CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE CROCODILE (WEST), MARICO, MOKOLO AND MATLABAS CATCHMENTS: WP 10506

ECOLOGICAL WATER REQUIREMENTS REPORT

FINAL

REPORT NO: **RDM/WMA 1,3/00/CON/CLA/0312**

Directorate: Water Resource Classification

JUNE 2013

water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Published by

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

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This report is to be cited as:

Directorate Water Resource Classification. Department of Water Affairs, South Africa, June 2013. **CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE CROCODILE (WEST), MARICO, MOKOLO AND MATLABAS CATCHMENTS:** Ecological Water Requirements Report. Report No: RDM/WMA 1,3/00/CON/CLA/0312

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Title:	*Ecological Water Requirements Report*
Authors:	*Study Team*
Project Name:	*Classification of significant water resources in the Crocodile (West), Marico, Mokolo and Matlabas catchments: WP 10506*
DWA Report no:	*RDM/WMA 1,3/00/CON/CLA/0312*
Status of Report:	*Final*
First Issue:	*April 2013*
Final Issue:	*June 2013*

Professional Service Providers: **Golder Associates Africa/ Zitholele Consulting/ Prime Africa/ Wetland Consulting Services/ RMM Stassen and Department of Water Affairs**

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INDEX

Reports as part of this study:

Bold type indicates this report.

Report Index	Report number	Report title
1	RDM/WMA1,3/00/CON/CLA/0111	Inception Report
2a	RDM/WMA1,3/00/CON/CLA/0112A	Information Analysis Report : Crocodile (West) Marico WMA
2b	RDM/WMA1,3/00/CON/CLA/0112B	Information Analysis Report : Mokolo and Matlabas catchments
3	RDM/WMA1,3/00/CON/CLA/0212	Integrated Units of Analysis Delineation Report
4	**RDM/WMA 1,3/00/CON/CLA/0312**	**Ecological Water Requirements Report**

LIST OF ABBREVIATIONS AND ACRONYMS

CD: RDM	Chief Directorate: Resource Directed Measures
CSIR	Council for Scientific and Industrial Research
D: RQS	Directorate: Resource Quality Services
DWA	Department of Water Affairs
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
GDP	Gross Domestic Product
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
MC	Management Class
MU	Management Unit
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
SEZ	Socio-Economic Zones
WMA	Water Management Area
WMS	Water Management System
WRC	Water Resource Classification
WRCS	Water Resource Classification System
WRYM	Water Resources Yield Model
WRPM	Water Resources Planning Model

EXECUTIVE SUMMARY

Background

The Chief Directorate: Resource Directed Measures (RDM) has initiated the Classification of Significant Water Resources Study for the Crocodile (West), Marico, Mokolo and Matlabas catchments. The purpose of this study is to coordinate the implementation of the 7 step process of the Water Resource Classification System (WRCS) in the Crocodile (West), Marico, Mokolo and Matlabas catchments in order to determine a suitable management class (MC) for all significant water resources and in so doing deliver the IWRM template with recommendations for presentation to the delegated authority. As part of the Classification process, Step 3requires that the Ecological Water Requirements (EWRs) be quantified.

The objective of step 3 of the WRCS is to provide the necessary ecological and Reserve data to enable the determination of the MC of all the significant water resources of the Crocodile (West), Marico, Mokolo and Matlabas catchments by quantifying the EWRs and describing the changes in non-water ecosystem goods, services and attributes (EGSAs) at the established EWR sites and at biophysical nodes to which Reserve data can be extrapolated.

Approach

The process followed in terms of quantification of EWRs and EGSA changes is that described in the WRCS Guidelines, Volumes 1 and 2 (Overview and the 7-step classification procedure; and Ecological, hydrological and water quality guidelines for the 7-step classification procedure) (DWA, February 2007a and 2007b).

In terms of the RDM data required as part of the WRCS process the available ecological/EWR information has been assessed and the information required for the determination of the catchment configuration scenarios are presented in this report. This RDM data includes the:

- Final identified nodes (hydro nodes) based on either management or biophysical considerations;
- EWR information available from previous Reserve determination studies;
- Additional rapid Reserve determination studies undertaken to enhance the existing information;
- Extrapolation of existing and new EWR results to all the identified hydro nodes;
- Development of the rule curves, summary tables and modified time series at each hydro node for use in the Water Resources Yield Model during the scenario analysis; and
- EGSAs changes at the established EWR sites and at biophysical nodes to which Reserve data can be extrapolated.

EWR Quantification

A number of Reserve studies were undertaken at various levels of detail. The most significant were the intermediate studies initiated in 2009 and completed in 2012 for the Crocodile West/Marico WMA and during 2009 to 2011 for the Mokolo catchment.

No Reserve study has been undertaken in the Matlabas catchment.

Additional Rapid III Reserve determination studies were undertaken in the Crocodile West/Marico WMA to enhance the existing information and to enable the extrapolation of EWRs to all the identified hydro nodes.

Four EWR sites were identified in the Matlabas catchment on which Rapid Reserve studies were undertaken to provide the necessary information for the WRCS.

All EWR all sites (existing and additional Rapid sites) are listed in Table E1 and E2 below.

Table E1: Information on previous Reserve studies in the catchments of the study area

EWR site	**River**	**Quaternary catchment**	**PES**	**EIS**	**REC**	**nMAR[(1)] ($10^6 m^3$)**	**%EWR**	**Level**
CROCODILE WEST								
EWR 1	Crocodile: Upstream of the Hartbeespoort Dam	A21H	*D*	Moderate	D	87.8	24.07	Intermediate
EWR 2	Jukskei: Heron Bridge School	A21C	*E*	Moderate	D	34.4	29.19	Intermediate
EWR 3	Crocodile: Downstream of Hartbeespoort Dam in Mount Amanzi	A21J	*C/D*	High	C/D	153.6	25.02	Intermediate
EWR 4	Pienaars: Downstream of Roodeplaat Dam	A23B	*C*	High	C	28.2	20.98	Intermediate
EWR 5	Pienaars/Moretele: Downstream of the Klipvoor Dam in Borakalalo National Park	A23J	*D*	High	D	113.0	11.82	Intermediate
EWR 6	Hex: Upstream of Vaalkop Dam	A22J	*D*	Moderate	D	26.9	14.96	Intermediate
EWR 7	Crocodile: Upstream of the confluence with theBierspruit	A24C	*D*	Moderate	D	463.4	9.14	Intermediate
EWR 8	Crocodile: Downstream of the confluence with the Bierspruit in Ben Alberts Nature Reserve	A24H	*C*	Moderate	C	559.9	14.22	Intermediate
Rapid EWR 9	Magalies: Downstream of Malony's Eye	A21F	*B*	Very high	B	14.7	45.58	Rapid 3
Rapid EWR 10	Elands: Upstream Swartruggens Dam	A22A	*C*	High	B/C	10.1	30.48	Rapid 3
Rapid EWR 11	Sterkstroom: Upstream Buffelspoort Dam	A21K	*C*	High	C	14.0	28.41	Rapid 3
MARICO								
EWR 1	Kaaloog-se-Loop: Below gorge	A31A	*B*	Very high	B	10.539	76.32	Intermediate

EWR site	River	Quaternary catchment	PES	EIS	REC	nMAR[1] ($10^6 m^3$)	%EWR	Level
EWR 2	Groot Marico: Upstream confluence with Sterkstroom	A31B	*B*	Very high	B	42.08	50.26	Intermediate
EWR 3	Groot Marico: Downstream Marico Bosveld Dam	A31F	*C/D*	High	C/D	65.083	23.62	Intermediate
EWR 4	Groot Marico: Downstream Tswasa Weir	A32D	*C*	High	C	153.251	7.96	Intermediate
EWR 5	Klein Marico downstream Klein Maricopoort Dam	A31E	*C*	Moderate	C	39.42	4.67	Rapid 3
EFR M8	Molopo: Wetland	D41A	*C*	-	-	-	-	-
MOKOLO								
EWR 1a	Mokolo: Vaalwater	A42C	*C/D*	High	B/C	84.84	22.6	Intermediate
EWR 1b	Mokolo: Tobacco	A42E	*B/C*	High	B	135.03	17.6	Intermediate
EWR 2	Mokolo: Ka'ingo	A42F	*B/C*	Very high	B	196.2	19.8	Intermediate
EWR 3	Mokolo: Gorge	A42G	*B/C*	Very high	B	214.5	12.5	Intermediate
EWR 4	Mokolo: Malalatau	A42G	*C*	Very high	B	253.3	16.5	Intermediate
EWR 5	Mokolo: Tambotie floodplain	A42G	*D*	-	-	-	-	-

1) nMAR – Natural Mean Annual Runoff is based on the updated hydrology from the DWA 2010and 2011 studies

Table E2: Selected EWR sites for additional rapids undertaken

EWR site	Quaternary catchment	River	Level of determination	Latitude	Longitude	Eco-region level 2	MAR ($10^6 m^3$)
CROCODILE WEST							
EWR 12	A23G	Buffelspruit	Rapid III	-24.8304	28.2224	8.01	3.144
EWR 13	A22E	Elands	Rapid III	-25.48108	26.69039	7.03	18.77
EWR 14	A22H	Waterkloofspruit	Rapid III	-25.48108	26.69039	8.05	5.469*
EWR 15	A21F	Magalies	Rapid III	-25.89690	27.59820	7.04	21.89
EWR 16	A21A	Rietvlei	Rapid III	-26.01885	28.30442	11.01	4.788
MARICO							
EWR 6	A31B	Polkadraaispruit	Rapid III	-25.64697	26.48928	7.04	9.866
MATLABAS							
EWR 1	A41A	Matlabas ZynKloof	Rapid III	-24.41203	27.60324	7.04	5.23
EWR 2	A41B	Matlabas Haarlem East (A4H004)	Rapid II	-24.160139	27.4797111	1.03	32.80
EWR 3	A41B	Mamba River Bridge	Rapid II	-24.2127	27.50718	1.02	9.54
EWR 4	A41C	Matlabas Phofu	Rapid I	-24.05159	27.35922	1.02	35.58

Initial hydro nodes were selected as part of the IUA report and summarised rationale per IUA provided. After field visits and consideration of the groundwater zones, wetland areas and requirements for the model, the identified hydro nodes have been updated slightly throughout the study area and are reflected in the map, together with the EWR sites (from the previous Reserve studies and additional Rapid sites.

Quantification of the changes in Ecosystem Goods, Services and Attributes (EGSAs)

Based on the above established EWR sites and identified biophysical nodes to which Reserve data can be extrapolated, the changes in relevant ecosystem aspects as they relate to identified EGSAs for the Crocodile (West), Marico, Mokolo and Matlabas catchments were assessed.

The relevant EGSAs for the WMA are listed with the RDM aspects to be considered. The possible ecosystem changes as they relate to the EGSAs and RDM aspects are then described.

Water Quality

The Crocodile River is highly impacted in terms of water quality. The Upper Elands River displays good to fair conditions in terms of water quality. However the middle and lower reaches are of a fair quality with mining activities in the catchment impacting on the river. Water quality has also deteriorated as a result of erosion and high sediment loads. The Hex River shows elevated concentrations of salts and nutrients as well as toxicants. There are impacts from agricultural (intensive irrigation) activities in the catchment. Other contributors to the poor water quality are industries and abandoned mines. Fertilizers and pesticides from agricultural activities are expected to also have a negative impact on the catchment, however this has not been quantified yet.

Water quality issues are mainly related to nutrient status and salinity impacts due to wastewater discharges and flow regulation in the catchment. Microbial water quality concerns are also expected to be a problem in the upper catchment because of extensive urbanisation which includes informal settlement areas, often along the banks of water resources. Large volumes of wastewater are discharged daily from several domestic wastewater treatment works and there are a few industrial discharges. Water quality in the rivers is poor with high levels of nutrients and salt concentrations. One exception is the Magalies River where water quality is relatively good with localised impacts from land based activities. The impoundment of water in the system impacts on the water quality in the rivers.

The water quality of the Apies Pienaars catchment is of poor quality with certain areas being impacted by nutrients and salinisation. There are thirteen point source discharges into the system from industries and domestic wastewater treatment works.

The Lower Crocodile River water quality is deteriorating because of increased salts and nutrients. There are also increased levels of toxicants in the middle reaches of the river. Urbanisations, industrial diffuse sources and high agricultural return flows are the major impacting activities.

Treated wastewater return flows from the Upper Vaal WMA play an important role downstream where the water is used in the Crocodile West catchment area (makes up approximately 27% of available water - 356 million m^3/a). The quantities of return flows are increasing and while serving as a potential source of water for future development in the catchment, the cascading effect of the return flows and the associated water quality need to be monitored and the impact determined.

Water quality of the Upper Marico River is relatively good with localised impacts from land based activities. The tributaries are impacted to some extent by slate mining activities and agriculture. Turbidity and erosion are the main water quality concerns. The Marico Bosveld Dam impacts on the water quality in the river.

Water quality of the Klein Marico River catchment is good in the upper reaches. However the water quality in the middle and lower reaches are fair with impacts from the urban centres and the dams in the catchmentas flows are largely managed on demand for irrigation purposes. High agricultural return flows are the major impacting activity in the lower catchment.Water quality has also deteriorated as a result of erosion and sedimentation. The Klein Marico River shows elevated levels of nutrients. There are impacts from agricultural activities in the catchment.There are also increased levels of toxicants in the middle reaches of the river.

The current surface water quality of the Mokolo River is generally good upstream of the Mokolo Dam with all variables either acceptable or ideal. The exception is phosphate which is in the tolerable to unacceptable range. It is likely that this is from agriculture return flows in the area. Groundwater quality in much of the Mokolo area is generally poor due to the coal and gas fields and cannot be used for domestic use, although surface water quality is generally good.

Flows in the catchment are variable, with reductions in low and moderate flows, and unseasonal releases from Mokolo Dam having an impact on water quality.The planned Mokolo pipeline that will originate in the Crocodile West WMA will potentially result in water quality changes in the Mokolo catchment.

There is only one water quality monitoring point in the Matlabas catchment. It is located at Haarlem East, downstream of the confluence with the Mamba River. The water quality at this point in the catchment is still very good. The only current impacts in the catchment are from the Marakele National Park and the game farms along the river. Flows in the catchment are variable.

The process followed in terms of quantification of EWRs and EGSA changes is that described in the WRCS Guidelines.

This purpose of this report is to provide the rationale and the results of the following:

- Finalisation of the nodes (hydro nodes) based on either management or biophysical considerations;
- EWR information available from previous Reserve determination studies;
- Additional rapid Reserve determination studies undertaken to enhance the existing information;
- Extrapolation of existing and new EWR results to all the identified hydro nodes;
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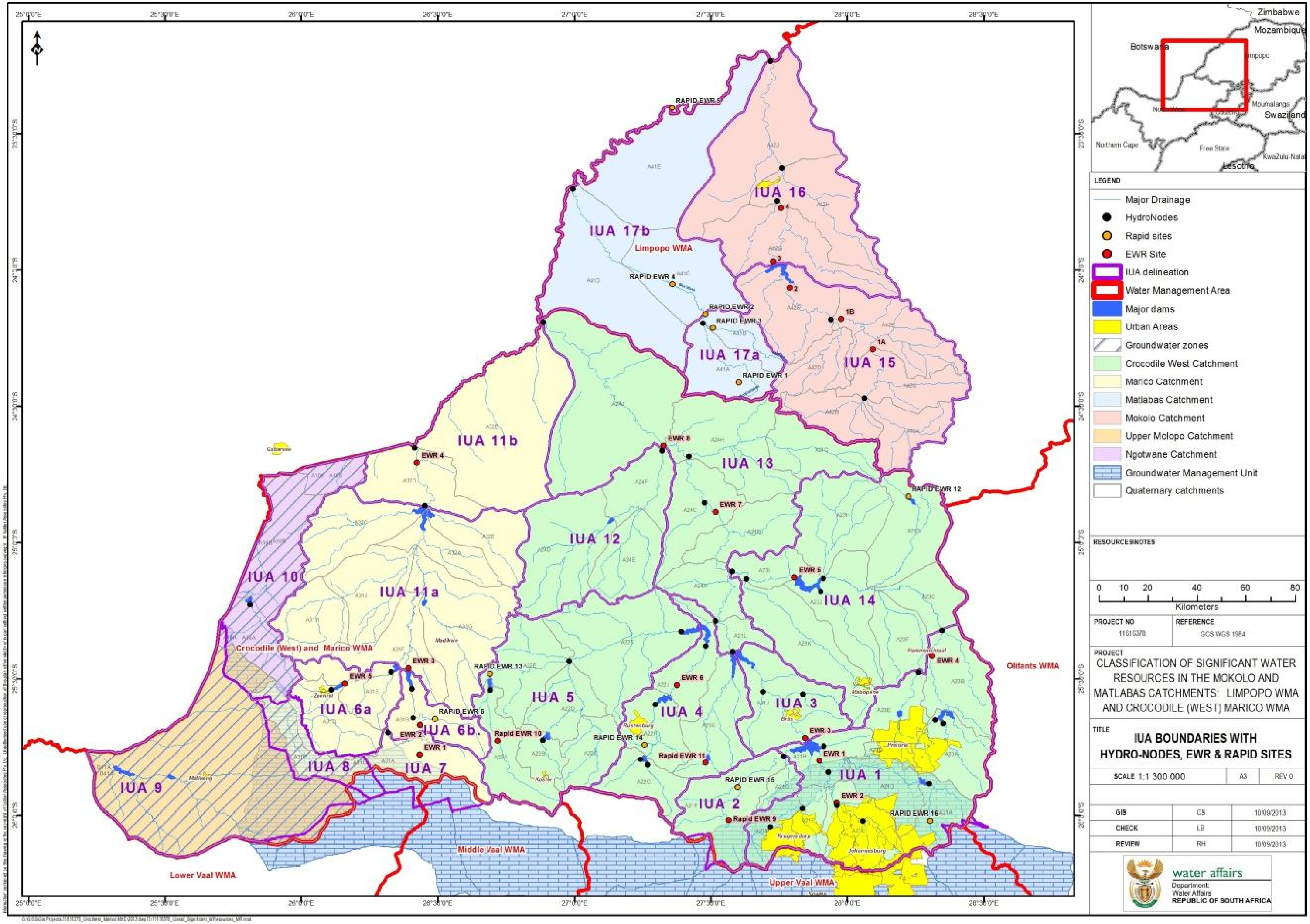

Crocodile (West), Marico, Mokolo and Matlabas catchments **indicating IUAs with location of hydro nodes and EWR sites**

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ELECTRONIC DATA

The following electronic data is available electronically.

- Photos of additional rapid EWR sites
- Hydraulic survey data
- Hydraulic modelling results
- Macro-invertebrate data sheets
- Rule tables
- Summary tables
- Modified time series

1 INTRODUCTION

The Chief Directorate: Resource Directed Measures (RDM) has initiated the Classification of Significant Water Resources Study for the Crocodile (West), Marico, Mokolo and Matlabas catchments. The purpose of this study is to coordinate the implementation of the 7 step process of the Water Resource Classification System (WRCS) in the Crocodile (West), Marico, Mokolo and Matlabas catchments in order to determine a suitable management class (MC) for all significant water resources and in so doing deliver the IWRM template with recommendations for presentation to the delegated authority. As part of the Classification process Step 3 requires that the Ecological Water Requirements (EWRs) be quantified.

The objective of step 3 of the WRCS is to provide the necessary ecological and Reserve data to enable the determination of the MC of all the significant water resources of the Crocodile (West), Marico, Mokolo and Matlabas catchments by quantifying the EWRs and describing the changes in non-water ecosystem goods, services and attributes (EGSAs) at the established EWR sites and at biophysical nodes to which Reserve data can be extrapolated.

1.1 Background to the catchments

Mokolo and Matlabas catchments

Between Bela-Bela and Lephalale in the north eastern section of the study area, lays the Waterberg. The Waterberg comprises the watershed and upper catchments of the Mokolo and Matlabas Rivers. This area is characterized by steep mountain slopes with sandy nutrient poor soils, rocky plateaus and mixed broad leaved savanna bushveld. The wetland systems typically found in the Waterberg include hillslope seeps, sheetrock wetlands and channelled and unchannelled valley-bottom systems. Water quality is typically good, and the streams are flanked by narrow riparian zones with the larger dominant tree typically being the Waterberry (*Syzygium cordatum*) and water pear (*Syzygium guineense)*. Valley-bottom wetlands typically comprise a mixture of tall emergent plants such as the common reed *Phragmites australis* and the grass *Miscanthus junceus* and shorter grass-sedge meadows dominated by *Leersiahexandra* and Red vlei grass (*Ischaemum fasciculatum*). The main ecosystem services supplied by these systems include flood attenuation, water quality enhancement, streamflow augmentation and biodiversity maintenance.

Extensive wetland systems occur in the Sand River catchment (southern-most watershed of the Mokolo River). They form important habitat for Blue cranes and are thus of high importance from a conservation and biodiversity perspective. Land use in the area is mostly agricultural and as a result many of the wetland systems have been degraded. Working for Wetlands targeted the area for wetland rehabilitation and to date a number of projects have been implemented. In addition to these wetlands, the riparian and instream habitats of the Sterkstroom, Taaibosspruit and Rietspruit are also considered important ecologically. These are also some of the remaining rivers in the catchment that still support flow dependent fish species (River Health Programme, 2006).

Downstream of the Mokolo Dam the Mokolo River enters the Limpopo plain. Here colluvial processes dominate and the river and associated riparian and wetland habitats are controlled by the deposition, transport and erosion of sediment. The alluvial (river process driven) aquifer supports an extensive riparian forest fringe and instream biota. The riparian zone in particular, which includes large specimens of the Nyala berry (*Xanthocercis zambesiaca*), Waterberry (*Syzygium cordatum*) and the Tamboti (*Spirostachys africana*), is dependent on this shallow alluvial aquifer system. The lower reaches also support Leadwood trees (*Combretum imberbe*). In the vicinity of Lephalale, the river is extensively used for sand mining. This together with the regulated flows from the Mokolo Dam upstream has affected the structure of the river along this reach with resulting alterations to the flow regime and pattern. There is also evidence suggesting that the resulting changes have not only affected the distribution and abundance of reed beds in the system, but also the alluvial aquifer which in turn is impacting on the instream and riparian ecosystem.

The Tambotie River which flows through D'Nyala Nature Reserve and joins the Mokolo River near Lephalale, is also regarded as an important system. The floodplain of the Tambotie River supports an extensive population of Tamboti (*Spirostachys Africana*) and Leadwood trees (*Combretum imberbe*). Water abstraction and the droughts experienced in the 1980's and early 1990's impacted on the system and with the drying out of the alluvial aquifer during this time, many of the Leadwood trees died. This floodplain system is nevertheless considered to have high ecological importance and sensitivity and is a key wetland in the region.

The Matlabas River flows through the Marakele Nature Reserve. The park is characterized by the Waterberg Moist Bushveld vegetation type (veld type 12), mixed Bushveld (veld type 18) and the Sweet Bushveld (veld type 17). The Sweet Bushveld is mostly found along the banks of the Matlabas River and forms an important winter refuge area for game particularly during limiting periods at the end of the dry season. The planned western expansion of the park will include more of this vegetation type, which is crucial to sustain adequate numbers of prey species for large predators such as lion and spotted hyena. One of the rare and threatened plant species of Marakele is the Waterberg cycad (Waterberg broodboom) *Encephalartoseugene-maraisii*. This cycad is endemic to the Waterberg region and grows to 5 m tall among low shrubs at an altitude of 1 450 m. Channeled valley bottom wetlands and meandering floodplains occur in the Matlabas catchment. The species that occur in those wetlands include marginal zone riparian obligates, permanent or seasonal wetland obligates, or aquatic species, which are more sensitive to water availability than other riparian species.

Crocodile (West) and Marico WMA

Dolomite forms the main watershed of the Molopo, Marico and Malmani Rivers to the southwest of the study area, as well the upper reaches of the Apies, Pienaars and other tributaries of the Crocodile River to the southeast of the study area. The actual source of the Molopo, Ngotwane, Marico and Malmani rivers are known as dolomitic eyes, which are wetlands fed by groundwater originating from fractures in the underlying dolomite. The water from these dolomitic eyes is typically alkaline (pH range from 7.5 to 9.3) having picked up magnesium and calcium carbonates through solution from the parent dolomite. Associated with this is the active tufa waterfall in Bokkraal se loop (fed by dolomitic eye, on tributary of Marico River) and the associated active- seasonal tufa cascade on Kuilfontein; a tributary of Marico River. Being perennial, all the wetland systems associated with, and downstream of, the eyes form peat wetlands or peatlands. Peatlands are defined as peat-accumulating fresh water wetlands which develop in areas where there is a net surplus of water with an accreting substrate comprising a high percentage of un-decomposed organic plant material (usually with more than 20 - 35% organic matter on a dry weight basis - Mitsch and Gosselink, 1986).

Three Peat Wetland Eco-regions are represented in the study area, being the Highveld, Central Highlands and Bushveld Basin (Marneweck, Grundling and Muller, 2001). The peat wetlands within the former two regions in particular have developed over long periods ranging between 7000 to 15000 years (depending on peat depth) with peat accumulation rates of between 0.3 to 0.6mm/year (Grundling and Marneweck, 1999; Marneweck *et. al.*, 2001). Peatlands in general, and more specifically those associated with the dolomitic eyes, are rare in South Africa and southern Africa in general. Those associated with the dolomites in the Molopo, Malmani and Marico Rivers in particular comprise unique ecosystems characterised by a high degree of endemicity (species which are found only there). The results from both the morphological and genetic studies of the fish species showed that the indigenous cichlid populations inhabiting these dolomitic wetlands are unique, with a number of populations having differentiated to the extent where they may be considered as separate species (DEA&T, 1995). One cyprinid species in particular, *Barbus cf. brevipinnis* (a type of ghieliemientjie) is endemic to the Molopo and is currently under high risk of extinction due to loss of habitat as a result of reduced flows to the wetland area. Also *Barbus motabensis* type locality and NFEPA Fish species.

Studies on the aquatic invertebrates of these dolomitic wetlands have also produced several new distribution records for South Africa and also 21 new species to science (DEA&T, 1995). Similarly, the ostracod diversity from the Molopo system showed that of all the species found in the area at the time of the survey, 30% were new to southern Africa and one species was new to science (DEA&T, 1995). For this reason, dolomitic eyes and their associated peatlands are regarded as sensitive systems. Most of these systems are also important water supply sources and thus the associated ecosystems have been impacted by water abstraction. They are also threatened by groundwater contamination from agriculture, industry and mining, habitat transformation and invasions by alien species (particularly exotic plants e.g. poplars and fish species e.g. black bass) and some have been mined for peat. Working for Wetlands (WfWetlands) started doing rehabilitation work in the Molopo catchment in 2001 including in the headwaters. It has long been recognized that an integrated management strategy is required for conserving or maintaining these unique wetland systems.

The wetlands within the Borakalalo National Park are also considered of high conservation value, despite being heavily degraded. They have also been the focus of WfWetlands work over the past few years. Borakalalo forms the western end of the Moretele floodplain. This is the second largest floodplain in the Bushveld Ecoregion and represents the southern-most natural distribution of Wild Rice (*Oryzalongistaminata*) in Africa. The floodplain is used extensively by the surrounding communities for fishing and grazing and is also regarded as an important birding area, with the floodplain and surrounding area supporting 362 of the 461 species recorded in the North West Province. The wetland also includes traditionally sacred sites which have high cultural significance.

The Mareetsane wetland near Mafeking also provides important ecosystem services for people, livestock and wildlife, including water supply and livelihoods support. It is on the Mareetsane River, which flows into the Molopo River. Working for Wetlands (WfWetlands) has been undertaking wetland rehabilitation work on this system. Other rehabilitation projects within the study area targeted by WfW include a wetland system within the Rustenburg Nature Reserve and on the Hex River. These projects were undertaken in partnership with the Local Municipality and Tribal Authority.

A wetland type not well represented in the study area is pans. Pan complexes (groups of pans) occur in three main areas in the study area, namely: south and northwest of Koster (a complex of approximately 24 pans); northeast of Derby (7 pans); and in Johannesburg (approximately 24 pans between Midrand and Kempton Park). Despite impacts from agriculture, an extensive complex of hillslope seepage and valley-bottom wetlands remains associated with the pans near Koster and Derby. Pans are recognized as being important for biodiversity support and more recently their links to other wetland systems in relation to landscape hydrology have also been highlighted. Pans are also unique in terms of their individual biogeochemical attributes. This combination of an extensive network of pans, hillslope seepages and valley-bottom systems, and also that they are unaffected by urbanization and not found elsewhere in the catchments under consideration, renders this an important water resource in the study area. The pans in the Midrand and Kempton Park area are also considered important, but mainly from a biodiversity perspective as they support related bird and amphibian populations. Those that still have some of their catchments intact or that still have associated hillslope seepage wetlands also support some of the last remaining populations of the endangered Giant bullfrog (*Pyxicephalus adspersus*) on the Highveld. The remaining pans and wetlands are thus regarded as critical habitat for these populations. The wetlands including the pans in this area are all threatened by impacts from urbanization. Wetland habitat loss continues as urbanization expands and the hydrology of the related systems and catchments change largely due to storm water management or lack thereof. It is likely that populations of the Giant bullfrog may occur or be found in the pans in the Koster and Derby areas.

1.2 Approach

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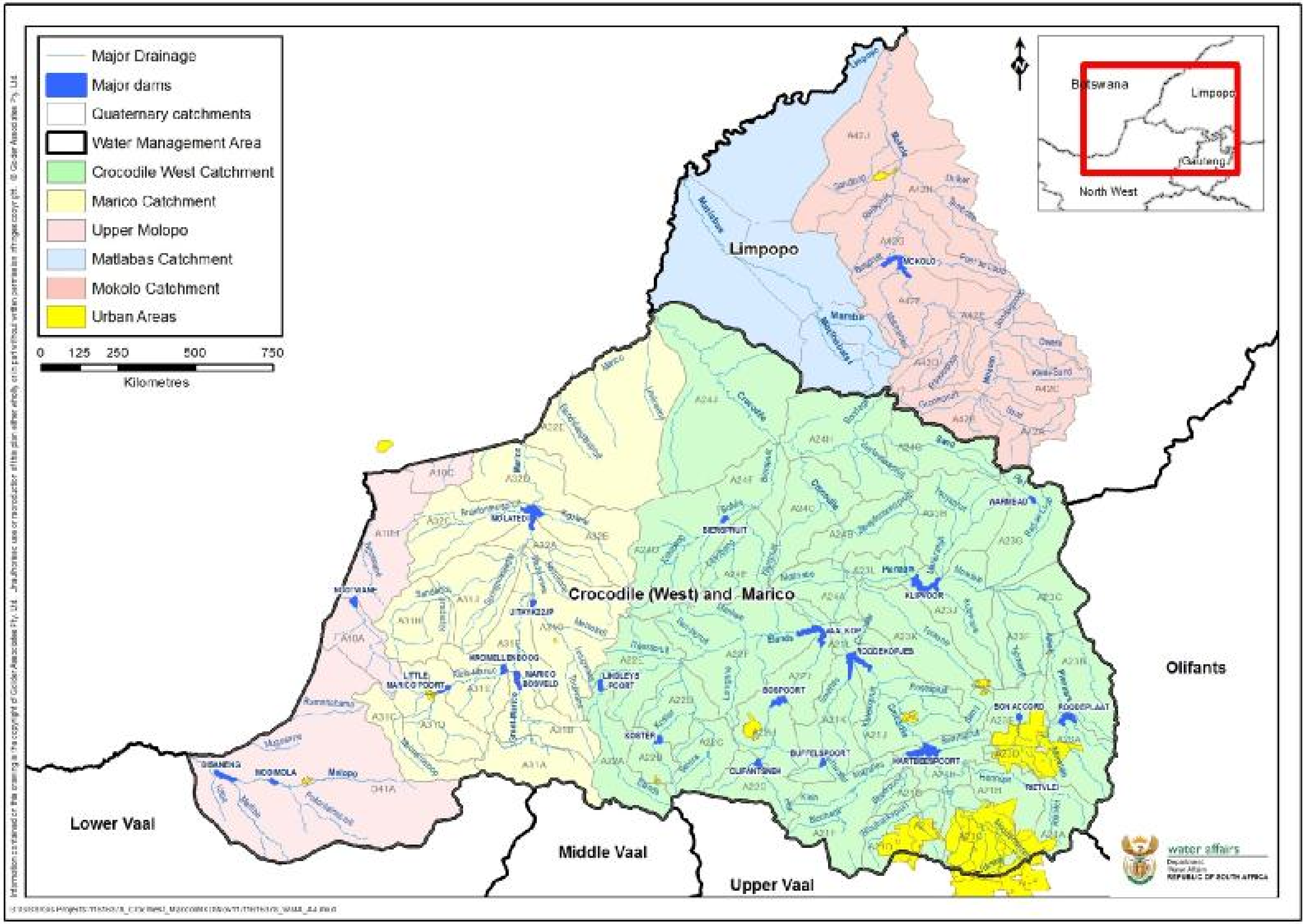

Figure 1: The Crocodile (West), Marico, Mokolo and Matlabas catchments

June 2013

2 CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE CROCODILE (WEST), MARICO, MOKOLO AND MATLABAS CATCHMENTS

The National Water Act (Act No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility for and authority over water resource management for the benefit of the public without seriously affecting the functioning of the water resource systems. In order to achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the implementation of resource directed measures (RDM). As part of the RDM, a management class (MC) has to be determined for a significant water resource, as the means to ensure a desired level of protection. The purpose of the MC is to establish clear goals relating to the quantity and quality of the relevant water resource.

The classification system, the Reserve and RQOs together are intended to ensure comprehensive protection of all water resources. An important consideration in the determination of RDM is that they should be technically sound, scientifically credible, practical and affordable.

The Chief Directorate: Resource Directed Measures (CD: RDM) of the Department of Water Affairs (DWA) is tasked with the responsibility of ensuring that the water resources are classified in terms of the Water Resource Classification System (WRCS) to ensure that a balance is sought between the need to protect and sustain water resources on one hand and the need to develop and use them on the other. The CD: RDM has identified the need to undertake the classification of significant water resources (rivers, wetlands, groundwater and lakes) in the Crocodile (West), Marico, Mokolo and Matlabas catchments in accordance with the WRCS.

The MC and associated resource quality objectives (RQOs) will assist the DWA to make informed decisions regarding the authorisation of future water uses, operation and management of the system and the evaluation of the magnitude of the impacts of the present and proposed developments.

The purpose of this study is to coordinate the implementation of the 7 step process of the WRCS to classify all significant water resources in the Crocodile (West), Marico, Mokolo and Matlabas catchments, in order to determine a suitable MC for the relevant water resources and in so doing deliver the IWRM template with recommendations for presentation to the delegated authority.

The determination of the MC is necessary to facilitate a balance between protection and use of water resources. In determining the class, it is important to recognise that different water resources will require different levels of protection. In addition to achieving ecological sustainability of the significant water resources through classification, the process will allow due consideration of the social and economic needs of competing interests by all who rely on the water resources. The WRCS will be applied taking account of the local conditions, socio-economic imperatives and system dynamics within the context of South African conditions. The process will also require a wide range of complex trade-offs to be assessed and evaluated at a number of scales.

The study approach for the determination of the MC includes:

- An assessment of the the Crocodile (West), Marico, Mokolo and Matlabas catchments to understand the status quo assessment with regard to issues such as water resource quality, existing monitoring programmes, infrastructure, institutional environment, socio-economics and sectoral water uses and users;
- The delineation of the WMA into integrated units of analysis (IUAs) based on identified

criteria and system understanding and characteristics;

- The application of the WRCS within each IUA by establishing the MC by integration of the economic, social and ecological goals through a suitable analytical decision-making system (trade-offs); and
- Population of the classification templates.

The study approach is defined by 6 tasks depicted in**Figure 2.**

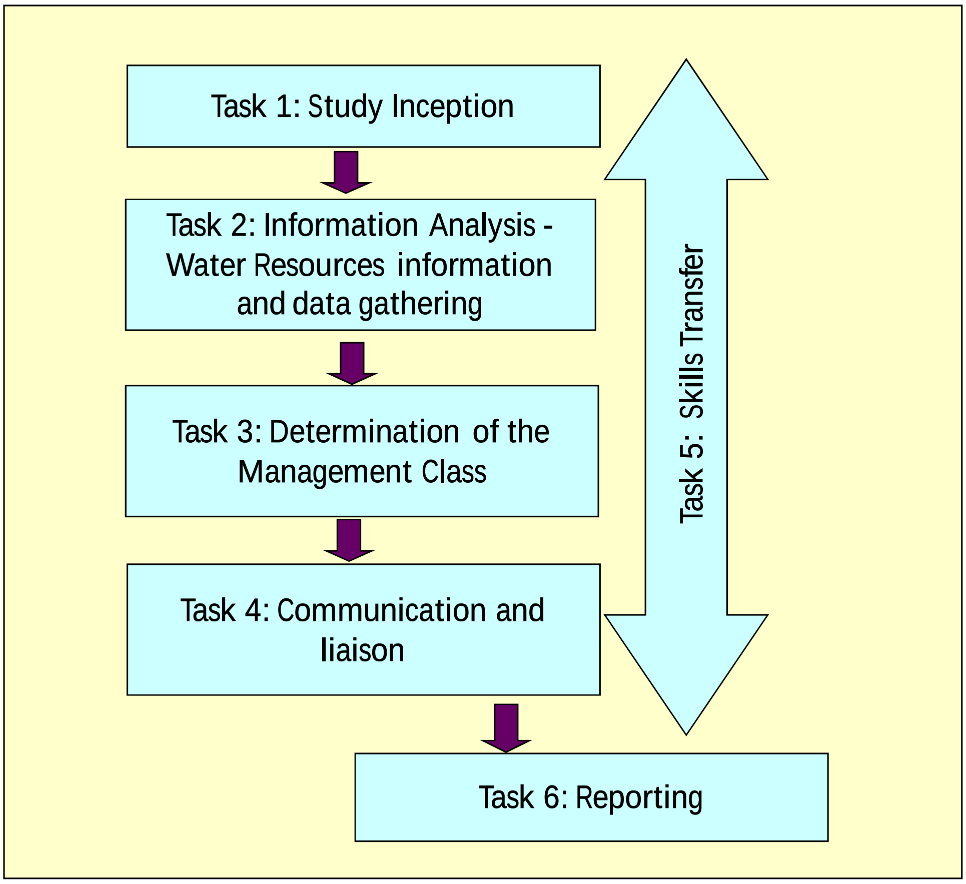

Figure 2: Study tasks

2.1 THE QUANTIFICATION OF ECOLOGICAL WATER REQUIREMENTS (TASK 3: STEP 3)

In order for the Department to effectively classify the significant water resources of the Crocodile (West), Marico, Mokolo and Matlabas catchments a Reserve determination has to be undertaken as part of the WRC process. The Reserve determination requires the quantification of EWRs that forms an integral component of the classification process. With respect to the Crocodile (West), Marico, Mokolo and Matlabas catchments the classification process is being undertaken in catchments with an existing Reserve at various levels of detail. In this respect the existing Reserve information will be used and extrapolation of EWRs to identified nodes will be done.

