southern mouthbrooder)

EXECUTIVE SUMMARY

The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) in March 2016, has 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 the determination of the RQOs follows on from this process. 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 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.

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 also taken account of land based activities and considered anticipated potential impacts that these activities may have on water resources within the WMA. 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 Step four 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 form the basis for development of RQOs and associated numerical limits. As part of the RQO development process, a key component has been stakeholder consultation.

Step 5 of the RQO Determination procedure comprises the development of the draft resource quality objectives. This report presents the proposed RQOs and numerical limits for the significant water resources in the Mokolo, Matlabas, Crocodile (West) and Marico catchments based on the sub-components and indicators prioritised per resource unit.

The draft RQOs proposed will be taken through various stakeholder consultation processes to obtain comments, guidance and inputs.

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

Draft Resource Quality Objectives and Numerical Limits Report

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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 Resource Quality Objectives (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.

Resource Quality Objectives 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. In addition to achieving the Water Resource Class, the RQOs determined will ensure that the needs of all users and competing interests who rely on the water resources are considered.

The Chief Directorate: Water Ecosystems of the Department of Water and Sanitation (DWS) has initiated the development of Resource Quality Objectives (RQOs) for the Mokolo, Matlabas, Crocodile (West) and Marico catchments. With the water resources in these catchment areas having been classified, RQOs are to be determined as the next step of the protection framework.

In terms of the National Water Act, the RQOs are based on the Water Resource Class and may relate to the following:

- the Reserve;
- the in-stream flow;
- the water level;
- presence and concentration of particular substances in the water;
- the characteristics and quality of the water resource;
- the in-stream and riparian habitat quality;
- characteristics and distribution of aquatic biota; and
- the regulation or prohibition of in-stream or land-based activities which may affect the quantity of water in or quality of the water resource, and
- any other characteristic of the water resource in question.

RQOs encompass four components of the resource:

- Water quantity;
- Water quality;
- Habitat integrity; and
- Biotic characteristics.

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

1.2 STUDY OVERVIEW

The objective of the study is to determine Resource Quality Objectives (RQOs) for all significant water resources in the Mokolo, Matlabas, Crocodile (West) and Marico Catchments that must give effect to the Water Resources Classes that have been determined.

RQOs are developed following the seven step process for determining RQOs (DWA, 2011) which is depicted in Figure 1. Once gazetting has been finalised, implementation, monitoring and review would then follow. The process also requires engagement and communication with stakeholders at key steps in the process.

Step 1: Delineate the integrated units of analysis and define the resource units;

↓

Step 2: Establish a vision for the catchment and integrated units of analysis;

↓

Step 3: Prioritise and select preliminary resource units for RQO determination;

↓

Step 4: Prioritise sub-components for RQO determination and select indicators for monitoring;

↓

Step 5: Develop draft resource quality objectives and numerical limits;

↓

Step 6: Agree on resource units, RQOs and numerical limits with stakeholders;

↓

Step 7: Finalise and gazette RQOs.

Figure 1: Seven step process for RQO determination

As part of the RQO process in the Mokolo, Matlabas, Crocodile (West) and Marico Catchments, the first step was to delineate the units of analysis and define Resource Units (RUs). Each integrated unit of analysis (IUA) represents a homogenous catchment area of similar impacts which must be considered in the determination of RQOs. A RU on the other hand is a section of a water resource within an IUA that is sufficiently ecologically distinct to warrant its own specification.

The IUA delineation of the Mokolo, Matlabas, Crocodile (West) and Marico Catchments was done as part of the Water Resource Classification process, through which 20 IUAs have been delineated. The IUAs delineated form the basis for the RQO determination process. Through this study the resource units for the water resources in Mokolo, Matlabas, Crocodile (West) and Marico Catchments were delineated and prioritised. Various components and considerations were assessed for RU delineation and prioritisation and was based on the understanding and expert knowledge of the Mokolo, Matlabas, Crocodile (West) and Marico Catchments (DWS, 2016)

The next step of the RQO determination process was to prioritise sub-components for RQO determination and select indicators for monitoring (DWS, 2016). These components and sub-components were recently prioritised for resource units, groundwater systems and wetland systems/clusters.

1.3 PURPOSE OF THIS REPORT

Based on the components and sub-components that have been prioritised for the RUs draft RQOs and numerical limits for these may now be formulated. This report therefore presents the proposed draft RQOs and numerical limits for the significant water resources in the Mokolo, Matlabas, Crocodile (West) and Marico catchments that have been developed. RQOs are essentially narrative statements but sometimes provide broad quantitative descriptions of the water resource. 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. Supporting information relating to the approach followed, the context and the rationale where applicable, on the proposed RQOs and numerical limits formulated have also been included.

1.4 STUDY AREA

The study area for the RQO Determination study is the Mokolo, Matlabas, Crocodile (West) and Marico Catchments (Figure 2) 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 (Table 1).

Table 1:Sub-catchments and related quaternary drainage regions comprising the Mokolo, Matlabas and Crocodile (West) and Marico Catchment areas

Sub-catchment	Catchment Area (km^2)	Quaternary catchments
Upper Crocodile (A21)	6 336	A21 A – L
Elands (A22)	6 221	A22 A – J
Apies/Pienaars (A23)	7 588	A23 A – L
Lower Crocodile (A24)	9 204	A24 A – J;
Marico (A31 and A 32)	12 030	A32 A – E; A31 A – J
Ngotwane (A10)	1 842	A10 A – C
Upper Molopo (D41)	4 300	D41 A
Matlabas (A41)	6 014	A41A – E
Mokolo (A42)	8 387	A42 A – J

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 Pilanesberg 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 Pilanesberg 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 boundary of the area. The 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.

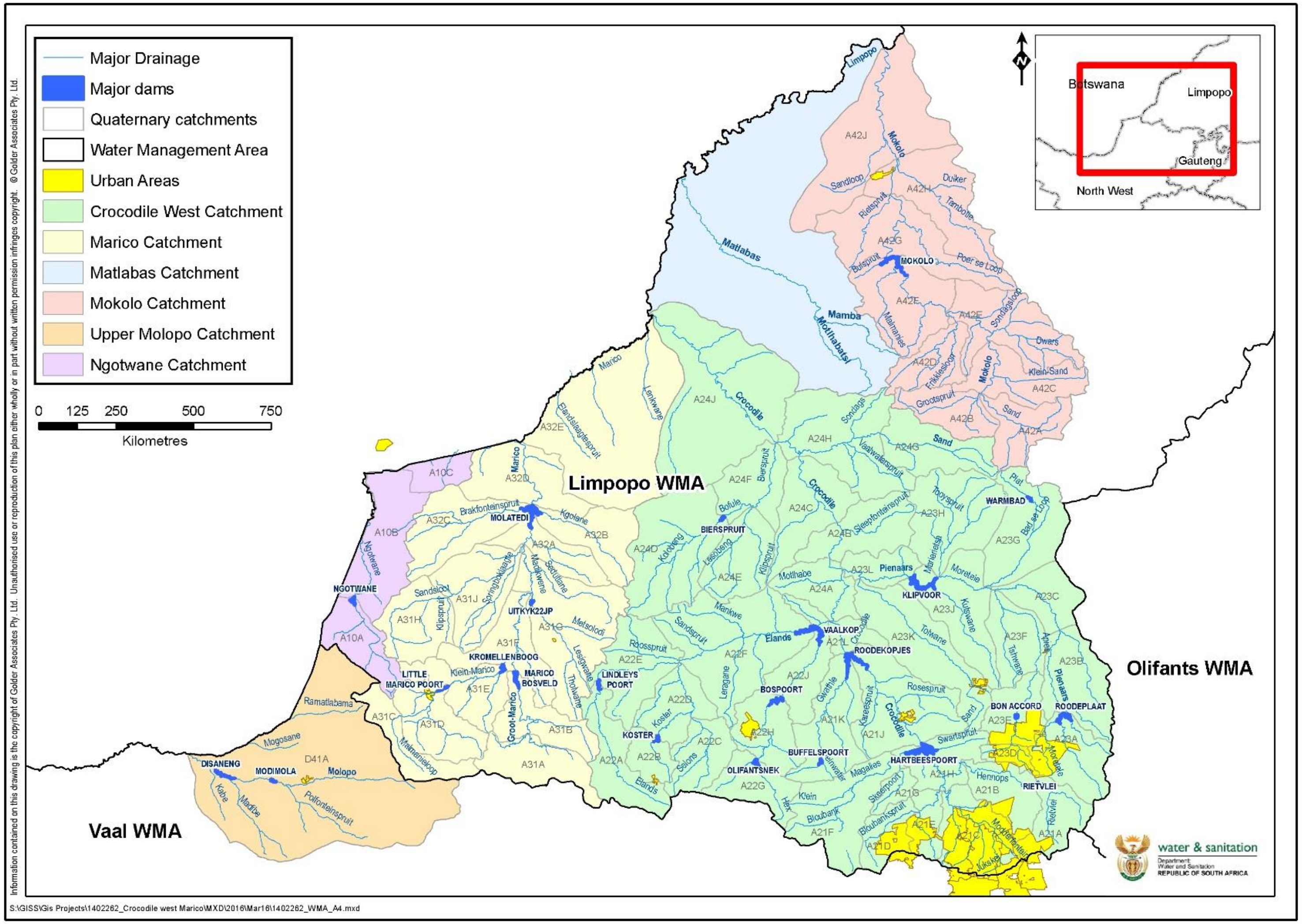


Figure 2: The Study Area - Mokolo, Matlabas, Crocodile (West) and Marico catchments

2 INTEGRATED UNITS OF ANALYSIS (IUAS)

The Water Resource Classification and the Reserve Determination studies for the Mokolo, Matlabas, Crocodile (West) and Marico catchments have been completed in 2014 and 2009 respectively. Through the classification study, the IUAs for the catchment were delineated and the EWR sites and river nodes were specified. These outputs from the classification study form the basis for the RQO determination process, and primarily for the RU definition.

In terms of the classification study, 20 IUAs were delineated (DWA, 2012a). These are listed in Table 2 and shown in Figure 3. The IUAs form the boundaries for RU delineation.

Table 2: IUAs delineated for the Crocodile (West), Marico, Mokolo and Matlabas catchments

IUA No.	Main river system/ IUA name	Quaternary catchments
1	Upper Crocodile/Hennops/Hartebeespoort	A21A, A21B, A21C, A21D, A21E, A21H, A23A, A23B,A23D, A23E
2	Magalies	A21F, A21G
3	Crocodile/Roodekopjes	A21J
4	Hex/Waterkloofspruit/Vaalkop	A21K, A22G, A22H, A22J
5	Elands/Vaalkop	A22A, A22B, A22C, A22D, A22E, A22F
6a	Klein Marico	A31D, A31E
6b	Groot Marico	A31B
7	Kaaloog-se-Loop	A31A
8	Malmaniesloop	A31C
9	Molopo	D41A
10	Dinokana Eye/Ngotwane Dam	A10A
11a	Groot Marico/Molatedi Dam	A31F, A31G, A31H, A31J, A32A, A32B, A32C, A10B
11b	Groot Marico/seasonal tributaries	A10C, A32D, A32E
12	Bierspruit	A24D, A24E, A24F
13	Lower Crocodile	A21L, A24A, A24B, A24C, A24G, A24H, A24J
14	Tolwane/Kulwane/Moretele/Klipvoor	A23C, A23F, A23G, A23H, A23J, A23K, A23L
15	Upper Mokolo	A42A, A42B, A42C, A42D, A42E, A42F
16	Lower Mokolo	A42G, A42H, A42J
17a	Mothlabatsi/Mamba	A41A, A41B
17b	Matlabas	A41C, A41D, A41E

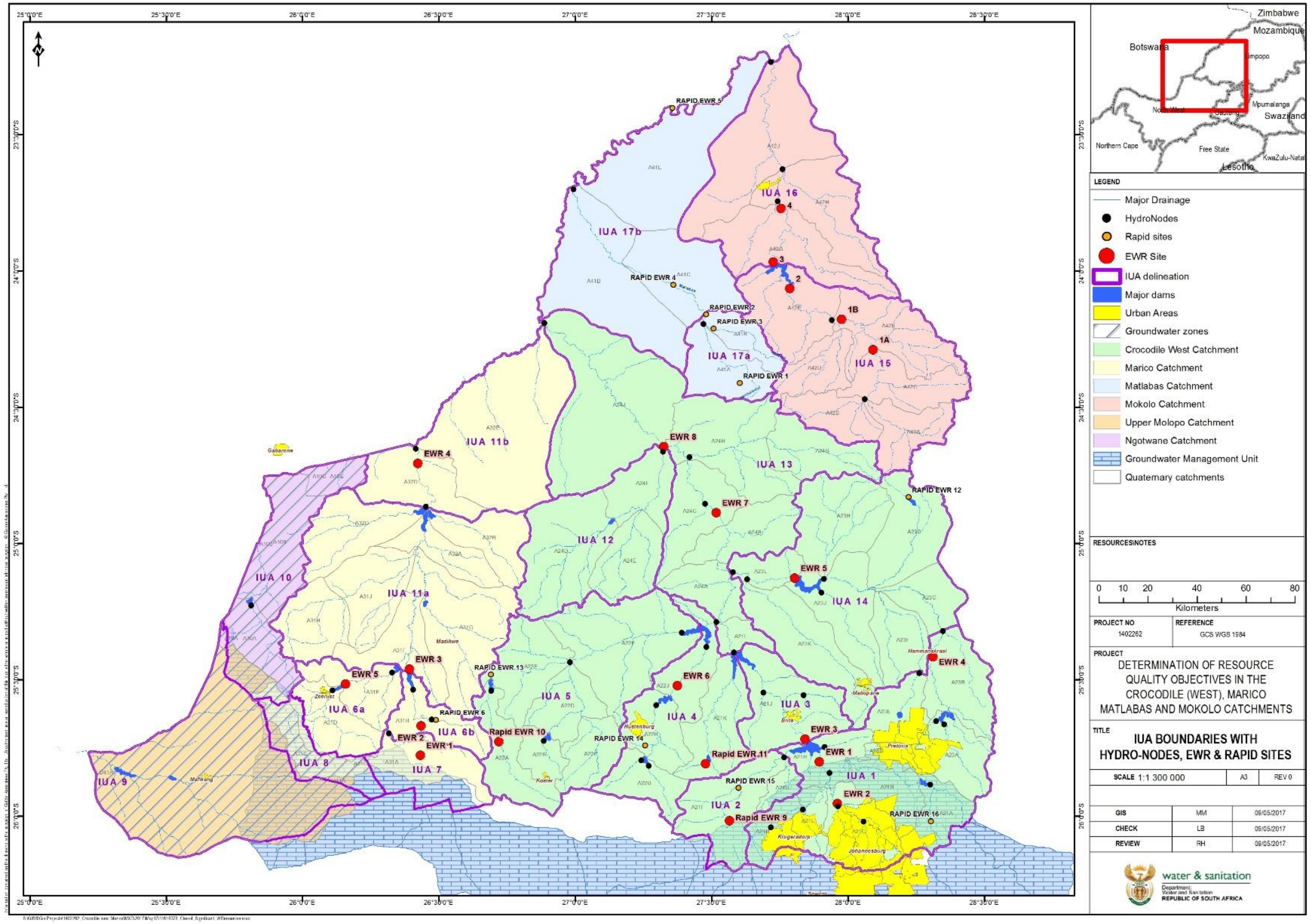


Figure 3: IUAs delineated within Crocodile (West), Marico, Mokolo and Matlabas catchments

3 RESOURCE UNITS PRIORTISATION

Delineation and prioritisation of RUs is required as it would not be appropriate to set the same RQOs for all water resources in a catchment. The RUs are aligned to the IUA boundaries to prevent overlap between two IUAs. Based on a range of characteristics and considerations a total of 82 RUs were delineated (incorporating dams and priority groundwater and wetlands components) in the Mokolo, Matlabas, Crocodile (West) and Marico catchments. The RUs delineated are shown in Figure 4.

The RQO determination procedure proposes RQOs for each resource unit, however this may not always be possible due the potentially large number of RUs that could be delineated for a catchment. In order to prioritise and select the most useful RUs for RQO determination, the rationalisation process developed as part of the RQO Determination Procedure (DWA, 2011) was applied. Based on the priority ratings obtained through application of the RU prioritisation tool, priority RUs were selected for RQO determination, which were then taken through stakeholder consultation process to confirm priority.

The rationalisation process for RU selection and prioritisation is based on a decision support tool. The 'Resource Unit Prioritisation Tool' incorporates a multi criteria decision analyses approach to assess the importance of monitoring each RU as part of management operations to identify important RUs.

The criteria assessed per RU include:

- Position of RUs within an IUA;
- Importance of the RU to users;
- Threat posed to water resource quality for users;
- Threat posed to water resource quality for the environment;
- Ecological considerations;
- Practical Constraints, and
- Management Considerations.

Based on the priority ratings obtained through application of the RU prioritisation tool, consultation with specialists and stakeholders, priority RUs for RQO determination were selected. In terms of the 85 RUs that were delineated (Figure 4), 79 have been prioritised for RQO determination. The prioritised units are listed in Table 3 and shown in Figure 5. Of the final prioritised RUs:

- 60 are surface water RUs;
- 19 are dam RUs;
- Wetlands/wetland priority areas within the surface water RUs;
- Groundwater priority areas were identified (dolomite aquifer systems, alluvial aquifer systems, and deep fractured systems).

The detailed results of the above are detailed in the Preliminary Resource Units Report (DWS, 2016a).

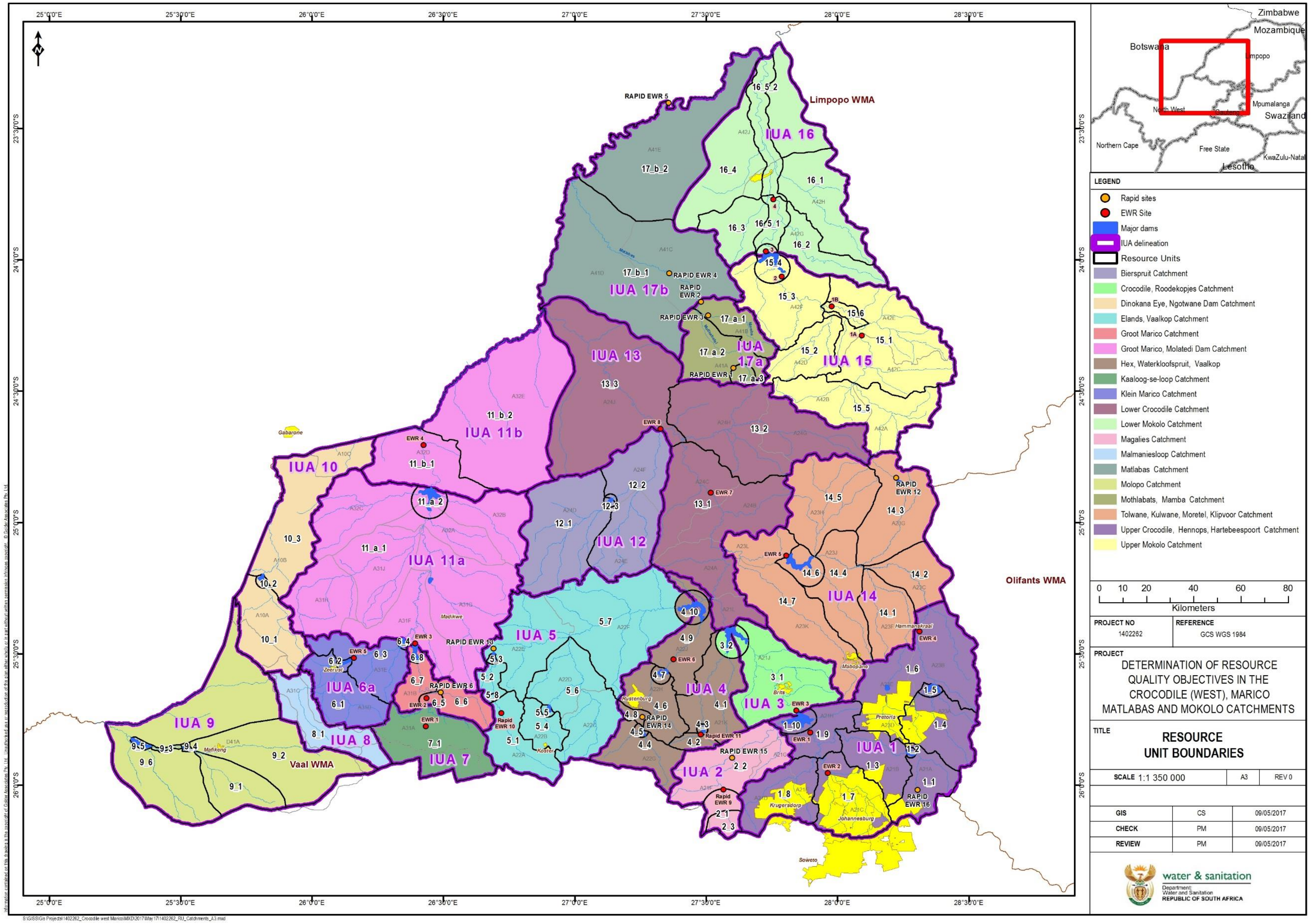


Figure 4: Delineated Resource Units

Table 3: Prioritised Resource Units for the Crocodile (West) catchment, Marico catchment and Mokolo and Matlabas catchments

IUA1	Upper Crocodile/Hennops/Hartebeespoort	
RU	**Delineation**	**Catchment**
1_1	Upper Hennops and Rietvlei Rivers to inflow to Rietvlei Dam, and dolomite aquifer systems.	A21A
1_2	Rietvlei Dam, and dolomite aquifer systems.	A21A
1_3	Hennops River from outflow Rietvlei Dam to the A21B catchment (including Kaalspruit and Olifantspruit tributaries), and dolomite aquifer systems.	A21B
1_4	Upper Pienaars River, Edendalespruit and Moretlele Rivers to Roodeplaat Dam	A23A
1_5	Roodeplaat Dam	A23A
1_6	Upper and middle reaches of Apies River, Skinnerspruit, Pienaars River from outflow Roodeplaat Dam to Boekenhoutspruit confluence, Roodeplaatspruit, Boekenhoutspruit	A23B, A23D, A23E
1_7	Jukskei, Klein Jukskei, Modderfonteinspruit	A21C
1_8	Upper reaches of Crocodile River and Bloubank Spruit, and dolomite aquifer systems.	A21D, A21E
1_9	Crocodile River from Jukskei confluence to inflow Hartebeespoort Dam, Swartspruit	A21H
1_10	Hartebeespoort Dam	A21H
IUA2	**Magalies**	
RU	**Delineation**	**Catchment**
2_1	Maloneys Eye	A21F
2_2	Magalies River, Klein Magalies, Bloubank, Skeerpoort Rivers	A21F, A21G
2_3	Rietspruit catchment area	South eastern portion of A21F
IUA3	**Crocodile/Roodekopjes**	
RU	**Delineation**	**Catchment**
3_1	Crocodile River from outflow Hartebeespoort Dam to inflow Roodekopjes Dam, Rosespruit, Ramogatla and Kareespruit, and alluvial aquifers systems in river valley	A21J
3_2	Roodekopjes Dam	A21J
IUA4	**Hex/Waterkloofspruit/Vaalkop**	
RU	**Delineation**	**Catchment**
4_1	Sterkstroom from outflow Buffelspoort Dam to inflow Roodekopjes Dam, Maretwane, Tshukutswe	A21K middle and lower catchment below dam
4_3	Buffelspoort Dam	A21K
4_2	Upper reaches of Sterkstroom to inflow Bueffelspoort Dam , Kleinwater	A21K upper catchment to dam
4_4	Upper Hex River to Olifantsnek Dam, Rooikloofspruit	A22G
4_5	Olifantsnek Dam	A22G
4_6	Hex River outflow Olifantsnek Dam to inflow Bospoort Dam, Sandspruit	A22H
4_7	Bospoort Dam	A22H
4_8	Water Kloofspruit tributary catchment	A22H
4_9	Hex River outflow Bospoort Dam to inflow Vaalkop Dam	A22J
4_10	Vaalkop Dam	A22J

IUA5	Elands/Vaalkop	
RU	Delineation	Catchment
5_1	Upper reaches of Elands to Swartruggens Dam	A22A south eastern portion
5_2	Elands river downstream Swartruggens Dam to Lindleyspoort Dam	A22A
5_3	Lindleyspoort Dam	A22A
5_4	Upper Koster River to Koster Dam	A22B
5_6	Selons River, Koedoespruit, Dwarsspruit, lower Koster River	A22C, A22D
5_7	Elands River outflow Lindleyspoort Dam to inflow Vaalkop Dam, Brakkloofspruit, Roosspruit, Sandspruit Mankwe. Leragane, Molapongwamongana	A22E, A22F
IUA6a	Klein Marico	
RU	Delineation	Catchment
6_1	Upper Klein Marico to inflow Klein Maricopoort dam, Rhenosterfonteinspruit, Malmanieloop, Kareespruit, and upstream dolomite aquifer systems	A31D
6_2	Klein Maricopoort dam	A31D
6_3	Klein Marico downstream Klein Maricopoort Dam to Kromellenboog Dam, Wilgeboomspruit	A31E
6_4	Kromellenboog Dam	A31E
IUA6b	Groot Marico	
RU	Delineation	Catchment
6_5	Groot Marico main stem upstream to Polkadraaispruit confluence	A31B
6_6	Polkadraaispruit	A31B
6_7	Groot Marico from Polkadraaispruit confluence to N4 bridge	A31B
6_8	Marico Bosveld Dam	A31B
IUA7	Kaaloog-se-Loop	
RU	Delineation	Catchment
7_1	Marico Eye, Kaaloog-se-Loop, Bokkraal-se-Loop, Ribbokfontein-se-Loop, Rietspruit (southern eye), Kuilsfontein, Syferfontein, Bronkhorstfontein and dolomite aquifer systems	A31A
IUA8	Malmaniesloop	
RU	Delineation	Catchment
8_1	Malmanie se loop (dolomite water area)	A31C
IUA9	Molopo	
RU	Delineation	Catchment
9_1	Bodibe Eye (dolomite water area)	D41A (Polfonteinspruit and Lotlhakane tributary catchment area)
9_2	Molopo Eye, Grootfontein Eye, Molopo headwaters to inflow Setumo (Modimola) dam (dolomite water area)	D41A
9_3	Molopo River main stem only from Modimola Dam to Disaneng Dam	D41A (main stem)
9_4	Setumo (Modimola) Dam	D41A
9_5	Disaneng Dam	D41A
IUA10	Dinokana Eye/Ngotwane Dam	
RU	Delineation	Catchment
10_1	Upper Ngotwane, Dinokane Eye (dolomite water area)	A10A

10_2	Ngotwane Dam	A10A
IUA11a	**Groot Marico/Molatedi Dam**	
RU	**Delineation**	**Catchment**
11a_1	Groot Marico from outflow Marico Bosveld Dam to Molatedi Dam, all tributaries	A31G, A31H, A31F, A31J, A32A, A32B, A32C
11a_2	Molatedi dam	A32A, A32B, A32C
IUA11b	**Groot Marico/Seasonal tributaries**	
RU	**Delineation**	**Catchment**
11b_1	Groot Marico main stem from outflow Molatedi Dam, Rasweu, Maselaje rivers	A32D
11b_2	Elandslaagtespruit, Lengope la Kgamanyane, Lenkwane	A32E
IUA12	**Bierspruit**	
RU	**Delineation**	**Catchment**
12_1	Wilgespruit, Bofule, Kolobeng, Magoditshane, Motlhabe	A24D
12_2	Bierspruit outflow Bierspruit Dam to confluence with the Crocodile River, Brakspruit, Phufane, Sefatlhane, Lesobeng, lower reach Bofule	A24E, A24F
IUA13	**Lower Crocodile**	
RU	**Delineation**	**Catchment**
13_1	Crocodile River outflow Roodekopjes Dam to upstream Sand River confluence, Sleepfonteinspruit, Klipspruit tributaries and alluvial aquifer systems in river valley	A21L, A24A, A24B, A24C
13_2	Sand River to confluence with the Crocodile River to Bierspruit confluence, Sondags, Vaalwaterspruit and Monyagole tributaries	A24G, A24H
13_3	Lower Crocodile from Bierspruit confluence to the Botswana border (Limpopo River)	A24J
IUA14	**Tolwane/Kulwane/Moretele/Klipvoor**	
RU	**Delineation**	**Catchment**
14_1	Apies River, Tshwane tributary	A23F
14_2	Pienaars River from Boekenshout confluence to Apies River confluence	A23C
14_3	Plat River	A23G
14_4	Moretele (Pienaars) River from Plat River confluence to Klipvoor Dam, Kutswane to Klipvoor Dam	A23J
14_6	Klipvoor Dam	23J
14_7	Pienaars River from Klipvoor Dam to Crocodile River confluence, Tolwane tributary	A23K, A23L
IUA15	**Upper Mokolo**	
RU	**Delineation**	**Catchment**
15_1	Moloko River, Klein Sand, Sondagsloop, Heuningspruit, Dwars, Jim se loop tributaries	A42C, A42E
15_2	Sterkstroom, Frikkie-se-Loop	A42D, A42E
15_3	Mokolo River in A42F to inflow Mokolo Dam, Taaibosspruit, Malmanies and Bulspruit tributaries	A42F
15_4	Mokolo Dam to upper portion of A42G (10km downstream of dam)	A42F
15_5	Grootspruit and Sandspruit tributaries (Mokolo headwater catchment)	A42A, A42B

15_6	Mokolo River from Dwars river to confluence with Sterkstroom, Klein Vaalwaterspruit, Brakspruit	A42E
IUA16	**Lower Mokolo**	
RU	**Delineation**	**Catchment**
16_1	Tambotie River catchment	A42H (major portion - eastern)
16_2	Poer-se-Loop catchment	A42G
16_4	Sandloop and alluvial aquifer systems in river valley	A42J and remaining portion of A42H
16_5_1	Mokolo main stem - Mokolo from below EWR3 to the Tambotie confluence	A42G, H along main stem
16_5_2	Mokolo main stem - from Tambotie confluence to Limpopo	A42J along main stem
IUA17a	**Mothlabatsi/Mamba**	
RU	**Delineation**	**Catchment**
17a_1	Mamba River	A41B
17a_2	Mothlabatsi River	A41A, A41B
17a_3	Headwaters Mothlabatsi (Matlabas-Zyn-Kloof, peatlands)	A41A (south eastern)
IUA17b	**Matlabas**	
RU	**Delineation**	**Catchment**
17b_1	Matlabas	A41D, A41C
17b_2	Catchment area including Steenbokpan (excluding Limpopo River)	A41E

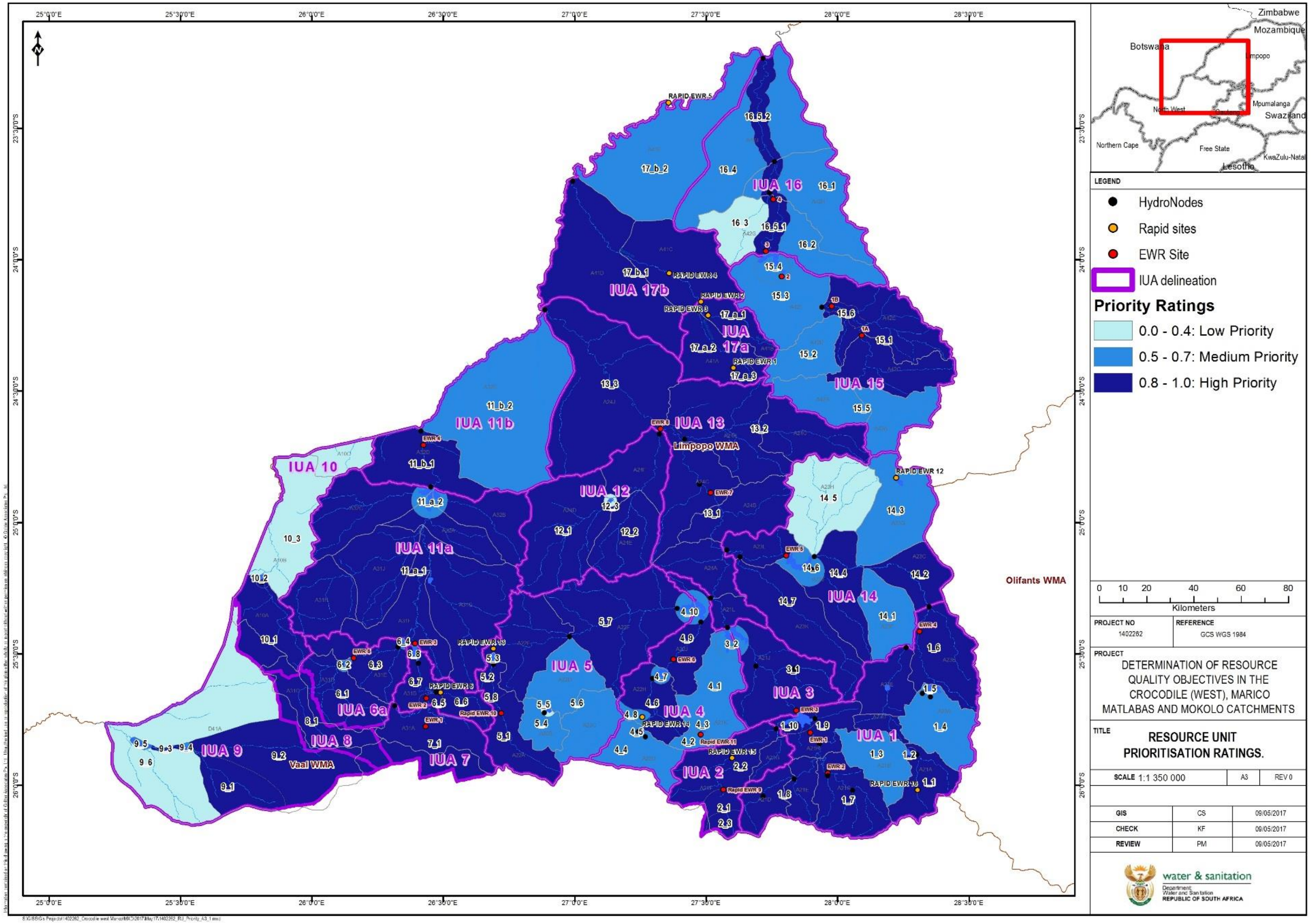


Figure 5: Prioritised Resource Units for the Crocodile (West) catchment, Marico catchment and Mokolo and Matlabas catchment

3.1 PRIORITY GROUNDWATER AREAS

Two important aquifer systems have been identified in terms of specifying groundwater priority areas, *i.e.*:

- Alluvial aquifer systems; and
- Dolomite (karst) aquifer systems.

The priority groundwater areas selected for RQO determination are listed in Table 4 and shown in Figure 6, Figure 7, Figure 8 and Figure 9.

Table 4: Priority Groundwater Areas selected for RQO Determination

SELECTED GROUNDWATER PRIORITY UNITS		
Dolomitic GMA1 (RU1_1; 1_2; 1_3; 1_6)	Centurion, Pretoria and Rietvlei-Kempton Park dolomite resources.	A21A, A21B, A23D
Dolomitic GMA 2 (RU 2_1; 2_2; 2_3)	Maloney's Eye (Steenkoppies Catchment and Tarlton dolomite resources	A21D, A21F, A21G
Dolomitic GMA3 (RU 7_1, 8_1, 9_1)	Upper-Molopo Catchment, Marico/Holpan and Dinokana-Zeerust dolomite resources	A31A, A31C, D41A
General: Alluvial aquifer systems	Systems along major drainage channels *viz.*the Lower Crocodile River, Thabazimbi to Limpopo River confluence and the Lower Mokolo	A24B, A24C, A24H, A24J;

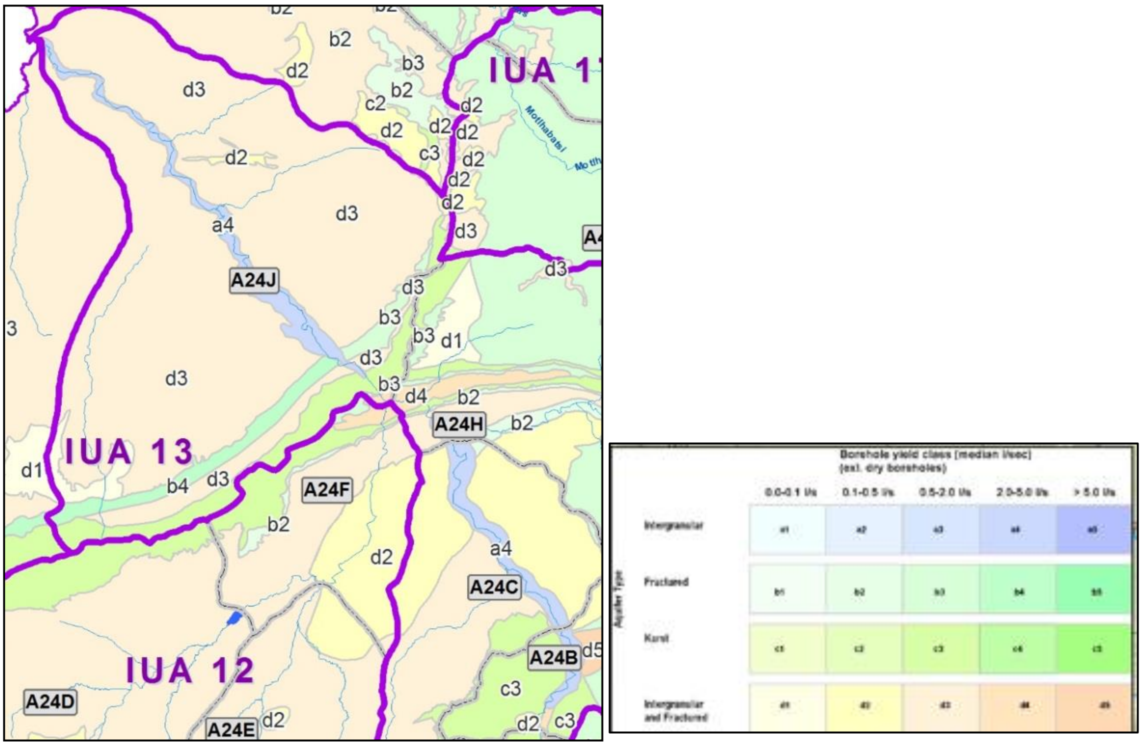


Figure 6: Alluvial aquifer systems along major drainage channels (shown the lower Crocodile (West) River between Thabazimbi and Limpopo Confluence)

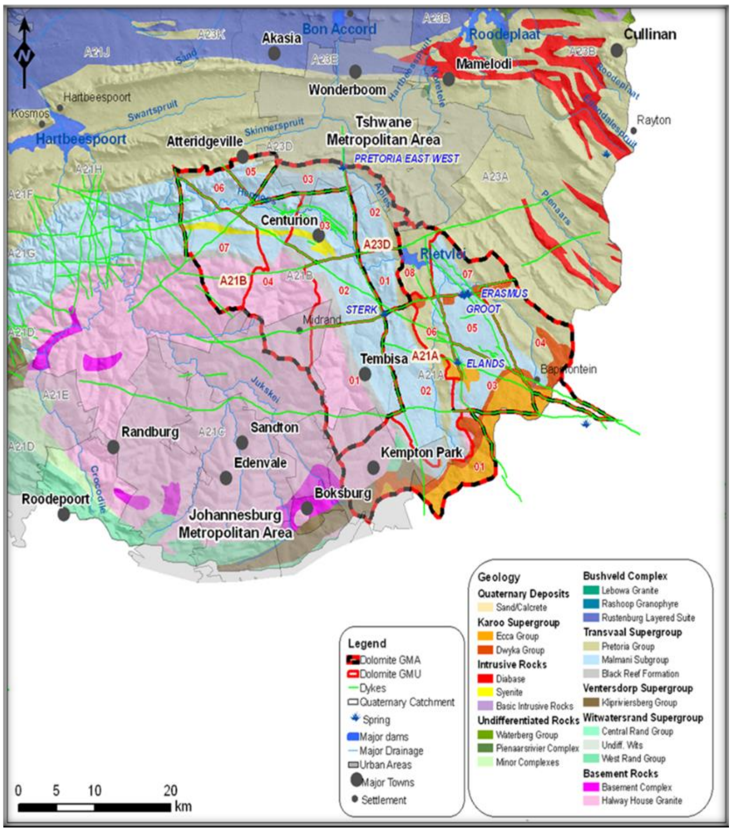


Figure 7: Centurion, Pretoria and Rietvlei-Kempton Park dolomite resources

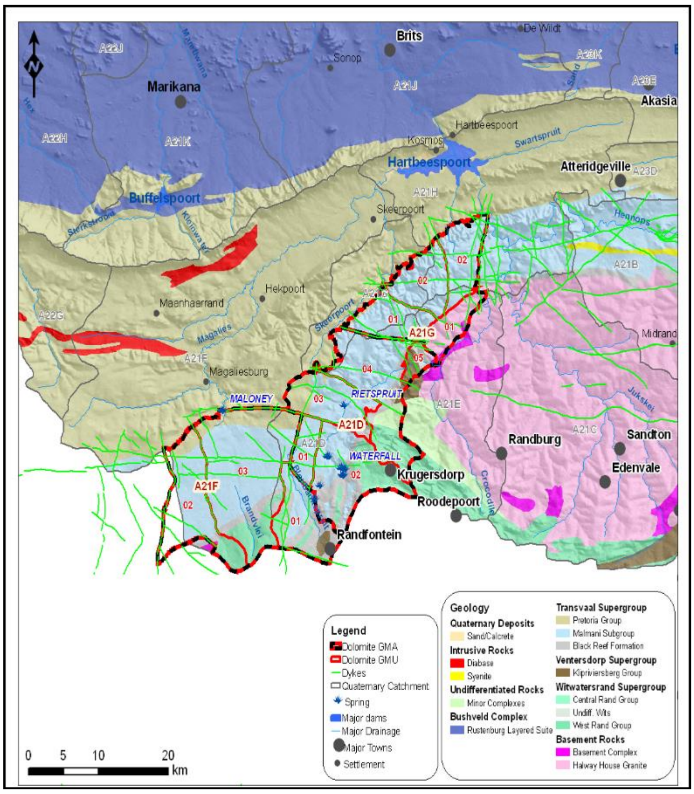


Figure 8: Maloney's Eye (Steenkoppies Catchment and Tarlton dolomite resources)

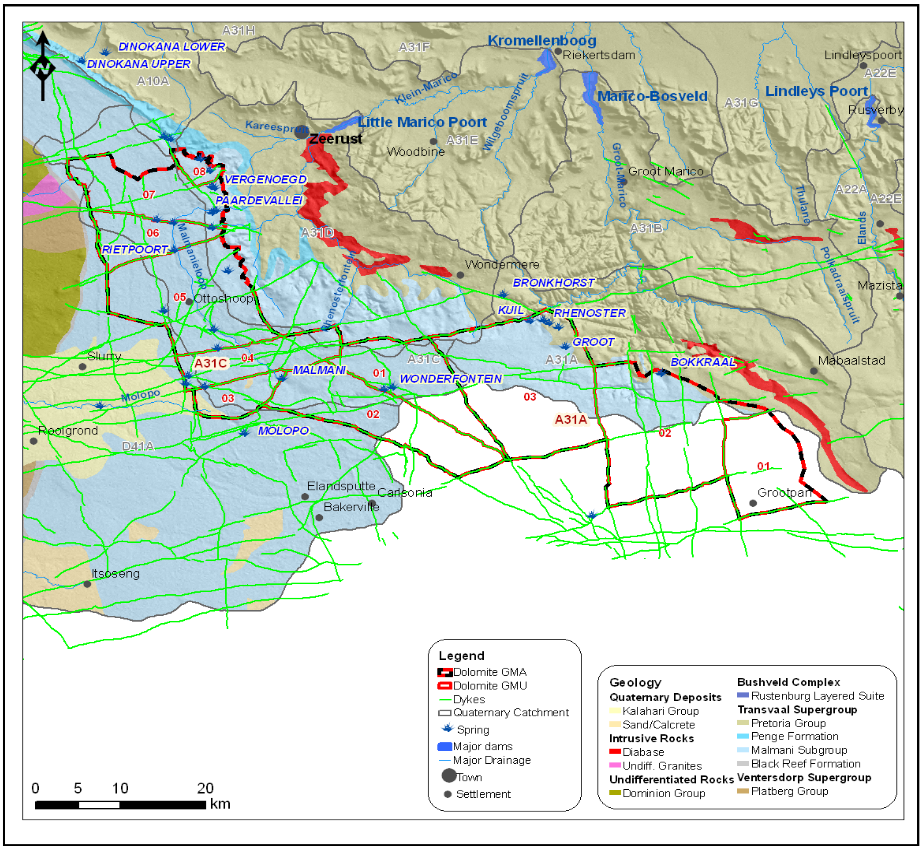


Figure 9: Upper-Molopo Catchment, Marico/Holpan and Dinokana-Zeerust dolomite resources

3.2 PRIORITY WETLANDS

The priority list of most important identified wetlands was derived from the wetland component of the DWA (2013) and WCS (2013) reports. The prioritisation of the wetlands in those reports was based predominantly on available information supported by inputs provided during various task team, steering committee and other consultative meetings held as part of the DWA (2013) study. During the RQO study some wetlands were removed from the original priority list while others were added based on inputs provided during the Project Steering Committee meetings, new information made available to the team, and expert inputs using updated knowledge of the study area.

A total of 38 priority wetlands were identified as part of the RQO process, with 27 RU's containing priority wetlands. The largest wetland systems in the WMA are the floodplains with the Moretele River Floodplain being the largest at approximately 4 563 hectares in extent followed by the Apies River Floodplain at approximately 3 200 hectares. Both the Lower Crocodile River and Plat River Floodplains are in the order of 2 500 hectares in extent while Mokolo and Tambotie River Floodplains are approximately 1 310 and 1 130 hectares in extent respectively. The Lower Matlabas Floodplain is approximately 850 hectares in extent. The Kolobeng Wetland which includes some floodplain habitat also forms a large wetland complex estimated at approximately 1 200 hectares in extent. The remainder of the wetlands range from approximately 460 hectares to 2.7 hectares in extent where the wetland forms part of a wetland complex.

Wetland Mapping

As part of this study, the mapping of the priority wetlands was updated. This was done by digitizing the wetlands at a desktop level using available remote imagery. Mapping was carried out at a scale of between 1:5 000 and 1:10 000 wherever possible where the imagery was of sufficient resolution for this purpose. Due to the extent of the area and the mapping scale used, the actual extent of the boundaries of these systems is likely to be underestimated or overestimated in places. This may range from metres to tens of metres but generally is regarded as being of sufficient accuracy for the purposes of this level of study. While an attempt was made to cover as many of the wetlands as possible where wetland complexes were concerned, it is likely that some wetlands may have been missed and not mapped due to difficulty with identifying the wetland signatures on the imagery or due to uncertainty as to whether or not the area concerned was actually wetland. Limited to no field verification was undertaken in most instances. An attempt was made to at least try to visit as many of the systems as possible, either during the 2013 studies, or as part of the RQO study, albeit at a very rapid visual assessment level, this was limited by budget and time constraints as well as accessibility. The wetland delineations produced must thus be considered in this context and serve as indicative of the wetland systems and their extent and field verification would be required to update and verify the mapping in future. In addition, while an indication of the hydrogeomorphic (HGM) types of wetland systems that comprise the priority wetland complexes is provided in the relevant tables that form part of the report, these were not mapped separately as part of the desktop mapping. As such the desktop map of the wetlands only indicates the approximate extent of the wetland systems prioritized and does not include a breakdown of the systems into individual HGM units.

The list of priority wetlands per IUA and RU is provided in Table 5. A map showing the distribution of wetlands per IUA and RU is shown in Figure 10.

Table 5: Priority wetlands per IUA and RU indicating the type of system and a brief description of any unique features associated with the wetland systems

IUA	RU	Wetland	Type	Unique features
IUA 1	1_1	Bronkhorstfontein Pan Complex	Depressions/Pans	Endorheic seasonal grass-sedge pans.
	1_1	Rietvlei Wetland Complex	Channelled and unchannelled valley bottom	Parts of the wetland complex comprise peat and associated peat habitats.
	1_3	Glen Austin Pan	Depression/Pan	Endorheic seasonal grass-sedge pan.
	1_4	Colbyn Valley Wetland	Channelled and unchannelled valley bottom	Parts of the wetland comprise peat and associated peat habitats.
IUA 4	4_6	Waterkloofspruit Wetland	Unchannelled valley bottom	Peatland at the headwaters of the Waterkloofspruit.
IUA 5	5_1	Koster Pan Complex	Depressions/Pans	Endorheic seasonal grass-sedge pans.
IUA 6 and IUA 8	6_1 8_1	Buffelshoek Wetland Complex	Channelled and Unchannelled valley bottom	Has as its source a dolomitic eye and expected to have peat in the system.
	6_1 8_1	Paardenvallei Wetland Complex (Malmaniesloop)	Channelled and Unchannelled valley bottom	Has as its source a dolomitic eye and expected to have peat in the system.
IUA 7	7_1	Marico Eye Wetland (Kaaloog se Loop)	Unchannelled valley bottom (peatland)	Dolomitic eye with a valley bottom peatland downstream.

IUA	RU	Wetland	Type	Unique features
		Rietspruit Wetland	Channelled and Unchannelled valley bottom	Has as its source a dolomitic eye and expected to have peat in the system.
		Tufa Waterfall	Tufa	Waterfall composed of limestone or calcium carbonate formed by the precipitation of carbonate minerals. Very rare type of waterfall in SA.
IUA 8 and IUA 9	8_1	Malmanieloop Wetland Complex	Channelled and Unchannelled valley bottom (peatland)	Have as their source dolomitic eyes and are valley bottom peatlands. Have unique biota associated with the dolomitic eyes.
	8_1 9_2	Upper Molopo River Wetland Complex	Channelled and Unchannelled valley bottom (peatland)	
	8_1	Vergenoegd Wetland	Channelled and Unchannelled valley bottom	Has as its source a dolomitic eye and expected to have peat in the system.
IUA 9	9_2	Middle Molopo River Wetland Complex	Channelled valley bottom	Have at their source a dolomitic eye and forms part of the Upper Molopo River Wetland Complex.
	9_3, 9_5	Lower Molopo River Wetland Complex	Channelled valley bottom	
IUA 10	10_1	Dinokana Wetland	Unchannelled and Channelled valley bottom and Hillslope seepage wetlands	Has as its source a dolomitic eye and important for water supply.
		Ngotwane Wetland	Unchannelled valley bottom	Wetland is located upstream of the Ngotwane Dam in a fairly dry region and is thus important for water supply and water quality improvement. Important grazing resource for local livestock.
IUA 11b	11_b_2	Lower Lenkwane River Wetland	Unchannelled valley bottom linked to Floodplain	Unchannelled valley bottom system feeding a section of the Limpopo River floodplain. Has a number of backwater and floodplain-related habitats close to the Limpopo River.
IUA 12	12_1	Kolobeng Wetland Complex	Channelled valley bottom and floodplain	Extensive wetland system in the region linked to floodplain habitats as well as extensive hydromorphic grasslands on clay rich soils.
IUA 13 and IUA 17	13_3, 17_b_1	Lower Crocodile River Floodplain	Floodplain	Floodplain-related habitats and associated riparian forest assemblages associated with flooding and an alluvial aquifer system. Floodplain and backwater features occur linked to the Limpopo River floodplain.
IUA 14	14_1, 14_2 14_3 14_4	Moretele River Floodplain	Floodplain	Extensive floodplain system with floodplain-related habitats. High biodiversity wetland and important bird habitat. Important grazing resource for local livestock.
	14_1	Apies River Floodplain	Floodplain	Extensive floodplain system with

IUA	RU	Wetland	Type	Unique features
				floodplain-related habitats and is an important tributary of the Moretele River floodplain. Important grazing resource for local livestock.
	14_3	Plat River Floodplain	Floodplain	Important tributary of the Moretele River floodplain system
	14_4	Tswaing Crater Pan	Depression/Pan	Unique endorheic pan linked to an ancient meteor crater.
IUA 15	15_1	Upper Mokolo River Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	Complex of valley bottom and hillslope seepage wetlands in the headwaters of the Mokolo River. Also Part of the Waterberg system with a unique combination of flora and faunal associations. Blue Cranes have been reported in the area intersected by parts of the wetland complexes.
	15_1	Klein Sand River Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	
	15_2	Grootfonteinspruit Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	
	15_2	Frikkiesloon River Wetland Complex	Channelled and Unchannelled valley bottom	Complex of valley bottom and hillslope seepage wetlands in the headwaters of the Mokolo River. Also Part of the Waterberg system with a unique combination of flora and faunal associations.
	15_5	Grootspruit Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	Complex of valley bottom and hillslope seepage wetlands in the headwaters of the Mokolo River. Also Part of the Waterberg system with a unique combination of flora and faunal associations. Blue Cranes have been reported in the area intersected by the lower sections of the wetland complexes.
	15_5	Sand River Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	
	15_5	Sandspruit Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	Complex of valley bottom and hillslope seepage wetlands in the headwaters of the Mokolo River. Also Part of the Waterberg system with a unique combination of flora and faunal associations. The wetlands and associated terrestrial grassland habitats support Blue Cranes.
	15_5	Sand River Tributary Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	Complex of valley bottom and hillslope seepage wetlands in the headwaters of the Mokolo River. Also Part of the Waterberg system with a unique combination of flora and faunal associations.
IUA 16	16_1 16_5_2	Tambotie River Floodplain	Floodplain	Floodplain system with floodplain-related habitats and flows into the Mokolo River floodplain. High

IUA	RU	Wetland	Type	Unique features
				biodiversity wetland and important wildlife habitat. Also has old growth riparian forest assemblages associated with flooding and an alluvial aquifer system.
	16_3	Rietspruit Wetland 2	Channelled and Unchannelled valley bottom	Wetland forms part of an important tributary which feeds the floodplain of the Mokolo River
	16_5_2	Mokolo River Floodplain	Floodplain	Has old growth riparian forest assemblages associated with flooding and an alluvial aquifer system. Floodplain as well as backwater features are prevalent and provide important habitat for biota.
IUA 17a and IUA 17b	17_a_2	Matlabas Wetland (Peatland)	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	Peatland in the headwaters of a tributary of the Motlhabatsi River.
	17_b_1	Lower Matlabas River Floodplain	Floodplain	Has old growth riparian forest assemblages associated with flooding and an alluvial aquifer system. Floodplain as well as backwater features occur linked to the Limpopo River floodplain.

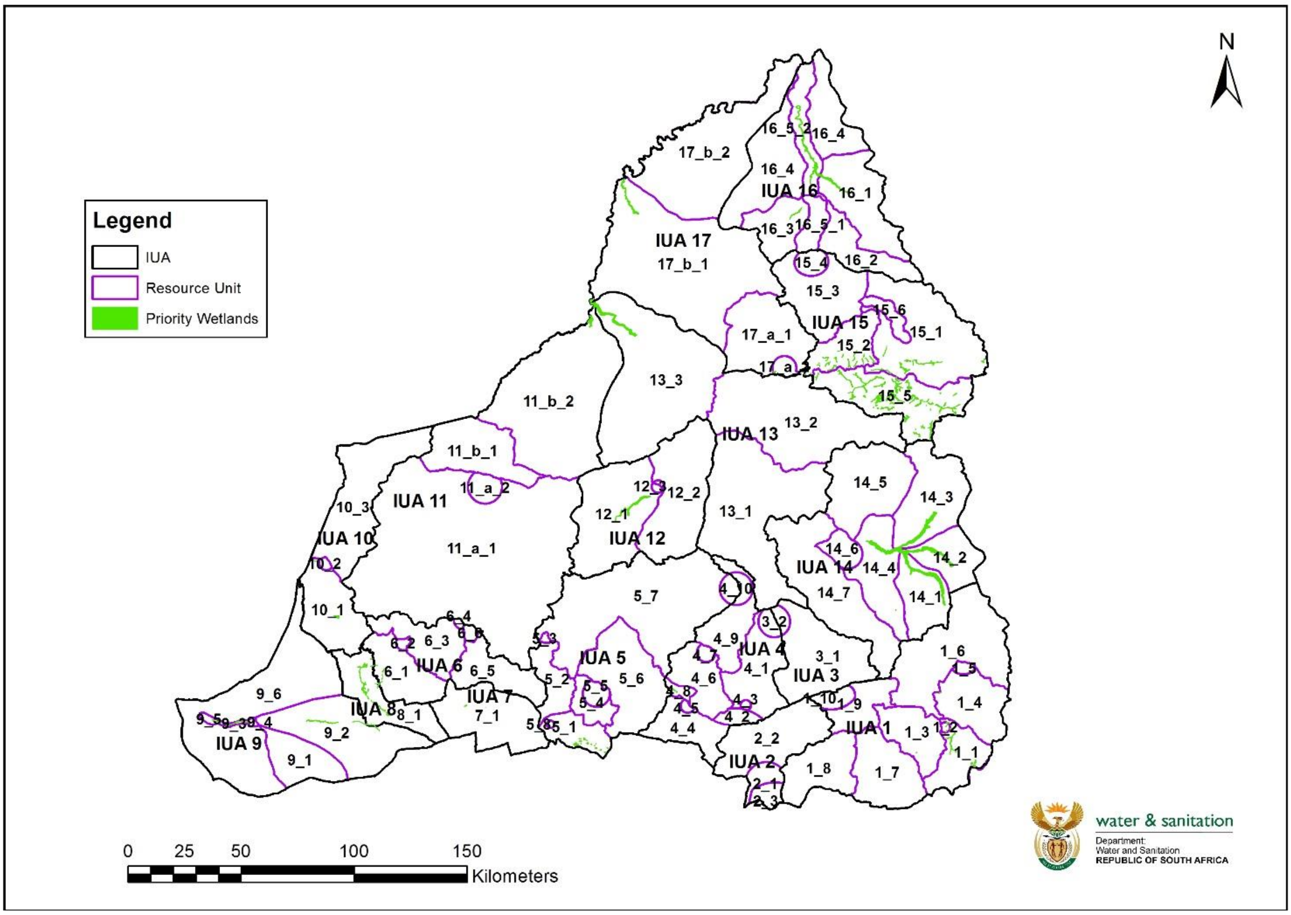


Figure 10: Map showing the priority wetlands identified within the study area

4 PRIORITISATION OF SUB-COMPONENTS AND SELECTION OF INDICATORS

Step 4 of the RQO development process, required the selection of components and the identification of proposed sub-components and indicators for which RQOs should be formulated for water resources within the prioritised resource units of the Mokolo, Matlabas, Crocodile (West) and Marico catchments.

The step has two key objectives, firstly to identify and prioritise sub-components that may be important to users or the environment; and secondly to select those sub-components and associated indicators for which RQOs and numerical limits should be developed. This step allows for a process of rationalisation in order to determine relevant importance and also requires consideration of the impacts of land based activities on the water resource.

The resource unit evaluation was undertaken for the water resources in the Mokolo, Matlabas, Crocodile (West) and Marico catchments using desktop information, local expert knowledge, previous studies, specialist studies and a detailed understanding of the catchment. The assessment was undertaken in a workshop environment with technical specialists, catchment managers and key stakeholders. The overall priorities identified through the evaluation process was used to guide the selection of sub-components for RQO determination. Once the sub-components were selected, suitable indicators for monitoring were then identified. Sub-components for wetlands and groundwater were also selected through independent approaches based on assessment and evaluation of relevant aspects. These were then presented to stakeholders to obtain agreement on the proposed components and the identification of proposed sub-components and indicators.

The components and sub-components include the following:

- Quantity
    - Low Flows, including drought flows
    - High Flows
- Quality
    - Nutrients
    - Salts
    - Systems variables
    - Toxics
    - Pathogens
- Habitat
    - Instream habitat
    - Riparian habitat
- Biota
    - Fish
    - Aquatic and riparian vegetation
    - Mammals
    - Birds

- Amphibians and reptiles
- Periphyton
- Aquatic macro-invertebrates
- Diatoms

For wetlands the RQOs are related to the four components habitat, quality, quantity and biota, while for groundwater the RQOs are related to the water level (*viz.* aquifer saturation levels), quality, abstraction and protection zones.

Once the sub-components were selected per resource unit for the rivers, suitable indicators for monitoring were then identified. The components and indicators for groundwater systems and wetland systems/clusters were also identified and prioritised. This prioritisation has been used as the basis for developing RQOs and numerical limits proposed in the sections that follow.

The list of sub-components, indicators selected for monitoring and the rationale for consideration (where applicable) for the rivers, dams, wetlands and groundwater in the Mokolo, Matlabas, Crocodile (West) and Marico catchments are detailed in the Resource Units Prioritisation, Sub-component Prioritisation and Indicator Selection Report. (DWS, 2016b).

5 SETTING OF RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS

Based on the prioritisation of sub-components undertaken in Step 4, RQOs have now been developed for rivers, dams, wetlands and groundwater in the Mokolo, Matlabas, Crocodile (West) and Marico catchments. Numerical limits are proposed where applicable for the draft RQOs recommended for the water resources. Numerical limits translate the narrative RQOs into numerical values which can be monitored and assessed for compliance.

The basic approaches to the drafting of RQOs for rivers, dams, wetlands and groundwater are briefly outlined below. The draft RQOs proposed will be reviewed, updated and refined based on stakeholder consultation still to be undertaken.

5.1 Rivers and Dams

The drafting of the RQOs for rivers and dams were based on and included the following aspects which were applied accordingly in the context of each resource unit:

- Understanding of the catchment context and priorities;
- Collation and assessment of available data and information (present state and historic);
- Assessment of ecological classification and river health information;
- Assessment of water quality information;
- Incorporation of the requirements of the Water Resource Classification – Water Resource Classes and Ecological Categories recommended;
- Present Ecological State;
- Incorporation of flow specifications (summaries of required flow durations (tables) and summary tables of drought, low and high flow reqiirements per month (tab tables) as specified in the Classification and preliminary Reserve results)
- Incorporation of any direction of change required for any sub-components;
- Consideration of land based impacts;
- Stakeholder requirements;
- Feasibility of achievement of desired state;
- Alignment between resource units;
- Specification of 'quantifiable' numerical limits in line with the draft RQOs; and
- Determination of appropriate measures, sampling methods and sampling frequency.

The RQOs developed for the Mokolo, Matlabas, Crocodile (West) and Marico catchments rivers and dams relate to and are based on/or derived from the following:

- The Water Resource Classes (and Reserve where applicable) and associated Ecological Categories:
    - As per the specifications of the Water Resource Classification.
- The instream flows are prescribed as specified at ecological water requirement sites and

biophysical nodes:

- Flows were determined as part of Water Resource Classification Study, "Classification of Significant Water Resources in the Crocodile (West) Marico, Mokolo and Matlabas Catchments (DWA, 2012) (includes ecological water requirements also considering strategic/user demands).
- High Flows or Low Flows (Maintenance and Drought Flows) or both were selected based on prioritisation in the specific RU;
- RQO flow specifications are those prescribed in terms of the Water Resource Classification Study, and where applicable the Intermediate Reserve Determination Study for the Crocodile (West) and Marico WMA (DWA, 2009), and the Intermediate Reserve Determination Study for the Surface and Groundwater Resources in the Mokolo Catchment, Limpopo Province (DWA, 2010).
- RQOs are specified in terms of flow requirements at nodes and EWR sites (meeting ecological requirements and user specifications).

- The presence and concentration of particular substances in the water resource (more stringent value of either the ecological category (PES or Class) or present water quality state):
    - The sub-components of salts, nutrients, pathogens, toxics or system variables were selected when water quality was prioritised in a RU. Sub-component(s) of importance/relevance to the user and /or the ecological system was selected.
    - Indicators of relevance and appropriateness to the sub-components were then identified. For example, for salts – electrical conductivity; nutrients – orthophosphate, inorganic nitrogen or system variables – pH, etc.) . Consideration of impacts and user requirements (Domestic, Agriculture, Industry, Recreation, Ecosystem) as well as ease of monitoring was considered.
    - RQOs were then developed for the sub-components and limits set for the indicators. Decision criteria applied:
        - Ecological category of water resource – Maintenance or improvement
        - Consideration of present state water quality of resource – Maintenance or improvement
        - User requirements - strictest user requirements
    - RQOs were then set and numerical limits specified based on one or more of the above decision criteria. If present state water quality was stricter than ecological water quality, RQO was set based on status quo quality. If not the ecological water quality specification was adopted. The Water Resource Class and related ecological category was met, user requirements were complied with and alignment with downstream/upstream reaches was applied.

- Numerical and narrative RQOs were produced using all existing data sources.
- The key water quality issues/impacts in the resource unit were also considered and relevant indicators were included if applicable.

- The characteristics and quality of the water resource including instream and riparian habitat (maintenance or improvement of ecological state):
  - Instream and/or Riparian component of the habitat was prioritised for a RU.
  - Ecological categories per component, Ecostatus, habitat integrity and the landuse activities and available data were considered.
  - Maintenance or improvement of a component was recommended based on Present State and Recommended Ecological Category (REC) specified. Any potential threats were considered.
  - Vegetation components were assessed (general vegetation structure and composition, invasion by alien species, abundance of terrestrial species) to determine the overall state of the riparian zone.
  - RQOs were specified in terms of meeting the Recommended Ecological Category (REC).
- The characteristics and distribution of aquatic and semi-aquatic biota (maintenance or improvement of ecological state):
  - Sub-components were selected for a RU, if Biota was prioritised as a component. Fish, macroinvertebrates, or diatoms were selected based on relevance to a specific RU.
  - Ecological Categories per component, Ecostatus and habitat integrity, landuse activities present and relevant, available data were considered.
  - Maintenance or improvement of the biotic sub-component was recommended based on Present Ecological State (PES) and Recommended Ecological Category (REC). Any important species as well as potential threats were also considered.
  - RQOs were specified in terms of meeting the Recommended Ecological Category (REC) (and Water Resource Class); recommended condition and monitoring.
  - For Fish: Available information provided by the PES/EIS project was used as a key source of information, and data obtained through the River EcoStatus Monitoring Programme (REMP). Aerial footage (Google Earth), and all relevant information were used to determine the expected present suitability of each reach for each species. This was transferred to the Fish Response Assessment Index (FRAI) and refined based on expert judgement and additional information. The FRAI results were then used to describe narrative RQOs and numerical limits for each sub-components indicators.

- For macroinvertebrates: Available information provided by the PES/EIS project was used as a key source of information, data obtained through the River EcoStatus Monitoring Programme (REMP) and macroinvertebrate data retrieved from the Rivers Database. Narrative RQOs were set according to the specific Ecological Category as determined by the Macroinvertebrate Response Assessment Index (MIRAI) for a specific site representative of the resource unit or area considered. Numerical limits were then set for the specific MIRAI Ecological Category, and for the SASS5 (South African Scoring System Version 5) total score and ASPT (Average Score Per Taxon).

5.2 Wetlands

RQOs for the priority wetlands in the Mokolo, Matlabas, Crocodile (West) and Marico catchments were developed as follows:

- Resource Unit scale wetland RQOs

  RQOs based on clusters and wetland types were developed considering development and other risks or impacts that the systems may be exposed to.

Specific RQOs for selected priority wetlands were developed based on expert inputs with specific knowledge of the systems being considered. Reliance was made on previous data and assessments. The following approach was undertaken:

- Review of the categorisation of the priority systems (condition and ecological importance and sensitivity) – for those where this information is available.
- Consideration and recommendation of targeted Ecological Categories for the priority wetlands where possible. This was largely based on information already available but revised where necessary based on site visits to the priority systems.
- Recommendation of ecological specifications (protection, management, mitigation and monitoring measures) for the priority systems.
- RQOs were then determined where sufficient data was available for this purpose. At this stage it was based mostly on generic measures with reference to specific measures where appropriate or where suitable information existed for this purpose.
- RQOs are mostly narrative, and include general RQOs aimed mostly at the largest impacts to wetland integrity and continuity, as well as to the sub-components identified.

The PES of the priority wetlands was assessed using a semi-quantitative desktop method. This method utilized calculations of within wetland and surrounding wetland land-uses as a proxy to determine wetland impacts, and consequently wetland ecological state. The method was modified from “A method to assess wetland ecological condition based on land-cover type” as published by the Water Research Commission (Kotze, 2016a and 2016b), a recently completed project.

The method as performed here calculates the percentages of various types of land-uses both within wetland boundaries and within a 200 m buffer outside of the wetland boundaries. This was achieved utilizing existing land-cover data from the 2013-2014 National Land Cover (NLC) dataset (Department of Environmental Affairs, 2015), available via SANBI. Each land cover type was assigned an impact score as proposed by Kotze (2016a and 2016b) and an area based weighted average of all impact scores were summed. For the 200 m wetland buffers, resulting land–use based impact scores were further multiplied by a “natural vegetation buffer” score between 0.6-1,0 (as per

Kotze, 2016a and 2016b) meant to assess the level to which natural vegetation buffering a particular wetland can mitigate the effects of surrounding land-use impacts. Resulting total impact scores for both within wetlands and within the 200 m buffer outside the wetland boundaries were then summed, resulting in a final overall wetland impact score between 0 and 10. These scores were then used to determine appropriate individual wetland PES category scores as per Kotze (2016a and 2016b). Finally, for wetlands that formed part of a “complex” with other wetlands, a weighted average based on an individual wetlands proportional area relative to the total area of the complex was computed and applied to individual overall wetland impact scores. Resulting fractional impact scores were then summed to determine the overall impact score for the complex. Again these scores were used to determine resulting complex PES categories as per Kotze (2016a and 2016b). It is important to note that for some cases where the operator/expert knowledge did not correspond with the derived impact score or category attributed by the method, the scores or categories were amended where possible.

The method is subject to several limitations and assumptions. Foremost among these is the use of the coarse NLC dataset as proxy for land-use based wetland impacts. It is notable that the methodology proposed by Kotze (2016a and 2016b) and resulting scoring system is intended to be used in conjunction with field-based observation of wetland condition/impacts, and as a result the types and categories of impacts are generally more detailed. At a desktop level using NLC data it is very difficult if not impossible in some cases to determine the presence or absence of certain fine scale impact details. Moreover, using existing land-cover data as inputs to impact scoring, means that categories may not precisely match the categories as proposed by Kotze (2016a and 2016b). This is especially the case using the NLC land-cover dataset, where land-cover is broadly categorized. Thus, a significant amount of operator discretion is required to assign relevant land-covers to appropriate categories and impact scores as per Kotze (2016a and 2016b). This additionally may vary on a per-wetland basis. Aside from accuracy and precision issues related to the NLC dataset, a further assumption/limitation includes the use of a 200 m buffer to assess surrounding wetland impacts (due to time/resource constraints), whereas an assessment at a wetland catchment level may be more comprehensive. Finally, whereas the Kotze (2016a and 2016b) method allows for the assessment of a wetlands “natural vegetation buffer” to mitigate surrounding land-use impacts, due to the difficulty of assessing such a buffer at a desktop level, a standard value of 0.8 (see Kotze 2016a and 2016b) indicating an “intermediate vegetation buffer” (and thus an intermediate moderation of surrounding impacts) was generally used except in obvious or extreme cases.

There are several ways to improve upon the method, including using better field verified delineation of the wetland boundaries associated with high-level field PES verification as well as more detailed desktop mapping of the surrounding land uses based on high resolution aerial imagery. This could further be supported by field verification of the land-use categorization of the wetland buffers. However, even if time and budget allowed, such field verification would likely be limited by access. Even in cases where there is access to a particular wetland or part of a wetland, the areas being accessed and visited may not always represent the general conditions throughout the wetland and the buffers across the entire system. These are some of the challenges that any method for remotely determining the PES of wetlands would have when the wetlands extend over such large areas and where many of the systems form complexes of wetland systems comprised of different HGM units. It is thus important to point out that the application of this type of method for remotely determining the PES of wetlands at the scales appropriate here is still in its infancy and should be considered preliminary requiring further testing and verification prior to general application for these types of studies. It nevertheless represents a far more robust and detailed method than has been applied before for these types of studies. It thus represents a much improved step towards the development of a catchment-level approach that could be rolled out for these types of studies in the future.