This task has been undertaken in compliance with the requirements of the study terms of reference that specify that the classification process is required to build from existing and current initiatives undertaken, in support of integrated water resource management.

Step 3 of the determination of the MC and application of the WRCS requires that the Ecological Water Requirements (EWRs) be quantified at identified nodes.

2.2 SPATIAL EXTENT OF STUDY

The spatial extent includes secondary drainage regions A1 to A3 as well as the Mokolo and Matlabas catchments of secondary drainage region A4. The Upper Molopo in secondary drainage region D4 is also included (

Figure 1). The sub-catchments are indicated in Table 1.

Table 1: The sub-catchment areas within the study area

Sub-catchment	Catchment Area (km^2)	Quaternary catchments
Upper Crocodile (A21)	6 336	A21A – L
Elands (A22)	6 221	A22A – J
Apies/Pienaars (A23)	7 588	A23A – L
Lower Crocodile (A24)	9 204	A24A – J;
Marico (A31 and A32)	12 030	A32A – E; A31A – J
Ngotwane (A10)	1 842	A10A – C
Upper Molopo (D41)	4 300	D41A
Matlabas (A41)	6 014	A41A – E
Mokolo (A42)	8 387	A42A – J

2.3 OBJECTIVES OF STEP 3 OF THE WRCS

The objective of step 3 of the WRCS is to provide the necessary ecological and Reserve data to enable the determination of the MC of all the significant water resources of the Crocodile (West), Marico, Mokolo and Matlabas catchments. The purpose of step 3 of the process is to specifically quantify the EWRs and describe the changes in non-water ecosystem goods, services and attributes (EGSAs) at the established EWR sites and at biophysical nodes to which Reserve data can be extrapolated.

The following activities have been undertaken as part of Step 3 of the WRCS, the quantification of the EWRs and changes in non-water quality Ecosystem Goods, Services and Attributes (EGSAs):

- Identification of the nodes to which Resource Directed Measures (RDM) data can be extrapolated;
- Development of the rule curves, summary tables and modified time series for each node; and
- Quantification of the changes in relevant ecosystem components' functions and attributes for the ecological category at each node.

The process followed is that described in the WRCS Guidelines, Volumes 1 and 2 (Overview and the 7-step classification procedure; and Ecological, hydrological and water quality guidelines for the 7-step classification procedure) (DWA, 2007a and 2007b).

2.4 PURPOSE OF THE REPORT

This purpose of this report is to provide the rationale and the results of the following:

- Finalisation of the nodes (hydro nodes) based on either management or biophysical considerations;
- EWR information available from previous Reserve determination studies;
- Additional rapid Reserve determination studies undertaken to enhance the existing information;
- Extrapolation of existing and new EWR results to all the identified hydro nodes;
- Development of the rule curves, summary tables and modified time series at each hydro node for use in the Water Resources Yield Model during the scenario analysis; and
- EGSAs changes at the established EWR sites and at biophysical nodes to which Reserve data can be extrapolated.

3 ECOLOGICAL WATER REQUIREMENTS

3.1 THE APPROACH ADOPTED

The approach followed to provide the information required in step 3 of the WRCS is discussed in sections 3.2 to 3.5. All information and results are summarised in tables and the rationale for the various decisions is included. Detailed information, such as rule tables for the hydro nodes, is provided in electronic format.

3.2 FINALISATION OF HYDRO NODE SELECTION

Initial hydro nodes were selected as part of the IUA report and summarised rationale provided. This is described in section 4 of the report: *Department of Water Affairs, South Africa, August 2012. Classification of significant water resources in the Mokolo and Matlabas catchments: Limpopo Water Management Area (WMA) and Crocodile (West) and Marico WMA: WP 10506: Integrated Units of Analysis (IUA) Delineation Report. Report No: RDM/WMA1,3/00/CON/CLA/0212 Directorate Water Resource Classification.*

The identified hydro nodes were revised as necessary after discussions with various specialists and after field visits and consideration of the groundwater zones, wetland areas and requirements for the model, the identified hydro nodes have been updated slightly throughout the study area and are reflected in the map, together with the EWR sites (from the previous Reserve studies and additional Rapid sites).

The Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) per hydro node were provided by the desktop PES, EI and ES studies, previous high confidence Reserve studies and additional rapid studies that were undertaken. In situations where the selected hydro node is an existing EWR site from the Reserve study, that PES and EIS information has been included.

Table 2 summarises the selected hydro nodes for further analysis during the scenario analysis. All the EWR sites (from the previous Reserve studies and additional Rapid sites) are indicated in Figure 3.

Table 2: Final selected hydro nodes for the Crocodile (West), Marico, Mokolo and Matlabas catchments

IUA	No	Quaternary catchment	Hydro node	EI	ES	PES	Node type and considerations	
1	HN1	A21A	Rietspruit (source) to Rietvlei Dam (CROC_EWR16)	Low	Low	C	Management, urban impacts, Rietvlei Dam	Quantity/quality, dolomitic
	HN2	A21B	Sesmylspruit with its' tributaries to confluence with Hennops	Moderate	Moderate	E	Biophysical, urban impacts	Quality
	HN3	A21C	Modderfonteinspruit to confluence with Jukskei	Moderate	Moderate	E	Biophysical, urban, industrial;	Quality
	HN4	A21C	Klein Jukskei at confluence with Jukske	Moderate	Moderate	E	Biophysical. semi urban	Quality
	HN5	A21C	Jukskei River at CROC_ EWR2	Moderate	Moderate	E	Biophysical, WWTW	Quantity/quality
	HN6	A21D	Bloubankspruit and tributaries (outlet of quaternary/confluence with Crocodile)	Moderate	Moderate	D	Biophysical, acid mine drainage, dolomitic, Botanical gardens, Cradle of Humankind	Quality/quantity
	HN7	A21A, B, H	Hennops (source) to confluence with Crocodile	Moderate	Moderate	D	Biophysical, urban, industrial	Quantity/quality
	HN8	A21H	Swartspruit to Hartbeespoort Dam	Moderate	Moderate	D	Semi urban	Quality
	HN9	A21E, H	Crocodile (source) to CROC_EWR1	Moderate	Moderate	D	Biophysical, urban	Quantity/quality
	HN10	A21H, J	Crocodile at Hartbeespoort Dam, outlet of IUA1	High	High	C/D	Hartbeespoort Dam, Management	Quantity/quality
	HN11	A23A	Pienaars(source) and including Moreletaspruit and Edendalespruit to outlet of Roodeplaat Dam	Low	Low	E	Management, urban, industrial; WWTW, canalised, Roodeplaat Dam	Quantity/quality
	HN12	A23B	Pienaars from Roodeplaat Dam to outlet of quaternary catchment (outlet of IUA1) (CROC_EWR4)	High	High	C	Management, sand mining	Quantity/quality
	HN13	A23B	Boekenhoutspruit to confluence with Pienaars	High	High	C	Biophysical	Quantity/quality
	HN14	A23D	Skinnerspruit (source) to confluence with Apies	Low	Low	E	Biophysical, urban, canalised urban river	Quantity/quality
	HN15	A23D, E	Apies (source) to Bon Accord Dam, below the dam at outlet of IUA1	Low	Low	F	Management, dolomitic at source	Quantity/quality,
2	HN16	A21F	Magalies below Maloney's Eye at CROC_EWR9	Very high	Very high	B	Biophysical, dolomitic at source	Quantity
	HN17	A21G, F	Magalies (CROC_EWR15)	Low	Low	C/D	Management	Quantity/quality
	HN18	A21G, F	Skeerpoort at outlet of IUA2	Low	Low	C/D	Management	Quantity/quality

IUA	No	Quaternary catchment	Hydro node	EI	ES	PES	Node type and considerations	
3	HN19	A21J	Rosespruit at confluence with Crocodile	High	High	C/D	Biophysical	Ecological
	HN20	A21J	Crocodile from Hartbeespoort Dam to upstream Roodekopjes Dam, outlet of IUA3	Moderate	Moderate	D	Biophysical	Ecological
4	HN21	A21K	Sterkstroom (source) to Buffelspoort Dam (CROC_EWR11)	High	High	C	Biophysical	Quantity/quality
	HN22	A21K	Sterkstroom from Buffelskloof Dam to Roodekopjes Dam, outlet of IUA4	High	High	C	Management	Quantity/quality
	HN23	A22G	Hex (source) to Olifantsnek Dam	Moderate	High	C	Management, Olifantsnek Dam	Quantity/quality
	HN24	A22H	Waterkloofspruit (CROC_EWR14) to confluence with Hex	Low	Low	B/C	Biophysical, wetland, nature reserve	Wetland driven
	HN25	A22H	Hex from Olifantsnek Dam to Bospoort Dam	Moderate	Moderate	D	Management, urban, mining, Bospoort Dam	Quantity
	HN26	A22J	Hex from Bospoort Dam to Vaalkop Dam (CROC_EWR6)	Moderate	Moderate	D	Biophysical, Bospoort Dam	Quantity/quality
	HN27	A22J	Elands from Vaalkop Dam to confluence with Crocodile, outlet of IUA4	Moderate	Moderate	D	Management, Vaalkop Dam	Quantity/quality
5	HN28	A22A	Elands (source) to Swartruggens Dam (CROC_EWR10)	High	High	C	Management	Quantity
	HN29	A22A	Elands from Swartruggens Dam to Lindleypoort Dam	Moderate	High	C	Management, Swartruggens Dam, WWTWs	Quantity/quality, management
	HN30	A22B	Koster (source) to Koster Dam	Moderate	High	C	Biophysical, wetland	Wetland driven
	HN31	A22C, A22D	Selons to confluence with Elands	Moderate	High	C	Biophysical	Quantity/quality
	HN32	A22E, A22F	Elands from Lindleypoort Dam (CROC_EWR13) to Vaalkop Dam, outlet of IUA5	Low	Low	C	Management, Lindleyspoort Dam	Quantity/quality, management
6b	HN33	A31B	Polkadraaispruit to confluence with Marico (MAR_EWR6)	Moderate	Moderate	B/C	Biophysical	Quantity/quality
	HN34	A31B	Marico from MAR_EWR2 to N4 road at town	Very High	Very High	B	Biophysical	Quantity/quality
	HN63	A31B	Marico from N4 road to Marico-Bosveld Dam, outlet of IUA6b	Very High	Very High	B	Biophysical	Quantity/quality
6a	HN64	A31D	Malmaniesloop to confluence with Klein Marico Klein Marico and tributaries upstream of Zeerust	High	High	C	Biophysical, groundwater, WWTW, urban	Groundwater node

IUA	No	Quaternary catchment	Hydro node	EI	ES	PES	Node type and considerations	
	HN35	A31D	Klein Marico from Zeerust to Klein Maricopoort Dam	High	High	C	Biophysical	Quantity/quality
	HN65	A31E	Klein Mario from Klein Maricopoort Dam to	High	High	C	Management, Klein Maricopoort Dam	Quantity/quality
	HN36	A31E	Kromellemboog Dam (MAR_EWR5), outlet of IUA6a	Moderate	Moderate	C	Management, Kromellemboog Dam	Quantity/quality
7	HN37	A31A	Kaaloog-se-Loop (MAR_EWR1) to concluence with Groot Marico	Very High	Very High	B	Biophysical, dolomitic	Quantity
	HN38	A31A	Vanstraatenvlei and tributaries at confluence with Kaaloog-se-Loop, outlet of IUA7	High	High	B	Biophysical, dolomitic	Quantity
8	-	A31C	Groundwater	-	-	-	Management, groundwater	Groundwater node
9	HN66	D41A	Molopo at outlet of wetland	-	-	-	Management, groundwater	Groundwater node
	HN67	D41A	Molopo at Modimola	Low	Low	E	Biophysical	Quality
	HN39	D41A	Molopo at outlet of IUA9	Low	Low	E	Management	Quality
10	HN68 -	A10A A10A, B, C	Ngotwane from Dinokana to Ngotwane Dam Ngotwane from Dinokana to outlet of IUA10	- -	- -	- -	Management, groundwater, Ngotwane Dam Management	Groundwater node
11a	HN40	A31F, G, A32A	Marico from Marico Bosveld and Kromelmboog Dam to Molatedi Dam (MAR_EWR3), outlet of IUA11a	High	High	C/D	Management, Madikwe Nature Reserve, Marico-Bosveld Dam	Quantity
11b	HN41	A32D, E	Marico from Molatedi Dam to confluence with Crocodile (MAR_EWR4), outlet of IUA11b	High	High	C	Management, Molatedi Dam, Twasa weir, international, Madikwe Nature Reserve	Quantity/quality
12	HN42	A24D, E, F	Bierspruit to confluence with Crocodile River, outlet of IUA12	Moderate	Moderate	D	Mining	Seasonal rivers, quantity
13	HN43	A24G, A24H	Sand to confluence with Crocodile	Moderate	Moderate	C	Biophysical	Quantity/quality
	HN44	A21L, A24A-C, A24H	Crocodile from Roodekopjes Dam (CROC_EWR7) to proposed Mokolo transfer (CROC_EWR8)	Moderate	Moderate	D	Management, irrigation, mining, transfer	Quantity/quality,

IUA	No	Quaternary catchment	Hydro node	EI	ES	PES	Node type and considerations	
	HN45	A24J	Crocodile from CROC_EWR8 to confluence with Limpopo, outlet of IUA13	Moderate	Moderate	C	Management for international, groundwater	Quantity/quality
14	HN46	A23G	Platspruit (source, CROC_EWR12) to confluence with Pienaars	Moderate	Moderate	B/C	Biophysical	Quantity
	-	A23C, A23F	Wetland at Pienaars & Apies confluence and inflow to Klipvoor Dam	Moderate	Moderate	C	Biophysical; floodplain	Quantity/wetland
	HN47	A23H	Karee/Rietspruit to confluence with Pienaars	Moderate	Moderate	C	Biophysical	Quantity
	HN48	A23J A23J, A23L	Moretele (Pienaars) to confluence with Crocodile (CROC_EWR5), outlet of IUA14	High	High	D	Management, Klipvoor Dam, Borakalalo Nature Reserve	Quantity/quality
	HN49	A23K	Tolwane to confluence with Moretele	High	High	D	Biophysical	Quantity/quality
15	HN50	A42A	Sand (source) to confluence with Grootspruit	Moderate	Moderate	C	Biophysical	Quantity/quality
	HN51	A42B	Grootspruit (source) to confluence with Sand	Moderate	Moderate	C	Biophysical	Quantity/quality
	HN52	A42C	Mokolo to confluence with Dwars (MOK_EWR1a)	High	High	C/D	Biophysical	Quantity/quality
	HN53	A42D, A42E	Mokolo to confluence with Sterkstroom (MOK_EWR1b)	High	High	B/C	Biophysical	Quantity/quality
	HN54	A42D	Sterkstroom (source) to confluence with Mokolo, including Dwars	High	High	B/C	Biophysical, Ecological	Quantity,
	HN55	A42F	Mokolo from Sterkstroom to Mokolo Dam (MOK_EWR2), outlet of IUA15	Very high	Very high	B/C	Biophysical	Quantity/quality
16	HN56	A42G	Rietspruit (source) to Mokolo confluence	Moderate	Moderate	B/C	Biophysical	Quantity/quality
	HN57	A42G	Mokolo below dam (MOK_EWR3) to Rietspruit confluence (MOK_EWR4)	Very High	Very High	B/C	Management, Mokolo Dam	Quantity/quality
	HN58	A42H, A42J	Mokolo from MOK_EWR4 to confluence with Limpopo, outlet of IUA16.	Very High	Very High	C	Biophysical, floodplain	Use wetlands requirements for river
17a	HN59	A41A	Mothlabatsi to confluence with Mamba	Very High	Very High	B	Biophysical, Marekele National Park	Quantit,
	HN60	A41B	Mamba to confluence with Mothlabatsi, outlet of IUA17a	Moderate	Moderate	B/C	Biophysical	Quantity
17b	HN61	A41C	Matlabas from Mamba confluence to MAT_EWR2	High	High	B/C	Biophysical	Quantity/quality
	HN62	A41C, D	Matlabas from MAT_EWR2 to confluence with Limpopo, outlet of IUA17b	Moderate	Moderate	B	Management, international	Quantity/quality

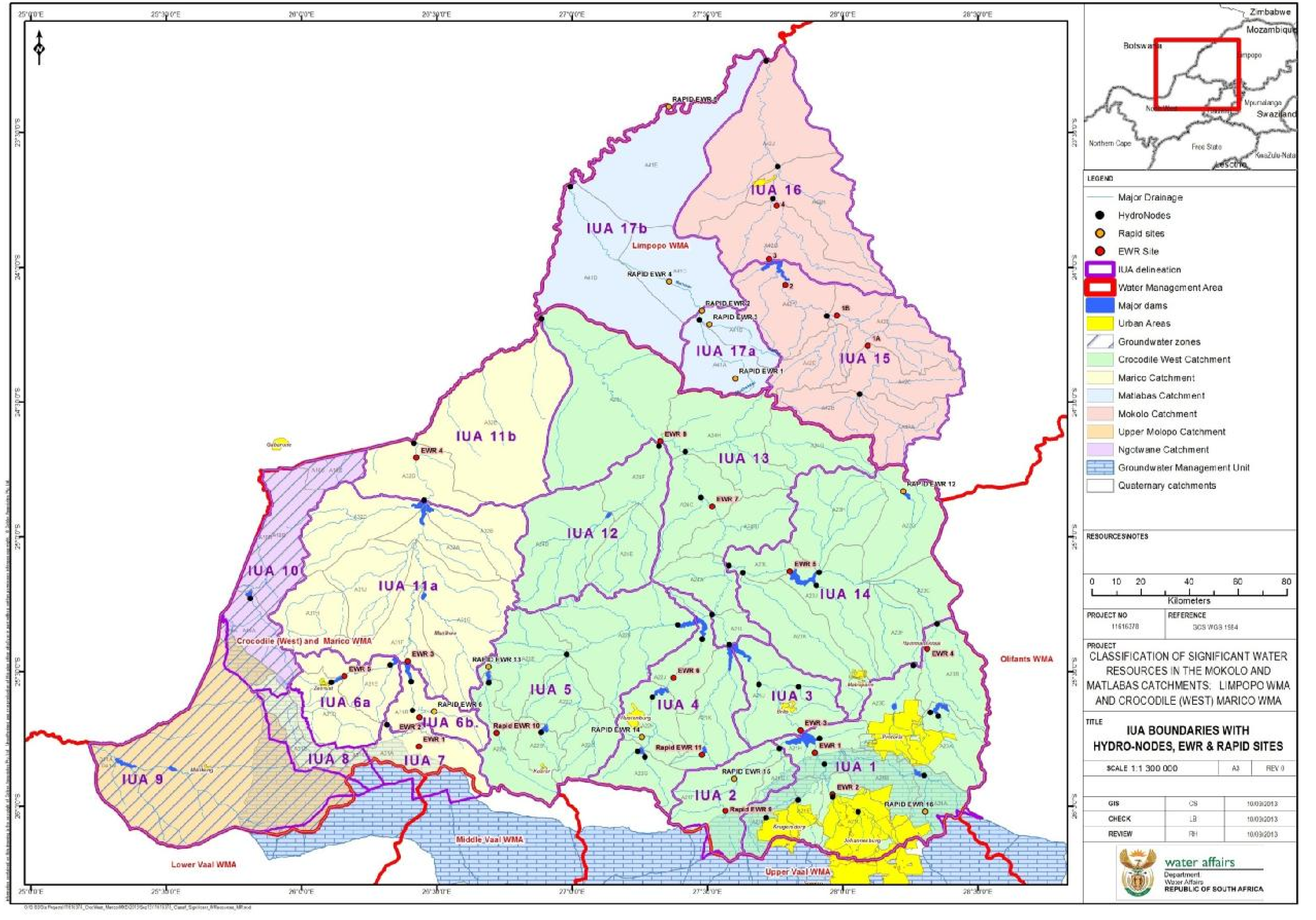

Figure 3: Final selected hydro nodes and EWR sites for the Crocodile (West), Marico, Mokolo and Matlabas catchments

3.3 EWR INFORMATION FROM PREVIOUS STUDIES

Intermediate Reserve determination studies were undertaken for all of the major catchments from 2008 to 2011. The results are available for the Crocodile West and its main tributaries (Pienaars, Elands and Jukskei), the Mokolo River and the Groot Marico and Klein Marico Rivers. The results were enhanced by additional Rapid III studies and extrapolations undertaken in those areas that were not covered by an intermediate assessment.

The Molopo catchment was assessed as part of the ORASECOM study in 2010, but due to the almost episodic nature of the river, only the Molopo wetland in quaternary catchment D41A was assessed. This catchment is mainly groundwater driven and will be assessed from a groundwater perspective during the classification process.

Table 3 provides a summary of the studies that were undertaken.

Table 3: Information on Reserve studies in the Crocodile (West), Marico, Mokolo and Matlabas catchments

EWR site	River	Quaternary catchment	PES	EIS	REC	nMAR[1)] (10^6m^3)	%EWR	Level
CROCODILE WEST								
EWR 1	Crocodile: Upstream of the Hartbeespoort Dam	A21H	D	Moderate	D	87.8	24.07	Intermediate
EWR 2	Jukskei: Heron Bridge School	A21C	E	Moderate	D	34.4	29.19	Intermediate
EWR 3	Crocodile: Downstream of Hartbeespoort Dam in Mount Amanzi	A21J	C/D	High	C/D	153.6	25.02	Intermediate
EWR 4	Pienaars: Downstream of Roodeplaat Dam	A23B	C	High	C	28.2	20.98	Intermediate
EWR 5	Pienaars/Moretele: Downstream of the Klipvoor Dam in Borakalalo National Park	A23J	D	High	D	113.0	11.82	Intermediate
EWR 6	Hex: Upstream of Vaalkop Dam	A22J	D	Moderate	D	26.9	14.96	Intermediate
EWR 7	Crocodile: Upstream of the confluence with theBierspruit	A24C	D	Moderate	D	463.4	9.14	Intermediate
EWR 8	Crocodile: Downstream of the confluence with the Bierspruit in Ben	A24H	C	Moderate	C	559.9	14.22	Intermediate

EWR site	River	Quaternary catchment	PES	EIS	REC	nMAR1) (10^6m^3)	%EWR	Level
	Alberts Nature Reserve							
Rapid EWR 9	Magalies: Downstream of Malony's Eye	A21F	B	Very high	B	14.7	45.58	Rapid 3
Rapid EWR 10	Elands: Upstream Swartruggens Dam	A22A	C	High	B/C	10.1	30.48	Rapid 3
Rapid EWR 11	Sterkstroom: Upstream Buffelspoort Dam	A21K	C	High	C	14.0	28.41	Rapid 3
MARICO								
EWR 1	Kaaloog-se-Loop: Below gorge	A31A	B	Very high	B	10.539	76.32	Intermediate
EWR 2	Groot Marico: Upstream confluence with Sterkstroom	A31B	B	Very high	B	42.08	50.26	Intermediate
EWR 3	Groot Marico: Downstream Marico Bosveld Dam	A31F	C/D	High	C/D	65.083	23.62	Intermediate
EWR 4	Groot Marico: Downstream Tswasa Weir	A32D	C	High	C	153.251	7.96	Intermediate
EWR 5	Klein MaricoDownstream Klein Maricopoort Dam	A31E	C	Moderate	C	39.42	4.67	Rapid 3
EFR M8	Molopo: Wetland	D41A	C	-	-	-	-	-
MOKOLO								
EWR 1a	Mokolo: Vaalwater	A42C	C/D	High	B/C	84.84	22.6	Intermediate
EWR 1b	Mokolo: Tobacco	A42E	B/C	High	B	135.03	17.6	Intermediate
EWR 2	Mokolo: Ka'ingo	A42F	B/C	Very high	B	196.2	19.8	Intermediate
EWR 3	Mokolo: Gorge	A42G	B/C	Very high	B	214.5	12.5	Intermediate
EWR 4	Mokolo: Malalatau	A42G	C	Very high	B	253.3	16.5	Intermediate
EWR 5	Mokolo: Tambotie floodplain	A42G	D	-	-	-	-	-

1) nMAR – natural Mean Annual Runoff is based on the updated hydrology from the DWA 2010 and 2011 studies

As part of the process additional sites were identified for Rapid Reserve studies that were undertaken subsequent to the comprehensive studies as part of this classification process to improve the confidence in the final requirements per hydro node.

3.4 ADDITIONAL RAPID RESERVE DETERMINATION STUDIES

Additional sites were identified for Rapid Reserve studies in the Crocodile West, Marico and Matlabas catchments. These studies were undertaken to enhance the existing information and to enable the extrapolation of EWRs to all the identified hydro nodes. A total of 11 additional sites were identified where no or very little information was available for further use during the classification process.

The sites in the Crocodile West/Marico WMA were assessed during the period 28th May to 1st June 2012 and the sites in the Matlabas catchment were assessed during May 2012 and January 2013. At the time of the first site visit to the Matlabas catchment, limited hydraulic data was obtained as only slopes and discharge were measured. During the subsequent visit during January 2013, detailed hydraulic data was collected at EWR site 1. However, no surveys were undertaken at EWR sites 2, 3 and 4 as the visit was after a major flood in the system and the flows were too high compared to the expected flows. Access to the sites was also a problem as most of the areas were fenced in for game farming. Attempts to find alternative suitable sites were also not successful, mostly due to inaccessibility of the river. In this respect, a desktop hydraulic cross-section was modelled to determine the EWRs, albeit at a lower confidence level. Details of the additional selected EWR sites per river are provided in Table 4.

Table 4: Selected EWR sites for additional rapid III survey

EWR site	Quaternary catchment	River	Level of determination	Latitude	Longitude	Ecoregion level 2	MAR ($10^6 m^3$)
CROCODILE WEST							
EWR 12	A23G	Buffelspruit	Rapid III	-24.8304	28.2224	8.01	3.144
EWR 13	A22E	Elands	Rapid III	-25.48108	26.69039	7.03	18.77
EWR 14	A22H	Waterkloofspruit	Rapid III	-25.48108	26.69039	7.05	5.469*
EWR 15	A21H	Magalies	Rapid III	-25.89690	27.59820	7.05	21.89
CROC 16	A21A	Rietvlei	Rapid III	-26.01885	28.30442	11.01	4.788
MARICO							
EWR 6	A31B	Polkadraaispruit	Rapid III	-25.64697	26.48928	7.04	9.866
MATLABAS							
EWR 1	A41A	MatlabasZynKloof	Rapid III	-24.41203	27.60324	1.03	5.23
EWR 2	A41B	Matlabas Haarlem East (A4H004)	Rapid II	-24.160139	27.4797111	1.02	32.80
EWR 3	A41B	Mamba River Bridge	Rapid II	-24.2127	27.50718	1.02	9.54
EWR 4	A41C	MatlabasPhofu	Rapid I	-24.05159	27.35922	1.02	35.58

The following sites (Table 5) were also assessed but found to be unsuitable for a Rapid Reserve determination.

Table 5: Details of sites assessed for potential Rapid III determination but found to be unsuitable

River Name	Latitude	Longitude	Quaternary	Comment
Bierspruit	-24.83830	27.28370	A24F	Dry, Habitat Integrity only
Upper Hex	-25.88189	27.31008	A22G	Dry, Habitat Integrity only
Hennops	-25.82556	27.98944	A21H	Flows too high, habitat integrity only
Bloubankspruit	-25.96778	27.80111	A21D	Flows too high, habitat integrity, discharge

The detailed reports for the additional rapids are attached as Appendix B and C and the supporting information is available electronically.

3.5 EXTRAPOLATION AND EWRs FOR HYDRO NODES

The information available from sections 3.3 and 3.4 was used for extrapolation to all the identified hydro nodes. Table 6 lists all the hydro nodes with the EWR sites that were used for extrapolation. The eco-region level 2 information as well as discussions with specialists were used as a guide during this process.

The rule and summary tables and the long term EWR time series as generated with the Desktop Reserve Model in SPATSIM is provided as electronic data. This information will be used during steps 4 and 5 of the WRCS.

The PES and REC information from the desktop study, the existing EWR sites and the additional rapid studies were used as the basis for extrapolation as indicated in Table 6.

Table 6: **Hydro nodes and associated EWR sites used for extrapolation**

IUA	No	Quaternary catchment	Hydro node	EWR sites used for extrapolation
1	HN1	A21A	Rietspruit (source) to Rietvlei Dam (CROC_EWR16)	CROC_EWR 16
	HN2	A21B	Sesmylspruit with its' tributaries to confluence with Hennops	CROC_EWR 16
	HN3	A21C	Modderfonteinspruit to confluence with Jukskei	CROC_EWR 2
	HN4	A21C	Klein Jukskei at confluence with Jukske	CROC_EWR 2
	HN5	A21C	Jukskei River at CROC_ EWR2	CROC_EWR 2
	HN6	A21D	Bloubankspruit and tributaries (outlet of quaternary/confluence with Crocodile)	Use updated PES with DRM
	HN7	A21A, B, H	Hennops (source) to confluence with Crocodile	CROC_EWR 2
	HN8	A21H	Swartspruit to Hartbeespoort Dam	Use DRM
	HN9	A21E, H	Crocodile (source) to CROC_EWR1	CROC_EWR 1
	HN10	A21H, J	Crocodile at Hartbeespoort Dam, outlet of IUA1	CROC_EWR 3
	HN11	A23A	Pienaars(source) and including Moreletaspruit and Edendalespruit to	Use updated PES with DRM

IUA	No	Quaternary catchment	Hydro node	EWR sites used for extrapolation
			outlet of Roodeplaat Dam	
	HN12	A23B	Pienaars from Roodeplaat Dam to outlet of quaternary catchment (outlet of IUA1) (CROC_EWR4)	CROC_EWR 4
	HN13	A23B	Boekenhoutspruit to confluence with Pienaars	Use updated PES with DRM
	HN14	A23D	Skinnerspruit (source) to confluence with Apies	Use updated PES with DRM
	HN15	A23D, E	Apies (source) to Bon Accord Dam, below the dam at outlet of IUA1	Use updated PES with DRM
2	HN16	A21F	Magalies below Maloney's Eye at CROC_EWR9	CROC_EWR 9
	HN17	A21G, F	Magalies (CROC_EWR15)	CROC_EWR 15
	HN18	A21G, F	Skeerpoort at outlet of IUA2	Use updated PES with DRM
3	HN19	A21J	Rosespruit at confluence with Crocodile	Use updated PES with DRM
	HN20	A21J	Crocodile from Hartbeespoort Dam to upstream Roodekopjes Dam, outlet of IUA3	CROC_EWR 3
4	HN21	A21K	Sterkstroom (source) to Buffelspoort Dam (CROC_EWR11)	CROC_EWR 11
	HN22	A21K	Sterkstroom from Buffelskloof Dam to Roodekopjes Dam, outlet of IUA4	Use updated PES with DRM
	HN23	A22G	Hex (source) to Olifantsnek Dam	CROC_EWR 11
	HN24	A22H	Waterkloofspruit (CROC_EWR14) to confluence with Hex	CROC_EWR 14
	HN25	A22H	Hex from Olifantsnek Dam to Bospoort Dam	Use updated PES with DRM
	HN26	A22J	Hex from Bospoort Dam to Vaalkop Dam (CROC_EWR6)	CROC_EWR 6
	HN27	A22J	Elands from Vaalkop Dam to confluence with Crocodile, outlet of IUA4	Use updated PES with DRM
5	HN28	A22A	Elands (source) to Swartruggens Dam (CROC_EWR10)	CROC_EWR 10
	HN29	A22A	Elands from Swartruggens Dam to Lindleypoort Dam	CROC_EWR 10
	HN30	A22B	Koster (source) to Koster Dam	CROC_EWR 10
	HN31	A22C, A22D	Selons to confluence with Elands	CROC_EWR 13
	HN32	A22E, A22F	Elands from Lindleypoort Dam (CROC_EWR13) to Vaalkop Dam, outlet of IUA5	CROC_EWR 13
6b	HN33	A31B	Polkadraaispruit to confluence with Marico (MAR_EWR6)	MAR_EWR 6
	HN34	A31B	Marico from MAR_EWR2 to N4 road at town	MAR_EWR 2
	HN63	A31B	Marico from N4 road to Marico-Bosveld Dam, outlet of IUA6b	MAR_EWR 6
6a	HN64	A31D	Malmaniesloop to confluence with Klein Marico	MAR_EWR 5
	HN35	A31D	Klein Marico from Zeerust to Klein Maricopoort Dam	MAR_EWR 5

IUA	No	Quaternary catchment	Hydro node	EWR sites used for extrapolation
	HN65	A31E	Klein Mario from Klein Maricopoort Dam to Kromellemboog Dam	MAR_EWR 5
	HN36	A31E	Kromellemboog Dam (MAR_EWR5), outlet of IUA6a	MAR_EWR 5
7	HN37	A31A	Kaaloog-se-Loop (MAR_EWR1) to concluence with Groot Marico	MAR_EWR 1
	HN38	A31A	Vanstraatenvlei and tributaries at confluence with Kaaloog-se-Loop, outlet of IUA7	MAR_EWR 1
8	-	A31C	Groundwater	-
9	HN66	D41A	Molopo at outlet of wetland	MAR_EFR M8, Use updated PES with DRM
	HN67	D41A	Molopo at Modimolla	MAR_EFR M8, Use updated PES with DRM
	HN39	D41A	Molopo at outlet of IUA9	MAR_EFR M8, Use updated PES with DRM
10	HN68	A10A	Ngotwane from Dinokana to Ngotwane Dam	-
	-	A10A, B, C	Ngotwane from Dinokana to outlet of IUA10	-
11a	HN40	A31F, G, A32A	Marico from Marico Bosveld and Kromelmboog Dam to Molatedi Dam (MAR_EWR3), outlet of IUA11a	MAR_EWR 3
11b	HN41	A32D, E	Marico from Molatedi Dam to confluence with Crocodile (MAR_EWR4), outlet of IUA11b	MAR_EWR 3
12	HN42	A24D, E, F	Bierspruit to confluence with Crocodile River, outlet of IUA12	Use updated PES with DRM
13	HN43	A24G, A24H	Sand to confluence with Crocodile	CROC_EWR 7
	HN44	A21L, A24A-C, A24H	Crocodile from Roodekopjes Dam (CROC_EWR7) to proposed Mokolo transfer (CROC_EWR8)	CROC_EWR 8
	HN45	A24J	Crocodile from CROC_EWR8 to confluence with Limpopo, outlet of IUA13	CROC_EWR 8
14	HN46	A23G	Platspruit (source, CROC_EWR12) to confluence with Pienaars	CROC_EWR 12
	-	A23C, A23F	Wetland at Pienaars & Apies confluence and inflow to Klipvoor Dam	-
	HN47	A23H	Karee/Rietspruit to confluence with Pienaars	CROC_EWR 12
	HN48	A23J A23J, A23L	Moretele (Pienaars) to confluence with Crocodile (CROC_EWR5), outlet of IUA14	CROC_EWR 5
	HN49	A23K	Tolwane to confluence with Moretele	Use updated PES with DRM
15	HN50	A42A	Sand (source) to confluence with Grootspruit	MOK_EWR 1a
	HN51	A42B	Grootspruit (source) to confluence with Sand	MOK_EWR 1a
	HN52	A42C	Mokolo to confluence with Dwars	MOK_EWR 1a

IUA	No	Quaternary catchment	Hydro node	EWR sites used for extrapolation
			(MOK_EWR1a)	
	HN53	A42D, A42E	Mokolo to confluence with Sterkstroom (MOK_EWR1b)	MOK_EWR 1b
	HN54	A42D	Sterkstroom (source) to confluence with Mokolo, including Dwars	MOK_EWR 1b
	HN55	A42F	Mokolo from Sterkstroom to Mokolo Dam (MOK_EWR2), outlet of IUA15	MOK_EWR 2
16	HN56	A42G	Rietspruit (source) to Mokolo confluence	Use updated PES with DRM
	HN57	A42G	Mokolo below dam (MOK_EWR3) to Rietspruit confluence (MOK_EWR4)	MOK_EWR 3, MOK_EWR 4
	HN58	A42H, A42J	Mokolo from MOK_EWR4 to confluence with Limpopo, outlet of IUA16.	MOK_EWR 4 and wetland requirements
17a	HN59	A41A	Mothlabatsi to confluence with Mamba	MAT_EWR 1, MAT_EWR 2
	HN60	A41B	Mamba to confluence with Mothlabatsi, outlet of IUA17a	MAT_EWR 3
17b	HN61	A41C	Matlabas from Mamba confluence to MAT_EWR2	MAT_EWR 4
	HN62	A41C, D	Matlabas from MAT_EWR2 to confluence with Limpopo, outlet of IUA17b	MAT_EWR 2

4 QUANTIFICATION OF CHANGES IN RELEVANT ECOSYSTEM GOODS, SERVICES AND ATTRIBUTES

The quantification of the changes in the relevant ecosystem components, functions and attributes for each ecological category for each node supports the evaluation of the socio-economic and ecological components in Step 4 of the classification procedure (DWAF, 2007a). The ecosystem changes at different ecological categories allow for the consideration of ecological and socio-economic information at different scales and enable the evaluation of various ecological catchment configurations. Thus in terms of the socio-economic evaluation of scenarios it is important to understand what the EGSAs for the IUAs are, the nodes at which the changes can be provided and the changes that occur based on different characteristics within the water resource.

EGSA information can only be provided if the node is an EWR site, if Reserve data can be extrapolated to a node from a site with high confidence data and if the EGSA was considered during the Reserve determination (DWA, 2007b).

As per the WRCS guidelines the required information on changes in ecosystem components can be related to hydrological characteristics, biological components and processes, physical components and processes, structure and organisation of aquatic ecosystems and water quality characteristics.

This section details the EGSAs information required for socio-economic evaluation and the ecosystem changes that relate to these EGSAs considered for Crocodile (West), Marico, Mokolo and Matlabas catchments. The EGSAs aspects considered were assessed based on a change in ecological category. The significance of the change is described in terms of the socio-economic assessment. In many instances the ecosystem changes will be quantified in the assessment of the scenarios (catchment configurations).

4.1 EGSAs CONSIDERED FOR THE CROCODILE (WEST), MARICO, MOKOLO AND MATLABAS CATCHMENTS

The EGSAs considered for the Crocodile (West), Marico, Mokolo and Matlabas catchments are listed in Table 7.

Table 7: EGSAs considered for the Crocodile (West), Marico, Mokolo and Matlabas catchments for rivers

Ecosystem Service	Description of Value	Aspects Considered	Output from RDM studies
Domestic water use	Subsistence use of water	Loss of river use: Replacement cost of water shipped via containers	Yield model – changes in yield/supply Water quality – change fitness for use
Grazing	Grazing	Loss of available grazing land: Replacement cost of buying fodder in winter months	Loss of riparian habitat (non-flow) – index of change
Livestock watering	Livestock watering	Replacement cost of boreholes	Drought and maintenance low flows
Harvested products	Sand & clay	Building sand & clay for making bricks/households	Loss of riparian habitat (non-flow) and in-stream habitat
	Fuel wood	Amount harvested/ households	Loss of riparian habitat (non-flow) – index of change
	Raw Materials	Amount harvested/ households	
	Wild foods & medicines	Amount harvested/ households	
	Hunting	Amount harvested/ households	Not provided
	Fishing	Amount harvested/ households	Index of change in abundance (non-flow)
Water regulation		Maintenance of base flows	Yield model (EWR)
Carbon Sequestration	Riparian vegetation has the ability to store carbon	Amount of riparian habitat	Not provided
Tourism	Rafting, adventure tourism	Benefits accrued by tourism operators	Hydraulics/Yield model
Aesthetic value	House prices	Amount of houses near rivers and wetlands	Ecostatus
Education	Peer reviewed journal output	Peer reviewed journal subsidy	Not provided

Table 8: EGSAs considered for the Crocodile (West), Marico, Mokolo and Matlabas catchments for wetlands

Ecosystem Service	Description of Value	Aspects Considered	RDM output
Livestock watering	Livestock watering	Replacement cost of boreholes	Drought and maintenance low flows
Harvested products	Sand & clay	Building sand & clay for making bricks/households	Loss of riparian habitat (non-flow) and in-stream habitat
	Fuel wood	Amount harvested/households	Loss of riparian habitat (non-flow) – index of change
	Raw Materials	Amount harvested/households	
	Wild foods & medicines	Amount harvested/households	
	Hunting	Amount harvested/households	Not provided
	Fishing	Amount harvested/households	Index of change in abundance (non-flow)
Flood attenuation	Ability of wetlands to lessen the impact of flooding	Replacement cost from flood damage	EWR High flows
Groundwater recharge	Ability of wetlands to contribute to groundwater recharge. Utilised through boreholes and wells during dry months	Replacement cost of dam construction	Baseflow contribution
Water purification	Wetlands absorb and breakdown organic and inorganic pollutants	Treatment cost abatement curve	Water Quality – change in fitness for use
Carbon Sequestration	Wetlands seen as a carbon sink	Amount of carbon sequestered by different wetland types	Not provided
Angling	Freshwater angling.	Value of trout industry and other fishing industries	Hydraulics/Yield model
Tourism	Ecotourism value	Tourism market sizing	Not provided

4.2 IDENTIFIED CHANGES IN ECOSYSTEM COMPONENTS, FUNCTIONS AND ATTRIBUTES

4.2.1 Hydrological Characteristics

In terms of yield, the yield model calculates the consequence of the nMAR-EWRs. This hydrological EGSA will be assessed in detail in the next step Step 4 of the classification procedure, the determination of the ESBC.

Other hydrological aspects of relevance in the Crocodile (West), Marico, Mokolo and Matlabas catchments for the EGSAs assessment include:

- domestic water use;
- livestock water; and
- rafting/adventure tourism.

The hydrological components considered were the dry and maintenance low flows.

4.2.2 Biological components and functions

Biological EGSAs of relevance to the Crocodile (West), Marico, Mokolo and Matlabas catchments include:

- Grazing; and
- Harvested products – sand and clay, fuel wood, raw materials, wild foods, medicines and fishing.

The aspects considered with respect to the above include riparian vegetation and fish abundance and are mostly non-flow related.

The risk to grazing is low. The consequence of a change in ecological category could be insignificant and is extremely unlikely to change stock numbers. The risk to harvested products is low. A change in ecological category could have a minor consequence and is very unlikely to change the type and number of products which can be harvested. It is also unlikely to change wetland area.

A change in the ecological category of fish abundance and riparian vegetation will have a negligible effect and therefore did not require quantification.

4.2.3 Structure and organisation of Biological Communities

The estimated retained functioning and biodiversity relative to the established EWR sites are provided in Table 9.

Table 9: Estimated retained functioning and biodiversity relative to the established EWR sites

Sub Catchment	Node (EWR site)	Quaternary catchment	% Retained of natural functioning and biodiversity		
			PES	REC	Estimated Change
Crocodile-West	CROC_1	A21H	57,4	57,4	
	CROC_2	A21C	37,4	57,4	
	CROC_3	A21J	67,45	67,4	

Sub Catchment	Node (EWR site)	Quaternary catchment	% Retained of natural functioning and biodiversity		
			PES	REC	Estimated Change
	CROC_4	A23B	77,4	77,4	All benefits of ecosystems services will increase with an improvement in ecological condition.
	CROC_5	A23J	57,4	77,4	
	CROC_6	A22J	57,4	57,4	
	CROC_7	A24C	57,4	57,4	
	CROC_8	A24H	77,4	77,4	
	CROC_9	A21F	87,4	87,4	
	CROC_10	A22A	77,4	82,4	
	CROC_11	A21K	77,4	77,4	
	CROC_12	A23G	82,4	82,4	
	CROC_13	A22E	77,4	77,4	
	CROC_14	A22H	82,4	82,4	
	CROC_15	A21F	67,45	67,4	
	CROC_16	A21A	77,4	77,4	
Marico	MAR_1	A31A	87,4	87,4	All benefits of ecosystems services will increase with an improvement in ecological condition.
	MAR_2	A31B	87,4	87,4	
	MAR_3	A31F	67,4	67,4	
	MAR_4	A32D	77,4	77,4	
	MAR_5	A31E	77,4	77,4	
	MAR_6	A31B	82,4	82,4	
Mokolo	MOK_1a	A42C	67,4	82,4	All benefits of ecosystems services will increase with an improvement in ecological condition.
	MOK_1b	A42E	82,4	87,4	
	MOK_2	A42F	82,4	87,4	
	MOK_3	A42G	82,4	87,4	
	MOK_4	A42G	77,4	87,4	
Matlabas	MAT_1	A41A	87.4	87.4	All benefits of ecosystems services will increase with an improvement in ecological condition.
	MAT_2	A41B	82.4	82.4	
	MAT_3	A41B	82.4	82.4	
	MAT_4	A41C	77.4	77.4	

4.2.4 Water Quality Characteristics

The water quality characteristic of relevance to the EGSAs is a ‘change in fitness for use’ of water quality which impacts on the requirements of users. The present day water quality status for water users in the Crocodile (West), Marico, Mokolo and Matlabas catchments are described in this section.

4.2.4.1 The water user sectors

The water requirement values for the Crocodile West Catchment are taken from the Crocodile (West) River Reconciliation Strategy (DWA 2008) and are based on four growth scenarios (Table 10):

1. Scenario D High: medium water demand management efficiency, high population growth
2. Scenario D Base: medium water demand management efficiency, base population growth
3. Scenario D Low: medium water demand management efficiency, low population growth
4. Scenario C High: high water demand management efficiency, high population growth

Table 10: Summary of water requirements (units: million m^3) for the Crocodile West catchment

Scenario	2005	2010	2015	2020	2025	2030
D: High	1 121	1 191	1 276	1 355	1 409	1 480
D: Base	1 112	1 170	1 237	1 299	1 344	1 404
D: Low	1 110	1 147	1 190	1 221	1 232	1 255
C: High	1 121	1 196	1 228	1 275	1 308	1376

The total water requirements for the Marico, Upper Molopo and Ngotwana catchments for different users are set out in Table 11(DWAF 2004).

Table 11: Total water requirements for the Upper Molopo and Ngotwane catchments

Sub Area	Irrigation	Urban	Rural	Mining and bulk industry	Transfers Out	Total
Marico	32	9	12	5	7	65
Upper Molopo	24	13	6	5	0	48
Upper Ngotwane	5	2	3	0	0	10

The water requirements for the Matlabas and Mokolo catchments are given in Table 12 (DWAF 2004c).

Table 12: Water requirements in the Matlabas and Mokolo catchments (at 1:50 year assurance) in the year 2003(units: million m^3)

Catchment	Irrigation	Urban	Rural	Mining	Power Generation	Transfers Out	Total
Matlabas	4	0	2	0	0	0	6
Mokolo	68	2	2	4	7	0	83

Strategic Water Requirements

The Crocodile (West) catchment is one of the most developed catchments in the country. The catchment is characterised by the sprawling urban and industrial areas of northern Johannesburg and City of Tshwane (Pretoria), extensive irrigation downstream of Hartbeespoort Dam and large mining developments north of the Magaliesberg.

Due to the extensive developments and high level of human activity in the catchment, water use in the catchment exceeds the water available from the local sources. Most of the water used in the catchment is therefore supplied from the Vaal River system via Rand Water, mainly to serve the metropolitan areas and some mining developments. This results in large quantities of effluent from urban and industrial users, most of which is discharged to the river system after treatment, for re-use downstream. In many of the streams and impoundments, water quality is severely compromised by the proportionate large return flows.

The economy of the Marico, Upper Molopo and Upper Ngotwane is focused on agriculture on the dolomites of the Upper Molopo and the Marico catchment as well as mining around Zeerust, with some secondary industries such as cement manufacturing at the Slurry.

Water requirement data was sourced from the ISP for Marico, Upper Molopo and Upper Ngotwane Catchments (DWAF 2004a).

The main water user sectors in the three catchments are:

- Commercial irrigation farming in all three catchments;
- Urban water use in the main towns of Mafikeng, Zeerust, Groot Marico and Itsoseng; and
- Rural domestic water use.

Both the Mokolo and Matlabas catchments are in areas which are defined as semi-arid regions, with economic activity centred on livestock farming, irrigation and future mining developments.

Irrigation Water Requirements

The total irrigation water requirements for the Crocodile West catchment are set out in Table 13.

Table 13: Irrigation water requirements (units: million m^3) for the Crocodile West catchment

Sub catchment	Irrigation Area	Irrigation Requirement	Distribution losses	Total Irrigation Requirement		Irrigation Return Flows
				Volume	1:50 assurance	
Unit	ha	million m^3/annum				million m^3/a
Upper Crocodile	20 260	115	57	172	147	11
Elands	1 514	8	2	10	8	1
Apies-Pienaar	6 164	32	3	36	30	3
Lower Crocodile	28 036	153	76	229	191	15
Total	55 974	308	138	447	376	30

The major water user in the Marico is irrigation (at 32 million m^3/a) along the Groot Marico River and the Klein Marico as well as downstream of Marico Bosveld and Klein Maricopoort.

In the Upper Molopo sub-area irrigation and urban water use are the major water users:

- Urban water use: 24 million m^3/a; and
- 13 million m^3/a respectively.

The sources of supply are the dolomitic aquifers of the Grootfontein compartment and Molopo springs.

Irrigated agriculture is the dominant water user in the Upper Ngotwane sub-area (5 million m^3/a) followed by rural water use of approximately 3 million m^3/a.

Irrigation is the largest water user in the Matlabas catchment with an approximate requirement of 4 million m^3/aof which 2 million m^3/a is sourced from groundwater sources and 2 million m^3/a is sourced from surface water resources.

Irrigation, is the largest user in the Mokolo catchment, takes place mostly upstream of the Mokolo Dam, with water sourced from farm dams and run-of-river. There is an allocation of 10.4 million m^3/a (at 70% assurance) from the Mokolo Dam to downstream irrigators.

Urban and Industrial Water Requirements

The total urban water requirements for the Crocodile West catchment (as per the four growth scenarios listed above) are given in Table 14.

Table 14: Urban water requirements (units: million m^3) for the Crocodile West catchment

Scenario	2005	2010	2015	2020	2025	2030
D: High	579	604	673	736	790	850
D: Base	570	586	640	689	733	782
D: Low	568	565	597	615	626	638
C: High	579	609	626	657	688	746

Urban water use in the Marico catchment is third after irrigation and rural use and is estimated at 9 million m^3/a.

In the Upper Molopo sub-area urban water use is second to irrigation at 13 million m^3/a. The sources of supply are the dolomitic aquifers of the Grootfontein compartment and Molopo springs.

In the Mokolo catchment the towns of Lephalale and Vaalwater constitute the urban requirements in the catchment (DWAF 2004c).

Power Generation Water Requirements

There are three power stations in the Crocodile River catchment: Kelvin in the Upper Crocodile sub-catchment and Pretoria-West and Rooiwal in the Apies-Pienaars sub-catchment. The water requirements of the Kelvin, Pretoria-West and Rooiwal power stations are 11 million m^3/a, 6 million m^3/aand17 million m^3/a respectively.The water requirements of the power stations in the Crocodile West catchment are summarised in Table 15.

Table 15: Power sector water requirements (units: million m^3) for the Crocodile West catchment

Power Station	**million m^3/a**
Kelvin	11
Pretoria-West	6
Rooiwal	17
Total	**34**

In the Mokolo catchment there is an allocation of 7.3 million m^3/a to the Matimba power station.

Rural Water Requirements

The total rural water requirements for the Crocodile West catchment (as per the four growth scenarios listed above) are given in Table 16.

Table 16: Rural water requirements (units: million m^3) for the Crocodile West catchment

Population Growth	**2005**	**2010**	**2015**
High	15	23	23
Base	15	23	22
Low	15	22	22

Rural water use in the Marico catchment is the second largest user following irrigation at 12 million m^3/a, and in the Upper Ngotwane sub-area rural water use is estimated at approximately 3 million m^3/a.

Rural water use in the Mokolo and Matlabas catchments is estimated at 4 million m^3/a (2 million m^3/a in each catchment).

Mining Water Requirements

The total mining water requirements for the Crocodile West catchment are set out in **Table 17**.

Table 17: Mining water requirements (units: million m^3) for the Crocodile West catchment

Scenario	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
High	92	129	145	152	152	151
Base	92	126	139	144	145	145
Low	92	124	136	142	142	142

Water use for the mining and bulk industry sectors in the Marico, Upper Molopo and Ngotwana catchments is estimated at 5 million m^3/a, the lowest user in the Marico catchment.

In the Mokolo catchment there is an allocation of 9,9 million m^3/a to the Grootgeluk coal mine.

Stock Watering

The water requirements for stock watering occur throughout the Crocodile West catchment and the total water requirements are 22 million m^3/a (DWA 2008).

4.2.4.2 Resource water quality objectives (RWQOs)

The key water user sectors in the Crocodile (West), Marico, Mokolo and Matlabas catchments are irrigation, mining, rural and domestic water use.

The process of setting Resource Water Quality Objectives (RWQOs) is a mechanism through which the balance between sustainable and optimal water use and protection of the water resource can be achieved. RWQOs are the water quality components of the Resource Quality Objectives (RQOs) which are defined by the National Water Act as "clear goals relating to the quality of the relevant water resources" (DWAF, 2006a).

RWQOs are descriptive or quantitative, spatial or temporal, and ultimately allow realisation of the catchment vision by giving effect to the water quality component of the gazetted (RQOs). RWQOs are typically set at a finer resolution than RQOs to provide greater detail upon which to base the management of water quality.

Fitness for use is a scientific judgement, involving objective evaluation of available evidence, of how suitable the quality of the water is for its intended use. Water quality can therefore only be expressed in terms of fitness for use. Water quality assessment to determine fitness for use is based on resource water quality objectives (RWQOs) that have been set for the water resource.

In South Africa, the South African Water Quality Guidelines (SAWQGs) have been developed as discrete values that depict the change from one category of fitness for use to another (DWAF, 1996). The SAWQGs recognises only one management category, namely the Target Water Quality Range (TWQR). Above this value / range, the categories describe an ever increasing negative impact with respect to the use of the water. Thus, for any resource it is necessary to determine whether or not the effect is acceptable to the user (DWAF, 2006c).

The water quality guidelines describe the "fitness for use" of a water resource, while the water quality objectives define "what management action is required" for a water resource. The fitness for use of water is a judgement as to how suitable the quality of water is for its intended use. The following fitness for use categories are linked to the SAWQGs:

- **Ideal** – the use of water is not affected in any way; 100% fit for use by all users at all times; desirable water quality (TWQR);
- **Acceptable** – slight to moderate problems encountered on a few occasions or for short periods of time;
- **Tolerable** – moderate to severe problems are encountered; usually for a limited period only; and
- **Unacceptable** – water cannot be used for its intended use under normal circumstances at any time (DWAF, 2006c).

The generic RWQOs set out in Table18, developed as part of the national water quality assessment study (DWA, 2011) were used in the assessment of the catchment water quality.

Table18: Resource Water Quality Objectives used for the present day water quality assessment (DWA, 2011)

Variable	Units	Ideal	Sensitive user	Acceptable	Sensitive user	Tolerable	Sensitive user
Alkalinity, $CaCO_3$	mg/l	20	AAq	97.5	AAq	175	AAq
Ammonia, NH_3-N	mg/l	0.015	Ecological	0.044	Ecological	0.073	Ecological
Calcium,Ca	mg/l	10	Dom	80	BHN	80	BHN
Chloride, Cl	mg/l	40	In2	120	In2	175	In2
Electrical Conductivity, EC	mS/m	30	In2	50	In2	85	Ecological
Fluoride, F	mg/l	0.7	Dom	1	Dom	1.5	Dom
Magnesium, Mg	mg/l	70	Dom	100	Dom	100	Dom
Nitrate, NO_3-N	mg/l	6	AIr	10	AIr	20	AIr
pH	units	≤8	In2	<8.4	In2		
		≥6.5	AIrAAq In2	>8.0	AIrAAq In2		
Potassium, K	mg/l	25	Dom	50	Dom	100	Dom
Phosphate, PO_4-P	mg/l	0.005	Ecological	0.015	Ecological	0.025	Ecological
Sodium Absorption Ratio	mmol/l	2	AIr	8	AIr	15	AIr
Sodium, Na	mg/l	70	AIr	92.5	AIr	115	AIr
Sulphate, SO_4	mg/l	80	In2	165	In2	250	In2
Total Dissolved Solids	mg/l	200	In2	350	In2	800	In2
Silica, Si	mg/l	10	In2	25	In2	40	In2

Basic Human Needs	BHN	Agriculture - Aquaculture	AAq
Domestic use	Dom	Industrial - Category 2	In2
Agriculture - Irrigation	AIr		

4.2.4.3 Water quality data collection

Water quality data wassourced from the Department's Water Management System (WMS) obtained from the Directorate: Resource Quality Services (D: RQS). Results of the intermediate Reserve determination for the Crocodile (West)/Marico WMA (DWA, 2011) as well as the Mokolo intermediate Reserve determination study (DWA, 2011) have been incorporated.

4.2.4.4 Water quality data analysis

The water quality status assessment is based on the routine monitoring conducted by the Department at various sites in the respective catchments. It is important to note that this is a high level qualitative assessment of historical water quality in the Crocodile West/Marico WMA and theMokolo and Matlabas catchments, making use of the available data.

Table **19** sets out the water quality monitoring points in the Crocodile (West), Marico, Mokolo and Matlabas catchments used for the present day water quality assessment. However, Table 22 shows the water quality for specific points within the catchments to give a broad overview of the water quality.

The selection of the variables was based on the following reasoning:

- *Electrical Conductivity (EC) (mS/m):* an indication of salinisation of water resources;
- *Orthophosphate (PO_4-P) (mg/l):* an indicator of the nutrient levels in water resources to show where eutrophication is becoming a threat. As part of the study, nitrate (NO_3+NO_2-N)

(mg/l) was also assessed. The results showed a 97% compliance rate to ideal RWQO due to the upper limit being set at 6 mg/l based on the most sensitive user.

- *Sulphate (SO_4^{2-}) (mg/l):*an indicator of mining impacts (a major issue in the Crocodile West and Marico catchment areas and which may become an issue in the Mokolo catchment in future with the expansion of mining in the Lephalale area);
- *Chloride (Cl^-) (mg/l):*an indicator of agricultural impacts, sewage effluent discharges and industrial impacts;
- *Ammonia (NH_3-N) (mg/l):* an indicator of toxicity; and
- *pH (pH units):* an indicator of mining impacts as well as natural variability.

Crocodile Catchment

Water quality is a driver of the status of rivers in the catchment. As part of the Reserve determination, water quality sub-units (WQSUs), areas of homogenous water quality,were defined. The land use defines the anthropogenic influences on water quality and provides a good indicator of which water quality variables would change over time. A water quality sub-unit is a length of river for which a single description of water quality can be given. This may be determined by determinants such as ecoregions, dams, tributaries, towns and point sources of pollution. Changes in water quality may be natural, for example the input of water from tributaries, or man-made, for example, abstractions and discharges in urban areas. All these factors can cause changes in water quality and define WQSUs. The water quality sub-units delineated for the Crocodile (West) catchment are illustrated in Figure 4.The water quality monitoring sites selected from the DWA National Monitoring programme from the Water management System (WMS) that relate to the Crocodile (West) EWR sites are listed in Table 19. These water quality monitoring stations were used for the present state assessment.

Table 19: DWA water quality sites related to the Crocodile (West) EWR sites

EWR site no.	EWR site	Co-ordinates	Quaternary catchment	WQ weirs close to site	Other information
1	Crocodile River upstream of Hartbeespoort Dam	S25.8004; E27.896	A21H	Nearest weir is A2H012 – Crocodile River at Kalkheuwel	Downstream of the confluences of the Jukskei, Hennops and Rietspruit Rivers with the Crocodile River, and upstream of Hartbeespoort Dam
2	Jukskei River at Heron Bridge School	S25.9539; E27.9621	A21C	Nearest weir is A2H023 – Jukskei River at Nietgedacht	Situated at the confluence of the Jukskei River with the Upper Crocodile River, and upstream of Hartbeespoort Dam
3	Crocodile River downstream of Hartbeespoort Dam in Mount Amanzi	S25.7168; E27.8431	A21J	Nearest weir is A2H083 – Hartbeespoort Dam: downstream weir	Crocodile River immediately downstream of Hartbeespoort Dam

EWR site no.	EWR site	Co-ordinates	Quaternary catchment	WQ weirs close to site	Other information
4	Pienaars River downstream of Roodeplaat Dam	S25.4155; E28.312	A23B	Nearest weir is A2H006 – Pienaars River at Klipdrift	Weir is downstream of EWR site
5	Pienaars River downstream of Klipvoor Dam in Borakalalo National Park	S25.12657; E27.80457	A23L	Nearest weir is A2H021 – Pienaars River at Buffelspoort	Weir is 21 km downstream of EWR site
6	Hex River upstream of Vaalkop Dam	S25.5214; E27.3749	A22J	Nearest weir is A2H094 – Bospoort Dam: downstream weir	Weir is situated at Tweedepoort, 4 km downstream of EWR site
7	Crocodile River upstream of the confluence with the Bierspruit	S24.88661; E27.51743	A24C	Nearest weir is A2H060 - Crocodile River at Nooitgedacht	WQ site is 23 km upstream of the EWR
8	Crocodile River downstream of confluence with Bierspruit in Ben Alberts Nature Reserve	S24.64476; E27.32569	A24F/H/J	Nearest weir is A2H116 – Paul Hugo Dam: downstream weir	Weir is situated at Haakdoorndrift

The water quality of the Upper Crocodile River is impacted by urbanisation and large volumes of wastewater discharges (sewage works and industrial). Water quality in the rivers is relatively poor with high levels of nutrients and salt concentrations. The water quality of the Magalies River is relatively good with localised impacts from land based activities. The impoundments in the system impact on the water quality in the rivers.

Water quality of the Elands River catchment is good in the upper reaches. However the middle and lower reaches are of a fair quality with mining activities in the catchment impacting on the river. Water quality has also deteriorated as a result of erosion and high sediment loads. The Hex River shows elevated concentrations of salts and nutrients as well as toxicants. There are impacts from agricultural (intensive irrigation) activities in the catchment.

The water quality of the Apies Pienaars catchment is of poor quality with certain areas being impacted by nutrients and salinisation. There are thirteen point source discharges into the system from industries and domestic wastewater treatment works. The water quality of the upper catchments is deteriorating even further in certain areas. pH is high but salts are stable. Sources of pollution are mainly from urban return flows, sewage works and land based activities.

The Lower Crocodile River is deteriorating in terms of water quality. Salts and nutrients are high. There are also increased levels of toxicants in the middle reaches of the river. Urbanisations, industrial diffuse sources and high agricultural return flows are the major impacting activities.

Table 20 provides a brief assessment of the water quality issues per WQSU.

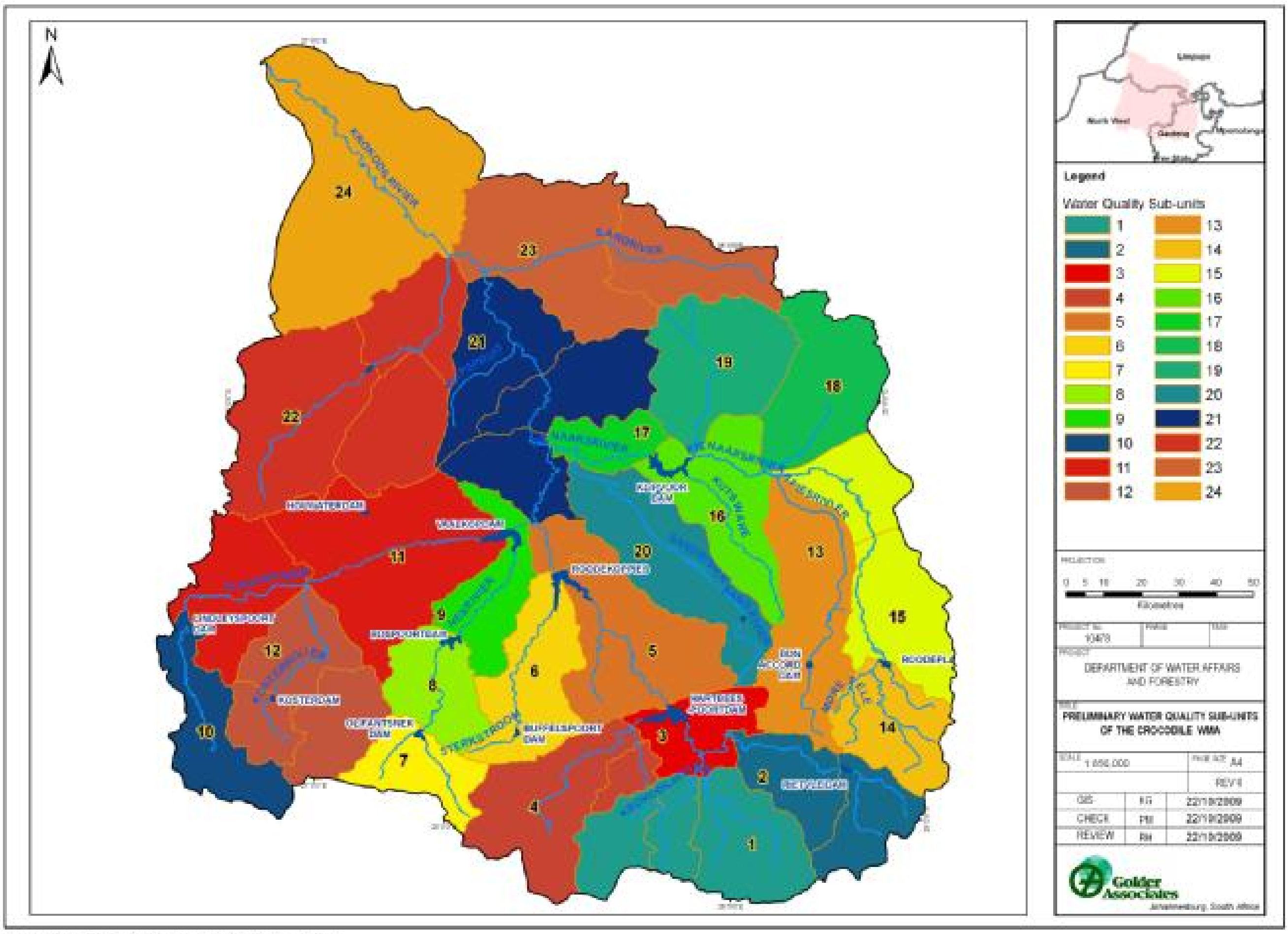

Figure 4: WQ Sub-units delineation of the Crocodile (West) catchment area (DWA, 2011)

Table 20: Water Quality Sub-Units (WQSU) and descriptive information on the water quality issues

Sub – catchment	WQ Subunit No.	Water Quality Subunit	Water quality status and issues
Upper Crocodile	1	Jukskei, Klein Juskei and Bloubankspruit (headwaters of Crocodile River)	High salinity concentrations and high nutrient concentrations, especially high nitrogen concentrations. Highly impacted/heavily urbanised with major wastewater discharges.
	2	Hennops River	Highly polluted. High nutrient concentrations. Salinity also very high.
	3	Hartebeespoort Dam	Water quality is very poor. Severe nutrient over-enrichment. Frequent algal blooms and water hyacinths. Heavily impacted by large wastewater loads from the Johannesburg, Midrand and Tshwane. Increased development around the dam.
	4	Magalies River/ Skeerpoort	Fairly good water quality. Localised impacts from mining and agriculture.
	5	Crocodile River	Salinity impacts and high nutrient concentrations. Agricultural run-off is a major impact on the water quality of the river. Some impacts from urbanization.
		Roodekopjes Dam	Constant releases are made for agricultural water use. Agricultural runoff – nutrients and sediments.
	6	Sterkstroom	High salinity due to mining impacts. Some impact from nutrients. Water quality in upper reaches of river is fairly good
Elands	7	Upper Hex (headwaters and Klein Hex)	Intensive agricultural activity. Increased nutrient and salt concentrations.
		Olifantsnek Dam	Impacts on river flow – water quality in dam shows occasional algal blooms and is overall in a good water quality status
	8	Hex River between Olifantsnek Dam and Bospoort Dam	High salts and nutrients. Alien encroachment is a problem. Erosion impacts and increased turbidity are a problem. Impacts from mining and agriculture.
		Bospoort Dam	Impacts on river flow – water quality in dam is impacted by upstream formal and informal urbanization and waste water treatment works. Seasonal algal blooms have been recorded.
	9	Lower Hex River	Salinity concentrations are high. Mining activities in the catchment are impacting on the river. Informal cattle grazing is also characteristic of the lower reaches.
		Vaalkop Dam	Water quality is fairly good but due to upstream activities it is deteriorating. Occasional algal problems in the dam. Water is treated for drinking water by Magalies Water.
	10	Upper Elands River	Water quality is fairly good but is deteriorating due to impacts of slate mining in the catchment. Turbidity is increasing.
		Lindleyspoort Dam	Water is release for agricultural use (irrigation). Impacts of flow of river.
	11	Lower Elands River	Erosion and high sediment loads.
	12	Koster River	Water quality is fairly good.
Apies/ Pienaars	13	Apies River	Nutrients are high. Water quality is deteriorating due to impacts of urbanization and impact of Rooiwal Sewage works discharges. Some heavy metal contamination in upper reaches of river due to industrial activities.
		Bon Accord Dam	Eutrophic to hyper-trophic (potential for toxic algal blooms to exist)
	14	Upper Pienaars River (headwaters, Edendalespruit,	High nutrient concentrations and salinity. Significant impacts from urban run-off and two large sewage works.

Sub – catchment	WQ Subunit No.	Water Quality Subunit	Water quality status and issues
		Hartebeesspruit)	
		Roodeplaat Dam	Water quality is poor. High nutrient concentrations. Dam is hyper-eutrophic. Toxic algal blooms occur.
	15	Pienaars River before confluence with Apies River	High nutrient and toxicant concentrations. Salt concentrations are stable. Agricultural run-off impacts on water quality of river.
	16	Pienaars/Moretele River to Klipvoor Dam	Impacts of agriculture and upstream activities. Impacted by Apies, Plat and Rietspruit tributaries. High salts and nutrient concentrations.
		Klipvoor Dam	Hyper-eutrophic. Potential to develop toxic algal blooms.
		Kutswane	
	17	Lower Pienaars River	Influence by releases from dam. Some impacts are experienced from irrigation return flows.
	18	Plat River	Limited data available. However upper reaches appear to have fairly good water quality.
	19	Rietspruit	Limited water quality data available.
	20	Sand (Tolwane) River	Headwaters of river highly impacted by urban run-off. High nutrient concentrations in river due to sewage works discharges. Microbiological contamination is a problem.
Lower Crocodile	21	Middle Crocodile (from confluence of Pienaars to confluence with Bierspruit and Sand Rivers)	High nutrients concentrations. Impacts of agricultural activities, urban and industrial diffuse sources. Salt levels are stable.
		Klipspruit	Water quality is relatively good.
	22	Bierspruit	Water quality is relatively good.
	23	Sand (Sundays)	Water quality is relatively good.
	24	Lower Crocodile	High nutrient concentrations. Agricultural run-off impacts on river.

Marico Catchment

As for the Crocodile (West) catchment as part of the intermediate Reserve determination water quality sub units were determined for the Marico catchment. These are indicated in

Figure 5.

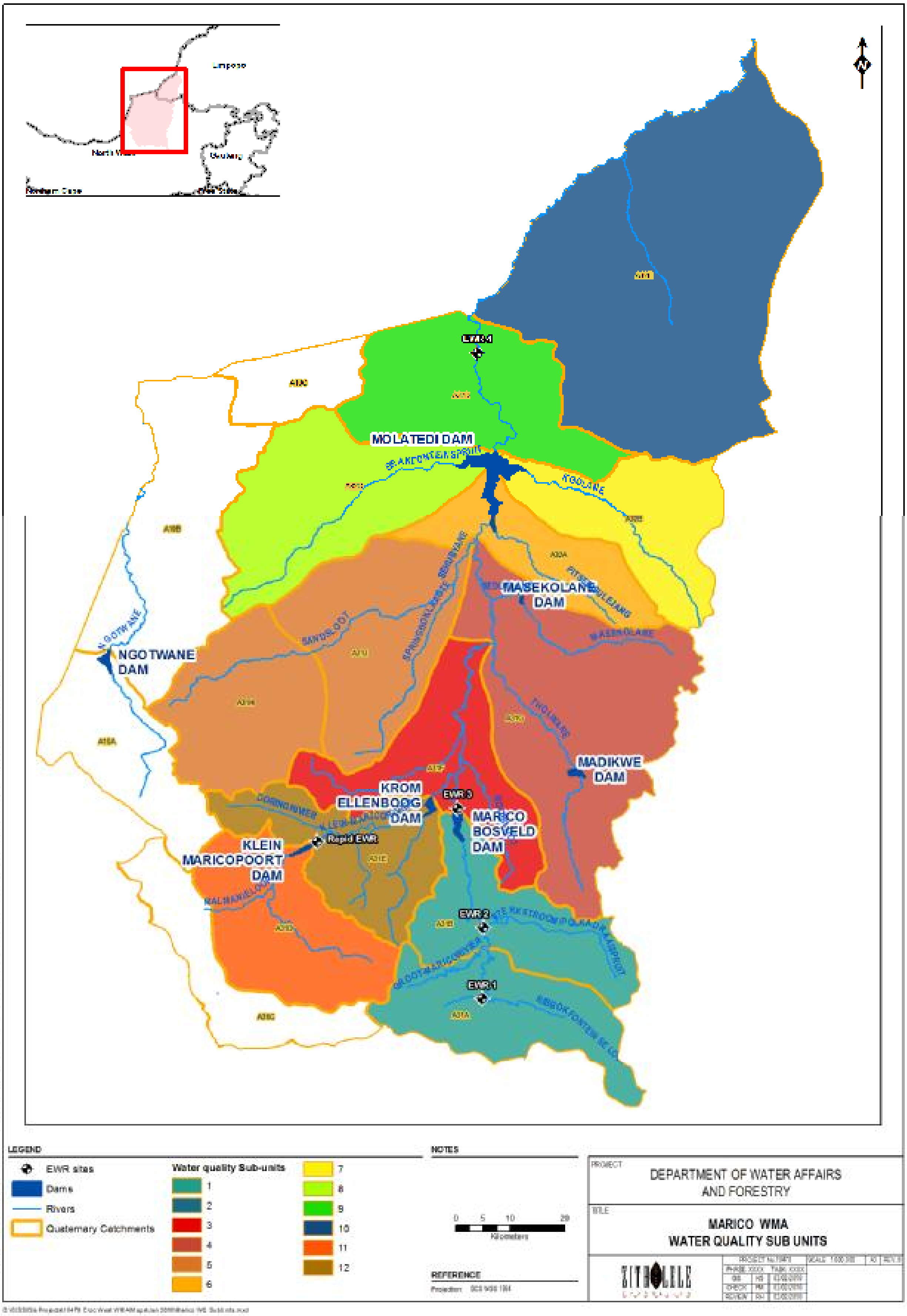

Figure 5: WQ Sub-units delineation of the Marico catchment (DWA, 2011)

The water quality of the Upper Marico River is relatively good with localised impacts from land based activities. The tributaries are impacted to some extent by slate mining activities and agricultural impacts. Turbidity and erosion are the main water quality issues. The Marico Bosveld dam impacts on the water quality in the river.