Besides the limitations related to the wetland mapping and PES assessments undertaken as part of this study, it should also be noted that there may be other wetlands that were not identified or covered as part of either the WCS (2013) or the RQO study due to the level of investigation undertaken, the extent of the study area, the limited nature of field verification, and accuracy and level of detail of the information used to derive the wetland coverage. Some of these could also potentially rank as important. The prioritisation provided for the purpose of this RQO study cannot therefore be considered finite but rather part of an on-going process where new systems may be identified and prioritised in future as more information becomes available or as the wetland coverage of the study area improves.

5.3 Groundwater

Groundwater RQOs were established on a resource unit scale (regional and local). The dolomite resource unit demarcations were adapted to portray the actual groundwater flow boundaries as per the mapped dolomite compartment boundaries. The approach to specify RQO for groundwater was as follows:

- Collation of catchment wide hydrogeological information from the NGA (aquifer characteristics, groundwater qualities and average depth to water levels), WARMS (groundwater use), and the Water Quality Assessment Tool (groundwater quality and water level trends);
- Groundwater use, aquifer recharge information, assessment of groundwater resources, groundwater contribution to baseflow, interflow and total baseflow information and related data was considered (assessments based on the GRA II methodology). The assessment undertaken during the Water Resource Classification study was a key source of information.
- Water resources sustainability in terms of supply assurance, the environmental impact of abstraction (quantities), and use (qualities), should be the main focus areas for management and protection. In the case of large dolomite water areas, impact assessment of large scale abstractions for bulk water supply (domestic and irrigation) on the natural discharge status of Dolomite Eyes should be conducted as part of management strategies. Impacts on Dolomite Eyes is a critical issue and high-level assessments are eventually required to specify discharge values for dolomite compartment unit's and supporting downstream water requirements.
- Qualitative and quantitative RQOs were established, including numerical limits for groundwater resource protection, and they are;
    - As per specifications of GRDM, a stress index (SI) of 0.65 (or 65%) was used as a limit for the RQO (quantity). A stress index is obtained from present day groundwater use divided by long-term, average aquifer recharge and presented as a factor (of percentage). The GRDM methodology proposes a SI of 0.65 (65%);
    - A limit on lowering the water table elevation (i.e. drawing down aquifer saturation levels) in dolomite RUs as this has an impact on Dolomite Eyes discharges, and to some extent, ground stability;

- Long-term groundwater level time series trend limits have been specified where possible in metres per annum – negative trends (i.e. water table recession) should be managed and reversed. Dedicated groundwater monitoring programmes should be established to provide the datasets for managing long-term water resource recessions;
- A range of Protection Zoning (specifically for dolomite RUs discharging as eyes (radius of influence, a stream deflection factor, distance from eye and distance from wetland at eye);
- In the case of river flood plain alluvial aquifer, a stream depletion factor should be specified, (i.e. during groundwater abstraction in the flood plain, the percentage of the borehole yield that should come from the surface water resource should be limited);
- Consideration of microbial zoning for activities related to river flood plain alluvial aquifers;
- Water quality RQOs for nitrate, sulphate, and electrical conductivity are proposed as natural indicators of water quality deterioration and should be applied at all times. In certain geological environments, naturally elevated values for certain hydrochemical constituents (viz. macro, micro, and trace elements) should be taken note of. Cases have been reported where natural concentration levels of salinity, nitrates (NO_3–N), chromium, iron, and manganese are elevated due to the geological nature of an area.

- For irrigation with groundwater, it is proposed that limits be specified through water use regulation on the percentage of irrigated land per deed area (i.e. only a certain percentage of the property/deeds area should be allowed to be irrigated from the local groundwater resources); and
- Abstraction of bulk water supplies from dolomite compartment units supporting flows at Dolomite Eyes to external water supply schemes should be regulated in terms of the above-mentioned resource quality objectives, (*i.e*. apply the SI principle at a lower index, and protection criteria for associated wetlands at the eye).

6 PROPOSED RESOURCE QUALITY OBJECTIVES FOR THE MOKOLO, MATLABAS, CROCODILE (WEST) AND MARICO CATCHMENTS

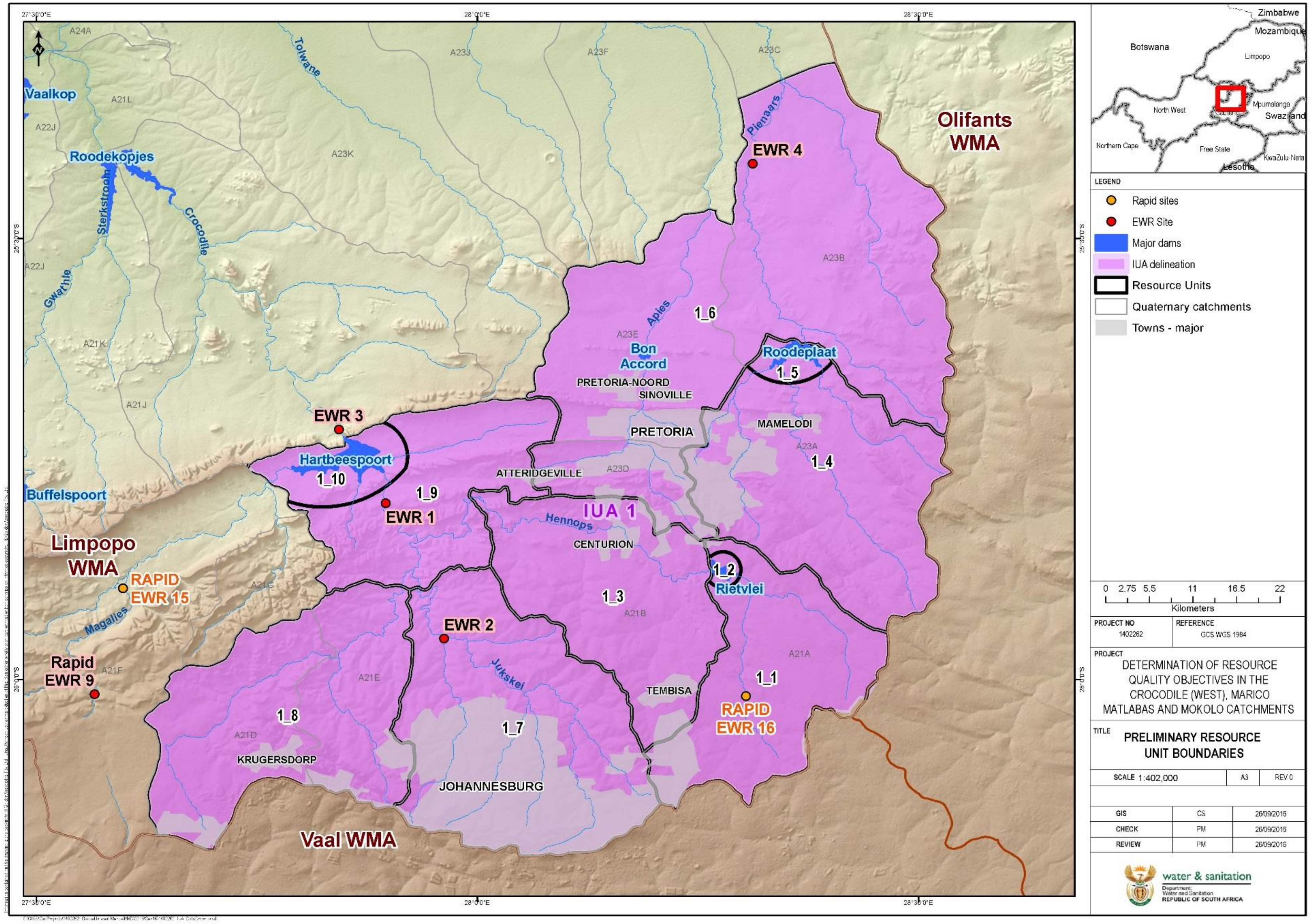
The sections below detail the proposed RQOs for rivers, dams, wetlands and groundwater in the Mokolo, Matlabas, Crocodile (West) and Marico catchments. This is detailed per resource unit and IUA and includes the context and the rationale where applicable on the proposed RQOs and numerical limits formulated.

It serves to guide and provide understanding to the reader on the reasoning and context to on the proposed RQOs. The RQOs are presented in the following sub-sections for rivers and dams, wetlands and groundwater respectively.

6.1 RIVER AND DAM RESOURCE QUALITY OBJECTIVES

6.1.1 UPPER CROCODILE/HENNOPS/HARTBEESPOORT

RU	Delineation	Catchment
1_1	Upper Hennops and Rietvlei Rivers to inflow to Rietvlei Dam	A21A
1_2	Rietvlei Dam	A21A
1_3	Hennops River from outflow Rietvlei Dam to the A21B catchment (including Sesmylspruit, Kaalspruit and Olifantspruit tributaries)	A21B
1_4	Upper Pienaars River, Edendalespruit and Moretlele Rivers to Roodeplaat Dam	A23A
1_5	Roodeplaat Dam	A23A
1_6	Upper and middle reaches of Apies River, Skinnerspruit, Pienaars River from outflow Roodeplaat Dam to Boekenhoutpruit confluence, Roodeplaatspruit, Boekenhoutspruit	A23B, A23D, A23E
1_7	Jukskei, Klein Jukskei, Modderfonteinspruit	A21C
1_8	Upper reaches of Crocodile River and Bloubank Spruit	A21D, A21E
1_9	Crocodile River from Jukskei confluence to inflow Hartebeespoort Dam, Swartspruit	A21H
1_10	Hartbeespoort Dam	A21H


Olifants WMA
Limpopo WMA
Vaal WMA
IUA 1
EWR 1
EWR 2
EWR 3
EWR 4
RAPID EWR 15
RAPID EWR 16
Rapid EWR 9
Hartbeespoort
Roodeplaat
Rietvlei
Bon Accord
Vaalkop
Roodekopjes
Buffelspoort
PRETORIA
PRETORIA-NOORD
SINOVILLE
MAMELODI
ATTERIDGEVILLE
CENTURION
TEMBISA
KRUGERSDORP
JOHANNESBURG
1_1
1_2
1_3
1_4
1_5
1_6
1_7
1_8
1_9
1_10
LEGEND
Rapid sites
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
Towns - major
0 2.75 5.5 11 16.5 22
Kilometers
PROJECT NO 1402262
REFERENCE GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
PRELIMINARY RESOURCE UNIT BOUNDARIES
SCALE 1:402,000
A3
REV 0
GIS CS 26/09/2016
CHECK PM 26/09/2016
REVIEW PM 26/09/2016
water & sanitation
Department: Water and Sanitation REPUBLIC OF SOUTH AFRICA

IUA 1 – Upper Crocodile/Hennops/Hartbeespoort
RESOURCE UNIT : 1_1– Upper Hennops and Rietvlei Rivers to inflow to Rietvlei Dam - Quaternary catchment A21A
DESCRIPTION
The IUA is a Class III. Includes EWR 16 on the Rietvlei.This is a threatened system. The headwaters require protection owing to the upstream economic activities and downstream water abstraction for water service provision (human health). Some wetland FEPAs, pans, peatlands and valley bottom wetlands are present. The Rietvlei Nature Reserve is located at the downstream end of this unit, which is a rehabilitation FEPA and an important protected area. Flow into the dam is supported by discharges from Hartbeesfontein Wastewater Treatment Works (WWTW). The PES of the river is a D category and is impacted due urbanisation, return flows and poor water quality. The river reach is impacted by agricultural activities, industrial and urban effluent discharges. Area includes parts of Kempton Park, Tembisa, Elandsfontein and Bapasfontein. This unit also includes the Irene-Pretoria dolomites and quantity and quality is important in terms of RQOs. Large volumes of water is abstracted from this dolomite aquifer system. Ground stability is a concern for large infrastructure. The aquifer is highly impacted by land based activities and pollution.
RESOURCE UNIT : 1_2 – Rietvlei Dam - Quaternary catchment A21A
DESCRIPTION
The IUA is a Class III. This dam supplies Tshwane with raw water. Water quality impacts remain a threat to the system. Flow into the dam is supported by Hartbeesfontein WWTW discharges in the Rier River. The dam is located within the Rietvlei Nature reserve, which is an important protected area. The Rietvlei wetland system is situated immediately upstream of the Rietvlei Dam within the Rietvlei Dam Nature Reserve. The wetland is a peatland.
RESOURCE UNIT : 1_3 – Hennops River from outflow Rietvlei Dam in A21B catchment (including Sesmylspruit, Kaalspruit and Olifantspruit tributaries): Quaternary catchment A21B
DESCRIPTION
The IUA is a Class III. This system is degraded due to discharges from WWTWs (Olifantsfontein asnd Sunderland Ridge). Includes the Sesmylspruit, Kaalspruit and Olifantspruit tributaries. Rehabilitation FEPAs are present. *Barbus rappax* (Southern Papermouth) is still present in the system and a population of *Labeobarbus polyepsis* on the Sesmylspruit. Some hillslope seepage wetlands are present with high botanical diversity. This unit includes the Irene-Pretoria dolomites and quantity and quality is important in terms of RQOs. Due to large volumes of water being abstracted from the aquifer, ground stability is a concern for large infrastructure. The aquifer is highly impacted by irrigation and pollution. The PES of the river is an E category due to urbanisation, return flows and poor water quality. Resource unit includes parts of urban areas of Kempton Park, Tembisa, Midrand and Centurion.
RESOURCE UNIT : 1_4 – Upper Pienaars River, Edendalespruit, Moretele Rivers and Hartbeespruit to Roodeplaat Dam Quaternary catchment A23A
DESCRIPTION
This system supports the supply of water to Roodeplaat Dam. Abstraction by Magalies Water indirectly through a tunnel (used by Tshwane). This system is degraded due to impacts of the Zeekoeigat and Baviaanspoort WWTWs discharges. However the quantity is required for recharge of Roodeplaat Dam. Can be classified as an ‘urban river’. Includes eastern suburbs of Pretoria, such as Silverton, Faerie Glen, Silver Lakes, Mooikloof, Mamelodi. The PES of the Moretele and upper Hartbeespruit rivers are in an E category due to urbanisation, return flows and poor water quality. The PES of the Pienaars, Edendalespruit and lower Hartbeespruit are in a D category. Water quality and flow monitoring present. Colbyn Valley wetland (peatlands) is present. Rare fish species noted in this area.

IUA 1 – Upper Crocodile/Hennops/Hartebeespoort
RESOURCE UNIT : 1_5 – Roodeplaat Dam - Quaternary catchment A23A
DESCRIPTION
The IUA is a Class III. This dam is eutrophic with algal blooms impacting on the taste of the water. The dam is depended upon for the supply of raw water. It is a conservation area, and supports a wide range of recreational activities (international training for canoeists during summer). Toxic algal blooms are present. Nutrient management and a remediation programme is required. Severely impacted by Zeekoeigat and Baviaanspoort WWTWs discharges, urbanisation and industrial effluent.
RESOURCE UNIT : 1_6 – Upper and middle reaches of Apies River, Skinnerspruit, Pienaars River from outflow Roodeplaat Dam to Boekenhoutpruit confluence, Roodeplaatspruit, Boekenhoutspruit - Quaternary catchment A23B, A23D, A23E
DESCRIPTION
The IUA is a Class III with the resource unit delineated from the outlet of Roodeplaat Dam to the confluence of the Pienaars River with the Boekenshoutspruit. It includes the upper and middle reaches of the Apies River, Skinnerspruit and Walkerspruit. The Pienaars River downstream of the dam provides for the colonization of several fish species no longer found in other tributaries and the system is thus important for fish movement, especially with Roodeplaat Dam upstream and Klipvoor Dam downstream. The Boekenhoutspruit is a rehabilitation FEPA. Sand mining is practiced in the Boekenhoutspruit. Water users include agriculture and domestic water use (direct reliance). Magalies Water abstract water at Klipdrift (option of canal or weir).The upper parts of the catchment are impacted by urbanisation, irrigation runoff and WWTWs (Daspoort, Rooiwal and Roodeplaatspruit). The Ecological Importance and Sensitivity (EIS) of the middle Pienaars River (outflow from Roodplaat Dam) is high. The PES category of the Pienaars and Boekenhoutspruit rivers are in a C category. The Apies River, Skinnerspruit nd Walkerspruit have a PES of an E category. EWR site 4 on the Pienaars River is present in this resource unit. Parts of the Apies and Pienaars rivers can be classified as an urban river.
RESOURCE UNIT : 1_7 – Jukskei, Klein Jukskei, Modderfonteinspruit: Quaternary catchment A21C
DESCRIPTION
The IUA is a Class III. This RU includes the headwaters of Jukskei. The river reach can be classified as an uban river. Includes parts of the northern and western suburbs of Johannesburg, Sandton, Alexandra, Randburg. There are several WWTWs located both upstream and downstream of the Jukskei and Klein Jukskei river systems. The systems are highly impacted from nutrient input thus threatening the biotic integrity of the systems. Serious water quality problems exist as the rivers are severely impacted by WWTWs discharges (largest being Johannesburg Water Northern Works), urbanisation and industrial effluent. Sedimentation is also problem. PES is an E category. EWR site 2 on the Jukskei River is present in this resource unit. The management strategy may require urban load targets to be set.
RESOURCE UNIT : 1_8 – Upper reaches of Crocodile River and Bloubankspruit: Quaternary catchment A21D, A21E
DESCRIPTION
The IUA is a Class III. This is the headwaters of the Crocodile River, and includes urban areas of Krugersdorp, Mogale City, and the Westrand. Tourism activities are high. Water users include agriculture. Some reliance on groundwater in the catchment (supports flower farms). Water quality is impacted. The serious threat to the system is mining and the acid mine decant from the Western Basin. The Crocodile River is a FEPA fish support area (nature reserve). The Tweelopiespruit flows into the Bloubankspruit and forms part of the Krugersdorp Game Reserve and the Cradle of Humankind World Heritage Site. Groundwater: Dolomite aquifer systems, heavily impacted by historic mine dewatering and discharges of acid mine drainage (AMD) into Tweelopiespruit and further downstream. Water quality needs to be addressed. Percy Stewart, Driefontein East and Randfontein WWTWs discharge into this RU. Ground stability problems are a concern. The Crocodile River has a PES of an E category while the Bloubankspruit is a D category.

IUA 1 – Upper Crocodile/Hennops/Hartebeespoort
RESOURCE UNIT : 1_9 – Crocodile River from Jukskei confluence to inflow Hartebeespoort Dam, Swartspruit - Quaternary catchment A21H
DESCRIPTION
The IUA is a Class III. EWR site 1 on the Crocodile River upstream of Hartbeespoort Dam is present in this resource unit. The Crocodile River has a PES of an E category. This river reach includes flows for the planned transfers of wastewater discharges to the Mokolo catchment at Thabazimbi from IUA 13 (Lower Crocodile). The system is highly impacted from upstream activities (Pelindaba WWTW, urban activities, discharges, settlements – poorly serviced, solid wastes etc.). There are wetland FEPAs in the vicinity of the EWR 1 site. This river reach supports recreational activities and tourism, irrigation and industrial water users. Radioactive pollution has been identified. There is also excessive sedimentation of the rivers, and aquatic weed infestation. Groundwater: Upstream part of unit (southern portion of quaternary catchment) is the Irene-Pretoria dolomites and quantity and quality is important in terms of RQOs. Contains the Centurion dolomite aquifer system where large volumes of water is abstracted, ground stability is a concern for large infrastructure.
RESOURCE UNIT : 1_10 – Hartbeespoort Dam - Quaternary catchment A21H
DESCRIPTION
The IUA is a Class III. The dam is located at the outlet of IUA1, and includes the towns of Hartbeespoort and Broederstroom. The dam will contribute to the regulation of flow for the planned water transfer to Mokolo (future). The dam is highly impacted and continues to be threatened from upstream activities and primarily from a nutrient perspective with significant eutrophication. The dam is used for water supply coupled with recreation and supporting livelihoods. Threatened by upstream activities.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
1_1 **Upper Hennops and Rietvlei Rivers (inflow into Rietvlei Dam)** **A21A**	Quantity	Low flows	EWR maintenance low and drought flows: Hennops River at A2H090 in A21A NMAR = 11.66x10^{6}m^3 REC=C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows - specifically required after confluence of Rietvlei and Hennops Rivers Maintenance flows and drought flows Monitoring of Hennops River with surveys of biota at A2H090)	Maintenance Low flows (m^3/s) / Drought flows m^3/s) Oct 0.041 0.007 Nov 0.054 0.007 Dec 0.056 0.010 Jan 0.078 0.017 Feb 0.100 0.015 Mar 0.087 0.017 Apr 0.072 0.014 May 0.065 0.013 Jun 0.064 0.017 Jul 0.059 0.016 Aug 0.054 0.013 Sep 0.048 0.007	Flow limits specified are to maintain ecological state of the water resource in the recommended ecological category C and meet the Water Resource Class III. Required flows as per the Reserve summary table (rule and tab tables)
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category is met. Application of the concentration limits must be undertaken in conjunction with a nutrient load balance for the catchment.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.060 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem is the driver. Ecological specification. Ecological Reserve manual (2008).
				Dissolved Inorganic Nitrogen (DIN) as Nitrogen	≤1.25 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem and user as the drivers. Ecological Reserve manual (2008).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Aquatic ecosystem defined specification. Improvement in instream quality required.
		Salts	Instream salinity must be maintained or improved upon to support the aquatic ecosystem and the water quality requirements of the water users.	Electrical conductivity (EC)	≤ 55 milliSiemens/metre (mS/m) (95th percentile) Hennops above confluence with Rietvlei ≤ 70 milliSiemens/metre (mS/m) (95th percentile) below confluence	Ecological category and user requirements met. Limit based on present state water quality.
				Sulphate (SO_4)	≤ 80 milligrams/litre (mg/l) (95th percentile)	Present state quality. Within target user driven and aquatic ecosystem requirements.
				Sodium (Na)	≤ 70 milligrams/litre (mg/l) (95th percentile)	Present state quality. Within target user driven and aquatic ecosystem requirements.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH must be maintained at present state.	pH range	6.5 (5th percentile) and 9.0 (95th percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	6-7 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxins should not be toxic to aquatic organisms and a threat to human health. (Pesticides to be confirmed)	Ammonia as N	≤ 0.0725 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Aluminium (Al)	≤ 0.105 milligrams/litre (mg/l) (95th percentile)	
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0095 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0073 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
				Mancozeb	≤0.009 milligrams/litre (mg/l)	Human health is the driver. Australian drinking water guideline.
				Glyphosate	≤0.7 milligrams/litre (mg/l)	Human health is the driver. USEPA drinking water guideline
				Endosulfan	≤0.13 micrograms/litre (ug/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
				Oil and grease	2.5 mg/l	General and special standards for effluent in terms of NWA, 1956. No monitoring data.
				Hormone driven Pharmaceuticals	17ß-oestradiol: ≤ 0.001 mglℓ	Hormone driven pharmaceuticals emanating from water treatment activities are potentially threatening the sustainability of animals and humans Genthe *et al.* 2009).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
	Habitat	Instream	Sufficient velocity depth for flow sensitive species must be attained.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model Method and Model (RHAMM)	Instream Habitat Integrity ecological category = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Alien invasive control should be implemented. Riparian vegetation should be maintained at a C ecological category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI ecological category = C ≥ 62% Riparian IHI = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	Fish community should be maintained at a C ecological category. Flow velocity linked to seasonal requirements needed for *BMAR., AURA and CPRE*	Fish Response Assessment Index (FRAI). Seasonality must be noted.	Fish ecology category = C FRAI ≥ 62% Fish survey determining diversity and quantity should be conducted during the wet and dry seasons. No less than 20min survey effort must be conducted for fish sampling. The FRAI should be conducted to monitor against the prescribed C ecological category. REMP site: Tweefontein (A21A-01171)	Attainment of Water Resource Class and associated ecological category. Based on available monitoring data.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a moderately modified condition or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5).	MIRAI C ecological category ≥ 62% SASS ≥ 80 ASPT ≥ 4.8	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category. Ecological Reserve
		Semi-aquatic biota	The suitability of this stretch of river to serve as a habitat and migration corridor for aquatic bird and mammal populations must be maintained through proper habitat management.	Aquatic birds/Indicator mammal species	Determine representative bird species (types and population numbers to serve as indicators). There is a need to set a numerical limits for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
1_2 **Rietvlei Dam** **A21A**	Quantity	Dam levels	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained.	Minimum operating level required in dam	Operation rules as applicable. Mininum level to sustain aquatic ecosystem (15-18%).		

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system or better.	Orthophosphate	≤ 0.025 mg/ℓ 50th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Rietvlei Dam is known to experience high nutrient concentrations due to the influx of sewage effluent in the catchment. (Van Ginkel 2008) The system is a hypertrophic system and all attempts must be made to improve the water quality in the system as it contributes to the drinking water of the Tshwane Metropolitan Area and lies within a Nature Reserve. High nutrient concentration leads to the development of toxic cyanobacteria within the system which is difficult to remove and may cause animal deaths in the reserve.
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Total phosphorous	≤ 0.130 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Rietvlei Dam is a hypertrophic system, which need to be improved for sustainable use. Total phosphorous concentrations must be kept within this limit (Van Ginkel *et al.* 2001; Van Ginkel 2008; Wetzel 2001).
			Concentration of total Ammonia as Nmust be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Total Ammonia as N	≤ 0.0725 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Rietvlei is subject to severe nutrient enrichment that leads to increased algal growth that impact negatively on the water treatment works.
			Concentration of total nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system or better.	Nitrite& Nitrate	≤ 1.00 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Rietvlei is subject to severe nutrient enrichment that leads to increased algal growth that impact negatively on the water treatment works.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 70 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The salinity of the system should be maintained with thin the prescribed limit.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Sulphate	≤ 80 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The salinity of the system should be maintained with thin the prescribed limit.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Sodium	≤ 70 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The sodium a contributing variable within the salts and the system must be maintained with the limit.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli*	≤ 130 counts/100 millilitres (ml) (95th percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	The water must be acceptable for recreation use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity with reading ≥0.4 m	Turbidity	Minimum 95th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
			Moderate change	Temperature	No more than 2 °C increasing change in both minimum and maximum	Bi-weekly depth profile monitoring with a DO meter.	Increased temperatures will favour the growth of potentially toxic cyanobacteria.
			The oxygen levels in the system must maintain the ecological system.	Dissolved Oxygen	≥ 7.0 mg/L O_2 95th percentile	Bi-weekly depth profile monitoring with a DO meter.	Low oxygen levels associated with organic matter emanating from upstream industries and Wastewater Treatment Works are negatively impacting on the ecosystem.
		Toxics	The dam must be managed to minimize the development of toxic cyanobacterial blooms	Cyanobacteria	Cyanobacterial dominance with Chl *a* concentration higher than 30µg/ℓ must be kept at less than 20% of the time.	Bi-weekly integrated (0-5m hosepipe) water collection in prewashed plastic glass bottle with Lugol's Solution Preservative.	The Cyanobacteria produce harmful toxins for wildlife and humans, which are problematic in Water treatment removal.
			The river water should not be toxic to aquatic organisms or be a threat to human health.	Pesticides	Cyanide:≤ 110 µg/ℓ Endosulfan:≤ 20 µg/ℓ Atrazine:≤ 100 µg/ℓ 95th percentile	Sub-surface water collection in prewashed plastic bottles. Monthly sampling	Pesticides emanating from agriculture activities are potentially threatening the ecosystem maintenance.
			The impoundment water should not be a threat to animal or human sustainability.	Hormone driven Pharmaceuticals	17ß-oestradiol: ≤ 1 µg/ℓ	Sub-surface water collection in prewashed 1ℓ glass bottle with a foil covered mouth and pH adjusted (3). Quarterly sampling (4 x per annum)	Hormone driven pharmaceuticals emanating from water treatment activities are potentially threatening the sustainability of animals and humans Genthe *et al.* 2009).
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to	Riparian vegetation Health	80% riparian vegetation cover	Riparian zone vegetation survey at least every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			ensure necessary habitat.				
	Biota	Fish	Ensure that the diversity and quantities are maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every two years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl a concentrations must be maintained in a eutrophic state.	Chl *a*	20-30µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection, filtering 500ml and preserved in ethanol in glass test tube.	The eutrophic state of the Rietvlei Dam is seriously impaired but need to be improved. With the implementation of the SolarBee's already installed since 2009 for management purposes the RQO is achievable.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
1_3 **Hennops from outflow Rietvlei Dam to A21H** **Sesmylspruit, Kaalspruit and Olifantspruit** **A21B**	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category and the water quality requirements of the water users are met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.125 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008).
				Dissolved Inorganic Nitrogen	≤ 3.0 milligrams/litre (50th percentile)	Ecological specification. Improvement in instream quality required.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Ecological specification. Improvement in instream quality required.
		Salts	Instream salinity must be improved to meet the recommended ecological category and the water quality requirements of the water users. Land based impacts and wastewater discharges must be controlled and managed to protect the resource.	Electrical conductivity (EC)	≤ 85 milliSiemens/metre (mS/m) (95th percentile)	Ecological specification. Ecological Reserve manual (2008). Requirements improvement.
				Sulphate	≤ 70 milligrams/litre (95th percentile)	Present state quality. Within target user driven and aquatic ecosystem requirements.
				Sodium	≤ 70 milligrams/litre (mg/l) (95th percentile)	Present state quality. Within target user driven and aquatic ecosystem requirements.
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli*	130 counts/100 millilitres (95th percentile)	User driven specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	pH range 7.5 (5th percentile) - 9.2 (95th percentile)	Aquatic ecosystem and user as the drivers.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
		Toxics	A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Aquatic ecosystem is the driver. Ecological specification for prescribed ecological category. Ecological Reserve manual (2008). No data available.
			The concentrations of toxins should not be toxic to aquatic organisms and a threat to human health	Ammonia as N	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Aluminium (Al)	≤ 0.150 milligrams/litre (mg/l) (95th percentile)	
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.013 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0075 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
				Mancozeb	0.009 milligrams/litre (mg/l)	Human health is the driver. Australian drinking water guideline.
				Glyphosate	0.7 milligrams/litre (mg/l)	Human health is the driver. USEPA drinking water guideline
				Endosulfan	0.13 micrograms/litre (ug/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
	Habitat	Instream	Habitat diversity should be maintained in a D Ecological Category or improved upon. Velocity depth for flow sensitive species (*AURA* and *CPRE)* and taxa is required.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model Method and Model (RHAMM)	Instream Habitat Integrity category ≥ D ≥ 42%	Attainment of Water Resource Class and associated Ecological Category.
		Riparian habitat	Alien invasive control required. Riparian vegetation should be improved from an E ecological category to a D category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI ecology category = D ≥ 42% Riparian IHI = D ≥ 42%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	Fish community should be improved from the current E ecological category to a D	Fish Response Assessment Index (FRAI)	FRAI should be conducted annually to monitor against the prescribed D ecological category.	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
			category. Flow velocity linked to seasonal requirements needed for *BMAR* and *BMAT*.		FRAI ≥ 42%	Based on available monitoring data.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5).	MIRAI EC = D ≥ 42% SASS ≥ 55 ASPT ≥ 4.2	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
1_4 **Upper Pienaars River, Edendalespruit and Moretele Rivers to Roodeplaat** **A23A**	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category and the water quality requirements of the water users are met. Control of nutrients required to improve instream water quality status.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.125 milligrams/litre (mg/l) (50th percentile)	Improvement required in-stream and in Roodeplaat Dam. Meets ecological specification.
				Dissolved Inorganic Nitrogen (DIN) as Nitrogen	≤1.25 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem and user as the drivers. Within ecological category C upper boundary value as per the water quality component of the Ecological Reserve manual (2008).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Improvement required in-stream and in Roodeplaat Dam. Meets ecological specification.
		Salts	Instream salinity must be maintained to support the aquatic ecosystem and the water quality requirements of the water users.	Electrical conductivity (EC)	≤ 65 milliSiemens/metre (mS/m) (95th percentile)	Present state quality. Within C ecological category for aquatic ecosystem, Ecological Reserve manual (2008).
				Sulphate (SO_4)	≤ 50 milligrams/litre (mg/l) (95th percentile)	Present salinity state.
				Chloride (Cl)	≤ 50 milligrams/litre (mg/l) (95th percentile)	
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli*	130 counts/100 millilitres (95th percentile)	User driven specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996). Present water quality state is unacceptable
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 9.0 (95th percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
		Toxics	The concentrations of toxins should not be toxic to aquatic organisms and a threat to human health. (Dissolved)	Ammonia as N	≤ 0.0725 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Aluminium (Al)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.007 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0075 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Fluoride (F)	≤ 2.54 milligrams/litre (mg/l) (95th percentile)	
				Benzene	≤0.01 milligrams/litre (mg/l) (95th percentile)	WHO drinking water guideline. Human health limit. No available monitoring data.
				Toluene	≤0.7 milligrams/litre (mg/l) (95th percentile)	WHO drinking water guideline. Human health limit. No available monitoring data
				Hormone driven Pharmaceuticals	17ß-oestradiol: ≤ 0.001 mglℓ	Hormone driven pharmaceuticals emanating from water treatment activities are potentially threatening the sustainability of animals and humans Genthe *et al.* 2009).
	Habitat	Instream	Habitat availability for fish and macroinvertebrates must be maintained, to sustain biotope diversity. Marginal vegetation required to support *BANO.*	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model Method and Model (RHAMM)	Instream Habitat Integrity ecological category = D ≥ 42% (A2HART-KAMEE and A2PIEN-BAVIA)	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Alien invasive control required. Riparian vegetation should be improved from E ecological category to a D category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI ecological category = D ≥ 42% Riparian IHI = D ≥ 42% (A2HART-KAMEE and A2PIEN-BAVIA)	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.
	Biota	Diatoms	Diatom assemblage must be maintained within a largely modified condition or improved upon.	Specific Pollution Index	Diatom ecological category = D ≥ 42% (for both REMP sites A2HART-KAMEE and A2PIEN-BAVIA)	Attainment of associated ecological category. Indicator of water quality and health state of water resource.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5).	MIRAI ecological category = D ≥ 42% REMP Site At A2PIEN-BAVIA: SASS ≥ 60	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
					ASPT ≥ 3.8 REMP Site A2HART-KAMEE: SASS ≥ 60 ASPT ≥ 3.8	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
1_5 **Roodeplaat Dam**	Quanity	Dam levels	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic state. Hyacinth growth must be managed. Management strategy to address load in sediments required.	Orthophosphate	≤ 0.025 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) and depth profile (1m, 2m, 5m, 10m, 15m & 20m) water collection in prewashed plastic bottles.	Roodeplaat Dam is a hypertrophic system that is seriously nutrient enriched due to the influx of treated effluent with very high nutrient concentrations (Van Ginkel 2008). The nutrients have caused serious cyanobacterial growth as well as excessive aquatic plant growth. The site is a high profile and internationally known rowing site and should be managed for sustainable use.
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Total phosphorous	≤ 0.130 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Roodeplaat Dam is a hypertrophic system, which needs to be improved for sustainable use. Total phosphorous concentrations must be kept within these limits (Van Ginkel *et al.* 2001; Van Ginkel 2008; Wetzel 2001).
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Nitrite & Nitrate	≤ 1.00 mg/ℓ N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Roodeplaat is subject to severe nutrient enrichment that leads to increased algal and aquatic plant growth that impact negatively on the ecology, recreation and water treatment works. The system range is within reach and should be maintained.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 55 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system is still within this category and should be maintained.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Sulphate	≤ 80 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system is still within this category and should be maintained.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Sodium	≤ 70 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Sodium is a contributing variable within the salts and the system must be kept with the numerical limit concentration.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli*	≤ 130 counts/100 millilitres (ml) (95^{th} percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity with reading ≥0.4 m	Turbidity	Minimum 95th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
			Moderate change	Temperature	No more than 2 °C increasing change in both minimum and maximum	Bi-weekly depth profile monitoring with a DO meter.	Increased temperatures will favour the growth of potentially toxic cyanobacteria.
			The oxygen levels in the system must maintain the ecological system.	Dissolved Oxygen	≥ 7.0 mg/L O_2 95th percentile	Bi-weekly depth profile monitoring with a DO meter.	Low oxygen levels associated with organic matter emanating from upstream industries and Wastewater Treatment Works are negatively impacting on the ecosystem.
		Toxics	The dam must be managed to minimize the development of toxic cyanobacterial blooms	Cyanobacteria	Cyanobacterial dominance with Chl a concentration higher than 30µg/ℓ must be kept at less than 20% of the time.	Bi-weekly integrated (0-5m hosepipe) water collection in prewashed plastic glass bottle with Lugo'sl Solution Preservative.	Roodeplaat is hypertrophic and cyanobacteria are the dominant algae during the summer period. The Cyanobacteria produce harmful toxins for wildlife and humans, which are problematic in water treatment removal.
			The impoundment water should not be a threat to animal or human sustainability.	Hormone driven Pharmaceuticals	17ß-oestradiol: ≤ 1 µg/ℓ	Sub-surface water collection in prewashed 1ℓ glass bottle with a foil covered mouth and pH adjusted (3). Quarterly sampling (4 x per annum)	Hormone driven pharmaceuticals emanating from water treatment activities are potentially threatening the sustainability of animals and humans.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	70% riparian vegetation cover Prohibit any further development into riparian zone. The Index of Habitat Integrity and Vegetation Response Assessment Index should be conducted during the wet season only).	Riparian zone vegetation survey every year during the wet season. (Index of Habitat Integrity, Vegetation Response Assessment Index).	The dam must be monitored annually due to the presence of noxious aquatic weeds that need to be managed. Hyacinths are a serious probem. The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every two years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl *a* concentrations must be maintained in a eutrophic state.	Chl *a*	20-30µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection, filtering 500ml and preserved in ethanol in glass test tube.	The hypertrophic state and the resultant phytoplankton growth that lead to toxic cyanobacterial blooms of the Roodeplaat Dam is seriously impaired but need to be improved for ecological, recreational and potable water supply uses.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context of the RQO and/or Numerical limit
1_6 **Upper reaches_ Apies, Skinner-spruit and Pienaars River outflow from Roodeplaat Dam**	Quantity	Low flows	EWR maintenance low and drought flows: Pienaars River at CROC_EWR4 in A23B NMAR = 28.20x10^6 m^3 REC=C category The maintenance low flows and drought flows must be attained so that the environmental flows requirements are met to support a healthy condition for the ecosystem and users.	Base flows Maintenance flows and drought flows. Intermediate EWR site 4 on Pienaars River (monitoring at A2H006)		Maintenance Low flows (m^3/s)	Drought flows (m^3/s)	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)
					Oct	0.104	0.063	
					Nov	0.136	0.081	
					Dec	0.146	0.086	
					Jan	0.211	0.122	
					Feb	0.242	0.140	
					Mar	0.208	0.119	
					Apr	0.174	0.102	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
A23B, **A23D,** **A23E**					May 0.144 0.085 Jun 0.133 0.080 Jul 0.120 0.072 Aug 0.111 0.067 Sep 0.103 0.063	
		High flows	EWR high flows: Pienaars River at CROC_EWR4 in A23B NMAR = 28.20x10^6 m^3 REC=C category The high flows must be attained so that the environmental flows requirements are met to support a healthy condition for the ecosystem	Floods (See Appendix A for detail on flood requirements) Intermediate EWR site 4 on Pienaars River (monitoring at A2H006)	High flows (m^3/s) Oct 0 Nov 0.210 Dec 0.339 Jan 0.203 Feb 0.56 Mar 0.203 Apr 0 May 0 Jun 0 Jul 0 Aug 0 Sep 0	
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category is met. Concentrations should not be allowed to deteriorate.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.5 milligrams/litre (mg/l) (50^{th} percentile) Apies ≤ 0.09 milligrams/litre (mg/l) (50^{th} percentile) Pienaars ≤ 0.05 milligrams/litre (mg/l) (50^{th} percentile) Skinnerspruit	Meets ecological specification.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 3.0 milligrams/litre (50^{th} percentile) Skinnerspruit and Apies ≤ 1.0 milligrams/litre (mg/l) (50^{th} percentile) Pienaars	Meets ecological specification.
		Salts	Instream salinity must be maintained at acceptable levels to support a healthy aquatic ecosystem and the water quality requirements of water users.	Electrical conductivity (EC)	≤ 55 milliSiemens/metre (mS/m) (95^{th}percentile) Pienaars River ≤ 70 milliSiemens/metre (mS/m) (95^{th}percentile) Apies River	Ecological specifications. Ecological Reserve manual (2008). Present state
				Sulphate (SO_4)	≤ 70 milligrams/litre (95^{th} percentile)	Present state water quality state. Satisfies user requirements and ecological category.
				Sodium (Na)	≤ 50 milligrams/litre (95^{th} percentile)	
		Pathogens	The presence of pathogens should pose a	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (95^{th} percentile)	User specification. Limit is the target

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
			low risk to human health.			water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 9.0 (95th percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Aquatic ecosystem is the driver. Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxins must not be at a level that is toxic to aquatic organisms and a threat to human health	Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
				Mancozeb	0.009 milligrams/litre (mg/l)	Human health is the driver. Australian drinking water guideline. No monitoring data. No monitoring data.
				Glyphosate	0.7 milligrams/litre (mg/l)	Human health is the driver. USEPA drinking water guideline
				Endosulfan	0.13 micrograms/litre (ug/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
	Habitat	Instream	Habitat availability for fish and macroinvertebrates must be maintained, to sustain biotope diversity, especially maintaining marginal vegetation to support fish species *MBRE* and *BANO.*	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity ecological category = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Alien invasive control required. Rparian vegetation should be maintained at an ecological category of C.	Index of Habitat Integrity, Vegetation Response Assessment Index (VEGRAI)	VEGRAI ecological category = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	Fish community should be improved from the current E ecological category to a D category.	Fish Response Assessment Index (FRAI)	Fish ecology category = D FRAI ≥ 42% (Apies/Skinnerspruit Rivers)	Attainment of Water Resource Class and associated ecological category. Score based on present state.
			An assessment of the fish community should be conducted annually to monitor against present state C ecological category. Maintain the species diversity present. Flow should be maintained to accommodate species *LCYL, LMOL* and *BMAR*	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62% (Pienaars River at REMP site A2PIEN-DINOK (d/s EWR 4)	Attainment of Water Resource Class and associated ecological category. Based on available monitoring data.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category	Macroinvertebrate Response Assessment Index and the South African Scoring	MIRAI EC = D ≥ 42% SASS ≥ 50 ASPT ≥ 3.4	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
			or improved upon.	System Version 5 (SASS5).	(Apies and Skinner at REMP site A2APIE-BOSCH (A23D & A23E)	
			Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5).	MIRAI EC = C ≥ 62% SASS ≥ 120 ASPT ≥ 5.0 (REMP site A2PIEN-DINOK (d/s EWR 4)	Attainment of Water Resource Class and associated ecological category.
		Diatoms	Pienaars downstream of Roodeplaat Dam to Boekenhoutspruit confluence (A23B): Diatom assemblage must be maintained within a largely modified condition or improved upon.	Specific Pollution Index	Diatom EC = D ≥ 42%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
1_7 **Jukskei, Klein Jukskei, Modderfontein spruit** **A21C**	Quantity	Low flows	EWR maintenance low and drought flows: Jukskei River at CROC_EWR2 in A21C PMAR = $139.9x10^6 m^3$ REC=D category Ecological water requirements (Reserve) must be attained so that the environmental flows requirements are met to support a healthy condition for the ecosystem and users.	Base Flows Maintenance flows and drought flows Intermediate EWR site 2 on Jukskei River (monitoring at A2H023/ A2H044)	<table><tr><td></td><td>Maintenance Low flows (m^3/s)</td><td>Drought flows (m^3/s)</td></tr><tr><td>Oct</td><td>0.725</td><td>0.725</td></tr><tr><td>Nov</td><td>0.775</td><td>0.775</td></tr><tr><td>Dec</td><td>0.770</td><td>0.770</td></tr><tr><td>Jan</td><td>0.814</td><td>0.814</td></tr><tr><td>Feb</td><td>0.936</td><td>0.936</td></tr><tr><td>Mar</td><td>0.845</td><td>0.845</td></tr><tr><td>Apr</td><td>0.839</td><td>0.839</td></tr><tr><td>May</td><td>0.795</td><td>0.795</td></tr><tr><td>Jun</td><td>0.815</td><td>0.815</td></tr><tr><td>Jul</td><td>0.785</td><td>0.785</td></tr><tr><td>Aug</td><td>0.774</td><td>0.774</td></tr><tr><td>Sep</td><td>0.762</td><td>0.762</td></tr></table>	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category and the water quality requirements of the water users are met. Nutrient management required to improve current state and ensure sustainability of the system.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.5 milligrams/litre (mg/l) (50th percentile) (interim numeric limit) ≤ 0.125 milligrams/litre (mg/l) (50th percentile) (long term numeric limit)	Improvement in instream concentrations required.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Improvement in instream concentrations required.
		Salts	Instream salinity must be maintained to support the aquatic ecosystem and the water quality requirements of the water users.	Electrical conductivity (EC)	≤ 65 milliSiemens/metre (mS/m) (95th percentile)	Present state quality. Within C ecological category for aquatic ecosystem, Ecological Reserve manual (2008).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
				Sulphate (SO_4)	≤ 70 milligrams/litre (mg/l) (95th percentile)	Maintain within present salinity state.
				Sodium (Na)	≤ 70 milligrams/litre (mg/l) (95th percentile)	Maintain within present salinity state.
				Chloride	≤ 60 milligrams/litre (mg/l) (95th percentile)	
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 9.0 (95th percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxins should not be toxic to aquatic organisms and a threat to human health	Ammonia as N	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Aluminium (Al)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.3 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤0.013 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤0.0075 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤0.07 milligrams/litre (mg/l) (95th percentile)	
				Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
				Mancozeb	0.009 milligrams/litre (mg/l)	Human health is the driver. Australian drinking water guideline. No monitoring data. No monitoring data.
				Glyphosate	0.7 milligrams/litre (mg/l)	Human health is the driver. USEPA drinking water guideline
				Endosulfan	0.13 micrograms/litre (ug/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
	Habitat	Instream	Habitat diversity should be improved from an E ecological category to a D category. Ecological integrity of system must improve.	Index of Habitat Integrity	Instream Habitat Integrity EC = D ≥ 42%	Maintenance of aquatic ecosystem at prescribed ecological category.
		Riparian habitat	Riparian vegetation must be maintained at a C ecological category. Control of alien invasive vegetation required.	Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	
	Biota	Fish	Fish community should be improved from the current E ecological category to a D category. Ensure presence of species *BMAR* and *BMOT* (flow dependent species). Flow depth must be present to support habitat availability for *TSPA, CGAR, BANO, BMAR* and *BMOT*	Fish Response Assessment Index (FRAI)	Fish ecology category = D FRAI ≥ 42%	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5).	MIRAI ecological category = D ≥ 42% SASS ≥ 50 ASPT ≥ 3.8 (EWR2, A2JUKS-DIENR)	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.
		Diatoms	Diatom assemblage must be maintained within a D ecological category or improved upon.	Specific Pollution Index	Diatom EC ≥ 42% A2JUKS-DIENR	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
1_8 **Upper reaches of the Crocodile River and Bloubank spruit** **A21D, A21E**	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health and to ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.125 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem requirements.
				Nitrate (NO_3) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Aquatic ecosystem requirements.
		Salts	Instream salinity must be maintained at present state quality. Control impacts and future development.	Electrical conductivity (EC)	Crocodile upstream Bloubankspruit confluence: ≤ 45 milliSiemens/metre (mS/m) (95th percentile)	Present state water quality. Within C ecological category for aquatic ecosystem, Ecological Reserve manual (2008).
			Salinity levels are significantly high. Instream salinity must be improved to maintain the aquatic ecosystem in a sustainable state and support the water quality requirements of the water users		Bloubankspruit: ≤ 85 milliSiemens/metre (mS/m) (95th percentile)	Improvement in instream concentrations required.
				Sulphate (SO_4)	Crocodile upstream Bloubankspruit confluence ≤ 40 milligrams/litre (mg/l) (95th percentile)	Present state water quality.
					Bloubankspruit:	Improvement in water quality required.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
					≤ 200 milligrams/litre (mg/l) (95th percentile)	Present state 401 mg/l at outlet of quaternary catchment
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem and user as the drivers.
		Toxics	The concentrations of toxins must be maintained at levels that are not toxic to aquatic organisms and a threat to human health.	Cyanide	≤ 0.110 milligrams/litre (95th percentile)	Aquatic ecosystem driver - Ecological Reserve manual (2008),
				Uranium (U) (238)	≤ 0.03 milligrams/litre (95th percentile	WHO guideline (2011)
				Arsenic (As)	≤ 0.130 milligrams/litre (95th percentile	Aquatic ecosystem driver - Ecological Reserve manual (2008),
				Gross α	0.42 Bq/litres	Need to confirm with baseline monitoring data. South African Water Quality Guidelines (1996) (domestic)
				Gross β	0.42 Bq/litres	Need to confirm with baseline monitoring data. South African Water Quality Guidelines (1996) (domestic)
				Aluminium (Al)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.3 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0095 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0075 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity must be improved to maintain a D ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = D ≥ 42%	Monitoring of and improvement in habitat condition required.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
		Riparian habitat	Riparian vegetation should be maintained at D ecological category. Marginal vegetation must be improved. Alien invasive control and rehabilitation of marginal zone is required. Limited habitat is available. Rehabilitation of riparian zone required to support semi-aquatic species (birdlife).	Index of Habitat Integrity, Vegetation Response Assessment Index (VEGRAI)	VEGRAI EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	The fish community should be managed to the prescribed ecological category D ecological category or improved upon. Habitat requirements for *BMOT* (vegetation) and substrate and flow for *CPRE* must be met	Fish Response Assessment Index (FRAI)	Ecological category = D FRAI ≥ 42%	Attainment of Water Resource Class and associated ecological category Based on available monitoring data.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5).	MIRAI ecological category = D ≥ 42% SASS ≥ 60 ASPT ≥ 4.0 (A2CROC-ELAND)	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context of the RQO and/or Numerical limit
1_9 **Crocodile River from Jukskei confluence to Hartbeespoort Dam** **A21H**	Quantity	Low flows	EWR maintenance low and drought flows: Crocodile River at CROC_EWR1 in A21H PMAR = 231.05x10^6 m^3 REC=D category The maintenance and drought flows must be attained so that the environmental flows requirements are met to support a healthy condition for the ecosystem and users.	Base Flows Maintenance flows and drought flows Intermediate EWR site 1 on Crocodile River (monitoring at A2H012)		Maintenance Low flows (m^3/s)	Drought flows (m^3/s)	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)
					Oct	1.179	1.179	
					Nov	1.259	1.259	
					Dec	1.246	1.246	
					Jan	1.321	1.321	
					Feb	1.538	1.538	
					Mar	1.400	1.400	
					Apr	1.402	1.402	
					May	1.334	1.334	
					Jun	1.368	1.368	
					Jul	1.313	1.313	
					Aug	1.279	1.279	
					Sep	1.244	1.244	
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category and the water quality requirements of the water users are met. Nutrient management	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.20 milligrams/litre (mg/l) (50th percentile)			Improvement in instream concentrations required.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 2.0 milligrams/litre (50th percentile)			Improvement in instream concentrations required.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
			required to improve current state and ensure sustainability of the system.			
		Salts	Instream salinity must be maintained to support the aquatic ecosystem and the water quality requirements of the water users.	Electrical conductivity (EC)	≤ 75 milliSiemens/metre (mS/m) (95th percentile)	Present state water quality. Within prescribed ecological category for aquatic ecosystem, Ecological Reserve manual (2008).
				Sodium	≤ 60 milligrams/litre (mg/l) (95th percentile)	Maintain within present salinity state.
				Chloride	≤ 60 milligrams/litre (mg/l) (95th percentile)	Maintain within present salinity state
				Sulphate	≤ 75 milligrams/litre (mg/l) (95th percentile)	Maintain within present salinity state
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxins must be maintained at levels that are not toxic to aquatic organisms and a threat to human health.	Cyanide	≤ 0.110 milligrams/litre (95th percentile)	Aquatic ecosystem driver - Ecological Reserve manual (2008),
				Uranium (U) (238)	≤ 0.03 milligrams/litre (95th percentile)	WHO guideline (2011)
				Gross α	0.42 Bq/litres	Need to confirm with baseline monitoring data. South African Water Quality Guidelines (1996) (domestic)
				Gross β	0.42 Bq/litres	Need to confirm with baseline monitoring data. South African Water Quality Guidelines (1996) (domestic)
				Aluminium (Al)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.013 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0075 milligrams/litre (mg/l) (95th percentile)	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context of the RQO and/or Numerical limit
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	No further degradation of the instream habitat should occur Habitat diversity should be improved from an E ecological category to a D category.	Index of Habitat Integrity, Geomorphic Assessment Index	Instream Habitat Integrity EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Conserve, maintain, rehabiliate and add artificial functional systems in shoreline and riparian zone. Alien invasive control required. Riparian vegetation should be maintained at an ecological category D or improved upon.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological category. Ecological Reserve.
	Biota	Fish	Fish community should be maintained at a D ecological category or improved upon. Habitat and water quality improvement required for *CFLA* and flow should be adequate for flow dependant spp. *BMAR, BPOL, CPRE*	Fish Response Assessment Index (FRAI)	Fish ecology category = D FRAI ≥ 42%	Attainment of Water Resource Class and associated ecological category. Based on available monitoring data.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a largely modified condition or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5).	MIRAI EC = D ≥ 42% SASS ≥ 50 ASPT ≥ 3.8 (at EWR1 = A2CROC-HARTB)	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.
		Semi aquatic biota	The suitability of this stretch of river to serve as a habitat and migration corridor for aquatic bird and mammal populations must be maintained through proper habitat management.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Diatoms	Diatom assemblage must be maintained within a largely modified condition or improved upon.	Specific Pollution Index	Diatom EC = D ≥ 42% (at EWR1 = A2CROC-HARTB)	Based on available monitoring data. Attainment of associated ecological category. Indicator of water quality and health state of water resource.

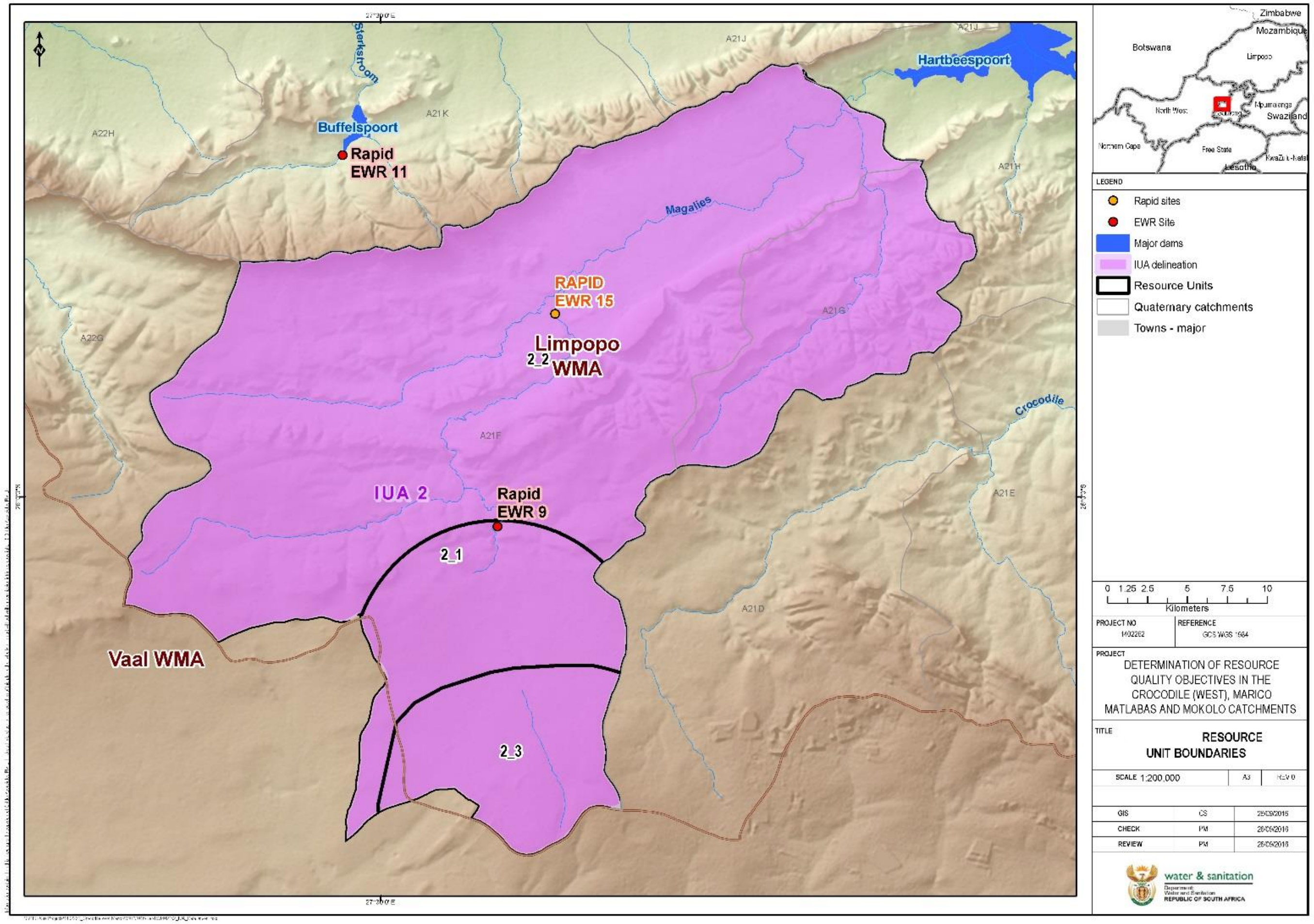
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
1_10 **Hartbeespoort Dam**	Quantity	Dam levels	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic state.	Orthophosphate	≤ 0.050 mg/ℓ 95th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) and depth profile (1m, 2m, 5m, 10m, 15m & 20m) water collection in prewashed plastic bottles.	Hartbeespoort Dam is a hypertrophic system that is seriously nutrient enriched due to the influx of treated effluent with very high nutrient concentrations. The nutrients have caused serious cyanobacterial growth, toxic incidents, as well as excessive aquatic plant growth. The importance of the site is high due to extensive agriculture, industrial and potable use. It is an important development hub for the North West Province and should be managed to improve the conditions within the system.
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Total phosphorous	≤ 0.130 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Hartbeespoort Dam is a hypertrophic system, which need to be improved for sustainable use. Total phosphorous concentrations must be kept within this limit (Van Ginkel *et al.* 2001; Van Ginkel 2008; Wetzel 2001).
			Concentration of total Ammonia as Nmust be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Total Ammonia	≤ 00725 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Hartbeespoort Dam is subject to severe nutrient enrichment that leads to increased algal growth that impact negatively on the water treatment works.
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Nitrite& Nitrate	≤ 1.00 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Hartbeespoort Dam is subject to severe nutrient enrichment that leads to increased algal and aquatic plant growth that impact negatively on the ecology, recreation and potable uses. The system range is higher within this system reach and should be improved.
		Aesthetic quallity	The aesthetic quality of the dam must be managed to support recreational use and tourism	Litter, debris, algae, aquatic weeds	To be determined		

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 85 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The sainity of the system should be maintained or improved upon.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Sulphate	≤ 100 mg/L 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The salinity of the system is still should be maintained within numerical limit.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Chloride	≤ 50 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Chloride is a contributing variable within the salts and the system concentrations must be maintained within numerical limit.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95^{th} percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	The water must be acceptable for recreation use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity	Turbidity	≥0.4 m 5th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
			Moderate change	Temperature	No more than 2 °C increasing change in both minimum and maximum	Bi-weekly depth profile monitoring with a DO meter.	Increased temperatures will favour the growth of potentially toxic cyanobacteria.
			The oxygen levels in the system must maintain the ecological system.	Dissolved Oxygen	≥ 7.0 mg/L O_2 95th percentile	Bi-weekly depth profile monitoring with a DO meter.	Low oxygen levels associated with organic matter emanating from upstream industries and Wastewater Treatment Works are negatively impacting on the ecosystem.
		Toxics	The dam must be managed to minimize the development of toxic cyanobacterial blooms	Cyanobacteria	Cyanobacterial dominance with Chl *a* concentration higher than 30µg/ℓ must be kept at less than 20% of the time.	Bi-weekly integrated (0-5m hosepipe) water collection in prewashed plastic glass bottle with Lugol's Solution Preservative.	The Cyanobacteria produce harmful toxins for wildlife and humans, which are problematic in water treatment.
			The impoundment water should not be toxic to aquatic organisms or be a	Pesticides	Cyanide: ≤ 110 µg/ℓ Endosulfan: ≤ 20	Sub-surface water collection in	Pesticides emanating from agriculture activities are potentially threatening

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			threat to human health.		µg/ℓ Atrazine: ≤ 100 µg/ℓ 95th percentile	prewashed plastic bottles. Monthly sampling	the ecosystem maintenance
			The impoundment water should not be a threat to animal or human sustainability.	Hormone driven Pharmaceuticals	17ß-oestradiol: ≤ 1 µg/ℓ	Sub-surface water collection in prewashed 1ℓ glass bottle with a foil covered mouth and pH adjusted (3). Quarterly sampling (4 x per annum)	Hormone driven pharmaceuticals emanating from water treatment activities are potentially threatening the sustainability of animals and humans.
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat. The aesthetic and visual quality of the dam must be maintained in good state (free of litter, and limited hyacinth growth)	Riparian vegetation Health	50% riparian vegetation cover	Riparian zone vegetation survey annually.	The dam must be monitored annually due to the presence of noxious aquatic weeds that need to be managed. The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every two years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl *a* concentrations must be maintained in a eutrophic state or improved upon.	Chl a	20-30µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection, filtering 500ml and preserved in ethanol in glass test tube.	The eutrophic state and the resultant phytoplankton growth that can lead to toxic cyanobacterial blooms of the Hartbeespoort Dam is seriously impaired but need to be improved for ecological, agricultural, recreational and water treatment purposes.

6.1.2 MAGALIES CATCHMENT AREA

RU	Delineation	Catchment
2_1	Maloneys Eye	A21F
2_2	Magalies River, Klein Magalies, Bloubank, Skeerpoort Rivers	A21F, A21G
2_3	Rietspruit catchment area	South eastern portion of A21F



IUA 2 – Magalies Catchment
RESOURCE UNIT : 2_1– Maloneys Eye - Quaternary catchment A21F
DESCRIPTION
The IUA is a Class II with a very high EIS. The resource unit includes Maloney's Eye. The Magalies River in the vicinity of Maloney's Eye has a PES of a B category. EWR Rapid site 9 is present in the resource unit. Regarded as a priority river system, with the species naturally intolerant to changes in flow, high invertebrate species diversity and contains unique habitats and fisah species. Magalies River downstream of Maloneys Eye dependent on dolomitic outflows (constant high baseflows) and not similar to other tributaries. Areas associated with the eye have been identified as irreplaceable and the eye is important for tourism.
RESOURCE UNIT : 2_2 - Magalies River, Klein Magalies, Bloubank, Skeerpoort Rivers: Quaternary catchment A21F, A21G
DESCRIPTION
The IUA is a Class II with the PES of the Skeerpoort in a C category and the lower Magalies River in a D category in the resource unit. EWR Rapid site 9 is present at the outlet from resource unit 2_1. The primary economic activities include eco-tourism and agriculture (irrigation). This IUA contains the town of Magaliesburg, Magaliesburg conservation area and the Cradle of Humankind World Heritage Site. These rivers pose as a fish support area (i.e. *Barbus motebensis*). Magalies River downstream of Maloneys Eye is dependent on dolomitic outflows (constant high baseflows) and is not similar to other tributaries. The area also supports populations of Koi fish. Alteration of the river regime has been noted. Water quality is impacted by the Magaliesburg WWTW discharges and irrigation retun flows. Hillsope seepage wetlands with high botanical diversity. A tufa waterfall and wetland area is present, as well as the Nouklip eye on the Skeerpoort. This is a sensitive system and the Upper Skeerpoort River has a very high diversity of habitats types (including the waterfall), contains species naturally intolerant to changes in flow, is a species refuge and has high species diversity. Conservation and protection of these habitats are needed. Groundwater: Discharges from upper reaches Steenkoppies dolomitic compartment unit. Interaction between surface and groundwater systems need to be determined.
RESOURCE UNIT : 2_3 – Rietspruit catchment area: south eastern portion of Quaternary catchment A21F
DESCRIPTION
The IUA is a Class II. Regarded as a priority groundwater system. The surface water streams are not well defined and not flowing. Quantity (abstractions) and flow of the surface water needs to be managed. Area is impacted by mining and sewage effluent discharges. However impacts may be originating outside the catchment divide (to the south). The agricultural sector is important to the economy of the area and relies on groundwater (Steenkoppies compartment). Upper part of the Steenkoppies dolomite compartment unit support the irrigation in the Tarlton area. Water quality impact from the sewage effluent (Randfontein) seepage into dolomitic compartment unit (Steenkoppies) is a serious impact (Gatsrand). Flow and quality impacts have been noted at the Eye. Illegal peat mining is also occurring. Management of the system is extremely important for the sustainability of Maloneys Eye.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
2_1 **Maloneys Eye** **A21F**	Quantity	Low flows	EWR maintenance low and drought flows: Magalies River at CROC_EWR9 in A21F NMAR = $14.68x10^6 m^3$ REC=B category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows (Rapid EWR site 9 on Magalies River Monitoring at A2H010)	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.211 0.211 Nov 0.216 0.216 Dec 0.211 0.211 Jan 0.212 0.212 Feb 0.224 0.224 Mar 0.206 0.206 Apr 0.212 0.212 May 0.208 0.208 Jun 0.214 0.214 Jul 0.210 0.210 Aug 0.211 0.211 Sep 0.217 0.217	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)
	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.020 milligrams/litre (mg/l) (50th percentile)	Maintenance of present ecological state. B category. Protection of ecological integrity.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	
		Salts	Instream salinity must be maintained at current status to ensure protection of good ecological integrity or resource.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Present state water quality to be maintained.
				Sulphate	≤ 10 milligrams/litre (95th percentile)	
				Sodium	≤ 10 milligrams/litre (95th percentile)	
				Chloride	≤ 10 milligrams/litre (95th percentile)	
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.0 (95th percentile)	Aquatic ecosystem as the driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
	Habitat	Instream	Habitat diversity and suitability should be maintained at prescribed B ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82% (Rapid EWR 9)	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
		Riparian habitat	Riparian vegettion should be maintained at prescribed B ecological category.	Vegetation Response Assessment Index Index of Habitat Integrity	VEGRAI EC = B ≥ 82% (Rapid EWR 9)	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	The fish community should be managed to the prescribed B ecological category Ensure presence of species *Yellow fish (BPOL), AURA, CPRE, BMOT*	Fish Response Assessment Index (FRAI)	Fish ecology category = B FRAI ≥ 82% Fish survey determining diversity and quantity should be conducted during the wet and dry seasons. No less than 20min survey effort must be conducted for fish sampling. The following indicator species should be recorded in that effort: Yellow fish (*BPOL*), *AURA, CPRE, BMOT*. The FRAI should be conducted to monitor against the prescribed B ecological category. (Rapid EWR site 9 = REMP site A2MAGA-MALON)	Attainment of Water Resource Class and associated ecological category. Based on available monitoring data.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a largely natural condition or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System, Version 5 (SASS5).	MIRAI EC = B ≥ 82% SASS ≥ 200 ASPT ≥ 6.5 (Rapid EWR site 9 = REMP site A2MAGA-MALON)	Attainment of Water Resource Class and associated ecological category. Based on available data.
		Semi aquatic biota	The suitability of this stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.

<table>
<tr><th>Resource Unit</th><th>Component</th><th>Sub-component</th><th>RQO</th><th>Indicator</th><th colspan="3">Numerical Limit</th><th>Context/Rationale for RQO/numerical limit</th></tr>
<tr><td rowspan="7">2_2
Magalies River, Klein Magalies, Bloubank, Skeerpoort Rivers

A21F</td><td rowspan="7">Quantity</td><td rowspan="7">Low flows</td><td rowspan="7">EWR maintenance low and drought flows:
Magalies River at CROC_EWR15 in A21F
NMAR = 21.899x10^{6} m^{3}
REC=C/D category

The maintenance low flows and drought flows must be attained to support the</td><td rowspan="7">Base Flows

Maintenance flows and drought flows

(Rapid site CROC_EWR 15 on Magalies River</td><td></td><td>Maintenance Low flows (m^{3}/s)</td><td>Drought flows (m^{3}/s)</td><td rowspan="7">Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set.