Water quality of the Klein Marico River catchment is good in the upper reaches. However the middle and lower reaches are of a fair water quality with urbanisation and the dams in the catchment impacting on water quality. Water quality has also deteriorated as a result of erosion and sedimentation. The Klein Marico River shows elevated concentrations of nutrients. There are impacts from agricultural activities in the catchment.

The water quality of the middle and lower Marico River is of fair to poor quality with certain areas being impacted by nutrients, erosion and salinisation. The impoundments impact on the water quality of the river as flows are largely managed on demand for irrigation purposes. There are also increased levels of toxicants in the middle reaches of the river. The Lower Marico River is deteriorating in terms of water quality. Nutrients are high because of the impacts of high agricultural return flows.

Table 21 provides a brief assessment of the water quality issues per WQSU.

Table 21: Water Quality Sub-Units (WQSU) and descriptive information on the water quality issues

Sub – catchment	WQ Subunit No.	Water Quality Subunit	Water quality consideration
Upper Marico	1	Groot Marico River	Headwaters are of fairly good water quality. Localised impacts from mining and agriculture.
	2	Marico Bosveld Dam	Water quality is fairly good. Constant releases are made for agricultural water use.
Lower Marico	3	Marico River below Marico Bospoort Dam	Agricultural run-off is a major impact on the water quality of the river – nutrients and sediments.
		Rooisloot	Water quality is acceptable
	4	Marico River	Intensive agricultural activity. Increased nutrients and salts.
		Thlowane	Water quality is acceptable
		Masekolane	Water quality is acceptable
	5	Sandsloot	Water quality is acceptable
	6	Pitsedisulejang	Water quality is acceptable
		Molatedi Dam	Water quality is impacted by agricultural activity. Releases are made for water requirements in Gaborone.

Sub – catchment	WQ Subunit No.	Water Quality Subunit	Water quality consideration
	7	Kgolane River	Water quality is acceptable
	8	Brakfonteinspruit	Water quality is acceptable
	9	Marico River	Nutrients are high due to agricultural impacts. Sedimentation and high turbidity are also a problem.
	10	Marico River	Nutrients are high due to agricultural impacts. Sedimentation and high turbidity are also a problem.
Klein Marico	11	Klein Marico River from origin to Klein Maricopoort Dam	Water quality is acceptable
		Klein Maricopoort Dam	Water quality is acceptable
	12	Klein Marico River between Klein Maricopoort and Kromellenboog Dams	Urban run-off impacts on water quality. Impacts are also related localized catchment activities. Nutrients are impacting on water quality.
		Kromellenboog Dam	Sedimentation in the dam is a problem.
		Lower Klein Marico River	Water quality is impacted by upstream activities. Nutrients are impacting on water quality.

Mokolo catchment

The current surface water quality of the Mokolo River is generally good upstream of the Mokolo Dam with all variables either acceptable or ideal. The exception is phosphate which is in the tolerable to unacceptable range. It is likely that this is from agriculture return flows in the area.

Groundwater quality in much of the Mokolo area is generally poor due to the coal and gas fields and cannot be used for domestic use, although surface water quality is generally good (DWAF, 2004).

Flows in the catchment are variable, with reductions in low and moderate flows, and unseasonal releases from Mokolo Dam having an impact on water quality.

The planned Mokolo pipeline that will originate in the Crocodile West WMA will potentially result in water quality changes in the Mokolo catchment.

Matlabas catchment

There is only one water quality monitoring point in the Matlabas catchment. It is located at Haarlem East, downstream of the confluence with the Mamba River. The water quality at this point in the catchment is still very good. The only current impacts in the catchment are from the Marakele National Park and the game farms along the river. Flows in the catchment are variable.

Appendix A sets out the monitoring points registered on WMS for the study catchments; many of which are no longer monitored regularly. Table 22shows the results of the water quality assessment at specific points in the catchments used for determining the present day fitness for use. In most cases, on average, the areas of concern are related to nutrients and increased alkalinity.

Table 22: Water quality assessment (5 year) of selected water quality variables at selected water quality monitoring points in the Crocodile (West), Marico, Mokolo and Matlabas catchments

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
A2H013Q01	Min	2	0.20	22	10	7.64	26.40	5	3	90	0.10	0.01	0.02	0.04
	Max	11	9.30	45	33	8.67	50.70	36	29	225	0.40	0.19	0.25	2.55
	Ave	7.19	1	36.84	26.06	8.22	41.45	7.98	13.33	186.19	0.18	0.03	0.05	1.03
	0.95	10	1.90	42	30	8.49	46.27	12	21.80	209	0.20	0.05	0.11	1.54
	0.9	9	1.60	41	29.60	8.40	45.24	12	20	205	0.20	0.04	0.09	1.41
	Med	7	0.80	37	26	8.22	41.60	8	13	189	0.20	0.02	0.04	1.05
	0.05	4	0.40	29.40	21	7.99	36.01	5	8	152.80	0.10	0.01	0.02	0.45
	n	204	205	205	205	205	204	205	205	205	205	204	204	205
88737	Min	nd	nd	nd	nd	7.30	34	33	36	nd	nd	0.05	0.05	0.50
	Max	nd	nd	nd	nd	8.70	66	69	73	nd	nd	1.90	3.70	9.30
	Ave	nd	nd	nd	nd	7.96	52.83	51.39	55.04	nd	nd	0.67	0.64	4.93
	0.95	nd	nd	nd	nd	8.40	61	63	63	nd	nd	1.68	1.78	7.10
	0.9	nd	nd	nd	nd	8.40	60	59	62	nd	nd	1.52	1.52	6.50
	Med	nd	nd	nd	nd	8	55	52.50	55	nd	nd	0.50	0.40	5
	0.05	nd	nd	nd	nd	7.43	36.50	38	46	nd	nd	0.05	0.05	2.83
	n	nd	nd	nd	nd	46	46	46	46	nd	nd	45	45	46
A2H006	Min	12.30	0.72	8.70	4.90	6.87	17.50	9	4.92	46.60	nd	0	0.02	0.02
	Max	102.20	15.19	50.80	34.90	9.41	88.60	87.60	84.30	259.10	nd	2.94	0.44	3.59
	Ave	39.07	6.21	30.08	17.86	8.22	48.86	41.27	31.97	149.06	nd	0.08	0.05	0.41
	0.95	53.96	8.44	36.40	21.90	8.54	58.58	59.36	43.44	189.06	nd	0.19	0.12	1.26
	0.9	50.70	8.04	34.83	21.10	8.43	55.32	54.27	40.20	177.20	nd	0.15	0.09	1.02
	Med	38.15	6.02	30.53	18.01	8.24	49.40	41.46	32.01	148.87	nd	0.06	0.03	0.27
	0.05	26.30	4.16	23.08	13.21	7.83	37.46	23.41	19.80	112.90	nd	0.01	0.02	0.02
	n	745	745	745	745	745	745	745	745	745	nd	745	744	745
A2H012	Min	2.80	0.35	10.70	5.40	5.41	16.10	3.20	2	19.50	nd	0	0.02	0.02
	Max	178.30	17.85	73.20	34.52	10	147	312.70	139	238.40	nd	2.95	4.74	18.09
	Ave	52.41	10.07	42.65	16.72	8.04	61.55	58.78	77.24	115.79	nd	0.56	0.16	6.82
	0.95	71.40	13.18	51.86	22.10	8.51	75.86	80.20	112.76	151.78	nd	1.47	0.65	11.57
	0.9	69.20	12.55	49.80	21.20	8.42	73.10	76.32	105.12	145.07	nd	1.16	0.35	10.60
	Med	52.70	10.26	43.20	16.70	8.15	62.20	57.30	76.60	117.20	nd	0.41	0.06	6.48
	0.05	29.94	6.55	31.21	11	7.33	43.62	34.36	45.53	73.52	nd	0.11	0.02	2.88
	n	1509	1509	1509	1509	1509	1509	1509	1509	1509	nd	1509	1509	1509
A2H014	Min	5.80	0.58	4.80	2.60	6.80	8	5	5.10	26.50	nd	0.01	0.02	0.02
	Max	387	28.47	135	35.40	9.18	287	771.40	139.20	219	nd	7.73	10.08	12.59
	Ave	52.25	9.44	44.36	19.64	8.14	64.24	58.98	56.17	156.38	nd	0.66	0.32	4.96
	0.95	75.63	12.85	54.11	25	8.44	77.51	102.32	90	194.60	nd	1.72	1.77	8.63
	0.9	64.98	11.93	52.40	24.45	8.37	73.20	80.19	79.87	188.90	nd	1.36	0.63	7.84

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
	Med	49.90	9.38	44.70	19.71	8.20	64.30	50.25	52.81	160.35	nd	0.49	0.05	4.66
	0.05	33.31	6.06	32.09	12.59	7.58	47.19	35.56	35.14	100.65	nd	0.16	0.02	1.85
	n	760	760	760	759	760	760	760	760		nd	760	760	760
A2H023	Min	21.57	6.43	26.70	6.17	6.82	34.20	26.76	27.58	65.42	nd	0.02	0	0.18
	Max	62.11	13.20	55.15	16.80	8.96	66.20	74.80	90.51	147.30	nd	3.89	3.65	13.35
	Ave	46.92	10.13	38.63	10.93	7.78	55.52	52.31	51.05	108.40	nd	0.56	0.42	5.34
	0.95	57.38	12.27	48.77	14.85	8.10	63	65.99	70.79	135.06	nd	1.94	1.39	8.84
	0.9	55.68	11.86	46.30	14.05	8.06	61.55	60.53	60.77	128.97	nd	1.37	1.15	7.77
	Med	49.06	10.29	37.82	10.64	7.86	56.55	53.21	49.76	107.42	nd	0.25	0.17	4.94
	0.05	32.32	7.70	31.21	8.04	7.08	45.95	39.51	38.79	82.88	nd	0.08	0.02	3.54
	n	116	116	116	116	116	116	116	116	116	nd	116	116	116
A2H030	Min	0.10	0.15	1.80	1	6.80	2.40	3	2	8.50	nd	0.01	0.02	0.02
	Max	179.10	16.54	84.55	59.03	9.13	140	75.85	247.68	531	nd	0.56	1.55	1.48
	Ave	107.42	7.23	46.57	29.90	8.35	85.35	29	129.18	294.75	nd	0.06	0.08	0.12
	0.95	148.17	12.26	66.40	40.11	8.66	109.52	56.44	210.10	391.55	nd	0.26	0.19	0.66
	0.9	140.88	11.31	61.82	37.94	8.56	103.48	49.68	201.48	370.48	nd	0.12	0.09	0.29
	Med	113.40	6.94	46.40	30.50	8.37	88.40	24.47	127.70	305.60	nd	0.03	0.02	0.04
	0.05	44.81	3.69	31.64	18.20	8.03	52.89	12.35	41.69	171.46	nd	0.01	0.02	0.02
	n	223	223	223	223	223	223	223	223	223	nd	223	222	223
A2H058	Min	0.10	0.30	10.40	5.60	7.10	12.40	3.50	6.10	30.70	nd	0	0.02	0.02
	Max	131.38	19.74	82.70	53.40	9.22	114	134.82	103.70	360.90	nd	7.75	7.69	4.82
	Ave	55.27	8.09	50.11	29.01	8.29	70.59	59.39	54.09	227.10	nd	1.38	0.33	0.71
	0.95	94.84	16.45	72.27	42.59	8.79	92.68	106.19	90.66	318.69	nd	4.26	2.44	2.52
	0.9	86.53	14.69	66.49	39.44	8.64	89.77	100.16	79.21	295.08	nd	3.62	0.30	1.94
	Med	54.56	6.66	49.77	28.63	8.30	72.75	57.60	54.20	226.18	nd	0.91	0.05	0.31
	0.05	19.44	2.20	27.06	15.85	7.73	37.35	15.88	24.61	131.57	nd	0.02	0.02	0.02
	n	304	304	304	304	304	304	304	304	304	nd	304	304	304
A2H059	Min	22.59	3.55	18.27	6.90	6.97	27.50	17.76	24.50	64.44	nd	0	0.02	0.02
	Max	134.20	12.34	79	58.70	8.90	864	242.20	165.80	288.10	nd	0.50	0.58	2.88
	Ave	70.59	6.97	45.79	29.61	8.20	77.91	89.31	90.44	175.18	nd	0.03	0.05	0.51
	0.95	105.41	8.99	59.37	40.80	8.50	109.20	135.16	134.74	225	nd	0.08	0.12	1.55
	0.9	96.81	8.49	56.92	38.30	8.43	93.27	123.41	124.60	213.22	nd	0.05	0.09	1.16
	Med	70.30	6.95	45.80	29.07	8.23	73.70	85.98	87.20	174.40	nd	0.02	0.05	0.40
	0.05	37.79	5.08	32.85	18.06	7.80	54.62	49.49	56.53	121.62	nd	0	0.02	0.02
	n	779	779	779	779	842	342	779	779	779	nd	837	840	842
A2H060	Min	3.80	0.15	9	3.50	6.50	9.60	12.80	10.70	16.40	nd	0	0.02	0.02
	Max	111.80	17.08	60.09	45.04	9.20	103.20	165	141.70	243.16	nd	3.84	1.02	9.85
	Ave	63.83	8.96	39.67	22.74	8.22	67.93	73.23	69.76	163.35	nd	0.15	0.07	0.40
	0.95	92.70	12.81	50.30	32.62	8.63	90.09	105.80	100.29	206.19	nd	0.41	0.18	1.13

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
	0.9	87.39	11.97	48.11	29.21	8.54	84.20	97.30	90.30	197.18	nd	0.31	0.13	0.89
	Med	64.73	8.69	40.28	22.90	8.29	68.70	73.50	69.82	169.55	nd	0.11	0.05	0.28
	0.05	32.32	5.78	25.80	11.80	7.50	42.12	36.81	38.87	97.67	nd	0.02	0.02	0.02
	n	922	922	922	922	922	922	922	922	922	nd	922	922	922
A2H083	Min	19.50	4.70	18.10	7.80	5.09	27.70	23.50	22.20	73.20	nd	0	0.02	0.02
	Max	66.20	23.05	50.20	28.19	9.50	73	75.90	135.20	156.18	nd	2.31	5.28	3.65
	Ave	43.09	8.71	33.86	16.17	8.21	53.28	48.68	60.92	118.69	nd	0.14	0.33	1.54
	0.95	56.16	11.29	42.67	19.80	8.75	63.96	60.54	84.94	143.59	nd	0.35	1.26	2.89
	0.9	53.78	10.63	40.71	19.20	8.62	59.92	57.29	77.82	136.91	nd	0.25	0.83	2.56
	Med	42.32	8.81	33.60	15.90	8.25	52.90	48.42	58.40	119.05	nd	0.08	0.16	1.47
	0.05	31.64	6.06	24.86	12.90	7.42	45.69	37.98	42.77	94.99	nd	0.02	0.02	0.36
	n	530	530		530	530	530	529	529	530	nd	530	530	530
A2H094	Min	16	3.70	25	12	7.32	30.50	23	37	66	0.10	0.02	0.02	0.02
	Max	94	16.90	70	41	9.28	111.90	179	122	206	0.40	0.50	0.61	5.20
	Ave	45.21	7.44	47.43	25.22	8.42	66.72	78.44	79.35	137.44	0.20	0.20	0.06	0.67
	0.95	79	13.31	66.90	39.90	9.08	95.28	126.70	102.70	177.70	0.30	0.44	0.25	1.93
	0.9	64.20	10.04	60.80	37.60	8.92	84.90	117.40	98.60	173.60	0.30	0.36	0.13	1.64
	Med	44	6.70	46	24	8.49	64.60	76	79	139	0.20	0.20	0.02	0.26
	0.05	24.30	4.42	31.20	16	7.61	43.17	32.50	53	94.20	0.10	0.02	0.02	0.02
	n	63	63	63	63	63	63	63	63	63	63	62	62	63
A2H106	Min	18	4.50	19	8	7.43	29.10	21	17	81	0.40	0.03	0.02	0.02
	Max	102	15.90	48	24	9	82.60	87	80	231	0.70	1.94	1.01	1.30
	Ave	63.72	11.43	36.47	18.07	8.41	63.76	60.18	50.50	177.94	0.50	0.65	0.17	0.16
	0.95	91	14.94	44	21.35	8.92	79.17	82	68.35	223.35	0.60	1.47	0.67	0.82
	0.9	87.40	14.50	42.70	21	8.82	76.97	79	66.40	214.40	0.60	1.21	0.53	0.28
	Med	62.50	11.35	37	18.50	8.45	65.60	61	50	182	0.50	0.53	0.07	0.06
	0.05	33.65	7.87	27.30	13	7.85	44.02	34.65	33	116	0.40	0.17	0.02	0.02
	n	154	154	154	154	154	154	154	154	154	154	154	154	154
A2H116	Min	12.50	4.71	11.50	4.10	7.23	18.20	9.60	18.20	48.80	nd	0.01	0.02	0.02
	Max	112.06	15.76	70.10	49.15	9.06	111.30	152.50	168.10	254.60	nd	0.78	0.26	1.63
	Ave	68.46	8.92	42.58	25.40	8.33	72.89	81.23	74.90	177.14	nd	0.09	0.05	0.30
	0.95	95.76	12.51	55.13	35.86	8.73	92.70	115.13	105.78	215.51	nd	0.23	0.14	1.24
	0.9	89.63	11.86	53.02	33.41	8.62	87.01	106.90	95.50	207.91	nd	0.18	0.11	0.84
	Med	69.67	8.69	42.66	25.31	8.33	74.05	81.50	73.13	179.55	nd	0.06	0.04	0.09
	0.05	40.09	5.96	29.88	15.14	7.97	50.64	46.31	46.54	126.11	nd	0.02	0.02	0.02
	n	430	430	430	430	430	430	429	430	430	nd	429	428	430
A2H127	Min	6.25	1.05	11.89	20.20	7.04	8.29	8.36	9.01	59.47	nd	0.01	0.02	0.04
	Max	43.20	8.92	45.88	64.10	8.54	39.69	45.12	72.91	240.19	nd	1.62	6.95	8.75
	Ave	16.82	4.04	34.14	46.84	8.05	26.14	21.73	26.78	167.84	nd	0.16	0.37	2.49

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
	0.95	25.67	6.89	41.32	57.80	8.47	35.57	30.21	37.69	219.27	nd	0.51	1.80	4.51
	0.9	20.76	6.11	39.20	55.70	8.38	33.74	27.45	34.47	205.01	nd	0.39	0.64	3.96
	Med	16.41	3.76	35.33	47.30	8.12	26.77	21.67	26.04	171.53	nd	0.08	0.09	2.32
	0.05	10.13	2.23	24.65	32.82	7.34	14.58	14.14	17.65	105.67	nd	0.03	0.02	0.53
	n	117	117	117	117	117	117	117	117	117	nd	117	117	117
A2R001	Min	29.87	6.65	16.22	10.65	6.98	43	38.05	30.99	74.11	nd	0.01	0.02	0.02
	Max	62.15	13.26	45.92	19.29	9.71	74.30	71.17	86.86	224.77	nd	3.40	20.12	6.14
	Ave	45.02	9	31.58	14.59	8.37	52.60	52.89	48.87	118.94	nd	0.16	0.32	1.06
	0.95	53.12	10.22	41	16.93	9.28	58.70	63.07	58.70	142.13	nd	0.39	1.11	2.20
	0.9	51.26	9.99	39.60	16.27	9.08	57.20	61.43	55.86	135.07	nd	0.33	0.60	2.02
	Med	45.25	8.99	32.12	14.56	8.26	53	52.49	48.22	120.73	nd	0.09	0.10	1.10
	0.05	36.53	7.73	20.56	12.37	7.67	46.50	43.76	40.26	90.96	nd	0.02	0.02	0.04
	n	1016	1016	1016	1016	1016	1016	1016	1015	1016	nd	1015	1016	1016
A2R009	Min	17.07	2.86	14.49	10.07	6.57	29.20	19.78	2	67.28	nd	0.01	0.02	0.02
	Max	53.03	13.86	39.43	19.56	9.93	61.70	60.79	111.98	192.64	nd	2.34	3.95	12.45
	Ave	36.21	7.70	26.76	14.87	8.33	46.08	41.68	34.34	119.62	nd	0.14	0.40	0.61
	0.95	47.43	9.80	34.10	17.57	9.55	53.23	51.93	45.16	144.84	nd	0.28	1.33	1.49
	0.9	45	9.40	32.57	17.01	9.28	51.20	50.49	41.88	138.42	nd	0.22	0.99	1.40
	Med	36.83	7.84	26.70	14.93	8.17	47	42.66	34.03	118.78	nd	0.13	0.24	0.51
	0.05	22.47	5.14	19.25	12.27	7.58	37.48	26.10	24.43	97.95	nd	0.04	0.02	0.02
	n	996	996	996	996	998	996	996	996	996	nd	995	995	996
A2R009	Min	19	3.20	13	11	7.38	36.30	24	21	91	0.20	0.01	0.02	0.02
	Max	54	10.20	36	19	9.72	55.90	58	68	147	0.40	0.22	1.12	1.78
	Ave	37.23	7.83	26	15	8.51	46.21	42.95	34.44	118.94	0.30	0.11	0.22	0.57
	0.95	48	9.84	33	17	9.52	52.48	52	43.40	140	0.30	0.20	0.76	1.40
	0.9	45	9.48	32	17	9.34	50.80	51	41	136	0.30	0.19	0.58	1.34
	Med	38	7.90	27	15	8.42	47	44	34	119	0.30	0.11	0.09	0.50
	0.05	27	5.86	18	13	7.74	39.24	33	26	100	0.26	0.03	0.02	0.02
	n	133	133	133	133	133	133	133	133	133	133	133	133	133
A3R001	Min	3	0.80	12	10	7.78	18.20	2	2	85	0.20	0.01	0.02	0.02
	Max	8	1.80	33	24	8.68	38.10	8	23	179	0.30	0.10	0.15	0.31
	Ave	5.78	1.22	25	18	8.28	29.99	5.16	7.99	140	0.23	0.02	0.04	0.07
	95%	8	1.60	31	22	8.56	37.38	7	14.20	168	0.30	0.06	0.11	0.20
	90%	7	1.50	29	22	8.48	36.72	7	12	164	0.30	0.04	0.08	0.12
	Med	6	1.30	26	19	8.28	30.70	5	7	145	0.20	0.02	0.02	0.06
	5%	4	0.80	17.40	13	7.99	20.34	2	3	95.60	0.20	0.01	0.02	0.03
	n	69	69	69	69	69	69	69	69	69	69	69	69	69
188039	Min	5.47	nd	19.77	13	8.06	24	2.50	2	101.05	0.15	0.01	0.02	0.04
	Max	6.54	nd	25.89	19.82	8.38	30.80	6.74	7.44	144.49	0.26	0.50	0.12	0.12

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
	Ave	6.09	nd	23.65	17.38	8.19	28.57	5.28	4.83	131.50	0.22	0.08	0.05	0.05
	95%	6.45	nd	25.71	19.51	8.36	30.64	6.49	7.44	143.72	0.25	0.33	0.11	0.09
	90%	6.36	nd	25.53	19.20	8.34	30.48	6.23	7.44	142.96	0.25	0.16	0.11	0.07
	Med	6.06	nd	24.09	17.77	8.19	29.20	5.48	6.06	130.85	0.23	0.02	0.02	0.04
	5%	5.65	nd	20.38	14.35	8.06	25.04	3.48	2	111.45	0.17	0.01	0.02	0.04
	n	9	nd	9	9	9		9	9	9	9	9	9	9
188041	Min	2.12	0.15	28.20	16	8.09	27.70	2	2	134.84	0.10	0.01	0.02	0.04
	Max	3.49	0.55	29.48	17.82	8.50	32.10	4.72	4.66	144.90	0.14	0.04	0.18	0.22
	Ave	2.59	0.32	28.83	17.03	8.30	28.80	2.41	2.80	139.78	0.11	0.02	0.06	0.13
	95%	3.34	0.51	29.47	17.82	8.45	31.06	3.83	4.61	144.69	0.13	0.04	0.15	0.20
	90%	3.20	0.46	29.46	17.82	8.40	30.02	2.94	4.55	144.48	0.12	0.03	0.12	0.19
	Med	2.30	0.36	28.70	16.96	8.30	28.60	2	2	138.10	0.11	0.02	0.02	0.13
	5%	2.15	0.15	28.29	16.23	8.15	27.70	2	2	135.82	0.10	0.01	0.02	0.06
	n	9	9	8	9	9	9	9	9	9	9	9	9	9
100000763	Min	70	nd	nd	nd	7.10	27	65	42	194	nd	0.70	0.05	0.80
	Max	70	nd	nd	nd	8.30	90	75	133	198	nd	7.80	17.90	5.40
	Ave	70	nd	nd	nd	7.79	68.18	70	65.55	196	nd	2.82	4.35	2.96
	95%	70	nd	nd	nd	8.12	82.30	74.50	95.40	197.80	nd	5.61	12.89	4.38
	90%	70	nd	nd	nd	8.10	78.30	74	80.60	197.60	nd	4.28	9.01	4.02
	Med	70	nd	nd	nd	7.80	69	70	62	196	nd	2.70	3.35	2.80
	5%	70	nd	nd	nd	7.39	52.55	65.50	47.55	194.20	nd	0.97	0.26	1.17
	n	1	nd	nd	nd	38	38	2	38	2	nd	38	38	35
188041	Min	2.12	0.15	28.20	16	8.09	27.70	2	2	134.84	0.10	0.01	0.02	0.04
	Max	3.49	0.55	29.48	17.82	8.50	32.10	4.72	4.66	144.90	0.14	0.04	0.18	0.22
	Ave	2.59	0.32	28.83	17.03	8.30	28.80	2.41	2.80	139.78	0.11	0.02	0.06	0.13
	95%	3.34	0.51	29.47	17.82	8.45	31.06	3.83	4.61	144.69	0.13	0.04	0.15	0.20
	90%	3.20	0.46	29.46	17.82	8.40	30.02	2.94	4.55	144.48	0.12	0.03	0.12	0.19
	Med	2.30	0.36	28.70	16.96	8.30	28.60	2	2	138.10	0.11	0.02	0.02	0.13
	5%	2.15	0.15	28.29	16.23	8.15	27.70	2	2	135.82	0.10	0.01	0.02	0.06
	n	9	9	8	9	9	9	9	9	9	9	9	9	9
188034	Min	1	0.20	29	16	8.06	27.90	2	2	136	0.10	0.01	0.02	0.14
	Max	4	0.70	33	18	8.53	29.90	5	5	150	0.20	0.31	0.12	0.24
	Ave	2.38	0.35	30.25	17.13	8.24	29.11	2.88	2.63	142.13	0.13	0.05	0.04	0.20
	95%	3.65	0.63	32.30	18	8.48	29.87	4.65	4.30	149.65	0.20	0.21	0.09	0.24
	90%	3.30	0.56	31.60	18	8.43	29.83	4.30	3.60	149.30	0.20	0.11	0.06	0.24
	Med	2	0.30	30	17	8.23	29.30	2.50	2	142	0.10	0.02	0.02	0.20
	5%	1.35	0.20	29	16.35	8.07	28.04	2	2	136.35	0.10	0.01	0.02	0.14
	n	8	8	8	8	8	8	8	8	8	8	8	8	8

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
188035	Min	3	0.40	21	14	8.02	23.70	2	2	101	0.10	0.01	0.02	0.04
	Max	4	0.70	34	20	8.42	35.50	5	9	154	0.20	0.06	0.13	0.18
	Ave	3.25	0.53	28.88	17.88	8.19	29.95	3.63	4.38	142.13	0.13	0.02	0.05	0.11
	95%	4	0.67	32.95	19.65	8.38	34.10	5	7.95	153.65	0.20	0.05	0.13	0.16
	90%	4	0.63	31.90	19.30	8.34	32.70	5	6.90	153.30	0.20	0.04	0.12	0.15
	Med	3	0.50	29.50	18	8.20	30.70	3.50	4	148	0.10	0.02	0.02	0.11
	5%	3	0.40	23.45	15.05	8.02	24.86	2	2	113.95	0.10	0.01	0.02	0.05
	n	8	8	8	8	8	8	8	8	8	8	8	8	8
188252	Min	4	0.50	8	7	7.63	12.30	2	2	54	0.10	0.02	0.02	0.04
	Max	5	1.40	10	9	7.97	16	5	7	67	0.20	0.14	0.07	0.44
	Ave	4.67	0.93	9	8.17	7.85	14.35	4	3.67	60.33	0.15	0.05	0.04	0.12
	95%	5	1.38	10	9	7.96	15.80	5	7	66.25	0.20	0.13	0.07	0.36
	90%	5	1.35	10	9	7.94	15.60	5	7	65.50	0.20	0.12	0.07	0.28
	Med	5	0.85	9	8	7.88	14.50	5	2	61	0.15	0.03	0.02	0.04
	5%	4	0.55	8	7.25	7.69	12.63	2	2	54.25	0.10	0.02	0.02	0.04
	n	6	6	6	6	6	6	6	6	6	6	6	6	6
188258	Min	3	0.80	29	18	7.81	31.10	2	6	142	0.20	0.02	0.02	0.11
	Max	4	1.10	33	20	8.35	33.60	5	8	165	0.20	0.02	0.15	0.36
	Ave	3.20	0.96	31.40	18.60	8.08	32.60	4	6.60	150.40	0.20	0.02	0.08	0.18
	95%	3.80	1.10	33	19.80	8.34	33.54	5	7.80	162.20	0.20	0.02	0.14	0.33
	90%	3.60	1.10	33	19.60	8.32	33.48	5	7.60	159.40	0.20	0.02	0.13	0.29
	Med	3	0.90	31	18	8.07	33	4	6	148	0.20	0.02	0.09	0.12
	5%	3	0.82	29.40	18	7.82	31.28	2.40	6	142.80	0.20	0.02	0.02	0.11
	n	5	5	5	5	5	5	5	5	5	5	5	5	5
A3R001	Min	3	0.80	12	10	7.78	18.20	2	2	85	0.20	0.01	0.02	0.02
	Max	8	1.80	33	24	8.68	38.10	8	23	179	0.30	0.10	0.15	0.31
	Ave	5.78	1.22	25.12	18.32	8.28	29.99	5.16	7.99	139.78	0.23	0.02	0.04	0.07
	95%	8	1.60	31	22.60	8.56	37.38	7	14.20	168	0.30	0.06	0.11	0.20
	90%	7	1.50	29	22	8.48	36.72	7	12	164	0.30	0.04	0.08	0.12
	Med	6	1.30	26	19	8.28	30.70	5	7	145	0.20	0.02	0.02	0.06
	5%	4	0.80	17.40	13	7.99	20.34	2	3	95.60	0.20	0.01	0.02	0.03
	n	69	69	69	69	69	69	69	69	69	69	69	69	69
A3H028	Min	3	0.80	13	9	7.35	16.70	2	2	72	0.10	0.01	0.02	0.02
	Max	9	2.60	32	25	8.55	38.30	9	17	176	0.50	0.33	0.16	0.70
	Ave	5.84	1.33	25.91	18.67	8.17	30.17	5.50	8.22	143.02	0.24	0.03	0.05	0.08
	95%	8	1.70	31	23	8.44	37.30	8	14	171.60	0.30	0.06	0.12	0.19
	90%	7	1.60	30	22	8.38	36.02	7	12	166.60	0.30	0.05	0.10	0.17

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
	Med	6	1.30	27	19	8.19	30.80	5	8	148	0.20	0.02	0.05	0.06
	5%	4	0.90	18	12	7.80	20.45	3	4	100.10	0.20	0.01	0.02	0.04
	n	116	115	115	115	140	139	116	116	115	116	140	140	139
A3H029	Min	6	2.50	10	5	7.94	12.30	4	9	43	0.30	0.02	0.02	0.02
	Max	10	3.10	36	26	8.62	38.50	7	14	194	0.60	0.04	0.10	0.74
	Ave	7.83	2.78	26.17	19	8.29	29.68	5.17	11	144.50	0.38	0.02	0.04	0.16
	95%	10	3.08	35.75	26	8.60	38.35	6.75	13.25	192.75	0.55	0.03	0.09	0.58
	90%	10	3.05	35.50	26	8.58	38.20	6.50	12.50	191.50	0.50	0.03	0.07	0.42
	Med	7.50	2.75	25.50	19.50	8.32	30.30	5	11	148	0.35	0.02	0.02	0.06
	5%	6	2.53	13.75	8.25	7.96	16.43	4	9.25	68.50	0.30	0.02	0.02	0.02
	n	6	6	6	6	6	6	6	6	6	6	6	6	6
188039	Min	5.47	0.90	19.77	13	8.06	24	2.50	2	101.05	0.15	0.01	0.02	0.04
	Max	6.54	1.49	25.89	19.82	8.38	30.80	6.74	7.44	144.49	0.26	0.50	0.12	0.12
	Ave	6.09	1.15	23.65	17.38	8.19	28.57	5.28	4.83	131.50	0.22	0.08	0.05	0.05
	95%	6.45	1.44	25.71	19.51	8.36	30.64	6.49	7.44	143.72	0.25	0.33	0.11	0.09
	90%	6.36	1.39	25.53	19.20	8.34	30.48	6.23	7.44	142.96	0.25	0.16	0.11	0.07
	Med	6.06	1.06	24.09	17.77	8.19	29.20	5.48	6.06	130.85	0.23	0.02	0.02	0.04
	5%	5.65	0.91	20.38	14.35	8.06	25.04	3.48	2	111.45	0.17	0.01	0.02	0.04
	n	9	9	9	9	9	9	9	9	9	9	9	9	9
A3H040	Min	5	3	12	8	7.26	20.20	5	8	75	0.20	0.01	0.02	0.02
	Max	19	10	53	66	8.70	66.60	17	44	348	1.20	0.50	0.15	0.36
	Ave	10.18	5.67	29.17	25.01	8.29	39.03	8.09	18.32	171.46	0.39	0.03	0.04	0.05
	95%	17	9.31	40.10	38	8.52	54.20	14	26	247	0.60	0.05	0.10	0.10
	90%	14	8.10	37	36.10	8.48	52.70	13	24	229	0.50	0.03	0.08	0.08
	Med	10	5.60	28	23	8.31	37.40	7.50	18	162	0.40	0.02	0.02	0.04
	5%	6	3.90	20	17	8.03	28.50	5	12	122	0.20	0.01	0.02	0.02
	n	180	180	180	180	181	181	180	181	181	181	181	181	180
188072	Min	4	0.60	4	3	7.22	7.20	5	2	23	0.10	0.02	0.02	0.04
	Max	5	1.20	6	5	7.91	9.70	7	7	36	0.30	0.03	0.45	0.11
	Ave	4.25	0.95	4.75	3.75	7.63	8.58	5.75	4.25	28.50	0.20	0.02	0.13	0.08
	95%	4.85	1.19	5.85	4.85	7.88	9.70	6.85	6.85	35.10	0.29	0.03	0.39	0.11
	90%	4.70	1.17	5.70	4.70	7.85	9.70	6.70	6.70	34.20	0.27	0.03	0.32	0.10
	Med	4	1	4.50	3.50	7.70	8.70	5.50	4	27.50	0.20	0.02	0.02	0.09
	5%	4	0.65	4	3	7.29	7.28	5	2	23.30	0.12	0.02	0.02	0.05
	n	4	4	4	4	4	4	4	4	4	4	4	4	4
A2H107	Min	3	0.80	4	3	6.78	7.50	3	2	19	0.10	0.01	0.02	0.02
	Max	10	3.60	14	8	8.22	18.60	9	17	83	0.30	0.12	0.31	0.39

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
	Ave	4.72	1.56	6.68	4.71	7.68	10.51	5.51	6.52	35.58	0.14	0.02	0.05	0.09
	95%	7	2.88	10	6.40	8.05	14.53	7.50	11.50	52.45	0.20	0.05	0.10	0.22
	90%	6	2.30	9	6	7.99	13.37	7	10	49	0.20	0.04	0.09	0.18
	Med	5	1.40	6	5	7.68	9.90	5	7	34	0.10	0.02	0.04	0.06
	5%	3	0.90	4	3	7.18	7.96	3	2	22	0.10	0.01	0.02	0.02
	n	93	93	92	93	93	92	91	91	92	93	93	93	92
A2R013	Min	3	0.80	4	2	7.18	7.50	2	2	22	0.10	0.01	0.02	0.02
	Max	7	4.30	10	7	8.13	15.70	10	15	58	0.20	0.08	0.33	0.63
	Ave	5.02	1.57	6.69	4.77	7.72	10.92	5.47	6.27	37.03	0.15	0.02	0.06	0.09
	95%	7	2.30	9	6	7.98	14.69	8	10.95	49.95	0.20	0.05	0.25	0.25
	90%	6	2.09	9	6	7.97	13.65	7	9	48	0.20	0.04	0.10	0.21
	Med	5	1.45	7	5	7.74	10.45	5	6.50	37	0.10	0.02	0.02	0.06
	5%	4	0.90	5	3.05	7.42	7.90	2	2	24.05	0.10	0.01	0.02	0.02
	n	62	62	62	62	62	62	62	62	62	62	62	62	61
A2H036	Min	3	0.50	4	3	6.71	7.90	2	2	20	0.10	0.01	0.02	0.02
	Max	9	4.40	19	11	8.09	23.60	10	20	87	0.30	0.09	0.13	0.29
	Ave	5.06	1.13	9.15	5.31	7.71	12.30	6.51	5.33	44.33	0.12	0.02	0.04	0.06
	95%	7	1.80	12	7.20	7.98	16.58	9	12.25	62	0.20	0.03	0.08	0.11
	90%	7	1.60	11	7	7.95	15.30	8	10.50	56	0.20	0.03	0.07	0.10
	Med	5	1	9	5	7.75	12	7	4	44	0.10	0.02	0.02	0.06
	5%	3	0.68	6	3	7.36	8.63	5	2	27.80	0.10	0.01	0.02	0.04
	n	97	97	96	97	97	96	96	96	97	97	97	97	97
A3H031	Min	5	1.10	29	13	7.54	31.40	9	12	127	0.20	0	0.02	0.02
	Max	39	7.80	68	80	8.69	90	62	205	234	0.60	0.19	1.51	0.96
	Ave	21.01	4.40	48.87	47.11	8.18	68.45	32.06	121.31	190.67	0.47	0.03	0.33	0.25
	95%	35	6	62	63.20	8.44	83.41	52.20	178	224.60	0.52	0.08	0.72	0.66
	90%	32.40	5.70	59	60	8.38	80.52	50	168	215	0.50	0.05	0.55	0.45
	Med	22	4.40	49	51	8.19	73.70	33	140	194	0.50	0.03	0.33	0.22
	5%	8	3.10	34.80	17.80	7.91	35.60	10.80	20.80	141	0.40	0.01	0.02	0.02
	n	157	157	157	157	180	180	157	157	157	157	180	180	180
A4H002	Min	2.10	0.06	2.80	0.80	6.40	5.50	5	0.40	nd	0.03	0.01	0.02	0.01
	Max	16.40	3.80	9.70	6.50	8.70	18	18	19	nd	0.50	4.80	0.17	0.50
	Ave	5.80	1.40	5.70	2.80	7.50	9	6.30	5.20	nd	0.15	0.06	0.03	0.14
	95%	8.40	2.70	8.50	4	7.80	11	10	10.50	nd	0.20	0.04	0.08	0.30
	90%	7.60	2.30	7.30	3.60	7.80	11	9	10	nd	0.18	0.03	0.05	0.30
	Med	5.60	1.10	5.30	2.80	7.60	8.70	5	5	nd	0.15	0.02	0.02	0.11
	5%	3.80	0.70	4	1.90	7.10	7.20	5	1.50	nd	0.07	0.01	0.02	0.02