Required flows as per the Reserve summary table (rule and tab tables)</td></tr>
<tr><td>Oct</td><td>0.042</td><td>0.015</td></tr>
<tr><td>Nov</td><td>0.044</td><td>0.016</td></tr>
<tr><td>Dec</td><td>0.052</td><td>0.019</td></tr>
<tr><td>Jan</td><td>0.100</td><td>0.035</td></tr>
<tr><td>Feb</td><td>0.163</td><td>0.031</td></tr>
<tr><td>Mar</td><td>0.151</td><td>0.045</td></tr>
</table>

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context/Rationale for RQO/numerical limit
			aquatic ecosystem and the downstream users.	Monitoring of discharge during biological surveys	Apr	0.111	0.039	
					May	0.080	0.028	
					Jun	0.066	0.023	
					Jul	0.057	0.020	
					Aug	0.051	0.018	
					Sep	0.045	0.016	
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.090 milligrams/litre (mg/l) (50th percentile)			Aquatic ecosystem is the driver. Improvement required to meet ecological category (station A2H013Q01).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)			
		Salts	Instream salinity must be maintained at current status to ensure protection of the water resource.	Electrical Conductivity (EC)	≤ 40 milliSiemens/metre (mS/m) (95th percentile)			Maintenance of present state water quality.
				Sulphate	≤ 15 milligrams/litre (95th percentile)			
				Sodium	≤ 10 milligrams/litre (95th percentile)			
				Chloride	≤ 15 milligrams/litre (95th percentile)			
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)			User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)			Aquatic ecosystem as the driver
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.			No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)			Aquatic ecosystem is the driver. Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxins must be maintained at levels that are not toxic to aquatic organisms and a threat to human health	Ammonia as N	≤ 0.072 milligrams/litre (mg/l) (95th percentile)			Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Aluminium (Al)	≤ 0.062 milligrams/litre (mg/l) (95th percentile)			
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)			
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)			
				Lead (Pb) hard	≤ 0.006 milligrams/litre (mg/l) (95th percentile)			
				Copper (Cu) hard	≤ 0.0073 milligrams/litre (mg/l) (95th percentile)			
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)			
				Atrazine	≤0.078 milligrams/litre (mg/l)			Ecological specification. Ecological

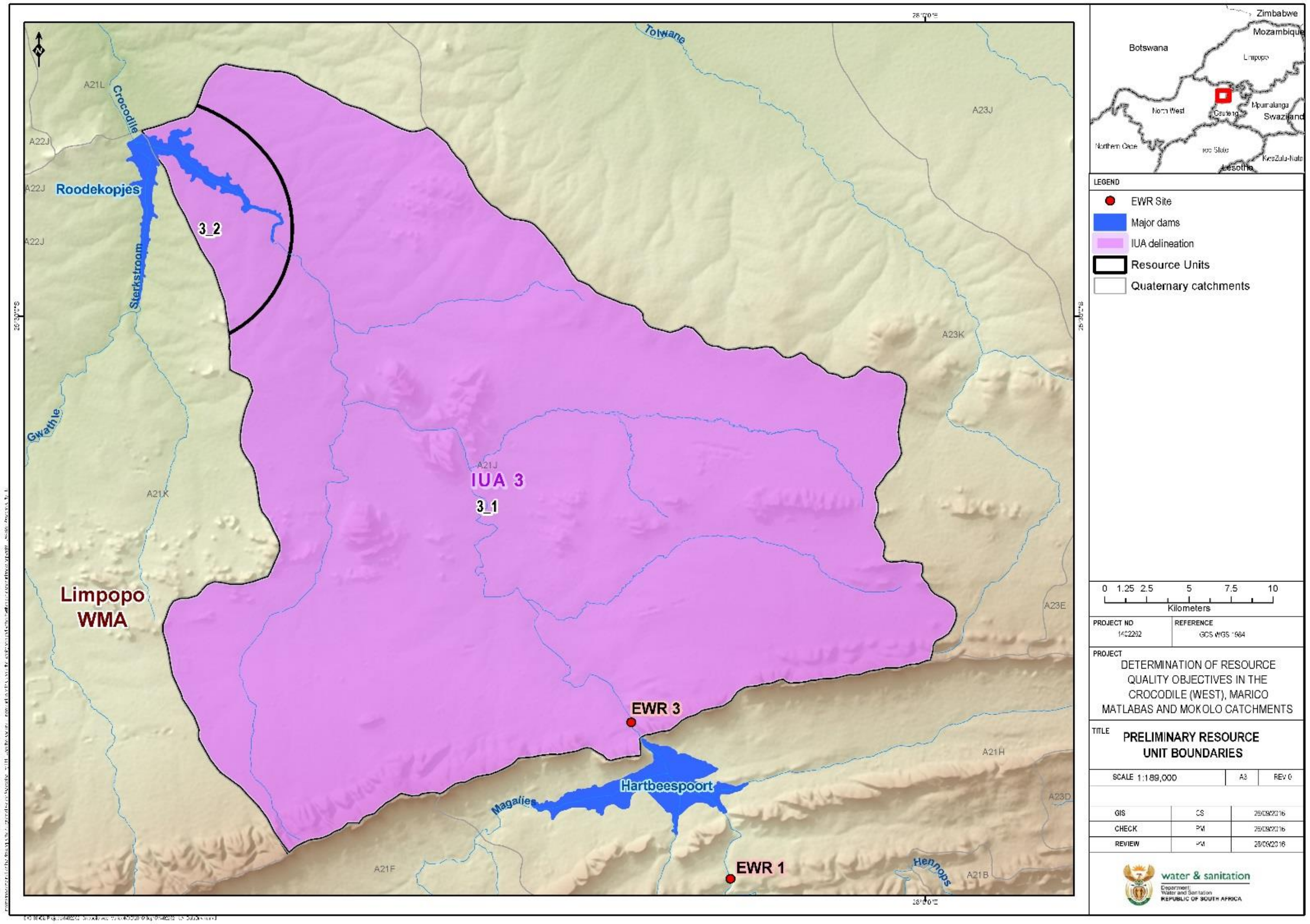
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
						Reserve manual (2008). No monitoring data.
				Mancozeb	0.009 milligrams/litre (mg/l)	Human health considerations. Australian drinking water guideline. No monitoring data. No monitoring data.
				Glyphosate	0.7 milligrams/litre (mg/l)	Human health considerations. USEPA drinking water guideline
				Endosulfan	0.13 micrograms/litre (ug/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
	Habitat	Instream	Habitat diversity must be maintained at the C/D ecological category. Good marginal vegetation and low silt load in riffles must be maintained.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C/D ≥ 58%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be maintained at the C/D ecological category. Alien invasive control must be undertaken and protection of riparian zone must improve. Encroachment must be managed. Exotic invasive plant species must be controlled.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C/D ≥ 58%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	Fish community should be maintained at the prescribed C/D ecological category. Ensure presence of indicator species. Flow should be maintained to accommodate species.	Fish Response Assessment Index (FRAI).	Fish ecology category = C/D FRAI ≥ 58% Fish survey determining diversity and quantity should be conducted during the wet and dry seasons. No less than 20min survey effort must be conducted for fish sampling. The following indicator species should be recorded in that effort: *Yellow fish (BPOL), AURA, CPRE , BMOT* The FRAI should be conducted to monitor against the prescribed C/D ecological category. (Lower Skeerpoort site A2SKEE-R560B – proposed new; Magalies Rapid EWR 15 – reach A21F-01168)	Attainment of Water Resource Class and associated ecological category.
		Aquatic macroinvertebrates	Upper Skeerpoort (A2SKEE-UITKO): Macroinvertebrate assemblage must be maintained within a largely natural	Macroinvertebrate Response Assessment Index and the South African Scoring System, Version 5 (SASS5).	Upper Skeerpoort site: A2SKEE-UITKO; MIRAI EC = B ≥ 82%	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			condition or improved upon (B ecological category). Lower Skeerpoort (A2SKEE-R560B): and Magalies River (CROC_ EWR 15): Macroinvertebrate assemblage must be maintained within a moderately modified condition or improved upon (C ecological category).		SASS ≥ 200 ASPT ≥ 6.5 Lower Skeerpoort A2SKEE-R560B proposed new site and Magalies River Rapid EWR 15 – reach A21F-01168; MIRAI EC = C ≥ 62% SASS ≥ 150 ASPT ≥ 6.0	
		Semi aquatic biota	The suitability of this stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Diatoms	Diatom assemblage must be maintained within a moderately modified condition or improved upon.	Specific Pollution Index	Diatom EC = C ≥ 62%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
2_3 Rietspruit catchment area **South eastern portion of A21F**	Quantity	Low flows	Refer to Groundwater RQOs	Base Flows	Groundwater driven system (dolomites) Steenkoppies compartment over abstraction. Stress index should not be <65%	
	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.010 milligrams/litre (mg/l) (50th percentile)	Maintenance of present state water quality.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.05 milligrams/litre (50th percentile)	
		Salts	Instream salinity must be maintained at current status to ensure protection of resource.	Electrical Conductivity (EC)	≤ 20 milliSiemens/metre (mS/m) (95th percentile)	
				Sulphate	≤ 10 milligrams/litre (95th percentile)	
				Sodium	≤ 10 milligrams/litre (95th percentile)	
				Chloride	≤ 10 milligrams/litre (95th percentile)	

6.1.3 CROCODILE/ROODEKOPJES

RU	Delineation	Catchment
3_1	Crocodile River from outflow Hartebeespoort Dam to inflow Roodekopjes Dam, Rosespruit, Ramogatla and Kareespruit	A21J
3_2	Roodekopjes Dam	A21J



Tolwane
A21L
Crocodile
A22J
Roodekopjes
3_2
Sterkstroom
A23J
A23K
Gwathe
A21X
A21J
IUA 3
3_1
Limpopo
WMA
A23E
EWR 3
A21H
Hartbeespoort
Magalies
A23D
A21F
EWR 1
Hennops
A21B
Zimbabwe
Mozambique
Botswana
Limpopo
North West
Gauteng
Mpumalanga
Swaziland
Northern Cape
Free State
KwaZulu-Natal
Lesotho
LEGEND
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
0 1.25 2.5 5 7.5 10
Kilometers
PROJECT NO
REFERENCE
GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
PRELIMINARY RESOURCE UNIT BOUNDARIES
SCALE 1:189,000
A3
REV 0
GIS
CHECK
REVIEW
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

IUA 3 – Crocodile/Rooodekopjes
RESOURCE UNIT : 3_1– Crocodile River from outflow Hartebeespoort Dam to inflow Roodekopjes Dam, Rosespruit, Ramogatla and Kareespruit - Quaternary catchment A21J
DESCRIPTION
The IUA is a Class III. EWR site 3 in the Crocodile River is present in the resource unit (PES of an E category). The water resources are in a degraded state owing to the changes in the flow regime as a result of the Hartbeespoort Dam just upstream of this IUA. Agriculture is the primary activity in this area, and there is direct abstraction from the Crocodile River. Madibeng and Magalies Water are dependent on this reach for water supply for consumers. The water transfer to the Mokolo Catchment is via flow through the reach. Wetland FEPAs are present within this IUA. Sensitive fish species (*AJON*) are expected to occur within this reach and flow dependent species (*CPRE* and *BMAR*). The Rosespruit and Kareespruit have water quality impacts (degradation due to mining impacts, informal settlements, irrigation return flows, industrial, chrome smelters). There are impacts from the Brits area as well. The Brits, Sonop and Lopersfontein WWTWs discharge into the catchment. Hyacinth growth is observed in the Crocodile River below Brits. Encroachment and sedimentation is extensive. The towns of Brits, Bapong, Majakaneng, Makau, Motholung and Sonop are located within the resource unit.
RESOURCE UNIT : 3_2 – Roodekopjes Dam - Quaternary catchment A21J
DESCRIPTION
The IUA is a Class III. Dam is a source of domestic water supply (25% allocated to Magalies water – transfer to Vaalkop Dam via a canal). The dam also supports recreation, angling and irrigation water use downstream. Impacted by surrounding activities (irrigation, mining and industrial). Nutrient enrichment of dam due to return flows from upstream catchment. Water to be transferred to the Mokolo Catchment through releases from this dam. Currently, the flow in the river system exceeds what would naturally be present.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
3_1_ **Crocodile River outflow Hartbeespoort Dam to Roodekopjes Dam** **A21J**	Quantity	Low flows	EWR maintenance low and drought flows: Crocodile River at CROC_EWR3 in A21J NMAR = 143.3x10^6 m^3 REC=C/D category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows (Intermediate EWR site on Crocodile River Monitoring at A2H083)	Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 1.425 1.446 Nov 1.591 1.607 Dec 1.690 1.703 Jan 1.993 1.995 Feb 2.276 2.267 Mar 2.290 2.279 Apr 2.022 2.024 May 1.870 1.878 Jun 1.765 1.776 Jul 1.679 1.690 Aug 1.564 1.580 Sep 1.441 1.462	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)
		High flows	EWR high flows: Crocodile River at CROC_EWR3 in A21J NMAR = 143.3x10^6 m^3 REC=C/D category	Floods High flow also specified as individual flood requirements in terms of size and duration (see Appendix A)	High flows (m^3/s) Oct 0 Nov 1.717 Dec 2.942 Jan 0 Feb 6.191 Mar 1.668 Apr 0 May 0 Jun 0 Jul 0 Aug 0 Sep 1.729	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.050 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem driver. Ecological specification. Ecological Reserve manual (2008).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Improvement in current state required. Aquatic ecosystem driver. Ecological specification. Ecological Reserve manual (2008).
		Salts	Instream salinity must be maintained at current status to ensure protection of resource and sustainability of the resource.	Electrical Conductivity (EC)	≤ 75 milliSiemens/metre (mS/m) (95th percentile)	Maintenance of present water quality state and prescribed ecological category.
				Sulphate	≤ 90 milligrams/litre (95th percentile)	Maintenance of present water quality state and prescribed ecological category.
				Sodium	≤ 60 milligrams/litre (95th percentile)	Maintenance of present water

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
						quality state and prescribed ecological category.
				Chloride	≤ 70 milligrams/litre (95th percentile)	Maintenance of present water quality state and prescribed ecological category.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem as the driver
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Ammonia as N	≤ 0.0725 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Aluminium (Al)	≤ 0.105 milligrams/litre (mg/l) (95th percentile)	
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.005 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0073 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
				Mancozeb	0.009 milligrams/litre (mg/l)	Human health is the driver. Australian drinking water guideline.
				Glyphosate	0.7 milligrams/litre (mg/l)	Human health is the driver. USEPA drinking water guideline
				Endosulfan	0.13 micrograms/litre (ug/l)	Ecological specification. Ecological Reserve manual (2008).
	Habitat	Instream	Habitat diversity should be improved from a D ecological category to a C/D category. Flow variation concern for flow and habitat dependant biota. Flow should be adequate	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM), Geomorphic Assessment Index	Instream Habitat Integrity EC = C/D ≥ 58%	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			for flow dependent taxa.			
		Riparian habitat	Riparian vegetation should be maintained at a C/D ecological category or improved upon. Alien vegetation infestation must be controlled and developments into the riparian zone should be prohibited.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C/D ≥ 58%. Prohibit any further development into riparian zone.	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	Fish community should be improved from a D ecological category to a C/D category. Regulated seasonality required to accommodate flow sensitive fish species.	Fish Response Assessment Index (FRAI)	Fish ecology category = C/D FRAI ≥ 58% Indicator species in *(Crocodile River): AJOH,* and flow dependant *BMAR, CPRE*	Attainment of Water Resource Class and associated ecological category. Based on available monitoring data.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = D ≥ 42% SASS ≥ 60 ASPT ≥ 4.0	Attainment of Water Resource Class and associated ecological category. Ecological Reserve.
		Semi aquatic biota	The suitability of this stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management. Riparian zone habitat must be improved.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Diatoms	Diatom assemblage must be maintained within a D ecological category or improved upon.	Specific Pollution Index	Diatom EC = D ≥ 42%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
3_2 **Roodekopjes Dam** **A21J**	Quantity	Dam levels	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must	Orthophosphate	≤ 0.050 mg/ℓ 95^{th} percentile	Bi-weekly sub-surface,	Roodekopjes Dam is a hypertrophic

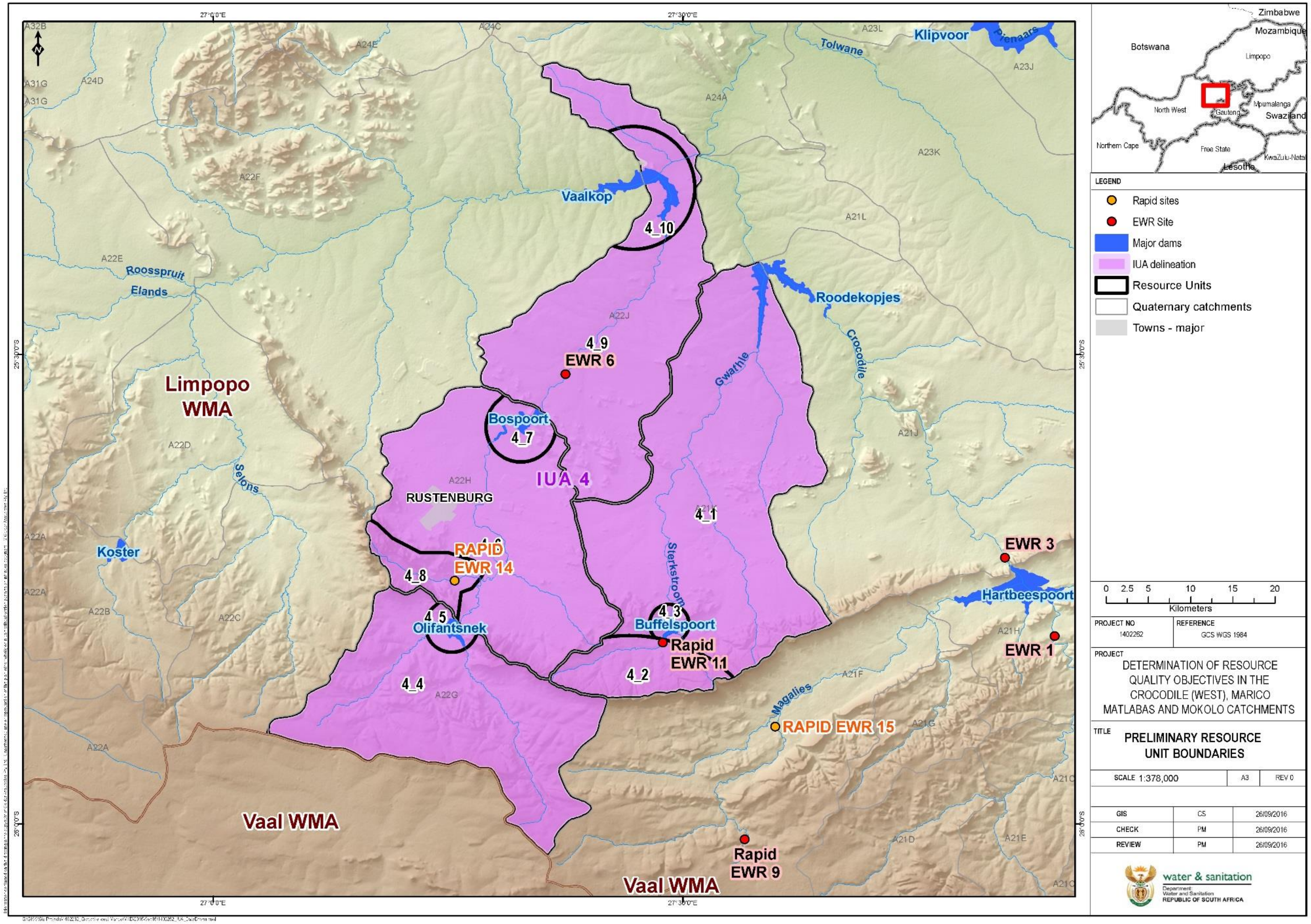
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.			integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	system that is nutrient enriched due to the locality downstream of Hartbeespoort Dam and also the influx of nutrient enriched treated effluent. The nutrients have caused cyanobacterial growth, as well as excessive aquatic plant growth. The importance of the site is moderate with agriculture, recreational, industrial and potable use.
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Total phosphorous	≤ 0.130 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Roodekopjes Dam is a hypertrophic system, which need to be improved to a mesotrophic system for sustainable use. Total phosphorous concentrations must be kept within these limits (Van Ginkel *et al.* 2001; Van Ginkel 2008; Wetzel 2001).
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Nitrite& Nitrate	≤ 0.70 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Roodekopjes Dam is subject to nutrient enrichment that leads to increased algal and aquatic plant growth that impact negatively on the ecology, recreation and potable uses.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 70 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The salinity of the system must be maintained for sustainable use.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Sulphate	≤ 85 mg/L 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The salinity of the system is should be maintained to support the aquatic ecosystem and downstream users.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Sodium	≤ 70 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The sodium is a contributing variable within the salts and the system must maintained at present state.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95^{th} percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection.	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
						Monthly sampling	
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity	Turbidity	≥0.4 m 5th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
			Moderate change	Temperature	No more than 2 °C increasing change in both minimum and maximum	Bi-weekly depth profile monitoring with a DO meter.	Increased temperatures will favour the growth of potentially toxic cyanobacteria.
			The oxygen levels in the system must maintain the ecological system.	Dissolved Oxygen	≥ 7.0 mg/L O2 95th percentile	Bi-weekly depth profile monitoring with a DO meter.	Low oxygen levels associated with organic matter emanating from upstream industries and Wastewater Treatment Works are negatively impacting on the ecosystem.
		Toxics	The dam must be managed to minimize the development of toxic cyanobacterial blooms	Cyanobacteria	Cyanobacterial dominance with Chl *a* concentration higher than 30µg/ℓ must be kept at less than 20% of the time.	Bi-weekly integrated (0-5m hosepipe) water collection in prewashed plastic glass bottle	Roodekopjes has moved into a hypertrophic state and annual presence of cyanobacterial dominance will be a problem to the potable use at Vaalkop WTW's. The Cyanobacteria produce harmful toxins for wildlife and humans, which are problematic in water treatment removal.
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	70% riparian vegetation cover	Riparian zone vegetation survey annually.	The dam must be monitored annually due to the presence of noxious aquatic weeds that need to be managed. The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined.	Fish survey determining diversity and quantity should be conducted every four years.	This will ensure that the system remain sustainable for ecological and recreational purposes.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
					Target fish stocks should be determined.		
		Periphyton/ Phytoplankton	The Chl a concentrations must be maintained in a eutrophic state.	Chl *a*	20-30µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection; filtering 500ml and preserved in ethanol in glass test tube.	The hypertrophic state and the resultant phytoplankton growth that can lead to toxic cyanobacterial blooms of the Roodekopjes Dam is impaired but need to be improved for ecological, agricultural, recreational and water treatment purposes.

6.1.4 HEX/WATERKLOOFSPRUIT/VAALKOP

RU	Delineation	Catchment
4_1	Sterkstroom from outflow Buffelspoort Dam to inflow Roodekopjes Dam, Maretwane, Tshukutswe	A21K middle and lower catchment below dam
4_2	Upper reaches of Sterkstroom to inflow Bueffelspoort Dam , Kleinwater	A21K upper catchment to dam
4_3	Buffelspoort Dam	A21K
4_4	Upper Hex River to Olifantsnek Dam, Rooikloofspruit	A22G
4_5	Olifantsnek Dam	A22G
4_6	Hex River outflow Olifantsnek Dam to inflow Bospoort Dam, Sandspruit	A22H
4_7	Bospoort Dam	A22H
4_8	Waterkloofspruit tributary catchment	A22H
4_9	Hex River outflow Bospoort Dam to inflow Vaalkop Dam	A22J
4_10	Vaalkop Dam	A22J



Limpopo WMA
Vaal WMA
Vaal WMA
IUA 4
RUSTENBURG
Vaalkop
Bospoort
Olifantsnek
Buffelspoort
Roodekopjes
Hartbeespoort
Klipvoor
Koster
4_10
4_9
4_7
4_1
4_8
4_5
4_4
4_3
4_2
EWR 6
RAPID EWR 14
Rapid EWR 11
RAPID EWR 15
Rapid EWR 9
EWR 3
EWR 1
Roosspruit
Elands
Selons
Gwathle
Sterkstroom
Crocodile
Magalies
Tolwane
Pienaars
Zimbabwe
Mozambique
Botswana
Limpopo
North West
Gauteng
Mpumalanga
Swaziland
Northern Cape
Free State
KwaZulu-Natal
Lesotho
LEGEND
Rapid sites
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
Towns - major
Kilometers
PROJECT NO 1402262
REFERENCE GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
PRELIMINARY RESOURCE UNIT BOUNDARIES
SCALE 1:378,000
A3
REV 0
GIS CS 26/09/2016
CHECK PM 26/09/2016
REVIEW PM 26/09/2016
water & sanitation
Department: Water and Sanitation REPUBLIC OF SOUTH AFRICA

IUA 4 – Hex/Waterkloofspruit/Vaalkop
RESOURCE UNIT : 4_1– Sterkstroom from outflow Buffelspoort Dam to inflow Roodekopjes Dam, Maretwane, Tshukutswe - Quaternary catchment A21K middle and lower catchment below dam
DESCRIPTION
The IUA is a Class II. Some irrigation is present in the upper reaches of the system. Includes thetowns of Mooinooi, Marikana, Wonderkop, Barseba, Bethanie and Modikwe. The EIS is high due to the presence of the vulnerable *Barbus motebensis* (Marico Barb) and high abundance of the unique *Amphilius uranoscopus* (Common Mountain Catfish) and *B. motebensis* upstream in the catchment. Wetland FEPAs and a FEPA fish support area are within this IUA and it is partly a protected area. Area forms part of the Magaliesberg Biosphere Reserve (MBR). Water users include agriculture and mining and Eco-tourism. Game farms present are dependent on groundwater. Resources are impacted by mining activities, settlements along the river and WWTWs (ATKV Buffelspoort, Mooinooi). Significant groundwater levels to the north have been observed. This is possibly linked to natural flow ingress into the mines.
RESOURCE UNIT : 4_2 – Upper reaches of Sterkstroom to inflow Buffelspoort Dam: Quaternary catchment A21K upper catchment to dam
DESCRIPTION
The IUA is a Class II. EWR rapid III site 11 on the Sterkstroom is present in the resource unit. The EIS is high due to the presence of the vulnerable *B. motebensis* and high abundance of the unique *A. uranoscopus* and *B. motebensis* upstream in the catchment. The upper Sterkstroom contains unique species, fairly pristine and diverse habitat and has good water quality. Wetland FEPAs, river FEPAs and FEPA fish support areas are found within this resource unit and it is partly a protected area. Area forms part of the Magaliesberg Biosphere Reserve (MBR). Water users in the area include recreational activities, some agriculture and eco-tourism (guest houses). Water resources are in a fairly good condition with limited impacts.
RESOURCE UNIT : 4_3 – Buffelspoort Dam - Quaternary catchment A21K
DESCRIPTION
The IUA is a Class II. The dam supports irrigation, and recreational water use –angling, boating, swimming, however the primary use is for the downstream irrigation. Dam is classed as a nature reserve. Irrigation water allocations are now being used for mining uses.
RESOURCE UNIT : 4_4 – Upper Hex River to Olifantsnek Dam, Rooikloofspruit: Quaternary catchment A22G
DESCRIPTION
The IUA is a Class II. This area is located within a nature reserve with limited land use and thus is protected with high tourism value. Cattle farming and chicken farms are present in the area. There is minor irrigation and some return flows present. This system has river FEPAs and the Hex River is a fish support FEPA. The srea contains important fish species such as *BMOT,* wetlands and is thought to be a groundwater seepage area after rainfall events (sill requiring further investigation). Catchment forms part of the Magaliesberg Biosphere Reserve (MBR).
RESOURCE UNIT : 4_5 – Olifantsnek Dam - Quaternary catchment A22G
DESCRIPTION
The IUA is a Class II. The dam primarily supports downstream irrigation and recreational water use. Some water quality impacts are present in the dam. The town of Olifantsnek is located adjacent to the dam.

IUA 4 – Hex/Waterkloofspruit/Vaalkop
RESOURCE UNIT : 4_6 – Hex River outflow Olifantsnek Dam to inflow Bospoort Dam, Sandspruit- Quaternary catchment A22H
DESCRIPTION
The IUA is a Class II. Water users reliant on the river, include agriculture (cattle and irrigation), subsistence use and domestic water supply (Dorpspruit – weir). The towns of Rustenburg and Boitenkong located in the resource unit. The water resources of the Hex River have been impacted due to the Olifantsnek, Bospoort and Vaalkop Dams situated on the river. Rustenburg and extensive mining and agriculture in the middle reaches of the catchment further impacts on the water resources, both quality and quantity. Further impacts include urbanisation, irrigation return flows and discharges from WWTWs (Paardekraal and Rustenburg). Forms part of the Magaliesberg Biosphere Reserve (MBR). There is direct supply of water from the WWTWs to the Rustenburg mines.
RESOURCE UNIT : 4_7 – Bospoort Dam: Quaternary catchment A22H
DESCRIPTION
The IUA is a Class II. The dam supports irrigation and recreational activity, subsistence fishing and domestic water supply. Poor water quality currently present in the dam. Eutrophication impacts due to nutrients. Hyacinth growth present in dam. Water quality needs to be improved to improve drinking water quality. The tribal authority in the area has requested remediation of the dam.
RESOURCE UNIT : 4_8 – Waterkloofspruit tributary catchment: Quaternary catchment A22H
DESCRIPTION
The IUA is a Class II. EWR rapid III site 14 is present in the resource unit with a PES of a B/C. The upper catchment is within the Rustenburg Nature Reserve. River FEPAs, wetland FEPAs are present and further wetland priority areas are present (Waterval valley bottom mire - peatlands). The triburary contains high habitat diversity (e.g. riffles. Gorges, etc.). The protected area that must be maintained. Flow dependent fish species present (*BMOT*). Forms part of the Magaliesberg Biosphere Reserve (MBR). Some impacts by furrows to supply agricultural water use.
RESOURCE UNIT : 4_9 – Hex River outflow Bospoort Dam to inflow Vaalkop Dam - Quaternary catchment A22J
DESCRIPTION
The IUA is a Class II. EWR site 6 is present in the resource unit. The water resources of the Hex River have been degraded due to upstream urban, irrigation and mining impacts. The towns of Lethabong, Mosenthal, Ikageng, Mogajane and Tsitsing are located in the catchment area. The town of Lethabong has a WWTW.This reach includes localised subsistence use, game farms and domestic water supply. High conductivity observed. Impacts also due to settlements along river.
RESOURCE UNIT : 4_10 – Vaalkop Dam - Quaternary catchment A22J
DESCRIPTION

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
4_1_ **Sterkstroom from outflow Buffelspoort Dam to inflow Roodekopjes Dam, Maretwane, Tshukutswe** **A21K middle and lower catchment below dam**	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.050 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem driver. Ecological specification. Ecological Reserve manual (2008).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Improvement in current state required. Ecological specification. Ecological Reserve manual (2008).
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity (EC)	≤ 70 milliSiemens/metre (mS/m) (95th percentile)	Maintenance of prescribed ecological category.
				Sulphate	≤ 70 milligrams/litre (95th percentile)	Maintenance of prescribed ecological category.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem as the driver
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxins must be maintained at levels that are not toxic to aquatic organisms and a threat to human health	Ammonia as N	≤ 0.0725 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Aluminium (Al)	≤ 0.062 milligrams/litre (mg/l) (95th percentile)	
				Chromium (IV)	≤ 0.0675 milligrams/litre (mg/l) (95th percentile)	
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤0.005 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤0.0073 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤0.07 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity should be maintained in an ecological category C. The integrity of the habitat, water quality and flow	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM),	Instream Habitat Integrity E= C ≥ 62%	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			conditions must be maintained.	Geomorphic Assessment Index		
		Riparian habitat	Vegetation control must be maintained in a C ecological category. Alien infestation control must be implemented.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	The fish community must be maintained in a C/D ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI).	Fish ecology category= C/D FRAI ≥ 58% Collect 6 species in 20min sampling effort. Indicator species *BMOT* (site A2STER-MAMOG)	Attainment of Water Resource Class and associated ecological category. Based on available monitoring data.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = D ≥ 42% SASS ≥ 70 ASPT ≥ 4.2	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.
		Diatoms	Diatom assemblage must be maintained within a largely modified condition or improved upon	Specific Pollution Index	Diatom EC = D ≥ 42%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
4_2_ **Upper reaches of Sterkstroom to inflow Buffelspoort Dam** **A21K middle and upper catchment above dam**	Quantity	Low Flows	EWR maintenance low and drought flows: Sterkstroom at CROC_EWR11 in A21K NMAR = $14.0 \times 10^6 m^3$ REC=C category Adequate protection of instream flows required (must be maintained to support biota). Management of land based activites required.	Base Flows Maintenance flows and drought flows Rapid EWR site 11 on Sterkstroom (monitoring at A2H053)	(see flow table below)	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)
	Quality	Nutrients	Instream concentration of nutrients	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.010 milligrams/litre (mg/l) (50th	Aquatic ecosystem driver. Ecological specification. Ecological Reserve manual

	Maintenance Low flows (m^3/s)	Drought flows (m^3/s)
Oct	0.078	0.033
Nov	0.083	0.035
Dec	0.086	0.036
Jan	0.094	0.039
Feb	0.113	0.047
Mar	0.104	0.043
Apr	0.101	0.042
May	0.09	0.038
Jun	0.09	0.038
Jul	0.085	0.036
Aug	0.082	0.035
Sep	0.082	0.035

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.		percentile)	(2008).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Ecological specification. Ecological Reserve manual (2008).
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity (EC)	≤ 55 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem driver. Ecological specification. Ecological Reserve manual (2008).
				Sulphate	≤ 70 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Ecological specification. Ecological Reserve manual (2008).
	Habitat	Instream	Habitat diversity should be maintained within a B/C ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B/C ≥ 78%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be maintained within a B/C ecological category. Alien infestation must be controlled and managed.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = B/C ≥ 78%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	The fish community must be maintained in a C ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62% Collect 6 species in 20min sampling effort Indicator species – flow sensitive species, *AURA, BMOT* (Sterkstroom at CROC_EWR11 in A21K)	Attainment of Water Resource Class and associated ecological category. Based on available monitoring data.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = C ≥ 62% SASS ≥ 100 ASPT ≥ 5.7 (Sterkstroom at CROC_EWR11 in A21K)	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
4_3_ Buffelspoort Dam A21K	Quantity	Dam levels	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	

	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Orthophosphate	≤ 0.015 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Buffelspoort Dam is a mesotrophic system. The system should be managed for recreation, swimming, and agricultural uses.
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Nitrite& Nitrate	≤ 0.50 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Buffelspoort Dam is a mesotrophic system. The system should be managed for recreation, swimming, and agricultural uses.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 55 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system is well within this category and should be maintained for sustainable use.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95^{th} percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every four years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Birds	Habitat availability	Indicator species Birdlife.	Health assessment studies		

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
4_4 **Upper Hex river to Olifantsnek Dam, Rooikloofspruit**	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.015 milligrams/litre (mg/l) (50^{th} percentile)	Ecological specification. Ecological Reserve manual (2008).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50^{th} percentile)	Ecological specification. Ecological Reserve manual (2008).
		Salts	Instream salinity levels as specified must be attained to sustain aquatic	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95^{th} percentile)	Ecological specification. Ecological Reserve manual (2008).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
A22G			ecosystem health and ensure the prescribed ecological category is met.	Sodium	≤ 70 milligrams/litre (95th percentile)	Aquatic ecosystem driver. South African Water Quality guidelines
				Chloride	≤ 40 milligrams/litre (95th percentile)	Aquatic ecosystem driver. South African Water Quality guidelines
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
	Habitat	Instream	Habitat diversity should be maintained within a C ecological category. Flow must be adequate to support species and taxa and habitat.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category
		Riparian habitat	Riparian vegetation should be maintained within a C ecological category. Alien infestation must be controlled and managed.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category
	Biota	Fish	An assessment of the fish community should be conducted annually to monitor against the prescribed C ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62% Collect at least 20 BMOT in 20min sampling effort.	Attainment of Water Resource Class and associated ecological category
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	Macroinvertebrate EC= C ≥ 62% SASS ≥ 140 ASPT ≥ 5.8	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
4_5_ Olifantsnek Dam **A22G**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be	Orthophosphate	≤ 0.015 mg/ℓ 95th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe)	Olifantsnek Dam is a mesotrophic system but that

			improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.			water collection in prewashed plastic bottles.	does experience occasional high influxes of nutrients. The system should be managed for ecological and recreational uses.
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Nitrite& Nitrate	≤ 0.50 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Olifantsnek Dam is a mesotrophic system. The system should be managed for ecological and recreational uses.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 55 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system is well within this category and should be maintained for sustainable use.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation	50% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
4_6 Hex river from Olifantsnek Dam, to inflow Bospoort Dam, Sandspruit	Quantity	Low Flows	EWR maintenance low and drought flows: Hex River (at new W-component) in A22H NMAR = 12.11x10^{6}m^3 REC=D category The maintenance low flows and drought flows must be attained so that the environmental flows requirements are met	Base flows Maintenance flows and drought flows (Node on Hex River downstream Olifantsnek Dam. Monitoring at new W-	| Maintenance Low flows (m^3/s) | Drought flows (m^3/s) | Oct 0.013 0.011 Nov 0.014 0.012 Dec 0.015 0.013 Jan 0.019 0.016 Feb 0.028 0.023	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
A22H			to support a healthy condition for the ecosystem and users.	component of the dam	Mar 0.026 0.022 Apr 0.020 0.017 May 0.017 0.015 Jun 0.017 0.014 Jul 0.015 0.013 Aug 0.014 0.012 Sep 0.014 0.012	
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and the water quality requirements of the water users are met. Nutrient management required to ensure sustainability of the system. Water quality must be improved to improve present ecological state from E to D ecological category.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.125 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
		Salts	Salinity levels are significantly high. Instream salinity must be improved to support the aquatic ecosystem and the water quality requirements of the water users. Water quality must be improved to improve present ecological state from E to D ecological category.	Electrical Conductivity	≤ 85 milliSiemens/metre (mS/m) (95th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
				Sulphate	≤ 120 milligrams/litre (95th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
				Chloride	≤ 120 milligrams/litre (95th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem as the driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxins must be maintained at levels that are not toxic to aquatic organisms and a threat to human health	Ammonia as N	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese.
				Aluminium (Al)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	Manganese – domestic user

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
				Iron (Fe)	≤ 0.3 milligrams/litre (mg/l) (95th percentile)	requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Lead (Pb) hard	≤0.0095 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤0.0073 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤0.07 milligrams/litre (mg/l) (95th percentile)	
				Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
				Mancozeb	0.009 milligrams/litre (mg/l)	Human health is the driver. Australian drinking water guideline.
				Glyphosate	0.7 milligrams/litre (mg/l)	Human health is the driver. USEPA drinking water guideline
				Endosulfan	0.13 micrograms/litre (ug/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
	Habitat	Instream	Habitat diversity should be improved from a D ecological category to a C category to support the overall ecological integrity of the system.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category
		Riparian habitat	Riparian vegetation should be maintained at a D ecological category.	Index of Habitat Integrity	VEGRAI EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological category
	Biota	Fish	Fish community should be maintained at a D ecological category or improved upon. Flow should be adequate for flow dependant species.	Fish Response Assessment Index (FRAI)	Fish ecology category = D FRAI ≥ 42%	Attainment of Water Resource Class and associated ecological category
		Semi aquatic biota	The suitability of this stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management. Riparian zone habitat must be improved.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = D ≥ 42% SASS ≥ 70 ASPT ≥ 4.2 (SiteA2HEX-PAARD)	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
4_7 **Bospoort Dam** **A22H**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).		
	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Orthophosphate	≤ 0.5 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Bospoort Dam is a hypertrophic system that is nutrient enriched due to the influx of nutrient rich treated effluent with very high nutrient concentrations. The nutrients have caused toxic cyanobacterial growth incidents. The importance of the site is moderate with recreational, industrial and potable use.
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Total phosphorous	≤ 0.130 mg/ℓ 50^{th} percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Bospoort Dam is a hypertrophic system.
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Nitrite& Nitrate	≤ 1.00 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Bospoort Dam is subject to nutrient enrichment that leads to increased algal and aquatic plant growth that impact negatively on the ecology, recreation and potable uses.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 85 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system has increased since 2011 and should be decreased and maintained for sustainable use.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Sodium	≤ 100 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The sodium is the main contributing variable within the salts and the system must be kept within the numerical limit.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95^{th} percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed	Direct contact recreational use must cause minimal irritation.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
						plastic bottles.	
			Increased clarity with reading.	Turbidity	≥0.4 m 5th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
		Toxics	The dam must be managed to minimize the development of toxic cyanobacterial blooms	Cyanobacteria	Cyanobacterial dominance with Chl a concentration higher than 30µg/ℓ must be kept at less than 20% of the time.	Bi-weekly integrated (0-5m hosepipe) water collection in prewashed plastic glass bottle with Lugo'sl Solution Preservative.	Bospoort has experienced toxic cyanobacterial blooms. The Cyanobacteria produce harmful toxins for wildlife and humans, which are problematic in water treatment removal. There is a community situated right on the banks of the dam.
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	50% riparian vegetation cover	Riparian zone vegetation survey every 3 years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish assemblage should be determined.	Fish survey determining diversity and quantity should be conducted every four years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl *a* concentrations must be maintained in as eutrophic system. Aesthetic quality of the dam must be managed by control of phytoplankton/periphyton growth.	Chl *a*	20-30µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection; filtering 500ml and preserved in ethanol in glass test tube.	The eutrophic state and the resultant phytoplankton growth that can lead to toxic cyanobacterial blooms of the Bospoort Dam is impaired but need to be improved for ecological, industrial, recreational and water treatment purposes. The water is used as a supplement for the Vaalkop WTW's.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context/Rationale for RQO/numerical limit
4_8 **Waterkloofspruit**	Quantity	Low Flows	EWR maintenance low and drought flows: Waterkloofspruit at CROC_EWR14 in A22H	Base flows Maintenance flows and drought flows		Maintenance Low flows (m^3/s)	Drought flows (m^3/s)	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state
					Oct	0.028	0.010	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
A22H			NMAR = $5.469x10^6 m^3$ REC=B/C category The maintenance low flows and drought flows must be attained so that the environmental flows requirements are met to support a healthy condition for the ecosystem and users.	Rapid EWR site 14 on Waterkloofspruit (monitoring at A2H038)	Nov 0.027 0.010 Dec 0.028 0.010 Jan 0.035 0.013 Feb 0.039 0.014 Mar 0.038 0.014 Apr 0.035 0.013 May 0.033 0.012 Jun 0.033 0.012 Jul 0.031 0.011 Aug 0.03 0.011 Sep 0.03 0.010	and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)
	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.025 milligrams/litre (mg/l) (50th percentile)	Maintenance of present ecological state. B category. Protection of ecological integrity.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.25 milligrams/litre (50th percentile)	
		Salts	Instream salinity must be maintained at current status to ensure protection of good ecological integrity or resource.	Electrical Conductivity	≤ 20 milliSiemens/metre (mS/m) (95th percentile)	Present state water quality.
				Sulphate	≤ 10 milligrams/litre (95th percentile)	
				Chloride	≤ 10 milligrams/litre (95th percentile)	
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem as the driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
	Habitat	Instream	Habitat diversity should be maintained in the B ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Attainment of Water Resource Class and associated ecological category
		Riparian habitat	Riparian vegetation should be maintained at a B ecological category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Attainment of Water Resource Class and associated ecological category
	Biota	Fish	Fish community should be maintained at a B/C ecological category. Area above the waterfall must be protected due to presence of *TSPA* upstream of waterfall. FRAI should be conducted to monitor	Fish Response Assessment Index (FRAI)	Fish ecology category = B/C FRAI ≥ 78% Sample 20 BMOT in 20min sample effort	Attainment of Water Resource Class and associated ecological category

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			against current category			
		Semi-Aquatic species	The suitability of this stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management. Riparian zone habitat must be improved.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC =C ≥ 62% SASS ≥ 150 ASPT ≥ 6.0	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
4_9 Hex River outflow Bospoort Dam to inflow Vaalkop Dam **A22J**	Quantity	Low Flows	EWR maintenance low and drought flows: Hex River at CROC_EWR6 in A22J NMAR = $26.9 \times 10^6 m^3$ REC=D category The maintenance low flows and drought flows must be attained to support a healthy condition for the ecosystem and users.	Base flows Maintenance flows and drought flows Intermediate EWR site 6 on Hex River (monitoring at A2H094)	(see below)	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and the water quality requirements of the water users are met. Nutrient management required to ensure sustainability of the system. Water quality must be improved to improve present ecological state from E to D ecological category.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.050 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 2.0 milligrams/litre (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
		Salts	Salinity levels are significantly high.	Electrical Conductivity	≤ 85 milliSiemens/metre (mS/m)	Ecological specification. Ecological

Numerical Limit (Low Flows):

	Maintenance Low flows (m^3/s)	Drought flows (m^3/s)
Oct	0.024	0.015
Nov	0.026	0.023
Dec	0.035	0.022
Jan	0.052	0.022
Feb	0.093	0.070
Mar	0.084	0.067
Apr	0.055	0.054
May	0.039	0.039
Jun	0.035	0.035
Jul	0.030	0.030
Aug	0.028	0.028
Sep	0.025	0.023

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			Instream salinity must be improved to support the aquatic ecosystem and the water quality requirements of the water users. Water quality must be improved to improve present ecological state from E to D ecological category.		(95th percentile)	Reserve manual (2008). Present ecological state must be improved.
				Sulphate	≤ 120 milligrams/litre (95th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
				Chloride	≤ 120 milligrams/litre (95th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem as the driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxins must be maintained at levels that are not toxic to aquatic organisms and a threat to human health	Ammonia	≤ 0.007 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Aluminium (Al)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤0.3 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤0.0095 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤0.0073 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤0.07 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity should be maintained within a D ecological category or improved upon. Habitat diversity for flow and marginal vegetation sensitive species and taxa must be attained.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model	Instream Habitat Integrity EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological category
		Riparian habitat	Riparian vegetation should be maintained at a C ecological category or better condition. Habitat protection required. Developments into riparian zone must be controlled.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category
	Biota	Fish	An assessment of the fish community should be conducted annually to monitor against the prescribed D ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = D FRAI ≥ 42%	Attainment of Water Resource Class and associated ecological category

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = D ≥ 42% SASS ≥ 70 ASPT ≥ 4.2 REMP site A2HEXR-ROOIW	Based on available monitoring data. Attainment of Water Resource Class and associated ecological category
		Diatoms	Diatom assemblage must be maintained within a D ecological category or improved upon	Specific Pollution Index	Diatom EC = D ≥ 42%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

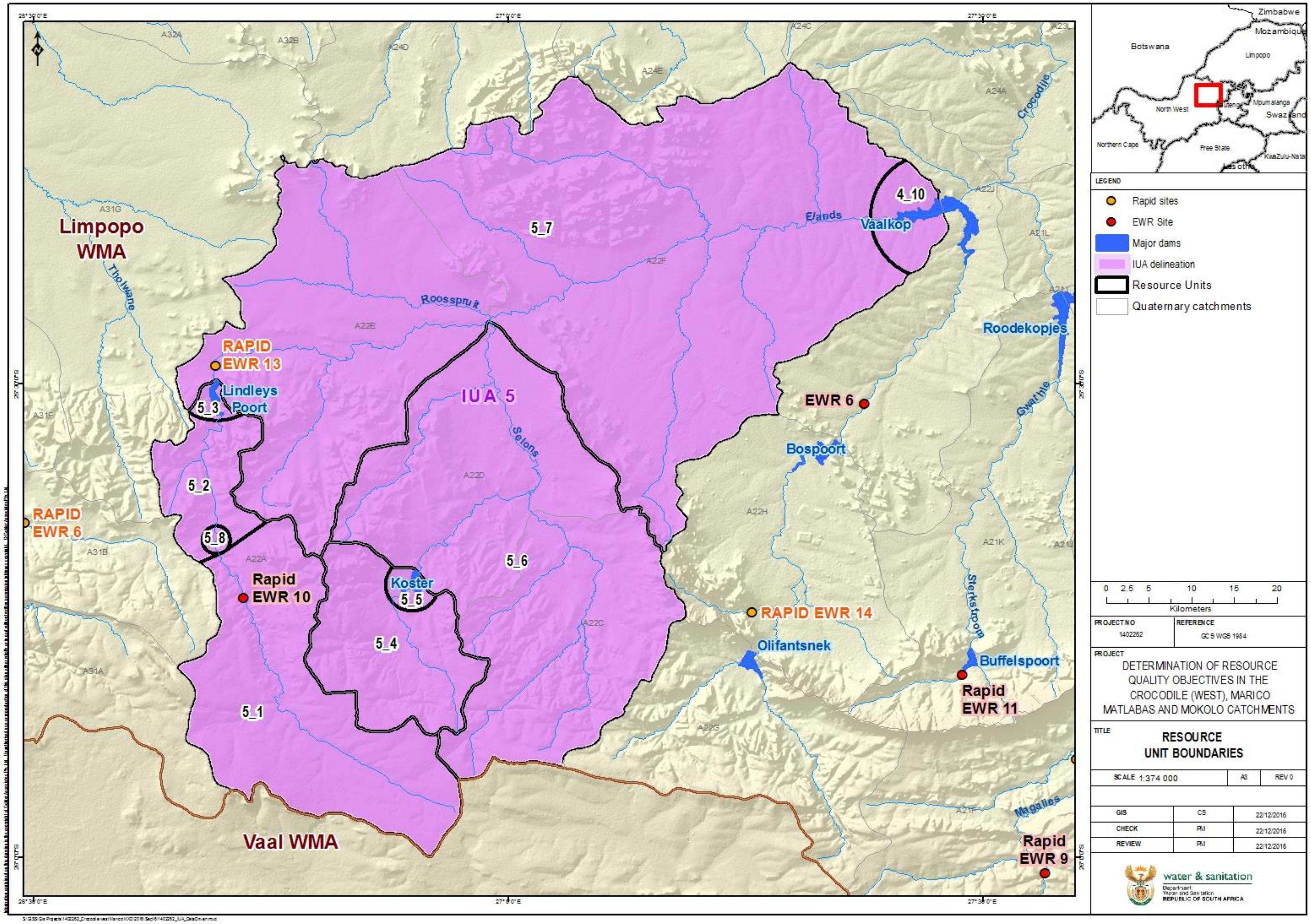
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
4_10 Vaalkop Dam **and lower reach of Elands before confluence with Crocodile** **A22J**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Orthophosphate	≤ 0.05 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Vaalkop Dam is a mesotrophic system that has occasional high nutrient influxes. The system is still of relatively good quality and should be maintained as such for ecological, recreational, agricultural and potable uses.
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Total phosphorous	≤ 0.055 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Vaalkop Dam is a mesotrophic system. The system is still of relatively good quality and should be maintained as such for ecological, recreational, agricultural and potable uses.
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Nitrite& Nitrate	≤ 0.70 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Vaalkop Dam is subject to occasional high nutrient influxes. The system is still of relatively good quality and should be maintained as such for ecological, recreational, agricultural and potable uses.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality	Electrical Conductivity	≤ 55 mS/m 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water	The electrical conductivity of the system must be improved.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			requirements of the downstream users.			collection in prewashed plastic bottles	
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Sulphate,	≤ 100 mg/ℓ 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	The electrical conductivity of the system must be maintained.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Chloride	≤ 100 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The chloride is one of the main contributing variables within the salts must be maintained within the numeric imit.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity	Turbidity	≥0.4 m 5th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
			Moderate change	Temperature	No more than 2 °C increasing change in both minimum and maximum	Bi-weekly depth profile monitoring with a DO meter.	Increased temperatures will favour the growth of potentially toxic cyanobacteria.
			The oxygen levels in the system must maintain the ecological system.	Dissolved Oxygen	≥ 7.0 mg/L O2 95th percentile	Bi-weekly depth profile monitoring with a DO meter.	Low oxygen levels associated with organic matter emanating from upstream industries and Wastewater Treatment Works are negatively impacting on the ecosystem.
		Toxics	The dam must be managed to minimize the development of toxic cyanobacterial blooms	Cyanobacteria	Cyanobacterial dominate with Chl *a* concentration higher than 30µg/ℓ must be kept at less than 20% of the time.	Bi-weekly integrated (0-5m hosepipe) water collection in prewashed plastic glass bottle with Lugol's Solution Preservative.	Vaalkop Dam Chl *a* concentrations has escalated into eutrophic conditions during the last 10 years and will be prone to serious cyanobacterial blooms. The Cyanobacteria produce harmful toxins for wildlife and humans, which are problematic in water treatment removal.
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian	Riparian vegetation Health	70% riparian vegetation cover	Riparian zone vegetation survey annually.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			zone should be preserved as far as possible to ensure necessary habitat.				
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every two years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl a concentrations must be maintained in a mesotrophic state.	Chl *a*	11-20µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection; filtering 500ml and preserved in ethanol in glass test tube.	The eutrophic state during the last 10 years and the resultant phytoplankton growth that can lead to toxic cyanobacterial blooms of the Vaalkop Dam is a serious concern and should be monitored and managed for precautionary purposes due to the potable water supply use of the system.

6.1.5 ELANDS/VAALKOP

RU	Delineation	Catchment
5_1	Upper reaches of Elands to Swartruggens Dam	A22A south eastern portion
5_2	Elands river downstream Swartruggens Dam to Lindleyspoort Dam	A22A
5_3	Lindleyspoort Dam	A22A
5_4	Upper Koster River to Koster Dam	A22B
5_6	Selons River, Koedoespruit, Dwarsspruit, lower Koster River	A22C, A22D
5_7	Elands River outflow Lindleyspoort Dam to inflow Vaalkop Dam, Brakkloofspruit, Roosspruit, Sandspruit Mankwe. Leragane, Molapongwamongana	A22E, A22F
5_8	Swartruggens Dam –not prioritised	A22A



Limpopo WMA
Vaal WMA
IUA 5
5_1
5_2
5_3
5_4
5_5
5_6
5_7
5_8
4_10
RAPID EWR 13
RAPID EWR 6
Rapid EWR 10
EWR 6
RAPID EWR 14
Rapid EWR 11
Rapid EWR 9
Lindleys Poort
Koster
Vaalkop
Bospoort
Roodekopjes
Olifantsnek
Buffelspoort
Elands
Roosspruit
Selons
Tholwane
Crocodile
Sterkstroom
Magalies
Gwathle
Botswana
Zimbabwe
Mozambique
Limpopo
North West
Mpumalanga
Swaziland
Northern Cape
Free State
KwaZulu-Natal
LEGEND
Rapid sites
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
0 2.5 5 10 15 20
Kilometers
PROJECT NO
1402262
REFERENCE
GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
RESOURCE UNIT BOUNDARIES
SCALE 1:374 000
A3
REV 0
GIS CS 22/12/2016
CHECK PM 22/12/2016
REVIEW PM 22/12/2016
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

IUA 5 – Elands/Vaalkop
RESOURCE UNIT : 5_1– Upper reaches of Elands to Swartruggens Dam - Quaternary catchment A22A south eastern portion
DESCRIPTION
The IUA is a Class II. EWR rapid site 10 is present is this RU. The PES is a C ecological category. The upper Elands River is a source area in the Highveld ecoregion. Area conbtains seepage areas, wetlandS, unique pans and diverse habitats. The presence of the vulnerable *B. motebensis* within the upper reaches of the Elands River contributes to a high EIS for the upper reaches. This upper reach of the Elands River also serves as refugia as the downstream catchment and river has been degraded. The wetlands are important and the rivers are FEPAs. There is some dry land farming (livestock and poultry producers) and slate mining are present. Some sedimentation due to slate mining.
RESOURCE UNIT : 5_2 – Elands river downstream Swartruggens Dam to Lindleyspoort Dam: Quaternary catchment A22A
DESCRIPTION
The IUA is a Class II. This reach of the Elands River is located below Swartruggens dam and includes the towns of Swartruggens, Nooigedacht and Rusverby. The reach is impacted upon by the Swartruggens (Kgetlengrivier) WWTW, urban activities, and slate mining. Water quality deterioration is observed. Flow impacts present and poor sanitation is also impacting on river system.
RESOURCE UNIT : 5_3 – Lindleyspoort Dam - Quaternary catchment A22A
DESCRIPTION
The IUA is a Class II. The dam is surrounded by agriculture and subsistence farming and thus primarily supports irrigation water users and some domestic use and provides flow regulating capacity. The upstream impacts include WWTWs. Dam supports mainly downstream irrigation activities. This dam forms part of the Lindleyspoort Government Water Scheme.
RESOURCE UNIT : 5_4 – Upper Koster to Koster Dam, Rooikloofspruit: Quaternary catchment A22B
DESCRIPTION
The IUA is a Class II. The upper Koster River is a fish support area. An unnamed tributary contains isolated populations of fish species *BMOT* and has high habitat diversity that includes pools, rapids and riffles. Cultivation activities occur along the reach of the Koster River. The PES is a C ecological category. The Koster town is dependent on the river for water supply (into Koster Dam). Impacts include WWTW discharges from the Koster WWTW (not operated appropiriately), intensive cattle and poultry farming and unauthorised abstraction.
RESOURCE UNIT : 5_6 – Selons River, Koedoespruit, Dwarsspruit, lower Koster River- Quaternary catchment A22C, A22D
DESCRIPTION
The IUA is a Class II. A small portion of the Selons River is protected and includes an unnamed tributary that contains fish species *BMOT*. Area is also a transition zone from Western Brackenveld to Highveld ecoregions. Cultivation (limited irrigation) activities occurs. The settlements of Wysfontein, Moedwil, Tweerivier, Woodstock, Dwarsspruit, Waterval, Sefaneskraal and Rhenosterdorings.
RESOURCE UNIT: 5_7 – Elands River outflow Lindleyspoort Dam to inflow Vaalkop Dam, Brakkloofspruit, Roosspruit, Sandspruit Mankwe. Leragane, Molapongwamongana: Quaternary catchment A22E, A22F
DESCRIPTION
The IUA is a Class II. EWR rapid site 13 is situated on the Elands River just downstream of Lindleyspoort Dam. The area is rural in nature, some irrigation, settlements present. The settlements of Krokodildrif, Brakkloof, Rothschild, Hoebome and towns of Lindleyspoort Phatsima, Ledig, Chaneng, Mogwase and Monakato are located in the catchment. The Mankwe tributary is protected in the Pilanesberg National Park. These rivers are however surrounded by mining activities on Leragane (impacted). WWTWs discharges from Sun City, Mogwase and Monakato impact on water quality of the Elands River.
RESOURCE UNIT: 5_8 – Swartruggens Dam - Quaternary catchment A22A
The IUA is a Class II. The dam is located upstream from the town of Swartruggens. The dam provides water supply to the town (all domestic supply).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
5_1 **Upper reaches of Elands to Swartruggens Dam** **A22A south eastern portion**	Quantity	Low flows	EWR maintenance low and drought flows: Elands River at CROC_EWR10 in A22A NMAR = $10.1x10^6 m^3$ REC=B/C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Rapid EWR site 10 on Elands River (monitoring during biological surveys)	Month – Maintenance Low flows (m^3/s) – Drought flows (m^3/s) Oct – 0.038 – 0.015 Nov – 0.045 – 0.012 Dec – 0.050 – 0.011 Jan – 0.070 – 0.026 Feb – 0.094 – 0.031 Mar – 0.091 – 0.019 Apr – 0.073 – 0.015 May – 0.056 – 0.015 Jun – 0.051 – 0.019 Jul – 0.046 – 0.017 Aug – 0.042 – 0.016 Sep – 0.039 – 0.015	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.025 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.
				Sulphate	≤ 30 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Ecological specification. Present ecological state must be maintained.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 9.0 (95th percentile)	Aquatic ecosystem and user as the drivers
			A baseline assessment to determine the present state instream turbidity is required. Limits must be defined to control the impacts of slate mining on the resource.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	6-7 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
	Habitat	Instream	Habitat diversity should be maintained for C ecological category.Habitat diversity for flow and marginal vegetation sensitive species must be maintained.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be maintained at a C ecological category. Protection of riparian habitat is required. Developments into riparian zone must be controlled and managed.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	The fish community must be maintained in a C ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI)	Fish ecological category = C FRAI ≥ 62% Sample 20 BMOT in 20min sample effort	Attainment of Water Resource Class and associated ecological category.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C category ecological condition or improved upon.	Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = C ≥ 62% SASS ≥ 155 ASPT ≥ 5.5	Attainment of Water Resource Class and associated ecological category. Ecological Reserve. Based on available data.
		Diatoms	Diatom assemblage must be maintained within a C ecological category or improved upon	Specific Pollution Index	Diatom EC ≥ 62%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

<table>
<tr><th>Resource Unit</th><th>Component</th><th>Sub-component</th><th>RQO</th><th>Indicator</th><th colspan="3">Numerical Limit</th><th>Context/Rationale for RQO/numerical limit</th></tr>
<tr><td rowspan="10">5_2

Elands downstream Swartruggens Dam to Lindleyspoort Dam

A22A</td><td rowspan="10">Quantity</td><td rowspan="10">Low flows</td><td rowspan="10">EWR maintenance low and drought flows:
Elands River at A2H107 in A22A
NMAR = 12.87x10⁶m³
REC=C category

The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.</td><td rowspan="10">Base Flows

Maintenance flows and drought flows
Monitoring of Elands River at A2H107</td><td></td><td>Maintenance Low flows (m³/s)</td><td>Drought flows (m³/s)</td><td rowspan="10">Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set.

Required flows as per the Reserve summary table (rule and tab tables).</td></tr>
<tr><td>Oct</td><td>0.030</td><td>0.016</td></tr>
<tr><td>Nov</td><td>0.037</td><td>0.014</td></tr>
<tr><td>Dec</td><td>0.044</td><td>0.013</td></tr>
<tr><td>Jan</td><td>0.063</td><td>0.028</td></tr>
<tr><td>Feb</td><td>0.083</td><td>0.009</td></tr>
<tr><td>Mar</td><td>0.081</td><td>0.018</td></tr>
<tr><td>Apr</td><td>0.064</td><td>0.016</td></tr>
<tr><td>May</td><td>0.047</td><td>0.018</td></tr>
<tr><td>Jun</td><td>0.042</td><td>0.019</td></tr>
</table>

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
					Jul 0.036 0.018 Aug 0.033 0.018 Sep 0.030 0.016	
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met. Control of wastewater treatment works discharges discharges is required.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.050 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Ecological specification. Ecological Reserve manual (2008).
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met. Control of land based impacts and WWTW discharges is required.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem and user requirements as drivers. Present ecological state must be maintained.
				Sulphate	≤ 80 milligrams/litre (95th percentile)	
				Chloride	≤ 40 milligrams/litre (95th percentile)	
				Sodium	≤ 70 milligrams/litre (95th percentile)	
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 9.0 (95th percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	6-7 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.
	Habitat	Instream	Habitat diversity should be maintained for C ecological category or improved upon.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be maintained at C ecological category or better condition.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
	Biota	Semi aquatic biota	The suitability of this stretch of river to	Aquatic birds/Indicator mammal	A baseline assessment should be	More detailed information and

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management.	species	conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C category ecological condition or improved upon.	Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	Macroinvertebrate EC = C ≥ 62% SASS ≥ 120 ASPT ≥ 5.3	Attainment of Water Resource Class and associated ecological category. Based on available data.
		Diatoms	Diatom assemblage must be maintained within a C/D ecological category or improved upon	Specific Pollution Index	Diatom EC ≥ 58%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
5_3 **Lindleyspoort Dam** **A22A**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Orthophosphates,	≤ 0.015 mg/ℓ 50^{th} percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Lindleyspoort Dam is a mesotrophic system that has occasional high nutrient influxes.
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Total phosphorous	≤ 0.055 mg/ℓ 50^{th} percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Lindleyspoort Dam is a mesotrophic system that has occasional high nutrient influxes.
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Nitrite& Nitrate	≤ 0.70 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Lindleyspoort Dam is a mesotrophic system that has occasional high nutrient influxes.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 55 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system is within this C category and must be maintained.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity	Turbidity	≥0.4 m 5th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	90% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Periphyton/ Phytoplankton	The Chl *a* concentrations must be maintained in a mesotrophic state.	Chl *a*	11-20µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection; filtering 500ml and preserved in ethanol in glass test tube.	The occasional influxes of extreme nutrient concentrations due to WTWW failures should be prevented to ensure that Lindleyspoort Dam stay within a mesotrophic state.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
5_4 **Upper Koster River to Koster Dam** **A22B**	Quantity	Low flows	EWR maintenance low and drought flows: Koster River at A2H036 in A22B NMAR = 2.54x10^{6}m^3 REC=C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows Monitoring of Koster River at A2H036	Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.006 0.002 Nov 0.004 0.002 Dec 0.006 0.001 Jan 0.009 0.004 Feb 0.020 0.005 Mar 0.032 0.006	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
					Apr 0.031 0.007 May 0.018 0.006 Jun 0.015 0.006 Jul 0.012 0.005 Aug 0.010 0.004 Sep 0.008 0.003	
	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.025 milligrams/litre (mg/l) (50th percentile)	Present water quality status. Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.05 milligrams/litre (50th percentile)	Present water quality status. Present ecological state maintained.
		Salts	Instream salinity must be maintained at current status to ensure protection of good ecological integrity or resource.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Present water quality status. Maintain current quality.
				Sodium	≤ 20 milligrams/litre (95th percentile)	
				Sulphate	≤ 20 milligrams/litre (95th percentile)	
				Chloride	≤ 20 milligrams/litre (95th percentile)	
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.0 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	6-7 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.
		Toxics	The concentrations of toxins must not toxic to aquatic organisms and a threat to human health	Hormone driven Pharmaceuticals	17ß-oestradiol: ≤ 0.001 mglℓ	Hormone driven pharmaceuticals emanating from water treatment activities are potentially threatening the sustainability of animals and humans Genthe *et al.* 2009).
	Biota	Fish	Fish community should be maintained at the prescribed C ecological category. Flow should adequate to support representative species.	Fish Response Assessment Index (FRAI).	Fish ecology category = C FRAI ≥ 62% Sample 20 BMOT in 20min sample effort	Attainment of Water Resource Class and associated ecological category
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C category ecological condition or improved upon.	Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = C ≥ 62% SASS ≥ 70 ASPT ≥ 4.2	Attainment of Water Resource Class and associated ecological category. Based on available data.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
5_6 Selons River, Koedoespruit, Dwarsspruit, lower Koster River **A22C, A22D**	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.050 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem driver. Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.
		Salts	Instream concentration of salinity must be maintained to preserve present state and to sustain aquatic ecosystem health in the prescribed ecological category is met.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Present state quality, howver *limited samples. More sampling required to confirm baseline.
				Sodium	≤ 20 milligrams/litre (95th percentile)	
				Sulphate	≤ 20 milligrams/litre (95th percentile)	
				Chloride	≤ 20 milligrams/litre (95th percentile)	
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.0 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.

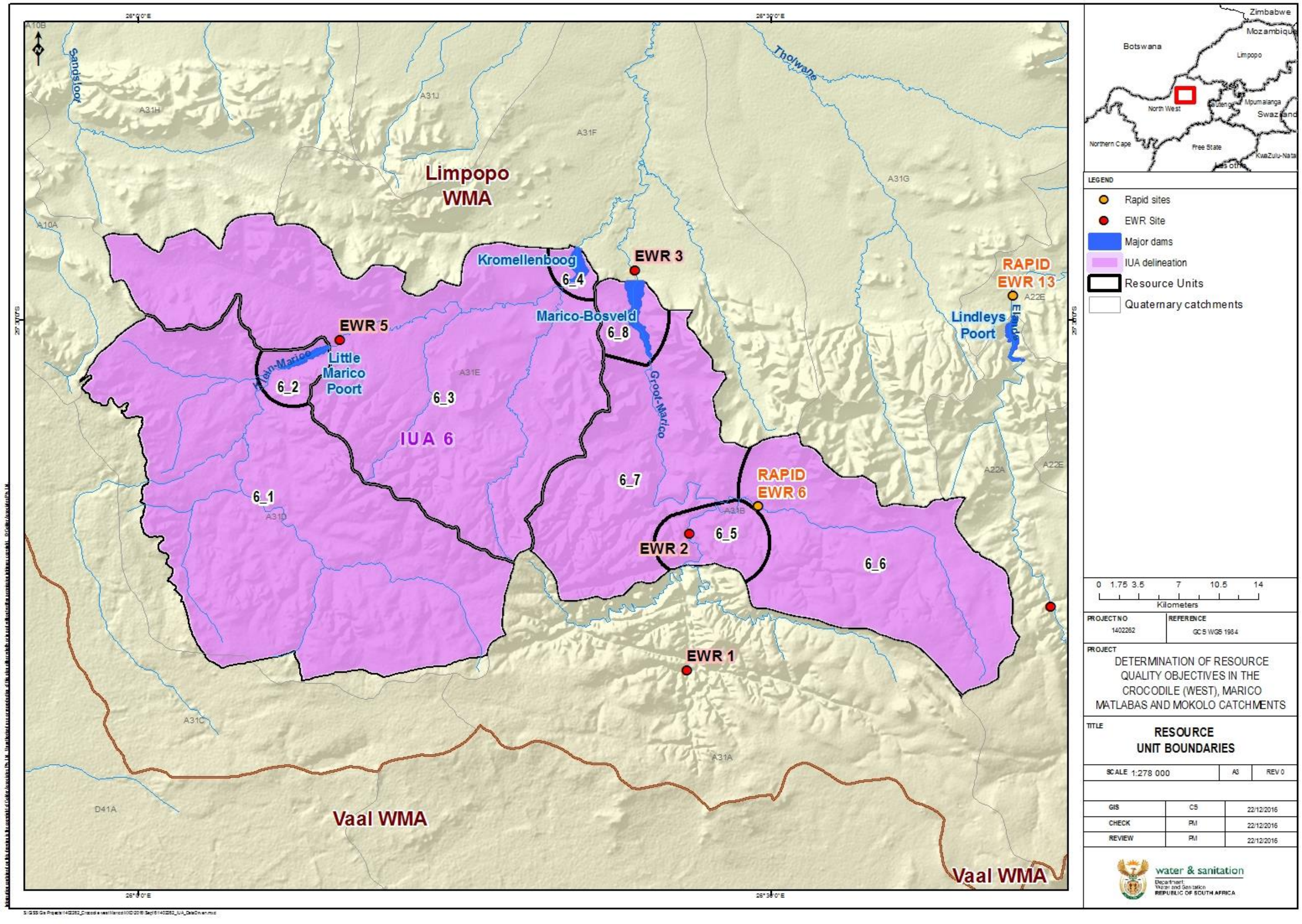
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context/Rationale for RQO/numerical limit
5_7 **Elands River outflow Lindleyspoort Dam to inflow Vaalkop Dam, Brakkloofspruit, Roosspruit, Sandspruit Mankwe. Leragane, Molapongwamongana** **A22E, A22F**	Quantity	Low flows	EWR maintenance low and drought flows: Elands River at CROC_EWR13 in A22E NMAR = $18.77x10^6 m^3$ REC=C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Monitor at new W-component of Lindleyspoort Dam		Maintenance	Drought	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
					(m^3/s)	Low flows (m^3/s)	flows	
					Oct	0.038	0.011	
					Nov	0.048	0.014	
					Dec	0.057	0.016	
					Jan	0.081	0.023	
					Feb	0.107	0.012	
					Mar	0.105	0.027	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
					Apr 0.082 0.023	
					May 0.06 0.017	
					Jun 0.054 0.016	
					Jul 0.047 0.014	
					Aug 0.042 0.012	
					Sep 0.038 0.011	
	Quality	Nutrients	Nutrient levels are high and must be reduced to meet the requirements of the aquatic ecosystem. Concentrations must be reduced to meet the prescribed C ecological category.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.010 milligrams/litre (mg/l) (50^{th} percentile)	Aquatic ecosystem driver. Present ecological state maintained. Limit contribution nutrients to dam (keep Vaalkop mesotrophic).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 2.0 milligrams/litre (50^{th} percentile)	Aquatic ecosystem driver. Present ecological state maintained. Limit contribution of nutrients to dam. (eutrophic condition).
		Salts	Salinity levels are significantly high. Instream salinity must be improved to support the aquatic ecosystem and the water quality requirements of the water users. Water quality must be improved to a C ecological category.	Electrical Conductivity	≤ 85 milliSiemens/metre (mS/m) (95^{th} percentile)	Based on present state. Significant improvement required.
				Sodium	≤ 100 milligrams/litre (95^{th} percentile)	Based on present state. Improvement required.
				Sulphate	≤ 120 milligrams/litre (95^{th} percentile)	Based on present state.
				Chloride	≤ 120 milligrams/litre (95^{th} percentile)	Based on present state. Improved requirement
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95^{th} percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.0 (5^{th} percentile) and 9.0 (95^{th} percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Aluminium (Al)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.3 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0095 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
	Habitat	Instream	Habitat diversity should be maintained in a C ecological category or better. Important to maintain marginal vegetation and in-stream substrate (flow depth classes) for fish and macroinvertebrate diversity.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model, Geomorphic Assessment Index	Instream Habitat Integrity EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be maintained at a C ecological category. Alien vegetation control is required. Riparian zone development must be limited.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 70%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	The fish community must be maintained in a D ecological category or better. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI).	Fish ecology category = D FRAI ≥ 42% Sample minimum of 4 species per 20min sample effort	Attainment of Water Resource Class and associated ecological category.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C category ecological condition or improved upon.	Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = C ≥ 62% SASS ≥ 110 ASPT ≥ 4.5	Attainment of Water Resource Class and associated ecological category. Based on available data.
		Diatoms	Diatom assemblage must be maintained within a C ecological category or improved upon.	Specific Pollution Index	Diatom EC ≥ 62%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.
		Semi-aquatic biota	The suitability of this stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.

6.1.6 KLEIN MARICO

RU	Delineation	Catchment
6_1	Upper Klein Marico to inflow Klein Maricopoort dam, Rhenosterfonteinspruit, Malmanieloop, Kareespruit	A31D
6_2	Klein Maricopoort dam	A31D
6_3	Klein Marico downstream Klein Maricopoort Dam to Kromellenboog Dam, Wilgeboomspruit	A31E
6_4	Kromellenboog Dam	A31E


Limpopo WMA
Vaal WMA
Vaal WMA
IUA 6
6_1
6_2
6_3
6_4
6_5
6_6
6_7
6_8
EWR 1
EWR 2
EWR 3
EWR 5
RAPID EWR 6
RAPID EWR 13
Kromellenboog
Marico-Bosveld
Little Marico Poort
Lindleys Poort
Groot-Marico
Tholwane
Sandsloot
A31H
A31J
A31F
A31G
A31E
A31D
A31B
A31C
A31A
A22A
A22E
A10A
A10B
D41A
Zimbabwe
Mozambique
Botswana
Limpopo
North West
Gauteng
Mpumalanga
Swaziland
Northern Cape
Free State
KwaZulu-Natal
LEGEND
Rapid sites
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
0 1.75 3.5 7 10.5 14
Kilometers
PROJECT NO
1402262
REFERENCE
GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
RESOURCE UNIT BOUNDARIES
SCALE 1:278 000
A3
REV 0
GIS
CS
22/12/2016
CHECK
PM
22/12/2016
REVIEW
PM
22/12/2016
water & sanitation
Department: Water and Sanitation REPUBLIC OF SOUTH AFRICA

IUA 6a – Klein Marico
RESOURCE UNIT : 6_1– Upper Klein Marico to inflow Klein Maricopoort dam, Rhenosterfonteinspruit, Malmanieloop, Kareespruit- Quaternary catchment A31D
DESCRIPTION
The IUA is a Class II. Klein Marico Eye fed by groundwater (groundwater driven system). This reach is located upstream of the town of Zeerust (urban). Zeerust is dependent on groundwater for its water supply. Water users in the area include irrigation. There are large abstractions from dolomites for irrigation and urban use. Impacts on Kareespruit from the Zeerust WWTW, irrigation and over abstraction. Mining activities are present. There are some flow issues for macroinvertebrates. *BMOT* and *BMAT* are on the expected list for this reach. *PPHI* populations present. Groundwater: Significantly impacted by bulk groundwater abstractions for municipal supplies; thus quantity and due to agricultural activities, quality may become an issue in future.
RESOURCE UNIT : 6_2 – Klein Maricopoort Dam: Quaternary catchment A31D
DESCRIPTION
The IUA is a Class II. The dam is mainly used for irrigation. Protection of quality of water in dam is necessary as it supports downstream habitat availability for biota ans serves as fish refugia. Recreational activities are present at the dam. Water quality impacts area present.
RESOURCE UNIT : 6_3 – Klein Marico downstream Klein Maricopoort Dam to Kromellenboog Dam, Wilgeboomspruit - Quaternary catchment A31E
DESCRIPTION
The IUA is a Class II. EWR site 5 on the Klein Marico River is located in this resource unit. A number of settlements are presents. Impacts include irrigation and over abstraction. Poor water quality due to irrigation return flows. River flow is very low, and is currently maintained by a leak from the dam. Water from the dam is released into canals for irrigation use. Poor fish diversity. Erosion and siltation impacts also present. Wilgeboomspruit is a small seasonal stream.
RESOURCE UNIT : 6_4 – Kromellenboog Dam: Quaternary catchment A31E
DESCRIPTION
The IUA is a Class II. Mainly supports downstream irrigation, but also recreational water use. Water is released into canals. General habitat for birds. Dam is impacted by upstream siltation, erosion, and nutrients.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
6_1 **Upper Klein Marico to inflow, Klein Maricopoort Dam, Rhenosterspruit, Malmaniesloop, Kareespruit** **A31D**	Quantity	Low flows	EWR maintenance low and drought flows: Klein Marico River just upstream of Klein Maricopoort Dam in A31D NMAR = 16.25x10^{6}m^3 REC=C/D category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows Monitoring of Klein Marico River with biological surveys	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.038 0.035 Nov 0.039 0.036 Dec 0.039 0.036 Jan 0.041 0.038 Feb 0.048 0.045 Mar 0.044 0.040 Apr 0.045 0.041 May 0.042 0.039 Jun 0.043 0.039 Jul 0.041 0.038 Aug 0.040 0.037 Sep 0.041 0.037	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.050 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.
				Sulphate	≤ 80 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Ecological specification. Present ecological state must be maintained.
				Chloride	≤ 40 milligrams/litre (95th percentile)	
				Sodium	≤ 70 milligrams/litre (95th percentile)	
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.0 (5th percentile) and 9.0 (95th percentile)	Aquatic ecosystem and user as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Fluoride	≤ 2.5 milligrams/litre (95th percentile)	Ecological specification. Ecological Reserve manual (2008).
	Habitat	Instream	Habitat diversity should be maintained in a C/D ecological category. Maintain marginal	Index of Habitat Integrity, Rapid Habitat Assessment Method and	Instream Habitat Integrity EC = C/D ≥ 58%	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			vegetation and in-stream substrate (velocity depth classes) for fish and macroinvertebrate diversity.	Model (RHAMM)		
		Riparian habitat	Riparian vegetation should be improved from a D ecological category to a C/D ecological category. Alien vegetation control must be implemented. Riparian zone development must be limited and controlled.	Vegetation Response Assessment Index	VEGRAI EC = C/D ≥ 58%	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
6_2 **Klein Maricopoort Dam** **A31D**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Orthophosphates	≤ 0.025 mg/ℓ 50^{th} percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Klein Maricopoort Dam is a eutrophic system with occasional high nutrient influxes.
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Total phosphorous	≤ 0.050 mg/ℓ 50^{th} percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Klein Maricopoort Dam is a eutrophic system with occasional high nutrient influxes.
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be	Nitrite& Nitrate	≤ 0.70 mg/L N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Klein Maricopoort Dam is a eutrophic system with occasional high nutrient influxes.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			maintained as a mesotrophic system.				
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 65 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the must be maintain improved. (Present state 79 mS/m)
				Chloride	≤ 40 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The chloride is one of the main contributing variables within the salts and the system must be managed.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli*	≤ 10 counts/100µℓ 95th percentile	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity with reading	Turbidity	≥0.4 m 5th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	50% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Periphyton/ Phytoplankton	The Chl a concentrations must be maintained in a mesotrophic state.	Chl *a*	11-20µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection; filtering 500ml and preserved in ethanol in glass test tube.	The Klein Maricopoort Dam has shown Chl *a* concentrations ≥ 30µg/ℓ for 40 % of the time during 2016 and this is a serious cause of concern as the water is used for potable water supply purposes.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
6_3 Klein Marico downstream Klein Maricopoort Dam to Kromellenboog Dam, Wilgeboomspruit **A31E**	Quantity	Low flows	EWR maintenance low and drought flows: Klein Marico River at MAR_EWR5 in A31E NMAR = $16.25 \times 10^6\ m^3$ REC=C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows Monitoring of Klein Marico River at A3H030	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.019 0.017 Nov 0.019 0.017 Dec 0.019 0.017 Jan 0.021 0.018 Feb 0.024 0.021 Mar 0.022 0.019 Apr 0.022 0.020 May 0.021 0.018 Jun 0.021 0.019 Jul 0.020 0.018 Aug 0.020 0.018 Sep 0.020 0.018	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.050 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.7 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 65 milliSiemens/metre (mS/m) (95th percentile)	Present state water quality to be maintained.
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 9.0 (95th percentile)	Aquatic ecosystem and user as the drivers
			Sedimentation must be controlled through management of land use practices. A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
	Habitat	Instream	Habitat diversity should be maintained in a C ecological category or better condition. Maintain marginal vegetation and in-stream substrate (velocity depth classes) for fish and	Index of Habitat Integrity	Instream Habitat Integrity EC =C ≥ 62%	Attainment of Water Resource Class and associated ecological category.

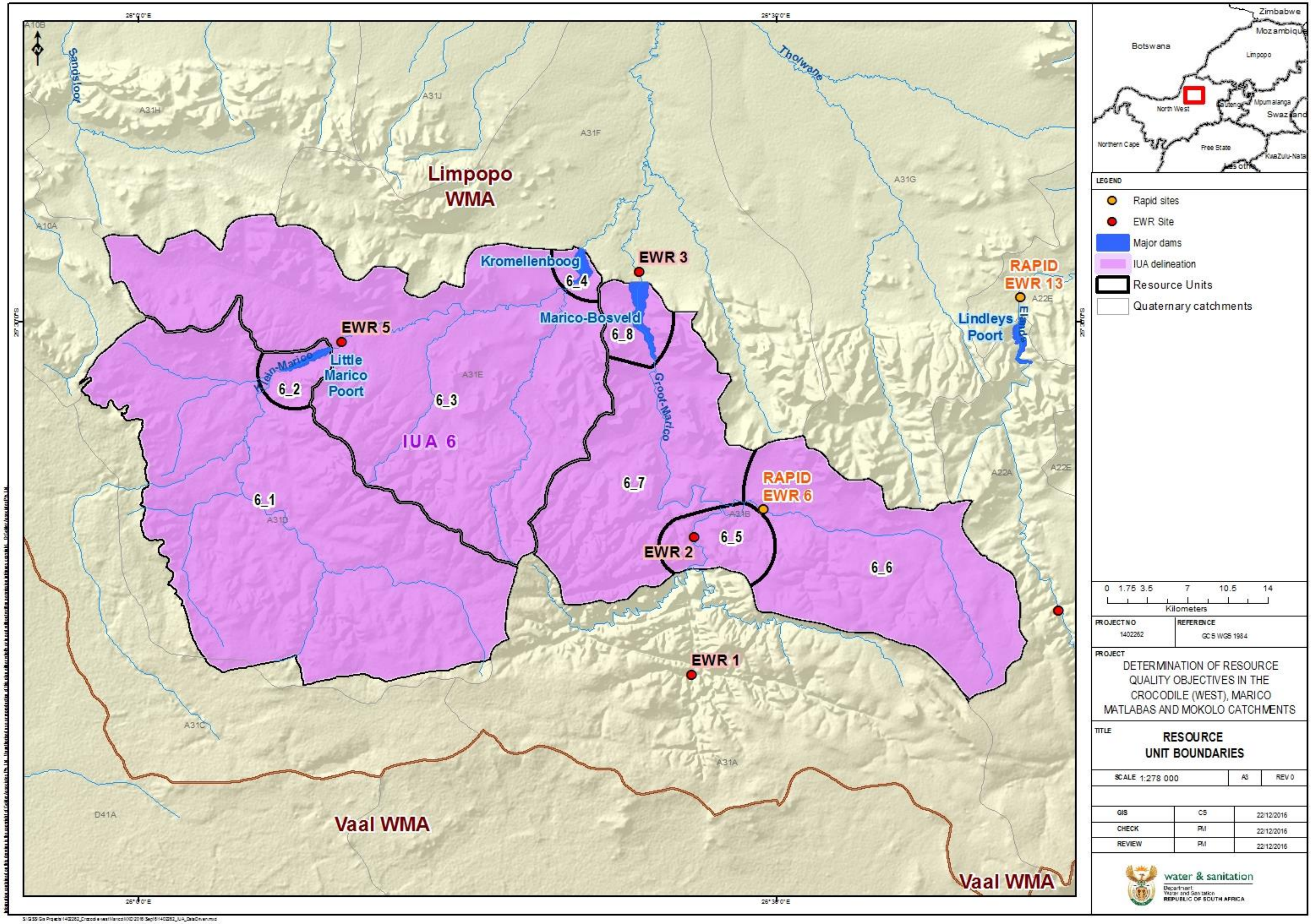
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			macroinvertebrate diversity.			
		Riparian habitat	Riparian vegetation should be maintained in a C ecological category or better condition.	Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	Fish community must be maintained within a C ecological condition or improved upon.	Fish Response Assessment Index (FRAI)	Fish ecological category = C FRAI ≥ 62% Collect 5 species in 20min sampling effort	Attainment of Water Resource Class and associated ecological category.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological condition or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	Macroinvertebrate EC = C ≥ 62% SASS ≥ 130 ASPT ≥ 5.0	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
6_4 **Kromellenboog Dam** **A31E**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Orthophosphates	≤ 0.015 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Kromellenboog Dam is a mesotrophic system and nutrient concentrations within the dam should be maintained at these levels.
			Concentration of total phosphorous must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Total phosphorous	≤ 0.025 mg/ℓ 50 th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Kromellenboog Dam is a mesotrophic system and nutrient concentrations within the dam should be maintained at these levels.
			Concentration of nitrate & nitrite must be maintained to sustain ecosystem health and the water quality requirements of water users.	Nitrite& Nitrate	≤ 0.70 mg/ℓ N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in	Kromellenboog Dam is a mesotrophic system and nutrient concentrations within the dam should be maintained at these

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			The dam must be maintained as a mesotrophic system.			prewashed plastic bottles	levels.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 55 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system must be maintained.
		Pathogens	Pathogens should be maintained at levels safe for human use.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	pH range must be maintained at within limits specified to support the aquatic ecosystem in the dam.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The system must remaim sustainable.
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	50% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every four years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl *a* concentrations must be maintained in a mesotrophic state.	Chl *a*	11-20µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection; filtering 500ml and preserved in ethanol in glass test tube.	There is little data available and the existing measurements class this system within an A Category. This status should be maintained for ecological, agricultural and recreational purposes.

6.1.7 GROOT MARICO

RU	Delineation	Catchment
6_5	Groot Marico main stem upstream to Polkadraaispruit confluence	A31B
6_6	Polkadraaispruit	
6_7	Groot Marico from Polkadraaispruit confluence to N4 bridge	
6_8	Marico Bosveld Dam	A31B


Limpopo WMA
IUA 6
EWR 5
EWR 3
EWR 2
EWR 1
RAPID EWR 6
RAPID EWR 13
Kromellenboog
Marico-Bosveld
Little Marico Poort
Lindleys Poort
Groot-Marico
Klein-Marico
Tholwane
Sandsloot
6_1
6_2
6_3
6_4
6_5
6_6
6_7
6_8
A31H
A31J
A31F
A31G
A31E
A31D
A31B
A31C
A31A
A10A
A10B
A22E
A22A
D41A
Vaal WMA
Vaal WMA
Zimbabwe
Mozambique
Botswana
Limpopo
North West
Gauteng
Mpumalanga
Swaziland
Northern Cape
Free State
KwaZulu-Natal
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LEGEND
Rapid sites
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
0 1.75 3.5 7 10.5 14
Kilometers
PROJECT NO
1402262
REFERENCE
GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
RESOURCE UNIT BOUNDARIES
SCALE 1:278 000
A3
REV 0
GIS CS 22/12/2016
CHECK PM 22/12/2016
REVIEW PM 22/12/2016
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

IUA 6b – Groot Marico
RESOURCE UNIT : 6_5, 6_6, 6_7 – Groot Marico, Polkadraaispruit - Quaternary catchment A31B
DESCRIPTION
The IUA is classified as a proposed Class II. EWR site 2 on the Marico and Rapid III site 6 on the Polkadraaispruit are located in the resource unit. Isolated occurrences to *BMOT, AURA, CPRE* and *AMOS* in the Polkadraaispruit, locality of aquatic macroinvertebrate as well as a large number of invertebrates and fish sensitive to water quality changes, are present. In terms of the Groot Marico, *AURA, CPRE* and to a certain degree *BMOT* occur. The water resources are in PES of B/C, and includes FEPA rivers and wetlands. The area surrounding the Marico Bosveld dam is protected. The catchment includes the town of Groot Marico, some smaller settlements and agricultural activities. Water quality is impacted in the lower reaches of the Marico river due to irrigation return flows and poorly treated sewage.
RESOURCE UNIT : 6_8 – Marico Bosveld Dam: Quaternary catchment A31B
DESCRIPTION
The IUA is classified as a proposed Class II. The Marico Bosveld Dam is situated at the outlet of this IUA. The dam supports some recreational activities (local angling) and extensive irrigation downstream. The dam is located within the Marico Bosveld nature reserve. Dam habitat functions as a fish refugia.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
6_5 **Groot Marico main stem upstream to Polkadraaispruit confluence** **A31B**	Quantity	Low flows	EWR maintenance low and drought flows: Groot Marico River at MAR_EWR2 in A31B NMAR = $42.08 \times 10^6 m^3$ REC=B category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows Monitoring of Groot Marico River at planned new weir close to EWR2	Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.510 0.268 Nov 0.540 0.283 Dec 0.560 0.291 Jan 0.620 0.319 Feb 0.710 0.364 Mar 0.637 0.327 Apr 0.628 0.324 May 0.584 0.302 Jun 0.588 0.305 Jul 0.557 0.290 Aug 0.547 0.285 Sep 0.546 0.285	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.020 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Ecological specification. Present ecological state must be maintained.
				Sulphate	≤ 10 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
				Chloride	≤ 10 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
				Sodium	≤ 10 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.8 (95th percentile)	Aquatic ecosystem driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	≥ 7 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to	Aluminium (Al)	≤ 0.062 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			human health.	Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0057 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0048 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity must be maintained in a B ecological category or better condition. Maintain marginal vegetation and in-stream substrate (velocity depth classes) for fish and macroinvertebrate diversity.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation must be maintained in a B ecological category or better condition.	Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	The fish community must be maintained in a B ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.Habitat and flow must be adequate for flow dependent species.	Fish Response Assessment Index (FRAI).	Fish ecology category = B FRAI ≥ 82% Sample 20 *BMOT*, 30 *CPRE* and 15 *AURA* in 20min sample effort.	Attainment of Water Resource Class and associated ecological category. Ecological Reserve
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within current state at the A/B ecological category.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = A/B ≥ 88% SASS ≥ 220 ASPT ≥ 6.5 (Site EWR 2 = A3GMAR-KOEDO)	Attainment of Water Resource Class and associated ecological category. Baseline data indicates present state of A/B category.
		Diatoms	Diatom assemblage must be maintained within a largely natural to natural condition.	Specific Pollution Index	Diatom EC ≥ 88%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context/Rationale for RQO/numerical limit
6_6 **Polkadraaispruit** **A31B**	Quantity	Low flows	EWR maintenance low and drought flows: Polkadraaispruit at MAR_EWR6 in A31B NMAR = $9.866 \times 10^6 m^3$ REC=B category	Base Flows Maintenance flows and		Maintenance Low flows (m^3/s)	Drought flows (m^3/s)	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water
					Oct	0.088	0.000	
					Nov	0.099	0.003	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	drought flows Monitoring of discharge of the Polkadraaispruit during biological surveys	Dec 0.113 0.003 Jan 0.138 0.024 Feb 0.157 0.010 Mar 0.130 0.007 Apr 0.118 0.005 May 0.104 0.003 Jun 0.105 0.002 Jul 0.098 0.000 Aug 0.095 0.000 Sep 0.095 0.000	Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.020 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Ecological specification. Present ecological state must be maintained.
				Sulphate	≤ 10 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
				Chloride	≤ 10 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
				Sodium	≤ 10 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.8 (95th percentile)	Aquatic ecosystem driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	≥ 7 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
	Habitat	Instream	Habitat diversity must be improved from a B/C ecological category to a B category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be improved from a B/C ecological category to a B ecological category. Protection of riparian habitat is required.	Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	The fish community must be maintained in a B/C ecological category or better condition. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = B/C FRAI ≥ 78%	Attainment of Water Resource Class and associated ecological category.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within current state at the B/C ecological category.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = B/C ≥ 78% SASS ≥ 155 ASPT ≥ 6.0	Attainment of Water Resource Class and associated ecological category. Baseline data indicates present state of B/C category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
6_7 **Groot Marico from Polkadraaispruit confluence to N4 bridge** **A31B**	Quantity	Low flows	EWR maintenance low and drought flows: Groot Marico River at N4 road bridge in A31B NMAR = $56.92 \times 10^6 m^3$ REC=B category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Monitoring of discharge of Groot Marico River during biological surveys	(m^3/s) | Maintenance Low flows (m^3/s) | Drought flows Oct | 0.649 | 0.345 Nov | 0.704 | 0.372 Dec | 0.762 | 0.398 Jan | 0.890 | 0.458 Feb | 1.030 | 0.513 Mar | 0.908 | 0.466 Apr | 0.864 | 0.447 May | 0.783 | 0.408 Jun | 0.779 | 0.407 Jul | 0.730 | 0.383 Aug | 0.709 | 0.373 Sep | 0.701 | 0.370	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables)
	Quality	Nutrients	Instream concentration of nutrients as specified must be improved to sustain aquatic ecosystem health in the prescribed ecological category and to support downstream users. Wastewater discharges must be controlled to protect the ecological integrity of the system.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.025 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem driver. Present ecological state must be improved upon. Limit contribution of the nutrients to Marico Bosveld Dam.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.7 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be improved upon. Limit contribution of the nutrients to Marico Bosveld dam.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
		Salts	Instream salinity levels as must be improved to sustain aquatic ecosystem health in the prescribed ecological category and to support downstream users. Wastewater discharges and land use impacts must be controlled to protect the ecological integrity of the system.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem driver. Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
				Sulphate	≤ 50 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Ecological specification. Present ecological state must be improved
				Chloride	≤ 40 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Ecological specification. Present ecological state must be improved.
				Sodium	≤ 50 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Ecological specification. Present ecological state must be improved.
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be improved to support the aquatic ecosystem.	Dissolved oxygen	≥ 7 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be improved.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Aluminium (Al)	≤ 0.062 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996) Safeguard against (future development)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0057 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0048 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity should be improved improved from a D ecological category to a C ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be improved from a D ecological category to a C	Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of Water Resource Class and associated ecological

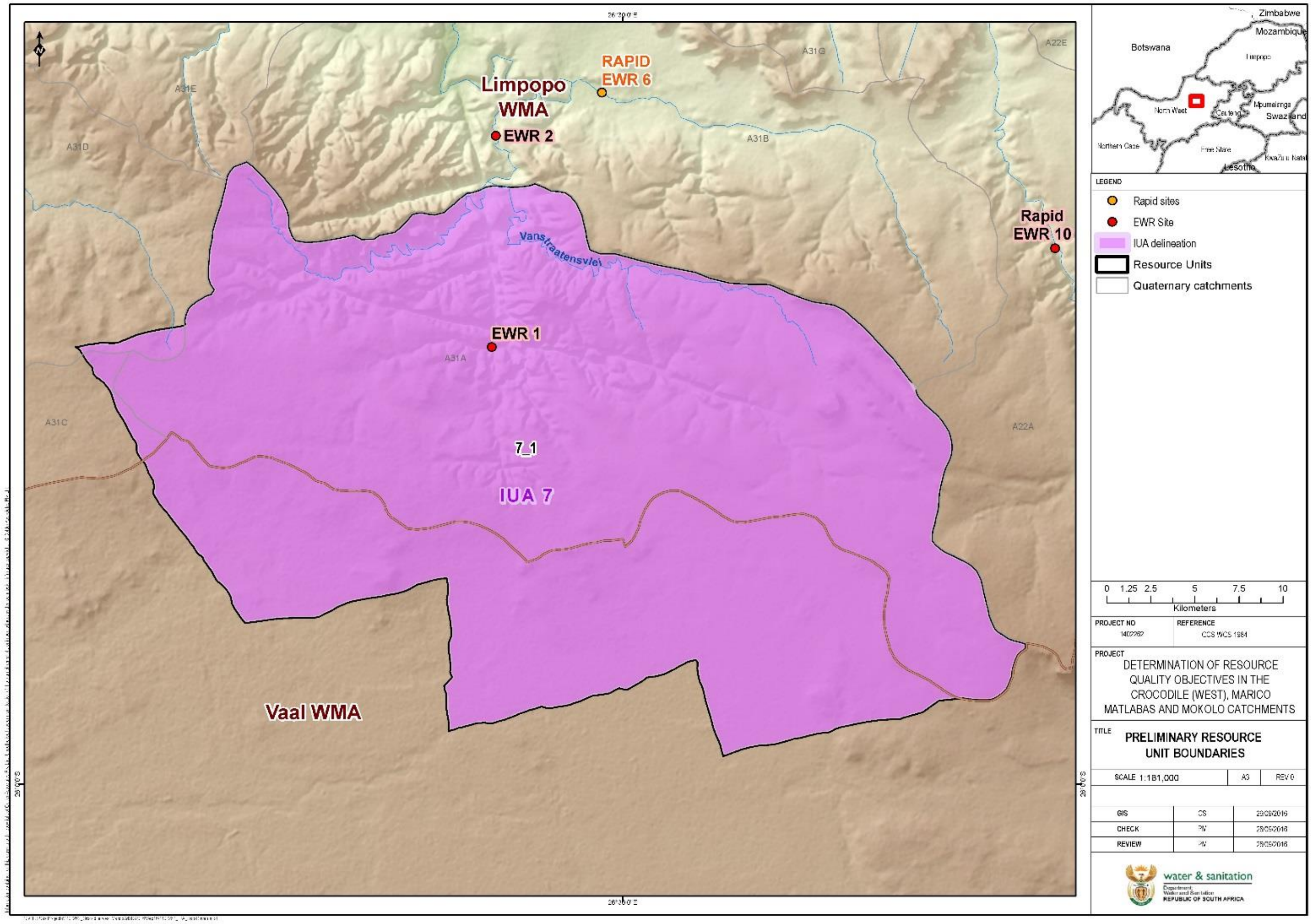
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			ecological category.			category.
	Biota	Fish	The fish community must be maintained in a C/D ecological category or better condition. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = C/D FRAI ≥ 58% Indicator species *certain BMOT, AURA, CPRE, AMOS*	Attainment of Water Resource Class and associated ecological category.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within current state at a B ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = B ≥ 82% SASS ≥ 210 ASPT ≥ 6.2 (Site A3GMAR-WONDE)	Attainment of Water Resource Class and associated ecological category. Baseline data indicates present state of B category.
		Diatoms	Diatom assemblage must be maintained within a natural to largely natural condition.	Specific Pollution Index	Diatom EC = A/B ≥ 88% (Site A3GMAR-WONDE)	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
6_8 Marico Bosveld Dam **A31B**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Orthophosphates	≤ 0.015 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Marico-Bosveld Dam is still a mesotrophic system and nutrient concentrations within the dam should be maintained at these levels.
			Concentration of total phosphorous must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Total phosphorous	≤ 0.025 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	
			Concentration of nitrate & nitrite must be maintained to sustain ecosystem health and the water	Nitrite& Nitrate	≤ 0.70 mg/ℓ N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			quality requirements of water users. The dam must be maintained as a mesotrophic system.			collection in prewashed plastic bottles	
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 35 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system must be not be allowed to deteriorate. Maintain present state salimity state.
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Microbial contamination of the dam water associated with human waste poses a threat to human health through direct consumption but via fish and vegetable consumption.
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	50% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every four years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl *a* concentrations must be maintained in a mesotrophic state.	Chl *a*	11-20µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection; filtering 500ml and preserved in ethanol in glass test tube.	The system is mesotrophic and this status must be maintained for ecological, agricultural and recreational purposes.

6.1.8 KAALOOG SE LOOP

RU	Delineation	Catchment
7_1	Marico Eye, Kaaloog-se-Loop, Bokkraal-se-Loop, Ribbokfontein-se-Loop, Rietspruit (southern eye), Kuilsfontein, Syferfontein and Bronkhorstfontein	A31A

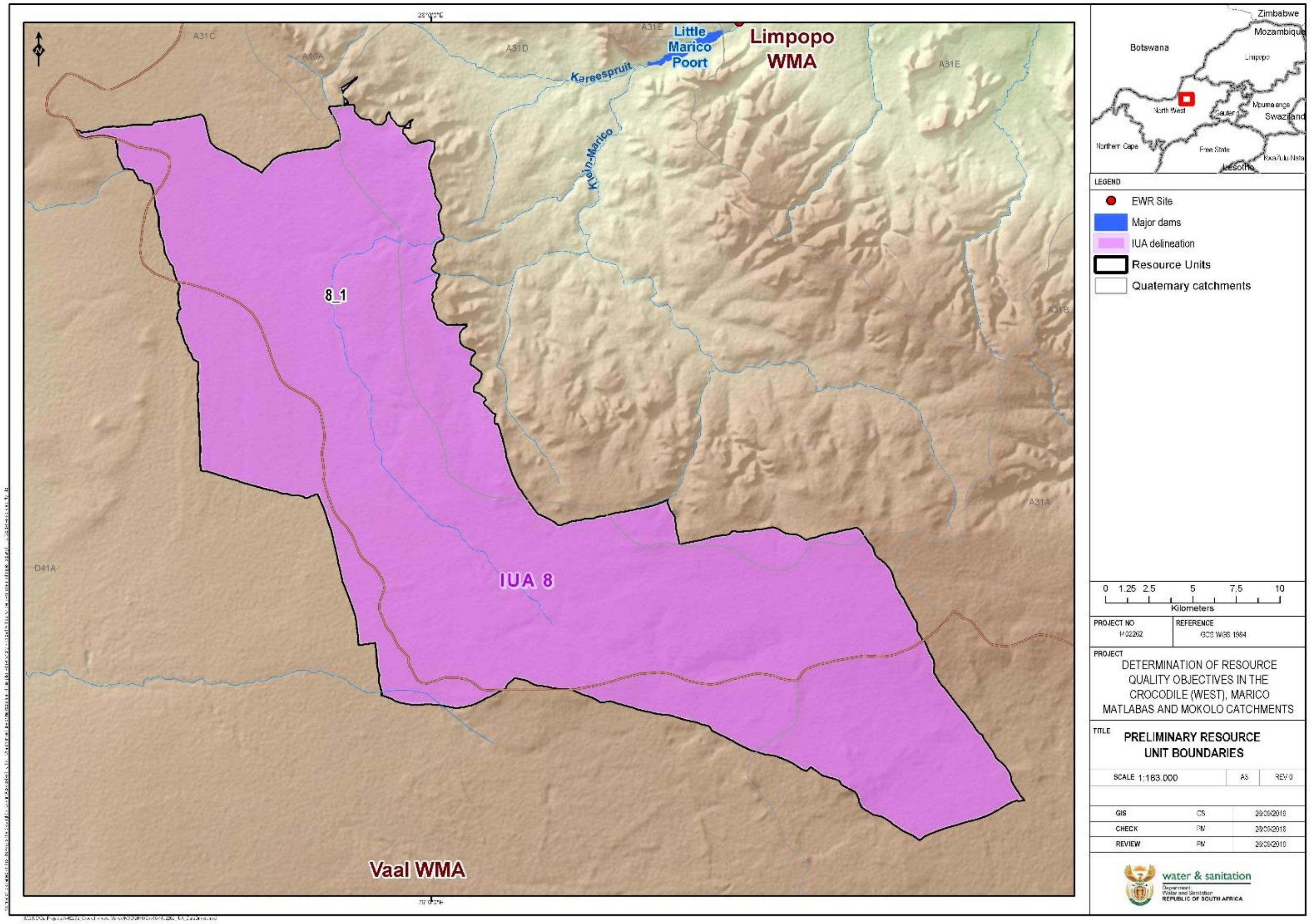


IUA 7 – Kaaloog-se-Loop
RESOURCE UNIT : 7_1– Marico Eye, Kaaloog-se-Loop, Bokkraal-se-Loop, Ribbokfontein-se-Loop, Rietspruit (southern eye), Kuilsfontein, Syferfontein and Bronkhorstfontein - Quaternary catchment A31A
DESCRIPTION
The IUA is a Class I. EWR site 1 is located on Kaaloog-se-Loop in the resource unit. The EIS is very high owing to the presence of the sensitive species and the very high taxon richness of inverts (≥ 45) due to good quality. Habitat protection is required due to the dolomitic eyes and associated fauna and flora, and high habitat diversity (Rietspruit, Grootfontein, Ribbokfontein se Loop and Draaifontein)). There is a threat from over abstraction. Groundwater resources and wetlands (pans and valley bottom) are priority. Tufa waterfall (unique feature) and the Vanstraatensvlei wetlands are present. This area has high habitat diversity, including various gorges and isolated species opulations. It is fairly pristine but alien vegetation is becoming problematic. Groundwater: Large abstractions for mining, agriculture and municipal supplies - current problems with high groundwater level recession rates in the Lichtenburg Area. There are some sedimentation impacts due to slate mining in the area.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
7_1 **Marico Eye,** **Kaaloog-se-Loop,** **Bokkraal se Loop** **Rietspruit** **Ribbokfontein-se-Loop** **Rietfontein** **Bronkhorstfontein** **Zyferfontein (Kuilfontein) Syferfontein** **A31A**	Quantity	Low flows	EWR maintenance low and drought flows: Kaaloog-se-Loop at MAR_EWR1 in A31A NMAR = 10.539x10^{6} m^{3} REC=B category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base flows Maintenance flows and drought flows. Monitoring of discharge at EWR site during biological surveys and downstream at the new planned weir.	Month / Maintenance Low flows (m^{3}/s) / Drought flows (m^{3}/s) Oct 0.244 0.159 Nov 0.252 0.164 Dec 0.245 0.160 Jan 0.250 0.162 Feb 0.280 0.182 Mar 0.254 0.165 Apr 0.262 0.170 May 0.253 0.164 Jun 0.261 0.170 Jul 0.252 0.164 Aug 0.252 0.163 Sep 0.257 0.167	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables). Flows at EWR site will give an indication if the outflow from the eye is reduced over time.
	Quality	Salts	Pristine water quality status must be maintained. No deterioration in water quality should be permitted. Instream salinity must be maintained to ensure the ecological integrity of the resource unit remains intact.	Electrical Conductivity	≤ 50 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained. Data required to confirm baseline quality.
	Habitat	Instream	Habitat diversity should be maintained within a B ecological category or better condition.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model	Instream Habitat Integrity EC = B ≥ 25%	Attainment of Water Resource Class and associated ecological category. Protect high ecological importance and sensitivity.
		Riparian habitat	Riparian vegetation should be maintained within a B ecological category or better condition.	Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Attainment of Water Resource Class and associated ecological category. Protect high ecological importance and sensitivity.
	Biota	Fish	The fish community must be maintained in a B ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI).	Fish ecology category = B FRAI ≥ 82%	Attainment of Water Resource Class and associated ecological category. Protect high ecological importance and sensitivity.
		Aquatic invertebrates	Macroinvertebrate assemblage must be maintained within the current state at a A/B ecological category.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = A/B ≥ 88% SASS ≥ 220 ASPT ≥ 6.4 (Site A3KAAL-RIETS)	Attainment of Water Resource Class and associated ecological category. Protect high ecological importance and sensitivity.
		Diatoms	Diatom assemblage must be maintained within a largely natural to natural condition.	Specific Pollution Index	Diatom EC ≥ 88%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

6.1.9 MALMANIESLOOP

RU	Delineation	Catchment
8_1	Malmanie se Loop, Dolomites	A31C

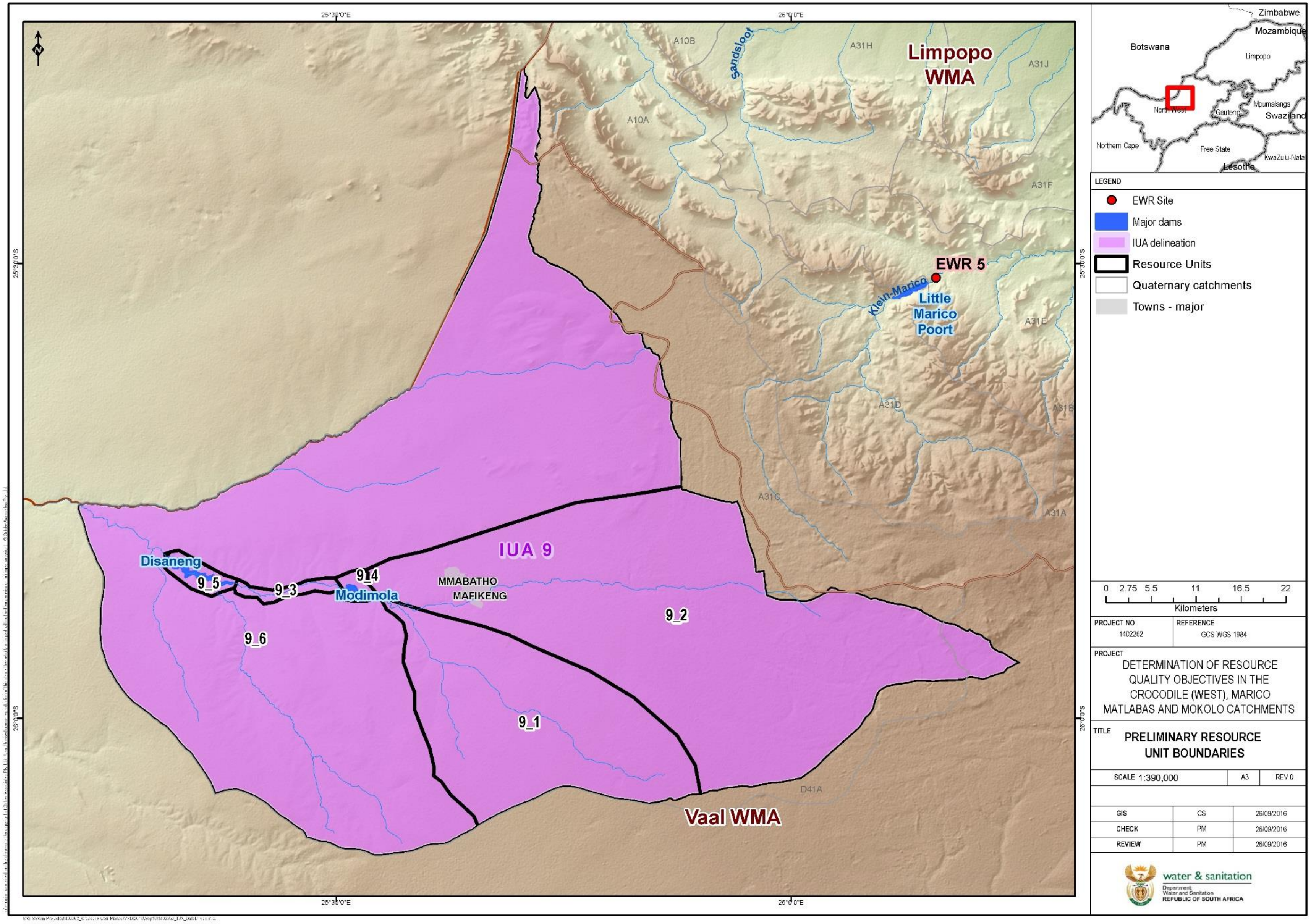


IUA 8– Malmaniesloop
RESOURCE UNIT : 8_1– Malmanie se Loop, Dolomites - Quaternary catchment A31C
DESCRIPTION
The IUA is a Class Groundwater II. Malmanie dolomitic eye is an unusually unique area both as a source zone and for wetlands (contains unique species with high taxon richness and is an important species refuge area). Catchment includes a number of game reserves and commercial agriculture. Flows are seasonal and systems are groundwater driven. Some abstractions occur at the lower reaches. An important wetland dominates this IUA (systems associated with the Malmanie River). There are peatlands as well. This area has FEPA rivers (seasonal) and protected areas. This IUA 8 is mainly groundwater related around Malamanie Eye. There is a huge impact on groundwater sustainability due to growing demand for municipal and irrigation needs; and localised quality impacts due to mining activities.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
8_1 **Malmanies se Loop** **A31C**	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and to maintain the water quality present ecological state.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.025 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem driver. Ecological Reserve manual (2008). Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity must be maintained to support the aquatic ecosystem and maintain the water quality present ecological state.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem driver. Ecological Reserve manual (2008). Present ecological state must be maintained or improved upon.
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem nd use requirements of water users.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
	Habitat	Wetland Vegetation	Refer to wetland RQOs, habitat is part of the wetland system.			
	Biota	Fish	The fish community must be maintained in a C ecological category or better condition. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category. Control and remove alien invasive fish species MSAL. Prevent spreading of the alien species.	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62% Sample 10 *BMOT* in 20min sample effort	Attainment of ecological category. Ensure the maintenance of current state.

6.1.10 MOLOPO

RU	Delineation	Catchment
9_1	Bodibe Eye	D41A (Polfonteinspruit and Lotlhakane tributary catchment area)
9_2	Molopo Eye, Grootfontein Eye, Molopo headwaters to inflow Modimola Dam	D41A
9_3	Molopo River main stem only from Modimola Dam to Disaneng Dam	D41A (main stem)
9_4	Setumo (Modimola) Dam	D41A
9_5	Disaneng Dam	D41A
9_6	Not prioritised	


Limpopo WMA
Vaal WMA
IUA 9
EWR 5
Klein-Marico
Little Marico Poort
Sandsloot
Disaneng
Modimola
MMABATHO
MAFIKENG
9_1
9_2
9_3
9_4
9_5
9_6
A10A
A10B
A31H
A31J
A31F
A31E
A31D
A31B
A31C
A31A
D41A
Zimbabwe
Mozambique
Botswana
Limpopo
Mpumalanga
Swaziland
North West
Gauteng
Northern Cape
Free State
KwaZulu-Natal
Lesotho
LEGEND
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
Towns - major
0 2.75 5.5 11 16.5 22
Kilometers
PROJECT NO 1402262
REFERENCE GCS WGS 1984
PROJECT DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE PRELIMINARY RESOURCE UNIT BOUNDARIES
SCALE 1:390,000 A3 REV 0
GIS CS 26/09/2016
CHECK PM 26/09/2016
REVIEW PM 26/09/2016
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

IUA 9 – Molopo
RESOURCE UNIT : 9_1– Bodibe Eye - Quaternary catchment D41A (Polfonteinspruit and Lotlhakane tributary catchment area)
DESCRIPTION
The IUA is a Class Groundwater II. Eye supports domestic water use and agricultural use. Catchment includes the town of Bodibe. Groundwater resources and wetlands are priority (pans and valleybottom wetlands). The Bodibe Eye is a peatland and important for water supply and biodiversity support. High groundwater abstraction in the area resulting in a decrease in groundwater which has further resulted in spontaneous combustion underground and the peatland oxidised and been burning for several years now, resulting in a loss of the peatland, and poses a health and safety hazard for people and livestock. The area is high in dolomite and impacts include urban and settlement activities and sand mining for cement. Serious depletion of groundwater levels in this area (~25m) due to over-utilisation. Large eyes (springs) already impacted and dry. No sensitive fish or inverts.
RESOURCE UNIT : 9_2 – Molopo Eye, Grootfontein Eye, Molopo headwaters to inflow Modimola dam: Quaternary catchment A41A
DESCRIPTION
The IUA is a Class Groundwater II. The town of Mahikeng and adjacent urban areas are located at the lower end ogf the resource unit. This IUA 9 is mainly groundwater related around Molopo Eye. The area has FEPA rivers and is a fish support area. The eye is important and is inhabited by *PPHI.* According to a study Malawian Cichlids have been introduced. Impacts include a cement factory and urban development in around Mahiken as well as from poorly treated sewage effluent from the wastewater treatment works. Groundwater resources and wetlands are priority (unchannelled valleybottom wetlands and peatlands). The Molopo eye is a peatland and important for water supply and biodiversity support. Grootfontein aquifer not productive anymore, and all Mahikeng's water is sourced from Molopo's Eye, thus it is vital that the flow is maintained. Recreational activity in the area is also impacting on the eye.
RESOURCE UNIT : 9_3 –- Molopo River main stem only from Modimola Dam to Disaneng Dam: Quaternary catchment A41A Main stem
DESCRIPTION
The IUA is a Class Groundwater II. Highly impact from urban settlement in Mahikeng which has resulted in a PES E category. Serious problem with water pollution in Mahikeng and catchment of the Modimole Dam (impact of the Mahikeng WWTW). Important wetland systems are present in this reach.
RESOURCE UNIT : 9_4 – Setumo (Modimola) Dam: Quaternary catchment A41A
DESCRIPTION
The IUA is a Class Groundwater II. Dam supports domestic water supply and some recreational activity (fishing, etc.). The WWTW of Mahikeng is located just upstream of the dam which is impacting on the dam water quality. Poor water quality. Habitat supporting birds.
RESOURCE UNIT : 9_5 – Dinaseng Dam- Quaternary catchment A41A
DESCRIPTION

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit
9_1 **Bodibe eye** **D41A (Polfonteinspruit and Lotlhakane tributary catchment area)**	Refer to Groundwater RQOs				

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
9_2 **Molopo Eye, Grootfontein Eye, Molopo headwaters to inflow Setumo/Modimola Dam** **D41A**	Quantity	Flows	Groundwater related (Molopo and Grootfontein Eye)			
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.025 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem driver. Ecological Reserve manual (2008). Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.7 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and to support downstream users. Improvement in salinity concentrations is required.	Electrical Conductivity	≤ 75 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem driver. Present ecological state must be improved upon.
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem nd use requirements of water users.	pH range	6.5 (5th percentile) and 8.8 (95th percentile)	Aquatic ecosystem driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
	Habitat	Instream	Refer to wetland RQOs, habitat is part of the wetland system.			
		Wetland Vegetation				
	Biota	Fish	Fish community should be improved from an E ecological category to a D category.	Fish Response Assessment Index (FRAI).	Fish ecology category = D FRAI ≥ 42% Sample 3 species, including *BBRI* in 20min survey. Sample 15 *PPHI* in 20min	Attainment of associated ecological category. Improvement of system required.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category (largely modified condition) or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = D ≥ 42% SASS ≥ 80 ASPT ≥ 4.0	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
9_3 **Molopo River main stem from Modimola Dam to Disaneng Dam** **D41A (main stem)**	Habitat	Instream	Habitat diversity must be improved from an E ecological category to a D category. Improve runoff water into the system to improve to D ecological category. Control siltation and organic material.	Index of Habitat Integrity	Instream Habitat Integrity EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation must be improved from an E ecological category to a D category. Alien invasive species must be controlled. Riparian zone must be rehabilitated.	Vegetation Response Assessment Index	VEGRAI EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
9_4 **Modimola (Setumo) Dam** **D41A**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system. Improvement required from hypertrophic state.	Orthophosphates	≤ 0.050 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Modimola (Setumo) Dam is a eutrophic system that is on the border of going hypertrophic. Managing the system as a eutrophic system is necessary as the water is used for recreation and potable user.
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Total phosphorous	≤ 0.055 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Modimola (Setumo) Dam is a eutrophic system that is on the border of going hypertrophic. Managing the system as a eutrophic system is necessary as the water is used for recreation and potable user.
			Concentration nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Nitrite& Nitrate	≤ 0.70 mg/ℓ N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Modimola (Setumo) Dam is a eutrophic system that is on the border of going hypertrophic. Managing the system as a eutrophic system is necessary as the water is used for recreation and potable user.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 85 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system must be improved. Salinity concentrations are high.
			The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Chloride	≤ 100 mg/ℓ 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The chloride is one of the main contributing variables within the salts and concentrations must be reduced.
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Limit for full contact recreational use (South African Water Quality guidelines – 1996)
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity with reading ≥0.4 m	Turbidity	Minimum 95th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
			Moderate change	Temperature	No more than 2 °C increasing change in both minimum and maximum	Bi-weekly depth profile monitoring with a DO meter.	Increased temperatures will favour the growth of potentially toxic cyanobacteria.
			The oxygen levels in the system must maintain the ecological system.	Dissolved Oxygen	≥ 7.0 mg/L O_2 95th percentile	Bi-weekly depth profile monitoring with a DO meter.	Low oxygen levels associated with organic matter emanating from upstream industries and Wastewater Treatment Works are negatively impacting on the ecosystem.
		Toxics	The dam must be managed within a eutrophic state to minimize the development of toxic cyanobacterial blooms	Cyanobacteria	Cyanobacterial dominance with Chl a concentration higher than 30µg/ℓ must be kept at less than 20% of the time.	Bi-weekly integrated (0-5m hosepipe) water collection in prewashed plastic glass bottle with Lugol's Solution Preservative.	Modimola (Setumo) Dam has experienced toxic cyanobacterial blooms. The Cyanobacteria produce harmful toxins for wildlife and humans, which are problematic in water treatment toxin removal..
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary	Riparian vegetation Health	50% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).

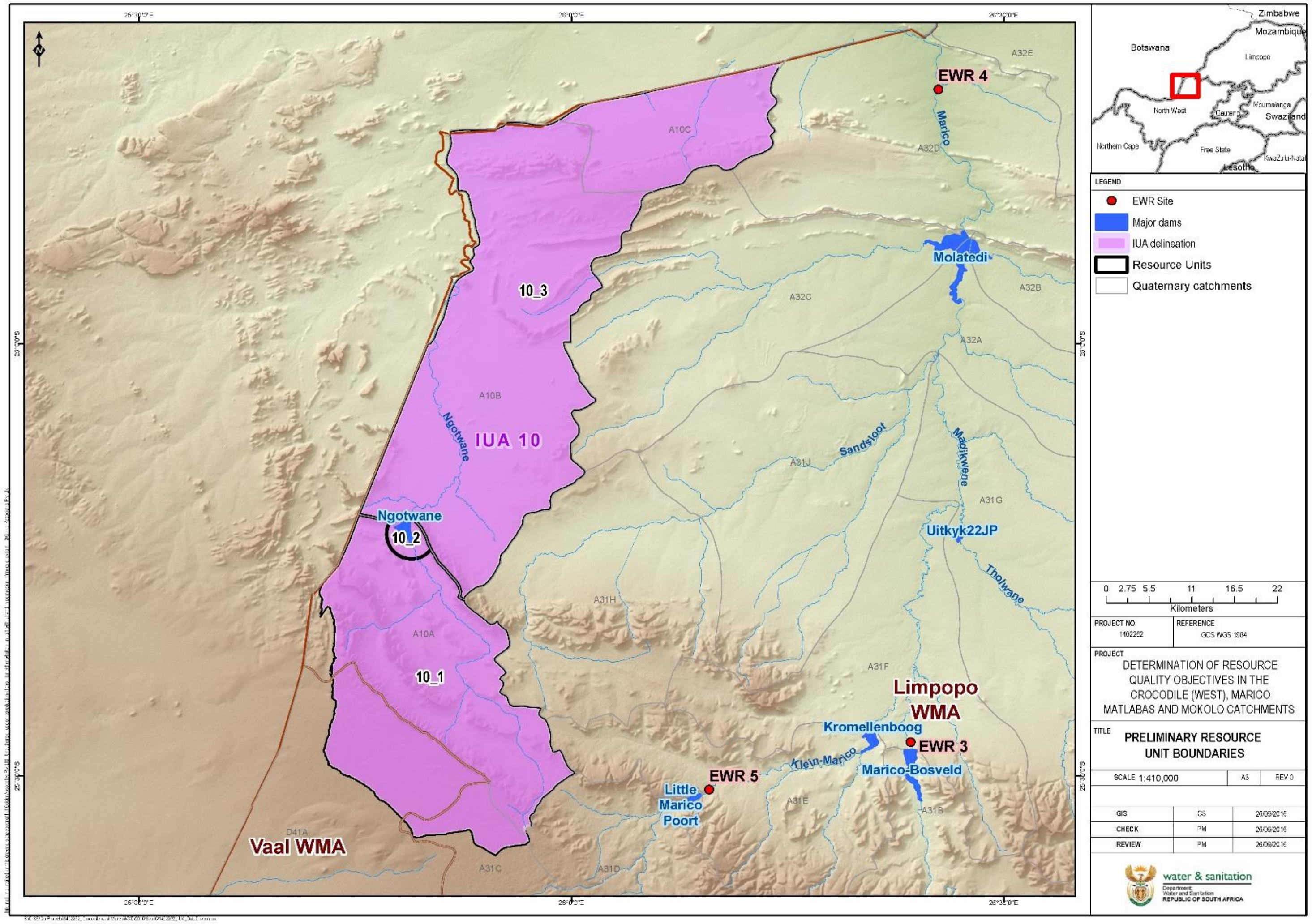
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			habitat.				
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every four years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl *a* concentration must be maintained in a eutrophic state.	Chl *a*	20-30µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection; filtering 500ml and preserved in ethanol in glass test tube.	The system has moved into eutrophic conditions since 2011 and this status be managed to improve or prevented not to move into a hypertrophic state. It must be maintained for ecological, agricultural, domestic use and recreational purposes.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
9_5 Disaneng Dam D41A	Quantity	Dam levels	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Orthophosphates	≤ 0.010 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Disaneng Dam is still a mesotrophic system and nutrient concentrations within the dam should be maintained at these levels.
			Concentration of total phosphorous must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Total phosphorous	≤ 0.025 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Disaneng Dam is a mesotrophic system and nutrient concentrations within the dam should be maintained at these levels.
			Concentration of nitrate & nitrite must be improved to sustain ecosystem health and the water quality requirements of water	Nitrite& Nitrate	≤ 0.70 mg/ℓ N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed	Disaneng Dam is a mesotrophic system and nutrient concentrations within the dam should be maintained at these levels.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			users. The dam must be maintained as a eutrophic system.			plastic bottles	
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 75 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system must be maintained or improved upon.
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	Limit for full contact recreational use (South African Water Quality guidelines – 1996)
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	70% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every four years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/Phytoplankton	The Chl *a* concentration must be maintained in a mesotrophic state.	Chl *a*	11-20µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection; filtering 500ml and preserved in ethanol in glass test tube.	The system is mesotrophic but high concentrations were found during 2016. It is thus essential that the system should be managed within the mesotrophic state for ecological, agricultural and recreational purposes, as well as the international agreements with Botswana.

6.1.11 DINOKANA EYE/NGOTWANE DAM

RU	Delineation	Catchment
10_1	Upper Ngotwane, Dinokane Eye	A10A
10_2	Ngotwane Dam - Not prioritised	A10A
10_3	Not prioritised	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IUA 10
10_3
10_2
10_1
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Ngotwane
Molatedi
Sandsloot
Madikwene
Uitkyk22JP
Tholwane
Limpopo
WMA
Kromellenboog
EWR 3
Marico-Bosveld
Klein-Marico
EWR 5
Little
Marico
Poort
Vaal WMA
A10C
A10B
A10A
A32E
A32D
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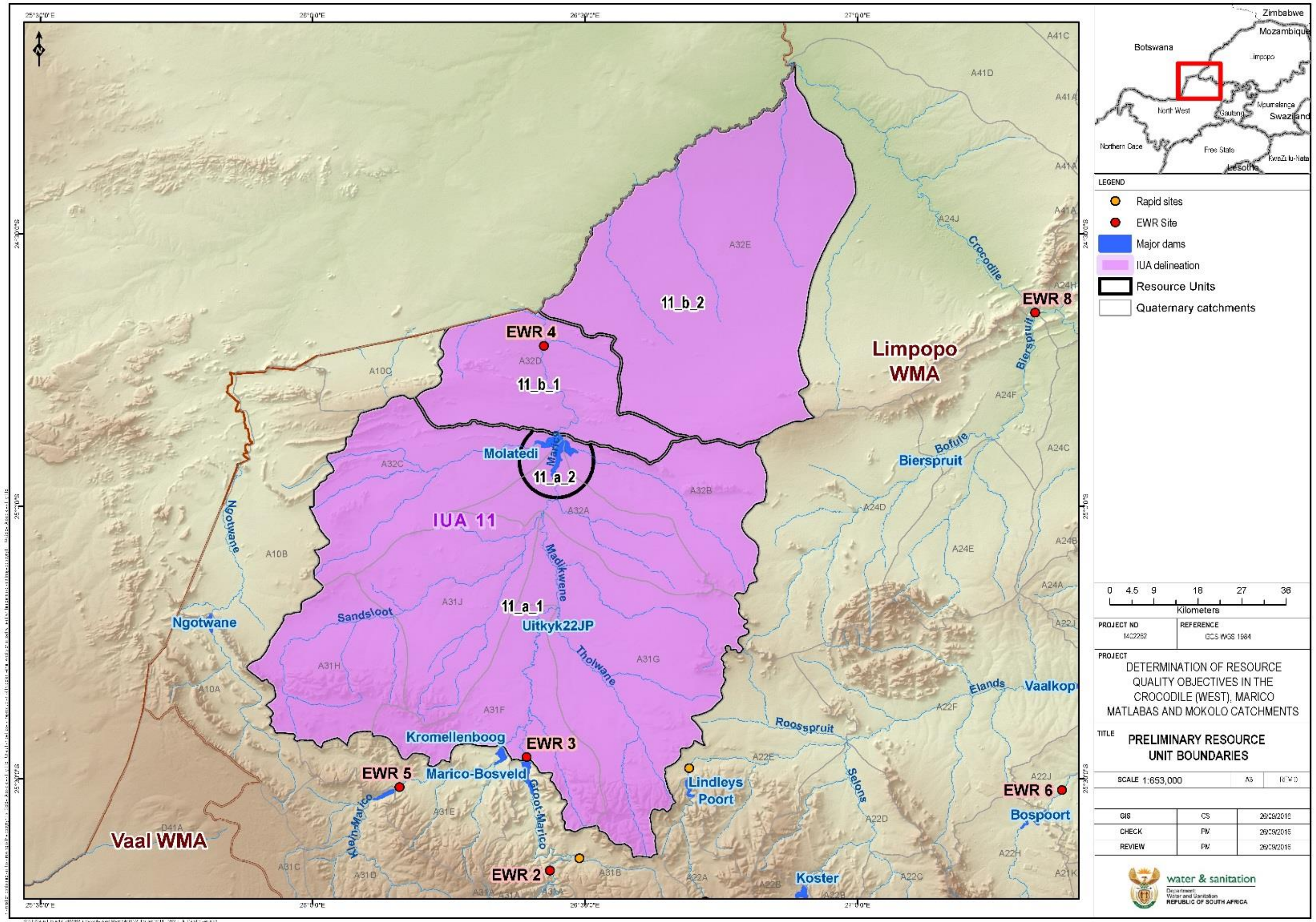
A31B
A31C
A31D
D41A
Zimbabwe
Mozambique
Botswana
Limpopo
North West
Gauteng
Mpumalanga
Swaziland
Northern Cape
Free State
KwaZulu-Natal
Lesotho
LEGEND
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
0 2.75 5.5 11 16.5 22
Kilometers
PROJECT NO
1602262
REFERENCE
GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
PRELIMINARY RESOURCE UNIT BOUNDARIES
SCALE 1:410,000
A3
REV 0
GIS CS 26/09/2016
CHECK PM 26/09/2016
REVIEW PM 26/09/2016
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

IUA 10 – Dinokana Eye/Ngotwane Dam
RESOURCE UNIT : 10_1– Upper Ngotwane, Donokana Eye - Quaternary catchment A10A
DESCRIPTION
The IUA is a Class II. This IUA is mainly groundwater related to the Dinokana Eye. The Dinokana Springs is a dolomitic eye. The water quality is good and there is high habitat diversity (high priority conservation area). Two important wetland systems occur namely the Dinokana eye and Ngotwane wetland (high biodiversity wetland in semi-arid climate with its source in Botswana) which both supply water for livelihood support for people, livestock and wildlife. *AJON* occurs within the upper Ngotwane. Groundwater priority area. Groundwater related subsistence use. Water balance in this area is a concern as this is a sole-aquifer system for Dinokana. Water level of eye has dropped due to over abstraction. The town of Dinokana is located in the resource unit as well as the Lehurutshe WWTW.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
10_1 **Upper Ngotwane, Dinokana Eye** **A10A**	Habitat	Instream	Ensure recommended "low flows" maintained to sustain the ecosystem in a B/C ecological category. Flow should be adequate to ensure habitats for flow dependent species and taxa.	Index of Habitat Integrity	Instream Habitat Integrity EC = B/C ≥ 82%	Attainment of associated ecological category. Baseline data of present state.
	Biota	Fish	Fish community should be improved from a D ecological category to a C/D category.	Fish Response Assessment Index (FRAI)	Fish ecology category = C/D FRAI ≥ 58% Sample at least 8 species in 20min sample effort. Sample 10 *AJOH*, 10 *CFLA* and 15 *BMOT* in 20min sample effort	
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within B/C ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC= B/C ≥ 78% SASS ≥ 180 ASPT ≥ 6.2 (Site A1NGOT-DINOK)	Attainment of associated ecological category. Baseline data of present state. Protection of system.
		Diatoms	Diatom assemblage must be maintained within a natural to largely natural condition.	Specific Pollution Index	Diatom EC ≥ 88%	Attainment of associated ecological category. Baseline data of present state.

6.1.12 GROOT MARICO/MOLATEDI DAM

RU	Delineation	Catchment
11a_1	Groot Marico from outflow Marico Bosveld Dam to Molatedi Dam, all tributaries	A31G, A31H, A31F, A31J, A32A, A32B, A32C
11a_2	Molatedi dam	A32A, A32B, A32C



IUA 11a – Groot Marico/ Molatedi Dam
RESOURCE UNIT : 11a_1– Groot Marico from outflow Marico Bosveld Dam to Molatedi Dam, all tributaries: Quaternary catchment A31G, A31H, A31F, A31J, A32A, A32B, A32C
DESCRIPTION
The IUA is a Class III. EWR site 3 on the Groot Marico River just downstream of Marico Bosveld Dam is present in the resource unit. PES is a C/D category. Towns in the catchment alng the Marico River include Madikwe, Pella, Vrede, Moses Kotane, Uitkyk and Tshwaro. The Groot Marico has a high EIS owing to the reach which forms a natural refugium with a number of perennial pools. The land area is degraded due to over grazing and development. The Madikwe WWTW discharges into the Tholwane River. Smaller dams are present on the tributaries supplying water to local communities (Pella Dam, Madikwe, Sehujane Dam). Water quality must be protected.
RESOURCE UNIT : 11a_2 – Molatedi Dam: Quaternary catchment A32A, A32B, A32C
DESCRIPTION
The IUA is a Class III. Releases are made in respect of meeting the international obligations with Botswana and for downstream irrigation use (Derdepoort). Dam habitat must be maintained for fish refugia and mammals. Some recreational activities (e.g. angling – due to good populations of fish).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
11a_1 **Groot Marico from outflow Marico Bosveld Dam to Molatedi Dam, All tributaries** **A31G, A31H, A31F, A31J, A32A, A32B, A32C**	Quantity	Low flows	EWR maintenance low and drought flows: Groot Marico River at MAR_EWR3 in A31F NMAR = 65.0839x$10^6 m^3$ REC=C/D category The maintenance low flows and drought flows must be attained to support the ecological requirement and downstream users.	Base Flows Maintenance flows and drought flows. Monitoring of Groot Marico River at A3H029	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.248 0.196 Nov 0.262 0.206 Dec 0.266 0.209 Jan 0.284 0.223 Feb 0.318 0.250 Mar 0.281 0.221 Apr 0.278 0.219 May 0.262 0.207 Jun 0.268 0.211 Jul 0.258 0.203 Aug 0.256 0.202 Sep 0.260 0.205	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set and ecological Reserve. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.090 milligrams/litre (mg/l) (50^{th} percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.7 milligrams/litre (50^{th} percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95^{th} percentile)	Ecological specification. Present ecological state must be maintained.
				Sulphate	≤ 50 milligrams/litre (95^{th} percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
				Chloride	≤ 40 milligrams/litre (95^{th} percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
				Sodium	≤ 50 milligrams/litre (95^{th} percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements. A baseline assessment to determine the present state instream turbidity is required.	pH range	6.5 (5^{th} percentile) and 8.8 (95^{th} percentile)	Aquatic ecosystem driver.
				Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
	Habitat	Instream	Habitat diversity should be maintained in a C/D ecological category. Runoff resulting in organic pollution and bacterial pollution of the resource must be managed.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C/D ≥ 58%	Attainment of the Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be maintained in a C/D ecological category. Alien invasive	Vegetation Response Assessment Index	VEGRAI EC = C/D ≥ 58%	Attainment of the Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			vegetation must be controlled and development into the riparian zone must be limited.			
	Biota	Fish	The fish community must be maintained in a D ecological category or improved upon. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = D FRAI ≥ 42% Collect 10+ species in 20min sampling effort	Attainment of the Water Resource Class and associated ecological category.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = C ≥ 62% SASS ≥ 120 ASPT ≥ 5.5	Based on available monitoring data. Attainment of associated ecological category.
		Diatoms	Diatom assemblage must be maintained within a natural to largely natural condition.	Specific Pollution Index	Diatom EC = A/B ≥ 88%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.
		Semi-Aquatic Biota	The suitability of this stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management. Riparian zone habitat must be improved.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.

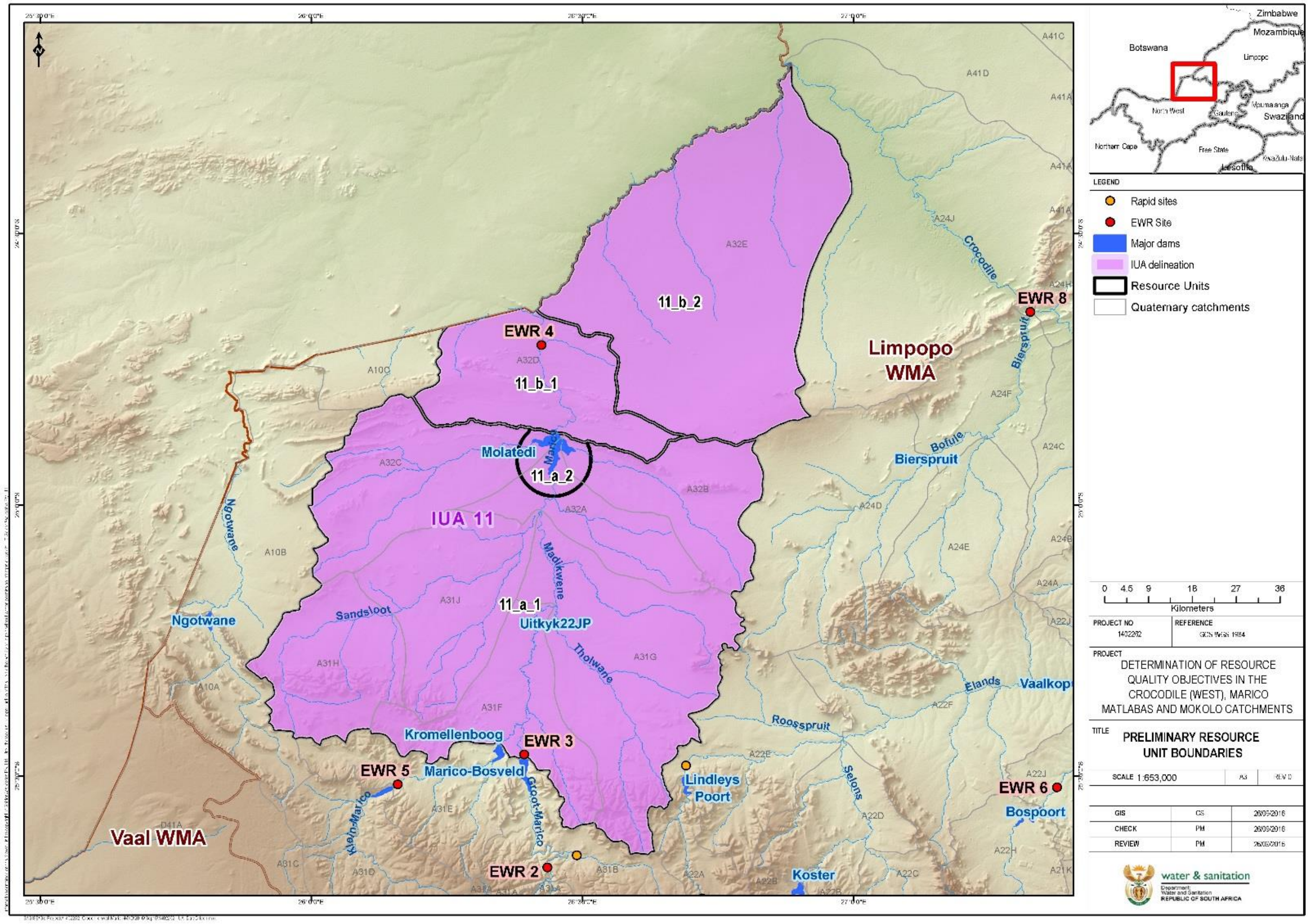
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
11a_2 **Molatedi Dam** **A32A, A32B, A32C**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be maintained to sustain ecosystem health and the water	Orthophosphates	≤ 0.015 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in	Molatedi Dam is still a mesotrophic system and nutrient concentrations within the dam

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			quality requirements of water users. The dam must be maintained as a mesotrophic system.			prewashed plastic bottles.	should be maintained at these levels.
			Concentration of total phosphorous must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Total phosphorous	≤ 0.055 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Molatedi Dam is a mesotrophic system and nutrient concentrations within the dam should be maintained at these levels.
			Concentration of nitrate & nitrite must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a mesotrophic system.	Nitrite& Nitrate	≤ 0.70 mg/ℓ N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Molatedi Dam is a mesotrophic system and nutrient concentrations within the dam should be maintained at these levels.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 55 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system must be maintained.
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			The oxygen levels in the system must maintain the ecological system.	Dissolved Oxygen	≥ 7.0 mg/ℓ O2 95th percentile	Monthly depth profile monitoring with a DO meter.	Dissolved oxygen sustains the complete ecological system and need to be within acceptable levels to ensure sustainability and as indicator of water quality health.
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	50% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every four years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl *a* concentration must be maintained in a mesotrophic state.	Chl a	11-20µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection.	No information is available yet.

6.1.13 GROOT MARICO SEASONAL TRIBUTARIES

RU	Delineation	Catchment
11b_1	Groot Marico main stem, outflow Molatedi Dam, Rasweu, Maselaje rivers	A32D
11b_2	Elandslaagtespruit, Lengope la Kgamanyane, Lenkwane	A32E



IUA 11b – Groot Marico/ Seasonal tributaries
RESOURCE UNIT : 11b_1– Groot Marico main stem, outflow Molatedi Dam, Rasweu, Maselaje rivers - Quaternary catchment A32D
DESCRIPTION
The IUA is a Class III. EWR site 4 on the Groot Marico River just downstream Tswasa Weir is present in the resource unit. PES is a C category. The Groot Marico (and tributaries and wetlands in the Madikwe Game Reserve) have diverse habitats and good riparian vegetation. Hippopotami play an important role in regulating the vegetation. The area is however under threat by human activities. Impacts are primarily as a result of the Molatedi Dam upstream and the release pattern from the Tswasa Weir for irrigation purposes. Tributaries are mostly dry, recently there has been no releases made for Botswana. Flow dependent fish species occur (*BMAR, LMOL* and *SZAM*). Riparian zone is heavily grazed. High sedimentation following rainfall events due to heavy erosion and overgrazing. Riparian zone and flood plain wetlands present. Molatedi town is located in theresource unit.
RESOURCE UNIT : 11b_2 – Elandslaagtespruit, Lengope la Kgamanyane, Lenkwane: Quaternary catchment A32E
DESCRIPTION
The IUA is a Class III. These are ephemeral tributaries. Game farms are present. Conservation areas and very sparsely populated. Wetlands are a priority in this resource unit.