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
	n	103	103	104	104	115	114	102	103	nd	93	113	113	112
A4H008	Min	0.20	0.15	0.50	0.50	5.10	2.20	1.60	0.40	nd	0.03	0.01	0.02	0.01
	Max	22	2.60	15	8	8.10	27	35	13	nd	0.50	0.09	0.20	3.40
	Ave	3.10	0.70	3	1.10	7.20	5	5	3.40	nd	0.10	0.02	0.03	0.09
	95%	6.60	1.70	8.20	2.30	7.80	9	7	8	nd	0.20	0.04	0.08	0.20
	90%	4.90	1.50	6	1.80	7.60	7	6	7	nd	0.20	0.03	0.06	0.09
	Med	2.60	0.50	2.20	0.80	7.20	4	5	2	nd	0.10	0.01	0.02	0.04
	5%	0.90	0.15	1.10	0.50	6.50	2.50	2.50	1.50	nd	0.05	0.01	0.02	0.01
	n	122	123	123	123	133	132	123	123	nd	109	131	131	131
A4R001	Min	0.20	0.90	2	0.80	6.30	5.40	4	1	nd	0.03	0.01	0.02	0.01
	Max	10	3	6	3	8.30	11	12	13	nd	0.30	0.40	0.30	0.40
	Ave	5	1.50	4	2	7.50	7.20	6	4	nd	0.12	0.03	0.04	0.06
	95%	8	3	5	2.60	7.80	9	8	10	nd	0.28	0.08	0.10	0.20
	90%	7	2.50	5.20	2.50	7.70	8.40	7	8	nd	0.17	0.03	0.09	0.13
	Med	5	1	4	2.10	7.50	7	5	2	nd	0.12	0.01	0.03	0.03
	5%	2	0.90	2.30	0.80	7.10	6	4.50	1.50	nd	0.03	0.01	0.02	0.02
	n	56	57	56	56	58	58	57	57	nd	56	58	58	56
A4H010	Min	2.70	0.90	2.20	0.50	5.90	5	3.70	1.50	nd	0.05	0	0.02	0.02
	Max	10	9	20	4.60	8.60	18	18	13	nd	0.50	0.17	0.29	1.03
	Ave	5.20	1.70	5.10	2.40	7.10	8	6.70	4.70	nd	0.14	0.02	0.04	0.12
	95%	7.90	2.70	12	3.60	7.90	14	11	9	nd	0.30	0.06	0.09	0.45
	90%	7.20	2.60	8	3.10	7.75	11	10	8	nd	0.25	0.02	0.08	0.27
	Med	5.10	1.60	4.40	2.30	7.20	7.30	6.20	4.50	nd	0.13	0.01	0.02	0.06
	5%	3	0.90	2.60	1.50	6.34	5.60	4.10	2	nd	0.05	0	0.02	0.02
	n	91	91	90	90	91	91	90	90	nd	89	90	90	89
A4H007	Min	4.40	0.50	1.30	0.50	5.50	5.50	10	1.50	nd	0.03	0.01	0.02	0.02
	Max	8	2	5.30	1.70	7.70	9	18	10	nd	0.50	0.14	0.23	0.11
	Ave	6.50	0.80	2.40	1.30	6.70	7	13	3.70	nd	0.13	0.02	0.05	0.03
	95%	8	1.50	4.40	1.70	7.60	9	17	9	nd	0.24	0.05	0.19	0.05
	90%	7.60	1.40	3.80	1.60	7.50	9	15	7	nd	0.22	0.04	0.09	0.04
	Med	6.80	0.60	2	1.40	6.90	6.40	12	2	nd	0.11	0.01	0.02	0.02
	5%	4.80	0.50	1.40	0.50	6.50	5.40	11	1.50	nd	0.05	0.01	0.02	0.02
	n	22	22	21	22	22	22	22	22	nd	22	22	22	22
A4H013	Min	4	0.40	2.20	0.80	7.10	6	4.40	1.50	nd	0.03	0.01	0.02	0.02
	Max	18	5	20	12	8.20	27	23	12	nd	0.40	0.11	0.62	0.51
	Ave	6.70	1.30	4.60	2.60	7.50	9	9	4.70	nd	0.15	0.02	0.04	0.06
	95%	8.70	2.70	6.20	3.40	7.90	12	13	8.70	nd	0.30	0.07	0.09	0.36

Monitoring Point ID		Sodium	Potassium	Calcium	Magnesium	pH	Electrical Conductivity	Chloride	Sulphate	Total alkalinity	Fluoride	Phosphate	Ammonia	Nitrate
	Units	mg/l	mg/l	mg/l	mg/l		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	RWQO (Acceptable range)	92.5	50	80	100	6.5-8.0	50	120	165	97.5	1	0.015	0.044	10
	90%	8	2.60	5.40	3	7.70	10	13	8.30	nd	0.20	0.04	0.07	0.10
	Med	6.50	1.03	4.30	2.40	7.50	8.40	10	4.50	nd	0.14	0.02	0.02	0.02
	5%	4.20	0.40	3	1.70	7.20	6.70	5	1.50	nd	0.10	0.01	0.02	0.02
	n	54	54	54	54	56	56	54	54	nd	54	56	56	56
A4H004	Min	0.22	0.33	1.40	0.80	6.30	3	2	nd	nd	0.03	0.01	0.02	0.02
	Max	38	2.50	11	5.70	8.10	29	36	nd	nd	0.40	0.18	0.15	1.40
	Ave	7.20	1.20	4	2.10	7.40	8	8	nd	nd	0.15	0.02	0.04	0.08
	95%	20	2.30	7	4.60	7.90	16	17	nd	nd	0.30	0.04	0.13	0.09
	90%	17	2	6.70	4.10	7.80	15	16	nd	nd	0.27	0.03	0.09	0.06
	Med	3.50	1	4	1.80	7.30	6	5.50	nd	nd	0.13	0.01	0.03	0.03
	5%	1.10	0.40	1.80	0.80	6.90	3.20	2.70	nd	nd	0.03	0.01	0.02	0.02
	n	29	29	44	29	29	28	29	nd	nd	24	29	29	28

Nd: no data available

4.2.4.4 Water quality implications

The assessment of the water quality implications on water users, which requires simulating the TDS concentrations at the outflows of the IUAs, will be addressed in the next steps of the WRCS procedure during the evaluation of the catchment configuration scenarios.

5 CONCLUSIONS

Several Reserve studies at Intermediate and Rapid III level of detail were undertaken for the Crocodile (West), Marico, Mokolo and Matlabas catchments. These studies focused on the main stem of the rivers and on major tributaries. For the purposes of the classification of the significant water resources of the Crocodile (West), Marico, Mokolo and Matlabas catchments, further detailed information was required. Additional Rapid Reserve studies were therefore undertaken on some of the smaller tributaries to provide the necessary information at a higher level of confidence.

A total of 62 hydro nodes were selected through a process of consultation with a number of role players and specialists. These hydro nodes were selected on the basis of management of the system including groundwater and wetland aspects, outlet of IUAs, biophysical considerations or where specific water quality impacts are present. The updated PES, EI and ES information available on a sub-quaternary catchment level was used to provide the present state per hydro node, or where EWR data was available, that was used.

Summary and rule tables have been developed for all the hydro nodes to be used during steps 4 and 5 of the WRCS.

The assessment of the ecosystem changes for the relevant EGSAs indicates that the RDM aspects considered do not have a significant effect in terms of the socio-economic consequences.

The ecological information currently available for the classification of the significant water resources of the Crocodile (West), Marico, Mokolo and Matlabas catchments is adequate to provide medium to high confidence input during the determination of the management class.

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APPENDIX A

MONITORING POINTS IN THE STUDY AREA

Surface water quality monitoring points in the Crocodile (West), Marico, Mokolo and Matlabas catchments

Station ID	Drainage Region Name	IUA Location	Monitoring Point Name	Location	Latitude	Longitude	*N*(number of samples)	First Sample Date	Last Sample Date
A4H004Q01	A41B	17a	A4H004Q01 MATLABAS RIVER AT HAARLEM EAST	MATLABAS	-24.159444	27.479722	263	28/09/1971	15/11/2011
A4H002Q01	A42C	15	A4H002Q01 MOKOLO RIVER AT ZANDRIVIER/VAALWATER	MOKOLO	-24.282222	28.090278	583	06/12/1977	07/12/2011
190211	A42C	15	VAALWATER 137 KR D/S VAALWATER PONDS 0.5 KM TO SEDERBERG REST CAMP ON MOKOLO	MOKOLO	-24.28756306	28.09559	45	22/03/2005	01/03/2011
A4H008Q01	A42D	15	A4H008Q01 STERKSTROOM RIVER AT DOORNSPRUIT	STERKSTROOM A42D TO A42D	-24.215833	27.973611	708	28/09/1971	15/11/2011
A4R001Q01	A42F	15	A4R001Q01 MOKOLO DAM ON MOKOLO RIVER: NEAR DAM WALL	MOKOLO DAM (A4)	-23.98513889	27.72366667	154	11/03/1981	28/11/2011
A4H005Q01	A42F	15	A4H005Q01 MOKOLO RIVER AT DWAALHOEK	MOKOLO	-24.082778	27.773056	472	28/09/1971	15/05/2001
A4H010Q01	A42G	16	A4H010Q01 MOKOLO DAM ON MOKOLO RIVER: DOWN STREAM WEIR	MOKOLO	-23.971389	27.726389	91	03/01/1984	16/02/2010
A4H007Q01	A42H	16	A4H007Q01 TAMBOTIE RIVER AT BLAKENEY	TAMBOTIE	-23.763056	27.908611	203	27/12/1977	28/09/2011
A4H013Q01	A42J	16	A4H013Q01 MOKOLO RIVER AT MOORDDRIFT/VUGHT	MOKOLO	-23.599167	27.741944	237	16/02/1994	04/07/2007
A2H090Q01	A21A	1	A2H090Q01 HENNOPS RIVER AT V RIEBEECK NAT RES UP/S RIETVLEI	HENNOPS	-25.88555556	28.30277778	342	25/04/1986	17/02/2004
100000762	A21A	1	A21 RIETVLEIRIVER 02 ON DIRT ROAD JUST DOWNSTREAM OF BRIDGE	HENNOPS	-25.9689	28.301	203	15/01/2002	26/02/2010
100000763	A21A	1	A21 RIETVLEI 03 UPSTREAM OF SEWAGE WORK CLOSE TO BRIDGE	HENNOPS	-26.0192	28.3043	206	15/01/2002	26/02/2010
100000766	A21A	1	A21 RIETVLEI 06 DOWNSTREAM OF FARM DAM ON ROAD R23	HENNOPS	-26.05225	28.266083	186	18/06/2002	26/02/2010
100000777	A21B	1	A21 OLIFANTSFONTEIN CULVERT ON IRENE ROAD	OLIFANTSFONTEIN STORMWATER CANAL	-25.936483	28.232833	98	23/10/2001	05/07/2007
A2R004Q01	A21B	1	A2R004Q01 RIETVLEI DAM ON HENNOPS RIVER: NEAR DAM WALL	A2R004 RIETVLEI DAM AT VAN RIEBEECK NAT.RES	-25.876389	28.265278	2427	24/06/1968	09/05/2012
100895	A21B	1	KAALSPRUIT 60M D/S OF OLIFANTSFONTEIN - MIDRAND OLD TAR ROAD	KAALSPRUIT V13E TO V13E	-25.9575	28.206944	244	06/02/1987	26/02/2010
100000752	A21B	1	A21 HENNOPS 01 ON SKURWEBERG DIRT ROAD AT SMALL BRIDGE	HENNOPS	-25.83085	28.12265	209	18/06/2002	26/02/2010
100000767	A21B	1	A21 HENNOPS O3 AT ZWARTKOPS LAPA	HENNOPS	-25.83085	28.12265	203	18/06/2002	26/02/2010
100000768	A21B	1	A21 HENNOPS 02 AT BRIDGE CLOSE TO ERASMIA	HENNOPS	-25.822283	28.082133	208	18/06/2002	26/02/2010
100000771	A21B	1	A21 RIETSPRUIT 01 @ OLD BRIDGE BEHIND SUTHERLAND RIDGE	HENNOPS	-25.837566	28.108066	250	18/06/2002	26/02/2010
100000772	A21B	1	A21 RIETSPRUIT 02 @ BRIDGE IN RASLOUW AH	HENNOPS	-25.854383	28.108066	206	18/06/2002	26/02/2010
100000773	A21B	1	A21 SWARTBOOISPRUIT @ BRIDGE ON R511 FROM R28 TO ERASMIA	HENNOPS	-25.837083	28.04485	193	18/06/2002	26/02/2010
100000774	A21B	1	A21 KAALSPRUIT 01 @ BRIDGE FROM CENTURION TO OLIFANTSFONTEIN	HENNOPS	-25.922933	28.2275	203	18/06/2002	26/02/2010
191608	A21C	1	ND2 DIEPSLOOT 388 JR - @ NORTHERN WWTW STORMWATER OXIDATION POND OUTLET	OUTLET FROM NORTHERN WWTW STORMWATER	-25.95094444	27.98744444	33	01/11/2006	28/12/2006

				OXIDATION POND					
191609	A21C	1	NFE_G - DIEPSLOOT 288 JR - @ NORTHERN WWTW FINAL EFFLUENT @ JUKSLEIRIVIER	OPEN CHANNEL FROM NORTHERN WWTW TO JUKSKEI RIVIER	-25.95658333	27.98966667	41	01/11/2006	28/12/2006
88648	A21C	1	DWJ12 JUKSKEI RIVER U/S CONFLUENCE MODDERFONTEIN MARLBORO	JUKSKEI A21C TO A21C	-26.086944	28.108889	158	11/12/2002	09/02/2012
A2H023	A21C	1	A2H023 NIETGEDACHT 535 JQ DWJ26 ON JUKSKEIRIVIER	JUKSKEI A21C TO A21C	-25.95465556	27.96217222	1440	02/05/1979	06/02/2012
A2H040 Q01	A21C	1	A2H040Q01 DWJ37 AT WATERVAL D/S R101 ON JUKSKEI	JUKSKEI A21C TO A21C	-26.031389	28.112222	1419	06/12/1971	26/03/2012
A2H047	A21C	1	A2H047 KLIPFONTEIN/RANDBURG ON KLEIN-JUKSKEIRIVIER	KLEIN JUKSKEI RIVER (A2)	-26.06818056	27.972025	554	06/12/1971	06/02/2012
185640	A21C	1	ON JUKSKEI RIVER 150 M D/S OF BRUMA LAKE	JUKSKEI A21C TO A21C	-26.1787	28.1096	257	11/12/2002	12/04/2012
185641	A21C	1	DWJ42 JUKSKEI RIVER - NORTHERN END OF EASTBANK ROAD	JUKSKEI A21C TO A21C	-26.0947	28.1066	73	11/12/2002	19/06/2007
185688	A21C	1	JUKSKEI RIVER U/S OF CONFLUENCE WITH KLIEN JUKSKEI BRAAMFONTEIN SPRUIT	JUKSKEI A21C TO A21C	-26.0144	28.0525	156	11/12/2002	09/02/2012
188139	A21C	1	FARM DAM RANDBURG ON OLIENHOUTSPOORTSPRUIT	OLIENHOUTSPOORT SPRUIT - DRAINAGE REGION A21C	-26.043444	27.96325	31	02/09/2004	02/04/2008
188141	A21C	1	DELTA PARK ON TRIBUTARY OF BRAAMFONTEIN SPRUIT	TRIBUTARY OF BRAAMFONTEIN SPRUIT - DRAINAGE REGION A21C	-26.125083	28.012556	32	02/09/2004	02/04/2008
188571	A21C	1	EASTGATE ON JUKSKEI	JUKSKEI A21C TO A21C	-26.08494444	28.10880556	544	13/10/2005	26/03/2012
188572	A21C	1	KNOPPIESLAAGTE U/S OF R28 ON JUKSKEI	JUKSKEI A21C TO A21C	-25.94933333	27.95877778	540	13/10/2005	26/03/2012
189089	A21D	1	RANDFONTEIN POLICE STATION WATER SUPPLIED BY RAND WATER	RAND WATER PIPELINE FROM PURIFICATION WORKS	-26.18055556	27.70638889	69	17/01/2006	31/03/2009
101008	A21D	1	ZWARTKRANS AT R563 BRIDGE ON BLOUBANKSPRUIT RIETSPRUIT	BLOUBANKSPRUIT RIETSPRUIT - DRAINAGE REGION A21D	-26.020833	27.720833	44	28/06/1989	30/09/2008
101438	A21D	1	ELANDSVLEI 249 IQ U/S OF RANDFONTEIN SEWAGE TREATMENT PLANT	BLOUBANKSPRUIT RIETSPRUIT - DRAINAGE REGION A21D	-26.145278	27.675278	66	11/03/1997	23/02/2010
187587	A21D	1	F11S12 AT STERKFONTEIN U/S N14 ON TWEELOPIESPRUIT	TWEELOPIESPRUIT A21D TO A21D	-26.06374	27.69589	116	14/11/2003	29/09/2008
187588	A21D	1	F10S11 AT NORTHERN FENCE IN KRUGERSDORP GAME RESERVE	TWEELOPIESPRUIT A21D TO A21D	-26.0762	27.69963	114	14/11/2003	30/09/2008
187589	A21D	1	F8S9 AT BROAD CREST IN KRUGERSDORP GAME RESERVE ON TWEELOPIE	TWEELOPIESPRUIT A21D TO A21D	-26.08527	27.70886	115	14/11/2003	30/09/2008
187590	A21D	1	F6S7 KRUGERSDORP GAME RESERVE - AT CEMETERY, ON TWEELOPIESPRUIT	TWEELOPIESPRUIT A21D TO A21D	-26.09671	27.71932	113	13/11/2003	02/07/2009
187591	A21D	1	W1S3 KRUGERSDORP GAME RESERVE - @ HIPPO DAM ON TWEELOPIESPRUIT	TWEELOPIESPRUIT A21D TO A21D	-26.09917	27.72128	122	13/11/2003	24/02/2010
187592	A21D	1	F2S2 AT WILLOW TREE IN KRUGERSDORP GAME RESERVE ON TWEELOPIE	TWEELOPIESPRUIT A21D TO A21D	-26.10653	27.72227	100	13/11/2003	30/09/2008
187593	A21D	1	F1S1 UPSTREAM OF R24 AT RANDFONTEIN ESTATES ON TWEELOPIESPRU	TWEELOPIESPRUIT A21D TO A21D	-26.10752	27.72268	103	13/11/2003	30/09/2008
188048	A21D	1	STERKFONTEIN WATERFALL ON TRIBUTARY OF	TRIBUTARY OF	-26.064167	27.720722	96	24/06/2004	30/09/2008

			RIETSPRUIT	RIETSPRUIT - DRAINAGE REGION A21D					
1000009 65	A21D	1	RTS1 RIETSPRUIT DOWNSTREAM CULTERA	BLOUBANKSPRUIT RIETSPRUIT - DRAINAGE REGION A21D	-26.1146	27.662	86	25/03/2003	23/02/2010
1000010 23	A21D	1	RFE RANDFONTEIN STW PLANT FINAL EFF D/S POINT ELANSVLEI	BLOUBANKSPRUIT RIETSPRUIT - DRAINAGE REGION A21D	-26.1414	27.6794	64	21/11/2002	23/02/2010
1000010 24	A21D	1	ELV1 ELANDSVLEI 249 IQ D/S OF RANDFONTEIN SEWAGE TREATMENT PLANT ON BLOUBANKSPRUIT	BLOUBANKSPRUIT RIETSPRUIT - DRAINAGE REGION A21D	-26.1417	27.6756	64	21/11/2002	23/02/2010
1000010 27	A21D	1	BGS2 BLOUGATSPRUIT U/S OF PERCY STEWART SEWAGE TREATMENT	BLOUBANKSPRUIT RIETSPRUIT - DRAINAGE REGION A21D	-26.07138	27.72888	53	21/11/2002	15/07/2009
1000010 32	A21D	1	BGS1 BLOUGATSPRUIT D/S OF PERCY STEWART SEWAGE TREATMENT	BLOUBANKSPRUIT RIETSPRUIT - DRAINAGE REGION A21D	-26.06555	27.72232	65	21/11/2002	23/02/2010
A2H049	A21E	1	A2H049 ZWARTKOP 525 JQ ON BLOUBANKSPRUIT / RIETSPRUIT	BLOUBANKSPRUIT RIETSPRUIT - DRAINAGE REGION A21D	-25.97681	27.83644	1140	23/05/1979	06/02/2012
A2H050	A21E	1	A2H050 ZWARTKOP 250 JQ HOI-HOI AT HOI-HOI ON KROKODILRIVIER	A21E-1-KROKODIL - DRAINAGE REGION A	-25.99136	27.84208	1153	02/05/1979	05/03/2012
A2H051	A21E	1	A2H051 VAN WYKS RESTANT 182 IQ AT MULDERSDRIFT ON KROKODILRIVIER	A21E-1-KROKODIL - DRAINAGE REGION A	-26.03311	27.84269	894	02/05/1979	27/06/2011
1000008 11	A21E	1	WGS1 A21 WILGESPRUIT	WILGESPRUIT - DRAINAGE REGION A21E	-26.0364	27.8504	60	11/12/2002	23/02/2010
1000009 07	A21E	1	MSL1 BOTANICAL GARDENS UPSTREAM	MULDERSDRIF SE LOOP - DRAINAGE REGION A21E	-26.1071	27.8389	30	21/11/2002	20/04/2005
1000009 08	A21E	1	CR2 CROCODILE RIVER DOWNSTREAM OF JW DRIEFONTEIN SEWAGE TREATMENT	A21E-1-KROKODIL - DRAINAGE REGION A	-25.93504	27.906	41	03/11/2006	28/04/2009
1000010 30	A21E	1	CR1 CROCODILE RIVER UPSTREAM OF JW DRIEFONTEIN SEWAGE TREATMENT	A21E-1-KROKODIL - DRAINAGE REGION A	-26.0123	27.8334	94	21/11/2002	17/11/2009
1000010 31	A21E	1	CCR1 CROCODILE D/S OF JW DRIEFONTEIN SEWAGE TREATMENT PLANT	A21E-1-KROKODIL - DRAINAGE REGION A	-26.0099	27.8325	47	21/11/2002	26/01/2010
A2H013	A21F	2	A2H013 SCHEERPOORT 477 JQ MAGALIES RIVER AT SCHEERPOORT	MAGALIES	-25.77703	27.76111	1671	04/07/1971	16/01/2012
A2H024	A21F	2	A2H024 BRANDVLEI 261 IQ ON BRANDVLEIRIVIER	BRANDVLEI RIVER - DRAINAGE REGION A21F	-26.15119	27.59486	341	09/02/1978	26/09/2011
1000008 07	A21F	2	MGR1 A21 MAGALIES DOWNSTREAM	MAGALIES	-25.8695	27.6149	72	21/11/2002	23/02/2010
1000009 03	A21F	2	KLR1 KLEIN RIVER DOWNSTREAM	KLEINRIVIER A21F TO A21F	-25.8957	27.5898	85	21/11/2002	23/02/2010
1000010	A21F	2	SPR1 SKEERPOORT RIVER BRIDGE AT R612 IN	MAGALIES	-25.78813	27.76698	83	21/11/2002	23/02/2010

25			HEKPOORT						
A2H034	A21G	2	A2H034 SCHEERPOORT 477 JO ON SKEERPOORTRIVIER	SKEERPOORT RIVER (A2)	-25.82483	27.77175	1600	21/01/1976	08/02/2012
A2H117	A21H	1	A2H117 HARTBEESFONTEIN HARTBEESPOORT	CANAL FROM DAM D/S OF RETURN FLOW PT. HARTBEESPOORT DAM	-25.724722	27.85	56	26/06/2008	20/12/2010
A2R001 Q01	A21H	1	A2R001Q01 HARTBEESPOORT DAM ON CROCODILE RIV: NEAR DAM WALL	A2R001 HARTBEESPOORT DAM AT HARTBEESFONTEIN	-25.7265404	27.84883934	13061	18/03/1968	02/05/2012
88737	A21H	1	ZDWJ32 CROCODILE RIVER D/S CONFLUENCE WITH JUKSKEI RIVER	A21E-1-KROKODIL - DRAINAGE REGION A	-25.865278	27.933333	111	12/01/2005	08/12/2009
A2H012	A21H	1	A2H012 KALKHEUWEL 493 JQ ON KROKODILRIVIER	A21E-1-KROKODIL - DRAINAGE REGION A	-25.81048333	27.90955222	3701	04/07/1971	28/03/2012
A2H014	A21H	1	A2H014 SCHURVEBERG 488 JQ AT SKURWEBERG ON HENNOPSRIVIER	HENNOPS	-25.79842	27.98533	1594	27/01/1976	18/01/2012
A2H044	A21H	1	A2H044 VLAKFONTEIN 494 JQ ON JUKSKEIRIVIER	JUKSKEI A21C TO A21C	-25.8955	27.93480556	1488	06/12/1971	08/02/2012
A2H045	A21H	1	A2H045 VLAKFONTEIN 494 JQ DWJ31 ON KROKODILRIVIER	A21E-1-KROKODIL - DRAINAGE REGION A	-25.89264444	27.91436667	1578	02/05/1979	08/02/2012
A2H058	A21H	1	A2H058 IFAFA 457 JQ AT RIETFONTEIN / SYFERFONTEIN ON SWARTSPRUIT	SWARTSPRUIT - DRAINAGE REGION A21H	-25.74819	27.90986	393	08/09/1982	07/02/2012
A2H083 Q01	A21H	1	A2H083Q01 HARTBEESPOORT DAM ON CROCODILE RIV: DOWN STREAM WEIR	A21E-1-KROKODIL - DRAINAGE REGION A	-25.724722	27.85	659	22/05/1979	21/11/2011
186804	A21H	1	EAGLES LANDING ON UNKNOWN RIVER U/S OF HARTBEESPOORT DAM	TRIBUTARY OF KROKODIL RIVER UPSTREAM OF HARTBEESPOORT DAM	-25.7764	27.8669	172	15/01/2003	13/01/2009
1000007 82	A21H	1	DWJ 30 JUKSKEI UPSTREAM OF CONFLUENCE WITH CROCODILE	JUKSKEI A21C TO A21C	-25.8889	27.933	124	12/01/2005	23/02/2010
A2H081 Q01	A21J	3	A2H081Q01 HARTBEESPOORT DAM ON CROCODILE RIVER: LEFT CANAL	LEFT CANAL FROM HARTBEESPOORT DAM	-25.7247176	27.84522634	1566	19/06/1962	05/12/2011
A2H082 Q01	A21J	3	A2H082Q01 HARTBEESPOORT DAM ON CROCODILE RIVER: RIGHT CANAL	RIGHT CANAL FROM HARTBEESPOORT DAM (DUPL NAME 3)	-25.72389486	27.84800779	317	19/06/1962	09/06/2008
184217	A21J	3	HBP(WEST)-A CANAL ON FARM SANDFONTEIN	HARTBEESPOORT DAM OUTLET CANAL ON LEFT BANK (WEST)	-25.6887	27.7864	45	07/06/2002	14/09/2004
184218	A21J	3	HBP(WEST)-B CANAL ON FARM UITVAL	HARTBEESPOORT DAM OUTLET CANAL ON LEFT BANK (WEST)	-25.657	27.7267	45	07/06/2002	14/09/2004
184220	A21J	3	HBP(EAST)-A CANAL ON FARM DE KROON	HARTBEESPOORT DAM OUTLET CANAL ON RIGHT BANK (EAST)	-25.6671	27.8279	43	07/06/2002	14/09/2004
184221	A21J	3	HBP(EAST)-B HARTEBEESTPOORT C 419 JO CANAL ON FARM HARTEBEESTPOORT	HARTBEESPOORT DAM OUTLET CANAL	-25.5002	27.7587	43	07/06/2002	14/09/2004

				ON RIGHT BANK (EAST)					
A2H048	A21J	3	A2H048 KROKODILPOORT 418 JO /THABA MOYA ON KROKODILRIVIER	A21E-1-KROKODIL - DRAINAGE REGION A	-25.57326944	27.75445	1579	19/02/1976	05/12/2011
184795	A21J	3	KROKODIL RIVER AT INLET TO ROODEKOPJES DAM	A21E-1-KROKODIL - DRAINAGE REGION A	-25.4444	27.65	33	28/07/1999	08/06/2004
186797	A21J	3	BRITS-UPSTREAM OF R511 ROAD BRIDGE-RIGHT BANK	A21E-1-KROKODIL - DRAINAGE REGION A	-25.6475	27.7797	314	15/01/2003	21/05/2012
188143	A21J	3	BRITS AT KROKODILDRIF OOS ON KROKODIL	A21E-1-KROKODIL - DRAINAGE REGION A	-25.651389	27.788944	30	27/08/2004	28/07/2008
A2H113 Q01	A21K	4	A2H113Q01 ROODEKOPJES DAM ON CROCODILE RIVER: LEFT CANAL	LEFT CANAL FROM ROODEKOPJES DAM	-25.40666667	27.57619444	337	20/05/1986	20/12/2011
A2H114 Q01	A21K	4	A2H114Q01 ROODEKOPJES DAM ON CROCODILE RIVER: RIGHT CANAL	RIGHT CANAL FROM ROODEKOPJES DAM	-25.40277778	27.57622222	216	28/10/1992	15/05/2007
A2R005 Q01	A21K	4	A2R005Q01 BUFFELSPOORT DAM ON STERKSTROOM RIV: NEAR DAM WALL	A2R005 BUFFELSPOORT DAM AT BUFFELSPOORT	-25.779167	27.4875	515	18/03/1968	08/05/2012
A2R015 Q01	A21K	4	A2R015Q01 ROODEKOPJES 203 JQ - ROODEKOPJES DAM ON KROKODILRIVIER: NEAR DAM WALL	A2R015 ROODEKOPJES DAM AT ROODEKOPJES	-25.4074	27.5772	977	15/11/1984	25/04/2012
A2H019 Q01	A21K	4	A2H019Q01 ROODEKOPJES DAM ON CROCODILE RIVER: DOWN STREAM WEIR	A21E-1-KROKODIL - DRAINAGE REGION A	-25.40361111	27.57477778	1328	06/02/1976	28/03/2012
187088	A21K	4	A2STER-SPRUI AT SPUITFONTEIN ROAD BRIDGE ON STERKSTROOM	STERKSTROOM A21K TO 99	-25.725166	27.483334	292	23/04/2003	21/05/2012
186800	A21L	13	TSHUKUTSWE RIVER-EAST BAKWENA TRIBAL AUTHORITY AT OLD BRIDGE	TSHUKUTSWE	-25.3904	27.6068	315	15/01/2003	21/05/2012
A2H096	A22A	5	A2H096 LINDLEYSPOORT 220 JP ON RIGHT CANAL FROM LINDLEY S POORT DAM	RIGHT CANAL FROM LINDLEYSPOORT DAM	-25.4975	26.69036	466	08/03/1983	11/10/2011
A2R007	A22A	5	A2R007 LINDLEYSPOORT DAM AT LINDLEYSPOORT 220 JP ON ELANDSRIVIER NEAR DAM WALL	A2R007 LINDLEYSPOORT DAM AT LINDLEYSPOORT	-25.49769	26.69047	1686	18/03/1968	03/05/2012
A2R013	A22A	5	A2R013 SWARTRUGGENS DAM AT BRAKFONTEIN 404 JP ON ELANDSRIVIER NEAR DAM WALL	A2R013 SWARTRUGGENS DAM AT BRAKFONTEIN	-25.66181	26.694	273	13/02/1980	30/08/2011
A2H107	A22A	5	A2H107 BRAKFONTEIN 404 JP DOWN STREAM WEIR FOR SWARTRUGGENS DAM ON ELANDSRIVIER	ELANDSRIVIER - DRAINAGE REGION A22	-25.657	26.69469	198	01/02/1985	26/04/2011
189635	A22A	5	BRAKFONTEIN 404 JP BOROLELO SWARTRUGGENS - DOWNSTREAM OF SWARTRUGGENS WWTW ON ELANDSRIVIER	ELANDSRIVIER - DRAINAGE REGION A22	-25.62513889	26.69047222	114	24/04/2007	21/05/2012
A2R011 Q01	A22B	5	A2R011Q01 KOSTER RIVER DAM ON KOSTER RIVER: NEAR DAM WALL	A2R011 KOSTERRIVIER DAM AT WATERKLOOF	-25.7	26.905	1490	30/11/1971	03/05/2012
A2H036	A22B	5	A2H036 STEENBOKFONTEIN 426 JP ON KOSTERRIVIER	KOSTER	-25.72586	26.88444	1480	24/09/1971	23/08/2011
A2H104	A22B	5	A2H104 WATERKLOOF 423 JP DOWN STREAM WEIR FOR KOSTER DAM ON KOSTERRIVIER	KOSTER	-25.69847	26.90569	645	15/01/1972	26/04/2011
90178	A22C	5	A2H032 MOEDWIL ON SELONSRIVIER	SELONSRIVIER - DRAINAGE REGION	-25.63753	27.02703	133	26/05/1977	27/11/2001

				A22					
183156	A22F	5	A2ELAN-RIETS MONNAKATO RIETSPRUIT AT ROAD BRIDGE ON ELANDSRIVIER	ELANDSRIVIER - DRAINAGE REGION A22	-25.3344	27.2914	37	09/11/1999	29/06/2006
183158	A22F	5	BUFFELSFONTEIN 85 JQ DOWNSTREAM OF MOGWASE WWTW ON SESHABELE	SESHABELE A22F TO A22F	-25.3319	27.2403	31	09/11/1999	08/06/2004
184794	A22F	5	BRIDGE ON ELANDS RIVER AT VAALKOP DAM INLET	ELANDSRIVIER - DRAINAGE REGION A22	-25.3262	27.4058	33	28/07/1999	08/06/2004
184800	A22F	5	LERAGANE RIVER UPSTREAM OF LEGADIGADI JUNCTION	LERAGANE	-25.4633	27.1914	30	14/03/2000	08/06/2004
A2R003	A22G	4	A2R003 OLIFANTSNEK DAM AT COMMISSIESDRIFT 327 JQ ON HEXRIVIER NEAR DAM WALL	A2R003 OLIFANTSNEK DAM AT COMMISSIESDRIFT	-25.78511	27.25933	278	05/03/1975	08/05/2012
A2R006	A22H	4	A2R006 BOSPOORT DAM AT TWEEDEPOORT 283 JQ ON HEXRIVIER NEAR DAM WALL	A2R006 BOSPOORT DAM AT BOSCHPOORT	-25.56281	27.34936	779	06/03/1975	08/05/2012
190398	A22H	4	RUSTENBURG CORRECTIONAL SERVICES AT CORRECTIONAL SERVICES DAM	RUSTENBURG CORRECTIONAL SERVICES DAM A22H	-25.63533333	27.25866667	100	18/03/2008	21/05/2012
A2H038	A22H	4	A2H038 RIETVALEI 314 JO ON WATERKLOOFSPRUIT LOWER SITE	WATERKLOOFSPRUI T - DRAINAGE REGION A22H	-25.73411	27.21422	262	12/07/1973	06/09/2011
A2H039 Q01	A22H	4	A2H039Q01 UPPER WATERKLOOF AT RIETVALLEI	WATERKLOOFSPRUI T - DRAINAGE REGION A22H	-25.716667	27.186111	64	12/07/1973	06/05/2008
184805	A22H	4	HEX RIVER BRIDGE NEAR TEKWANE	HEXRIVIER A22G TO A22J	-25.5844	27.305	31	09/11/1999	08/06/2004
184810	A22H	4	A2HEX-PAARD PAARDEKRAAL AT BRIDGE NEAR BOITEKONG ON HEXRIVIER	HEXRIVIER A22G TO A22J	-25.6081	27.2894	35	09/11/1999	08/09/2006
184812	A22H	4	AT BRIDGE NEAR PRISON IN RUSTENBURG ON DORPSPRUIT	DORPSPRUIT - DRAINAGE REGION A22H	-25.6294	27.2658	32	09/11/1999	08/06/2004
184813	A22H	4	PAARDEKRAAL DAM WALL	HEXRIVIER A22G TO A22J	-25.6492	27.2914	33	09/11/1999	08/06/2004
184814	A22H	4	NAUDE DAM OVERFLOW TO PAARDEKRAAL DAM	HEXRIVIER A22G TO A22J	-25.6506	27.2911	32	09/11/1999	08/06/2004
184817	A22H	4	AT RUSTENBURGKLOOF ON DORPSPRUIT	DORPSPRUIT - DRAINAGE REGION A22H	-25.6889	27.1928	33	09/11/1999	08/06/2004
184818	A22H	4	HEX RIVER BRIDGE NEAR KROONDAL	HEXRIVIER A22G TO A22J	-25.7144	27.2997	30	09/11/1999	27/01/2006
186802	A22H	4	KROONDAL VILLAGE RIVIERFONTEIN-NEAR RUSTENBURG ROAD BRIDGE	SANDSPRUIT-KROONDAL	-25.7091	27.3111	192	15/01/2003	21/05/2012
190401	A22H	4	WATERVAL SUBURB OF PHUKETBRUG ON HEXRIVIER TRIBUTARY	HEXRIVIER TRIBUTARY A22H TO A22H	-25.69741667	27.25602778	103	01/04/2008	21/05/2012
A2H110 Q01	A22J	4	A2H110Q01 CANAL FROM ROODEKOPJES DAM TO VAALKOP DAM AT BULHOEK	CANAL FROM ROODEKOPJES DAM	-25.308611	27.475278	241	09/06/1986	20/12/2011
A2R014 Q01	A22J	4	A2R014Q01 BULHOEK 75 JQ - VAALKOP DAM ON ELANDSRIVIER: NEAR DAM WALL	A2R014 VAALKOP DAM AT BULHOEK	-25.3093	27.475	1024	04/03/1975	25/04/2012
A2H094	A22J	4	A2H094 TWEEDEPOORT 289 JQ DOWN STREAM WEIR FOR BOSPOORT DAM ON HEXRIVIER	HEXRIVIER A22G TO A22J	-25.54769	27.35233	221	22/11/1978	02/01/2004
A2H111 Q01	A22J	4	A2H111Q01 VAALKOP DAM ON ELANDS RIVER: DOWN STREAM WEIR	ELANDSRIVIER - DRAINAGE REGION A22	-25.30658333	27.47622222	889	28/02/1985	28/03/2012