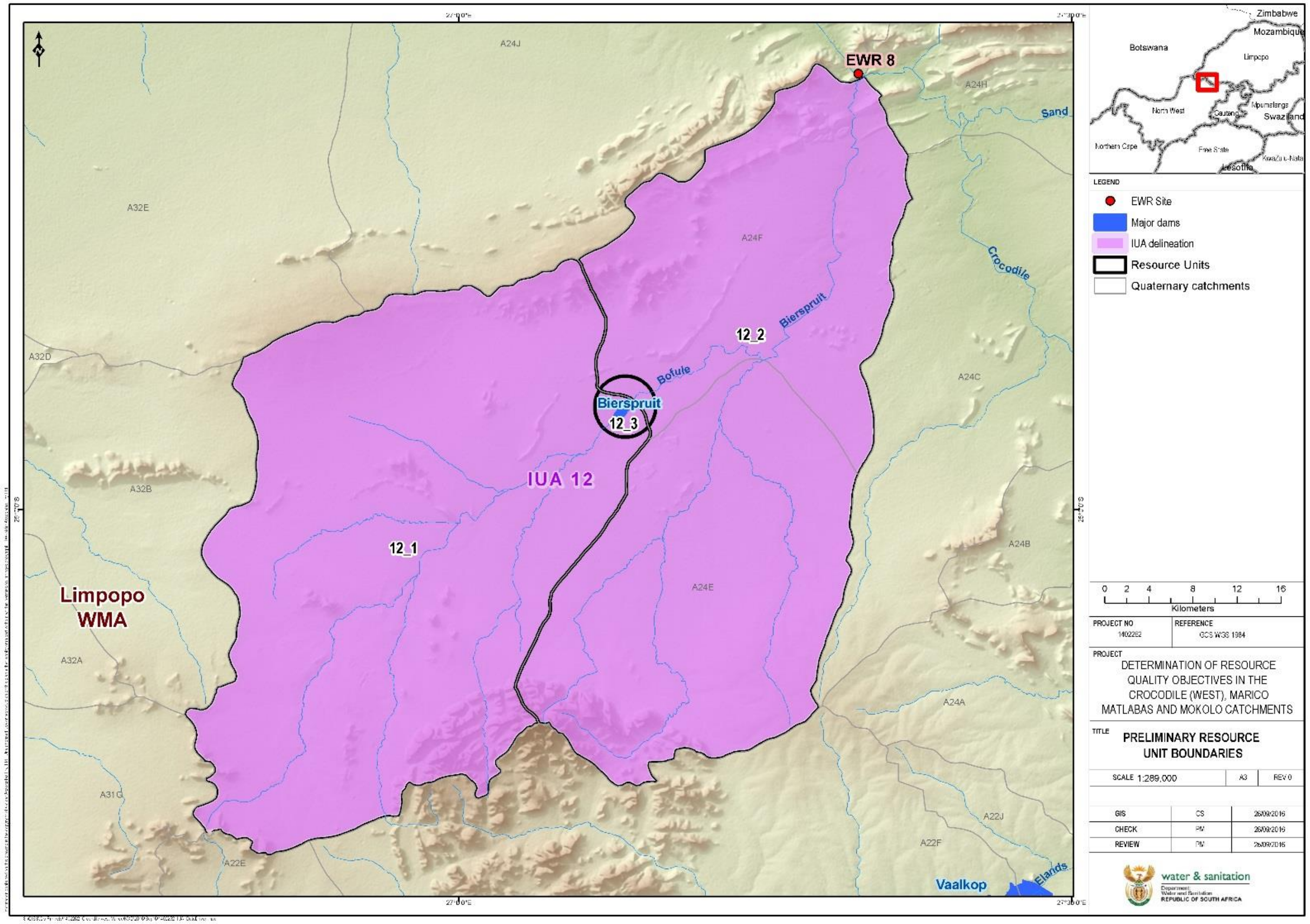
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
11b_1 **Groot Marico, Rasweu, Maselaje** **A32D**	Quantity	Low flows	EWR maintenance low and drought flows: Groot Marico River at MAR_EWR4 in A32D NMAR = 153.25x10^{6}m^3 REC=C category The maintenance low flows and drought flows must be attained so that the environmental flows requirements are met to support a healthy condition for the ecosystem and users.	Base Flows Maintenance flows and drought flows Monitoring of Groor Marico River at A3H007	Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.214 / 0.173 Nov 0.230 / 0.185 Dec 0.239 / 0.191 Jan 0.264 / 0.209 Feb 0.306 / 0.242 Mar 0.267 / 0.211 Apr 0.258 / 0.206 May 0.234 / 0.187 Jun 0.236 / 0.189 Jul 0.227 / 0.182 Aug 0.224 / 0.180 Sep 0.226 / 0.182	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set and ecological Reserve. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.090 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.7 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem driver. Present ecological state.
	Habitat	Instream	Habitat diversity should be maintained within a C ecological category. A natural flow pattern must be maintained. Improve instream habitat and velocity/depth for aquatic biota diversity. Connectivity to downstream to (11b_2) must be achieved,	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of the Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be maintained within a C ecological category. Impacts including grazing/trampling of riparian zone must be controlled. Management of siltation required.	Index of Habitat Integrity	VEGRAI EC = C ≥ 62%	Attainment of the Water Resource Class and associated ecological category.
	Biota	Fish	The fish community must be maintained in a C/D ecological category or better. An assessment	Fish Response Assessment Index (FRAI)	Fish ecology category = C/D	Attainment of the Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			of the fish community should be conducted annually to monitor against the prescribed ecological category. Fishways must be built for migratory species as currently there is no connectivity over numerous weirs.		FRAI ≥ 58% Sample 8+ species per sample survey Indicator species: *BMAR, LMOL, SZAM*	
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5)	MIRAI EC = C ≥ 62% SASS ≥ 120 ASPT ≥ 4.8	Attainment of associated ecological category. Baseline data of present state.
		Diatoms	Diatom assemblage must be maintained within a moderately modified condition or improved upon.	Specific Pollution Index	Diatom EC ≥ 62%	Attainment of associated ecological category. Baseline data of present state.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit
11b_2 **Elandslaagtespruit, Lengope la Kgamanyane, Lenkwane** **A32E**	Wetland RQOs applicable				

6.1.14 BIERSPRUIT

RU	Delineation	Catchment
12_1	Wilgespruit, Bofule, Kolobeng, Magoditshane, Motlhabe	A24D
12_2	Bierspruit outflow Bierspruit Dam to confluence with the Crocodile River, Brakspruit, Phufane, Sefatlhane, Lesobeng, lower reach Bofule	A24E, A24F
12_3	Not prioritised	


EWR 8
Sand
Crocodile
Biersspruit
Bofule
12_2
Bierspruit
12_3
IUA 12
12_1
Limpopo
WMA
Vaalkop
Elands
A24J
A24H
A32E
A24F
A32D
A24C
A32B
A24B
A24E
A32A
A24A
A31G
A22J
A22F
A22E
Zimbabwe
Mozambique
Botswana
Limpopo
North West
Gauteng
Mpumalanga
Swaziland
Northern Cape
Free State
Lesotho
KwaZulu-Natal
LEGEND
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
0 2 4 8 12 16
Kilometers
PROJECT NO
REFERENCE
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
PRELIMINARY RESOURCE UNIT BOUNDARIES
SCALE 1:289,000
A3
REV 0
GIS
CHECK
REVIEW
water & sanitation
REPUBLIC OF SOUTH AFRICA

IUA 12 – Bierspruit
RESOURCE UNIT : 12_1– Wilgespruit, Bofule, Kolobeng, Magoditshane, Motlhabe - Quaternary catchment A24D
DESCRIPTION
The IUA is a Class III. Area is very important from an ecotourism point of view (includes the Pilanesberg National Park). The water quality is degraded due to mining activities, town development and irrigation in the catchment. River FEPA are located in the upper reaches near Kolobeng. Severe water quality impacts on the some of the tributaries, viz. Mothlabe and Wilgespruit. Water quality must be addressed.
RESOURCE UNIT : 12_2 – Bierspruit outflow Bierspruit Dam to confluence with the Crocodile River, Brakspruit, Phufane, Sefatlhane, Lesobeng, lower reach Bofule: Quaternary catchment A24E, A24F
DESCRIPTION
The IUA is a Class III. The water quality is degraded due to platinum mining, town development (Northam WWTW), irrigation and cultivation. Groundwater use is important in the area.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
12_1 **Wilgespruit, Bofule, Kolobeng, Magoditshane, Motlhabe** **A24D**	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.090 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem driver. Ecological Reserve manual (2008).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.7 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
				Sulphate	≤ 80 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained. South African Water quality guidelines.
				Chloride	≤ 40 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained. South African Water quality guidelines.
				Sodium	≤ 70 milligrams/litre (95th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained. South African Water quality guidelines.
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.0 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem and users as the drivers.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Aluminium (Al)	≤ 0.105 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0095 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0073 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
		Pathogens	The presence of pathogens should pose a low risk to human	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full

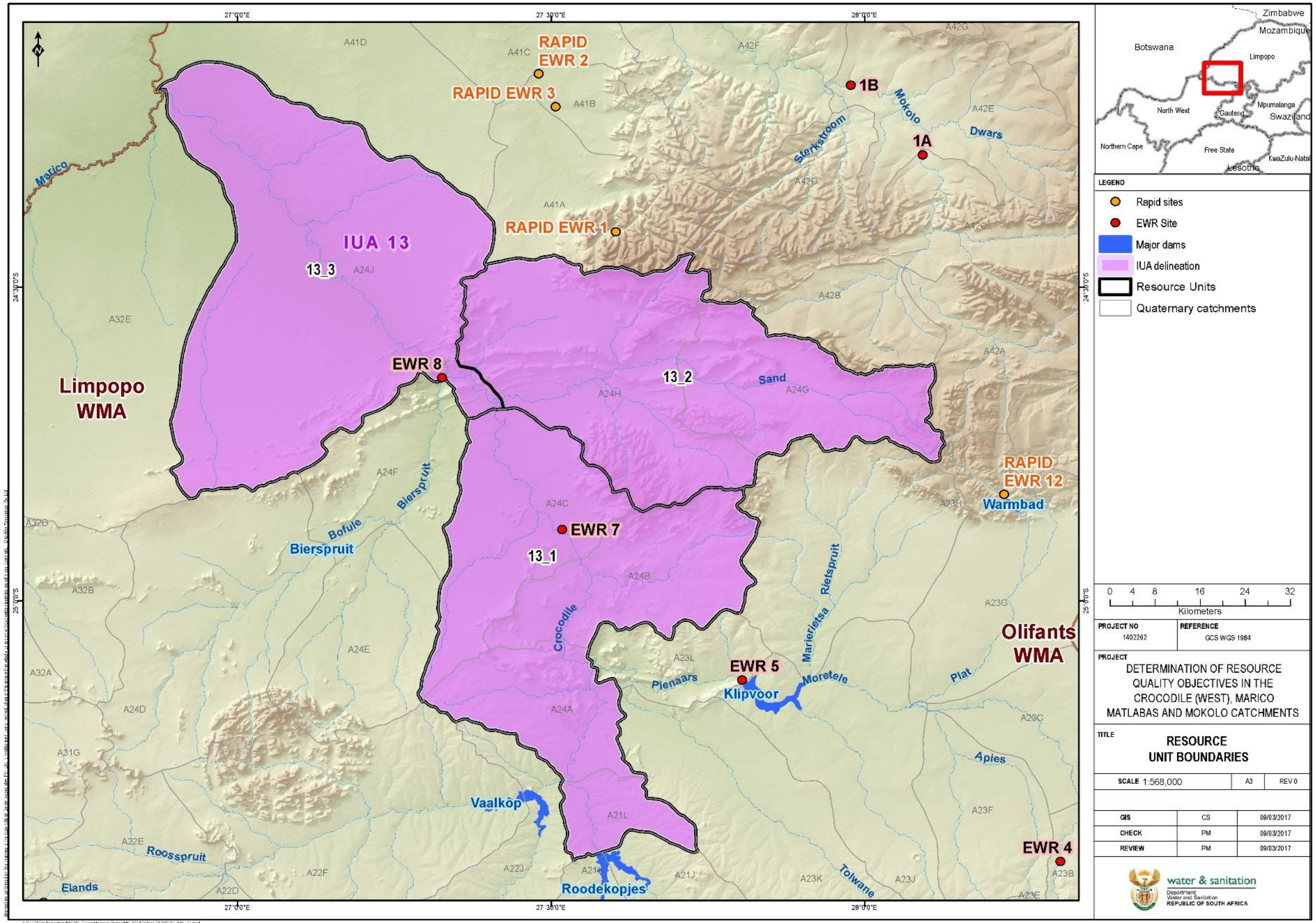
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			health.			contact recreational use – South African Water Quality Guidelines (1996).
	Habitat	Instream	Habitat diversity should be improved from a D ecological category to a C ecological category. Maintain natural flow regime. Improve instream habitat and velocity/depth for fish diversity.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of the Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be improved from a D ecological category to a C ecological category. Improve riparian zone. Remove alien vegetation.	Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of the Water Resource Class and associated ecological category.
	Biota	Fish	Fish community should be improved from a D ecological category to a C/D category. Maintain natural flow regime. Improve instream habitat and velocity/depth for fish diversity.	Fish Response Assessment Index (FRAI)	Fish ecology category = C/D FRAI ≥ 58% Sample at least 10+ species in 20min effort Indicator species: *AJOH, LCYL, BMAR, MBRE*	Attainment of the Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
12_2 **Bierspruit outflow Bierspruit Dam to confluence with the Crocodile River, Brakspruit, Phufane, Sefatlhane, Lesobeng** **A24E, A24F**	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category is met. Concentrations should not be allowed to deteriorate.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.125 milligrams/litre (mg/l) (50th percentile)	Ecological specification. No in stream water quality monitoring site.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	
		Salts	Instream salinity must be maintained at acceptable levels to support a healthy aquatic ecosystem and the water quality requirements of water users. Concentrations should not be allowed to deteriorate.	Electrical conductivity (EC)	≤ 85 milliSiemens/metre (mS/m) (95thpercentile)	Ecological specification. No in stream water quality monitoring site..
				Sulphate (SO_4)	≤ 100 milligrams/litre (95th percentile)	
				Sodium (Na)	≤ 100 milligrams/litre (95th percentile)	
				Chloride (Cl)	≤ 100 milligrams/litre (95th percentile)	
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.0 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem and user as the drivers

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Aluminium (Al)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.3 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0095 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0073 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
		Pathogens	The presence of pathogens should pose a low risk to human health.	*Escherichia coli* (*E. coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
	Habitat	Instream	Habitat diversity should be maintained within a D ecological category. Maintain natural flow regime. Improve instream habitat and velocity/depth for fish and macroinvertebrate diversity.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = D ≥ 42%	Attainment of the Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be maintained within a D ecological category. Development into the riparian zone must be controlled and limited. Siltation impacts must be managed.	Vegetation Response Assessment Index	VEGRAI EC = D ≥ 42%	Attainment of the Water Resource Class and associated ecological category.
	Biota	Fish	Fish community should be maintained within a D ecological category or improved upon. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = D FRAI ≥ 42% Collect 4+ species in 20min sampling effort.	Attainment of the Water Resource Class and associated ecological category.

6.1.15 LOWER CROCODILE

RU	Delineation	Catchment
13_1	Crocodile River outflow Roodekopjes Dam to upstream Sand River confluence, Sleepfonteinspruit, Klipspruit tributaries	A21L, A24A, A24B, A24C
13_2	Sand River to confluence with the Crocodile River to Bierspruit confluence, Sondags, Vaalwaterspruit and Monyagole tributaries	A24G, A24H
13_3	Lower Crocodile from Bierspruit confluence to the Botswana border (Limpopo River)	A24J


IUA 13
13_1
13_2
13_3
EWR 8
EWR 7
EWR 5
EWR 4
1A
1B
RAPID EWR 1
RAPID EWR 2
RAPID EWR 3
RAPID EWR 12
Limpopo WMA
Olifants WMA
LEGEND
Rapid sites
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
PROJECT NO 1402262
REFERENCE GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
RESOURCE UNIT BOUNDARIES
SCALE 1:568,000
A3
REV 0
GIS CS 09/03/2017
CHECK PM 09/03/2017
REVIEW PM 09/03/2017
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

IUA 13 – Lower Crocodile
RESOURCE UNIT : 13_1– Crocodile River outflow Roodekopjes Dam to upstream Sand River confluence, Sleepfonteinspruit, Klipspruit tributaries - Quaternary catchment A21L, A24A, A24B, A24C
DESCRIPTION
The IUA is a Class III. EWR site 7 on the Crocodile River is located in this resource unit. PES of a D ecological category. The reach is an important area for birds and riparian vegetation. It contains unique types of *Acacia galpinii* (Monkey thorn) riparian forests. Activities mainly include agricultural activities, with major irrigation. The town of Leeupoort is situated in the resource unit. Return flows are a major impact on the system. The area further has large hunting and private conservation areas. Flow dependent fish species (*LMOL, CPRE*) are present. Groundwater: Abstraction/discharges from/to irrigation on alluvium aquifer system along the Crocodile River. Sand aquifer systems present. Proximity of mines to the aquifers could lead to dewatering of the aquifer.
RESOURCE UNIT : 13_2 – Sand River to confluence with the Crocodile River to Bierspruit confluence, Sondags, Vaalwaterspruit and Monyagole tributaries: Quaternary catchment A24G, A24H
DESCRIPTION
The IUA is a Class III. Major water user is agriculture - irrigation use. Irrigation return flows are a major impact. Includes the town of Rooiberg (also the Rooiberg WWTW – activated sludge). The area include a number private conservation areas and game farms. Moderate and sensitive fish species (CPAR). Groundwater: Abstraction/discharges from/to irrigation on alluvium aquifer system along the Crocodile River.
RESOURCE UNIT : 13_3 –- Lower Crocodile from Bierspruit confluence to the Botswana border (Limpopo River): Quaternary catchment A24J
DESCRIPTION
The IUA is a Class III. EWR site 8 on the Crocodile River is located in this resource unit. PES of a D ecological category. The town of Thabazimbi is located in the resource unit. These reaches form an ecotone between the Western Brackenveld and Limpopo Plain ecoregions. The *Acacia galpinii* (Monkey thorn) riparian forest is unique. Activities mainly include irrigation water use and with return flows as a major impact. “Opportunistic irrigation” by abstraction from the sand aquifers could impact on aquifer system. The area includes a number of game farms downstream of Thabazimbi. The Thabazimbi WWTW discharges impacts on the water quality of the Crocodile River. Sensitive fish species present (*CPAR, LMOL*). During good flow, crocodiles move close to EWR site 8. There are also mining activities in the area. The transfer pipeline from the Crocodile to the Mokolo catchment will be in the vicinity of EWR site 8. An alternate river EcoStatus monitoring site downstream of the transfer site would then be required.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
13_1 **Crocodile outflow Roodekopjes Dam to Sand river confluence, Sleepfontein-spruit, Klipspruit tributaries** **A21L, A24A, A24B, A24C** **Main stem river**	Quantity	Low flows	EWR maintenance low and drought flows: Crocodile River at CROC_EWR7 in A24C NMAR = 463.4x10^{6}m^3 REC=D category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Monitoring of Crocodile River at A2H132	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 1.134 1.134 Nov 1.362 1.362 Dec 1.481 1.481 Jan 1.938 1.938 Feb 2.638 2.488 Mar 2.481 2.481 Apr 2.118 2.118 May 1.745 1.745 Jun 1.574 1.574 Jul 1.389 1.389 Aug 1.262 1.262 Sep 1.172 1.172	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
		High flows	EWR high flows: Crocodile River at CROC_EWR7 in A24C NMAR = 463.4x10^{6}m^3 REC=D category High flows must be attained as specified to support aquatic ecostem requirements.	Floods High flow also specified as individual flood requirements in terms of size and duration (See Appendix A) Monitoring of Crocodile River at A2H132	High flows (m^3/s) Oct 0 Nov 0.790 Dec 1.529 Jan 0 Feb 1.270 Mar 0 Apr 0.790 May 0 Jun 0 Jul 0 Aug 0 Sep 0	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category is met. Concentrations should not be allowed to deteriorate.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.060 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem and user as the drivers. Present water quality state. (site A2H059Q01)
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Aquatic ecosystem and user as the drivers. Present water quality state.
		Salts	Instream salinity must be maintained at the levels specified to support a healthy aquatic ecosystem and the water quality requirements of water users. Concentrations should not be allowed to deteriorate.	Electrical conductivity (EC)	≤ 85 milliSiemens/metre (mS/m) (95thpercentile)	Aquatic ecosystem and user as the drivers. Present water quality state.
				Sulphate (SO_4)	≤ 100 milligrams/litre (95th percentile)	Aquatic ecosystem and user as the drivers. Present water quality state.
				Sodium (Na)	≤ 80 milligrams/litre (95th percentile)	Aquatic ecosystem and user as

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
				Chloride (Cl)	≤ 80 milligrams/litre (95th percentile)	the drivers. Present water quality state.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Ecological specification.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Atrazine	≤0.078 milligrams/litre (mg/l)	(Maize). Human health is the driver. Ecological Reserve manual (2008). No monitoring data.
				Propiconazole	≤ 0.10 milligrams/litre (mg/l)	(Wheat). Human health considerations. Australian Drinking Water Guideline
				Metolachlor	≤0.30 milligrams/litre (mg/l)	(Soybeans)Human health considerations. Australian Drinking Water Guideline
				Aluminium (Al)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.3 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0095 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0073 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
				Aluminium (Al)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity should be maintained within a D ecological category or better	Index of Habitat Integrity, Rapid Habitat Assessment Method and	Instream Habitat Integrity EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			condition. Maintain good low flows to sustain habitat for substrate and habitat sensitive species and taxa.	Model (RHAMM)		category.
		Riparian habitat	Rehabilitation/remediation required. Indigenous vegetation must be protected (unique *Acacia galpinii* (Monkey thorn). Riparian vegetation should be maintained within a D ecological category or better condition. Maintain riparian zone in cultivated areas. Control development.	Vegetation Response Assessment Index	VEGRAI EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological category.
	Biota	Fish	Fish community should be maintained within a D ecological category or better condition. Flow velocity/depth must be adequate for flow sensitive species *CPRE* and *LMOL* and habitat sensitive species – *AJOH.*	Fish Response Assessment Index (FRAI)	Fish ecology category = D FRAI ≥ 42% Sample 6+ species per sample effort Indicator species *Sensitive fish species. Course substrate, CPRE, LMOL*	Attainment of Water Resource Class and associated ecological category.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5)	MIRAI EC = D ≥ 42% SASS ≥ 60 ASPT ≥ 4.5 (Site A2CROC-KOEDO)	Attainment of Water Resource Class and associated ecological category. Baseline data.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
13_2 **Sand River to confluence with Crocodile River** **A24G, A24H** **mainstem**	Quantity	Lows flows	EWR maintenance low and drought flows: Sand River upstream of Sondags River confluence at S24.6289, E27.6223 in A24H NMAR = $26.56 \times 10^6 m^3$ REC=B category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base flows Maintenance flows and drought flows. Monitoring of discharge of the Sand River during biological surveys	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.085 0.042 Nov 0.104 0.024 Dec 0.120 0.021 Jan 0.196 0.063 Feb 0.263 0.105 Mar 0.199 0.055 Apr 0.158 0.071 May 0.127 0.059 Jun 0.119 0.056 Jul 0.108 0.051 Aug 0.098 0.047 Sep 0.089 0.044	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
		High flows	EWR high flows: Sand River Monitoring of discharge of the Sand River during biological surveys at S24.6289, E27.6223 in A24H	Freshets for fish High flow also specified as individual flood requirements in	Month / High flows (m^3/s) Oct 0.009 Nov 0.056	Flows specified are to maintain ecological flow requirements for aquatic ecosystem to attain

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			NMAR = $26.56 \times 10^6 m^3$ REC=B category High flows must be attained to ensure freshets for fish communities.	terms of size and duration (see Appendix A)	Dec 0.090 Jan 0.181 Feb 0.500 Mar 0.181 Apr 0.093 May 0 Jun 0 Jul 0 Aug 0 Sep 0	prescribed ecological category. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.020 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Ecological Reserve manual (2008). Present ecological state must be maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Ecological specification. Present ecological state must be maintained.
				Sulphate	≤ 20 milligrams/litre (95th percentile)	Present ecological state must be maintained.
				Chloride	≤ 20 milligrams/litre (95th percentile)	Present ecological state must be maintained.
	Habitat	Instream	Habitat diversity should be maintained within a B ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Attainment of present ecological category.
		Riparian habitat	Riparian vegetation should be maintained within a B ecological category or better condition.	Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Attainment of present ecological category.
	Biota	Fish	The fish community must be maintained in a B ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.Habitat and flow must be adequate for *seasonal* flow dependent species, *CPAR.*	Fish Response Assessment Index (FRAI)	Fish ecology category = B FRAI ≥ 82%	Attainment of present ecological category.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5)	MIRAI EC = C ≥ 62% SASS ≥ 100 ASPT ≥ 5.5 (Site A2SUND-WATER)	Attainment of present ecological category.

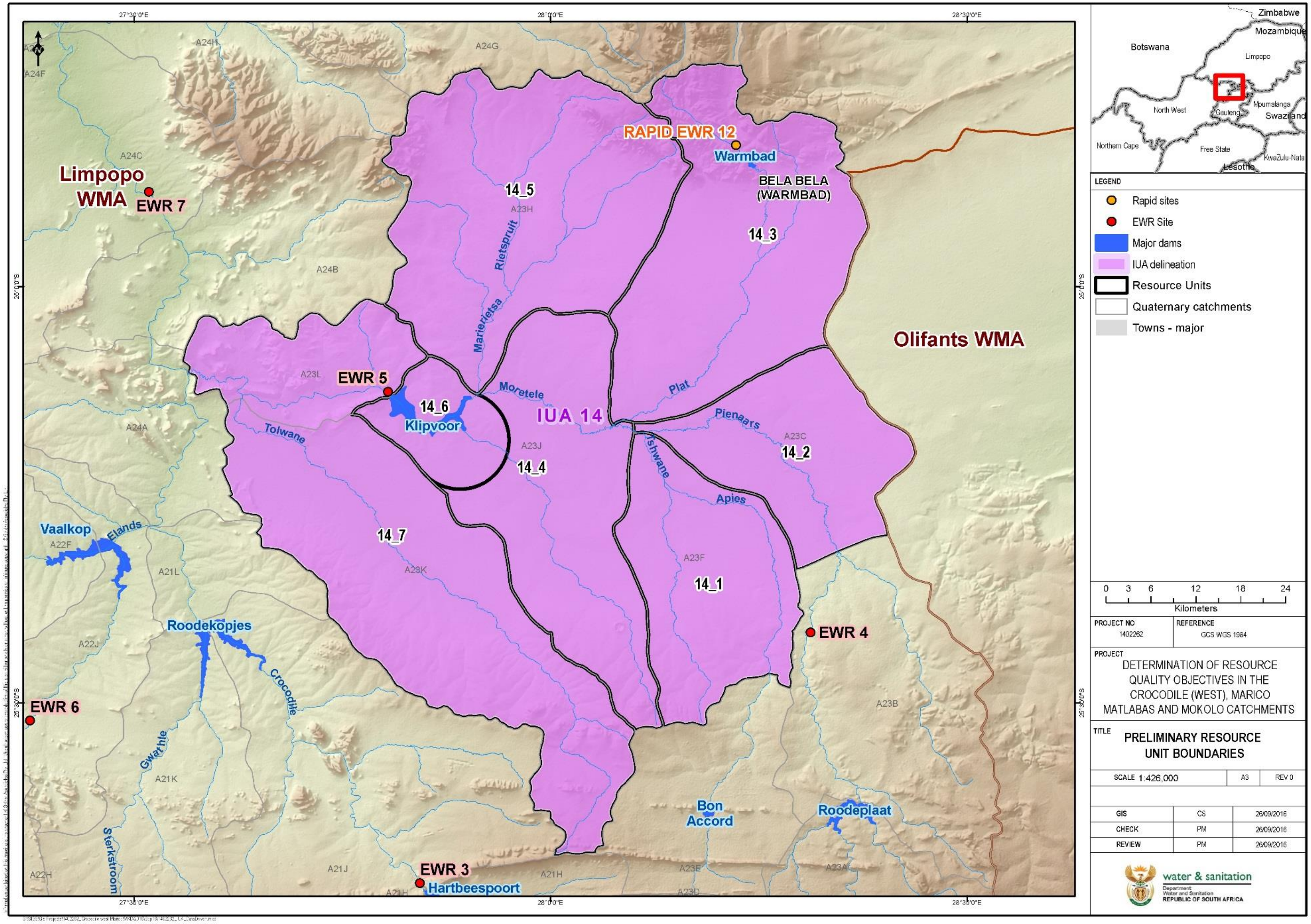
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
13_3 **Lower Crocodile from Bierspruit to the Botswana border (Limpopo River)** **A24J**	Quantity	Low flows	EWR maintenance low and drought flows: Crocodile River at A2H128 in A24J NMAR = $565.16 \times 10^6 m^3$ REC=D category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Monitoring of Crocodile River at A2H128	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.795 0.795 Nov 0.924 0.924 Dec 0.973 0.973 Jan 1.216 1.216 Feb 1.561 1.561 Mar 1.337 1.337 Apr 1.131 1.131 May 0.981 0.981 Jun 0.967 0.967 Jul 0.905 0.905 Aug 0.856 0.856 Sep 0.821 0.821	Flows specified are to maintain ecological categories of the water resource in prescribed ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).
		High flows	EWR high flows: Crocodile River at A2H128 in A24J NMAR = $565.16 \times 10^6 m^3$ REC=C/D category High flows must be attained to ensure flood requirements for fish communities.	Floods High flow also specified as individual flood requirements in terms of size and duration (see Appendix A). Monitoring of Crocodile River at A2H128	High flows (m^3/s) Oct 0 Nov 0.395 Dec 2.829 Jan 0 Feb 0.423 Mar 0 Apr 0 May 0 Jun 0 Jul 0 Aug 0 Sep 0	Flows specified are to maintain ecological flow requirements for aquatic ecosystem to attain prescribed ecological category. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category is met. Concentrations should not be allowed to deteriorate.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.06 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem and user as the drivers. Present water quality state.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Aquatic ecosystem and user as the drivers. Present water quality state.
		Salts	Instream salinity must be maintained at the levels specified to support a healthy aquatic ecosystem and the water quality requirements of water users. Concentrations should not be allowed to deteriorate.	Electrical conductivity (EC)	≤ 85 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem and user as the drivers. Present water quality state.
				Sulphate (SO_4)	≤ 100 milligrams/litre (95th percentile)	Aquatic ecosystem and user as the drivers. Present water quality state.
				Sodium (Na)	≤ 80 milligrams/litre (95th percentile)	Present water quality state. Aquatic

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
				Chloride (Cl)	≤ 100 milligrams/litre (95th percentile)	ecosystem and user as the drivers.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Ecological specification
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health	Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data. (Maize)
				Propiconazole	≤ 0.10 milligrams/litre (mg/l)	(Wheat). Human health considerations. Australian Drinking Water Guideline
				Mancozeb	0.009 milligrams/litre (mg/l)	Human health consideration. Australian drinking water guideline. (Beans)
	Habitat	Instream	Habitat diversity should be improved from D ecological category to C/D ecological category. Maintain good low flows to sustain habitat for substrate and habitat sensitive species and taxa.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C/D ≥ 58%	Attainment of associated ecological category and Water Resource Class
		Riparian habitat	Indigenous vegetation must be protected (unique *Acacia galpinii* (Monkey thorn). Riparian vegetation should be improved from D ecological category to C/D ecological category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C/D ≥ 58%	Attainment of associated ecological category and Water Resource Class.
	Biota	Fish	Fish community should be maintained within a D ecological category. Flow velocity/depth must be maintained for *CPAR, MACU* and *LMOL*, and habitat sensitive species – *MMAC, BANN.*	Fish Response Assessment Index (FRAI)	Fish ecology category = D FRAI ≥ 42% Sample 6+ species per sample effort	Attainment of associated ecological category and Water Resource Class.
		Semi-aquatic biota	The suitability of this stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management. Maintain good riparian cover for otters.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
					available/collected data.	
		Aquatic invertebrates	Macroinvertebrate assemblage must be maintained within a C/D ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5)	MIRAI EC = C/D ≥ 58% SASS ≥ 120 ASPT ≥ 5.0	Based on available monitoring data. Attainment of associated ecological category and Water Resource Class.
		Diatoms	Diatom assemblage must be maintained within a largely modified condition or improved upon.	Specific Pollution Index	Diatom EC ≥ 42%	Attainment of associated ecological category. Indicator of water quality and health state of water resource.

6.1.16 TOLWANE/KULWANE/MORETELE/KLIPVOOR

RU	Delineation	Catchment
14_1	Apies River, Tshwane tributary	A23F
14_2	Pienaars River from Boekenshout confluence to Apies River confluence	A23C
14_3	Plat River	A23G
14_4	Moretele (Pienaars) River from Plat River confluence to Klipvoor Dam, Kutswane to Klipvoor Dam	A23J
14_5	Rietspruit catchment - Not prioritised	A23H
14_6	Klipvoor Dam	A23J
14_7	Pienaars River from Klipvoor Dam to Crocodile River confluence, Tolwane tributary	A23K, A23L


Limpopo WMA
Olifants WMA
IUA 14
RAPID EWR 12
EWR 7
EWR 5
EWR 6
EWR 4
EWR 3
Warmbad
BELA BELA (WARMBAD)
Klipvoor
Vaalkop
Roodekopjes
Bon Accord
Roodeplaat
Hartbeespoort
14_1
14_2
14_3
14_4
14_5
14_6
14_7
Rietspruit
Marierietsa
Moretele
Plat
Pienaars
Tshwane
Apies
Tolwane
Elands
Crocodile
Gwathle
Sterkstroom
Zimbabwe
Mozambique
Botswana
Limpopo
North West
Gauteng
Mpumalanga
Swaziland
Northern Cape
Free State
KwaZulu-Natal
Lesotho
LEGEND
Rapid sites
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
Towns - major
0 3 6 12 18 24
Kilometers
PROJECT NO 1402262
REFERENCE GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
PRELIMINARY RESOURCE UNIT BOUNDARIES
SCALE 1:426,000
A3
REV 0
GIS CS 26/09/2016
CHECK PM 26/09/2016
REVIEW PM 26/09/2016
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

IUA 14 – Tolwane/Kulwane/Moretele/Klipvoor
RESOURCE UNIT : 14_1– Apies River, Tshwane tributary - Quaternary catchment A23F
DESCRIPTION
The IUA is a Class III. There are large villages within the catchment area – high density peri-urban towns (Hammanskraal, parts of Shoshanguve). Major water users are agriculture and subsistence water use. There is an abstraction at Temba (Leeukraal Weir) for domestic water supply. Water quality issues are prevalent, due to localised and upstream urban impacts. The Temba and Babelegi WWTWs discharge into the catchment. Wetland systems are important (Apies River floodplain is present).
RESOURCE UNIT : 14_2 – Pienaars River from Boekenshout confluence to Apies River confluence: Quaternary catchment A23C
DESCRIPTION
The IUA is a Class III. Magalies Water abstracts water for domestic supply on Boekenshoutspruit (Klipdrift). The area includes sprawling peri-urban villages. Land use impacts include cattle in river habitat, and impacts from solid waste and sewage effluent (Pienaarsrivier WWTW). The EIS is high due to the presence of the unique *B. rappax* fish species whom are intolerant to poor water quality and flow changes are also present namely *Chiloglanis pretoriae*, *Labeobarbus marequensis*, *Labeo cylindricus* and *L. molybdinus*). Sensitive invertebrates also reside in these reaches. There are rehabilitation FEPAs in the upper reaches of the Dinokeng Game Reserve. Irrigation activities occur downstream. Wetland priority area. Moretele floodplain present with high biodiversity and important bird habitat. Important resource for the adjacent community.
RESOURCE UNIT : 14_3 – Plat River - Quaternary catchment A23G
DESCRIPTION
The IUA is a Class III. The Plat River has its source in the Waterberg. The town of Bela Bela is located in the catchment area. Bela Bela Dam supplies water to the town. The area is a fish support area within a nature reserve. Rare fish species (*CTHE)* occurs within the Plat River (upper reaches). It requires certain flows and water qualities. Isolated group within the upper part. As soon as the river flows into the bushveld basin, the river dries out and *CTHE* does not occur. The important Plat river floodplain occurs. The upper reaches of the Plat river are in good ecological condition. Includes the Radium WWTW (oxidation ponds)
RESOURCE UNIT : 14_4 – Moretele (Pienaars) River from Plat River confluence to Klipvoor Dam, Kutswane to Klipvoor Dam: Quaternary catchment A23J
DESCRIPTION
The IUA is a Class III. Water quality impacts are primarily a result of urbanization, specifically deterioration in water quality due to WWTWs discharges. Increased development in Shoshanguve and Winterland. The present state of the Moretele River is in a D category owing to the releases from the dams and water quality impacts mentioned above. Currently too much water is released from the Rietgat WWTW in the Kutswane tributary. Moretele floodplain present with high biodiversity and important water bird habitat. The floodplain area is one of the few lowland rivers in the area. It is an Important resource for the adjacent community. Tswaing crater (unique endorhic wetland system). The fish species Aplocheilichthys (Topminnhow) is present which also occur within wetland systems.
RESOURCE UNIT : 14_6 – Klipvoor Dam - Quaternary catchment A23J
DESCRIPTION
The IUA is a Class III. The Kipvoor Dam is situated at the lower part of the catchment area. Dam supports some recreational activities (local angling) and is located within the Borakalalo National Park. Dam habitat functions as a fish refugia. Will Support fture domestic water supply to Bela Bela, Madibeng. The dam is impacted by nutrients (high algal growth).
RESOURCE UNIT : 14_7 – Pienaars River from Klipvoor Dam to Crocodile River confluence, Tolwane tributary - Quaternary catchment A23K, A23L
DESCRIPTION
The IUA is a Class III. EWR site 5 on the Pienaars River is located in this resource unit. PES of a D ecological category The rivers are impacted by urban development and irrigated agriculture. Includes the town of Mabopane. The Tolwane river is significantly impacted. The rivers are impacted by high nutrient levels and eutrophication is evident. Wastewater is discharged from the Klipgat WWTW into the Tolwane River and from Sandspruit WWTW into the Sand River. Extensive sand mining is also occurring in the area (largely unauthorised). Aquatic weeds also present. No flow dependent fish species. However, owing to the enrichment in the dam and flow release, the *LMAR* occur within the river below the dam due to the flow increase from the dam releases. Artificial fly fishing has been introduced downstream of the dam due to the *LMAR*. Therefore consistent flow management from the dam is vital in order to retain the population of *LMAR*. The fish cannot migrate as the dam functions as a migration barrier for the fish. An additional unique

IUA 14 – Tolwane/Kulwane/Moretele/Klipvoor
fish species is *LROS*.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
14_1 **Apies River, Tshwane tributary** **A23F**	Quantity	Flows	A management strategy to manage the excesss water present (return flows) in the system must be developed. Suitable management options must be assessed. The benefits of reducing the flow must be determined.	Low flows	To be determined once the management strategy is developed	Reduced flows are required to sustain the aquatic system health.
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.5 milligrams/litre (mg/l) (50^{th} percentile)	Aquatic ecosystem as the driver. Nutrient levels must be improved. Present state
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 3.0 milligrams/litre (50^{th} percentile)	Aquatic ecosystem as the driver. Nutrient levels must be improved. Present state.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical conductivity (EC)	≤ 80 milliSiemens/metre (mS/m) (95^{th}percentile)	Maintenance of the present water quality state. Prevent deterioration.
				Sulphate (SO_4)	≤ 70 milligrams/litre (95^{th} percentile)	
				Chloride (Cl)	≤ 75 milligrams/litre (95^{th} percentile)	
				Sodium (Na)	≤ 80 milligrams/litre (95^{th} percentile)	
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95^{th} percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5^{th} percentile) and 8.5 (95^{th} percentile)	Aquatic ecosystem as the driver.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Aquatic ecosystem is the driver. Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
				Mancozeb	0.009 milligrams/litre (mg/l)	Human health consideration. Australian drinking water guideline.
				Glyphosate	0.7 milligrams/litre (mg/l)	Human health consideration. USEPA drinking water guideline

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
				Endosulfan	0.13 micrograms/litre (ug/l)	Ecological specification. Ecological Reserve manual (2008).
				Chromium (VI)	≤ 0.2 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0013 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Cb)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity should be improved to a D ecological category. Maintain good low flows to sustain habitat for substrate sensitive species (*BMAR, BUNI)* and taxa.	Index of Habitat Integrity	Instream Habitat Integrity EC = D ≥ 42% (site below confluence of Apies and Tshwane)	Attainment of Water Resource Class and associated ecological category.
		Riparian habitat	Riparian vegetation should be maintained within a D ecological category or better condition. Maintain riparian zone in cultivated (subsistence) areas.	Vegetation Response Assessment Index	VEGRAI EC = D ≥ 42%	Attainment of Water Resource Class and associated ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
14_2 **Pienaars River from Boekenshout confluence to Apies River confluence** **A23C**	Quantity	Flows	A management strategy to manage the excesss water present (return flows) in the system must be developed. Suitable management options must be assessed. The benefits of reducing the flow must be determined.	Low flows	To be determined once the management strategy is developed	Reduced flows arerequired to sustain the aquatic system health.
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.090 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem driver. Present ecological state maintained.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.7 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present ecological state must be maintained.
		Salts	Instream salinity levels as specified must be attained to	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95th percentile)	Present ecological state must be maintained. Present state

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Sulphate	≤ 50 milligrams/litre (95th percentile)	upstream
				Chloride	≤ 50 milligrams/litre (95th percentile)	
				Sodium	≤ 70 milligrams/litre (95th percentile)	
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Ecological specification.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data. (Maize)
				Propiconazole	≤ 0.10 milligrams/litre (mg/l)	(Wheat). Human health considerations. Australian Drinking Water Guideline
				Imidacloprid	≤ 0.000038 milligrams/litre (mg/l)	Human health considerations. Environment Protection Authority of New Zealand – Environmental Exposure Limit
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Aquatic ecosystem is the driver. Ecological specification.
				Lead (Pb) hard	≤ 0.0095 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.00735 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity should be maintained within a C ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of present ecological category
		Riparian habitat	Riparian vegetation should be maintained within a C ecological category. Remediation of riparian zone	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of present ecological category

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			along Boekenshout required. Sand mining must be controlled.			
	Biota	Fish	The fish community must be maintained in a C ecological category or better. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category. Flow velocity/depth must be maintained for fish species – *CPAR* and *LMOL* and habitat sensitive species – *AKAT* that are likely to be present in the wetlands.	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62% Sample 10 *CPAR* and 10 *LMOL* in 20min effort	Attainment of present ecological category
		Semi-Aquatic Biota	Habitat in Moretele Floodplain must be maintained. The stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management. Maintain good riparian cover for otters. Maintain riparian zone as important bird habitat.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context/Rationale for RQO/numerical limit
14_3 **Plat River** **A23G**	Quantity	Low flows	EWR maintenance low and drought flows: Plat River at A2H064 in A23G NMAR = $9.64x10^6m^3$ REC=C/D category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows Monitoring of Plat River at A2H064		Maintenance Low flows (m^3/s)	Drought flows (m^3/s	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).
					Oct	0.021	0.012	
					Nov	0.023	0.012	
					Dec	0.023	0.013	
					Jan	0.025	0.014	
					Feb	0.030	0.016	
					Mar	0.027	0.015	
					Apr	0.027	0.014	
					May	0.025	0.013	
					Jun	0.025	0.014	
					Jul	0.024	0.013	
					Aug	0.024	0.013	
					Sep	0.023	0.012	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
	Habitat	Instream	Habitat diversity should be improved from a D ecological category to a C/D category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C/D ≥ 58%	Attainment of prescribed ecological category in terms of Ecological Reserve.
		Riparian habitat	Riparian vegetation should be improved from a D ecological category to a C/D category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C/D ≥ 58%	Attainment of prescribed ecological category in terms of Ecological Reserve.
	Biota	Fish	Fish community should be improved from a D ecological category to a C/D category. Maintain flow velocity/depth for fish species *LCYL* and *LMOL* and habitat sensitive species, *MBRE* and *BBR.* Isolated populations of *CTHE* in upper reaches of river must also be maintained.	Fish Response Assessment Index (FRAI)	Fish ecology category = C/D FRAI ≥ 58% Sample 2 or 3 *CTHE* and 10 *LMOL* in 20min effort (Site A2PLAT-KOMAN)	Attainment of prescribed ecological category in terms of Ecological Reserve.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5)	MIRAI EC = C ≥ 62% SASS ≥ 120 ASPT ≥ 6.0 (Site A2PLAT-KOMAN)	Attainment of prescribed ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
14_4 **Moretele (Pienaars) River from Plat River confluence to Klipvoor Dam, Kutswane to Klipvoor Dam** **A23J**	Quantity	Flows	A management strategy to manage the excesss water present (return flows) in the system must be developed. Suitable management options must be assessed. The benefits of reducing the flow must be determined.	Low flows	To be determined once the management strategy is developed	Reduced flows are required to sustain the aquatic system health.
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.5 milligrams/litre (mg/l) (50th percentile)	Present ecological state must be maintained
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 3.0 milligrams/litre (50th percentile)	Present ecological state must be maintained
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 85 milliSiemens/metre (mS/m) (95th percentile)	Ecological specification (EC) and Present state.
				Sulphate (SO_4)	≤ 70 milligrams/litre (95th percentile)	
				Chloride (Cl)	≤ 75 milligrams/litre (95th percentile)	
				Sodium (Na)	≤ 80 milligrams/litre (95th percentile)	
		Pathogens	The presence of pathogens should	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml)	User specification. Limit is the target

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			pose no risk to human health.		(95^{th} percentile)	water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5^{th} percentile) and 8.5 (95^{th} percentile)	Ecological specification.
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).

Resource Unit	Component prioritised	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
14_6 **Klipvoor Dam** **A23J**	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).	To be developed.	
	Quality	Nutrients	Concentration of orthophosphate must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Orthophosphate	≤ 0.05 mg/ℓ 50th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Klipvoor Dam is known to experience high nutrient concentrations due to the influx of sewage effluent in the catchment. (Van Ginkel 2008). The system is a hypertrophic system and all attempts should be made to improve the water quality in the system as it will contribute to the drinking water of the Bela Bela and Madibeng Areas in future and it is situated within a Nature Reserve. High nutrient concentration leads to the development of toxic cyanobacteria within the system which is difficult to remove and may cause animal deaths in the reserve.

Resource Unit	Component prioritised	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			Concentration of total phosphorous must be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Total phosphorous	≤ 0.130 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Klipvoor Dam is a hypertrophic system, which need to be improved to a eutrophic state for sustainable use.
			Concentration of total Ammonia as Nmust be improved to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as a eutrophic system.	Total Ammonia	≤ 0.072 mg/ℓ N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water collection in prewashed plastic bottles	Klipvoor Dam is a hypertrophic system, which need to be improved to a D category for sustainable use. Klipvoor is subject to severe nutrient enrichment that leads to increased algal growth that impact negatively on the ecological, recreational and future potable uses.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 75 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system must be maintained or improved upon.
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity	Turbidity	≥0.4 m 5th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
			Moderate change	Temperature	No more than 2 °C increasing change in both minimum and maximum	Bi-weekly depth profile monitoring with a DO meter.	Increased temperatures will favour the growth of potentially toxic cyanobacteria.
			The oxygen levels in the system must maintain the ecological system.	Dissolved Oxygen	≥ 7.0 mg/ℓ O_2 95th percentile	Bi-weekly depth profile monitoring with a DO meter.	Low oxygen levels associated with organic matter emanating from upstream industries and Wastewater Treatment Works are negatively impacting on the ecosystem.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines

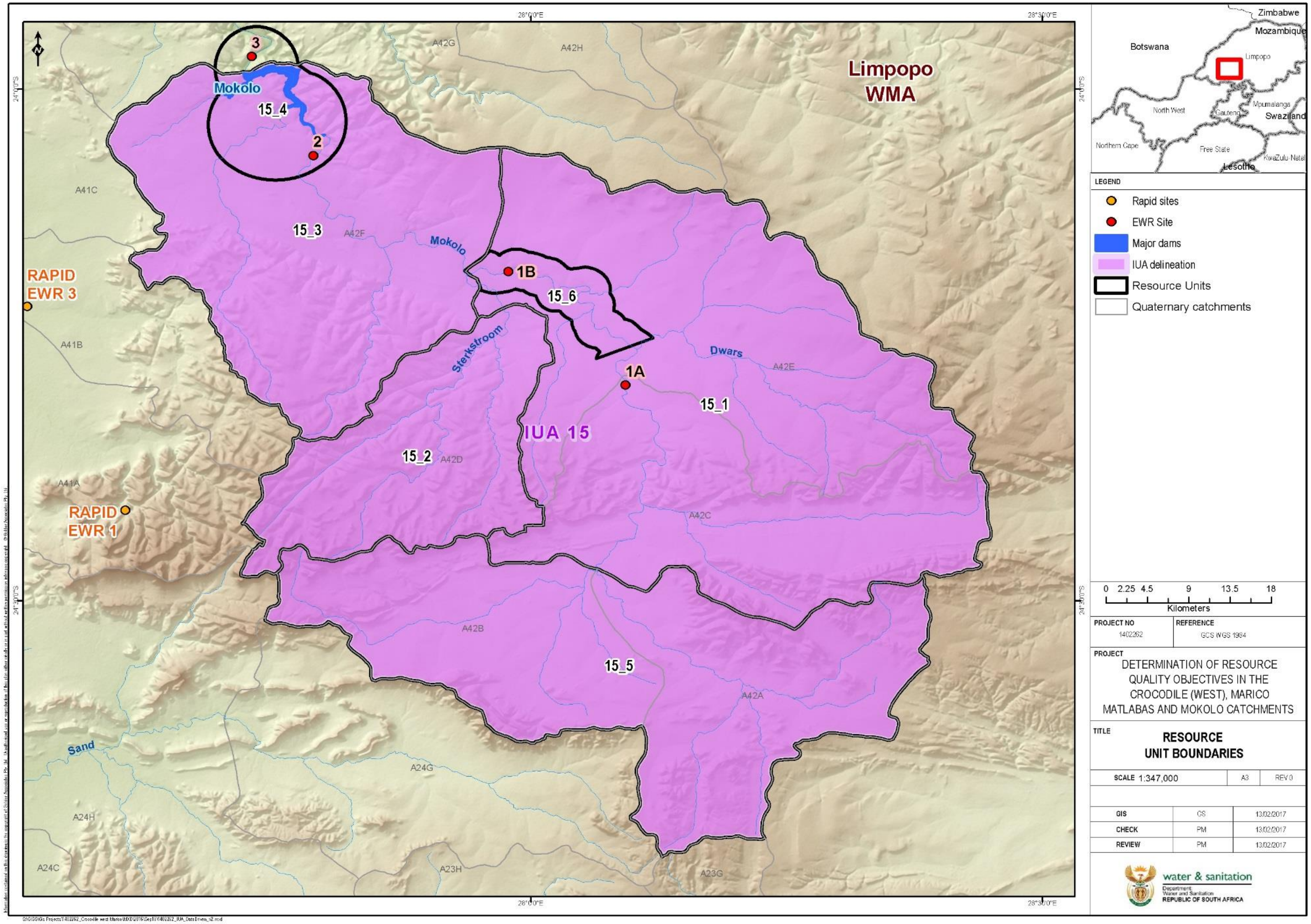
Resource Unit	Component prioritised	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
						24hours of the sample collection. Monthly sampling	(1996).
		Toxics	The dam must be managed to minimize the development of toxic cyanobacterial blooms	Cyanobacteria	Cyanobacterial dominate with Chl *a* concentration higher than 30µg/ℓ must be kept at less than 20% of the time.	Bi-weekly integrated (0-5m hosepipe) water collection in prewashed plastic glass bottle with Lugol's Solution Preservative.	Klipvoor Dam Chl a concentrations has escalated into hypertrophic conditions during the since 2000 and are subject to serious cyanobacterial and other algal blooms. The Cyanobacteria produce harmful toxins for wildlife and humans, which are problematic in water treatment removal.
			The river water should not be toxic to aquatic organisms or be a threat to human health.	Pesticides	Cyanide: ≤ 110 µg/ℓ Endosulfan: ≤ 20 µg/ℓ Atrazine: ≤ 100 µg/ℓ 95th percentile	Sub-surface water collection in prewashed plastic bottles. Monthly sampling	Pesticides emanating from agriculture activities are potentially threatening the ecosystem maintenance
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic and semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	90% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every two years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl a concentration must be maintained in a eutrophic state.	Chl a	20-30µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection.	The hypertrophic state and resultant serious algal blooms experienced annually in the Klipvoor Dam is need to be improved into a eutrophic state.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
14_7 **Moretele River from Klipvoor Dam to Crocodile River , Tolwane** **A23K, A23L**	Quantity	Low Flows	EWR maintenance low and drought flows: Moretele/ Pienaars River at CROC_EWR5 in A23J NMAR = $113.0 \times 10^6 m^3$ REC=D category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base flows Maintenance flows and drought flows Monitoring of Pienaars River at A2H106	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.162 0.159 Nov 0.210 0.206 Dec 0.230 0.226 Jan 0.303 0.298 Feb 0.356 0.351 Mar 0.309 0.304 Apr 0.260 0.256 May 0.220 0.216 Jun 0.208 0.205 Jul 0.188 0.185 Aug 0.174 0.171 Sep 0.160 0.158	Flow limits specified are to maintain ecological state of the water resource in the recommended ecological category C and meet the Water Resource Class III. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients must be improved to sustain aquatic ecosystem health and ensure the prescribed ecological category is met. Nutrient concentrations must be reduced.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.060 milligrams/litre (mg/l) (50th percentile)	Present water quality status. Improvement required. Phosphate levels are high.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 1.0 milligrams/litre (50th percentile)	Present water quality status. Present ecological state maintained.
		Salts	Instream salinity must be maintained to support the aquatic ecosystem and sustain present ecological state. No further deterioration should occur. Land based activities and WWTW discharges must be controlled.	Electrical Conductivity	≤ 75 milliSiemens/metre (mS/m) (95th percentile)	Present water quality status. Present ecological state maintained.
				Sulphate	≤ 60 milligrams/litre (95th percentile)	
				Chloride	≤ 70 milligrams/litre (95th percentile)	
				Sodium	≤ 100 milligrams/litre (95th percentile)	
		Pathogens	The presence of pathogens should pose no risk to human health. Microbial pollution must be minimised.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem as the driver
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Aquatic ecosystem is the driver. Ecological specification. Ecological Reserve manual (2008).

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data. (Maize)
				Propiconazole	≤ 0.10 milligrams/litre (mg/l)	(Wheat). Human health considerations. Australian Drinking Water Guideline
				Metolachlor	≤0.30 milligrams/litre (mg/l)	Human health considerations. Australian Drinking Water Guideline (Beans)
				Mancozeb	0.009 milligrams/litre (mg/l)	Human health consideration. Australian drinking water guideline.
	Habitat	Instream	Habitat diversity should be improved from a D ecological category to a C category. Maintain good low flows to sustain habitat for substrate and habitat sensitive species and taxa.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of prescribed ecological category.
		Riparian habitat	Riparian vegetation should be improved from a D ecological category to a C category. Sand mining in riparian zone must be limited.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of prescribed ecological category.
	Biota	Fish	The fish community must be maintained in a C/D ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category. Maintain flow velocity/depth species *LMOL LCYL* and *CPAR* and habitat sensitive species, *MBRE*.	Fish Response Assessment Index (FRAI)	Fish ecology category = C/D FRAI ≥ 58% Sample 10+ species per sample effort Sample 20 *BMAR* in 20min effort	Attainment of prescribed ecological category
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D ecological category or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	MIRAI EC = C ≥ 62% SASS ≥ 100 ASPT ≥ 5.0 (REMP site A2PIEN – BUFFE or EWR5)	Attainment of prescribed ecological category
		Semi aquatic biota	The river reach to serve as a habitat for aquatic bird populations must be maintained through proper habitat management. Maintain the riparian zone to provide suitable habitats.	Aquatic birds Indicator species	A baseline assessment should be conducted to determine the aquatic bird species along the river reach. There is a need to set a numerical RQO for density of birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Diatoms	Diatom assemblage must be maintained within a largely modified condition or improved upon.	Specific Pollution Index	Diatom EC = D ≥ 42%	

6.1.17 UPPER MOKOLO

RU	Delineation	Catchment
15_1	Moloko River, Klein Sand, Sondagsloop, Heuningspruit, Dwars, Jim se loop tributaries	A42C, A42E
15_2	Sterkstroom, Frikkie-se-Loop	A42D, A42E
15_3	Mokolo River in A42F to inflow Mokolo Dam, Taaibosspruit, Malmanies and Bulspruit tributaries	A42F
15_4	Mokolo Dam to upper portion of A42G (10km downstream of dam)	A42F
15_5	Grootspruit and Sandspruit tributaries (Mokolo headwater catchment)	A42A, A42B
15_6	Mokolo River from Dwars river to confluence with Sterkstroom, Klein Vaalwaterspruit, Brakspruit	A42E



Limpopo WMA
IUA 15
15_1
15_2
15_3
15_4
15_5
15_6
1A
1B
2
3
Mokolo
Sterkstroom
Dwars
Sand
RAPID EWR 3
RAPID EWR 1
A41C
A41B
A41A
A42G
A42H
A42F
A42E
A42D
A42C
A42B
A42A
A24G
A24H
A24C
A23H
A23G
Zimbabwe
Mozambique
Botswana
Limpopo
North West
Gauteng
Mpumalanga
Swaziland
Northern Cape
Free State
KwaZulu-Natal
Lesotho
LEGEND
Rapid sites
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
0 2.25 4.5 9 13.5 18
Kilometers
PROJECT NO 1402262
REFERENCE GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
RESOURCE UNIT BOUNDARIES
SCALE 1:347,000
A3
REV 0
GIS CS 13/02/2017
CHECK PM 13/02/2017
REVIEW PM 13/02/2017
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

IUA 15 – Upper Mokolo
RESOURCE UNIT : 15_1– Moloko River, Klein Sand, Dopperspruit, Wolvenfontein spruit Sondagsloop, Heuningspruit, Dwars, Jim se loop and Klein Vaalwaterspruit tributaries: Quaternary catchment A42C, A42E
DESCRIPTION
The IUA is a Class II. EWR site 1a on the Mokolo River is located in this resource unit. The catchment area includes the town of Vaalwater, a number of game farms, cattle farms, as well as irrigated (vegetables, tobacco, maize, lucern, wheat) and dryland agriculture, piggeries and small industries on farms such as cattle feed manufacturing. Water supply to the town is from the Mokolo River and boreholes. Vaalwater has developed so water requirements has increased – increase in abstraction. The main impact on the water resource is irrigation return flows, (Mabatlane (Vaalwater)) WWTW discharge from town and piggeries. The area is important as it plays a role as a corridor for fish (FEPA rivers). Important fish include *CPRE, AURA* and *AMOS* (flow dependent and water quality dependent fish species).
RESOURCE UNIT : 15_2 – Sterkstroom, Frikkie-se-Loop: Quaternary catchment A42D
DESCRIPTION
The IUA is a Class II. Game farming and eco-tourism are important in the area. The area als includes irrigated agriculture (lucerne, tobacco, maize and vegetables) Reliance on groundwater for water supply. The Sterkstroom has a high EIS, with a PES of a B category. The water use authorisation specifies that releases should be made from Douw Steyn dam.
RESOURCE UNIT : 15_3 – Mokolo River in A42F to inflow Mokolo Dam, Taaibosspruit, Malmanies, Platbosspruit and Bulspruit tributaries - Quaternary catchment A42F
DESCRIPTION
The IUA is a Class II. EWR site 2 on the Mokolo River is located at the downstream end of the resource unit. The major water user is irrigated agriculture. The main impact on the water resources include irrigation return flows and abstraction weirs. Water quality issues present due to septic tanks used by the game lodges. Rare and endangered mammals occur within the nature reserve contributing to the present state of a B/C, as well as unique fish and invertebrate species.
RESOURCE UNIT : 15_4 – Mokolo Dam to upper portion of A42G (10km downstream of dam): Quaternary catchment A42F, A42G
DESCRIPTION
The IUA is a Class II. EWR site 3 on the Mokolo River is located in this resource unit. This dam is located within a nature reserve and it's a protected area. It supplies Matimba Power Station, Exxaro Coal Mine and Lephalale (town) with domestic water. The dam also supports recreational activities (e.g. angling). Dam releases must be made to support downstream EWR site. The reach below the dam has unique habitat characteristics.
RESOURCE UNIT : 15_5 – Grootspruit, Sand, Venterspruit and Sandspruit tributaries (Mokolo headwater catchment)- Quaternary catchment A42A, A42B
DESCRIPTION
The IUA is a Class II. The main water user in the catchment area is agriculture (tobacco, maize, vegertables, lucern, wheat and seeds for export) and some farm dams – reliance on the rivers. Other activities include game farming and small industries. The main impact on the water resource is irrigation return flows and WWTW discharges town of Alma. Extensive wetland systems occur in the area coupled with the area being a fish support area. Important habitat for Blue Cranes (which have been identified within the Sand River catchment). No rheophilic species occur within these reaches. The fish, small barbs will occur during the wet season. Migration corridor for birds. Wetland systems are important (valley bottom and hillslope seepage wetlands present forming part of the Waterberg system (unique combination of flora and faunal associations)
RESOURCE UNIT : 15_6 – Mokolo River from Dwars river to confluence with Sterkstroom, Klein Vaalwaterspruit, Brakspruit - Quaternary catchment A42E
DESCRIPTION
The IUA is a Class II. EWR site 1b on the Mokolo River is located in the resource unit. This the main stem Mokolo river. The area is important as it plays a role as a corridor for fish.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context/Rationale for RQO/numerical limit
15_1 **Moloko River, Klein Sand, Sondagsloop, Heuningspruit, Dwars, Jim se loop tributaries** **A42C, A42E**	Quantity	Low flows	EWR maintenance low and drought flows: Mokolo River at MOK_EWR1a in A42C NMAR = $84.84x10^6 m^3$ PES=C/D category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Monitoring of Mokolo River at A4H002		Maintenance Low flows (m^3/s)	Drought flows (m^3/s)	Flows specified are to maintain ecological categories of the water resource in present ecological state and meet the Water Resource Class. Required flows as per the Reserve summary table (rule and tab tables).
					Oct	0.110	0.005	
					Nov	0.120	0.005	
					Dec	0.200	0.020	
					Jan	0.550	0.040	
					Feb	0.850	0.060	
					Mar	0.700	0.050	
					Apr	0.500	0.040	
					May	0.350	0.030	
					Jun	0.270	0.020	
					Jul	0.230	0.015	
					Aug	0.180	0.010	
					Sep	0.100	0.005	
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.025 milligrams/litre (mg/l) (50th percentile) Monitoring data – regional			Ecological specification. Present state must be maintained. Require additional baseline data.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)			Ecological specification. Present state must be maintained. Require additional baseline data.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)			Ecological specification. Present state must be maintained. Require additional baseline data.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)			User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.0 (95th percentile)			Ecological specification
			A baseline assessment to determine the present state instream turbidity is required. Limits must be defined to control the impacts of slate mining on the resource.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.			No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxicants must pose no risk to aquatic	Atrazine	≤0.078 milligrams/litre (mg/l)			Ecological specification. Ecological Reserve manual

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			organisms and to human health.			(2008). (Maize)
				Bromoxynil	≤0.010 milligrams/litre (mg/l)	Human health considerations. Australian Drinking Water Guideline (Wheat)
	Habitat	Instream	Habitat condition should be improved from a C/D ecological to a B/C category. Good low flows must be maintained to sustain habitat for substrate and habitat sensitive species. Return flows and abstraction in resource unit must be monitored and controlled to protect the instream habitat.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B/C ≥ 78%	Attainment of prescribed ecological category and Water Resource Class. To support aquatic ecosystem.
		Riparian habitat	Riparian vegetation must be improved from C/D to a C category. Riparian zones must remain in cultivated areas. Cultivation must be managed to prevent loss of riparian zone.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of prescribed ecological category and Water Resource Class. To support aquatic ecosystem and prevent degradation.
	Biota	Fish	Fish community should be improved from a C/D ecological category to a C category. Flow velocity/depth must be maintained for species, *LMOL, BMAR* and *CPRE* and habitat sensitive species, *BRAD, BVIV*.	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62% Sample 15+ species per sample effort Sample 25 *CPRE* and 15 *AURA* in 20min effort (Site EWR1a Dwars)	Attainment of prescribed ecological category and Water Resource Class.
		Semi-aquatic biota	This river reach must be maintained to serve as a habitat for aquatic bird and mammal populations through proper habitat management.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macromacroinvertebrates assemblage must be maintained within a C ecological category condition or improved upon.	Macroinvertebrate Response Assessment Index, and the South African Scoring System Version 5 (SASS5).	Sites: EWR 1a = A4MOKO-VAALW MIRAI EC = C ≥ 62% SASS ≥ 120 ASPT ≥ 5.5 A4SAND-TOPBR: MIRAI EC = C ≥ 62% SASS ≥ 120 ASPT ≥ 6.0 Site DWARS 1a = Rapid EWR site:	Attainment of prescribed ecological category and Water Resource Class. Based on baseline data.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
					MIRAI EC = C ≥ 62% SASS ≥ 120 ASPT ≥ 5.5	
		Diatoms	Diatom assemblage must be maintained within B ecological category or better condition.	Specific Pollution Index	Diatom EC ≥ 82%	Present ecological state.

<table>
<tr><th>Resource Unit</th><th>Component</th><th>Sub-component</th><th>RQO</th><th>Indicator</th><th>Numerical Limit</th><th>Context/Rationale for RQO/numerical limit</th></tr>
<tr><td rowspan="6">15_2

Sterkstroom, Frikkie se Loop

A42D</td><td>Quantity</td><td>Low flows</td><td>EWR maintenance low and drought flows:
Sterkstroom in A42D
NMAR = 43.43x10^{6}m^3
REC=B category

The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.</td><td>Base Flows

Maintenance flows and drought flows.

Monitoring of Sterkstroom at A4H008</td><td>| | Maintenance Low flows (m^3/s) | Drought flows (m^3/s) |
Oct	0.382	0.060
Nov	0.517	0.110
Dec	0.972	0.130
Jan	1.778	0.210
Feb	2.842	0.070
Mar	2.996	0.110
Apr	2.529	0.020
May	1.908	0.020
Jun	1.390	0.050
Jul	1.090	0.110
Aug	0.758	0.080
Sep	0.426	0.060 |</td><td>Flows specified are to maintain ecological categories of the water resource in present ecological state and meet the Water Resource Class set. Required flows as per the Reserve summary table (rule and tab tables).</td></tr>
<tr><td rowspan="5">Quality</td><td rowspan="2">Nutrients</td><td rowspan="2">Instream concentration of nutrients as specified maintained to protect the aquatic ecosystem health and ensure the prescribed ecological category is met.</td><td>Orthophosphate (PO_4^-) as Phosphorus</td><td>≤ 0.015 milligrams/litre (mg/l) (50th percentile)</td><td>Ecological specification. Maintain present state. Require additional baseline data.</td></tr>
<tr><td>Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen</td><td>≤ 0.5 milligrams/litre (50th percentile)</td><td>Ecological specification. Maintain present state. Require additional baseline data.</td></tr>
<tr><td>Salts</td><td>Instream salinity levels as specified must be maintained to protect the aquatic ecosystem health and ensure the prescribed ecological category is met.</td><td>Electrical Conductivity</td><td>≤ 20 milliSiemens/metre (mS/m) (95th percentile)</td><td>Ecological specification. Maintain present state. Require additional baseline data.</td></tr>
<tr><td rowspan="2">System Variables</td><td>pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.</td><td>pH range</td><td>6.5 (5th percentile) and 8.0 (95th percentile)</td><td>Aquatic ecosystem driver.</td></tr>
<tr><td>A baseline assessment to determine the present state instream turbidity is required.</td><td>Turbidity</td><td>A 10% variation from background concentration is allowed. Limits must be determined.</td><td>No baseline data available. Monitoring required to determine present state.</td></tr>
</table>

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
	Habitat	Instream	Habitat diversity should be maintained within a B/C ecological category. Maintain low flows to sustain habitat for substrate and habitat sensitive species and taxa.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC B/C ≥ 78%	Attainment of prescribed ecological category.
		Riparian habitat	Riparian vegetation should be maintained within a B/C ecological category or better condition.	Vegetation Response Assessment Index	VEGRAI EC = B/C ≥ 78%	Attainment of prescribed ecological category and Water Resource Class. Based on baseline data.
	Biota	Fish	The fish community must be maintained in a B/C ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category. Maintain flow velocity/depth for species, *LMOL, BMAR, AURA* and *CPRE* and habitat sensitive species – *CTHE*. Presence of new species: *B. waterbergensis* must be confirmed.	Fish Response Assessment Index (FRAI)	Fish ecology category = B/C FRAI ≥ 78% Sample 9+ species per sample effort Sample 10 *AJOH* and 2 *CTHE* in 20min effort	Attainment of prescribed ecological category and Water Resource Class. Based on baseline data.
		Semi-aquatic biota	This river reach must be maintained to serve as a habitat for aquatic bird and mammal populations through proper habitat management.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a B ecological category or improved upon. .	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5)	Macroinvertebrates EC ≥ 82% (Site A4STER-WELGE)	Maintenance of present ecological state.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context/Rationale for RQO/numerical limit
15_3 **Mokolo River A42F, inflow Mokolo Dam, Taaibosspruit, Malmanies and Bulspruit** **A42F**	Quantity	Low flows	EWR maintenance low and drought flows: Mokolo River at MOK_EWR2 in A42F NMAR = $195.69 \times 10^6 m^3$ PES=B/C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Monitoring of Mokolo River at A4H005		Maintenance Low flows (m^3/s)	Drought flows (m^3/s)	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).
					Oct	0.230	0.008	
					Nov	0.240	0.110	
					Dec	0.370	0.146	
					Jan	0.602	0.201	
					Feb	1.064	0.318	
					Mar	0.953	0.285	
					Apr	0.808	0.252	
					May	0.627	0.207	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
					Jun 0.512 0.181 Jul 0.400 0.120 Aug 0.320 0.008 Sep 0.230 0.005	
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.025 milligrams/litre (mg/l) (50^{th} percentile)	Ecological specification. Present state to be maintained. Require baseline data.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50^{th} percentile)	Ecological specification. Present state to be maintained. Require baseline data.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95^{th} percentile)	Ecological specification. Present state to be maintained. Require baseline data.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95^{th} percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5^{th} percentile) and 8.0 (95^{th} percentile)	Aquatic ecosystem as the driver. Present ate
			A baseline assessment to determine the present state instream turbidity is required. Limits must be defined to control the impacts of slate mining on the resource.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Metolachlor	≤0.30 milligrams/litre (mg/l)	Human health considerations. Australian Drinking Water Guideline (Groundnuts)
	Habitat	Instream	Habitat diversity should be improved from B/C ecological category to a B category. Return flows into habitat must be controlled.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Attainment of prescribed ecological category and Water Resource Class
		Riparian habitat	Riparian vegetation should be improved from B/C ecological category to a B category Maintain riparian zone in cultivated areas, and control cultivation onto riparian zone.	Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Attainment of prescribed ecological category and Water Resource Class

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
	Biota	Fish	The fish community must be maintained in a C ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category. Maintain flow velocity/depth species *CPRE* and habitat sensitive species, *MMAC* and *AJOH*.	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62% Sample 10+ species per sample effort Sample 10 *AJOH* in 20min effort	Attainment of prescribed ecological category and Water Resource Class
		Semi-aquatic biota	This river reach must be maintained to serve as a habitat for aquatic bird and mammal populations through proper habitat management.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Information not available yet. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5)	MIRAI EC = C ≥ 62% SASS ≥ 130 ASPT ≥ 6.0 (Site MOK_EWR2) (A4MOKO-MOKOL, A4MOKO-WITFO)	Attainment of prescribed ecological category. Based on baseline data.
		Diatoms	Diatom assemblage must be maintained within a largely natural condition or improved upon.	Specific Pollution Index	Diatom EC ≥ 82%	Present ecological state. Indicator of health of the system.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
15_4 **Mokolo Dam to upper portion of A42G (10km downstream of dam)**	Quantity	Low flows	EWR maintenance low and drought flows: Mokolo River at MOK_EWR3 in A42G NMAR = 215.995x10^{6}m^3 PES=B/C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Monitoring of Mokolo River at A4H010	See below	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).