184797	A22J	4	HEX RIVER DOWNSTREAM OF THE HARTEBEESFONTEIN STW	HEXRIVIER A22G TO A22J	-25.4186	27.4689	31	09/11/1999	08/06/2004
184801	A22J	4	HEX RIVER BRIDGE NEAR MOORDKOP	HEXRIVIER A22G TO A22J	-25.4764	27.4114	30	09/11/1999	08/06/2004
186798	A22J	4	HEX RIVER AT FIRST BRIDGE D/S OF BOSPOORT DAM-RIGHT BANK	HEXRIVIER A22G TO A22J	-25.5446	27.3555	297	15/01/2003	21/05/2012
1000009 96	A23A	1	A23 BAVIAANSPOORT SEWAGE WORKS DISCHARGE	BAVIAANSPOORT DISCHARGE CANAL	-25.689417	28.356783	114	23/06/2004	23/02/2010
A2R009 Q01	A23A	1	A2R009Q01 ROODEPLAAT DAM ON PIENAARS RIVER: NEAR DAM WALL	A2R009 ROODEPLAAT DAM (PIENAARS RIVER) AT ROODEPLAAT	-25.622	28.373	13595	14/03/1968	02/05/2012
A2R009 Q02	A23A	1	A2R009Q02 ROODEPLAAT DAM ON PIENAARS RIVER: POINT IN DAM	A2R009 ROODEPLAAT DAM (PIENAARS RIVER) AT ROODEPLAAT	-25.62	28.358	5364	09/02/1977	02/05/2012
A2R009 Q07	A23A	1	A2R009Q07 ROODEPLAAT DAM ON PIENAARS RIVER: POINT IN DAM	A2R009 ROODEPLAAT DAM (PIENAARS RIVER) AT ROODEPLAAT	-25.64	28.344	4914	07/01/1980	02/05/2012
A2R009 Q08	A23A	1	A2R009Q08 ROODEPLAAT DAM ON PIENAARS RIVER: POINT IN DAM	A2R009 ROODEPLAAT DAM (PIENAARS RIVER) AT ROODEPLAAT	-25.635	28.379	5397	07/01/1980	02/05/2012
A2R009 Q09	A23A	1	A2R009Q09 ROODEPLAAT DAM ON PIENAARS RIVER: POINT IN DAM	A2R009 ROODEPLAAT DAM (PIENAARS RIVER) AT ROODEPLAAT	-25.627	28.349	4245	06/04/1980	02/05/2012
A2R009 Q10	A23A	1	A2R009Q10 ROODEPLAAT DAM ON PIENAARS RIVER: POINT IN DAM	A2R009 ROODEPLAAT DAM (PIENAARS RIVER) AT ROODEPLAAT	-25.62554389	28.34544139	624	28/01/1982	02/05/2012
A2H027 Q01	A23A	1	A2H027Q01 PIENAARS RIVER AT BAVIAANSPOORT	PIENAARS A23A TO A23C	-25.6625	28.351389	4557	08/02/1967	02/05/2012
A2H028 Q01	A23A	1	A2H028Q01 AT KAMEELDRIFT ON HARTBEESSPRUIT	HARTBEESSPRUIT (MORETELE) - DRAINAGE REGION A23A	-25.650833	28.319444	3653	10/05/1967	02/05/2012
A2H029 Q01	A23A	1	A2H029Q01 AT LEEUWFONTEIN ON EDENDALSPRUIT	EDENDALSPRUIT - DRAINAGE REGION A23A	-25.648889	28.391944	2268	08/02/1967	02/05/2012
A2H054 Q01	A23A	1	A2H054Q01 AT WOLMARANSPOORT ON HARTBEESSPRUIT	HARTBEESSPRUIT (MORETELE) - DRAINAGE REGION A23A	-25.678889	28.290833	1175	16/11/1982	17/10/2011
A2H055 Q01	A23A	1	A2H055Q01 MORETELE SPRUIT AT DERDEPOORT PRETORIA/MORELETTA	MORETELE	-25.690556	28.292778	1246	16/11/1982	19/01/2012
A2H126 Q01	A23A	1	A2H126Q01 AT FRANSPOORT ROAD BRIDGE ON EDENDALSPRUIT	EDENDALSPRUIT - DRAINAGE REGION A23A	-25.677778	28.401944	1032	24/01/1995	02/05/2012
A2H127 Q01	A23A	1	A2H127Q01 PIENAARS RIVER AT BAVIAANSPOORT (MAGALIESBERG)	PIENAARS A23A TO A23C	-25.695	28.358611	1004	23/01/1995	02/05/2012
180560	A23A	1	PIENAARS RIVER U/S ROODEPLAAT DAM/ ZEEKOEGAT(300M D/S A2H	PIENAARS A23A TO A23C	-25.66	28.349444	31	31/05/1999	19/07/1999
188653	A23A	1	NOOITGEDACHT @ ROAD BRIDGE ON EDENDALSPRUIT	EDENDALSPRUIT - DRAINAGE REGION A23A	-25.68513889	28.4175	83	15/03/2006	23/02/2010
1000008	A23A	1	A23 BLOEMENDAL @ KAMEELFONTEIN ON GRAVEL	PIENAARS A23A TO	-25.66845	28.386066	113	23/06/2004	23/02/2010

82			ROAD	A23C					
100000883	A23A	1	A23 PIENAARSRIVER 1, UPSTREAM OF BOSCHKOP ROAD	PIENAARS A23A TO A23C	-25.85843306	28.45583306	113	23/06/2004	23/02/2010
100000884	A23A	1	A23 MORELETA SPRUIT @ KAMEELDRIFT	PIENAARS A23A TO A23C	-25.65688306	28.30841611	114	23/06/2004	23/02/2010
100000885	A23A	1	A23 PIENAARS RIVER 13 KAMEELFONTEIN ROAD	PIENAARS A23A TO A23C	-25.6625	28.35083333	109	27/07/2004	23/02/2010
100000886	A23A	1	A23 AT PRETORIA CULLINAN ROAD BRIDGE ON EDENDALSPRUIT	EDENDALSPRUIT - DRAINAGE REGION A23A	-25.678383	28.401716	113	23/06/2004	23/02/2010
100000887	A23A	1	A23 BAVIAANSPOORT 330 JR - DOWNSTREAM OF BAVIAANSPOORT WWTW ON PIENAARSRIVIER	PIENAARS A23A TO A23C	-25.678766	28.356783	111	23/06/2004	23/02/2010
A2H100Q01	A23B	1	A2H100Q01 ROODEPLAAT DAM ON PIENAARS RIVER: LEFT CANAL	LEFT CANAL FROM ROODEPLAAT DAM (DUPL NAME 1)	-25.6186	28.3719	2718	07/01/1980	12/12/2011
184206	A23B	1	RPD(L)-A ON FARM CROCOVANGO	PIENAARS RIVER GWS LEFT BANK CANAL FROM ROODEPLAAT DAM	-25.5965	28.334	531	12/10/2000	04/10/2007
184207	A23B	1	RPD(L)-B HAAKDOORNFONTEIN 119 JR @ MURRAYHILL ON PIENAARS RIV GWS LB CANAL FRM ROODEPLAAT DAM	PIENAARS RIVER GWS LEFT BANK CANAL FROM ROODEPLAAT DAM	-25.4856	28.334	520	19/10/2000	04/10/2007
184208	A23B	1	RPD(L)-C ALGHARK	PIENAARS RIVER GWS LEFT BANK CANAL FROM ROODEPLAAT DAM	-25.4067	28.3037	513	11/01/2001	04/10/2007
A2H006	A23B	1	A2H006 PIENAARSRIVIER 90 JR AT KLIPDRIFT ON PIENAARSRIVIER	PIENAARS A23A TO A23C	-25.380556	28.316667	1559	02/02/1976	19/01/2012
A2H030Q01	A23B	1	A2H030Q01 ROODEPLAAT SPRUIT AT ROODEPLAAT/LOUWSBAKEN SE LOOP	ROODEPLAAT SPRUIT (A2)	-25.601667	28.376111	537	15/05/1968	18/10/2011
A2H102Q01	A23B	1	A2H102Q01 ROODEPLAAT DAM ON PIENAARS RIVER: DOWN STREAM WEIR	PIENAARS A23A TO A23C	-25.6177	28.3721	673	07/01/1980	06/02/2012
186281	A23B	1	PIENAARSRIVIER 90 JR KLIPDRIF PURIFICATION RAW WATER EXTRACTION ON PIENAARSRIVIER	PIENAARS A23A TO A23C	-25.385833	28.311	47	18/12/2002	14/06/2007
100000881	A23B	1	A23 SWAVELPOORT TRIBUTORY 2 PIENAARS BELOW BOSCHKOP BRIDGE	SWAVELPOORT SPRUIT	-25.41585	28.405283	113	23/06/2004	23/02/2010
100000888	A23B	1	A23 ROODEPLAAT DAM OUTFLOW @ KWAMHLANGA RD @ BRIDGE	PIENAARS A23A TO A23C	-25.6082	28.367433	114	23/06/2004	23/02/2010
100001105	A23B	1	ROOIWAL BRIDGE DOWNSTREAM ROOIWAL SEWAGE WORKS OLD WARMBATH	PIENAARS A23A TO A23C	-25.5507	28.3104	94	17/02/2004	26/02/2010
100000967	A23C	14	A23 PIENAARS (PLAT) RIVER AT PIENAARS RIVER TOWN	PLATRIVIER (UTSANE) - BUFFELSPRUIT - DRAINAGE REGION A23	-25.2191	28.294383	102	23/06/2004	23/02/2010
A2H056Q01	A23D	1	A2H056Q01 STEENOOND SPRUIT AT BELLE OMBRE STATION/APIES CONFLUENCE	STEENOOND SPRUIT (A2)	-25.733333	28.179167	1286	14/09/1982	13/12/2011
A2H057Q01	A23D	1	A2H057Q01 SKINNER SPRUIT AT DASPOORT PRETORIA/BANTULE	SKINNERSPRUIT - DRAINAGE REGION A23D	-25.733333	28.168056	1282	17/11/1982	13/12/2011
A2H062Q01	A23D	1	A2H062Q01 WALKER SPRUIT AT SUNNYSIDE PRETORIA/LOFTUS VERSVELD	WALKERSPRUIT A23D TO A23D	-25.76	28.22	1200	07/08/1984	03/01/2012
188816	A23D	1	PRETORIA INDUSTRIAL AREA UPSTREAM OF PTA WEST POWER STATION ON ISCOR STREAM	ISCOR STREAM - DRAINAGE REGION A23D	-25.7605	28.14052778	62	13/03/2006	26/02/2010
188821	A23D	1	TRANS-ORANJE PRETORIA ON SKINNERSPRUIT	SKINNERSPRUIT - DRAINAGE REGION	-25.74708333	28.13272222	62	13/03/2006	26/02/2010

				A23D					
100000784	A23D	1	APIESRIVIER AT FONTEINE BRIDGE ON M18	APIES	-25.781361	28.194083	108	17/02/2004	26/02/2010
100001111	A23D	1	APIES RIVER UPSTREAM DASPOORT SEWAGE WORKS	APIES	-25.733611	28.178472	45	13/12/2005	26/02/2010
100001116	A23D	1	SKINNERSPRUIT AT CHURCH STREET ON KWAGGASRAND CENTRE	SKINNERSPRUIT - DRAINAGE REGION A23D	-25.744972	28.149222	100	17/02/2004	25/11/2009
A2H085Q01	A23E	1	A2H085Q01 BON ACCORD DAM ON APIES RIVER: RIGHT CANAL	RIGHT CANAL FROM BON ACCORD DAM (DUPL NAME 2)	-25.621944	28.191667	544	04/01/1980	13/12/2011
A2R002Q01	A23E	1	A2R002Q01 BON ACCORD DAM ON APIES RIVER: NEAR DAM WALL	A2R002 BON ACCORD DAM AT ONDERSTEPOORT	-25.621389	28.188889	2499	27/02/1975	09/05/2012
A2H061Q01	A23E	1	A2H061Q01 APIES RIVER AT RONDAVEL	APIES	-25.466667	28.263611	1197	04/07/1984	07/02/2012
A2H063Q01	A23E	1	A2H063Q01 WONDERBOOM SPRUIT AT MAYVILLE PRETORIA	WONDERBOOMSPRUIT A23E TO A23E	-25.700833	28.191111	1209	13/06/1984	18/01/2012
100000789	A23E	1	A23 SANDRIVER 2 ROSSLYN INDUSTRIAL AREAS	SAND A23K TO A23K	-25.6149	28.09475	118	12/08/2002	14/01/2010
100000790	A23E	1	A23 UPPER KAFFERSKRAALSPRUIT 1 @ GARANKUWA	SAND A23K TO A23K	-25.6128	28.113	117	08/08/2002	14/01/2010
100001104	A23E	1	STORMWATER CHANNEL DOWNSTREAM PPC ON DF MALAN GARAGE CALTEX	APIES	-25.7164	28.1686	107	17/02/2004	26/02/2010
100001106	A23E	1	ONDERSTEPOORT BRIGDE AFTER TURNING LEFT OLD WARMBATHS R101	APIES	-25.659056	28.187806	101	11/03/2004	26/02/2010
100001113	A23E	1	APIES ROOIWAL WWTW FINAL EFFLUENT	APIES	-25.551722	28.243917	36	11/05/2005	26/02/2010
100001114	A23E	1	APIES RIVER - AT PETRONELLA BRIGDE ON OLD WARMBATHS ROAD	APIESRIVIER A23D TO A23F	-25.500278	28.240306	92	11/03/2004	26/02/2010
100001171	A23E	1	HONINGNESTKRANS BRIDGE ROAD R101 WARMBATHS	APIES	-25.5995	28.2002	94	18/02/2004	26/02/2010
A2R016Q01	A23F	14	A2R016Q01 LEEUKRAAL DAM ON APIES RIVER: NEAR DAM WALL	A2R016 LEEUKRAAL DAM AT LEEUWKRAAL	-25.38969444	28.27738889	909	01/05/1985	16/02/2012
180555	A23F	14	ZAPI-MAKP APIES AT MAKAPANSTAD - SWARTDAMSTAD/HAMMANSKRAAL RD	APIES	-25.239444	28.144167	593	31/05/1999	08/05/2012
100001115	A23F	14	APIES RIVER - AT BABELEGI BRIDGE ON OLD WARMBATHS ROAD R101	APIESRIVIER A23D TO A23F	-25.3475	28.2708	79	17/02/2004	26/02/2010
100001117	A23F	14	TEMBA SEWAGE WORKS DOWNSTREAM FINAL EFFLUENT	APIES	-25.369	28.274083	40	13/03/2006	14/01/2010
A2R008Q01	A23G	14	A2R008Q01 WARMBAD DAM ON BUFFELS SPRUIT: NEAR DAM WALL	A2R008 WARMBAD DAM AT ROODEPOORT	-24.867222	28.26	221	18/02/1976	22/01/2004
A2R012Q01	A23J	14	A2R012Q01 KLIPVOOR DAM ON PIENAARS RIVER: NEAR DAM WALL	A2R012 KLIPVOOR DAM AT KLIPVOOR	-25.131111	27.811111	2202	05/03/1975	08/05/2012
A2H106Q01	A23J	14	A2H106Q01 KLIPVOOR DAM ON PIENAARS RIVER: DOWN STREAM WEIR	PIENAARS A23A TO A23C	-25.131111	27.811111	580	28/10/1985	14/02/2012
179682	A23J	14	MORETELE RIVER AT SUTELONG/RT TARRBRIDGE	MORETELE	-25.126167	27.956067	1562	11/01/2000	15/05/2012
100000824	A23J	14	RSW 1 SOUTSPANSPRUIT , RIETGAT SEWAGE WORK	KUTSWANE	-25.440433	28.098916	117	08/08/2002	14/01/2010
100000893	A23J	14	SOUTSPANSPRUIT UPSTREAM OF RIETGAT SEWAGE WORK	KUTSWANE	-25.454666	28.104666	123	08/08/2002	14/01/2010
100000792	A23K	14	NOITEGEDACHT DAM OUTLET	NOITEGEDACHT DAM	-25.511766	28.030483	32	08/08/2002	22/09/2005
179683	A23K	14	TOLWANE RIVER AT LEGONYANE 5M U/S BRIDGE	TOLWANE	-25.2592	27.775633	1533	11/01/2000	15/05/2012
179684	A23K	14	SAND RIVER AT MADIDI/50M D/S LEFT OF RIVER	TOLWANE (SAND)	-25.437417	27.959433	1533	11/01/2000	15/05/2012

				A23L TO A23K					
187089	A23K	14	AT MABOLOKA DOWNSTREAM OF SEWAGE WORKS ON PHULENG RIVER	PHULENG RIVER - DRAINAGE REGION A23K	-25.444584	27.862194	304	23/04/2003	21/05/2012
1000007 87	A23K	14	A23 TOLWANE RIVER 2, JERICHO @ BRIDGE	TOLWANE	-25.3283	27.8276	124	08/08/2002	14/01/2010
1000007 91	A23K	14	A2UNSP-OUDEK SJAMBOK ZYN OUDE KRAAL 258 JR ABOUT 820M U/S OF SANDRIVIER C CONFLUENCE	SAND A23K TO A23K	-25.5584	28.00665	123	03/09/2002	14/01/2010
1000007 94	A23K	14	A2SAND-NOOIT NOOITGEDACHT 256 JR ABOUT 380M U/S NOOITGEDACHT DAM ON SANDR RIVIER	SAND A23K TO A23K	-25.52735	28.027983	120	12/08/2002	14/01/2010
1000008 03	A23K	14	KSW 1 TOLWANE SEWAGE WORK FINAL EFFLUENT OF KLIPGAT	TOLWANE	-25.4805	28.0128	120	08/08/2002	14/01/2010
1000008 04	A23K	14	A2TOLW-NOOIT TOLWANE UPSTREAM OF KLIPGAT SEWAGE WORK ON TOLWANE	TOLWANE	-25.4945	28.0222	129	08/08/2002	14/01/2010
1000008 05	A23K	14	SSW1 SANDSPRUIT SEWAGE WORKS	SAND A23K TO A23K	-25.5757	28.0482	119	08/08/2002	14/01/2010
1000008 09	A23K	14	ISG 1 ITSOSENG TRIBUTARY	SAND A23K TO A23K	-25.532	28.0697	62	08/08/2002	08/05/2008
1000008 14	A23K	14	ISG2 ITSOSENG TRIBUTARY	SAND A23K TO A23K	-25.5319	28.0699	68	03/09/2002	11/07/2006
1000008 15	A23K	14	ISG 3 ITSOSENG TRIBUTARY CONFLUENCE	SAND A23K TO A23K	-25.5319	28.0695	554	03/09/2002	08/05/2012
1000008 16	A23K	14	SR4 TRIBUTARY AT GARANKUWA NEXT TO BP GARAGE	SAND A23K TO A23K	-25.6075	28.0064	118	08/08/2002	14/01/2010
1000008 25	A23K	14	TOL 3 TOLWANE RIVER AT MADIDI	TOLWANE	-25.44015	27.966033	126	08/08/2002	14/01/2010
1000008 38	A23K	14	KAFFERSKRAALSPRUIT OF CONFLUENCE WITH SANDRIVER	TOLWANE	-25.55275	28.01165	120	08/08/2002	14/01/2010
A2H021 Q01	A23L	14	A2H021Q01 PIENAARS RIVER AT BUFFELSPOORT	PIENAARS A23A TO A23C	-25.127778	27.628889	1589	27/09/1971	27/03/2012
187095	A23L	14	NEAR THE BRIDGE AT GA RASAI ON MORETELE	MORETELE	-25.136057	27.691418	295	23/04/2003	21/05/2012
A2H059	A24A	13	A2H059 VAALKOP 192 JQ AT ATLANTA ON KROKODILRIVIER	A21E-1-KROKODIL - DRAINAGE REGION A	-25.20639	27.558	951	07/02/1985	13/03/2012
A2H060 Q01	A24B	13	A2H060Q01 CROCODILE RIVER AT NOOITGEDACHT	A21E-1-KROKODIL - DRAINAGE REGION A	-25.062222	27.521111	1313	29/03/1984	27/03/2012
A2H132	A24H	13	A2H132 HAAKDOORNDRIFT 373 KQ @ PAUL HUGO DAM ON KROKODILRIVIER	A21E-1-KROKODIL - DRAINAGE REGION A	-24.69514	27.40906	616	07/12/1989	13/03/2012
A3R001	A31B	6	A3R001 MARICO-BOSVELD DAM AT DOORNKRAAL 110 JP ON GROOT-MARICO RIVIER NEAR DAM WALL	A3R001 MARICO-BOSVELD DAM (GROOT-MARICO DAM) AT RIEKERS	-25.47044	26.39258	265	18/03/1968	28/02/2012
188261	A31B	6	A3GMAR GROOT- MARICO WONDERFONTEIN 258 JP - @ N4 ROAD BRIDGE ON GROOT MARICO RIVIER	GROOT-MARICORIVIER - DRAINAGE REGION A31	-25.58902778	26.41252778	37	26/04/2005	17/04/2012
A3H019	A31C	8	A3H019 DOORNPLAAT 85 JO ON RIGHT CANAL OF MALMANIELOOP	MALMANIELOOP CANAL (A3)	-25.76408	25.99167	39	27/08/1992	06/11/2003
A3H031	A31D	6	A3H031 KALKDAM 241 JP ON LEFT CANAL FROM KLEIN-MARICOPOORT DAM	LITTLE MARICOPOORT DAM-OUTLET (A3)	-25.52169	26.15033	213	14/07/1981	08/06/2009
A3R002	A31D	6	A3R002 KLEIN-MARICOPOORT DAM AT KALKDAM 241 JP NEAR DAM WALL	A3R002 KLEIN MARICOPOORT DAM AT KALK DAM	-25.52189	26.14942	476	26/09/1971	28/02/2012
A3H041	A31D	6	A3H041Q01 ZEERUST HAZIA 240 JP - @ R27 ROAD	KAREESPRUIT -	-25.542222	26.101389	54	12/02/1996	17/04/2012

Q01			BRIDGE ON KAREESPRUIT, D/S OF ZEERUST WWTW	DRAINAGE REGION A31					
A3R003	A31E	6	A3R003 KROMELLENBOOG DAM AT KROMELLENBOOG 104 JP NEAR DAM WALL	A3R003 KROMELLENBOOG DAM AT KROMELLENBOOG	-25.44353	26.34539	171	19/07/1966	24/10/2011
A3H028	A31F	11a	A3H028 RIEKERSDAM 109 JP ON LEFT CANAL FROM MARICO-BOSVELD DAM	MARICO-BOSVELD DAM-OUTLET (A3)	-25.46847	26.39283	507	15/07/1981	19/09/2011
A3H033	A31F	11a	A3H033 KROMELLENBOOG 104 JP ON LEFT CANAL FROM KROMELLENBOOG DAM	KROMELLENBOOG DAM-OUTLET (A3)	-25.44281	26.34569	284	15/07/1981	24/08/2009
A3R004	A32C	11a	A3R004 MOLATEDI DAM AT EERSTEPOORT 136 KP ON MARICORIVIER NEAR DAM WALL	A3R004 MOLATEDI DAM (EERSTEPOORT DAM) AT LOTTERINGSKOP	-24.87017	26.454	504	09/05/1988	29/07/2011
A3H039 Q01	A32C	11a	A3H039Q01 NAAUPOORT AT MOLETEDI DAM (PIPELINE FROM DAM)	NAAUPOORT (PIPELINE FROM DAM)	-24.869722	26.453889	88	05/08/1998	15/11/2010
A3H040 Q01	A32D	11b	A3H040Q01 MARICO RIVER AT MOOIPLAATS/TZWASA WEIR ABSTRACTIO	MARICORIVIER - DRAINAGE REGION A31	-24.728889	26.418611	509	04/12/1995	06/10/2009
D4R003 Q01	D41A	9	D4R003Q01 DISANENG DAM ON MOLOPO RIVER: NEAR DAM WALL	DISANENG DAM	-25.823889	25.314722	846	01/08/1995	28/02/2012
D4R004 Q01	D41A	9	D4R004Q01 MOLOPO (RATSHIDI) - MODIMOLA DAM ON MOLOPORIVIER: NEAR DAM WALL	MODIMOLA DAM (D4)	-25.85674444	25.50934167	1013	02/08/1995	28/02/2012
D4H013 Q01	D41A	9	D4H013Q01 MOLOPO RIVER AT RIETVALLEI	MOLOPO	-25.854444	25.869167	91	29/06/1983	27/12/2002
D4H026 Q01	D41A	9	D4H026Q01 COOKE S LAKE (MOLOPO RIVER) AT MAFIKENG	MOLOPO D41A TO D42E	-25.86833306	25.65416694	394	20/10/1997	28/02/2012
D4H037 Q01	D41A	9	D4H037Q01 LOTLAMORENG DAM ON MOLOPO RIVER: NEAR DAM WALL	MOLOPO	-25.877778	25.600278	683	09/10/1995	28/02/2012
188262	D41A	9	D4MOLO-LOMAN MMABATHO - @ ROAD BRIDGE ON MOLOPO RIVER, D/S OF MAFIKENG	MOLOPO	-25.87436111	25.62455556	33	18/04/2005	17/04/2012

APPENDIX B

RAPID ECOLOGICAL RESERVE DETERMINATION STUDIES FOR THE CROCODILE WEST/MARICO WMA

TABLE OF CONTENTS

ANNEXURES

Annexure1: Map of study area

Annexure 2: FRAI tables

Annexure 3: MIRAI tables

Annexure 4: Water Quality Ecospecs, TPCs and sampling frequencies

ELECTRONIC FILES

E1: Output files from the Desktop Reserve Model

E2: Hydraulic tables

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

CD:RDM	Chief Directorate: Resource Directed Measures
DRM	Desktop Reserve Model
DWA	Department of Water Affairs
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurrence
GSM	Gravel, Mud and Sand
HI	Habitat Integrity
IHAS	Invertebrate Habitat Assessment System
MAR	Mean Annual Runoff
MIRAI	Macro-invertebrate Response Assessment Index
NWA	National Water Act
PES	Present Ecological State/Ecostatus
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
SASS5	South African Scoring System (Version 5)
SIC	Stones in Current
SOOC	Stones out of Current
TPC	Threshold of Potential Concern
VMAR	Virgin Mean Annual Runoff
WRCS	Water Resources Classification System

1. INTRODUCTION

1.1 Background

1.1.1 National Water Act

Chapter 3 of the National Water Act (NWA) (Act No. 36, 1998) requires the implementation of Resource Directed Measures (RDM) to protect the water resources of the country, based on the guiding principles of sustainability and equity. In terms of the Act, before the required authorization to utilise a particular water resource can be granted, it is necessary to determine the Reserve for the relevant ecological component of the resource that will be impacted by the proposed water use.

According to the Act all Reserve determinations that are currently determined and approved by the Department of Water Affairs (DWA) are preliminary Reserve determinations and the associated recommended class is a preliminary class (section 17(1)), until a system for the classifying of water resources has been prescribed.

The ecological component of the Reserve is defined as the quantity, quality and reliability of water required to "protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource" (National Water Act, 1998).

1.1.2 Resource Directed Measures (RDM)

Classification

The National Water Resource Classification System (WRCS) as required by the NWA in section 12 has been developed for the classification of all significant water resources. This system provides the 7 step process to classify all significant water resources and to determine the Management Class of a water resource. The Management Class is based on ecological, social and economic considerations.

Reserve

A suite of methods has been developed for determining the ecological Reserve depending on the level of accuracy and confidence in the results required. These are outlined in Volume 2 of the RDM method manuals (DWAF, 1999) and consist of approaches for Rapid, Intermediate and Comprehensive ecological Reserve determinations. The results of Reserve determinations are also linked to a level of confidence (very low to high), based on the availability of information and accuracy of the determination.

The application of the appropriate Reserve method to ensure that the necessary level of confidence in the results is obtained for the particular water resource under consideration depends on a number of factors. These include:

- The Ecological Importance and Sensitivity (EIS) of the catchment;
- The degree to which the catchment is already utilised;
- The potential impact of the proposed water use(s) to be authorised and possible future use; and
- The need to establish a catchment management plan.

The ecological Reserve is not intended to protect the aquatic ecosystem *per se*, but to maintain aquatic ecosystems in such a way that they can continue to provide the goods and services to society. The Reserve (ecological and basic human needs) is the only right to water; all other water uses are subject to authorizations.

A summary of the generic steps which form part of the procedure to determine the ecological Reserve for aquatic ecosystems is provided in Figure 1.

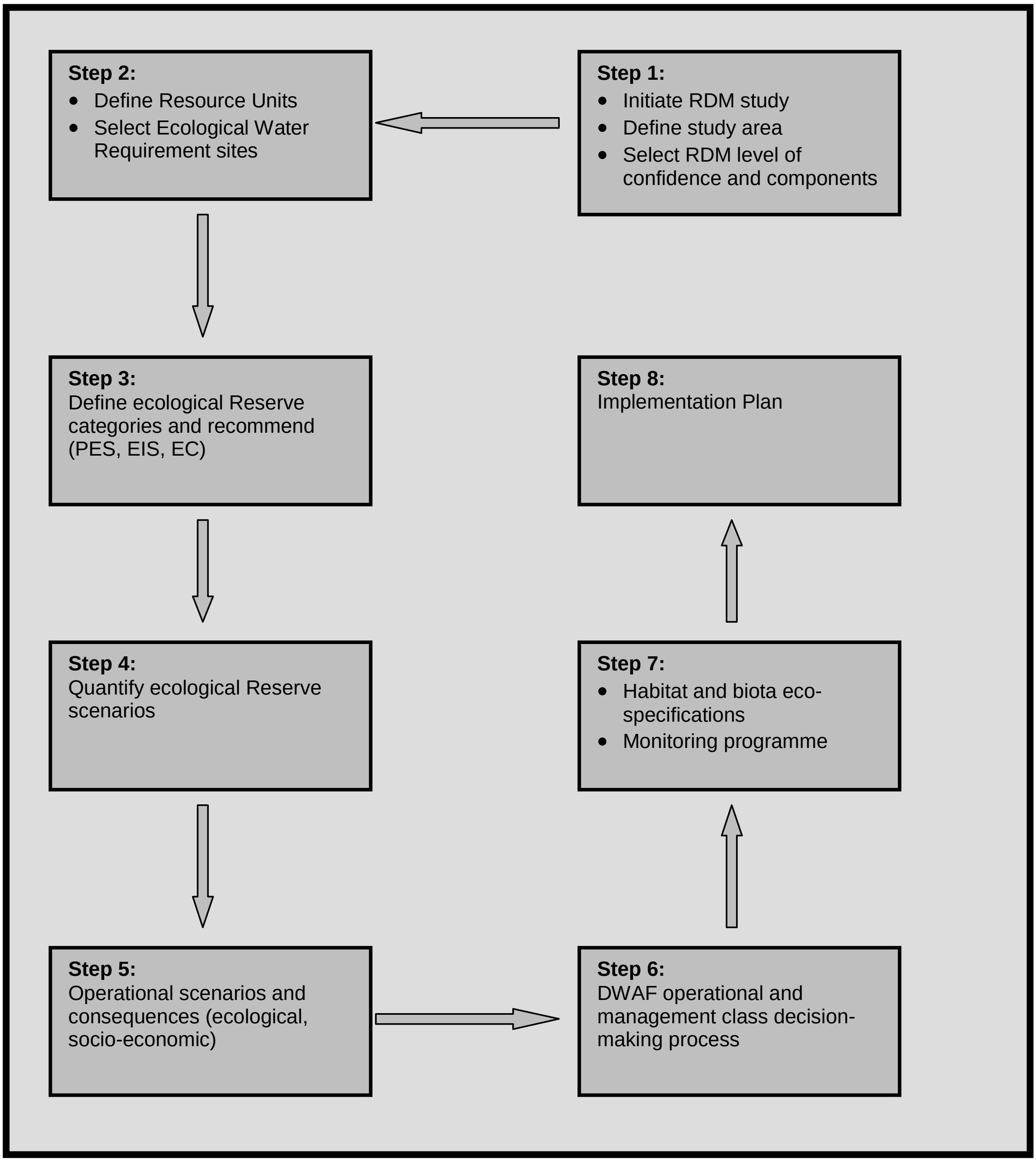

Figure 1: Generic procedure for the determination of the ecological Reserve

Resource Quality Objectives

Resource Quality Objectives (RQOs) are defined as clear goals (numerical or descriptive statements) relating to the quality of a water resource and are set in accordance to the management class (preliminary class in the absence of the classification system) specified for the resource to ensure the water resource is protected. The purpose of RQOs is to set clear objectives for the resource against which water use licenses and the related impacts can be evaluated and managed to achieve a balance between the need to protect and utilization of the resource.

1.1.3 Reserve determination procedures

The Reserve refers to the quantity and quality of water required to (i) supply basic human needs and (ii) protect aquatic ecosystems. The ecological component of the Reserve (i.e. water to protect aquatic ecosystems), refers to water quantity and water quality within the following four components:

- Groundwater;
- Wetlands;
- Rivers; and
- Estuaries.

The water quantity component for a river will typically refer to the flows and flow patterns (magnitude, timing and duration) needed to maintain a river ecosystem within acceptable limits of change, or the specified Ecological Category.

The DWA requires that a standard procedure be followed in order to determine the appropriate level of Ecological Reserve as set out in the RDM method manuals (DWAF, 1999) and any revised methodologies and approaches for each component of the water resource under consideration.

1.1.4 Purpose of this ecological Reserve determination study

The purpose of the ecological Reserve determination studies undertaken for the various rivers in the Crocodile West and Marico catchments is to provide higher confidence results than the current available desktop requirements to be used in the WRCS and to provide the necessary protection of the resource during the evaluation of water use license applications. The EWR sites selected for this study were in tributaries where no EWR information is available and where existing EWR information from previous high confidence studies could not be used for extrapolation and/or estimation.

This report provides the results of the determination of the quantity and quality requirements of the preliminary Reserve for the surface water component of the selected rivers in the Crocodile West and Marico catchments on a rapid level of detail.

The following main tasks were undertaken:

- Define the study area, delineate into resource units according to bio-physical considerations and select EWR sites.
- Undertake the field surveys for the fish, macro-invertebrates and hydraulics (flow measurement and profiling) at the selected EWR sites.

- Describe the reference conditions; determine the Present Ecological State (PES), Ecological Importance and Sensitivity (EIS), the Recommended Ecological Category (REC) and the ecological water requirements of the riversat the EWR sites.
- Prepare a report detailing the process followed, approaches, results and recommendations for the protection of the water resources and further analysis as part of the WRCS.

1.2 Study approach

The following main activities were undertaken to meet the objectives of the study:

- Field surveyswere undertaken from 28 – 31 May and 1 June 2012 (low flows) to collect data on fish, macroinvertebrates and to undertake the hydraulic measurements. It is important to note that rapid studies should ideally be undertaken during the dry season as this will provide the critical information required to ensure protection of the water resources.
- Integration of the results from the field surveys, to determine the ecostatus and ecological water requirements of the rivers at the EWR sites were done during a specialist workshop on 2 June and 25 September 2012.

The activities and tasks for this ecological Reserve determination study were undertaken in accordance with the appropriate approaches and methodologies for rivers as prescribed by the CD: RDM of DWA, namely:

- The methodology as set out in *DWAF (1999): Resource Directed Measures for Protection of Water Resources; Volume 3: River Ecosystems Version 1.0 (Revised water quality methodology, 2002)*.
- The revised methods as outlined in Louw and Hughes (2002), the Habitat Flow Stressor Response (HFSR) manual of IWR Source-to-Sea (2004) and the EcoClassification manual of Kleynhans *et al* (2005).
- Principles of a process to estimate and/or extrapolate environmental flow requirements, Kleynhans, Birkhead and Louw (2008).
- DWAF (2002): Hazard-based water quality ecological specifications for the Ecological Reserve in fresh water Resources. Report No. N/0000/REQ0000. Institute for Water Quality Studies, Department of Water Affairs and Forestry. Author: Jooste S.
- DWAF (2008): Methods for determining the water quality component of the Ecological Reserve. Report prepared for Department of Water Affairs and Forestry, Pretoria, South Africa by P-A Scherman. Draft 2, March 2008.