	Maintenance Low flows (m^3/s)	Drought flows (m^3/s)
Oct	0.383	0.005
Nov	0.399	0.005
Dec	0.406	0.005
Jan	0.444	0.015
Feb	0.559	0.020
Mar	0.504	0.018
Apr	0.493	0.015
May	0.450	0.010
Jun	0.441	0.008
Jul	0.413	0.006

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
					Aug 0.399 0.005 Sep 0.396 0.005	
		High flows	EWR maintenance high flows: Mokolo River at MOK_EWR3 in A42G NMAR = 215.995x10^{6}m^3 PES=B/C category High flows must be attained as specified to support aquatic ecostem requirements.	Floods High flow also specified as individual flood requirements in terms of size and duration. Monitoring of Mokolo River at A4H010	As per operating rule in Reserve template, section 3.	Flows specified are to support the flood requirements of aquatic species. Percentiles (of required flow rate) determined through EWR determination process as per application of appropriate Reserve models and methodology (rule curves).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.010 milligrams/litre (mg/l) (50th percentile)	Maintainence of present state. Require additional baselibne data.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Maintainence of present state. Require additional baselibne data.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Ecological specification. Require baseline data.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95th percentile)	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.0 (95th percentile)	Ecological specification
			A baseline assessment to determine the present state instream turbidity is required. Limits must be defined to control the impacts of slate mining on the resource.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
	Habitat	Instream	Habitat diversity should be improved from a B/C ecological category to a B category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Attainment of prescribed ecological category. Based on baseline data.
		Riparian habitat	Riparian vegetation should be maintained within the B/C ecological category. Maintain riparian zone with regard to *Syzygium cordatum*	Index of Habitat Integrity, Vegetation Response Assessment Index.	VEGRAI EC = B/C ≥ 78%	Attainment of prescribed ecological category. Based on baseline data.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
	Biota	Fish	Fish community should be maintained within the B/C ecological category. Maintain flow velocity/depth for species *CPRE.*	Fish Response Assessment Index (FRAI)	Fish ecology category = B/C FRAI ≥ 78%	Attainment of prescribed ecological category.
		Semi-aquatic biota	This river reach must be maintained to serve as a habitat for aquatic bird and mammal populations through proper habitat management.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5)	MIRAI EC = C ≥ 62% SASS ≥ 130 ASPT ≥ 6.0 A4MOKO-WWORK	Maintenance of ecological state.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
15_4 Mokolo Dam	Quantity	Dam level	The dam must be managed to protect ecosystem function as well as downstream users. Develop and update operational rules for the dam to sustain optimum dam levels in order to ensure that aquatic ecosystem diversity is maintained. Dam releases are required to meet downstream flows for ecological flow requirements.	Minimum operating level required in dam	Operation rules as applicable. Minimal level to sustain aquatic ecosystem (15-18%).		
	Quality	Nutrients	Concentration of orthophosphate must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as an oligotrophic system.	Orthophosphates	≤ 0.010 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Mokolo Dam is still an oligotrophic system with low nutrient concentrations and the system must be maintained at these levels.
			Concentration of total phosphorous must be maintained to sustain ecosystem health and the water quality requirements of water users. The dam must be maintained as an oligotrophic system.	Total phosphorous	≤ 0.025 mg/ℓ 50th percentile	Bi-weekly sub-surface, integrated (0-5m hosepipe) water collection in prewashed plastic bottles.	Mokolo Dam is still an oligotrophic system with low nutrient concentrations and the system must be maintained at these levels.
			Concentration of nitrate & nitrite must be maintained to sustain ecosystem health and the water	Nitrite& Nitrate	≤ 0.50 mg/ℓ N 95th percentile	Bi-weekly sub-surface and integrated (0-5m hosepipe) water	Mokolo Dam is still an oligotrophic system with low nutrient concentrations and the system

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Sampling method and frequency	Context/Rationale for RQO/numerical limit
			quality requirements of water users. The dam must be maintained as an oligotrophic system.			collection in prewashed plastic bottles	must be maintained at these levels.
		Salts	The salinity in the dam must be maintained to support ecosystem health and the water quality requirements of the downstream users.	Electrical Conductivity	≤ 20 mS/m 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	The electrical conductivity of the system should be maintained.
		Pathogens	The presence of pathogens should pose no risk to human health.	*Escherichia coli* (*E.coli*)	130 counts/100 millilitres (ml) (95^{th} percentile)	Sub-surface water collection in glass bottles. Analysis must be undertaken within 24hours of the sample collection. Monthly sampling	User specification. Limit is the target water quality range for full contact recreational use – South African Water Quality Guidelines (1996).
		System Variables	The water must be acceptable for recreational use.	pH	6.5 – 9.0 95th percentile	Bi-weekly sub-surface water collection in prewashed plastic bottles.	Direct contact recreational use must cause minimal irritation.
			Increased clarity with reading	Turbidity	≥0.4 m 5th percentile	Bi-weekly Secchi disc reading.	Water clarity is an indication of improved water quality
	Habitat	Dam Habitat	To manage the water resource for maintenance of aquatic ecosystem diversity (instream, biotic aqnd semi-aquatic species, riparian zones). Conserve, maintain, rehabilitate and establish artificial shoreline and riparian zones. The natural riparian zone should be preserved as far as possible to ensure necessary habitat.	Riparian vegetation Health	70% riparian vegetation cover	Riparian zone vegetation survey every three years.	The dam provides important refuge habitat for aquatic and semi-aquatic biota (mammals, birds, fish, etc.) and all components of its management (recreation, eco-tourism, abstraction, water quality impacts, dam releases).
	Biota	Fish	The fish diversity and quantities must be maintained.	Fish diversity and quantity	The fish population must be monitored through health assessment studies. Suitable abundances should be determined. Target fish stocks should be determined.	Fish survey determining diversity and quantity should be conducted every two years.	This will ensure that the system remain sustainable for ecological and recreational purposes.
		Periphyton/ Phytoplankton	The Chl *a* concentration must be maintained in an oligotrophic state.	Chl a	≤10µg/ℓ 50th percentile	Bi-weekly integrated (0-5m hosepipe) water collection.	The oligotrophic state of the Mokolo Dam must be maintained.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
15_5 **Grootspruit and Sandspruit tributaries (Mokolo headwater catchment)** **A42A, A42B**	Quantity	Low flows	EWR maintenance low and drought flows: Grootspruit in A42B NMAR = 27.8 x$10^6 m^3$ REC= D category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users	Baseflows Maintenance flows and drought flows. Monitoring of discharge during biological surveys.	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s): Oct 0.271 0.136 Nov 0.269 0.135 Dec 0.291 0.148 Jan 0.345 0.180 Feb 0.401 0.213 Mar 0.384 0.203 Apr 0.338 0.160 May 0.320 0.120 Jun 0.311 0.160 Jul 0.304 0.156 Aug 0.299 0.152 Sep 0.286 0.145	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.05 milligrams/litre (mg/l) (50^{th} percentile)	Ecological specification. Require baseline data.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.7 milligrams/litre (50^{th} percentile)	Ecological specification. Require baseline data.
		Salts	Instream salinity levels as specified must be attained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m) (95^{th} percentile)	Ecological specification. Require baseline data.
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5^{th} percentile) and 8.0 (95^{th} percentile)	Ecological specification.
			A baseline assessment to determine the present state instream turbidity is required. Limits must be defined to control the impacts of slate mining on the resource.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Atrazine	≤0.078 milligrams/litre (mg/l)	Human health as the driver. (Maize)
				Propiconazole	≤ 0.10 milligrams/litre (mg/l)	(Wheat). Human health considerations. Australian Drinking Water Guideline
	Habitat	Instream	Habitat diversity should be maintained within a C ecological category. Connectivity for migratory species must be maintained.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C ≥ 62%	Attainment of prescribed ecological category and Water Resource Class

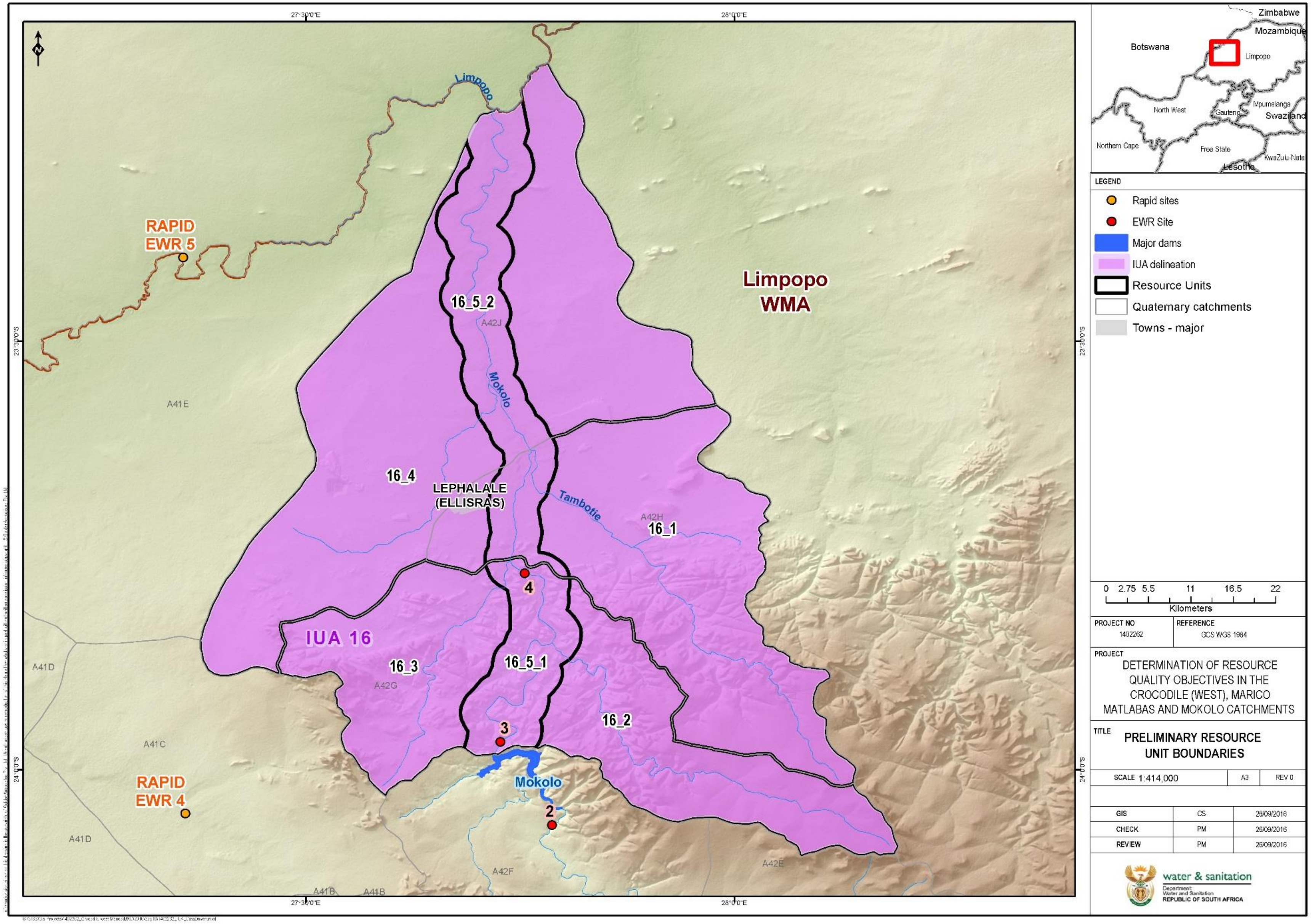
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
		Riparian habitat	Riparian vegetation should be maintained in a C ecological category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = C ≥ 62%	Attainment of prescribed ecological category and Water Resource Class.
	Biota	Fish	Fish community should be maintained within the C ecological category. Maintain flow velocity/depth for species *CPRE, AURA, LCYL* and habitat sensitive species *MMAC* and *AJOH*.	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62% Sample 10+ species per sample effort	Attainment of prescribed ecological category and Water Resource Class.
		Semi-aquatic biota	This river reach must be maintained to serve as a habitat and migration corridor for aquatic bird populations through proper habitat management. Manage riparian zone – remove alien vegetation, rehabilitate with indigenous species.	Aquatic birds species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a D category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5)	MIRAI EC = D ≥ 42% SASS ≥ 80 ASPT ≥ 5.5 (site A4GROO-GROOT)	Attainment of Water Resource Class and prescribed ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
15_6 **Mokolo River from Dwars River to confluence with Sterkstroom, Klein Vaalwaterspruit** **A42E**	Quantity	Low flows	EWR maintenance low and drought flows: Mokolo River at MOK_EWR1b in A42E NMAR = 135.03x$10^6$$m^3$ PES=B/C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users	Base Flows Maintenance flows and drought flows. Monitoring of discharge of Mokolo River during biological surveys	Maintenance Low flows (m^3/s) | Drought flows (m^3/s) Oct 0.120 | 0.005 Nov 0.120 | 0.005 Dec 0.320 | 0.020 Jan 0.700 | 0.050 Feb 1.400 | 0.080 Mar 1.150 | 0.065 Apr 0.850 | 0.050 May 0.600 | 0.040 Jun 0.450 | 0.020 Jul 0.320 | 0.015 Aug 0.250 | 0.010 Sep 0.120 | 0.005	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified must maintained to	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.020 milligrams/litre (mg/l) (50th percentile)	Ecological specification. Maintain present state. Need additional baseline data

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			protect the aquatic ecosystem health and ensure the prescribed ecological category is met.	Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.5 milligrams/litre (50th percentile)	Ecological specification. Maintain present state. Need additional baseline data
		Salts	Instream concentration of salinity must be maintained to protect present ecological state and the aquatic ecosystem health.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Maintain present state. Need additional baseline data.
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.0 (95th percentile)	Ecological specification.
			A baseline assessment to determine the present state instream turbidity is required. Limits must be defined to control the impacts of slate mining on the resource.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). (Maize)
				Propiconazole	≤ 0.10 milligrams/litre (mg/l)	(Wheat). Human health considerations. Australian Drinking Water Guideline
	Habitat	Instream	Habitat diversity should improve from a B/C ecological category to a B category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Attainment of prescribed ecological category
		Riparian habitat	Riparian vegetation should be maintained within a B/C ecological category or better condition.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = B/C ≥ 78%	Attainment of prescribed ecological category
	Biota	Fish	Fish community should be maintained within a B/C ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = B/C FRAI ≥ 78%	Attainment of prescribed ecological category
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within B/C ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System 5 (SASS5)	MIRAI EC = B/C ≥ 78% SASS ≥ 140 ASPT ≥ 6.0 (MOK_EWR1b in A42E)	Attainment of prescribed ecological category. Baseline data.

6.1.18 LOWER MOKOLO

RU	Delineation	Catchment
16_1	Tambotie River catchment	A42H (major portion -eastern)
16_2	Poer se Loop catchment	A42G
16_4	Sandloop	A42J and remaining portion of A42H
16_5_1	Mokolo main stem - Mokolo from below EWR3 to the Tambotie confluence	A42 G, A42H, A42J (along main stem river)
16_5_2	Mokolo main stem - from Tambotie confluence to Limpopo.	A42J along main stem



Limpopo
RAPID EWR 5
Limpopo WMA
16_5_2
A42J
Mokolo
A41E
16_4
LEPHALALE (ELLISRAS)
Tambotie
A42H
16_1
4
IUA 16
16_3
16_5_1
A41D
A42G
16_2
3
A41C
Mokolo
2
RAPID EWR 4
A41D
A42F
A42E
A41B
27°30'0"E
28°0'0"E
23°30'0"S
24°0'0"S
Zimbabwe
Mozambique
Botswana
Limpopo
North West
Gauteng
Mpumalanga
Swaziland
Northern Cape
Free State
KwaZulu-Natal
Lesotho
LEGEND
Rapid sites
EWR Site
Major dams
IUA delineation
Resource Units
Quaternary catchments
Towns - major
0 2.75 5.5 11 16.5 22
Kilometers
PROJECT NO 1402262
REFERENCE GCS WGS 1984
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
PRELIMINARY RESOURCE UNIT BOUNDARIES
SCALE 1:414,000
A3
REV 0
GIS CS 29/09/2016
CHECK PM 29/09/2016
REVIEW PM 29/09/2016
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

IUA 16 – Lower Mokolo
RESOURCE UNIT : 16_1–- Tambotie River catchment: Quaternary catchment A42H (major portion)
DESCRIPTION
The IUA is a Class II. This catchment includes the D'Nyala protected area and nature reserve and has a Present State of a B. It further includes game farms and high in tourism. Irrigated agriculture exists but on a smaller scale than other catchments. Crops are maize, lucern, vegetables. Sand mining activities and farm industries are also present. Fish species and aquatic macroinvertebrates occur along this tributary. Includes the Tambotie flood plain. A number of dams and weirs are present in the upper part of the catchment.
RESOURCE UNIT : 16_2 – Poer se Loop: Quaternary catchment A42G
DESCRIPTION
The IUA is a Class II. It has a Present Ecological State of a B category. It includes large game farms and related activites, and is high in tourism. Upper part of the river gets flow opposed to the lower section which becomes dry during dry seasons. Includes wetland systems in upper reaches.
RESOURCE UNIT : 16_4 – Sandloop - Quaternary catchment A42J and remaining portion of A42H
DESCRIPTION
The IUA is a Class II. Catchment area includes the Medupi and Matimba power stations, Grootegeluk coal mine, Marapong and Lephalale towns. Impacts on this system include coal mining, the power stations, coal bed methane extraction, impacts from the towns as well as agriculture. Irrigated agriculture is present with crops including maize, vegetables and citrus. Water quality impacts are a concern, with deterioration observed. Serious impacts of local groundwater resources due to dewatering and future acid mine drainage discharges. The Marapong (Zongesien), Nelsonskop (Eskom) and Paarl WWTWs are situated in the cachment (oxidation ponds of Paarl and Marapong discharging into the Mokolo River).
RESOURCE UNIT : 16_5_1 – Mokolo main stem - Mokolo from below EWR3 to the Tambotie confluence: Quaternary catchment A42G, H along main stem
DESCRIPTION
The IUA is a Class II. EWR site MOK_4 on the Mokolo River are located in this resource unit. Important vegetation namely *Syzygium cordatum* (Water Berry) and *Schotia brachypetala* (huilboerboon) which continues in the rocky areas. Major sand mining is occurring within the Mokolo main stem catchment. This has resulted in siltation and disturbance of substrate. Reed encroachment also present. Furthermore high density Anthocercis zambesiaca (Nyala tree) are present. These are good indicators of groundwater and thus assume that the large specimens are very dependent on groundwater. Downstream of the dam there are a number of unique wetland pans. These pans are most of the time not filled up by flow from the river but rather by water flowing from the surrounding ridge of low hills along the river during heavy rainfall periods. Some are quite sizeable and provided habitat for water birds. Mokolo River floodplain present.
RESOURCE UNIT : 16_5_2 - Mokolo main stem - from Tambotie confluence to Limpopo.: Quaternary catchment A42J (along main stem river)
DESCRIPTION
The IUA is a Class II. Abstraction activities is high in this main stem with sand mining being a considerable issue in the Lepahlale area. Other activities include irrigated agriculture (mainly maize, wheat, vegetables and some grapes and citrus), game farms and eco-tourism. Sand mining activities and irrigated return flows are impacting on the Mokolo river. Flow dependent fish occur (*BMAR, LMOL*). Owing to the floodplain, there are oxbow lakes. There are very large Faidherbia albida (Ana trees). Impact of land use on groundwater needs to be considered to ensure resource sustainability. Lower part of Tambotie River floodplain is present in the resource unit.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
16_1 **Tambotie River** **A42H (major portion-eastern)**	Habitat	Instream	Habitat diversity should be maintained in a B ecological category.	Index of Habitat Integrity	Instream Habitat Integrity EC = B ≥ 82%	Maintenance of ecological integrity. Present ecological state
		Riparian habitat	Riparian vegetation should be maintained within B ecological category. Maintain state of riparian zone.	Index of Habitat Integrity	VEGRAI EC = B ≥ 82%	Maintenance of ecological integrity. Present ecological state
	Biota	Fish	Fish community should be maintained within a B ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category. Maintain flow velocity/depth for species *CPRE, CPAR, LCYL, LRUD* and habitat sensitive species *MMAC* and *AJOH*.	Fish Response Assessment Index (FRAI)	Fish ecology category = B FRAI ≥ 82% Sample 20+ species per sample effort Sample 5 *BBRI* and 3 *PCAT* in 20min effort	Maintenance of ecological integrity. Present ecological state

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
16_2 **Poer-se-Loop (upper catchment)** **A42G**	Habitat	Instream	Habitat diversity must be maintained in a B ecological category. Monitor abstraction and flow regime.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Maintenance of ecological integrity. Present ecological state.
		Riparian habitat	Riparian vegetation must be maintained within B ecological category. Maintain state of riparian zone.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Maintenance of ecological integrity. Present ecological state
	Biota	Fish	Fish community should be maintained within a B ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category. Maintain flow velocity/depth for flow dependent and habitat sensitive species. (upper catchment)	Fish Response Assessment Index (FRAI)	Fish ecology category B FRAI ≥ 82% Sample 25+ species per sample effort Sample 5 *BBRI* and 3 *PCAT* in 20min effort	Maintenance of ecological integrity. Present ecological state

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
16_4 **Sandloop**	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.05 milligrams/litre (mg/l) (50th percentile)	Present ecological state maintained. Require baseline data.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.1 milligrams/litre (50th percentile	Present ecological state maintained. Require baseline data.
		Salts	Instream concentration of salinity must	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m)	Maintain present water quality.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
A42J and remaining portion of A42H			be maintained to protect present ecological state and the aquatic ecosystem health.		(95^{th} percentile)	
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5^{th} percentile) and 8.5 (95^{th} percentile)	Aquatic ecosystem as the driver. Present ate
			A baseline assessment to determine the present state instream turbidity is required. Limits must be defined to control the impacts of slate mining on the resource.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Atrazine	≤0.078 milligrams/litre (mg/l)	Human health is the driver. Aquatic ecosystem is the driver. Ecological specification. Ecological Reserve manual (2008). No monitoring data.
				Imidacloprid	≤ 0.000038 milligrams/litre (mg/l)	Human health considerations. Environment Protection Authority of New Zealand – Environmental Exposure Limit
				Aluminium (Al)	≤ 0.062 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0057 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0048 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity should be maintained in a B ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Maintenance of ecological integrity. Present ecological state.
		Riparian habitat	Riparian vegetation should be maintained within B ecological category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Maintenance of ecological integrity. Present ecological state

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
16_5_1 **Mokolo main stem to Tambotie confluence below (bedrock reach (sand deposit to, wider portion of river)** **A42G along main stem river**	Quantity	Low flows	EWR maintenance low and drought flows: Mokolo River at MOK_EWR4 in A42G NMAR = $253.5x10^6m^3$ PES=C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Monitoring of Mokolo River at A4H013	Month / Maintenance Low flows (m^3/s) / Drought flows (m^3/s): Oct 0.489 0 Nov 0.508 0 Dec 0.508 0 Jan 0.540 0 Feb 0.657 0 Mar 0.595 0 Apr 0.589 0 May 0.547 0 Jun 0.543 0 Jul 0.512 0 Aug 0.500 0 Sep 0.504 0	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).
		High flows	EWR high flows: Mokolo River at MOK_EWR4 in A42G NMAR = $253.5x10^6m^3$ REC=C category High flows must be met as specified to support aquatic ecosystem requirements.	Floods Monitoring of Mokolo River at A4H013	As per operating rule in Reserve template, section 3.	Flows specified are to support the flood requirements of aquatic species. Percentiles (of required flow rate) determined through EWR determination process as per application of appropriate Reserve models and methodology (rule curves).
	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health, and maintain ecological status.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.02 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem driver. Present state, require additional baseline data
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.05 milligrams/litre (50th percentile)	Aquatic ecosystem driver. Present state, require additional baseline data
		Salts	Instream concentration of salinity must be maintained to protect present ecological state and the aquatic ecosystem health.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Maintain present state good water quality, require additional baseline data.
				Sulphate	≤ 20 milligrams/litre (95th percentile)	
				Sodium	≤ 20 milligrams/litre (95th percentile)	
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Ecological specification. Ecological Reserve manual (2008).
			A baseline assessment to determine the present state instream turbidity is	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine

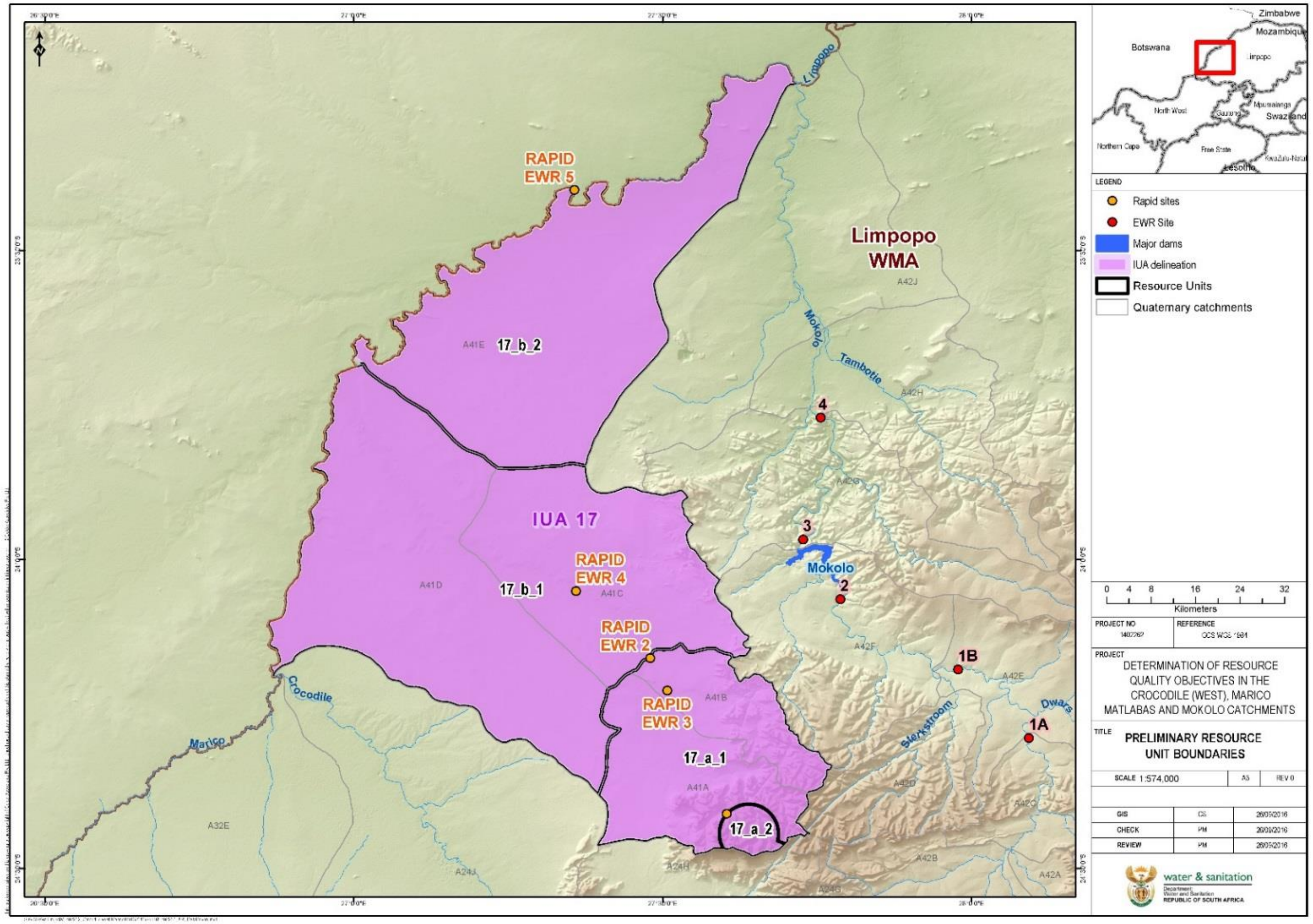
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			required.			present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
				Imidacloprid	≤ 0.000038 milligrams/litre (mg/l)	Human health considerations. Environment Protection Authority of New Zealand – Environmental Exposure Limit
				Simazine	≤0.002 milligrams/litre (mg/l)	(Grapes) Human health considerations. WHO Drinking Water Guidelines
	Habitat	Instream	Habitat diversity must be improved from a B/C ecological category to a B category. Monitor abstraction and flow regime.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Attainment of Water Resource Class and prescribed ecological category
		Riparian habitat	Riparian vegetation must be improved from a C ecological category to a B/C category. Ensure undergrowth maintained to allow for recruitment of *Xanthocercis zambesiaca* during VEGRAI assessments. Maintain riparian zone	Index of Habitat Integrity, Vegetation Response Assessment Index.	VEGRAI EC = B/C ≥ 80%	Attainment of Water Resource Class and prescribed ecological category.
	Biota	Fish	Fish community must be improved from a C ecological category to a B category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category. Maintain flow velocity/depth for flow dependent and habitat sensitive species.	Fish Response Assessment Index (FRAI)	Fish ecology category = B/C FRAI ≥ 78% Sample 25+ species per sample effort Sample 5 *BBRI* and 3 *PCAT* in 20min effort	Attainment of Water Resource Class and prescribed ecological category.
		Semi-Aquatic biota	The suitability of this stretch of river to serve as a habitat for aquatic bird and mammal populations must be maintained through proper habitat management	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5)	MIRAI macroinvertebrates EC = C ≥ 62% SASS ≥ 80 ASPT ≥ 5.2 Site A4MOKO-WITKO	Attainment of Water Resource Class and prescribed ecological category.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
16_5_2 **Mokolo main stem from Tambotie confluence to Limpopo A42H, A42J along main stem river**	Quantity	Low flows	Maintain flows in river to support wetland requirements at in A42J	Base Flows	Wetland requirements for the flood plain – Monitor flows at new weir (was A4H014)	
	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health, and maintain ecological status.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.01 milligrams/litre (mg/l) (50th percentile)	Maintain present state good water quality, require additional baseline data.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.05 milligrams/litre (50th percentile)	Maintain present state good water quality, require additional baseline data.
		Salts	Instream concentration of salinity must be maintained to protect present ecological state and the aquatic ecosystem health.	Electrical Conductivity	≤ 30 milliSiemens/metre (mS/m) (95th percentile)	Maintain present state good water quality, require additional baseline data.
				Sulphate	≤ 20 milligrams/litre (95th percentile)	
				Sodium	≤ 20 milligrams/litre (95th percentile)	
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem as the driver
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Aquatic ecosystem is the driver. Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Aluminium (Al)	≤ 0.062 milligrams/litre (mg/l) (95th percentile)	Ecological specifications or user Strictest of Ecological specifications for all metals except manganese. Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0057 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0048 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
				Atrazine	≤0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
				Imidacloprid	≤ 0.000038 milligrams/litre (mg/l)	Human health considerations. Environment Protection Authority of New Zealand – Environmental Exposure Limit
				Simazine	≤0.002 milligrams/litre (mg/l)	(Grapes) Human health

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
						considerations. WHO Drinking Water Guidelines
	Habitat	Instream	Habitat diversity must be improved from a D ecological category to a C/D category. Monitor abstraction and flow regime Maintain good connectivity to upstream areas (16_5_1).	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = C/D ≥ 58%	Attainment of Water Resource Class and prescribed ecological category.
		Riparian habitat	Riparian vegetation must be improved from a D ecological category to a C/D category. Ensure undergrowth maintained to allow for recruitment of *Xanthocercis zambesiaca* during VEGRAI assessment.	Index of Habitat Integrity, Vegetation Response Assessment Index.	VEGRAI EC = C/D ≥ 58%	Attainment of Water Resource Class and prescribed ecological category.
	Biota	Fish	Fish community must be improved from a D ecological category to a C/D category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = C/D FRAI ≥ 58% Sample 12+ species per sample effort	Attainment of Water Resource Class and prescribed ecological category.
		Semi-aquatic biota	This river reach must be maintained to serve as a habitat for aquatic bird and mammal populations through proper habitat management. Maintain riparian zone.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Requires inter-departmental and organisational co-ordination.

6.1.19 MOTHLABATSI/MAMBA

RU	Delineation	Catchment
17a_1	Mamba River	A41B
17a_2	Mothlabatsi River, Matlabas	A41A, A41B
17a_3	Headwaters Mothlabatsi (Matlabas-Zyn-Kloof, peatlands)	A41A (south eastern)



IUA 17a – Mothlabatsi/Mamba
RESOURCE UNIT : 17a_1 – Mamba River: Quaternary catchment A41B
DESCRIPTION
The IUA is a Class I. EWR site 3 on the Mamba River is located in the resource unit PES of B/C ecological category. Area is primarily eco-tourism. Groundwater is the major source of domestic water supply. *B. waterburgensis* (secret fish) has been noted to occur in the Mamba.
RESOURCE UNIT : 17a_2 - Mothlabatsi/Matlabas: Quaternary catchment A41A, A41B
DESCRIPTION
The IUA is a Class I. EWR site 2 on the Matlabas River is located at the outlet of the resource unit. The Matlabas River flows from the Marakele Nature Reserve (Mothlabatsi) with limited impacts through game farms, PES of a C category mainly due to farm dams and weirs. Area is primarily eco tourism, with some irrigated agriculture in the lower reaches of the catchment. Groundwater is the major source of domestic water supply. The system is a fish support area with limited impacts.
RESOURCE UNIT : 17a_3 – Headwaters Mothlabatsi (Matlabas-Zyn-Kloof, peatlands): Quaternary catchment A41A (south eastern)
DESCRIPTION
The IUA is a Class I. EWR site 1 on the Matlabas-Zyn-Kloof is located in the resource unit The Mothlabatsi River flows through the Marakele Nature Reserve (protected area), with a PES of B category, This resource unit comprises the headwaters of the Mothlabatsi. Area is a fish support area and within a protected area with limited impacts. Large wetlands occur within this IUA. Flow dependent fish species (AURA) in Matlabas Zyn Kloof. Isolated population of *CTHE.*

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
17a_1 **Mamba River** **A41B**	Quantity	Low flows	EWR maintenance low and drought flows: Mamba River at MAT_EWR3 in A41B NMAR = $9.54 \times 10^6 m^3$ REC=B/C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows. Monitoring of discharge of Mamba River during biological surveys	Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct 0.034 0.004 Nov 0.047 0.007 Dec 0.072 0.014 Jan 0.104 0.021 Feb 0.149 0.016 Mar 0.129 0.011 Apr 0.090 0.011 May 0.058 0.004 Jun 0.045 0.011 Jul 0.039 0.011 Aug 0.035 0.011 Sep 0.030 0.007	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified maintained to protect the aquatic ecosystem health and the ecological integrity of the system.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.015 milligrams/litre (mg/l) (50th percentile)	Need to maintain present water quality state. Require addionall baseline data.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.25 milligrams/litre (50th percentile)	Need to maintain present water quality state. Require addionall baseline data.
		Salts	Instream salinity levels as specified must be maintained to protect the aquatic ecosystem health and ecological integrity of the system.	Electrical Conductivity	≤ 20 milliSiemens/metre (mS/m) (95th percentile)	Need to maintain present water quality state. Require addionall baseline data.
	Habitat	Instream	Habitat diversity must be maintained in a B/C ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model Method and Model (RHAMM)	Instream Habitat Integrity EC= B/C ≥ 78%	Maintenance of ecological integrity. Present ecological state.
		Riparian habitat	Riparian vegetation must be maintained in a B/C ecological category. Ensure no development into riparian zone.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = B/C ≥ 78%	Maintenance of ecological integrity. Present ecological state.
	Biota	Fish	Fish community must be maintained within a C ecological category. Maintain low flow regime to accommodate flow	Fish Response Assessment Index (FRAI).	Fish ecology category = C FRAI ≥ 62% Sample 7+ species per sample effort.	Maintenance of ecological integrity. Present ecological state.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			velocity and depth classes for flow dependent species.		Sample 8 *AURA* and 2 *CTHE* during sampling effort	
		Semi-aquatic biota	This river reach must be maintained to serve as a habitat and migration corridor for aquatic bird populations through proper habitat management. Protected riparian zone – no encroachment into riparian.	Aquatic birds species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5)	MIRAI EC = C ≥ 62% SASS ≥ 130 ASPT ≥ 5.5	Present ecological state

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	
17a_2 **Mothlabatsi/ Matlabas River** **A41A, A41B**	Quantity	Low flows	EWR maintenance low and drought flows: Matlabas at MAT_EWR2 in A41C NMAR = $32.80 \times 10^6 m^3$ REC=B/C category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem.	Base Flows Maintenance flows and drought flows. Monitoring of discharge of Matlabas River at A4H004	(see monthly flows below)	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients as specified maintained to protect the aquatic ecosystem health and the ecological integrity of the system.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.015 milligrams/litre (mg/l) (50th percentile)	Need to maintain present water quality state. Require addionall baseline data.
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.25 milligrams/litre (50th percentile)	Need to maintain present water quality state. Require addionall baseline data.
		Salts	Instream salinity levels as specified must be maintained to protect the aquatic ecosystem health and ecological integrity of the system.	Electrical Conductivity	≤ 20 milliSiemens/metre (mS/m) (95th percentile)	Need to maintain present water quality state. Require addionall baseline data.
	Habitat	Instream	Habitat diversity must be improved	Index of Habitat Integrity,	Instream Habitat Integrity EC = B/C ≥	Attainment of Water Resource Class

	Maintenance Low flows (m^3/s)	Drought flows (m^3/s)
Oct	0.153	0.007
Nov	0.178	0.012
Dec	0.220	0.080
Jan	0.280	0.101
Feb	0.373	0.095
Mar	0.330	0.116
Apr	0.265	0.077
May	0.208	0.071
Jun	0.193	0.070
Jul	0.179	0.065
Aug	0.168	0.034
Sep	0.154	0.008

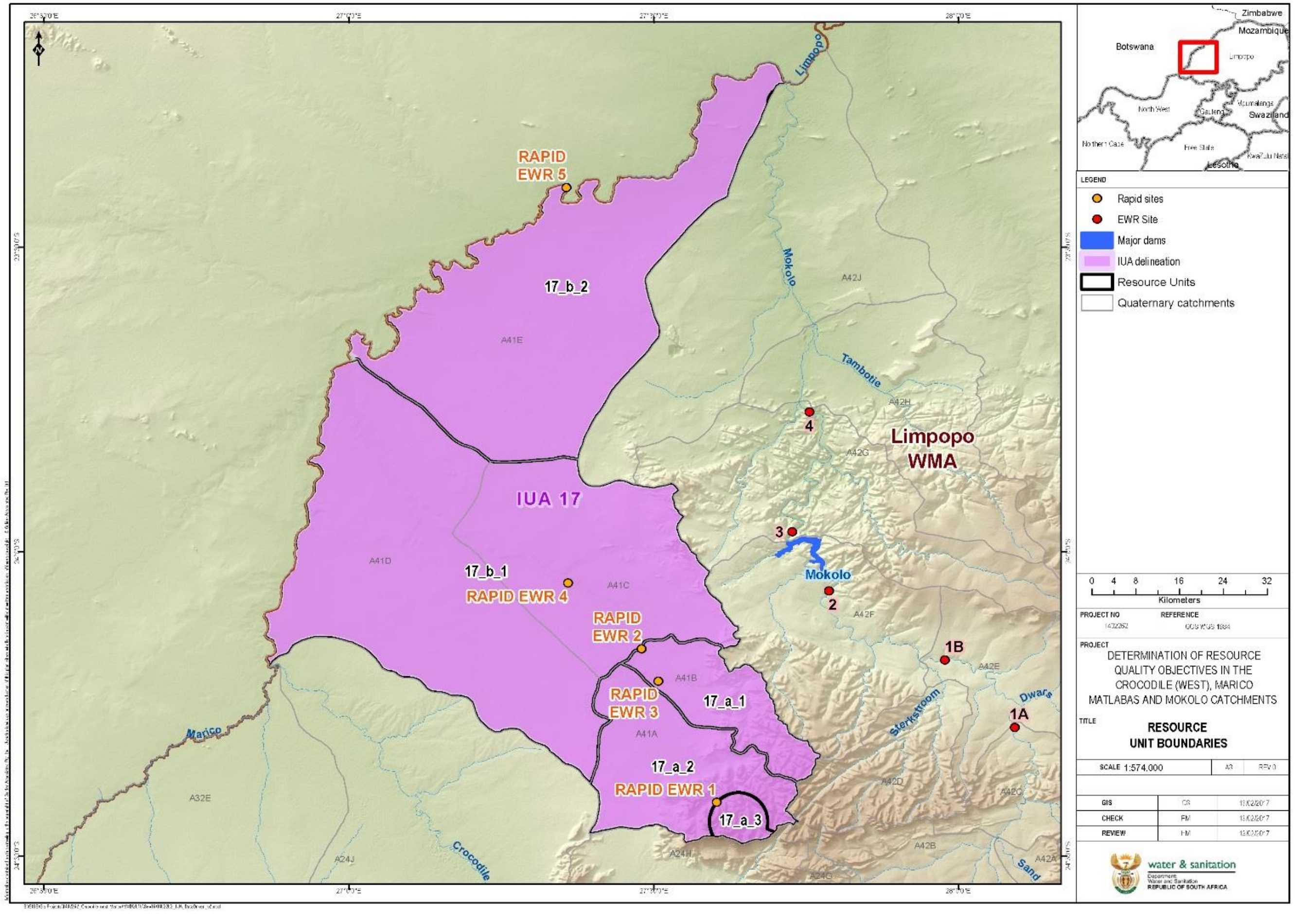
Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	
			from a C ecological category to a B/C category.	Rapid Habitat Assessment Method and Model (RHAMM)	78%	and prescribed ecological category.
		Riparian habitat	Riparian vegetation must be maintained in a C ecological category.	Index of Habitat Integrity, Vegetation Response Assessment Index.	VEGRAI EC = C ≥ 62%	Attainment of Water Resource Class and prescribed ecological category
	Biota	Fish	Fish community must be maintained within a C ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category.	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62%	Attainment of Water Resource Class and prescribed ecological category.
		Semi-aquatic biota	This river reach must be maintained to serve as a habitat for aquatic bird and mammal populations through proper habitat management. Maintain riparian zone.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System 5 (SASS5)	MIRAI EC = C ≥ 62% SASS ≥ 140 ASPT ≥ 5.5	Attainment of Water Resource Class and prescribed ecological category. Baseline data.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit			Context/Rationale for RQO/numerical limit
17a_3 **Headwaters Mothlabatsi (Matlabas-Zyn-Kloof, peatlands)** **A41A**	Quantity	Low flows	EWR maintenance low and drought flows: Matlabas Zyn Kloof at MAT_EWR1 in A41A NMAR = $5.23 \times 10^6 m^3$ REC=A category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem	Base Flows Maintenance flows and drought flows. Monitoring of discharge of Matlabas Zyn Kloof during biological surveys		Maintenance Low flows (m^3/s)	Drought flows (m^3/s)	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).
					Oct	0.053	0.022	
					Nov	0.057	0.027	
					Dec	0.063	0.030	
					Jan	0.075	0.037	
					Feb	0.094	0.041	
					Mar	0.086	0.037	
					Apr	0.076	0.031	
					May	0.065	0.030	
					Jun	0.065	0.033	
					Jul	0.061	0.032	
					Aug	0.060	0.031	
					Sep	0.056	0.030	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
	Habitat	Instream	Habitat diversity must be improved from a B ecological category to an A category.	Index of Habitat Integrity	Instream Habitat Integrity EC = A ≥ 90%	Attainment of Water Resource Class and prescribed ecological category.
		Riparian habitat	Riparian vegetation must be maintained in a B ecological category.	Index of Habitat Integrity, Vegetation Response Assessment Index.	VEGRAI EC = B ≥ 82%	Attainment of Water Resource Class and prescribed ecological category.
	Biota	Fish	Fish community must be maintained within a B ecological category. Maintain low flow regime to accommodate flow velocity and depth classes for flow dependent species.	Fish Response Assessment Index (FRAI).	Fish ecology category = B FRAI ≥ 82% Sample 5+ species per sample effort. Sample 8 *AURA* during sampling effort	Attainment of Water Resource Class and prescribed ecological category.

6.1.20 MATLABAS

RU	Delineation	Catchment
17b_1	Matlabas	A41D, A41C
17b_2	Catchment area including Steenbokpan (excluding Limpopo River)	A41E



IUA 17b – Matlabas
RESOURCE UNIT : 17b_1–- Matlabas River: Quaternary catchment A41C, A41D
DESCRIPTION
The IUA is a Class II. Rapid site EWR 4 on the Matlabas River is present in this resource unit. The primary land use is conservation and game farming. A small community is reliant on the river for domestic water supply (Kiesel). This IUA has been earmarked for future coal mining developments. FEPA wetlands are present. Migratory corridor to the Limpopo for the bird species. There is the Matlabas peatland/mire and valleybottom wetlands present and includes Aslaagte. The Matlabas transforms into a wide plain in the downstream areas (last 50km) when the river leaves the mountainous area up to Limpopo confluence. In some areas this plain is up to 1,5 km wide. When the lower sections of the Matlabas at the confluence with the Limpopo is in flood, it forms a large floodplain (important features). Large oxbows linked to the Limpopo River are present which flow once flooded. Irrigation exists in these areas but because of the non-availability of surface water the water is abstracted from boreholes along the flood plain. There are also a number of dams and weirs in the river. Crops are mainly lucern, maize and vegetables.
RESOURCE UNIT : 17b_2 – Catchment area including Steenbokpan (excluding Limpopo River): Quaternary catchment A41E
DESCRIPTION
The IUA is a Class II. A large wetland system is indicated on the maps associated with the lower Matlabas River. The Steenbokpan area has been earmarked for future coal mining in this IUA. Small communities of Steenbokpan and Sandbult are located in the catchment.

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
17b_1 **Matlabas** **A41D, A41C**	Quantity	Low flows	EWR maintenance low and drought flows: Matlabas at MAT_EWR4 in A41C NMAR = 35.58x10^{6}m^3 REC=B category The maintenance low flows and drought flows must be attained to support the aquatic ecosystem	Base Flows Maintenance flows and drought flows. Monitoring of discharge of Matlabas River during biological surveys	Month: Maintenance Low flows (m^3/s) / Drought flows (m^3/s) Oct: 0.151 / 0.007 Nov: 0.178 / 0.016 Dec: 0.225 / 0.072 Jan: 0.285 / 0.092 Feb: 0.398 / 0.100 Mar: 0.339 / 0.110 Apr: 0.266 / 0.077 May: 0.208 / 0.066 Jun: 0.192 / 0.061 Jul: 0.178 / 0.056 Aug: 0.166 / 0.034 Sep: 0.151 / 0.008	Flows specified are to maintain ecological category of aquatic ecosystem in prescribed ecological state. Required flows as per the Reserve summary table (rule and tab tables).
	Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health, and maintain ecological status.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.050 milligrams/litre (mg/l) (50th percentile)	Aquatic ecosystem is the driver. Mainain good quality present ecological state. Require baseline data.(u/s site present state).
				Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.07 milligrams/litre (50th percentile)	Aquatic ecosystem is the driver. Mainain good quality present ecological state. Require baseline data.(u/s site present state).
		Salts	Instream concentration of salinity must be maintained to protect present ecological state and the aquatic ecosystem health.	Electrical Conductivity	≤ 40 milliSiemens/metre (mS/m) (95th percentile)	Aquatic ecosystem is the driver. Mainain good quality present ecological state. Require baseline data.(u/s site present state).
				Sulphate	≤ 20 milligrams/litre (50th percentile)	
		System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 8.5 (95th percentile)	Aquatic ecosystem as the driver
			A baseline assessment to determine the present state instream turbidity is required.	Turbidity	A 10% variation from background concentration is allowed.	No baseline data available. Monitoring required to determine present state.
			Dissolved oxygen levels must be attained to support the aquatic ecosystem.	Dissolved oxygen	≥ 6 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008).
		Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human	Aluminium (Al)	≤ 0.062 milligrams/litre (mg/l) (95th percentile)	Strictest of Ecological specifications for all metals except manganese.
				Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l)	

Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
			health.		(95th percentile)	Manganese – domestic user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
				Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	
				Lead (Pb) hard	≤ 0.0057 milligrams/litre (mg/l) (95th percentile)	
				Copper (Cu) hard	≤ 0.0048 milligrams/litre (mg/l) (95th percentile)	
				Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
				Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
				Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
	Habitat	Instream	Habitat diversity must be maintained in a B ecological category. Protect instream integrity by controlling land based impacts. Connectivity to Limpopo River must be maintained.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Attainment of Water Resource Class and prescribed ecological category. Maintenance of ecological integrity.
		Riparian habitat	Riparian vegetation must be maintained in a B ecological category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Attainment of Water Resource Class and prescribed ecological category. Maintenance of ecological integrity.
	Biota	Fish	Fish community must be maintained within a B ecological category. Maintain flow velocity and depth class protection for sensitive species (flow sensitive: *LMOL, BIMB* and habitat sensitive: *PCAT*)	Fish Response Assessment Index (FRAI)	Fish ecology category = B FRAI ≥ 82% Sample 13+ species during sample effort	Attainment of Water Resource Class and prescribed ecological category. Baseline data.
		Semi-aquatic biota	This river reach must be maintained to serve as a habitat for aquatic bird and mammal populations through proper habitat management. Maintain riparian zone.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.	More detailed information and data required to specify limits. Requires inter-departmental and organisational co-ordination.
		Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5)	MIRAI EC = C ≥ 62% SASS ≥ 120 ASPT ≥ 5.0	Attainment of Water Resource Class and prescribed ecological category. Baseline data.

6.2 WETLANDS RESOURCE QUALITY OBJECTIVES

Resource Units (RU), Wetland/Site, Wetland Type, Desktop based area weighted average Present Ecological State (PES) Category, Desktop Ecological Importance and Sensitivity (EIS) Category, Recommended Ecological Category (REC), Likely Best Attainable State (Likely BAS), Component Prioritised, Indicator, Resource Quality Objective (RQO) and Numerical Criteria for Priority Wetlands in the Crocodile (West), Marico, Matlabas and Mokolo Catchments in the Limpopo Water Management Area (WMA).

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
1_1	Bronkhorstfontein Pan Complex	Depressions / Pans	D	High	C/D	C/D	Quantity	Pan wetted perimeter as measured from desktop mapping in relation to antecedent rainfall.	Water quantity impacts must be managed so as not to undermine the ecological value of these pan systems. In particular, abstraction or artificial water inputs should be limited in the pans so that the depth and duration of inundation is maintained within the normal range for high, average and low rainfall years.	Compile an accurate desktop basemap for the systems prior to the start of monitoring using the most recent available remote imagery and determine the wetted perimeter in relation to antecedent rainfall for selected pans. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there have been any measurable changes in the relationship between wetted perimeter and antecedent rainfall in the pans selected.
							Quality	pH, Electrical Conductivity, TDS, Total Alkalinity as $CaCO_3$, Sodium, Calcium, Magnesium, Sulphate, Iron, Chloride, Potassium, Magnesium, Manganese, Aluminium, Phosphorous, Silica, Fluoride Ammonia, Nitrate and Fluoride.	Water quality impacts to the pan systems must be restricted to ensure that the water and sediment chemistry remain within an acceptable normal range (anion and cation concentration to pan volume relationship) for this particular water chemistry pan type.	For selected pans, sample every 3 to 5 years.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all the pans units in the wetland complex	Area based weighted Average PES category of C/D.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of selected pans and take fixed point photographs of key features.
1_1 1_2	Rietvlei Wetland Complex	Channelled and Unchannelled valley bottom (peatland)	C	Very High	B	B/C	Quantity	Permanent saturation.	Permanent saturation is required to maintain the peat. The flows should also be such that they do not pose a threat to the unchannelled structure/geomorphology of the wetland system.	During the habitat assessment determine whether the system is saturated and peat is still present.
							Habitat	Desktop PES Category (based on a semi-quantitative score for	Wetland vegetation and geomorphology must be	Compile an accurate desktop basemap for the system prior to the start of monitoring using the

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
								the wetland. The extent and distribution of peat and populations of peat forming plants species in the wetland.	maintained to protect the unchannelled character of the system and overall biodiversity must be maintained including viable populations of peat forming plant species. Area based weighted Average PES category of B although the likely BAS Category is B/C. Peat distribution and extent should remain at least unchanged/stable or be increasing.	most recent available remote imagery and determine/estimate and map the extent of peat and peat forming plant species in the system. Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features. During the habitat assessment determine/estimate whether the extent of peat in the system has changed. Estimate the extent of peat forming plant species.
1_3	Glen Austin Pan	Depression / Pan	D	High	C/D	D	Quantity	Pan wetted perimeter as measured from desktop mapping in relation to antecedent rainfall.	Water quantity impacts must be managed so as not to undermine the ecological value of the pan. In particular, abstraction or artificial water inputs should be limited in the pans so that the depth and duration of inundation is maintained within the normal range for high, average and low rainfall years.	Compile an accurate desktop basemap for the pan prior to the start of monitoring using the most recent available remote imagery and determine the wetted perimeter in relation to antecedent rainfall for the pan. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there have been any measurable changes in the relationship between wetted perimeter and antecedent rainfall in the pan.
							Quality	pH, Electrical Conductivity, TDS, Total Alkalinity as $CaCO_3$, Sodium, Calcium, Magnesium, Sulphate, Iron, Chloride, Potassium, Magnesium, Manganese, Aluminium, Phosphorous, Silica, Fluoride Ammonia, Nitrate and Fluoride.	Water quality impacts to the pan systems must be restricted to ensure that the water and sediment chemistry remain within an acceptable normal range (anion and cation concentration to pan volume relationship) for this particular water chemistry pan type.	Sample every 3 to 5 years.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the pan – see the method of Kotze, 2016a and 2016b).	Area based weighted Average PES category of C/D although the likely BAS Category is D.	Undertake a desktop PES assessment and determine the area based weighted average score for the pan – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the pan and take fixed point

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
										photographs of key features.
							Biota	Breeding population of Giant Bullfrogs.	Maintain a viable breeding population of Giant Bullfrogs in the pan.	Verify from monitoring records and recorded sightings adult bullfrogs and recorded breeding events. Report on this every 3 to 5 years.
1_4	Colbyn Valley Wetland	Channelled and Unchannelled valley bottom (peatland)	C	High	B/C	C	Quantity	Permanent saturation.	Permanent saturation is required to maintain the peat. The flows should also be such that they do not pose a threat to the unchannelled structure/geomorphology of sections of the wetland system.	Determine whether the system is saturated and peat is still present.
							Habitat	Desktop PES Category (based on a semi-quantitative score for the wetland) . The extent and distribution of peat and populations of peat forming plants species in the wetland.	Wetland vegetation and geomorphology must be maintained to protect the system and overall biodiversity must be maintained including viable populations of peat forming plant species. Area based weighted Average PES category of B/C although the likely BAS Category is C. Peat distribution and extent should remain at least unchanged/stable or be increasing.	Compile an accurate desktop basemap for the system prior to the start of monitoring using the most recent available remote imagery and determine/estimate and map the extent of peat and peat forming plant species in the system. Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features. During the habitat assessment determine/estimate whether the extent of peat in the system has changed. Estimate the extent of peat forming plant species.
4_6	Waterkloofspruit Wetland	Unchannelled valley bottom	A/B*	Very High	A	A/B	Quantity	Permanent saturation.	Permanent saturation is required to maintain the peat. The flows should also be such that they do not pose a threat to the unchannelled structure/geomorphology of the wetland system.	During the habitat assessment determine whether the system is saturated and peat is still present.
							Habitat	Desktop PES Category (based on a semi-quantitative score for the wetland – see the method of Kotze, 2016a and 2016b). The extent and distribution of peat and populations of peat	Wetland vegetation and geomorphology must be maintained to protect the unchannelled character of the system and overall biodiversity must be maintained including viable populations of peat	Compile an accurate desktop basemap for the system prior to the start of monitoring using the most recent available remote imagery and determine/estimate and map the extent of peat and peat forming plant species in the system. Undertake a desktop PES assessment and

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
								forming plants species in the wetland.	forming plant species. Area based weighted Average PES category of A although the likely BAS Category is A/B. Peat distribution and extent should remain at least unchanged/stable or be increasing.	determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features. During the habitat assessment determine/estimate whether the extent of peat in the system has changed. Estimate the extent of peat forming plant species.
5_1	Koster Pan Complex	Depressions / Pans	C	High	B/C	C	Quantity	Pan wetted perimeter as measured from desktop mapping in relation to antecedent rainfall.	Water quantity impacts must be managed so as not to undermine the ecological value of these pan systems. In particular, abstraction or artificial water inputs should be limited in the pans so that the depth and duration of inundation is maintained within the normal range for high, average and low rainfall years.	Compile an accurate desktop basemap for the systems prior to the start of monitoring using the most recent available remote imagery and determine the wetted perimeter in relation to antecedent rainfall for selected pans. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there have been any measurable changes in the relationship between wetted perimeter and antecedent rainfall in the pans selected.
							Quality	pH, Electrical Conductivity, TDS, Total Alkalinity as $CaCO_3$, Sodium, Calcium, Magnesium, Sulphate, Iron, Chloride, Potassium, Magnesium, Manganese, Aluminium, Phosphorous, Silica, Fluoride Ammonia, Nitrate and Fluoride.	Water quality impacts to the pan systems must be restricted to ensure that the water and sediment chemistry remain within an acceptable normal range (anion and cation concentration to pan volume relationship) for this particular water chemistry pan type.	For selected pans, sample every 3 to 5 years.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all the pans units in the wetland complex).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of selected pans and take fixed point photographs of key features.
6_1 8_1	Buffelshoek Wetland Complex	Channelled and Unchannelled valley bottom	C/D*	High	C	C/D	Quantity	Groundwater indicators apply (see groundwater indicators).	A constant baseflow must be maintained to ensure that the system remains perennial.	Groundwater numerical limits apply (see groundwater numerical limits).

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
								Surface flow indicators need to be determined.	Groundwater RQO's apply (see groundwater RQO's).	Undertake a preliminary wetland Reserve for the system and determine the ecological flow requirements of the wetland. Use these to set the numerical criteria for the water quantity component of the RQO's.
							Quality	River and groundwater indicators apply (see river and groundwater indicators).	River and groundwater RQO's apply (see river and groundwater RQO's).	River and groundwater numerical limits apply (see river and groundwater numerical limits). Update these based on the findings of the water quality component of the preliminary wetland Reserve.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of C although the likely BAS Category is C/D.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of selected representative HGM units of the wetland complex and take fixed point photographs of key features.
							Protection zone	Groundwater indicators apply (see groundwater indicators).	Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
6_1 8_1	Paardenvallei Wetland Complex (Malmaniesloop)	Channelled and Unchannelled valley bottom	D* but on a negative trajectory	High	C/D	D	Quantity	Groundwater indicators apply (see groundwater indicators). Surface flow indicators need to be determined.	A constant baseflow must be maintained to ensure that the system remains perennial. Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits). Undertake a preliminary wetland Reserve for the system and determine the ecological flow requirements of the wetland. Use these to set the numerical criteria for the water quantity component of the RQO's.
							Quality	River and groundwater indicators apply (see river and groundwater indicators).	River and groundwater RQO's apply (see river and groundwater RQO's).	River and groundwater numerical limits apply (see river and groundwater numerical limits). Update these based on the findings of the water quality component of the preliminary wetland Reserve.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of C/D although the likely BAS Category is D.	Compile an accurate desktop basemap for the system prior to the start of monitoring using the most recent available remote imagery and determine/estimate and map the extent of peat and peat forming plant species in the system. Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
										have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features. During the habitat assessment determine/estimate whether the extent of peat in the system has changed. Estimate the extent of peat forming plant species
							Protection zone	Groundwater indicators apply (see groundwater indicators).	Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
7_1	Marico Eye Wetland (Kaaloog se Loop)	Unchannelled valley bottom (peatland)	B/C	Very High	A/B	B	Quantity	Groundwater indicators apply (see groundwater indicators). Surface flow indicators need to be determined.	A constant baseflow must be maintained that ensure that the system remains perennial. Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits). Undertake a preliminary wetland Reserve for the system and determine the ecological flow requirements of the wetland. Use these to set the numerical criteria for the water quantity component of the RQO's.
							Quality	River and groundwater indicators apply (see river and groundwater indicators).	River and groundwater RQO's apply (see river and groundwater RQO's).	River and groundwater numerical limits apply (see river and groundwater numerical limits). Update these based on the findings of the water quality component of the preliminary wetland Reserve.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland – see the method of Kotze, 2016a and 2016b).	Area based weighted Average PES category of A/B although the likely BAS Category is B.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features. During the habitat assessment determine/estimate whether the extent of peat in the system has changed. Estimate the extent of peat forming plant species
							Protection zone	Groundwater indicators apply (see groundwater indicators).	Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
7_1	Rietspruit Wetland	Channelled and Unchannelled valley bottom	C	Moderate to High	C	C	Quantity	Groundwater indicators apply (see groundwater indicators).	A constant baseflow must be maintained to ensure that the system remains perennial. Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
							Quality	River and groundwater indicators apply (see river and groundwater indicators).	River and groundwater RQO's apply (see river and groundwater RQO's).	River and groundwater numerical limits apply (see river and groundwater numerical limits).

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES Category of C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
							Protection zone	Groundwater indicators apply (see groundwater indicators).	Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
7_1	Tufa Waterfall	Tufa	B	Very High	A	B	Quantity	Groundwater indicators apply (see groundwater indicators).	A constant baseflow must be maintained that ensure that the system remains perennial and the waterfall has a constant water supply. Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
							Quality	pH, Electrical Conductivity, TDS, Total Alkalinity as $CaCO_3$, Sodium, Calcium, Magnesium, Sulphate, Iron, Chloride, Potassium, Magnesium, Manganese, Aluminium, Phosphorous, Silica, Fluoride Ammonia, Nitrate and Fluoride.	Salinity levels should not increase. Concentrations must be maintained at levels to secure an Ideal/Good water quality status rich in calcium carbonate.	Electrical Conductivity: ≤ 50 mS/m Annual long-term trend should not approach the 95th percentile (55 mS/m). Bi-annual monitoring of major constituents (macro elements).
							Protection zone	Groundwater indicators apply (see groundwater indicators).	Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
8_1	Malmanieloop Wetland Complex	Channelled and Unchannelled valley bottom (peatland)	C/D* but on a negative trajectory	Very High	B*	C	Quantity	Groundwater indicators apply (see groundwater indicators). Surface flow indicators need to be determined.	A constant baseflow must be maintained to ensure that the system remains perennial and that most of the marginal and instream vegetation remains inundated throughout the summer growing season and that the rooting zone is saturated throughout the year. This is a requirement for enabling perennial obligate hydrophytes to complete their life cycle and reproduce and in	Groundwater numerical limits apply (see groundwater numerical limits) Undertake a preliminary wetland Reserve for the system and determine the ecological flow requirements of the wetland. Use these to set the numerical criteria for the water quantity component of the RQO's.

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
									order to maintain the peat in the system. Groundwater RQO's apply (see groundwater RQO's).	
							Quality	River and groundwater indicators apply (see river and groundwater indicators).	River and groundwater RQO's apply (see river and groundwater RQO's).	River and groundwater numerical limits apply (see river and groundwater numerical limits). Update these based on the findings of the water quality component of the preliminary wetland Reserve.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex_. The extent and distribution of peat and populations of peat forming plants species in the wetland.	Wetland vegetation and geomorphology must be maintained to protect the unchannelled character of the system and overall biodiversity must be maintained including viable populations of peat forming plant species. Area based weighted Average PES category of B although the likely BAS Category is C. Peat distribution and extent should remain at least unchanged/stable or be increasing.	Compile an accurate desktop basemap for the system prior to the start of monitoring using the most recent available remote imagery and determine/estimate and map the extent of peat and peat forming plant species in the system. Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features. During the habitat assessment determine/estimate whether the extent of peat in the system has changed. Estimate the extent of peat forming plant species
							Protection zone	Groundwater indicators apply (see groundwater indicators).	Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
8_1 9_2	Upper Molopo River Wetland Complex	Channelled and Unchannelled valley bottom (peatland)	D* but on a negative trajectory	Very High	B*	C/D	Quantity	Groundwater indicators apply (see groundwater indicators). Surface flow indicators need to be determined.	A constant baseflow must be maintained to ensure that the system remains perennial and that most of the marginal and instream vegetation remains inundated throughout the summer growing season and that the rooting zone is saturated throughout the year. This is a requirement for enabling perennial obligate hydrophytes to complete their life cycle and reproduce and in order to maintain the peat in the system.	Groundwater numerical limits apply (see groundwater numerical limits). Undertake a preliminary wetland Reserve for the system and determine the ecological flow requirements of the wetland. Use these to set the numerical criteria for the water quantity component of the RQO's.

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
									Groundwater RQO's apply (see groundwater RQO's).	
							Quality	River and groundwater indicators apply (see river and groundwater indicators).	River and groundwater RQO's apply (see river and groundwater RQO's).	River and groundwater numerical limits apply (see river and groundwater numerical limits). Update these based on the findings of the water quality component of the preliminary wetland Reserve.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex). The extent and distribution of peat and populations of peat forming plants species in the wetland.	Wetland vegetation and geomorphology must be maintained to protect the unchannelled character of the system and overall biodiversity must be maintained including viable populations of peat forming plant species. Area based weighted Average PES category of B although the likely BAS Category is C/D. Peat distribution and extent should remain at least unchanged/stable or be increasing.	Compile an accurate desktop basemap for the system prior to the start of monitoring using the most recent available remote imagery and determine/estimate and map the extent of peat and peat forming plant species in the system. Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features. During the habitat assessment determine/estimate whether the extent of peat in the system has changed. Estimate the extent of peat forming plant species
							Protection zone	Groundwater indicators apply (see groundwater indicators).	Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
8_1	Vergenoegd Wetland	Channelled and Unchannelled valley bottom	C*	High	B/C	C	Quantity	Groundwater indicators apply (see groundwater indicators). Surface flow indicators need to be determined.	A constant baseflow must be maintained to ensure that the system remains perennial. Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits) Undertake a preliminary wetland Reserve for the system and determine the ecological flow requirements of the wetland. Use these to set the numerical criteria for the water quantity component of the RQO's.

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
							Quality	River and groundwater indicators apply (see river and groundwater indicators).	River and groundwater RQO's apply (see river and groundwater RQO's).	River and groundwater numerical limits apply (see river and groundwater numerical limits). Update these based on the findings of the water quality component of the preliminary wetland Reserve.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
							Protection zone	Groundwater indicators apply (see groundwater indicators).	Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
9_2	Middle Molopo River Wetland Complex	Channelled valley bottom	D* but on a negative trajectory	Moderate to High	C/D	D	Quantity	Groundwater indicators apply (see groundwater indicators). Surface flow indicators need to be determined.	A constant baseflow must be maintained to ensure that the system remains perennial. Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits) Undertake a preliminary wetland Reserve linked to the one for Upper Molopo River Wetland and determine the ecological flow requirements of the wetland. Use these to set the numerical criteria for the water quantity component of the RQO's.
							Quality	River and groundwater indicators apply (see river and groundwater indicators).	River and groundwater RQO's apply (see river and groundwater RQO's).	River and groundwater numerical limits apply (see river and groundwater numerical limits). Update these based on the findings of the water quality component of the preliminary wetland Reserve.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland – see the method of Kotze, 2016a and 2016b). The extent and distribution of peat and populations of peat forming plants species in the wetland.	Wetland vegetation and geomorphology must be maintained to protect the unchannelled character of the system and overall biodiversity must be maintained including viable populations of peat forming plant species. Area based weighted Average PES category of C/D although the likely BAS Category is D. Peat distribution and extent should remain at least unchanged/stable or be increasing.	Compile an accurate desktop basemap for the system prior to the start of monitoring using the most recent available remote imagery and determine/estimate and map the extent of peat and peat forming plant species in the system. Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features. During the habitat assessment determine/estimate whether the extent of peat in the system has changed. Estimate the

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
										extent of peat forming plant species
9_3 9_5	Lower Molopo River Wetland Complex	Channelled valley bottom	D	Moderate	D	D	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of D.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
10_1	Dinokana Wetland	Unchannelled and Channelled valley bottom and Hillslope seepage wetlands	C	Moderate to High	B/C	C	Quantity	Groundwater indicators apply (see groundwater indicators). Surface flow indicators need to be determined.	A constant baseflow must be maintained to ensure that the system remains perennial. Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits). Undertake a preliminary wetland Reserve for the system and determine the ecological flow requirements of the wetland. Use these to set the numerical criteria for the water quantity component of the RQO's.
							Quality	River and groundwater indicators apply (see river and groundwater indicators).	River and groundwater RQO's apply (see river and groundwater RQO's).	River and groundwater numerical limits apply (see river and groundwater numerical limits). Update these based on the findings of the water quality component of the preliminary wetland Reserve.
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze, 2016. Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
							Protection zone	Groundwater indicators apply (see groundwater indicators).	Groundwater RQO's apply (see groundwater RQO's).	Groundwater numerical limits apply (see groundwater numerical limits).
10_1	Ngotwane Wetland	Unchannelled valley bottom	C*	High	B/C	C	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland complex).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
11_b_2	Lower Lenkwane River Wetland	Unchannelled valley bottom linked to Floodplain	B	Moderate to High	B	B	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of B.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
12_1	Kolobeng Wetland Complex	Channelled valley bottom and floodplain	C	Moderate to High	B/C	C	Quantity	Extent and frequency of flooding in relation to rainfall in the catchment.	Floods are necessary to inundate the floodplain thereby providing the wetting regime required for supporting the floodplain vegetation, particularly the facultative hydrophytic grasses, sedges and forbs that are dependent on flooding for their life cycles.	Using available remote imagery, estimate the extent and frequency of inundation/flooding in relation to rainfall for the wetland. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there are any measurable changes in the relationship between flooding extent and rainfall events.
							Quality	River indicators apply (see river indicators).	River RQO's apply (see river RQO's).	River numerical limits apply (see river numerical limits).
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
13_3 **17_b_1**	Lower Crocodile River Floodplain	Floodplain	C	High	B/C	C	Quantity	Extent and frequency of flooding in relation to rainfall in the catchment.	Floods are necessary to inundate the floodplain thereby providing the wetting regime required for supporting the floodplain vegetation, particularly the facultative hydrophytic grasses, sedges and forbs that are dependent on flooding for their life cycles.	Using available remote imagery, estimate the extent and frequency of flooding in relation to rainfall for the wetland. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there are any measurable changes in the relationship between flooding extent and rainfall events.
							Quality	River indicators apply (see river indicators).	River RQO's apply (see river RQO's).	River numerical limits apply (see river numerical limits).
							Habitat	Desktop PES Category (based on a semi-quantitative area	Area based weighted Average PES category of B/C although	Undertake a desktop PES assessment and determine the area based weighted average score

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
								based weighted average score for the wetland).	the likely BAS Category is C.	for the floodplain – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the system and take fixed point photographs of key features.
							Biota	Maintenance of a structurally and species diverse riparian zone.	The overall structural and species diversity of the riparian zone must be maintained.	Using a rapid field-based assessment monitor the structure and species diversity of the riparian zone at selected sites along the floodplain. Take fixed point photographs of key features. Report on this every 3 to 5 years.
14_1	Apies River Floodplain	Floodplain	C	High	B/C	C	Quantity	Extent and frequency of flooding in relation to rainfall in the catchment.	Floods are necessary to inundate the floodplain thereby providing the wetting regime required for supporting the floodplain vegetation, particularly the facultative hydrophytic grasses, sedges and forbs that are dependent on flooding for their life cycles.	Using available remote imagery, estimate the extent and frequency of flooding in relation to rainfall for the wetland. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there are any measurable changes in the relationship between flooding extent and rainfall events.
							Quality	River indicators apply (see river indicators).	River RQO's apply (see river RQO's).	River numerical limits apply (see river numerical limits).
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the floodplain – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the system and take fixed point photographs of key features.
14_1 14_2 14_3 14_4	Moretele River Floodplain	Floodplain	C	Very High	B	C	Quantity	Extent and frequency of flooding in relation to rainfall in the catchment.	Floods are necessary to inundate the floodplain thereby providing the wetting regime required for supporting the floodplain vegetation, particularly the facultative hydrophytic grasses, sedges and forbs that are dependent on flooding for their life cycles.	Using available remote imagery, estimate the extent and frequency of flooding in relation to rainfall for the wetland. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there are any measurable changes in the relationship between flooding extent and rainfall events.
							Quality	River indicators apply (see river	River RQO's apply (see river	River numerical limits apply (see river numerical

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
								indicators).	RQO's).	limits).
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of B although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the floodplain – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the system and take fixed point photographs of key features.
							Biota	Reporting rates for aquatic/wetland dependent bird species.	Overall diversity and populations of aquatic/wetland dependent bird species must be maintained.	Verify from monitoring records and recorded sightings from available avifaunal reporting data. Report on this every 3 to 5 years.
14_3	Plat River Floodplain	Floodplain	C	High	B/C	C	Quantity	Extent and frequency of flooding in relation to rainfall in the catchment.	Floods are necessary to inundate the floodplain thereby providing the wetting regime required for supporting the floodplain vegetation, particularly the facultative hydrophytic grasses, sedges and forbs that are dependent on flooding for their life cycles.	Using available remote imagery, estimate the extent and frequency of flooding in relation to rainfall for the wetland. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there are any measurable changes in the relationship between flooding extent and rainfall events.
							Quality	River indicators apply (see river indicators).	River RQO's apply (see river RQO's).	River numerical limits apply (see river numerical limits).
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the floodplain – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the system and take fixed point photographs of key features.
							Biota	Reporting rates for aquatic/wetland dependent bird species.	Overall diversity and populations of aquatic/wetland dependent bird species must be maintained.	Verify from monitoring records and recorded sightings from available avifaunal reporting data. Report on this every 3 to 5 years.
14_4	Tswaing Crator Pan	Depression / Pan	B	Very High	A	B	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of A although the likely BAS Category is B.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
										and report on this with a view to assess if there have been any changes in the state of the system.
15_1	Upper Mokolo River Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	C/D	Moderate to High	C	C/D	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of C although the likely BAS Category is C/D.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze, 2016. Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
							Biota	The continued presence of Blue Cranes within the pentads (5x5 minute squares - the mapping unit used in BABAP2) covering the wetlands.	The continued presence of Blue Cranes must be maintained.	Using the data generated by the South African Bird Atlas Project 2 (SABAP2), the continued presence of Blue Cranes within the pentads must be confirmed by ensuring that a reporting rate higher than 5 % is maintained for the affected pentad (2425_2800 and 2425_2805).
15_1	Klein Sand River Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	C	Moderate	C	C	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
							Biota	The continued presence of Blue Cranes within the pentad (5x5 minute squares - the mapping unit used in BABAP2) covering the wetlands.	The continued presence of Blue Cranes must be maintained.	Using the data generated by the South African Bird Atlas Project 2 (SABAP2), the continued presence of Blue Cranes within the pentad must be confirmed by ensuring that a reporting rate higher than 5 % is maintained for the affected pentad (2425_2805).
15_2	Frikkiesloon River Wetland Complex	Channelled and Unchannelled valley bottom	C	Moderate to High	B/C	C	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
15_2	Grootfonteinspruit Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	C	Moderate to Low	C	C	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
							Biota	The continued presence of Blue Cranes within the pentad (5x5 minute squares - the mapping unit used in BABAP2) covering the wetlands.	The continued presence of Blue Cranes must be maintained.	Using the data generated by the South African Bird Atlas Project 2 (SABAP2), the continued presence of Blue Cranes within the pentad must be confirmed by ensuring that a reporting rate higher than 5 % is maintained for the affected pentad.
15_5	Grootspruit Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	C	Moderate to High	B/C	C	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
							Biota	The continued presence of Blue Cranes within the pentad (5x5 minute squares - the mapping unit used in BABAP2) covering the wetlands.	The continued presence of Blue Cranes must be maintained.	Using the data generated by the South African Bird Atlas Project 2 (SABAP2), the continued presence of Blue Cranes within the pentad must be confirmed by ensuring that a reporting rate higher than 5 % is maintained for the affected pentad (2425_2800).
15_5	Sandspruit Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	D	Moderate to High	C/D	D	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of C/D although the likely BAS Category is D.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
							Biota	The continued presence of Blue Cranes within the pentad (5x5	The continued presence of Blue Cranes must be maintained.	Using the data generated by the South African Bird Atlas Project 2 (SABAP2), the continued presence

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
								minute squares - the mapping unit used in BABAP2) covering the wetlands.		of Blue Cranes within the pentad must be confirmed by ensuring that a reporting rate higher than 5 % is maintained for the affected pentad (2430_2800).
15_5	Sand River Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	D	Moderate to High	C/D	D	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of C/D although the likely BAS Category is D.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
							Biota	The continued presence of Blue Cranes within the pentads (5x5 minute squares - the mapping unit used in BABAP2) covering the wetlands.	The continued presence of Blue Cranes must be maintained.	Using the data generated by the South African Bird Atlas Project 2 (SABAP2), the continued presence of Blue Cranes within the pentads must be confirmed by ensuring that a reporting rate higher than 5 % is maintained for the affected pentad (2425_2800 and 2425_2805).
15_5	Sand River Tributary Wetland Complex	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	C/D	Moderate to High	C	C/D	Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for all wetland units in the wetland complex).	Area based weighted Average PES category of C although the likely BAS Category is C/D.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.
16_1 16_5_2	Tambotie River Floodplain	Floodplain	B/C	Very High	A/B	B/C	Quantity	Extent and frequency of flooding in relation to rainfall in the catchment.	Floods are necessary to inundate the floodplain thereby providing the wetting regime required for supporting the floodplain vegetation, particularly the facultative hydrophytic grasses, sedges and forbs that are dependent on flooding for their life cycles.	Using available remote imagery, estimate the extent and frequency of flooding in relation to rainfall for the wetland. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there are any measurable changes in the relationship between flooding extent and rainfall events.
								River indicators for RU 16_5_2 and groundwater indicators as per the floodplain alluvial aquifer for RU 16_4 also apply (see river and groundwater	River RQO's for RU 16_5_2 and groundwater RQO's as per the floodplain alluvial aquifer for RU 16_4 also apply (see river and groundwater RQO's).	River numerical limits for RU 16_5_2 and groundwater numerical limits as per the floodplain alluvial aquifer for RU 16_4 also apply (see river and groundwater numerical limits).