1.3 Structure of the report

This appendix is divided into 5 main chapters and applicable annexures, where necessary.

The main chapters are:

- **Chapter 1** provides the general background to RDM and the study approach;

- **Chapter 2** describes the study protocol followed for the assessment of the rivers at the EWR sites;
- **Chapter 3** provides the results of the field surveys and specialist workshop for the rivers assessed;
- **Chapter 4**provides the main conclusions and recommendations; and
- **Chapter 5**cites the references used in this report.

2. STUDY PROTOCOL

This section of the report provides the protocol followed for the determination of the EWRs of the various rivers in the Crocodile West and Marico catchments.

2.1 Study team

The specialists involved in the assessment are listed in Table 1**.**

Table 1: Study team for the rapid ecological Reserve determination study

TEAM MEMBER	AFFILIATION	SPECIALIZATION/TASK
Stassen R	JMM Stassen	Co-ordination, SPATSIM
Todd, C	Golder Associates	Macroinvertebrates, habitat integrity
Aiken, W	Golder Associates	Fish, habitat integrity
Farrell, K	Golder Associates	Fish, trainee
Jordanova, A	Golder Associates	Hydraulics
Naidoo, E	Golder Associates	Hydraulics, trainee
Boyd, L	Golder Associates	Physico-chemical

2.2 Study area and site visit

The study area falls within the Crocodile West/Marico water management area and focused on some of the tributaries where no or limited data is available on EWRs to provide input to the WRCS.

The tasks undertaken during the site visit end included:

- A visual “survey” of the river reaches where no or little information is available to select EWR sites;
- Finding suitable EWR Sites. This was governed by the suitability of the river channel for accurate hydraulic modeling and flow measurement, as well as the presence of habitats critical for ecosystem functioning, such as riffles. Another criteria was that the selected site were representative of the catchment to allow extrapolation and/or estimation of the results to identified hydro nodes in the catchment;

- A cross-sectional profile and longitudinal water slope of the river channels were surveyed by the hydraulic specialist with a dumpy level and the discharge was measured with the aid of a current meter at the EWR sites;
- The fish specialist sampled fish in all suitable aquatic habitats in the vicinity of the EWR sites using an electro-fish shocker and nets, and noted any man-induced habitat modifications impacting on fish fauna; and
- The macroinvertebrate specialist surveyed the aquatic macroinvertebrates occurring within the range of instream habitats at the locality using the SASS5 methodology. A habitat assessment of the site pertaining to SASS was also conducted.
- *In situ* water quality measurements were taken for pH, electrical conductivity, dissolved oxygen and temperature.

Table 2 provides information on the selected EWR sites and a map of the study area is provided in **Annexure 1**.

Table 2: EWR site information for the rivers in the Crocodile West/Marico catchments

EWR site	Quaternary catchment	River	Level of determination	Latitude	Longitude	Eco-region level 2	MAR ($10^6 m^3$)
CROC12	A23G	Buffels	Rapid 3	S 24.8304°	E 28.2224°	8.01	3.144
CROC13	A22E	Lower Elands	Rapid 3	S 25.4811°	E 26.6904°	7.03	18.77
CROC14	A22H	Waterkloof-spruit	Rapid 3	S 25.7414°	E 27.2568°	7.05	5.469*
CROC15	A21F	Magalies	Rapid 3	S 25.8969°	E 27.5982°	7.05	21.89
CROC16	A21A	Rietvlei	Rapid 3	S 26.0189°	E 28.3044°	11.01	4.788
MAR6	A31B	Polkadraai-spruit	Rapid 3	S 25.6469°	E 26.4893°	7.04	9.866

* Due to the wetland nature and almost no water use in the upstream catchment, the observed flow data from A2H038 (1971-2010) was used rather than the simulated WRSM2000 monthly flows

The following rivers were also visited during the field surveys to undertake field surveys. However, for various reasons, no field surveys were done and the desktop EWRs will be used during the classification process.

i. Bierspruit (A42D-F) – various sections of the river were visited but either no flow or standing water. Access was also limited due to extensive mining operations in the catchment. The lack of flowing water was later confirmed with Ms Hermien Roux.

ii. Upper Hex (A22G) – the sites visited were mainly pools and the upper section was dry. Biological data is available from Ms Hermien Roux and this will be used during the classification process.

iii. Lower Hennops (A21H) – The flows were too high at the site visited due to WWTW return flows to safely sample in the river. This was the lowest site where the river has already widened. No other upstream sites were considered as the flows would be even higher. Biological data from the River Health Programme will be used.

iv. Bloubankspruit – A number of sites were visited, but due to the high flows it was unsafe to sample the river.

Most of the upstream sites have biological data available. However, due to the absence of hydraulics information, it will be difficult to interpret changes in flow during the ecological consequences workshops to assess the various scenarios.

2.3 Data collection, modeling and approach

2.3.1 Hydraulics

During the site visit the following activities were undertaken:

- EWR cross sections were selected and surveyed at each EWR site;
- Longitudinal water slope was surveyed;
- Discharge was measured; and
- EWR site photographs were taken.

The measured stage-discharge data for all the Rapid III assessments are listed inTable 3.

Table 3: Measured stage-discharge data per EWR site

EWR site	River	Discharge, *Q* (m3/s)	Max. flow depth, y (m)	Slope
CROC12	Buffels	0.079	0.29	0.032
CROC13	Lower Elands	0.005	0.05	0.022
CROC14	Waterkloofspruit	0.004	0.20	0.074
CROC15	Magalies	0.074	0.23	0.017
CROC16	Rietvlei	0.160	0.33	0.004
MAR6	Polkadraaispruit	0.028	0.75	0.012

The purpose of hydraulic modelling is to provide a stage-discharge rating curve. In order to develop stage-dischargerelationships, based on a single set of observed rating data, understanding of flow resistance innatural channels is required. Flow resistance in natural channels is generally a function of stage, particularlyat low flows where the flow depth is of the same order of magnitude as the size of the roughness elementsconstituting the bed (Birkhead et al., 1997; Broadhurst et al., 1997). With increased discharge, the localhydraulic controls become inundated, resulting in a tendency towards uniform water surface gradients andasymptotic resistance coefficient values (Birkhead et al., 2002).

The values of Manning's n resistance coefficients are required for extending the observed rating data.Manning's n was estimated using experience and coefficients given in the literature (Barnes, 1967; Hicksand Mason, 1991 and Chow, 1959).

The modelled stage-discharge data for each of the EWR sites assessed on a rapid 3 level are given inTable 4.

Table 4: Hydraulic data used to extend the measured rating data

EWR site	River	Discharge, *Q* (m3/s)	Manning's resistance, *n*	Max. flow depth, *y* (m)	Surface Slope, *S* (m/m)	Ave. Velocity, V (m/s)
CROC12	Buffels	0.024	0.20	0.20	0.032	0.162
		7.541	0.05	0.80	0.032	2.055
CROC13	Lower Elands	0.026	0.04	0.10	0.015	0.373
		2.372	0.09	0.75	0.015	0.829
CROC14	Waterkloofspruit	0.004	0.18	0.20	0.074	0.190
		1.835	0.08	0.75	0.037	1.112
CROC15	Magalies	0.023	0.25	0.20	0.011	0.087
		0.850	0.12	0.55	0.011	0.345
CROC16	Rietvlei	0.004	0.13	0.10	0.004	0.059
		2.168	0.08	0.76	0.011	0.775
MAR6	Polkadraaispruit	0.006	0.17	0.10	0.012	0.089
		2.290	0.10	0.75	0.012	0.748

A general depth-discharge power relationship for open channel flow (Birkhead and James, 1998) is derivedby using:

$$y = aQb + c \quad (1)$$

where:

y is the maximum flow depth (m), *Q* is the discharge rate (m3/s), and *a, b* and *c* areregression coefficients.A continuous rating function given by equation (1) was fitted to the measured and modelled data. The rating relationship coefficients in equation (1) for the EWR sites are given inTable 5.

Table 5: Regression coefficient in equation (1)

EWR site	River	Regression coefficients		
		a	b	C
CROC12	Buffels	0.5016	0.2364	0
CROC13	Lower Elands	0.5103	0.4545	0
CROC14	Waterkloofspruit	0.6604	0.2134	0
CROC15	Magalies	0.5750	0.2822	0
CROC16	Rietvlei	0.5936	0.3237	0
MAR6	Polkadraaispruit	0.5674	0.3403	0

The stage discharge relationships developed from the modeling for each of the EWR sites are shown in figures Figure 2, Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7to follow.

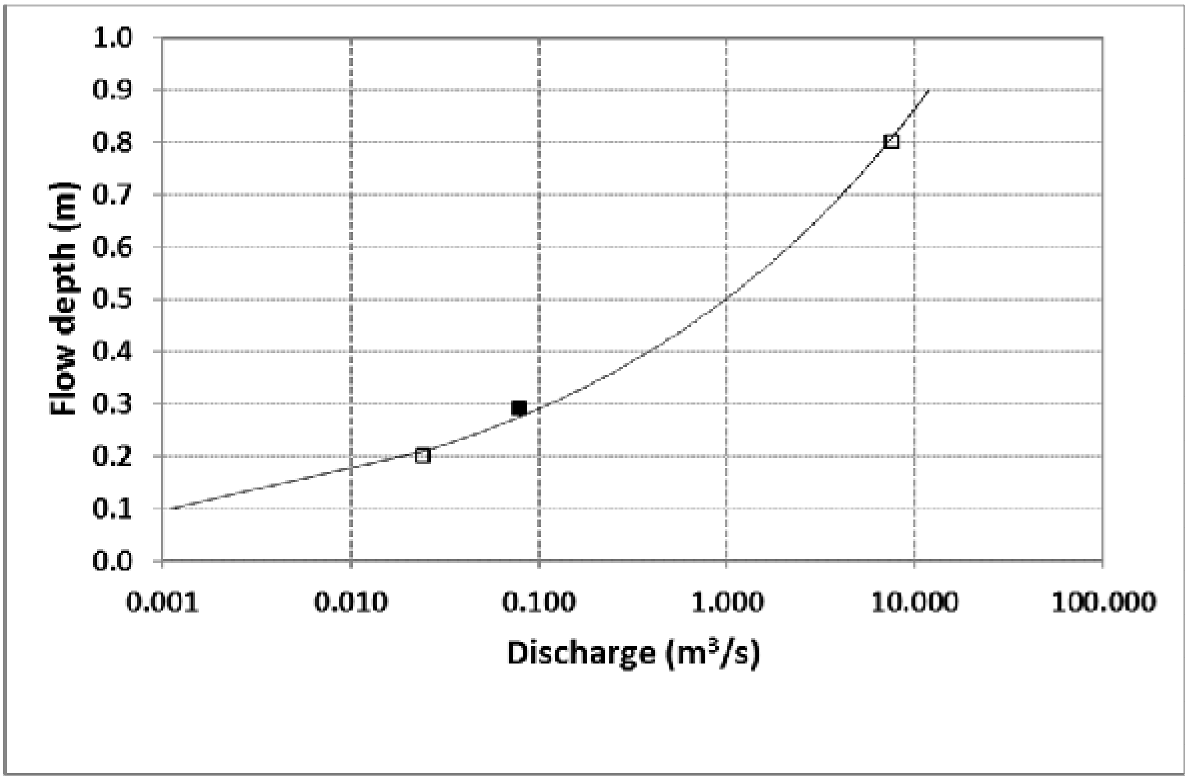

Figure 2: Relationship between flow depth and discharge for the EWR site: Buffels (Croc_EWR 12)

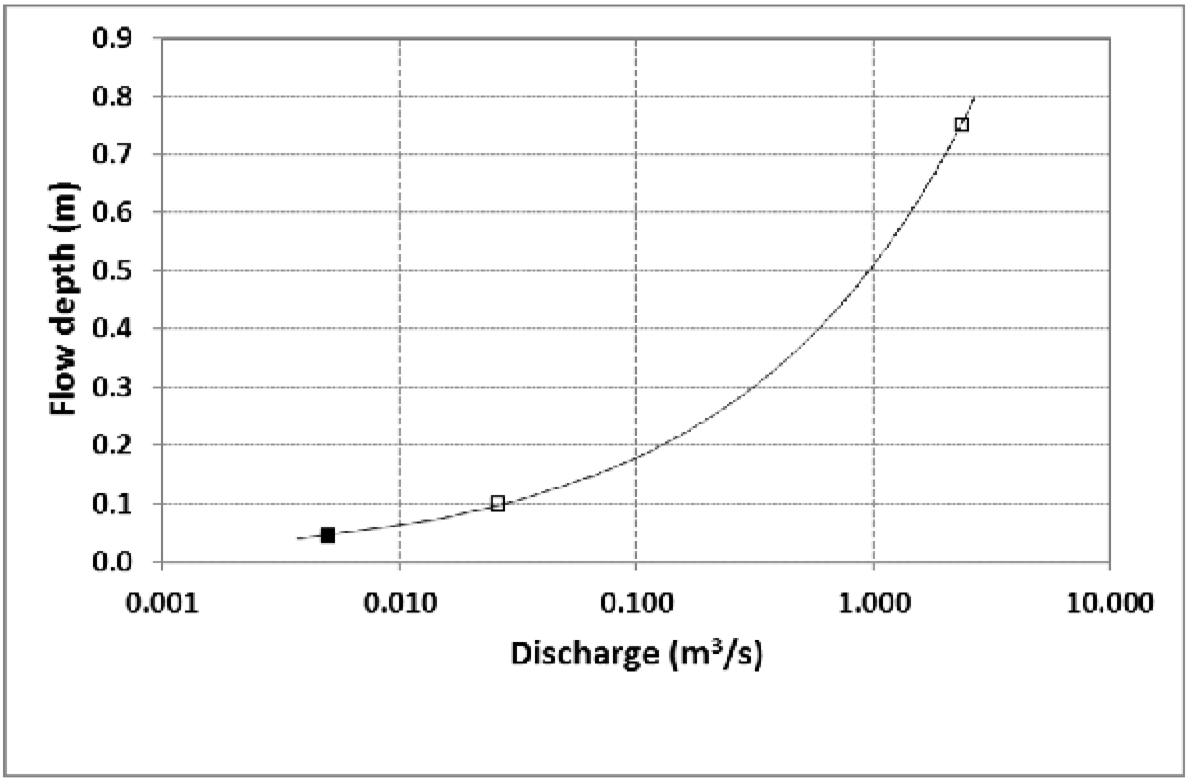

Figure 3: Relationship between flow depth and discharge for the EWR site: Lower Elands (Croc_EWR 13)

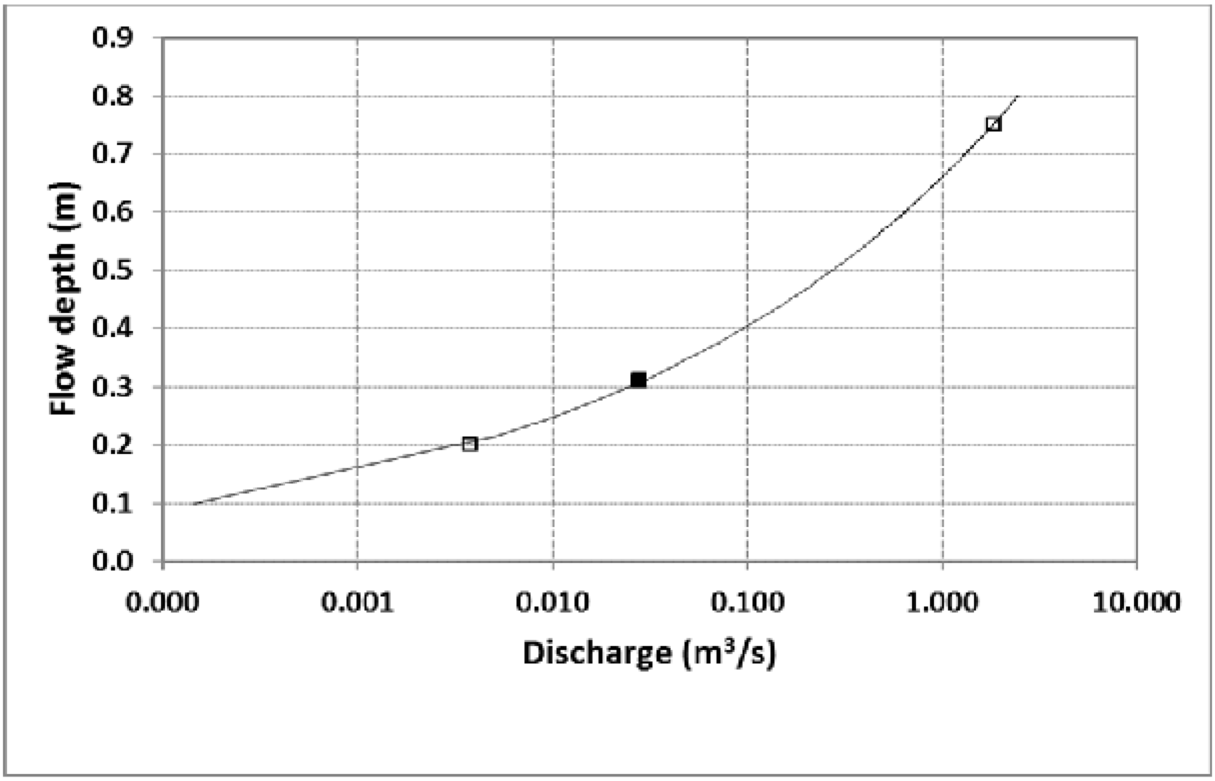

Figure 4: Relationship between flow depth and discharge for the EWR site:Waterkloofspruit (Croc_EWR 14)

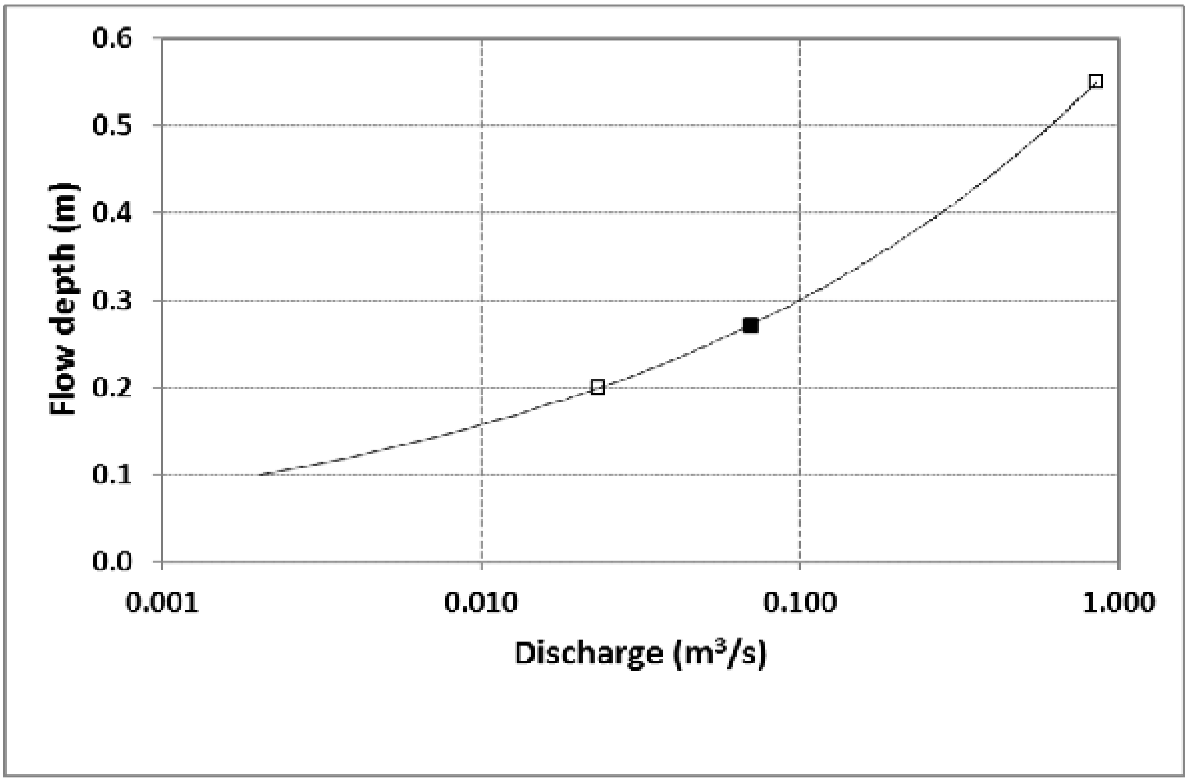

Figure 5: Relationship between flow depth and discharge for the EWR site: Magalies (Croc_EWR 15)

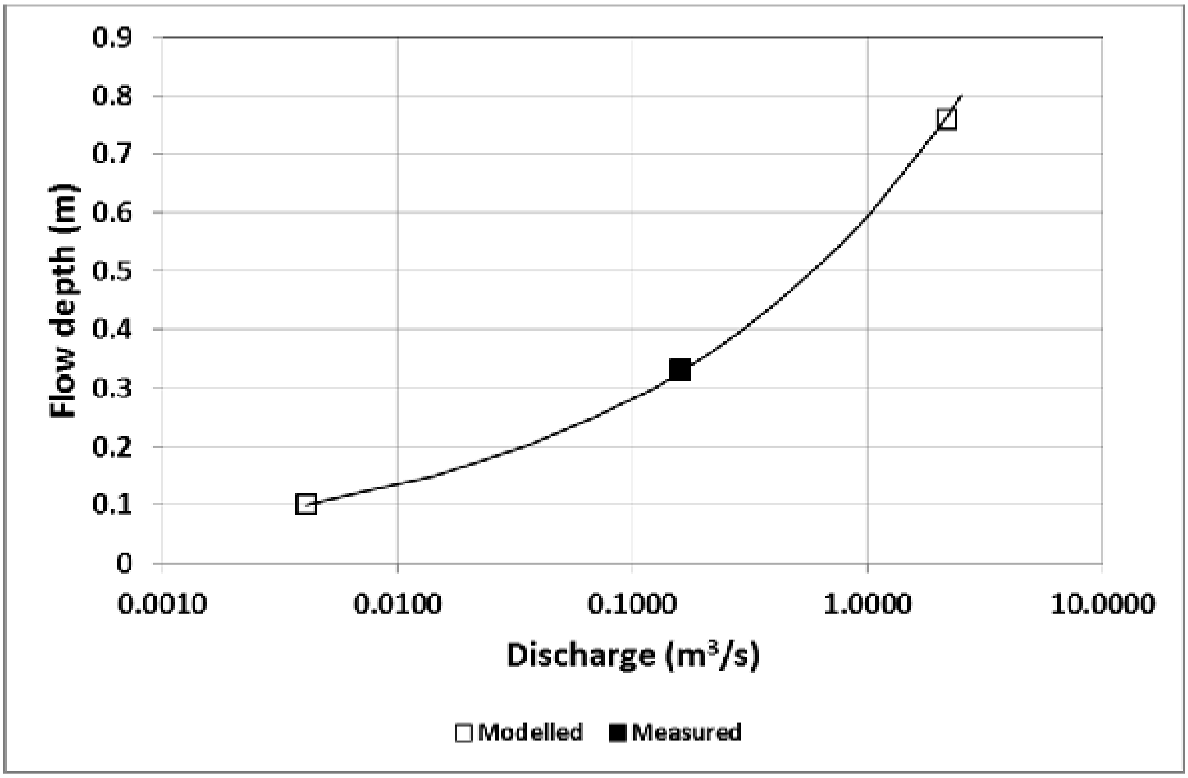

Figure 6: Relationship between flow depth and discharge for the EWR site:Rietvlei (Croc_EWR 16)

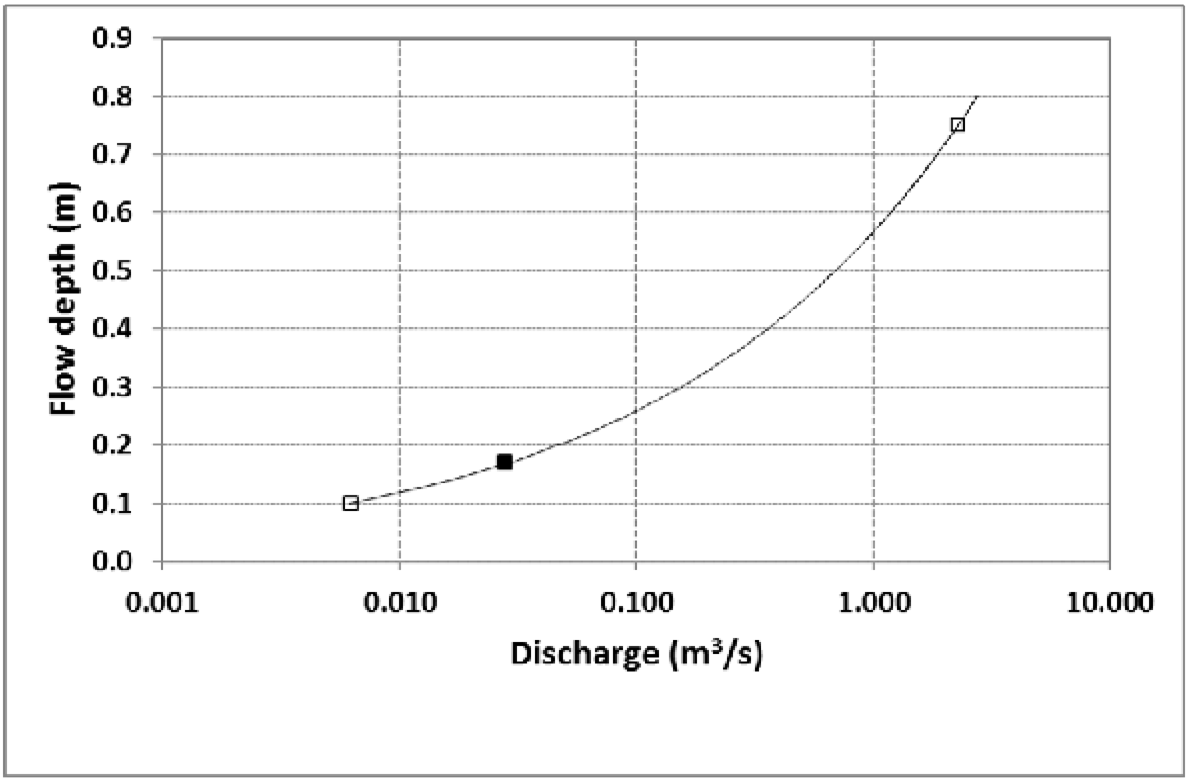

Figure 7: Relationship between flow depth and discharge for the EWR site: Polkadraaispruit(MAR_EWR 6)

The confidence rating in the hydraulic modeling results per EWR site ranges from 0=none to 5=high and is indicated in Table 6. The detailed hydraulic tables per EWR site are available electronically.

Table 6: Confidence in modeled results

EWR site	River	Limits of measured discharge range (m^3/s)	Confidence rating for discharge range	
		$Q_{measured}$	$Q < Q_{measured}$	$Q > Q_{measured}$
CROC12	Buffels	0.079		
CROC13	Lower Elands	0.005		
CROC14	Waterkloofspruit	0.004		
CROC15	Magalies	0.074		
CROC16	Rietvlei	0.160		
MAR6	Polkadraaispruit	0.028		

2.3.2 Fish

Fish sampling was undertaken at all the selected EWR sites using electro-narcosis. Electro-narcosis (conducting an electric current into the water, which immobilizes the fish momentarily) was applied at all available biotopes together with a 5mm-mesh scoop-net behind the anode of the electro shocking device. Electro shocking is highly effective and entails the use of an electronic device to rapidly catch fish in rivers. The sampling of fish by using an electro shocker is based on the fact that the flow of direct electric current (DC) in water causes an anode reaction (galvanotaxis) in fish. Under the influence of the electrical current fish are stunned and drawn towards the anode.

Observed fish assemblage diversity and abundance can vary greatly, depending on the season and the integrity of the available habitat. Based on baseline data obtained and available habitat for fish during the survey an Expected and Observed Frequency of Occurrence (FROC) of fish species was compiled. These FROC values were used to interrogate the Fish Response Assessment Index (FRAI) to evaluate changes from reference conditions.

FRAI is a rule-based model developed by DWA (Kleynhans et al., 2007) and is an assessment index based on the environmental intolerances and preferences of the reference fish assemblage and the response of the constituent species of the assemblage to particular groups of environmental determinants or drivers. These intolerance and preference attributes are categorized into metric groups with constituent metrics that relates to the environmental requirements and preferences of individual species.

Assessment of the response of the species metrics to changing environmental conditions occur either through direct measurement (surveys) or are inferred from changing environmental conditions (habitat). Evaluation of the derived response of species metrics to habitat changes are based on knowledge of species ecological requirements.

Usually,the FRAI is based on a combination of fish sample data and available habitat for fish. Changes in environmental conditions are related to fish stress and form the basis of ecological response interpretation and to determine the present Ecological Category of the fish assemblage.

Each fish specimen sampled was identified in the field to species leveland the standard length noted. Observations were also made on their general health and any anomalies were noted.

2.3.3 Macroinvertebrates

The macroinvertebrate diversity and abundance was measured at all the EWR sites. The following assessment methods were used:

- Macroinvertebrate diversity and abundance was measured using the South African Scoring System Version 5 (SASS5), (Dickens & Graham, 2002). This index measures aquatic macroinvertebrate presence at the family taxon level. The results are expressed as an index score (SASS score) and the Average Score Per Taxon (ASPT value). According to the method, each taxon is allocated a value between 1 and 15, according to its perceived sensitivity to water quality changes, with 1 being the least sensitive and 15 the most sensitive score allocated. Macroinvertebrate taxa (mostly family level) were identified and these data were entered into the Macroinvertebrate Response Assessment Index (MIRAI).
- The Invertebrate Habitat Assessment System (IHAS) was used to assist in assessing the instream and riparian habitat (McMillan, 1998). Sections of the site characterisation manual (Dallas, 2005) were used to assist in characterising the site and interpreting the data collected at the site. The data were either entered directly into the MIRAI, or were used indirectly to assist with data interpretation.
- The MIRAI is a method that uses SASS data and pre-determined reference conditions to determine the Present Ecological Status (PES) per site assessed. The three main drivers of a river are its flow conditions, geomorphology and water quality. Together, these drivers create certain instream habitat, to which the instream biota responds. The ecological category generated by the MIRAI therefore reflects the integrated driver condition at a site, as well as the response of the macroinvertebrates to the various driver components. Thus the MIRAI ecological category gives an indication of the ecological integrity of the resource at the site assessed.
- Historic sampled data and specialist knowledge were used to obtain the reference conditions. This data was included in the MIRAI along with the data obtained from the field assessments.

2.3.4 Hydrological data

Updated hydrology available from DWA for the Crocodile West (2008) and the Marico (2009) catchments were used as the basis. The data used is the same that was used during the intermediate Reserve determination studies undertaken for the rivers of the Crocodile West and Marico catchments from 2009 to 2012.

The natural MAR at the various EWR sites were determined using flow data from the above studies and the catchment areas at the selected EWR sites. Table 7 provides the natural MAR at each EWR site.

Table 7: Natural MAR at the selected EWR sites

EWR site	Quaternary catchment	River	MAR ($10^6 m^3$)
CROC12	A23G	Buffels	3.144
CROC13	A22E	Lower Elands	18.77
CROC14	A22H	Waterkloofspruit	5.469*
CROC15	A21F	Magalies	21.89
CROC16	A21A	Rietvlei	4.788
MAR6	A31B	Polkadraaispruit	9.866

* Observed flow data from A2H038 (1971-2010)

2.3.5 Physico-chemical data

Water quality data for the catchment was sourced from various databases and studies previously undertaken in the area. In situ data was also collected during the field surveys.

Details of the water quality assessment and methods used for this rapid assessment are given in DWAF (2008). The Physio-Chemical Driver Assessment Index (PAI) model can be used to disaggregate the overall water quality category into individual scores for each variable (e.g., dissolved oxygen [DO] or nutrients). Available water quality data was used and linked to the findings of the ecologists. The water quality ecospecs and TPCs were derived using methods from DWAF (2006).

The coordinates of the selected EWR sites and water quality site are given in Table 8.

Table 8: Coordinates of the EWR sites and notes on the water quality sites

EWR site		River	Co-ordinates of EWR site	Notes for water quality sampling point
1	EWR_CROC 12	Buffelspruit (Plat)	-24.8304; 28.2224	Upstream of dam in canal, no water quality site further down in the catchment
2	EWR_CROC 13	Lower Elands	-25.48108; 26.69039	150m upstream of EWR site
3	EWR_MAR 6	Polkadraaispruit	-25.64697; 26.48928	At site no additional water quality sites
4	EWR_CROC 14	Waterkloofspruit	-25.7414; 27.2568	Approximately 1.1 km downstream of EWR site
5	EWR_CROC 15	Magalies	-25.89690; 27.59820	Approximately 3km downstream of EWR site
6	EWR_CROC 16	Rietvlei	-26.01885; 28.30442	At EWR site

Water quality data was selected according to the availability of data and the locality of the water quality monitoring sites with respect to the EWR sites. It is important to note that the water quality data was on the whole very limited. The water quality data used is from the

DWA WMS data base. The level of confidence for the water quality data is set out in Table 9.

Table 9: Water quality data confidence

Data availability	Number of samples	Confidence
Sampling point 90222: Buffelspruit (Plat)	16	Low
Sampling point 90221: Elands upstream	233	High
Sampling point 188121: Waterkloofspruit	3	Very low
Sampling point 100000807: Magalies	39	Moderate
Sampling point 100000763: Rietvlei	102	High
Sampling point 188252: Polkadraaispruit	6	Very low
Sampling point 90328 (AH004)	225	Moderate

The driving issues on water quality at the EWR sites are set out in Table 10 .

Table 10: Water quality drivers

EWR site	Drivers
EWR_CROC 12	Nutrients; agriculture, cattle,
EWR_CROC 13	Nutrients: upstream domestic wastewater treatment works (Swartruggens), agriculture,
EWR_CROC 14	Limited impacts
EWR_CROC 15	Nutrients: intensive agriculture, urban, domestic wastewater treatment works
EWR_CROC 16	Nutrients: urban, agriculture
EWR_MAR 6	Nutrients: limited irrigation, agriculture, chicken farms upstream,

The sampling undertaken during the field visit is summarized in Table 11 and the statistical data in Table 12.

Table 11: Field results for physic-chemical parameters

EWR site	WMS site	River	DO (mg/l)	Temp (°C)	pH	TDS (mg/l)	EC (mS/m)
EWR_CROC 12	90222	Buffelspruit (Plat)	6.28	14.8	9	204	41.3
EWR_CROC 13	90221	Lower Elands	5.03	17.9	8.3	944	190.8
EWR_MAR 6	188252	Polkadraaispruit	5.93	12.7	8.3	484	96.9
EWR_CROC 14	188121	Waterkloofspruit	6.78	10.2	9	170	33.4
EWR_CROC 15	100000807	Magalies	6.56	14	8.2	1700	339
EWR_CROC 16	100000763	Rietvlei	8.1	14.5	8.7	2320	472

Table 12: Statistical water quality data for the water quality sampling points

EWR site	Sampling point ID	River	5th percentile	95th percentile	Inorganic Salts (mg/l)					95th percentile	Toxics (µg/l)		Nutrients (mg/l)	
					95th percentile						95th percentile		50th percentile	
			pH		Na	Ca	Mg	Cl	SO_4	EC mS/m	NH_4	F	PO_4	TIN
EWR_CROC 12	90222 N=16	Buffelspruit (Plat)	6.1	7.7	5.1	6.3	2.8	5.2	10.2	17.2	60	400	0.03	0.6
EWR_CROC 13	90221 N=233	Lower Elands	7.5	8.1	8.6	14.2	9.9	10.1	14.8	21	420	250	0.05	0.3
EWR_CROC 14	188121 N=3	Waterkloof spruit	7.1	7.6	3.6	1.1	3.2	3.6	6.8	5	19	155	0.012	0.06
EWR_CROC 15	100000807 N=39	Magalies	7.2	8.3	-	37	-	46	85	55	1080	340	0.05	0.4
EWR_CROC 16	100000763 N=102	Rietvlei	7.2	8.8	19.4	41	22	35	112	55	1100	300	0.05	0.6
EWR_MAR 6	188252 N=6	Polkadraai spruit	7.7	7.8	5.5	10	9	5.3	7.7	16	70	200	0.03	0.04

nd: no data

2.4 Specialist workshop (EcoClassification workshop)

The results of the field assessments of the various habitat and biotic components to obtain the Ecostatus and the recommended ecological category (REC) were compiled after the completion of the site visit. This assessment took place during the ecoclassification workshop with input from all the specialists. The process included the determination of the following:

Reference conditions: those conditions that occur under natural conditions before anthropogenic impacts.

Present Ecological State (PES) or ecostatus: the determination of the current state of the resource through rule-based models for the driver components (geomorphology – GAI, hydrology – HAI and water quality – PAI) and for the biological response components (fish – FRAI, macro-invertebrates – MIRAI and vegetation – VEGRAI). A rule-based model is then used to derive the ecostatus or overall/integrated condition/health of the resource by integrating the driver and response status. Only the FRAI and MIRAI models are used during a rapid ecological assessment. Where applicable, the PAI model is also used.

Ecological Importance and Sensitivity (EIS): the ecological importance is defined by Kleynhans (1999), and is regarded as an expression of the water resource’s ability to maintain the ecological diversity and functioning on local and wider scales. The ecological sensitivity refers to the river’s ability to recover from disturbance. The EIS model (Kleynhans 1999, updated 2002) was used to determine the EIS.

Habitat Integrity (HI): the Habitat Integrity model (Kleynhans, 1996) was used to evaluate the habitat integrity of both the instream and riparian components in the vicinity of the EWR sites. This assessment model is based on the qualitative assessment (allocation of scores) for various impact criteria on both the instream and riparian zones.

Recommended ecological category (REC): the PES and EIS is used in the decision on the REC as well as the feasibility to realistically be able to maintain or improve the current condition of the water resource.