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
								indicators).		
							Quality	River indicators for RU 16_5_2 and groundwater indicators as per the floodplain alluvial aquifer for RU 16_4 apply (see river and groundwater indicators).	River RQO's for RU 16_5_2 and groundwater RQO's as per the floodplain alluvial aquifer for RU 16_4 apply (see river and groundwater RQO's).	River numerical limits for RU 16_5_2 and groundwater numerical limits as per the floodplain alluvial aquifer for RU 16_4 apply (see river and groundwater numerical limits).
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of A/B although the likely BAS Category is B/C.	Undertake a desktop PES assessment and determine the area based weighted average score for the floodplain – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the system and take fixed point photographs of key features.
							Biota	Reporting rates (RR) for aquatic/wetland dependent Red Data bird species. Maintenance of a structurally and species diverse riparian zone.	Overall biodiversity and populations of floodplain dependent Red Data bird species must be maintained. The overall structural and species diversity of the riparian zone must be maintained.	Verify from monitoring records and recorded sightings from available avifaunal reporting rate data. Using a rapid field-based assessment monitor the structure and species diversity of the riparian zone at selected sites along the floodplain. Take fixed point photographs of key features. Report on the above every 3 to 5 years.
16_3	Rietspruit Wetland 2	Channelled and Unchannelled valley bottom	C*	Moderate to Low	C	C	Quantity	River indicators apply (see river indicators).	River RQO's apply (see river RQO's).	River numerical limits apply (see river numerical limits).
							Quality	River indicators apply (see river indicators).	River RQO's apply (see river RQO's).	River numerical limits apply (see river numerical limits).
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland complex).	Area based weighted Average PES category of C.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland complex – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland and take fixed point photographs of key features.

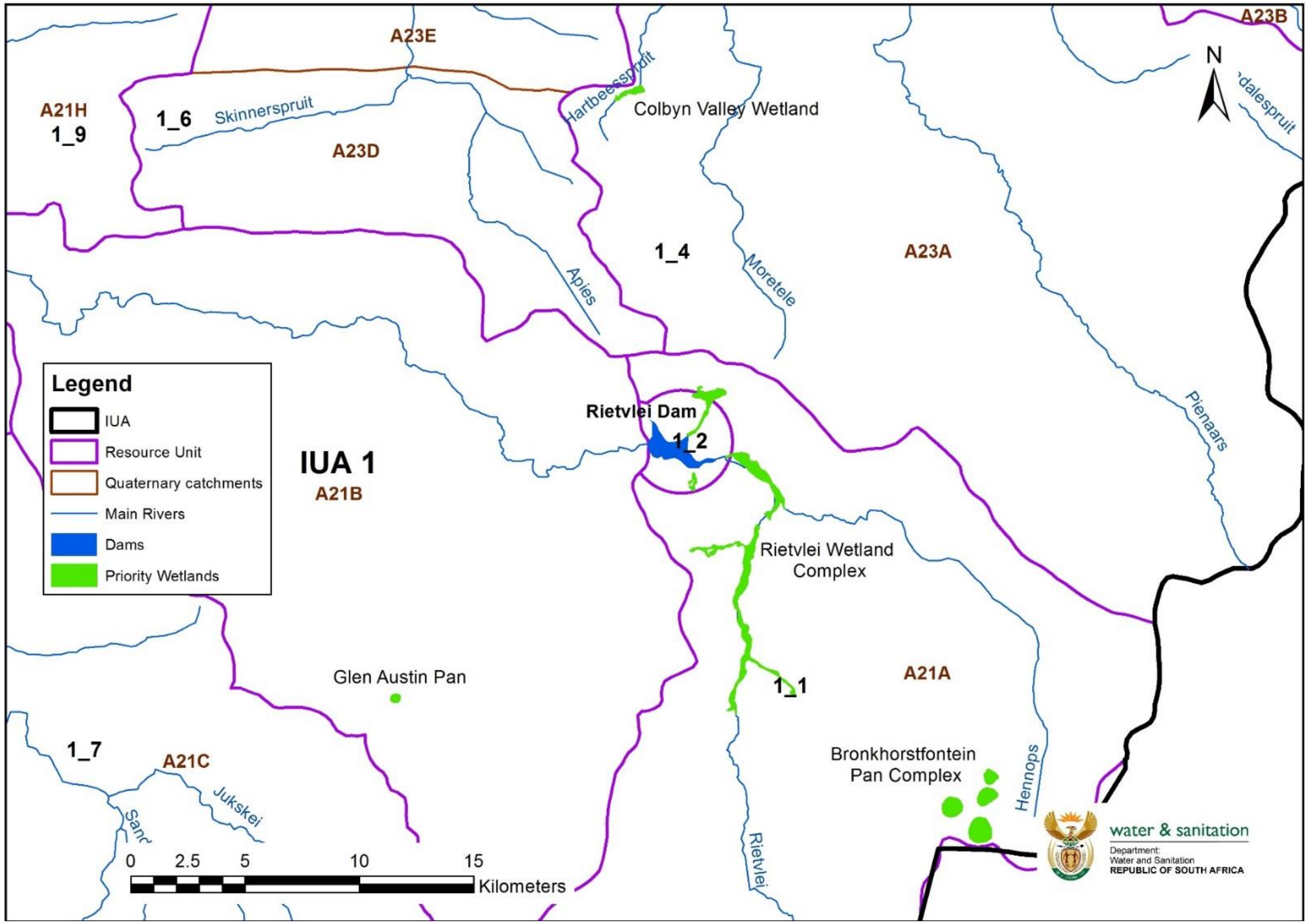
RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
16_5_2	Mokolo River Floodplain	Floodplain, Depressions, backwaters and Seepage wetlands	C	High	B/C	C	Quantity	Extent and frequency of flooding in relation to rainfall in the catchment.	Floods are necessary to inundate the floodplain thereby providing the wetting regime required for supporting the floodplain vegetation, particularly the facultative hydrophytic grasses, sedges and forbs that are dependent on flooding for their life cycles. Flooding together with water in the alluvial aquifer also supports the riparian trees along edges of the floodplain.	Using available remote imagery, estimate the extent and frequency of flooding in relation to rainfall for the floodplain. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there are any measurable changes in the relationship between flooding extent and rainfall events.
								River indicators for RU 16_5_2 and groundwater indicators as per the floodplain alluvial aquifer for RU 16_4 also apply (see river and groundwater indicators).	River RQO's for RU 16_5_2 and groundwater RQO's as per the floodplain alluvial aquifer for RU 16_4 also apply (see river and groundwater RQO's).	River numerical limits for RU 16_5_2 and groundwater numerical limits as per the floodplain alluvial aquifer for RU 16_4 also apply (see river and groundwater numerical limits).
							Quality	River indicators for RU 16_5_2 and groundwater indicators as per the floodplain alluvial aquifer for RU 16_4 apply (see river and groundwater indicators).	River RQO's for RU 16_5_2 and groundwater RQO's as per the floodplain alluvial aquifer for RU 16_4 apply (see river and groundwater RQO's).	River numerical limits for RU 16_5_2 and groundwater numerical limits as per the floodplain alluvial aquifer for RU 16_4 apply (see river and groundwater numerical limits).
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of B/C although the likely BAS Category is C.	Undertake a desktop PES assessment and determine the area based weighted average score for the floodpalin – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the floodplain and take fixed point photographs of key features.
							Biota	Reporting rates (RR) for aquatic/wetland dependent Red Data bird species. Maintenance of a structurally and species diverse riparian zone.	Overall biodiversity and populations of floodplain dependent Red Data bird species must be maintained. The overall structural and species diversity of the riparian zone must be maintained.	Verify from monitoring records and recorded sightings from available avifaunal reporting rate data. Using a rapid field-based assessment monitor the structure and species diversity of the riparian zone at selected sites along the floodplain. Take fixed point photographs of key features. Report on the above every 3 to 5 years.

RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
							Protection zone	Groundwater indicators as per the floodplain alluvial aquifer for RU 16_4 apply (see groundwater indicators).	Groundwater RQO's as per the floodplain alluvial aquifer for RU 16_4 apply (see groundwater RQO's).	Groundwater numerical limits as per the floodplain alluvial aquifer for RU 16_4 apply (see groundwater numerical limits).
17_a_2	Matlabas Wetland (Peatland)	Channelled and Unchannelled valley bottom and Hillslope seepage wetlands	A/B*	Very High	A	A/B	Quantity	Permanent saturation.	Permanent saturation is required to maintain the peat. The flows should also be such that they do not pose a threat to the unchannelled structure/geomorphology of the wetland system.	During the habitat assessment determine whether the system is saturated and peat is still present.
							Habitat	Desktop PES Category (based on a semi-quantitative score for the wetland).	Wetland vegetation and geomorphology must be maintained to protect the unchannelled character of the system and overall biodiversity must be maintained including viable populations of peat forming plant species. Area based weighted Average PES category of A although the likely BAS Category is A/B.	Undertake a desktop PES assessment and determine the area based weighted average score for the wetland – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the wetland.
17_b_1	Lower Matlabas River Floodplain	Floodplain	B	High	A/B	B	Quantity	Extent and frequency of flooding in relation to rainfall in the catchment.	Floods are necessary to inundate the floodplain thereby providing the wetting regime required for supporting the floodplain vegetation, particularly the facultative hydrophytic grasses, sedges and forbs that are dependent on flooding for their life cycles.	Using available remote imagery, estimate the extent and frequency of flooding in relation to rainfall for the floodplain. Repeat the above every 3 to 5 years and assess and report on this with a view to assess if there are any measurable changes in the relationship between flooding and rainfall events.
							Quality	River indicators apply (see river indicators).	River RQO's apply (see river RQO's).	River numerical limits apply (see river numerical limits).
							Habitat	Desktop PES Category (based on a semi-quantitative area based weighted average score for the wetland).	Area based weighted Average PES category of A/B although the likely BAS Category is B.	Undertake a desktop PES assessment and determine the area based weighted average score for the floodplain – see the method of Kotze (2016a and 2016b). Repeat every 3 to 5 years and assess and report on this with a view to assess if there have been any changes in the state of the system. Verify by undertaking a rapid field-based PES assessment of the system and take fixed point photographs of key features.
							Biota	Maintenance of a structurally	The overall structural and	Using a rapid field-based assessment monitor the

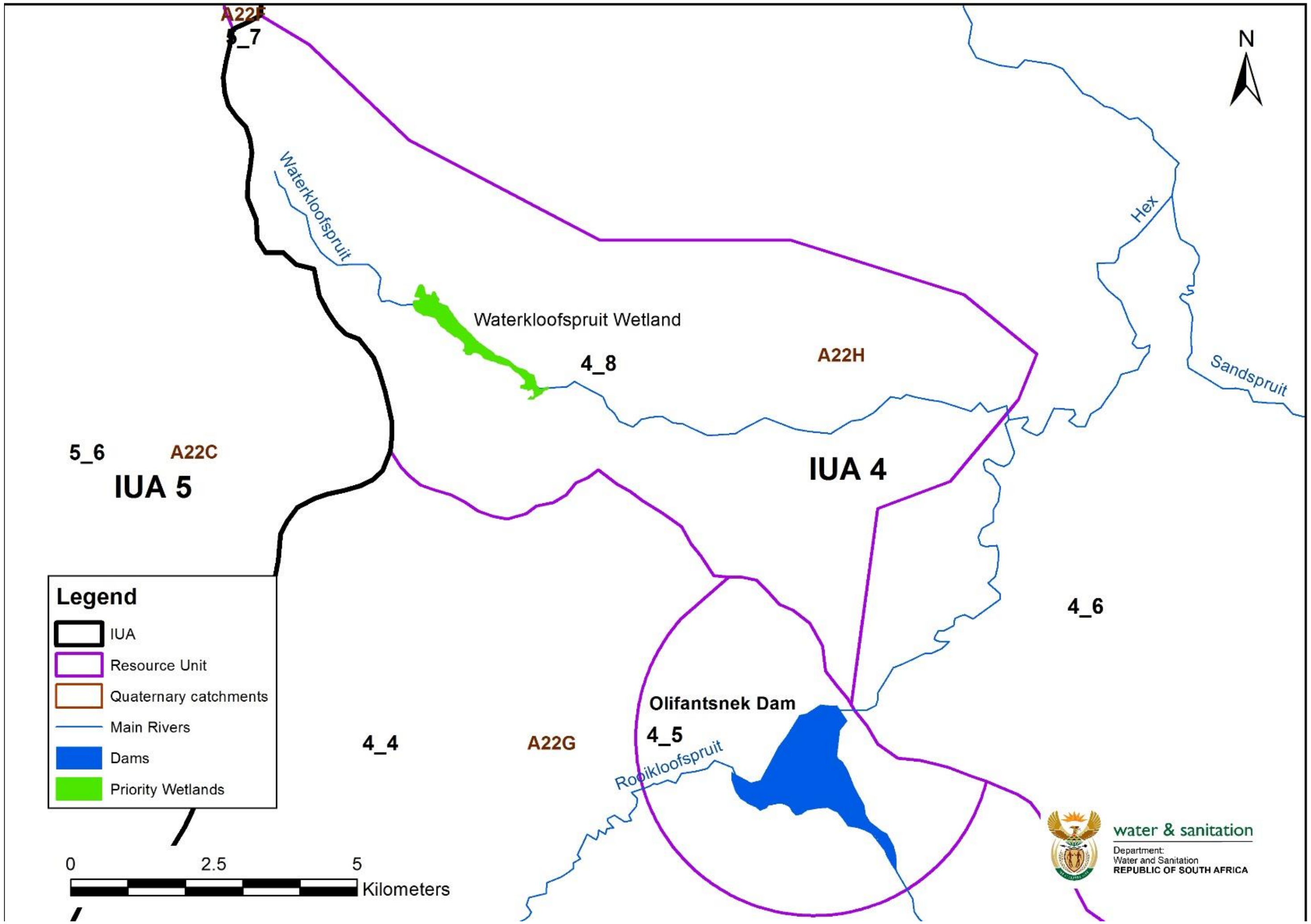
RU	Wetland/Site	Wetland Type	Desktop PES Category	Desktop EIS Category	REC	Likely BAS	Component prioritised	Indicator	RQO	Numerical Criteria
								and species diverse riparian zone.	species diversity of the riparian zone must be maintained.	structure and species diversity of the riparian zone at selected sites along the floodplain. Take fixed point photographs of key features. Report on this every 3 to 5 years.

* = Desktop PES or REC changed based on specialist knowledge/opinion.

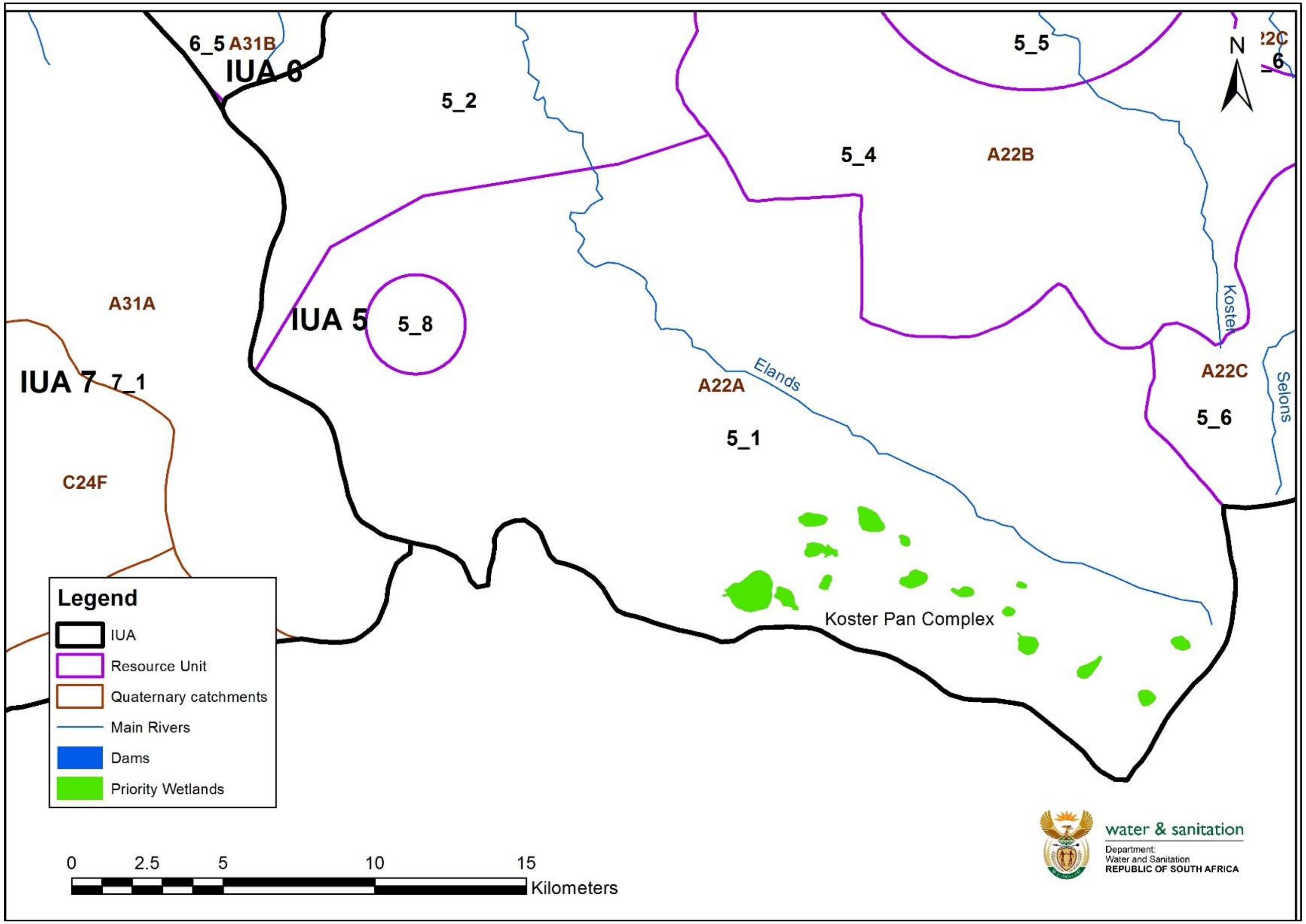
IUA 1: Upper Crocodile/Hennops/Hartbeespoort



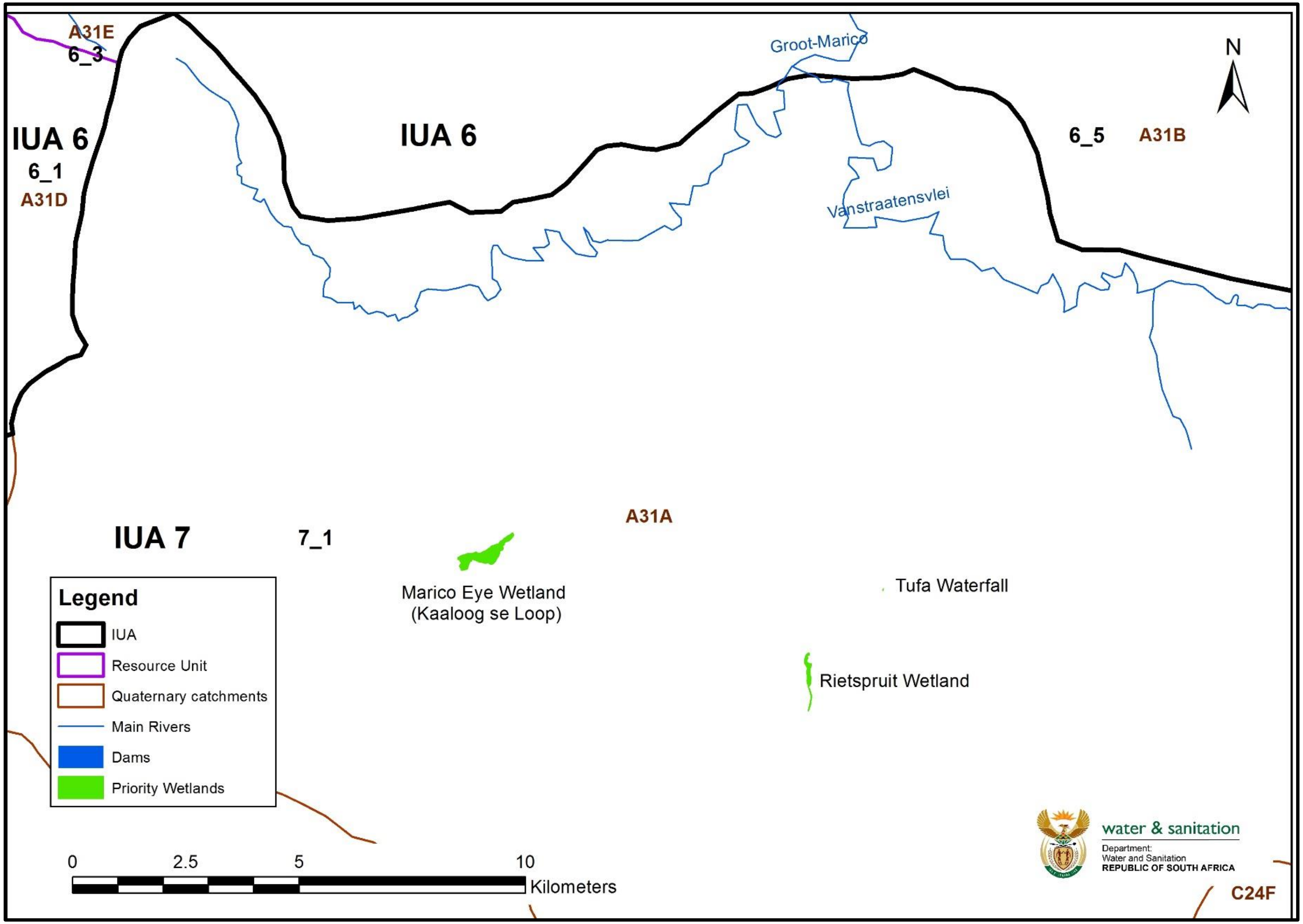
IUA 4: Hex/Waterkloofspruit/Vaalkop



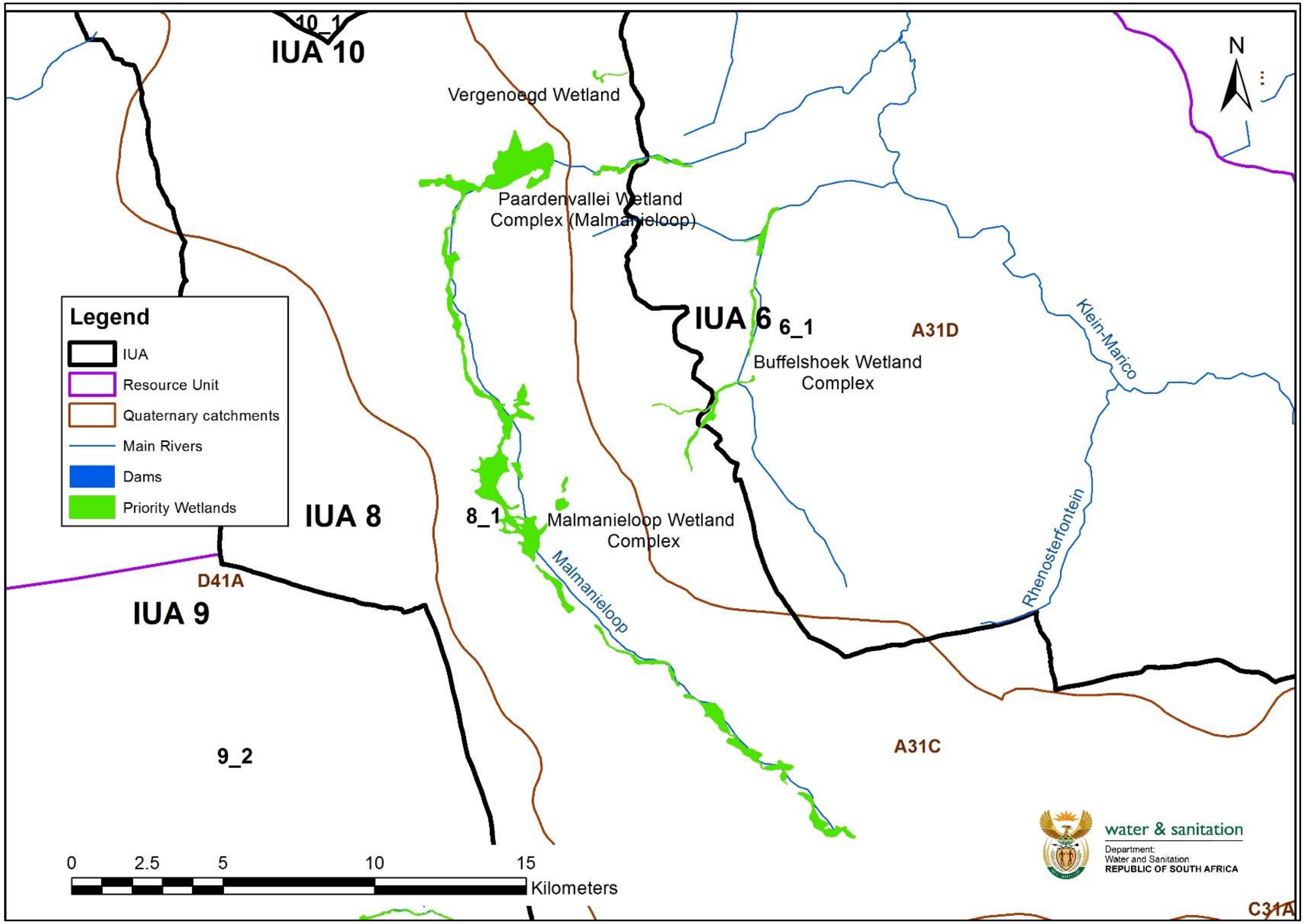
IUA 5: Elands/Vaalkop



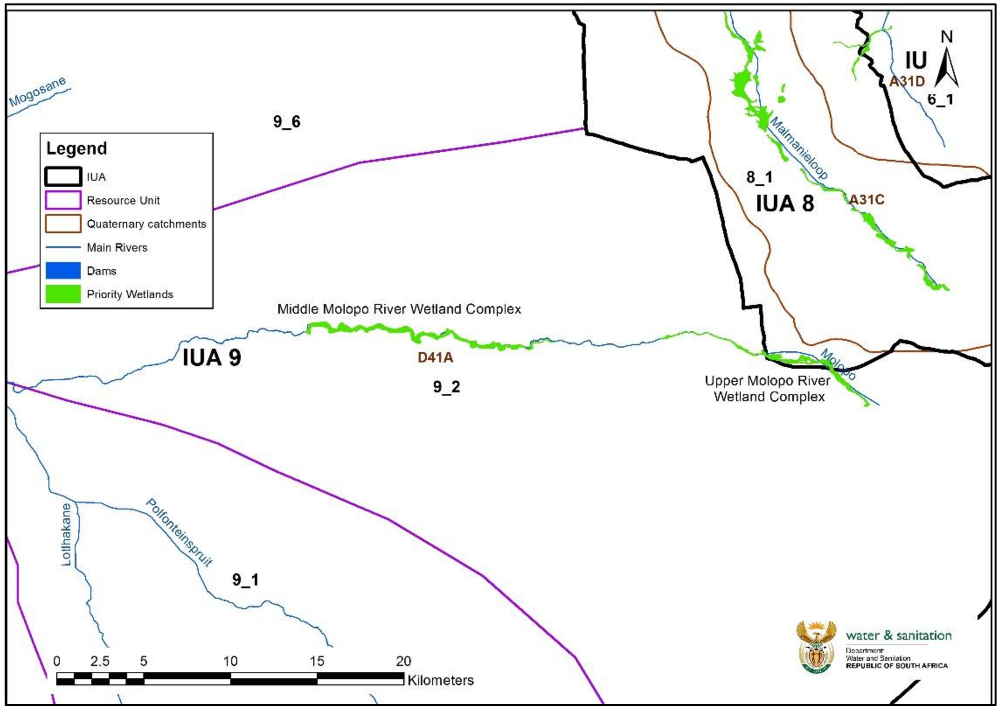
IUA 7: Kaaloog-se-Loop

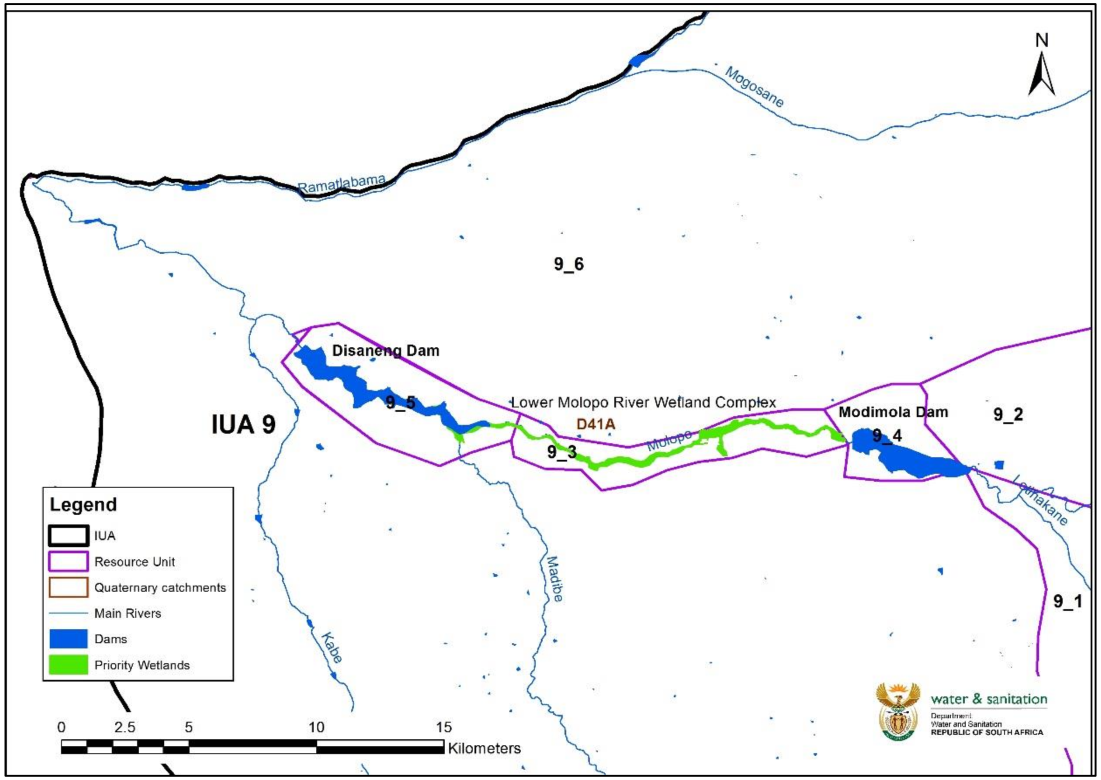


IUA 8: Malmaniesloop

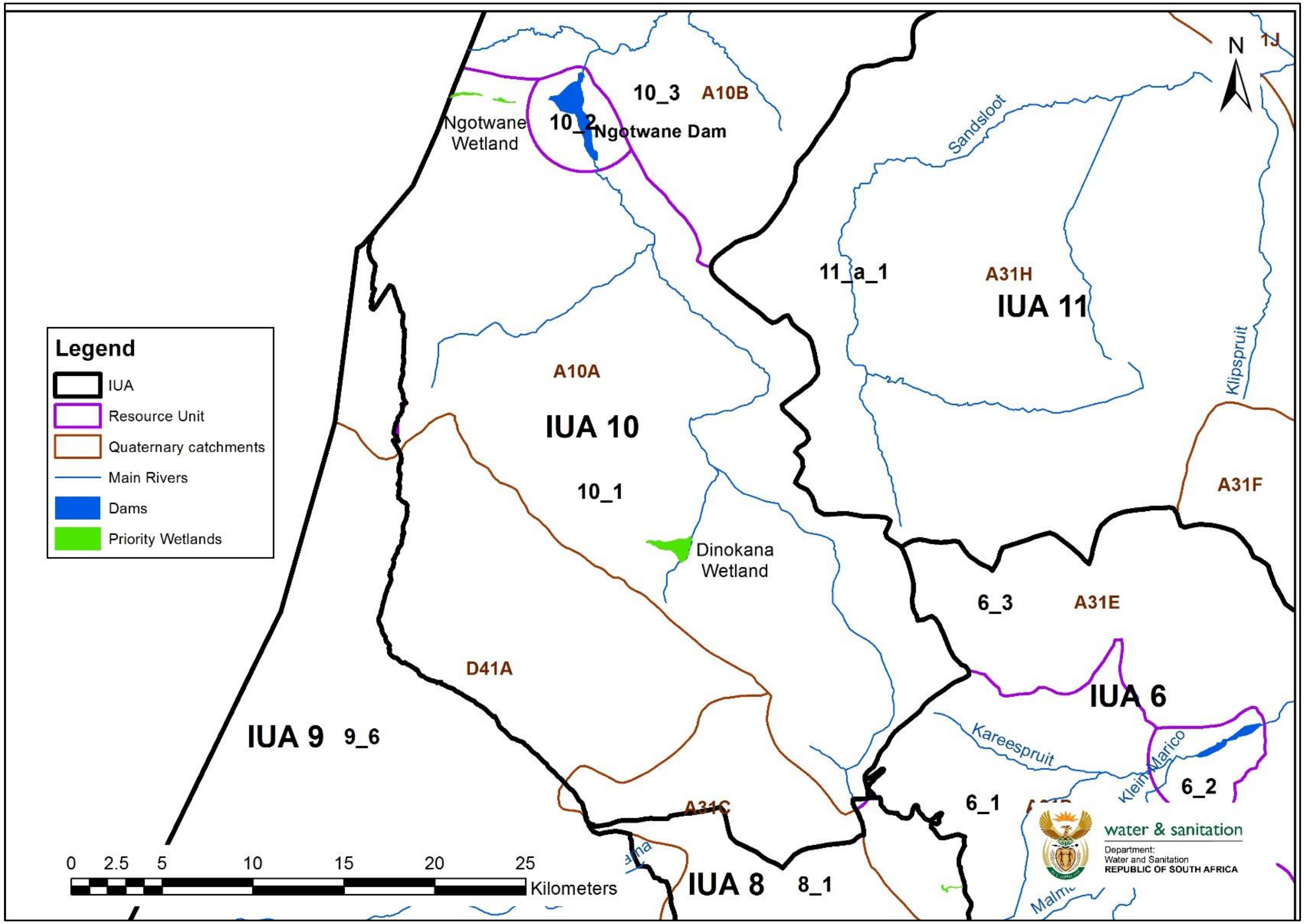


IUA 9: Molopo

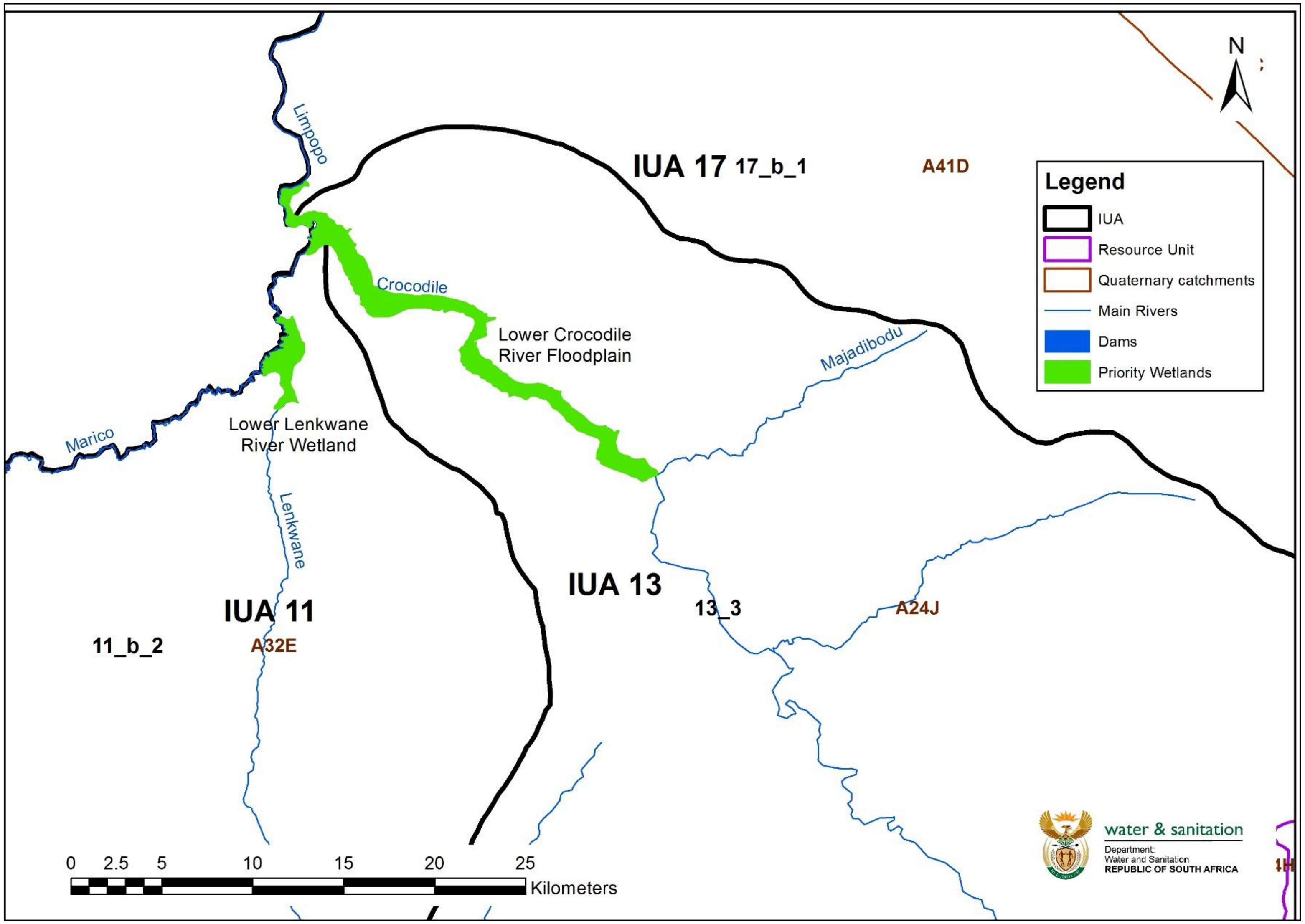

Mogosane
9_6
Legend
IUA
Resource Unit
Quaternary catchments
Main Rivers
Dams
Priority Wetlands
8_1
IUA 8
A31C
A31D
6_1
Malmanieloop
Middle Molopo River Wetland Complex
IUA 9
D41A
9_2
Upper Molopo River Wetland Complex
Molopo
Lotlhakane
Polfonteinspruit
9_1
0 2.5 5 10 15 20
Kilometers
water & sanitation
REPUBLIC OF SOUTH AFRICA


Mogosane
Ramatlabama
9_6
Disaneng Dam
Lower Molopo River Wetland Complex
Modimola Dam
9_2
IUA 9
9_5
D41A
9_3
Molopo
9_4
Lotlhakane
9_1
Madibe
Kabe
Legend
IUA
Resource Unit
Quaternary catchments
Main Rivers
Dams
Priority Wetlands
0 2.5 5 10 15
Kilometers
water & sanitation
REPUBLIC OF SOUTH AFRICA

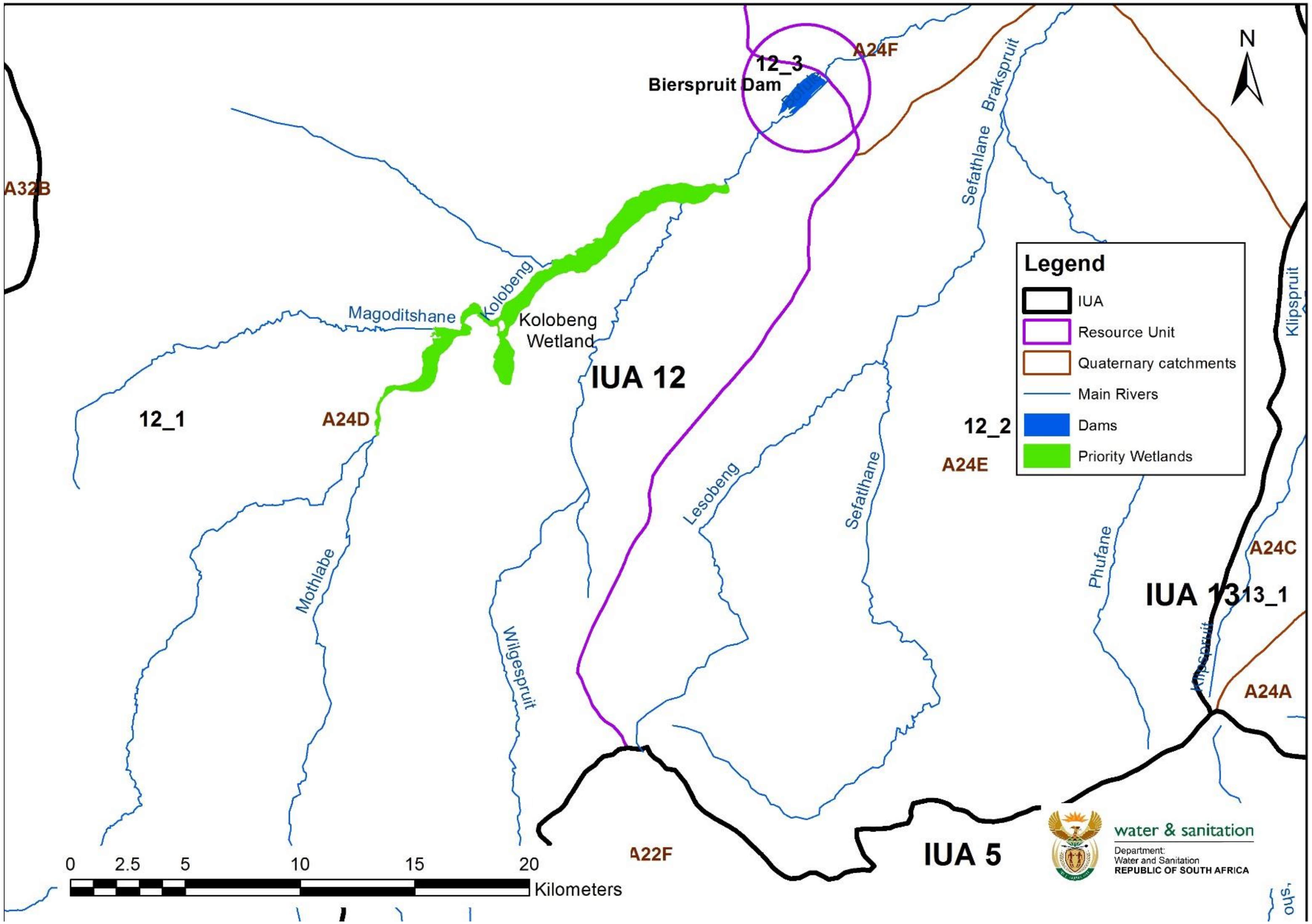
IUA 10: Dinokana Eye/Ngotwane Dam



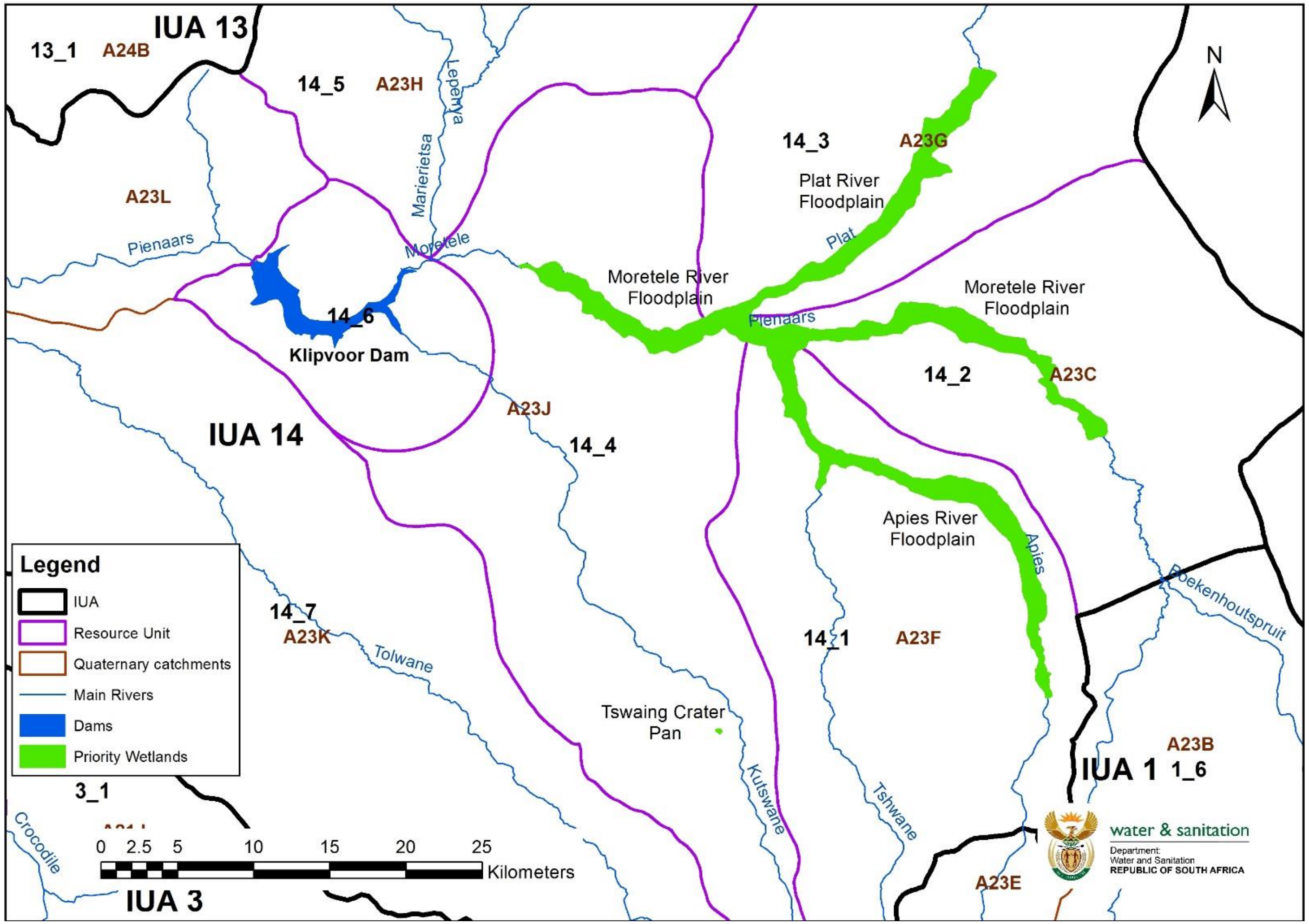
IUA 11b: Groot Marico/seasonal tributaries / IUA 13: Lower Crocodile



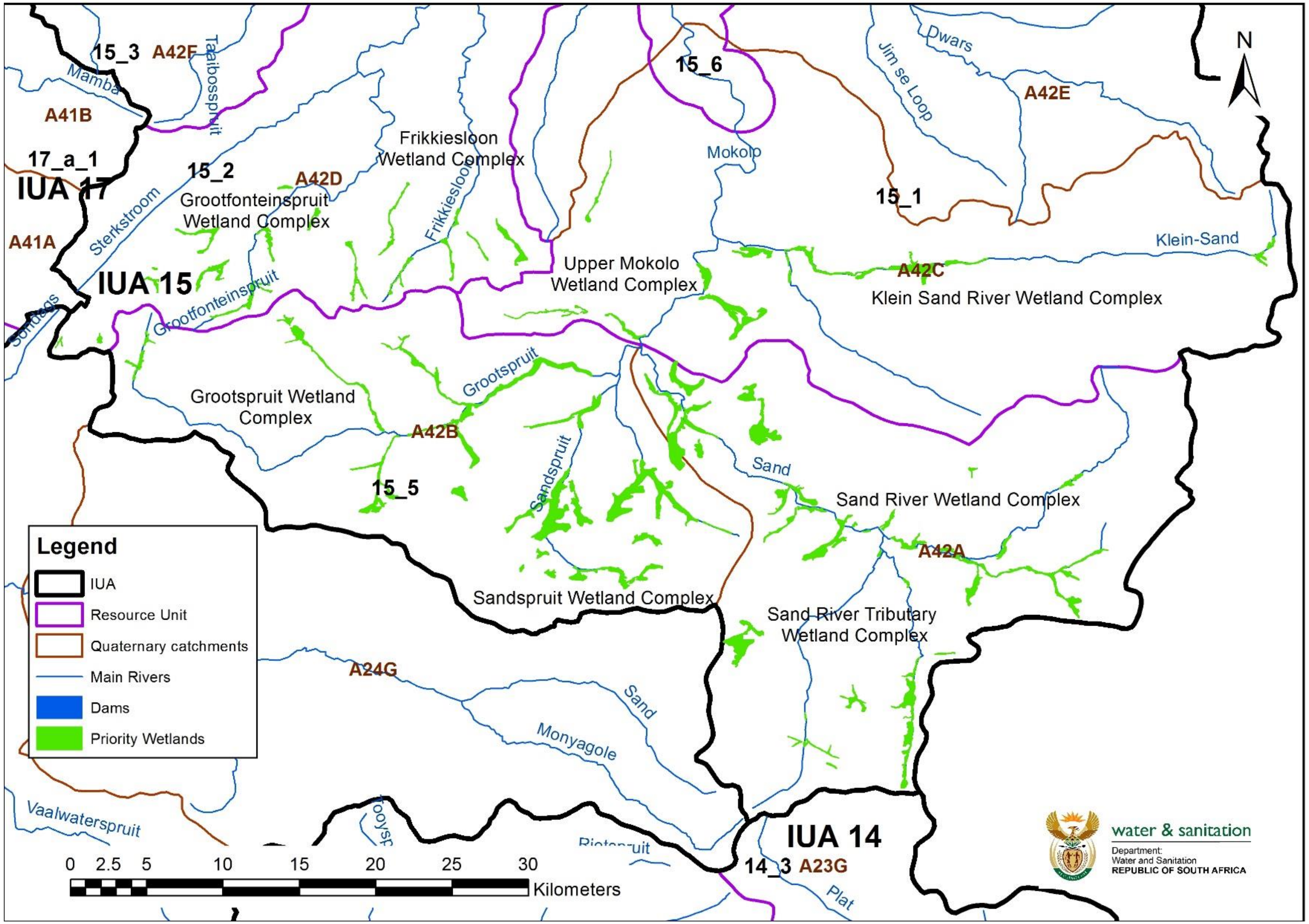
IUA 12: Bierspruit



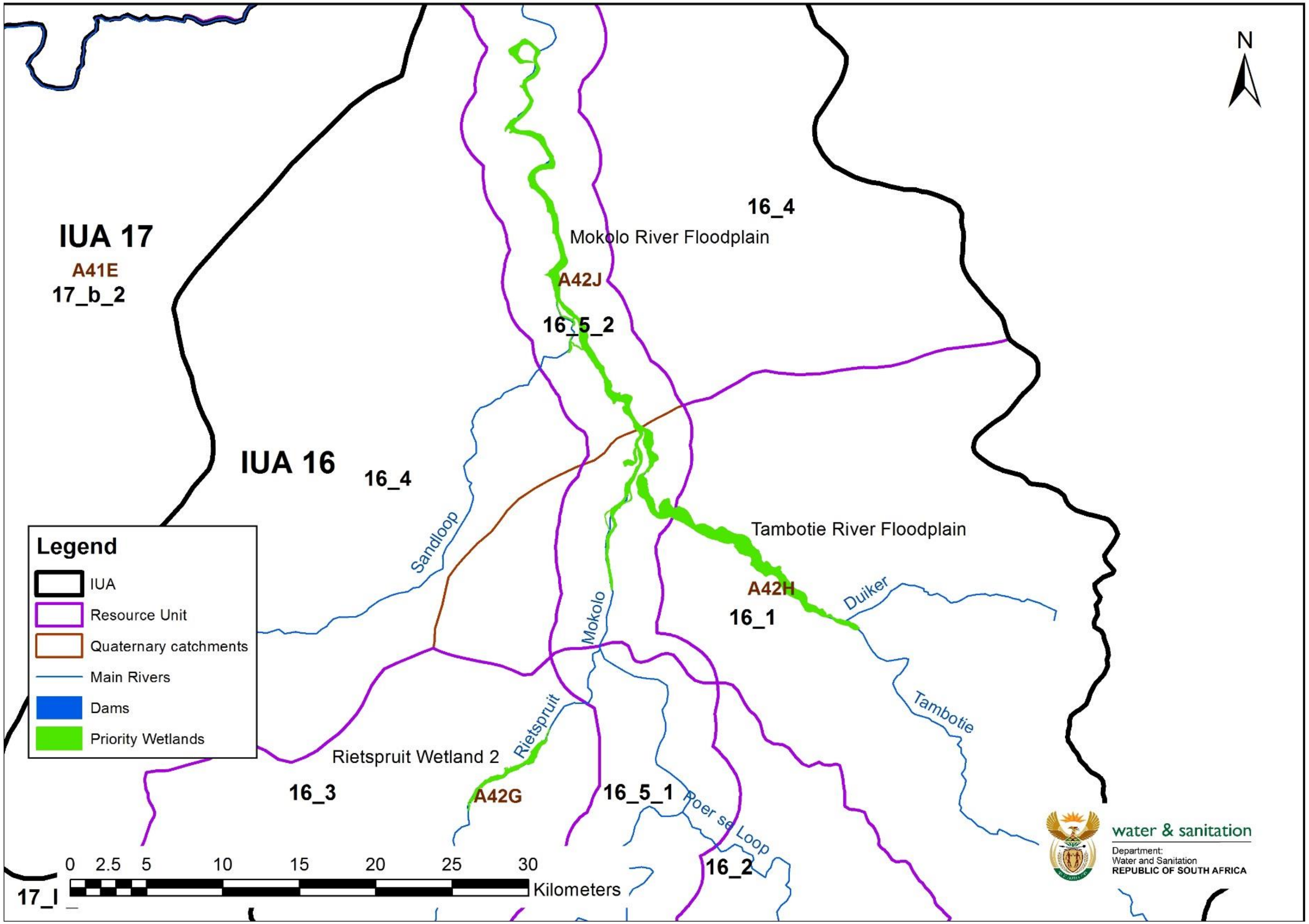
IUA 14: Tolwane/Kulwane/Moretele/Klipvoor



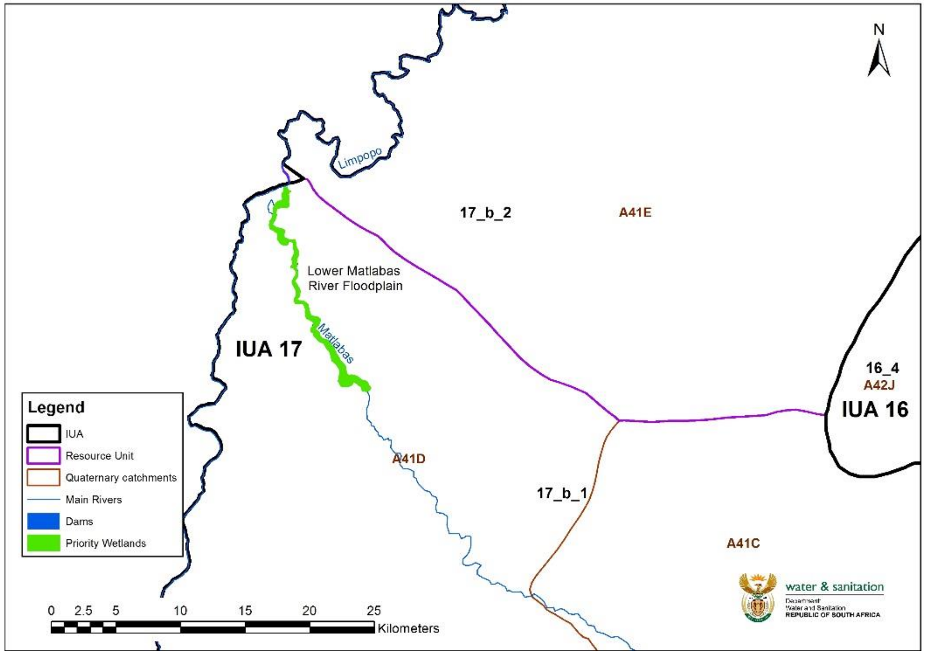
IUA 15: Upper Mokolo

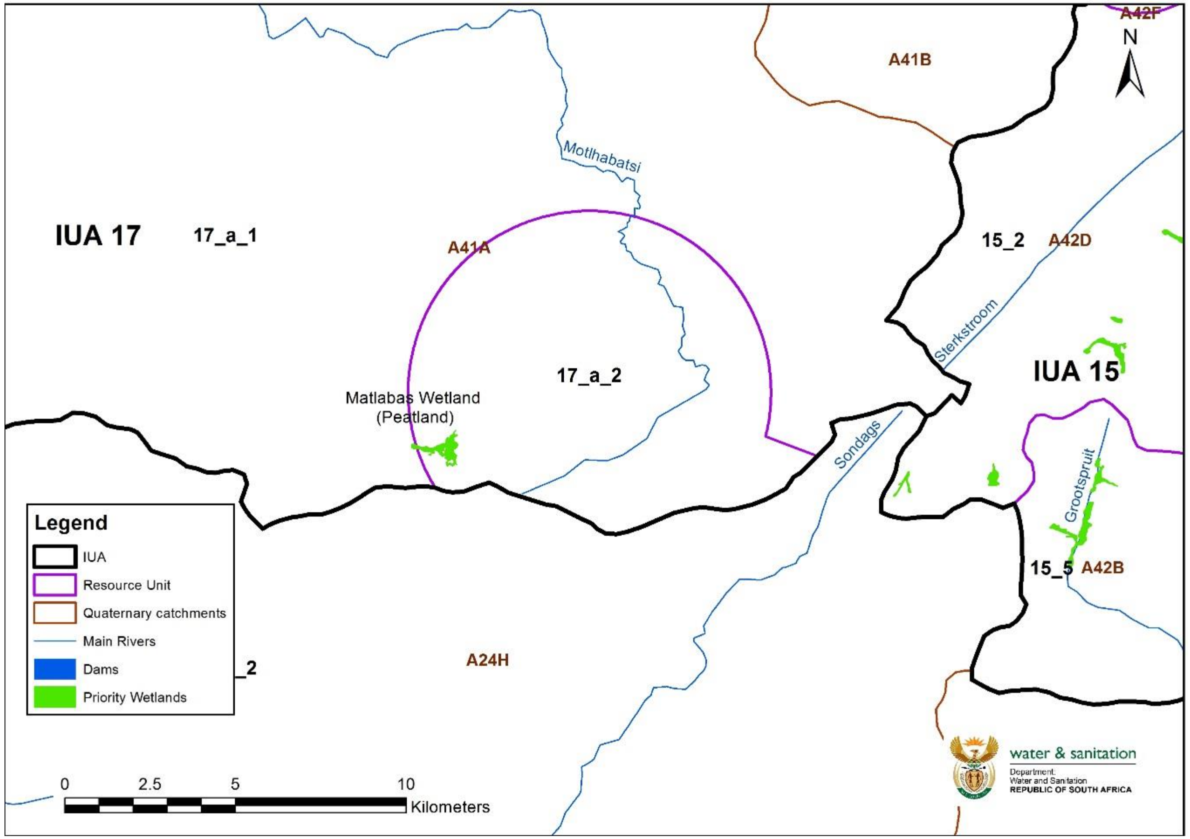


IUA 16: Lower Mokolo



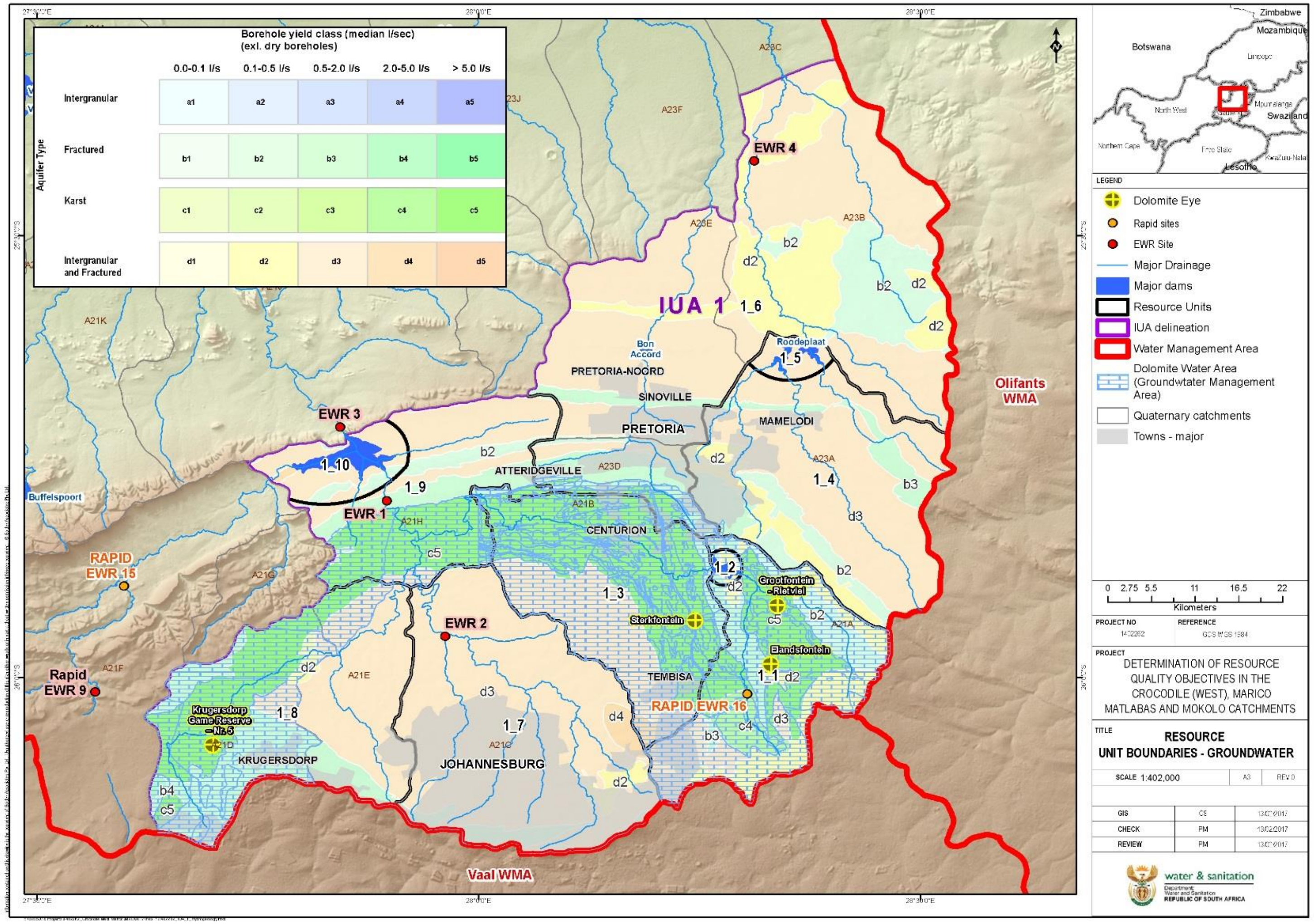
IUA 17a: Mothlabatsi/Mamba / IUA 17b: Matlabas





6.3 GROUNDWATER RESOURCE QUALITY OBJECTIVES

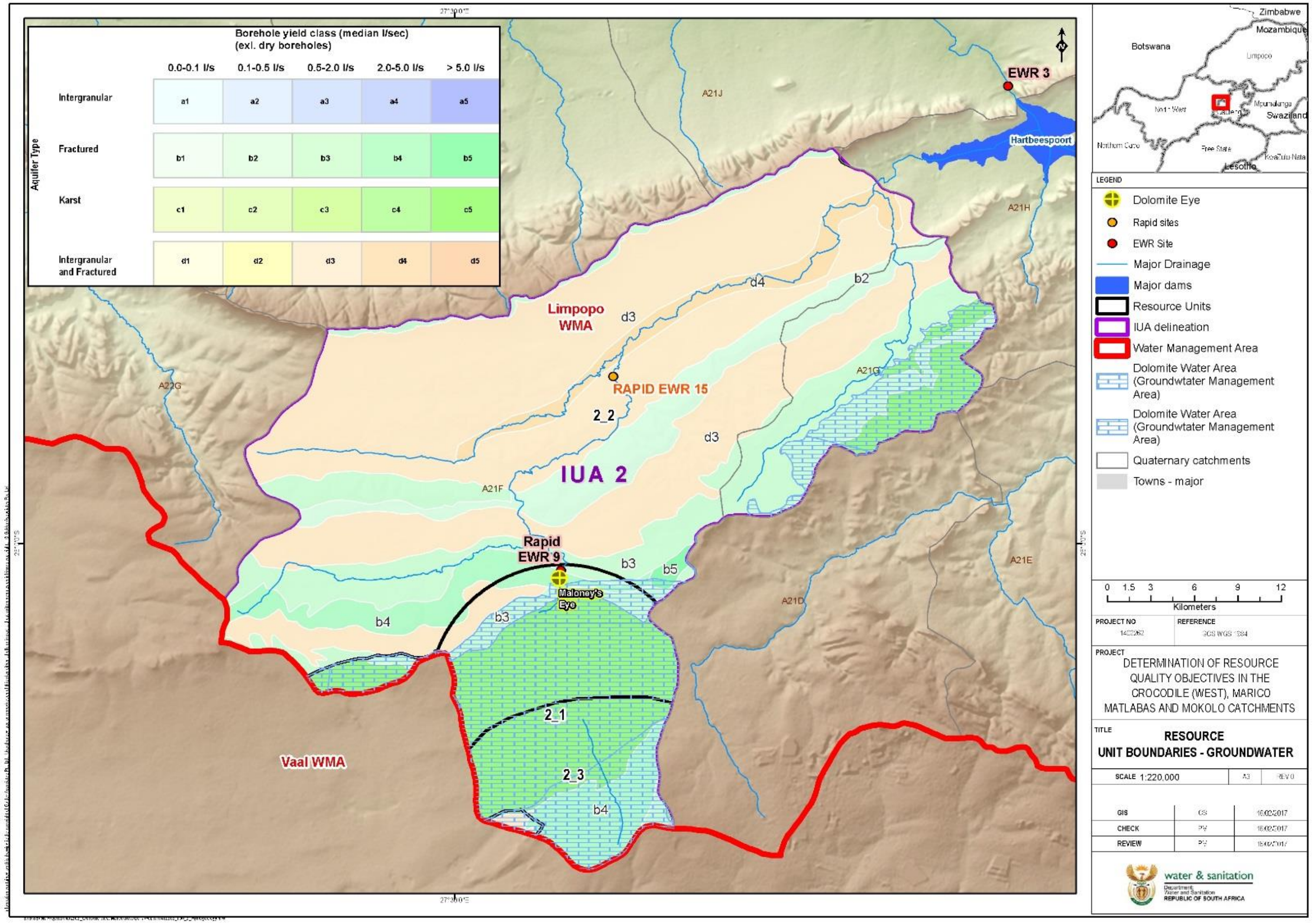
IUA 1: Upper Crocodile/Hennops/Hartbeespoort



IUA	Groundwater unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
IUA1: Upper Crocodile/Hennops/Hartbeespoort	RU - G1	1_1, 1_2, 1_3, 1_8 and 1_9.	Quantity	Groundwater flow patterns based on piezometric elevations in aquifer units should not be reversed from its natural flow directions toward the local drainages (Hennops, Rietvlei and Bloubankspruit systems).	Groundwater level depths (piezometric levels to show flow regime wrt surface water sources). Time series water level monitoring (Monthly) vs abstractions and rainfall input Abstraction of groundwater within prescribed zones from the river course/wetland/eye)	Dolomite aquifer systems: Saturation levels should not be lowered **>6 m** below an average water level depth of **~**22 m (1_1 – 1_2), ~20 m (1_3), ~15 m (1_9), and ~34 m (1_8) in the dolomite aquifer area. Water level recession rate must be less than 0.75 m/a. Abstraction zoning: should be regulated within a 1000 m radius from flowing eye's.
				Sustainable abstractions at Grootfontein-Rietvlei and Pretoria Eyes must be implemented.. Groundwater balance (aquifer recharge and abstraction) needs to be assessed for wet and dry cycles (to secure groundwater yields during dry periods).	Calculation of Stress Indexes (Aquifer Unit Use divided by Aquifer Unit Recharge) expressed as a percentage.	Annual abstraction should not be larger than 65% of average annual recharge (*i.e.* SI of 65%);
			Quality	Aquifer water quality must be maintained to support ideal/good quality domestic water supply.	Nutrients - Nitrate (NO_3–N, mg/l). Bi-annual monitoring.	Nitrate: Less than 1.0 mg/l. Annual long-term trend should not approach the 50th percentile (~0.9 NO_3–N mg/l).
					Salts - Electrical Conductivity (TDS), mg/l). Bi-annual monitoring of major constituents (macro elements).	Electrical Conductivity ≤30 mS/m; Annual long-term trend should not approach the 95th percentile (~60 mS/m).
				Background water quality status in dolomite aquifer system downstream from Tweelopiespruit and Bloubankspruit must be maintained. (Currently impacted EC=220 mS/m, SO4=965 mg/l, and NO_3–N=3.3 mg/l, median values).	EC, Sulphates and nitrates (origin AMD) in head water area (Tweelopiesspruit) Monthly water quality monitoring at source (TCTA WTW discharges).	Tweelopiespruit (RU 1_8): Limit long-term water quality indicators: EC level = 220 mS/m; SO_4 concentration = 200 mg/l; and NO_3–N concentration = 3.3 mg/l.
				Maintain good water quality status at Grootfontein-Rietvlei and Pretoria Dolomitic Eyes.	EC, pH, SO_4 and NO_3–N to be used was quality indicators.	Limit long-term–Annual long-term: EC: 25 mS/m–27 mS/m (95th percentile); SO_4: <4.5 mg/l–6.4 mg/l SO_4 (95th percentile); NO_3–N: 0.9 mg/l–1.0 mg/l (95th percentile).
			Protection	Specifically dolomite aquifer systems	Limit radius of influence (r) due to	Water level drawdown limited to dolomite

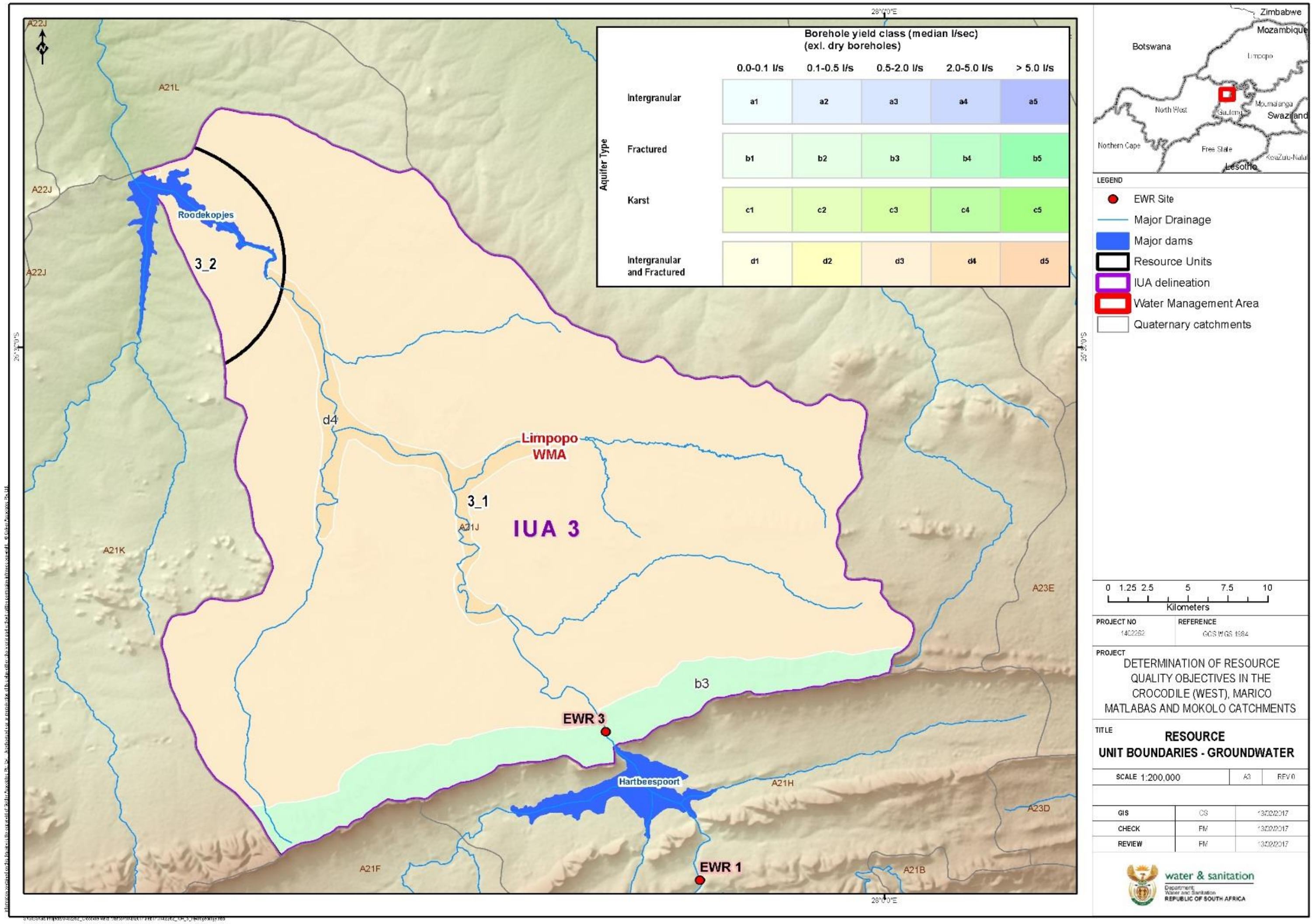
IUA	Groundwater unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
			Zone	(Hennops and Bloubankspruit, Rietvlei wet lands, Grootfontein-Rietvlei and Pretoria Eyes): must be protected. Specific water resource protection requirements should become audit conditions in water use licences.	abstractions	sub-compartment unit.
					Distance from river (L)	Activity should be >500 m.
					Distance from wetland (L)	Activity should be >1000 m.
					Distance from Dolomite Eye (L)	Activity should be >1000 m.
					Ground stability (draw down limit, L, to protect buildings/roads /infrastructures)	Limited to 6 m in sub-compartment unit, unless specifically authorised.

IUA2: Magalies Catchment



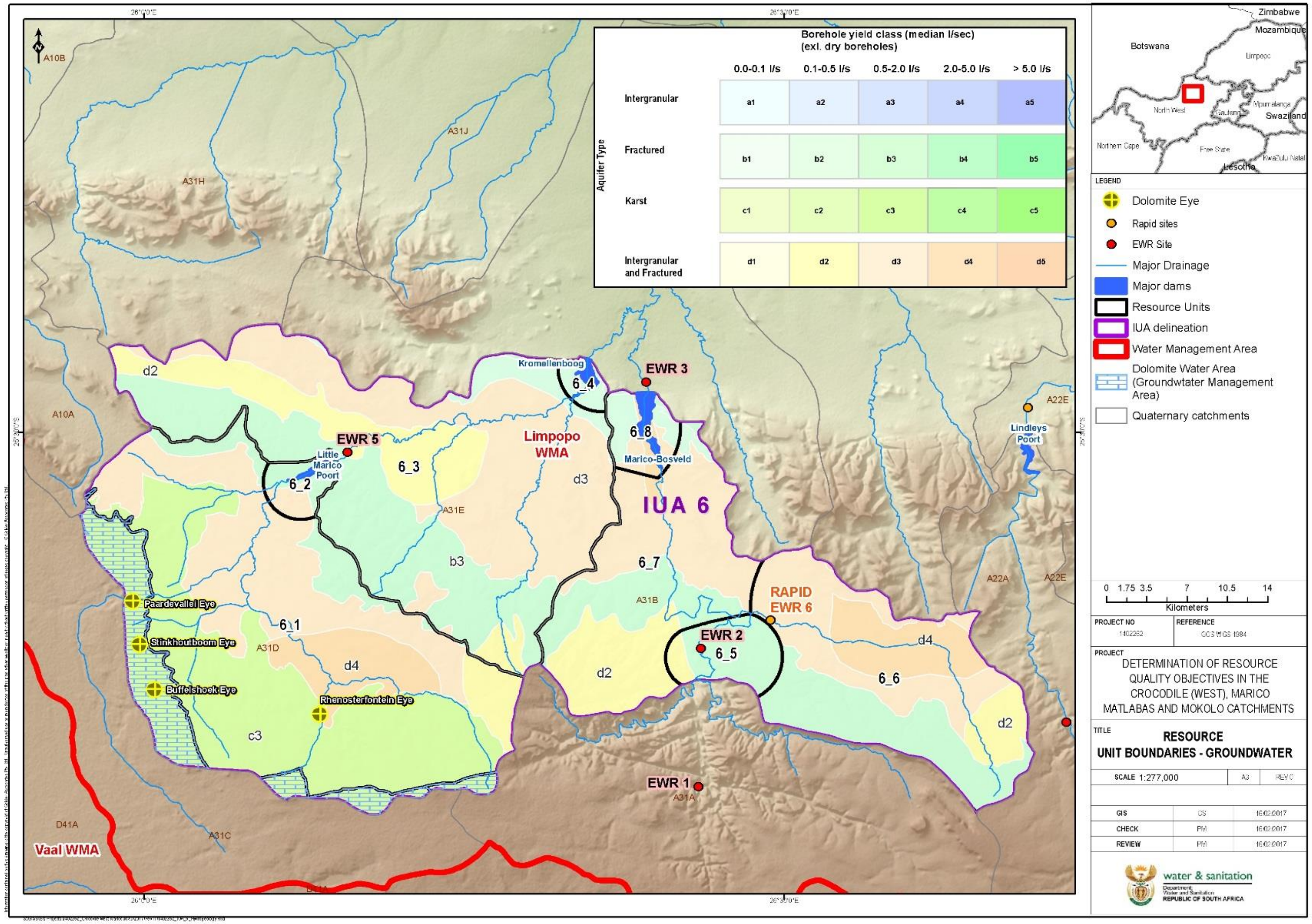
IUA	Groundwater unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
MALONEY'S EYE	**RU - G2**	**2_1; 2_3**	**Quantity**	Maloney's Eye – Continuous flow at eye discharge (head waters of the Magalies River – A21F and Skeerpoort River – A21G) must be maintained.	Groundwater Levels (boreholes) in the eye's catchment, *i.e*. depth to groundwater level from ground elevation; Flow volumes at Maloney's Eye (compared with rainfall input, water level trends and abstractions in catchment of the eye (i.e. Steenkoppies Compartment); Abstraction of groundwater within prescribed protection zones at the Maloney's Eye (pool and downstream course as per monitor programme).	Dolomite aquifer saturation levels should not be lowered more than 6 m below an average water level depth of **~30** m in the Maloney's Eye catchment area; Flow volume at Maloney's Eye must not be lower than ~4 Mm^3/a (i.e. the pre 1974 long-term yield since 1908 – 1973). Abstraction zoning: to be regulated with the flow at the eye in a radius of 1000 m from the eye pool area.
				Groundwater balance (aquifer recharge and irrigation abstraction) must be achieved.	Calculation of Stress Indexes (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	Limitation of SI value to 65%.
			Quality	Nitrate values in the recharge area must be maintained to support domestic water users.	Nutrients - Nitrate (NO^3–N, mg/l). Bi-annual Monitoring.	Nitrate: Less than 0.3 mg/l. Annual long-term trend should not approach the 95th Percentile (~0.5 mg/l)
				Pristine water quality status at Malony's Eye, Magalies and Skeerpoort Rivers must be maintained. No deterioration must be permitted.	Sulphates (origin AMD) in head water area in the Randfontein Spruit and Bloubank Spruit with possible link across A21D and A21F boundary (fractured Tarlton dyke). Bi-annual monitoring.	SO_4: Less than 5 mg/l. Annual long-term trend should not approach the 95th percentile (~10 mg/l)
				Salinity levels should not increase. Concentrations must be maintained at levels to secure an Ideal/Good water quality status.	Salinity - Electrical Conductivity (TDS), mg/l). Bi-annual monitoring of major constituents (macro elements).	Electrical Conductivity: Less than 25 mS/m; Annual long-term trend should not approach the 95th percentile (~30 mS/m).
			Protection Zone	Demarcated protection zones must be introduced, *i.e.* distances between activity and eye/pool. Specifically for dolomite aquifer systems (Maloney's Eye, Magalies River downstream, and Skeerpoort River).	Stream Depletion Factor	Limit to </=5% of wetland/surface water resource
					Distance from river (L).	Activity regulated if <500 m from downstream drainage
					Distance from Dolomite Eye (L).	Activity regulated if <1000 m from downstream drainage.
					Distance from wetland (L).	Activity regulated if <1000 m from downstream drainage.
					Ground stability (DCU drawdown limit, L) (Buildings/roads/infrastructures).	Limited to 6 m sub-compartment unit, unless specifically authorised.

IUA3: (Upper) Crocodile River (Alluvial Aquifers)



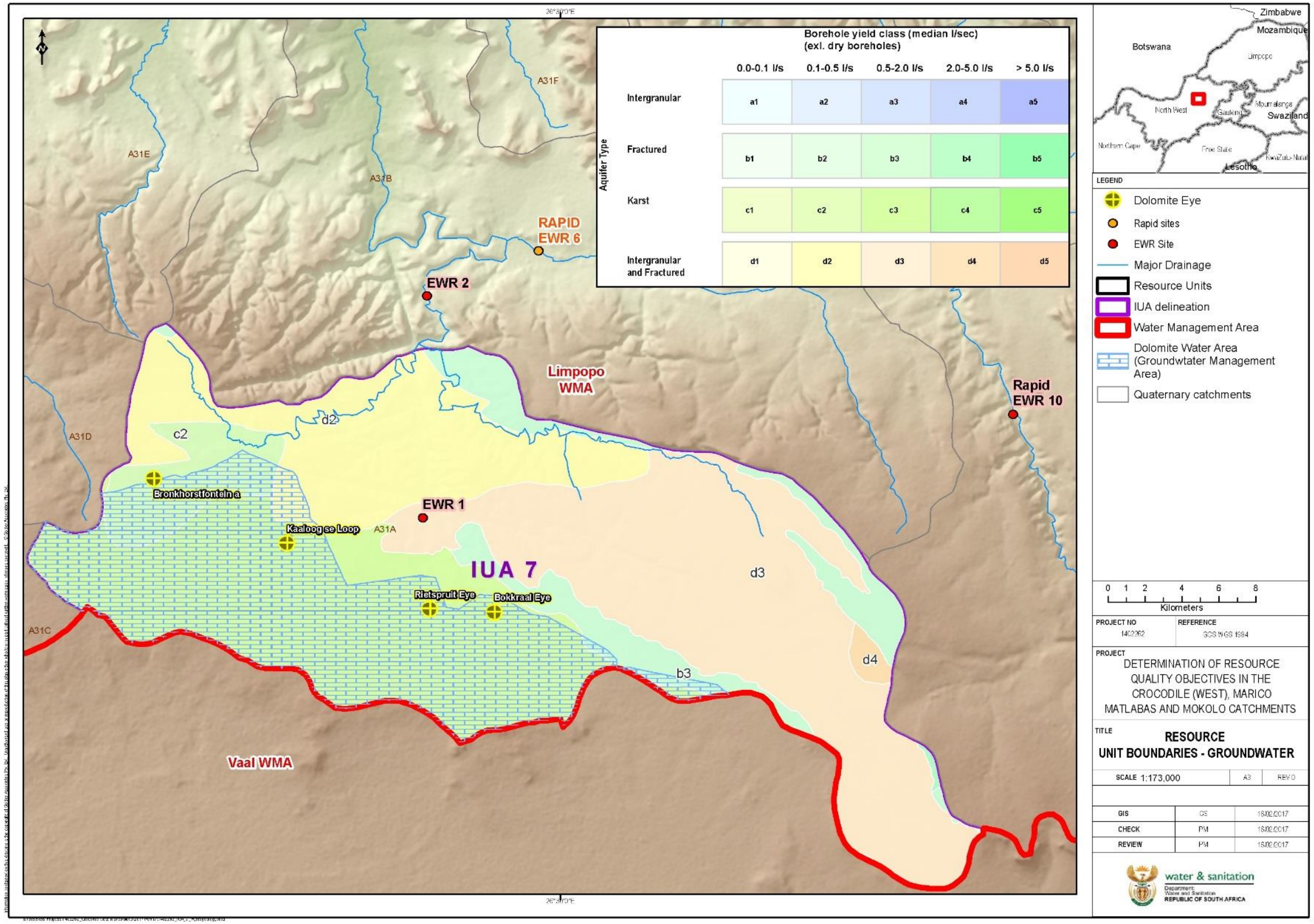
IUA	Groundwater unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
IUA3: (Upper) Crocodile River (Alluvial Aquifers)	RU – G3 Alluvial River Section	3_1 and 3_2	Quantity	Time series water level monitoring (L) across local intergranular and fractured aquifer to establish aquifer-river water interaction must be implemented; Water level observations (local piezometric status) must be recorded	Water Level - Depth to groundwater level on alluvial aquifer system. Groundwater level trends; and Groundwater level gradient in drainage valley.	Any diversion/depletion of the natural groundwater gradient in a 500 m zone along main stem not allowed. Water level recession rate must be less than 1.0 m/a.
				Water balance (interception of surface water) must be maintained..	Positive/Negative water balance estimations, Volume (Q); Flow depletion at downstream gauging weirs.	Surface water losses at gauging stations must equal authorised abstractions from river.
				Groundwater balance status in intergranular and fractured aquifer system must be achieved.	Calculation of Stress Indexes (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	Limitation of SI value (</=65%).
			Quality	Nitrate values in the recharge area must be maintained to support domestic water users.	Nutrients - Nitrate (NO^3–N, mg/l). Bi-annual Monitoring.	Nitrate: Less than 6.0 mg/l
				Manage irrigation return flows from alluvial aquifer system. Salinity levels should not increase. Concentrations must be maintained at levels to secure an Ideal - Good water quality status.	Salts - Electrical Conductivity Bi-annual monitoring of major constituents (macro elements). To monitor quality of return flows from alluvial area. Sodium absorption Ratio for alluvial aquifer water	Electrical Conductivity: Less than 75 mS/m
			Protection Zone	Protect Intergranular (alluvial) and fractured aquifer system along central Crocodile and Rose Spruit segments in terms of Sw-Gw Interaction.	Stream Depletion Factor (manage distance between surface water source and well fields).	Limit impact to <5% of abstraction yield intercepted from surface water source(s).
				Land use activities that may impact on the intergranular aquifer must be controlled.	Specify all land use activities on floodplain area and intergranular aquifer system.	Limit activities according to 50 day (microbial) and 365 (dilution) day water quality protection zoning (L).

IUA 6: 6a: Klein Marico Eye



IUA	Groundwater unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
6a: Klein Marico Eyes	RU – G6	**6_1,** Long-term water quality monitoring at background boreholes and Rhenosterfontein, Eye as water quality references.	**Quantity**	Groundwater flow patterns based on piezometric elevations in aquifer units should not be reversed from its natural flow directions toward the local drainages (Klein Marico River, Rhenosterfontein Spruit, and Lower Malmani Loop).	Water Levels - Depth to groundwater level from ground elevation. Time series water level monitoring (Monthly) vs abstractions and rainfall input	Dolomite aquifer systems: Saturation levels should not be lowered >6 metres below an average water level depth of ~**20** m in the dolomite aquifer area. Water level recession rate must be less than 0.75 m/a.
				Groundwater balance (aquifer recharge and irrigation abstraction) needs to be assessed for wet and dry cycles (to secure groundwater yields during dry periods).	Calculation of Stress Index (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	Annual abstraction should not be larger than 65% of average annual recharge (i.e. SI of 65%);
			Quality	Nitrate values must be maintained to support domestic water users (Ideal –Good water quality).	Nutrients - Nitrate (NO^3–N, mg/l). Bi-annual Monitoring.	Nitrate: ~0.3 mg/l Long-term trend should not approach 95th percentile (~1.2 mg/l)
				Flouride concentrations must not impact on water users. Flouride levels must be maintained within the prescribed limit.	Fluoride (F, mg/l); Bi-annual monitoring.	Fluoride: ~0.2 mg/l. Annual long-term trend should not approach the 95th percentile (~1.42 mg/l).
				Salinity levels should not increase. Concentrations must be maintained at levels to secure an Ideal-Good water quality status.	Salts - Electrical Conductivity (TDS), mg/l). Bi-annual monitoring of major constituents (macro elements). NaCl concentrations from mining activities in dolomitic Eye catchments (*i.e.* Rhenosterfontein Eye case)	Electrical Conductivity: ≤ 50 mS/m Annual long-term trend should not approach the 95th percentile (~60 mS/m)
			Protection Zone	Protection zoning of specifically dolomite aquifer systems (Irrigation area) must be implemented; Specific water resource protection requirements should become audit conditions in water use licences.	Restriction of abstraction based on application of the Stress Index approach. Abstraction zoning: should be regulated according to downstream flow requirement.	Abstraction restriction (SI<65%) within a radius of 1000 m from the dolomitic Eyes pool areas.
					Waterlevel drawdown limit in dolomite compartment unit.	Maximum 6 m (unless specifically authorised)
					Limitation of irrigation area on property size (ha's).	Limit to 9% of deed area (ha's)
					Distance from local river system	Activity should be >500 m.
					Distance from Dolomite Eye (L)	Activity should be >1000 m, unless specifically authorised.
					Ground stability (DCU drawdown limit, L) (buildings/roads/infrastructures).	Limited to 6 m sub-compartment unit.

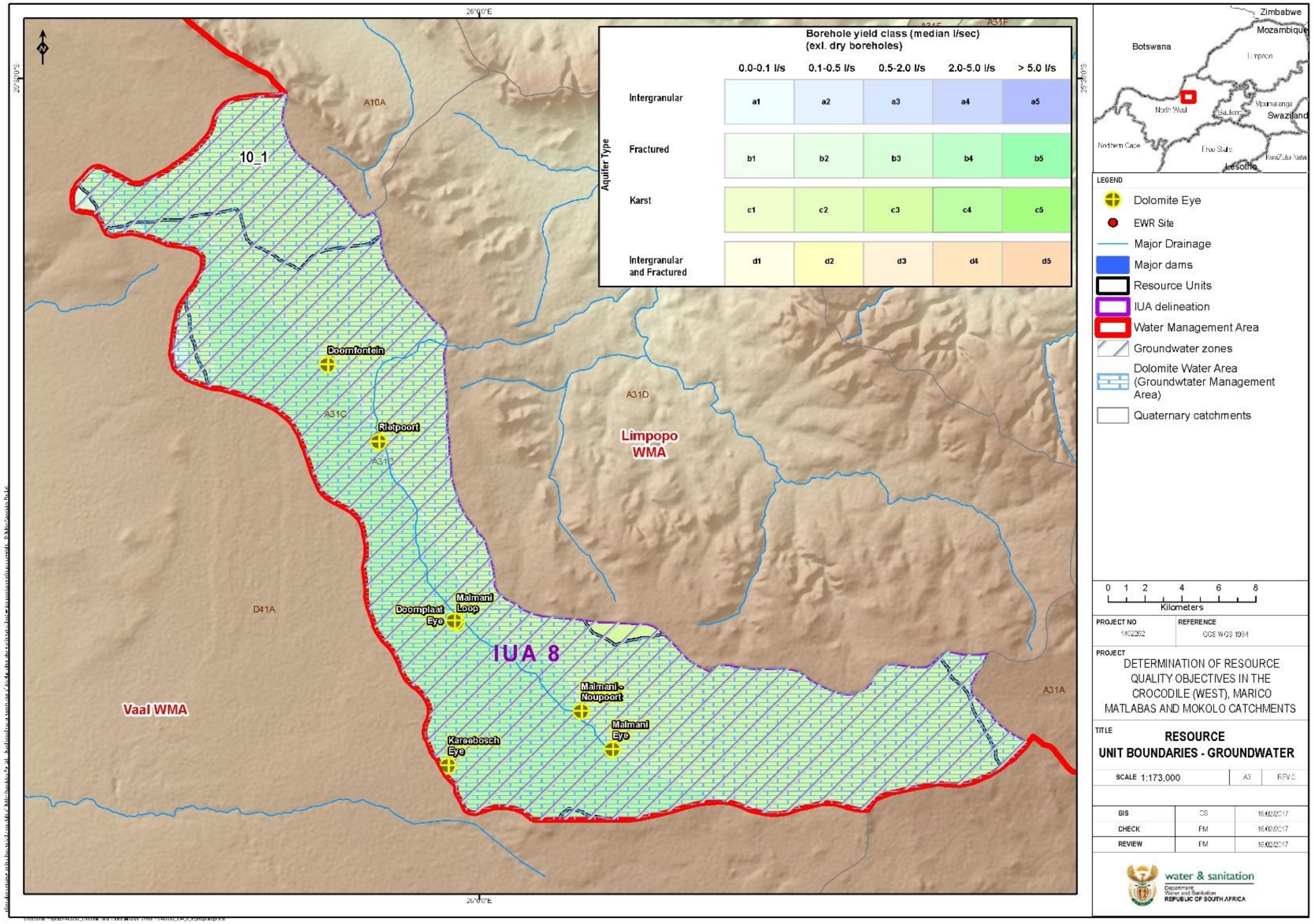
IUA 7: Kaaloog-se-loop



IUA	Groundwater unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
MARICO EYE (ref. Kaaloog Se Loop, Rietspruit and Bokkraal Eyes)	RU – G7	**7_1,** Water quality monitoring at Rhenosterhoek, Bokkraal, Groot Marico, Rietspruit, and Kaaloog se Loop dolomitic Eyes as water quality references.	**Quantity**	Continuous Flow measurement at selected dolomite eyes, i.e. Bokkraal Nr. 1 via the Vanstratensvlei River (only flow data from 1907 to 1943!) must be implemented. (Other important eye discharging into the upper Groot Marico River is Rietspruit (via the Vanstratensvlei River)); (Note: there are several other dolomitic eyes in the area, but flow dataset/information is not available).	Demarcation of eye catchment area (southern boundary not clear); Water Levels - Depth to groundwater level from ground elevation; Time series water level monitoring (Monthly) vs abstractions and rainfall input; and Abstraction of groundwater within prescribed zones from the river course/wetland/eye-spring)	Dolomite aquifer systems: Saturation levels should not be lowered >6 metres below an average water level depth of ~21 m in the eye catchment area. Water level recession rate must be less than 0.75 m/a. Abstraction zoning: should be regulated with flow of the eye in a radius of 1000 m from the Bokkraal and Rietspruit Eye pool areas.
				Groundwater balance (aquifer recharge and irrigation abstraction) needs to be assessed for wet and dry cycles (to secure groundwater yields during dry periods).	Calculation of Stress Indexes (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	Annual abstraction should not be larger than 65% of average annual recharge (i.e. SI of 65%);
			Quality	Nitrate values in the recharge area must be maintained to support domestic water users.	Nutrients - Nitrate (NO^3–N, mg/l). Bi-annual monitoring.	Nitrate: ≤ 0.2 mg/l; Annual long-term trend should not approach the 95th percentile (~1.10 mg/l)
				Flouride concentrations must not impact on water users. Flouride levels must be maintained within the prescribed limit.	Fluoride (F, mg/l) Bi-annual monitoring.	Fluoride: ~0.1 mg/l Annual long-term trend should not approach the 95th percentile (~1.3 mg/l).
				Salinity levels should not increase. Concentrations must be maintained at levels to secure an Ideal/Good water quality status.	Salts - Electrical Conductivity (TDS), mg/l). Bi-annual monitoring of major constituents (macro elements).	Electrical Conductivity: ≤ 35 mS/m Annual long-term trend should not approach the 95th percentile (~60 mS/m).
			Protection Zone	Demarcated protection zones to be introduced, *i.e.* distances between activity and eye/pool.	Map catchment (hectares) of the Eye and include a bulk water supply abstraction limitation.	Restriction of abstraction based on application of the Stress Index approach.

IUA	Groundwater unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
				Specifically for dolomite aquifer systems (Marico Eyes and Groot Marico, Rietspruit River downstream).	Limitation of irrigation area on property size (ha's).	Limit to 9% of deed area (ha's)
					Distance from local river system	Activity regulated if <500 m from downstream drainage
					Distance from Dolomite Eye (L)	Activity regulated if <1000 m from downstream drainage.
					Distance from wetland (L).	Activity regulated if <1000 m from downstream drainage.
					Waterlevel drawdown limit in dolomite compartment unit.	Limited to 6 m sub-compartment unit.

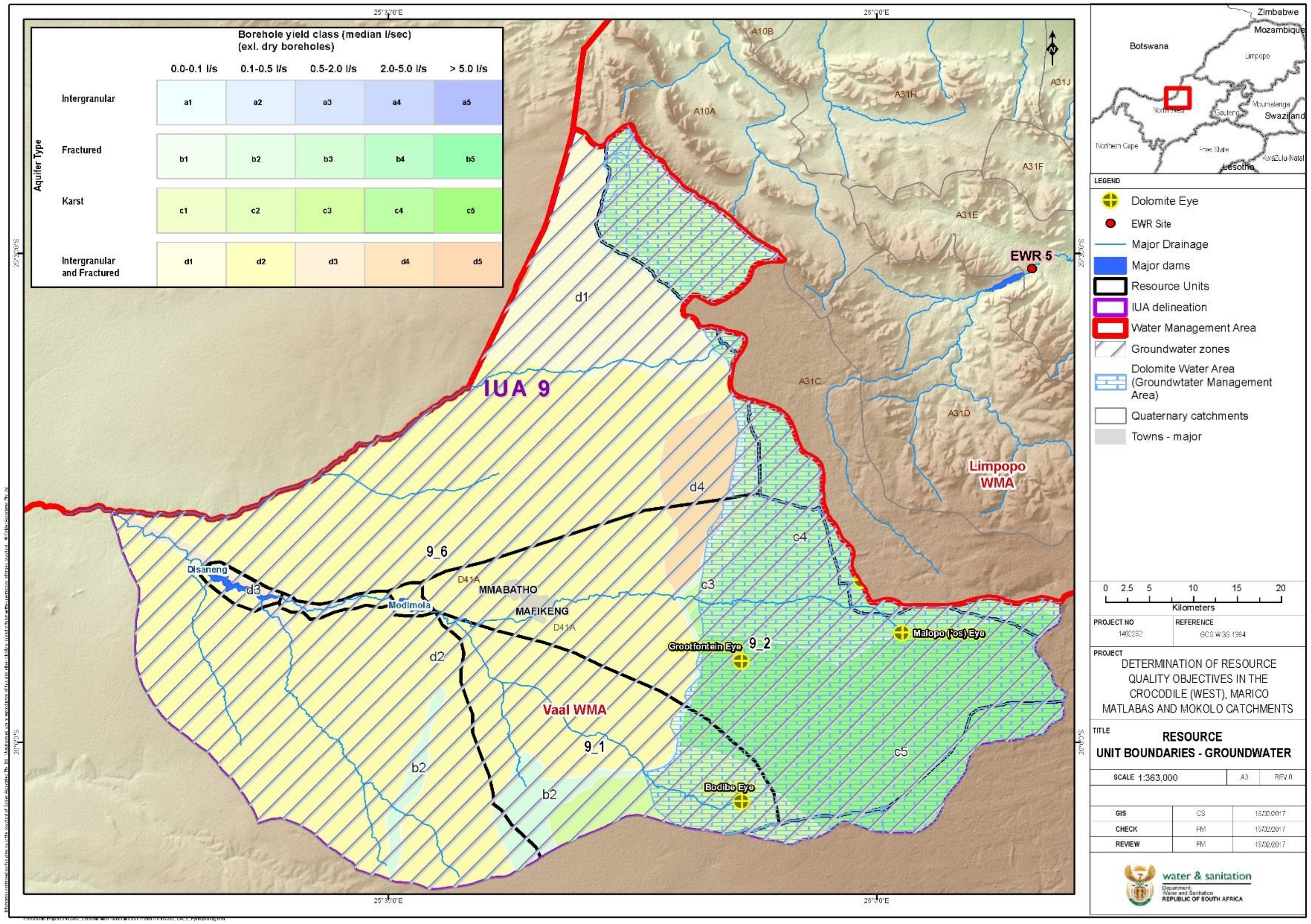
IUA8: Malmaniesloop



IUA	Ground-water unit	RU	Sub-component	Resource Quality Objectives	Indicator/ Measure	Numerical Limit
8: Malmanie Se Loop	**RU – G8**	**8_1** Water quality monitoring at Malmani Eye, Malmani-Noupoort, Doornplaat, Rietpoort, Doornfontein, Buffelshoek, Stinkhoutboom, and Paardevallei dolomitic Eyes as water quality references	**Quantity**	Groundwater flow patterns based on piezometric elevations in aquifer units should not be reversed from its natural flow directions toward the local drainages (Malmani Eye Se Loop). Discharge areas (i.e. Malmani Eye, Malmani-Noupoort, Doornplaat Eye, Rietpoort Eye, Doornfontein, Buffelshoek, Stinkhoutboom, and Paardevallei dolomitic Eyes) should be protected against depletion of water table below eye outflow gauge).	Water Levels - Depth to groundwater level from ground elevation. Time series water level monitoring (Monthly) vs abstractions and rainfall input Abstraction of groundwater within prescribed zones from the river course/wetland/eye-spring);	Dolomite aquifer systems: Saturation levels should not be lowered >6 metres below an average water level depth of ~**21** m in the dolomite aquifer area. Water level recession rate must be less than 0.75 m/a. Abstraction zoning: should be regulated (1000 m for eye pools).
				Groundwater balance (aquifer recharge and irrigation abstraction) needs to be assessed for wet and dry cycles (to secure groundwater yields during dry periods). Proper irrigation schedules need to be developed and applied at all times (100% compliance).	Abstraction - Volume (Q).Time series of abstraction-rainfall-water level of aquifer system. Annual groundwater balance (aquifer recharge and irrigation abstraction) needs to be for wet and dry cycles.	Annual abstraction should not be larger than 65% of average annual recharge (i.e. SI of 65%);
				Water balance Status must be determined	Calculation of Stress Indexes (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	
			Quality	Nitrate values in the recharge area must be maintained to support domestic water users (95th percentile = 18 mg/l).	Nutrients - Nitrate (NO^3–N, mg/l). Bi-annual Monitoring.	Nitrate: Less than 1.0 mg/l; Annual long-term trend should not approach the 75th percentile (i.e. ~3.5 mg/l)
				Salinity levels should not increase. Concentrations must be maintained at levels to secure a healthy water quality status.	Salts - Electrical Conductivity Bi-annual monitoring of major constituents (macro elements).	Electrical Conductivity: Less than 50 mS/m; Annual long-term trend should not approach the 95th percentile (i.e. ~85 mS/m)
				Flouride concentrations must not impact on water users. Flouride levels must be maintained within the prescribed limit.	Fluoride (F, mg/l) Bi-annual monitoring.	Fluoride: Less than 0.15 mg/l; Annual long-term trend should not approach the 95th percentile (~1.0 mg/l).

IUA	Ground-water unit	RU	Sub-component	Resource Quality Objectives	Indicator/ Measure	Numerical Limit
			Protection Zone	Protection zoning of specifically dolomite aquifer systems (*viz*. the larger dolomitic Eyes) must be implemented; Specific water resource protection requirements should become audit conditions in water use licences.	Waterlevel drawdown limit in dolomite compartment unit.	Maximum 6 m (unless specifically authorised)
					Stream Depletion Factor	Limit to </=5% of wetland/surface water resource
					Limitation of irrigation area on property size (ha's).	Limit to 9% of deed area (ha's)
					Distance from Dolomite Eye and wetland zone (L)	Should be >1000 m, unless specifically authorised for bulk water supplies.

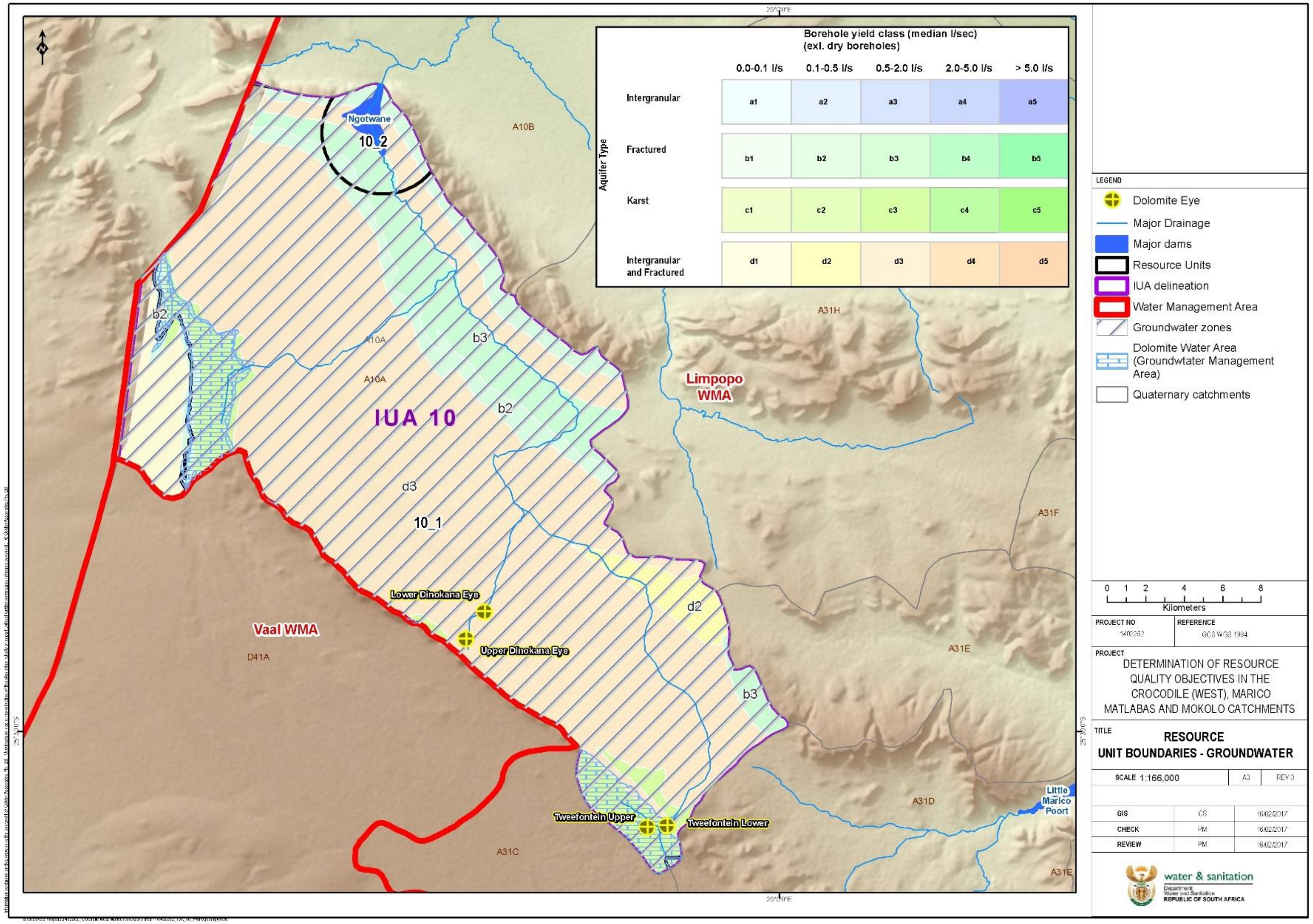
IUA 9: Molopo


Borehole yield class (median l/sec) (exl. dry boreholes)
0.0-0.1 l/s
0.1-0.5 l/s
0.5-2.0 l/s
2.0-5.0 l/s
> 5.0 l/s
Aquifer Type
Intergranular
Fractured
Karst
Intergranular and Fractured
IUA 9
Vaal WMA
Limpopo WMA
EWR 5
MMABATHO
MAFIKENG
Disaneng
Modimola
Grootfontein Eye
Malopo (los) Eye
Bodibe Eye
9_6
9_2
9_1
LEGEND
Dolomite Eye
EWR Site
Major Drainage
Major dams
Resource Units
IUA delineation
Water Management Area
Groundwater zones
Dolomite Water Area (Groundwtater Management Area)
Quaternary catchments
Towns - major
Kilometers
PROJECT
DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE CROCODILE (WEST), MARICO MATLABAS AND MOKOLO CATCHMENTS
TITLE
RESOURCE UNIT BOUNDARIES - GROUNDWATER
SCALE 1:363,000
water & sanitation

IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
9: Upper Molopo River	RU – G9	9_1 and 9_2	Quantity	Groundwater flow patterns based on piezometric elevations in aquifer units should not be reversed from its natural flow directions toward the local drainages Discharge areas (i.e. Malapo Eye) should be protected against total depletion of water table (i.e. as the case is for Grootfontein Eye and Bodibe Eye).	Water Levels - Depth to groundwater level from ground elevation. Time series water level monitoring (Monthly) vs abstractions and rainfall input Abstraction of groundwater within prescribed zones from the river course/wetland/eye-spring)	Dolomite aquifer systems: Saturation levels should not be lowered >6 metres below an average water level depth of ~**19** m in the dolomite water area. Water level recession rate must be less than 0.75 m/a. Abstraction zoning: should be regulated (1000 m for karst aquifer systems).
				Groundwater balance (aquifer recharge and irrigation abstraction) needs to be assessed for wet and dry cycles (to secure groundwater yields during dry periods). Proper irrigation schedules need to be developed and applied at all times (100% compliance).	Abstraction - Volume (Q).Time series of abstraction-rainfall-water level of aquifer system. Annual groundwater balance (aquifer recharge and irrigation abstraction) needs to be for wet and dry cycles.	Annual abstraction should not be larger than 65% of average annual recharge.
				Water balance Status must be determined.	Calculation of Stress Indexes (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	
			Quality	Nitrate values in the recharge area must be maintained to support domestic water users. (Agricultural sources for nitrate)	Nutrients - Nitrate (NO^3–N, mg/l). Bi-annual Monitoring Monthly monitoring at DWS gauging stations.	Nitrate: Less than 1.0 mg/l; Annual long-term trend should not approach the 95th percentile (~3.0 mg/l).
				Salinity levels should not increase. Concentrations must be maintained at levels to secure a healthy water quality status.	Salts - Electrical Conductivity. Monthly monitoring at DWS gauging stations.	Electrical Conductivity: Less than 50 mS/m; Annual long-term trend should not approach the 95th percentile (~80 mS/m).
				Industrial/agricultural pollutants for Molopo, Grootfontein, Itsoseng (Bodibe) Eyes must be controlled.	Sulphates SO_4 concentrations) Monthly water quality monitoring at source areas (eye's and well fields)	SO_4: Less than 5.0 mg/l; Annual long-term trend should not approach the 95th percentile (~30 mg/l).
			Protection Zone	Protection of Intergranular and Fractured Aquifers: Protect lower sections of Madibe, Polfontein Spruit	Distance from drainage valley: based on 50 Day travel time (microbial) and 365 day dilution period (inorganic	<1000 m Protection zoning (DLMT aquifers) <500 m Protection zoning (hard rock aquifers).

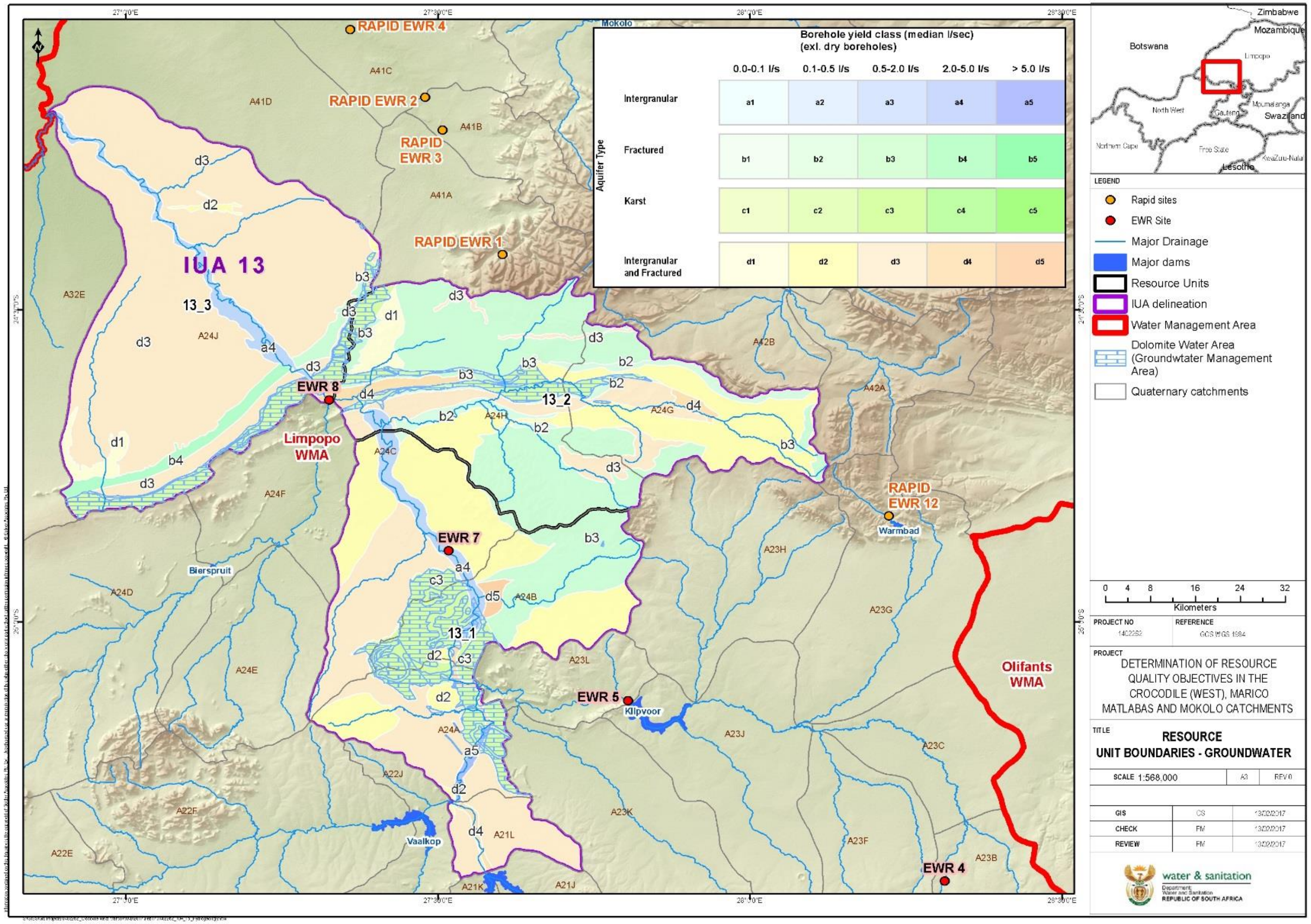
IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
				and Molopo River against industrial/agricultural/microbial pollution must be undertaken.	constituents)	
					Distance from discharge area of dolomite eyes: based on 50 Day travel time (microbial) and 365 day dilution period (inorganic constituents)	<1000 m Protection zoning (hard rock aquifers)

IUA10: Ngotwane



IUA	Ground-water unit	RU	Sub-component	Resource Quality Objectives	Indicator/ Measure	Numerical Limit
IUA10: Dinokana Eye	**RU – G10**	**10_1**	**Quantity**	Discharge areas (i.e. Eyes/springs) should be protected against total depletion of water table)	Water levels: Time series water level monitoring (Monthly) vs abstractions and rainfall input.	Dolomite aquifer systems: Saturation levels should not be lowered >6 metres below an average water level depth of ~**24** m in the dolomite aquifer area. Water level recession rate must be less than 0.75 m/a. Abstraction zoning: should be regulated (1000 m radius from eye pool)
				Water balance Status (Water use regulation in recharge area) must be maintained.	Flow gauging at Eye discharge. Calculation of Stress Indexes (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	Annual abstraction should not be larger than 65% of average annual recharge (i.e. SI of 65%).
			Quality	Nitrate values in the recharge area must be maintained to support domestic water users.	Nutrients - Nitrate (NO^3–N, mg/l). Bi-annual Monitoring.	Nitrate: ~1.0 mg/l; Annual long-term trend should not approach the 95^{th} percentile (1.1 mg/l).
				Flouride concentrations must not impact on water users. Flouride levels must be maintained within the prescribed limit.	Fluoride (F, mg/l) Bi-annual monitoring.	Fluoride ~0.15 mg/l; Annual long-term trend should not approach the 95^{th} percentile (0.5 mg/l).
				Salts: Concentrations must be maintained at levels to secure a healthy water quality status.	Salinity - Electrical Conductivity Monthly monitoring at discharge area.	Electrical Conductivity: ≤ 45 mS/m; Annual long-term trend should not approach the 95^{th} percentile (55 mS/m).
			Protection Zone	Protection zoning of specifically dolomite aquifer systems must be implemented ; Specific water resource protection requirements should become audit conditions in water use licences.	Map catchment (hectares) of the eye and include a bulk water supply abstraction limitation.	Restriction of abstraction based on application of the Stress Index approach.
					Waterlevel drawdown limit in dolomite compartment unit.	Maximum 6 m (unless specifically authorised).
				Additional wellfields in the catchment area of the dolomitic Eyes must be protected.	Limitation of irrigation area on property size (ha's).	Limit to 9% of deed area (ha's).
					Distance from Dolomite Eye (L).	Should be >1000 m, unless specifically authorised for bulk water supplies.

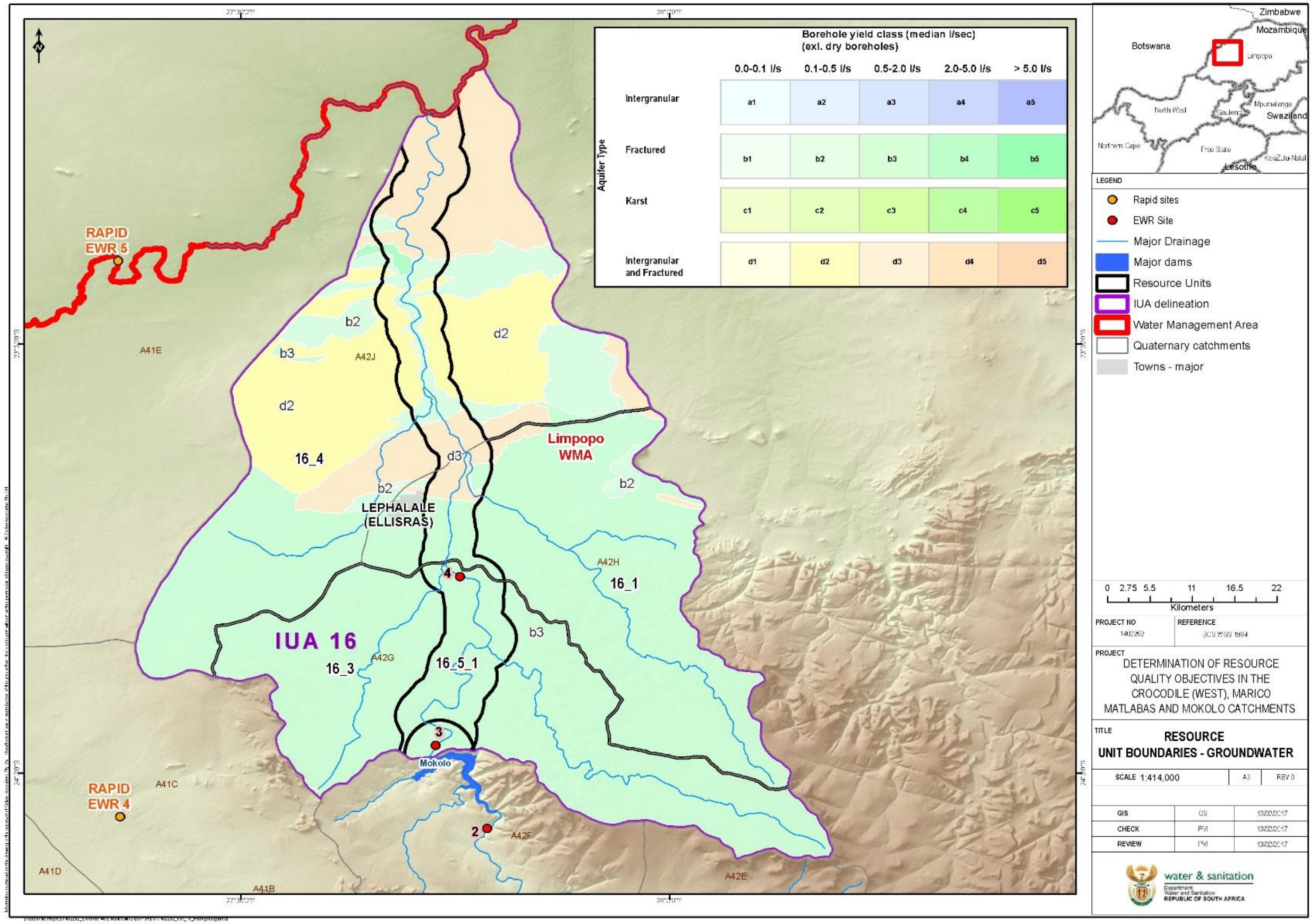
IUA 13: Lower Crocodile



IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
13: Lower Crocodile River	RU – G13 Alluvial River Section	13_1 and 13_3	Quantity	Limit capturing of surface water when abstracting water via boreholes in the flood plain alluvial aquifer systems (there should be a distance limit).	Groundwater level gradient across intergranular aquifer system; and Groundwater level trends on intergranular aquifer systems.	Reverse groundwater gradient (river towards borehole/well field in a 500 m zone along main stem not allowed. Water level recession rate must be less than 1.0 m/a.
					Stream/river flow gauging: Positive/Negative water balance estimations: Volume (Q); Flow depletion at downstream gauging weirs.	Surface water losses must be equal to authorised abstractions from river (incl. evapotranspiration losses).
				Groundwater balance status in intergranular and fractured aquifer system	Calculation of Stress Indexes (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	Annual abstraction should not be larger than 65% of average annual recharge (i.e. SI of 65%).
			Quality	Nitrate values in the recharge area must be maintained to support domestic water users.	Nutrients - Nitrate (NO_3–N, mg/l). Bi-annual Monitoring.	Nitrate: Less than 1.0 mg/l.
				Dissolved salts in groundwater resource must be maintained within the prescribed limit Manage irrigation return flow quality from intergranular (alluvial) aquifer system. Concentrations must be maintained at levels to secure an Ideal - Good water quality status.	Salinity - Electrical Conductivity Weekly/Monthly monitoring. Quality of intergranular (alluvial) aquifer system. SAR for alluvial aquifer water	Electrical Conductivity: Less than 85 mS/m. SAR: Within appropriate limit for irrigation water.
			Protection Zone	Minimum distance from surface water resource where groundwater may be abstracted (based on the hydraulic characteristics of the intergranular (alluvial) aquifer system must be enforced.	Stream Depletion Factor.	Limit borehole/well field abstraction yield to less than 5% of flow in surface water resources (at specific abstraction point).
				Land use activities that may impact on the alluvial aquifer must be controlled/limited.	Water quality measure (microbial migration towards surface water source);	Water quality limit (1): A 50 day (microbial) zoning, distance between activity and surface water source.

IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
				Specify protection zoning (i.e. distance from surface water resources) on intergranular (alluvial) aquifer system in terms of microbial and industrial/agricultural pollution migration.	Water quantity measure (impact on surface water whilst abstracting from intergranular (alluvial) aquifer system.	Water quantity limit (2): A 365 (dilution) day water quality protection zoning (L).

IUA 16: Mokolo



IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
16: Sandloop & Mokolo	RU – G16_4	16_4	**Quantity**	Limit depletion (lowering) of aquifer saturations levels (water levels).	Time series aquifer water level in a surrounding **Reference Area** which represent a background zone around a particular development, i.e. mining area, industrial area and agricultural development).	Water level recession rate must be less than 0.5 m/a in reference area of specific activity.
				Groundwater balance status in aquifer system (Inflow vs outflow).	Stress Index (Aquifer Unit Use/ Aquifer Unit Recharge), outside Area of Activity	Annual abstraction should not be larger than 65% of average annual recharge (i.e. SI of 65%) in Reference Area.
			Quality (Note that elevated background values for critical hydro-chemical elements may be a natural phenomenon and should be acknowledged, i.e. EC, NO_3-N, Cl, SO_4 and F).	The acidity of groundwater with regard to acid rock drainage potential (high in areas of coal mining and UCG's) must limited.	pH value of groundwater in specified Reference Area.	pH value between 6.1 and 8.2 in Reference Area.
				Nitrate values in the recharge area must be maintained to support domestic water users.	Nitrate (NO_3-N) concentration in groundwater in specified Reference Area (T3)	Nitrate: Less than 35 mg/l in Reference Area Annual long-term trend should not approach the 50^{th} percentile + 10% (~40 mg/l) – Based on local studies.
				Dissolved salts in groundwater resources must not be allowed to deteriorate. Monitoring Medupi/ Grootegeluk and other impact related monitoring networks.	Salinity: Electrical Conductivity (EC) of groundwater in specified Reference Area (T3).	Electrical Conductivity Less than 200 mS/m in Reference Area. Annual long-term trend should not approach the 50^{th} percentile + 10% (~220 mS/m) – Based on local studies.
				Macro chemical element of concern dissolved in groundwater.	Chloride (Cl) concentration in groundwater in specified reference area.	Chloride: ≤Less than 300 mg/l in Reference Area. Annual long-term trend should not approach the 50^{th} percentile + 10% (~330mg/l) – Based on local studies.
				Acid Mine Water (or ARD) and decanting into surface water resources must be controlled.Limit impact on groundwater resources.	Sulphates (SO_4) concentration in groundwater in specified Reference Area. (T3)	SO_4: Less than 200mg/l in Reference Area. Annual long-term trend should not approach the 50^{th} percentile + 10% (~220 mg/l) – Based on local studies.
				Fluoride concentrations in groundwater supplied to domestic users must be maintained at the prescribed limits.	Fluoride (F) concentration in groundwater in specified Reference Area. (T3)	Fluoride: Less than 2.5 mg/l in Reference Area. Annual long-term trend should not approach

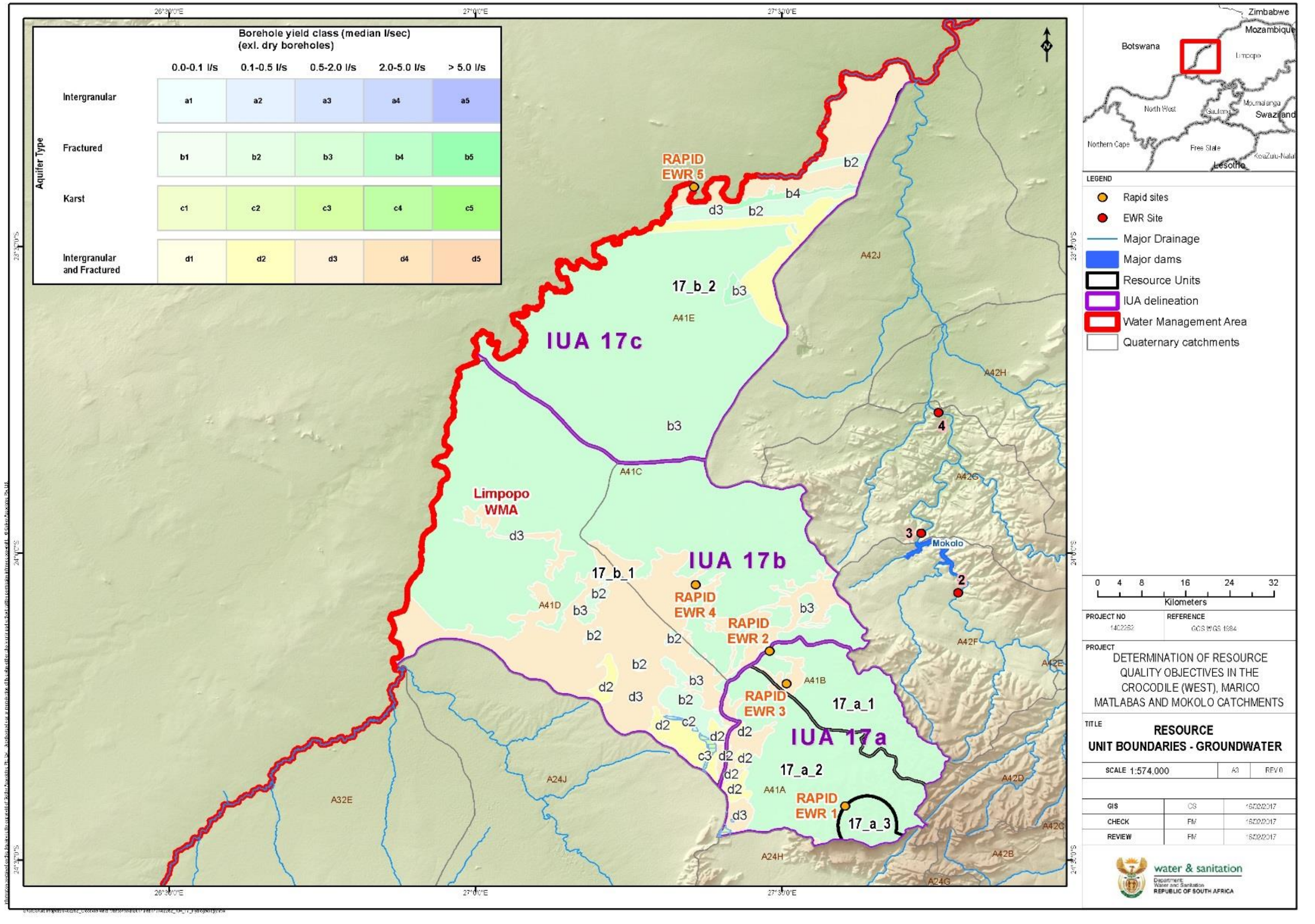
IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
						the 50th percentile + 10% (~2.7 mg/l) – Based on local studies.
			Protection Zone	Aquifer saturation levels	Water level set for a three (3) tier zoning area.	T1–Area of activity: Water level depletion required for activity. T2–Buffer Area: Water level recession rate must be less than 1.0 m/a. T3–Background or Reference Area: Water level recession rate must be less than 0.5 m/a.
				As per water quality specifications.	Water quality parameters set for a three (3) tier zoning area.	T1–Area of activity, concentration levels due to impact (95th Percentile of water quality in quaternary catchment): pH: 4.5 to 9.5; NO_3–N: 60 mg/l; Salinity EC: 780 mS/m; Chloride: 1500 mg/l; Sulphates: 1900 mg/l; and Fluoride: 6.4 mg/l. T2–Buffer Area: Allow up to 75th Percentile supported by a buffer area background study – actual values in observed in quaternary catchment A42J: pH: 6.5 to 8.5; NO_3–N: 35 mg/l; Salinity EC: 370 mg/l; Chloride: 650 mg/l; Sulphates: 600 mg/l; and Fluoride: 2.5 mg/l. T3–Background or Reference Area: Allow up to 50th Percentile + 10% in key constituents as indicated above (Quality).

IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
16: Mokolo	**RU – G16**	**16_5_2**	**Quantity**	Limit capturing of surface water when abstracting water via boreholes in the flood plain alluvial aquifer systems (there should be a distance limit).	Water levels in aquifer: Groundwater level gradient across intergranular aquifer system; and	Reverse groundwater gradient in a 500 m zone along main stem not allowed.

IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
					Groundwater level trends on intergranular aquifer systems.	Water level trends not <-1.0 m/a
				Interaction status between surface water and groundwater resources.	Positive/Negative water balance estimations: Volume (Q); Flow depletion at downstream gauging weirs.	Surface water losses must be equal to authorised abstractions from river (incl. evapotranspiration losses).
				Groundwater balance status in intergranular and fractured aquifer system	Calculation of Stress Index (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	Annual abstraction should not be larger than 65% of average annual recharge (i.e. SI of 65%).
			Quality (Note that elevated background values for critical hydro-chemical elements may be a natural phenomenon and should be acknowledged, *i.e.* EC, NO_3-N, Cl, SO_4, and F).	Nitrate values in the recharge area must be maintained to support domestic water users. Monthly monitoring at DWS gauging stations. Establish background “natural” nitrate concentration in water resource.	Nitrate (NO_3-N) concentration in groundwater Establish background “natural” nitrate concentration in water resource.	Nitrate: Less than 0.5 mg/l (95th percentile)
				Dissolved salts in groundwater resources must not be allowed to deteriorate. Monitoring Medupi/ Grootegeluk and other impact related monitoring networks.	Salinity - Electrical Conductivity Establish background “natural” salinity concentration in water resource.	Electrical Conductivity: Less than 55 mS/m (95th percentile)
				Acid Mine Water (or AMD). Monitoring at Medupi/ Grootegeluk and other industrial areas/activities.	Sulphates (SO_4) concentration levels in groundwater. Establish background “natural” sulphate concentration in water resource.	SO_4: Less than 80 mg/l. (95th percentile)
			Protection Zone	Limit capturing of surface water when abstracting water via boreholes in the flood plain alluvial aquifer systems (there should be a distance limit).	Stream Depletion Factor for Mokolo alluvial aquifer system, (L).	Limit borehole/well field abstraction yield to less than 5% of flow in surface water resources (at specific abstraction point).
				Land use activities that may impact on the intergranular (alluvial) aquifer	Water quality measure (microbial migration towards surface water	Water quality limit (1): A 50 day (microbial) zoning, distance

IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
				system.	source); Water quantity measure (impact on surface water whilst abstracting from intergranular (alluvial) aquifer system.	between activity and surface water source. Water quantity limit (2): A 365 (dilution) day water quality protection zoning (L).

IUA 17: Matlabas



IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
IUA 17: MATALBAS	**RU – G17_b_2**	**17_b_2**	**Quantity**	Limit depletion (lowering) of aquifer saturations levels (water levels).	Water levels in aquifer system; Groundwater level trends.	Water level recession rate must be less than 0.5 m/a.
				Groundwater balance status in aquifer system; Calculation of Stress Index (Aquifer Unit Use/ Aquifer Unit Recharge) as percentages.	A Positive/Negative water balance.	Annual abstraction should not be larger than 65% of average annual recharge (i.e. SI of 65%).
			Quality (Note that elevated background values for critical hydro-chemical elements may be a natural phenomenon and should be acknowledged, i.*e*. EC, NO_3-N, Cl, SO_4, and F).	Nitrate values in the recharge area must be maintained to support domestic water users.	Nitrate (NO_3-N) in groundwater in specified Reference Area (T3)	Nitrate: Less than 3.0 mg/l; Annual long-term trend should not approach the 75th percentile (~3.3 mg/l).
				Dissolved salts in groundwater resources	Salinity: Electrical Conductivity (EC) of groundwater.	Electrical Conductivity Less than 140 mS/m Annual long-term trend should not approach the 75th percentile +10% (~155 mS/m).
				Macro chemical element of concern dissolved in groundwater.	Chloride (Cl) concentration in groundwater in specified reference area.	Chloride: Less than 145 mg/l in Reference Area. Annual long-term trend should not approach the 75th percentile +10% (~160 mg/l).
				Generation of acid mine water from underlying potential acidic rocks; and Prevent future decanting of underground mine water into surface water resources.	Sulphates (SO_4) concentration in groundwater in specified reference area.	SO_4: Less than 85 mg/l. Annual long-term trend should not approach the 75^{h} percentile +10% (~94 mg/l).
				Fluoride concentrations in groundwater supplied to domestic users.	Fluoride (F) concentration in groundwater in specified reference area.	Fluoride: Less than 1.3 mg/l; Annual long-term trend should not approach the 75th percentile +10% (~1.4 mg/l).
			Protection zoning	Aquifer saturation levels	Water level set for a three (3) tier zoning area.	T1–Area of activity: Water level depletion required for activity. T2–Buffer Area: Water level recession rate must be less than 1.0 m/a. T3–Background or Reference Area: Water level recession rate must be less than 0.5 m/a.
				As per water quality specifications.	Water quality parameters set for a three (3) tier zoning area.	T1–Area of activity, maximum concentration levels due to impact (based on dataset in impacted area): pH: 4.5 to 9.5;

IUA	Ground-water unit	RU	Sub-component	Resource Quality Objective	Indicator/ Measure	Numerical Limit
						NO_3–N: 60 mg/l; Salinity EC: 780 mS/m; Chloride: 1500 mg/l; Sulphates: 1900 mg/l; and Fluoride: 6.4 mg/l. T2–Buffer Area: Allow up to 75th Percentile of actual background values in quaternary catchment A41E: pH: 6.0 – 8.5; NO_3–N: 35.0 mg/l; Salinity EC: 370 mg/l; Chloride: 650 mg/l; Sulphates: 600 mg/l; and Fluoride: 2.5 mg/l. T3–Background or Reference Area: Allow up to 50th Percentile + 10% in key constituents as indicated above (see Quality above).

7 CONCLUSION

The RQOs proposed in the above sections provides a set of objectives that are based on available data, information, previous studies, the Water Resource Classification study and inputs from stakeholders. These proposed RQOs and associated limits have been taken through various stakeholder consultation processes and are based on guidance received and best available information sources at the time of development.

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APPENDIX A:

RESOURCE QUALITY OBJECTIVES: FLOOD REQUIREMENTS AT SELECTED SITES

CROC_EWR4 – Pienaars River

Floods	Flood size (range)	Integrated	Equivalent Value used in SPATSIM to generate the floods
Class 1	0-3 daily average	3 cumec, 4-5 day duration 3 floods: Nov/Dec, Jan/Feb, Mar/Apr	3 cumec, 4 day duration 3 Floods, Jan, Mar, Nov
Class 2	3 - 8 daily average	5 cumec, 4 day duration 2 Floods: Dec, Feb	5 cumec, 4 day duration 2 Floods: Dec, Feb
Class 3	8 - 12 peak	12 cumec, 3 day duration 1:5 year, Feb	10 cumec, 3 day duration 1:10 year, Feb
Class 4	12 - 20 peak	20 cumec, 5 day duration 1:10 year, Feb	16 cumec, 4 day duration

CROC_EWR3 – Crocodile River

Floods	Flood size (range)	Integrated	Equivalent Value used in SPATSIM to generate the floods
Class 1	0-9 daily average	9 cumec, 5 day duration 3 floods: Sep, Nov, Mar	9 cumec, 5 day duration 3 floods: Sep, Nov, Mar
Class 2	10 - 15 daily average	15 cumec, 5 day duration 1 Flood: Nov/Dec	15 cumec, 5 day duration 1 Flood: Nov/Dec
Class 3	15 - 30 peak	29 cumec, 3 day duration 1 Flood: Feb	18 cumec, 3 day duration 1:2 year, Feb
Class 4	30 - 40 peak	40 cumec, 5 day duration	22 cumec, 5 day duration

		1:2 year, Feb	
Class 5	40 - 70 peak	70 cumec, 7 day duration 1:5 year, Feb	50 cumec, 7 day duration

CROC_EWR7 – Crocodile River

Floods	Flood size (range)	Integrated	Equivalent Value used in SPATSIM to generate the floods
Class 1	0-10 daily average	10 cumec, 5 day duration 2 floods: Nov/Jan & Feb/Apr	10 cumec, 5 day duration 2 Floods, Nove & Apr
Class 2	10 - 20 daily average	20 cumec, 5 day duration 1 Flood: Dec to Mar	20 cumecs, 5 day duration 1 Flood: Dec
Class 3	20 - 50 peak	35 cumec, 5 day duration 1:5 year, Feb	30 cumec, 5 day duration 1:5 year, Feb
Class 4	50 - 150 peak	112 cumec, 3 day duration 1:10 year, Feb	100 cumec, 3 day duration

Sand River (RU13_2)

Floods	Flood size (range)	Value used in SPATSIM to generate the floods
Class 1	0 - 2 daily average	0.2 cumecs, 2 day duration Oct 1.2 cumecs, 2 day duration Nov
Class 2	2 -4 daily average	2 cumecs, 2 day duration Dec, Apr 4 cumecs, 2 day duration Jan, Mar

Floods	Flood size (range)	Value used in SPATSIM to generate the floods
Class 3	4 – 10 daily average	10 cumecs, 2 day duration Feb