Ecological Water Requirements: the Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (quantity) for the recommended ecological category at the EWR sites. This EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model to be evaluated by the ecologists. Where the modeled requirements were not adequate to provide the envisaged protection, the DRM was adjusted accordingly.

Final ecological Reserve results: the EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3. RESULTS

The results of the ecological water requirements of the rivers of the Crocodile West and Marico catchments at the selected EWR sites are presented in this section.

3.1 Buffels River, tributary of the Plat River (CROC12): Rapid 3

3.1.1 EWR site evaluation

The selected EWR site (Figure 8) falls in quaternary catchment A23G and is situated downstream of a wetland area. The EWR site is just before the confluence of the Buffels River with the Plat River. An EWR site on the Plat River would have been preferred, but all the possible sites visited on the Plat River had limited flows due to instream dams and water abstraction for irrigation. A gauging weir (A2H065) is situated just upstream of the EWR site with data from 1985 to 2012.

The site is characterised by large and small boulder-dominated riffles with some cobbles, sparse marginal vegetation and limited gravel and sand. A run area is downstream of the surveyed cross-section.

Figure 8: View of the Buffels River EWR site in A23G

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in Table 13.

Table 13: Buffels River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics			
Fish	3	• Diversity of velocities present • Diversity of instream habitats present	• Only 5 out of the 12 expected fish species were present in low abundances at the site. • Instream obstructions in the form of a cement slab lying within the water course and diverting flow. This could potentially prevent the migration of fish species upstream.
Macroinvertebrates	3	• Good quality & quantity of cobble biotope present • Diversity of velocities present • Diversity of instream habitats present • Site situated downstream of a wetland	• Limited SOOC biotope present • Limited MVIC and MVOOC biotope present • Algae present on rocks • Concrete instream structure diverting flow

* Confidence scores: 0 = no confidence; 5 = high confidence

3.1.2 *Information Availability*

The available information for the EWR site is summarized in Table 14. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 14: Information availability for theBuffels RiverEWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						Once off monitoring; gauge upstream
Hydrology						Updated monthly hydrology was used for the period 1920-2003. Gauge A2H065 (1985 - 2012) is situated just upstream of the site
Fish						Expected fish species lists obtained from Dr Neels Kleynhans at DWA (2007), Skelton (2001) and May 2012 data set.
Macroinvertebrates						Single data set available
Physico-chemical						9 sampling events prior to 1987

3.1.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Buffels River per specialist component are summarized in Table 15**.**

Table 15: Description of reference conditions for the Buffels River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Barbus brevipinnis, Labeobarbus marequensis, Barbus paludinosus, Barbus trimaculatus, Barbus unitaeniatus, Chetia flaviventris, Clarias gariepinus, Labeo cylindricus, Labeo molybdinus, Oreochromis mossambicus, Pseudocrenilabrus philander, Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 220 Average Score Per Taxon (ASPT):7 List of taxa expected include: Perlidae, Baetidae >2spp., Tricorythidae, Heptageniidae, Leptophlebiidae, Lestidae, Chlorocyphidae, Aeshnidae, Libellulidae, Nepidae, Hydropsychidae >2pp., Leptoceridae, Psephenidae, Simuliidae, Athericidae, Dixidae, Ancylidae, Sphaeriidae.

Physico-chemical reference for Crocodile (West) catchment

As for the intermediate Reserve determination study undertaken for the Crocodile (West) catchment, the reference site chosen for the Crocodile (West) catchment is located on the lower reaches of the Magalies River, downstream of the confluence with the Skeerpoort River and upstream of Hartebeespoort Dam. The Magalies River upstream of this confluence is impacted by farming practices, water abstraction and flow modification and the River Health Programme has categorised it as poor with a moderate EIS (River Health Programme, 2005). However, the water coming in from the Skeerpoort River originates from a number of dolomitic eyes (e.g. the Nouklip Eye) which are still in pristine condition. As part of the report referenced above, the Skeerpoort River was classified as natural, with a high EIS. The physico-chemical reference conditions are presented in Table 16.

Table 16: Reference conditions for the Crocodile West catchment (WMS ID A2H013)

Component	**Description of Reference Conditions**		
Physico-chemical:	Physical Variables:	pH:	>= 7.5 (5th percentile) and <= 8.6 (95th percentile)
		EC:	<= 46.27 mS/m (used as a surrogate for salts)
		Temperature:	Catchment natural, no known problems with temperature. All temperature sensitive species present in abundances and frequencies of occurrence as expected for reference
		Clarity:	Some man-made modifications of the catchment, no known concerns about turbidity, changes in turbidity appears to be natural and related to natural catchment processes such as rainfall runoff.
		Oxygen:	>8.0 mg/ ℓ
	Nutrients:	PO_4 Median	<0.019 mg/ ℓ

Component	Description of Reference Conditions		
		TIN Median	<0.77 mg/ ℓ
	Toxins:	Ammonia	<20µg/ℓ

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the May 2012 survey the following fish species were present at the site:

- *Barbus brevipinnis;*
- *Labeobarbus marequensis;*
- *Chetia flaviventris;*
- *Pseudocrenilabrus philander;* and
- *Tilapia sparrmanii.*

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a C (70.5) present state mainly due to low species diversity and abundance at the EWR site. A cement slab was identified lying within the water course where sampling took place. This was thought to potentially prevent the fish species from migrating upstream. However, as fish species were recorded upstream of this obstacle, this may not be the case.Furthermore, several of the expected fish species no longer occur in this section of the river and upstream migration from refuge areas for re-establishment no longer available potentially due to the in-stream dam located upstream of the sample point.

The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a C (77.6%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water flow modification at 75.3%, followed by instream habitatat 78.6%, followed closely by the water qualitymetric at 78.8%.

Table 17 provides a summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include,Baetidae, Potamonautidae, Coenagrionidae, Aeshnidae, Chlorocyphidae, Hydropsychidae andPsephenidae.

Table 17: Summary of the data interpretation and the PES for the macroinvertebrates

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	75.3	*0.321*	24.2076	2	90
HABITAT	**H**	78.6	*0.321*	25.261	2	90
WATER QUALITY	**WQ**	78.8	*0.357*	28.125	1	100
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						280
INVERTEBRATE EC				77.5936		
INVERTEBRATE EC CATEGORY				**C**		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for standing water had the highest rating of 2, being impacted the most from the reference condition.

The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site. The occurrence of taxa with a preference for loose cobbles and vegetation is rated at 2, showing the highest impact at this site.

Taxa with a low and very low requirement for unmodified physic-chemical conditions have been rated the most at 2, indicating the most impacted metrics.

Annexure 3 provides the detailed tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Buffels River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in Table 18 and Table 19 respectively. The instream and riparian zone integrity is in a B category. The main impacts on the habitat integrity of the system are bed modifications due to the upstream weir and bridges and the presence of alien vegetation.

Table 18: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	May 2012 (Buffels EWR site)	COMMENT
VEGETATION REMOVAL (IMPACT 1-25)	2	Clearing of vegetation at the upstream weir
EXOTIC VEGETATION (IMPACT 1-25)	5	Eucalyptus, poplars, brambles
BANK EROSION (IMPACT 1-25)	3	Below culverts and causeway
CHANNEL MODIFICATION (IMPACT 1-25)	5	Poplars downstream site
WATER ABSTRACTION (IMPACT 1-25)	1	
INUNDATION (IMPACT 1-25)	2	Low water bridge just upstream of the site
FLOW MODIFICATION (IMPACT 1-25)	1	
WATER QUALITY (IMPACT 1-25)	1	
RIPARIAN VEGETATION INTEGRITY SCORE *	86.0	
RIPARIAN INTEGRITY CATEGORY	**B**	

* Weighted riparian integrity score

Table 19: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	May 2012 (Buffels EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	4	Few small dams upstream
FLOW MODIFICATION (IMPACT 1-25)	5	Weir and low water bridge upstream
BED MODIFICATION (IMPACT 1-25)	6	Weir, low water bridge and main bridge
CHANNEL MODIFICATION (IMPACT 1-25)	4	Bridge causes sedimentation and channelization
WATER QUALITY (IMPACT 1-25)	2	Silt increases, algae, nutrient enrichment
INUNDATION (IMPACT 1-25)	4	Concrete slabs from old bridge, dams upstream
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	
EXOTIC FAUNA (IMPACT 1-25)	0	
SOLID WASTE DISPOSAL (IMPACT 1-25)	2	General littering

IN STREAM HABITAT INTEGRITY SCORE *	86.4	
INSTREAM INTEGRITY CATEGORY	**B**	

* Weighted instream integrity score

(iv) Physico-chemical

The available physico-chemical data were fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings were used with the overall confidence as low since important constituents such as dissolved oxygen and temperature have insufficient data available and data is limited and very old.

The results have been determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the stream based on the current condition of the resource.Table 20shows the results of this assessment for the Buffels River.

Table 20: PAI table for the Buffels River

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	0.00	**60.00**		**50.00**
Salts	0.50	NONE SPECIFIED	0.00	**50.00**		**55.00**
Nutrients	0.50	NONE SPECIFIED	0.00	**75.00**		**60.00**
Water Temperature	1.50	N	0.00	**55.00**		**50.00**
Water clarity	0.50	NONE SPECIFIED	0.00	**50.00**		**60.00**
Oxygen	1.50	N	0.00	**65.00**		**75.00**
Toxics	1.50	N	0.00	**100.00**		**100.00**
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	**0.92**	**MEAN CONF ®**	**0.00**			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	**0.92**					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	**0.94**					

FINAL PC MODIFICATION RATING	**1.00**
P-C CATEGORY %	**P-C CATEGORY**
80.00	**B**

(v) Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in Table 21. The main impacts on the Buffels River areincreased flows as well as the poor water quality due to discharges from agriculture and increased urbanization upstream of the site.

Table 21: PES per component for the Buffels River

COMPONENT	PES	EXPLANATION
Fish	C	Expected species: 12 Previously recorded species: 11 Observed species: 5 The sampling was conducted on a tributary adjacent to the Buffels River. The tributary has a small capacity and low water velocity and depth. Consquentely, species associated with the larger Buffels River, namely *Labeo cylindricus* and *Labeo molybdinus* were not recorded.
Macro-invertebrates	C	SASS5 score: 214 No of Taxa: 33 ASPT: 6.5 Key taxa expected but not observed were generally those that show preference for the vegetation biotope, such as Lestidae, Haliplidae and Pleidae. Psephenidae and Potamonautidae were more abundant than expected, while Heptageniidae, Coenagrionidae and Simuliidae were less abundant than expected.
Habitat Integrity: Instream	B	IN STREAM HABITAT INTEGRITY SCORE: 86 Few small dams upstream; Weir and low water bridge upstream; Weir, low water bridge and main bridge; Bridge causes sedimentation and channelization; Silt increases, algae, nutrient enrichment; Concrete slabs from old bridge, dams upstream; general litter
Habitat Integrity: Riparian	B	RIPARIAN VEGETATION INTEGRITY SCORE: 86.4 Clearing of vegetation at the upstream weir; Eucalyptus, poplars, brambles; Below culverts and causeway; Poplars downstream site Low water bridge just upstream of the site
Physico-chemical	B	Elevated nutrients

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Buffels River are shown in

Table 22.

Table 22: Integrated results for the Buffels River

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	4	90		
2.What is the natural diversity of **fish** species with a preference for different cover types	5	100		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	4	90		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	3	75		
FISH ECOLOGICAL CATEGORY	16	355	**64.4**	**C**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	4	100		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	90		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	90		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**10**	280	**77.6**	**B/C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		635	**71.3**	**C**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	3	0.50	32.20
Confidence rating for **macro-invertebrate** information	3	0.50	38.80
	6	1.00	71.00
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**86.0**	**B**

ECOSTATUS	Confidence rating	Proporitons	Modified weights
Confidence rating for instream biological information	3	0.50	35.50
Confidence rating for riparian vegetation zone information	3	0.50	43.00
	6	1.00	78.50
ECOSTATUS	**EC**		**B/C**

Ecological Importance and Sensitivity (EIS)

The EIS for the Buffels River was determined as moderate as presented in Table 23.

Table 23: Ecological Importance and Sensitivity of the Buffels River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	
Unique (endemic, isolated)	0	
Intolerant (flow and flow related water quality)	2	Inverts: Perlidae, Heptageniidae, Hydropsychidae Fish: BBRI (Barbus brevipinnis) (no flow and modified water quality)
Species/taxon richness	3	33 invertebrate families. ASPT= 6.5 5 of 12expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	3	Riffle, pool, run, GSM, marginal veg, veg in and out of current, SIC, SOC, some bedrock, rapids, undercut banks
Refugia	2	All similar rivers in area dry
Sensitivity to flow changes	2	Small stream
Sensitivity to flow related water quality changes	1	
Migration route/corridor (instream and riparian)	0	
Importance of conservation and natural areas	2	Bateleur Nature Reserve upstream
MEDIAN OF DETERMINANTS	**2.0**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**MODERATE**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Buffels River is a B/C category and the EIS is moderate. No specific rare, endangered or unique species are present in the system. It is thus recommended that the REC for the Buffels River remains a B/C category.

3.1.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of B/C for the Buffels River at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for August and February. August is the lowest flow month and February the highest flow month based on the natural time series. May was used as the datum.

The water level in the Buffels River during the site visit on 28 May 2012 ($0.079 m^3/s$) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge, Figure 9) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements

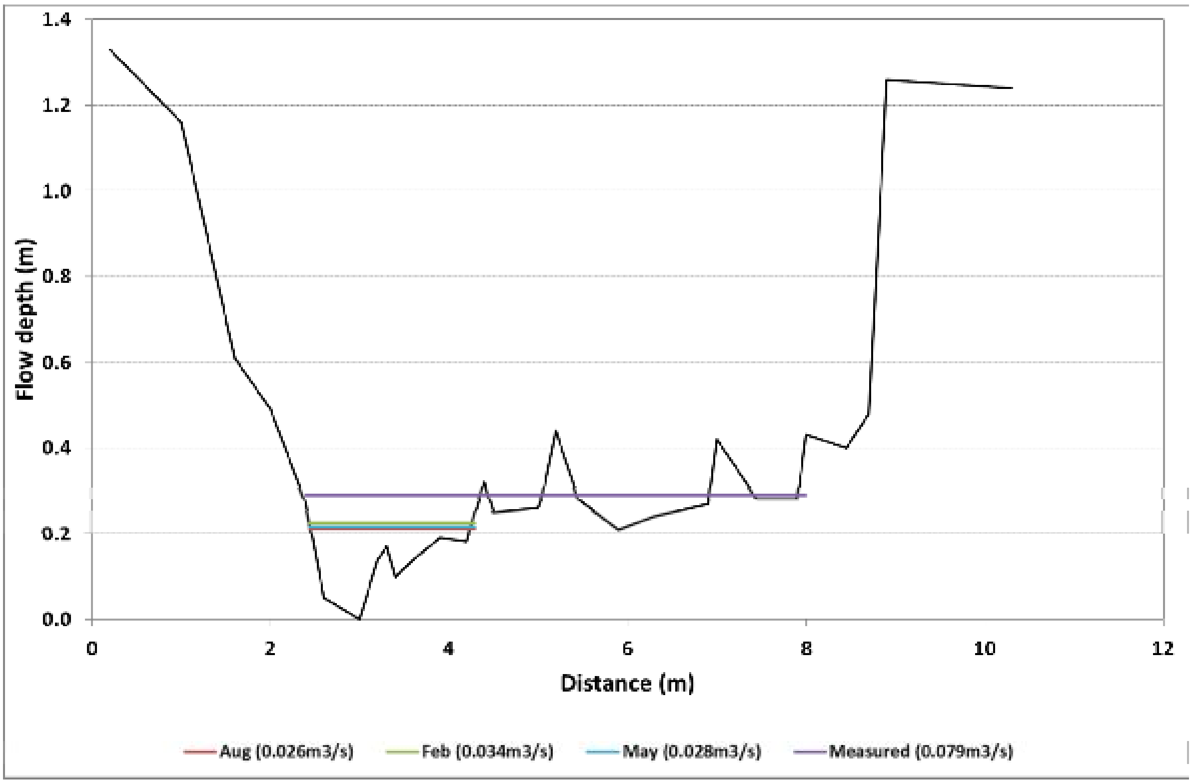

Figure 9: Calibrated cross-sectional profile of the Buffels River at the EWR site

The site-specific flow requirements were based mainly on the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of August was not adequate to maintain the system in aB/C category. The maintenance low flows were adjusted as follows to provide the necessary velocities for macroinvertebrates:

May 0.022 - 0.028m^3/s

August 0.021 - 0.026m^3/s

February 0.027 - 0.034m^3/s

Table 24 gives the results of the DRM at the EWR site in the Buffels River in quaternary catchment A23G and

Table 25 provides a summary of the recommended requirements.

Table 24:Results of the DRM for the BuffelsRiver (REC = B/C)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flow month	August	0.026	0.21	0.09	0.14
High flow month	February	0.034	0.23	0.09	0.15
Datum	May	0.028	0.22	0.09	0.14
Measured discharge at site visit (28 May 2012)		0.079	0.29	0.09	0.19

Table 25: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	A23G
River	Buffels
EWR Site Co-ordinates	S 24.8304°; E 28.2224°
Recommended Ecological Category	B/C
VMAR for Quaternary Catchment Area	3.14
Total EWR	1.126 (35.85 %MAR)
Maintenance Low flows	0.863 (27.48 %MAR)
Drought Low flows	0.272 (8.67 %MAR)
Maintenance High flows	0.263 (8.37 %MAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Buffels River are provided in **Annexure 4**.

3.2 Lower Elands River (CROC_EWR 13): Rapid 3

3.2.1 EWR site evaluation

The selected EWR site falls in quaternary catchment A22E and is situated downstream of Lindleyspoort Dam. The flow was very low due to no releases being made from the dam into the river. Water from the dam is released into a canal system for irrigation purposes. Data from the flow record at the dam (A2R007) is available from 1939 to present.

The site is characterised by large and small boulder-dominated riffle with some cobbles, sparse marginal vegetation and limited gravel and sand. A run area is downstream of the surveyed cross-section.

Figure 10: View of the Elands River EWR site in A22E

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in Table 26**.**

Table 26: Elands River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics			
Fish	3	• Length of run >10m for sampling	• Four of the expected 17 fish species were recorded at the Elands River in low abundances.

Component	Confidence Score*	Advantages	Disadvantages
			• Majority of the fish species sampled at the site showed signs of abnormalities in the form of black spots all over their body and fins representing parasites. Therefore, the health of the species was not considered good and consequently, this could potentially be one of the influences limiting the diversity and abundance of fish species within this reach.
Macroinvertebrates	2	• Length of run >10m for sampling • No algae present on rocks	• Limited SIC and SOOC present • Limited MVIC and MVOOC present • Limited gravel and sand present • Site downstream of road bridge

* Confidence scores: 0 = no confidence; 5 = high confidence

3.2.2 Information Availability

The available information for the EWR site is summarized in Table 27. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 27: Information availability for the Elands River EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						Once-off monitoring
Hydrology						Updated monthly hydrology was used for the period 1920-2003. Data fromLindleyspoort Dam (A2R007) is available for the period 1939– 2012.
Fish						Expected fish species lists obtained from Dr Neels Kleynhans at DWA (2007), Skelton (2001) and May 2012 data set.
Macroinvertebrates						Historic SASS data from June 2006, as well as present day data used.
Physico-chemical						Historic data from 2001 to 2011

3.2.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Elands River per specialist component are summarized in Table 28.

Table 28: Description of reference conditions for the Elands River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Anguilla mossambica, Amphilius uranoscopus, Labeobarbus marequensis, Barbus motebensis, Barbus paludinosus, Labeobarbus polylepis, Barbus trimaculatus, Barbus unitaeniatus, Clarias gariepinus, Chiloglanis pretoriae, Labeo cylindricus, Labeo molybdinus, Mesobola brevianalis, Oreochromis mossambicus, Pseudocrenilabrus philander, Tilapia sparrmanii, Barbus mattozi*
Macroinvertebrates	SASS5 scores: 220 Average Score Per Taxon (ASPT): 6 List of taxa expected include: Baetidae >2pp., Leptophlebiidae, Heptageniidae, Perlidae, Tricorythidae, Libellulidae, Ecnomidae, Psephenidae.

The physico-chemical reference conditions for the Elands River are presented in Table 16 for the Crocodile (West) catchment.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the May 2012 survey the following fish species were present at the site:

- *Pseudocrenilabrus philander;*
- *Labeobarbus marequensis;*
- *Tilapia sparrmanii; and*
- *Barbus paludinosus.*

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a C/D (57.6) present state mainly due to the poor water quality at the EWR site. Several of the expected fish species no longer occur in this section of the river and upstream migration from refuge areas for re-establishment no longer available potentially due to the in-stream dam located upstream of the sample point. It must be noted that majority of the fish species sampled at the site showed signs of abnormalities in the form of black spots all over their body and fins representing parasites. Therefore, the health of the species was not considered good and consequently, this could potentially be one of the influences limiting the diversity and abundance of fish species within this reach.

The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and 6%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water quality at 54.9%, followed by flow modification at 68.8%, followed by the habitatmetric at 74.6%. Table 29 provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include, Baetidae, Caenidae, Gomphidae, Aeshnidae, Chlorocyphidae and Gyrinidae.

Table 29: Macroinvertebrate Ecological Category, MIRAI

			INVERTEBRATE EC: BASED ON WEIGHTS OF METRIC GROUPS			
INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	68.8	*0.370*	25.4902	1	100
HABITAT	**H**	74.6	*0.333*	24.8627	2	90
WATER QUALITY	**WQ**	54.9	*0.296*	16.2573	3	80
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						270
INVERTEBRATE EC				66.6103		
INVERTEBRATE EC CATEGORY				**C**		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for very fast flowing water and standing water had the highest rating of 2.5, being impacted the most from the reference condition.

The occurrence of taxa with a preference for loose cobbles had been impacted the most from reference, with an allocated rating of 3 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site.

According to the water quality metrics, the number of taxa with a moderate requirement for unmodified physico-chemical conditions has been impacted the most with an allocated rating of 3.5. The SASS and ASPT scores were ranked the highest, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest.

Annexure 3 provides the detailed tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Elands River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in Table 30 and

Table 31 respectively. The instream habitat integrity is in a C category. The main impact on the instream habitat is the reduced flows due to no releases from Lindleyspoort Dam. The riparian zone integrity is in an A/B category.

Table 30: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	**May 2012 (Elands EWR site)**	**COMMENT**
VEGETATION REMOVAL (IMPACT 1-25)	1	
EXOTIC VEGETATION (IMPACT 1-25)	4	Eucalyptus
BANK EROSION (IMPACT 1-25)	3	Some through cattle trampling and infrequent high flows
CHANNEL MODIFICATION (IMPACT 1-25)	2	Localised, bridge directly upstream of site
WATER ABSTRACTION (IMPACT 1-25)	1	
INUNDATION (IMPACT 1-25)	2	
FLOW MODIFICATION (IMPACT 1-25)	15	Dam upstream impacts on all the flow components
WATER QUALITY (IMPACT 1-25)	2	Increased nutrients – irrigation return flows; poor quality effluent from the Swartruggens WWTW
RIPARIAN VEGETATION INTEGRITY SCORE *	90.0	
RIPARIAN INTEGRITY CATEGORY	**A/B**	

* Weighted riparian integrity score

Table 31: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	May 2012 (Elands EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	4	Some abstractions, irrigation mostly from canals
FLOW MODIFICATION (IMPACT 1-25)	16	Lindleyspoort Dam upstream impacting on all the flow components
BED MODIFICATION (IMPACT 1-25)	5	Localised from bridge, sediment - cattle, reduced floods
CHANNEL MODIFICATION (IMPACT 1-25)	3	Localised due to bridge
WATER QUALITY (IMPACT 1-25)	9	Nutrients in canal from dam, sediments - cattle, algae at bridge; poor quality effluent from the Swartruggens WWTW
INUNDATION (IMPACT 1-25)	4	Localised at bridge
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	
EXOTIC FAUNA (IMPACT 1-25)	0	
SOLID WASTE DISPOSAL (IMPACT 1-25)	3	General littering
IN STREAM HABITAT INTEGRITY SCORE *	70.5	
INSTREAM INTEGRITY CATEGORY	**C**	

* Weighted instream integrity score

(iv) Physico-chemical

The available physico-chemical data have been fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings have been used with the overall confidence as low since important constituents such as dissolved oxygen and temperature have insufficient data available.

The results have been determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the river based on the current condition of the resource.

Table 32shows the results of this assessment for the Elands River.

Table 32: PAI table for the Elands River

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	3.50	**60.00**		**55.00**
Salts	0.00	NONE SPECIFIED	3.50	**50.00**		**55.00**
Nutrients	3.00	NONE SPECIFIED	3.50	**75.00**		**70.00**
Water Temperature	1.00	N	1.50	**55.00**		**60.00**
Water clarity	2.00	NONE SPECIFIED	1.50	**50.00**		**50.00**
Oxygen	4.00	YES:THRESHOLD > 3.9	1.50	**65.00**		**90.00**
Toxics	0.00	N	4.00	**100.00**		**100.00**
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	**4.00**	**MEAN CONF ®**	**2.71**			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	**1.41**					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	**1.52**					
FINAL PC MODIFICATION RATING	**1.50**					
P-C CATEGORY %	**P-C CATEGORY**					
70.00	**C**					

(v) Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in

Table 33. The main impacts on the Elands River are the reduced flows due to Lindleyspoort Dam upstream of the site. No/small releases are made from the dam during low flow periods. The main releases from the dam are into a canal system for irrigation purposes. There is a concern about the increased nutrients from poor quality effluent from the Swartruggens WWTW. Currently it would appear that the dam is mitigating this but in the long term this could be a problem.

Table 33: PES per component for the Elands River

COMPONENT	PES	EXPLANATION
Fish	C	Expected species: 18 Previously recorded species: 10 Observed species: 4 Lower than expected species diversity. Most of the expected fish species have a preference for slow-deep or slow shallow habitats. Majority of the species are either moderately tolerant or tolerant of lack of flow and have a high level of preference habitats with overhanging vegetation cover and high substrate. Absence of most species associated with fast flowing water, riffles and rapids namely the*Labeobarbus polylepis*, *Amphilius uranoscopus* and *Chiloglanis pretoriae.*
Macro-invertebrates	C	29/05/2012 SASS5 score: 126 No of Taxa: 23 ASPT: 5.5 28/06/2006 SASS5 score: 85 No of Taxa: 19 ASPT: 4.5 Key taxa expected but not observed include Perlidae, Tricorythidae, Heptageniidae and Psephenidae. Turbellaria were more abundant than expected, while Atyidae, Ancylidae and Sphaeriidae were less abundant than expected.
Habitat Integrity: Instream	C	INSTREAM INTEGRITY SCORE: 70.5 Eucalyptus Some through cattle trampling and infrequent high flows Localised, bridge directly upstream of site Dam upstream impacts on all the flow components Increased nutrients – irrigation return flows and return flows from Swartruggens WWTW
Habitat Integrity: Riparian	A	RIPARIAN VEGETATION SCORE: 90 Some abstractions, irrigation mostly from canals Lindleyspoort Dam upstream impacting on all the flow components Localised from bridge, sediment - cattle, reduced floods Localised due to bridge Nutrients in canal from dam, sediments - cattle, algae at bridge Localised at bridge
Physico-chemical	C	Elevated nutrients due to irrigation return flows and return flows and return flows from Swartruggens WWTW

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Elands River are shown in

Table 34.

Table 34: Integrated results for the Elands River

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	5	100		
2.What is the natural diversity of **fish** species with a preference for different cover types	3	90		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	3.5	95		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2.5	80		
FISH ECOLOGICAL CATEGORY	14	365	**59.5**	**C/D**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	3	100		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	100		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	100		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**9**	300	**66.6**	**C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		665	**63.3**	**C**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	2	0.40	23.04
Confidence rating for **macro-invertebrate** information	3	0.60	39.96
	5	1.00	63.76
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**90.0**	**A/B**

ECOSTATUS	Confidence rating	Proporitons	Modified weights
Confidence rating for instream biological information	2.6	0.57	36.04
Confidence rating for riparian vegetation zone information	2	0.43	39.13
	4.6	1.00	75.17
ECOSTATUS	**EC**		**C**

Ecological Importance and Sensitivity (EIS)

The EIS for the Elands River was determined as low as presented in Table 35**.**

Table 35: Ecological Importance and Sensitivity of the Elands River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	
Unique (endemic, isolated)	0	
Intolerant (flow and flow related water quality)	1	Inverts: None Fish: BMAR and BPOL moderately intolerant
Species/taxon richness	1	23 invertebrate families. ASPT= 5.5 4 of 17 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	2	Riffle, pool and GSM, bedrock, SIC, SOC, low vegetation in and out current
Refugia	1	
Sensitivity to flow changes	1	Small stream
Sensitivity to flow related water quality changes	2	Sensitive due to almost constant low flows
Migration route/corridor (instream and riparian)	3	Expected eels (AMOS). Important for movement within the reach
Importance of conservation and natural areas	0	
MEDIAN OF DETERMINANTS	**1.0**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**LOW**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Elands River is a C category and the EIS is low. No specific rare, endangered or unique species are present in the system. However, increased flows will improve the overall state of the system. It is thus recommended that the REC for the Elands River remains a C category.

3.2.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of C for the Elands River at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for August andMarch. August is the lowest flow month and March the highest flow month based on the natural time series. May was used as the datum.

The water level in the Elands River during the site visit on 29 May 2012 ($0.005 m^3/s$) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge, Figure 11) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements.

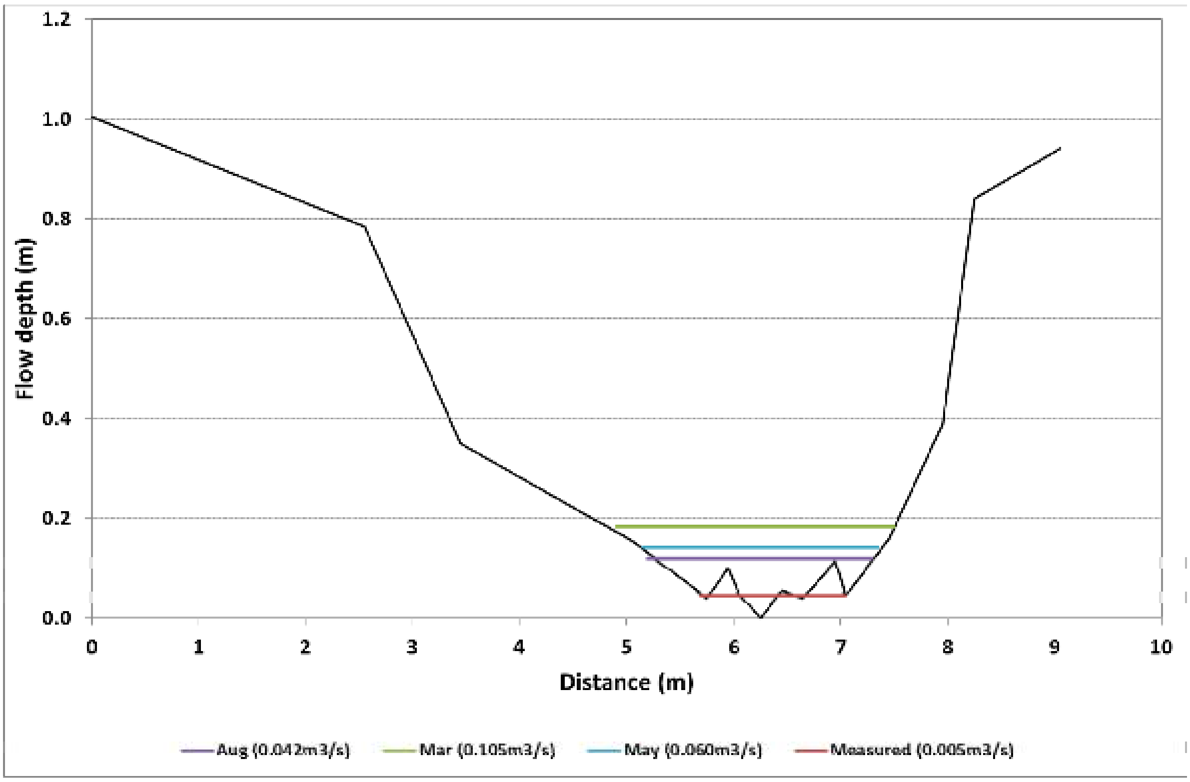

Figure 11: **Calibrated cross-sectional profile of the Elands River at the EWR site**

The site-specific flow requirements were based mainly on the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the month of May was not adequate to maintain the system in a C category. The maintenance low flows were adjusted as followsto provide the necessary velocities for macroinvertebrates:

May 0.040 - $0.060 m^3/s$

Table 36 gives the results of the DRM at the EWR site in the Elands River in quaternary catchment A22E and

Table 37 provides a summary of the recommended requirements.

Table 36: Results of the DRM for the Elands River (REC = C)

	Month	**Discharge (m^3/s)**	**Depth (m)**		**Velocity (m/s)**
			Maximum	**Average**	**Average**
Maintenance low flows					
Low flow month	August	0.042	0.12	0.05	0.38
High flow month	March	0.105	0.18	0.10	0.41
Datum	May	0.060	0.14	0.07	0.39
Measured discharge at site visit (29May 2012)		0.005	0.05	0.02	0.58

Table 37: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	**A22E**
River	Elands
EWR Site Co-ordinates	S 25.4811°; E 26.6904°
Recommended Ecological Category	C
VMAR for Quaternary Catchment Area	18.77
Total EWR	4.110 (21.90 %MAR)
Maintenance Low flows	1.984 (10.57 %MAR)
Drought Low flows	0.521 (2.78 %MAR)
Maintenance High flows	2.126 (11.33 %MAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Elands River are provided in **Annexure 4**.

3.3 Waterkloofspruit (CROC14): Rapid 3

3.3.1 EWR site evaluation

The selected EWR site falls in quaternary catchment A22H and is situated just outside of Rustenburg and Kgaswane Nature Reserves. The Waterkloofspruit drains a large wetland within this nature reserve. A gauging weir (A2H038) with flow data from 1985 to 2012 is situated just below the wetland. This data was used during the determination of the ecological water requirements.

The site is characterised by large and small boulder-dominated riffle with some cobbles, sparse marginal vegetation and limited gravel and sand. A run area is downstream of the surveyed cross-section.

Figure 12: **View of the Waterkloofspruit EWR site in A22H**

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in

Table 38.

Table 38: Waterkloofspruit EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics			
Fish	3	• Fair diversity of velocities present • Fair diversity of instream habitats present	• Of the eight species expected, three were caught in the Waterkloofspruit in considerably low abundances. • *Barbus motebensis* is a protected species (IUCN, 2008) that has been recorded in this area however, it was not recorded during the time of the survey. • As per information provided by a resident farmer, pre-historic contamination, in the form of a mines discard cobbles, fell into the river several years ago. This may be the only explanation as to why the fish diversity and abundance in this river reach is considerably low, as other upstream catchment activities from this site is merely a guest lodge. • Bank erosion present downstream of lowflow bridge
Macroinvertebrates	2	• Abundance of sand and gravel biotope present • Good diversity of SIC biotope present • Fair diversity of velocities present • Fair diversity of instream habitats present	• Limited diversity of MVIC and MVOOC present • Limited SOOC biotope present • Bank erosion present downstream of lowflow bridge

* Confidence scores: 0 = no confidence; 5 = high confidence

3.3.2 Information Availability

The available information for the EWR site is summarized in Table 39. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 39: Information availability for the Waterkloofspruit EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						Once-off monitoring
Hydrology						Monthly data from gauge A2H038 (1985 - 2010) situated upstream of the site was adjusted using catchment area
Fish						Expected fish species lists obtained from Dr Neels Kleynhans at DWA (2007), Skelton (2001) and May 2012 data set.
Macroinvertebrates						One data set only

Physico-chemical						Only 3 datasets

3.3.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Waterkloofspruit per specialist component are summarized in Table 40.

Table 40: Description of reference conditions for the Waterkloofspruit

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Labeobarbus marequensis, Barbus motebensis, Barbus paludinosus, Barbus trimaculatus*, *Barbus unitaeniatus*er, *Clarias gariepinus, Pseudocrenilabrus philander, Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 220 Average Score Per Taxon (ASPT): 7 List of taxa expected include: Perlidae, Heptageniidae, Baetidae >2pp. Gomphidae, Pleidae, Psephenidae.

The physic-chemical reference conditions for the Waterkloofspruit are presented in Table 41. The Reference point is DWA WMS point 90184 approximately 5 kms upstream above the gorge in the nature reserve.

Table 41: Reference conditions for the Waterkloofspruit (WMS sampling ID 90184)

Component	Description of Reference Conditions		
Physio-chemico:	Physical Variables:	pH:	>= 6.6 (5th percentile) and <= 7.8 (95th percentile)
		EC:	<= 5.5 mS/m (used as a surrogate for salts)
		Temperature:	Pristine river, catchment natural, no known problems with temperature. All temperature sensitive species present in abundances and frequencies of occurrence as expected for reference
		Clarity:	Pristine River, no known man-made modifications of the catchment, no known concerns about turbidity, changes in turbidity appears to be natural and related to natural catchment processes such as rainfall runoff.
		Oxygen:	>8.0 mg/ ℓ
	Nutrients:	SRP Median	<0.06 mg/ ℓ
		TIN Median	<0.11 mg/ ℓ

Component	Description of Reference Conditions		
	Toxins:	Ammonia	<90µg/ℓ

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the May 2012 survey the following fish species were present at the site:

- *Barbus trimaculatus;*
- *Barbus unitaeniatus; and*
- *Tilapia sparrmanii.*

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in aE (36.9) present state suspected to be due to the pre-historical contamination that occurred several years ago in the form of a mine discarding cobbles into the river. A resident farmer confirmed that since the incident, the biodiversity has not recovered. This may be the only explanation as to why the fish diversity and abundance in this river reach is considerably low, as other upstream catchment activities from this site is a guest lodge. The conditions of the Hex River may also play a role in this in respect of migration.

The macroinvertebrate Ecological Category is a C (71.5%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water quality at 65.9%, followed by flow modification at 71.2%, followed by the habitat metric at 78.2%. Table 42 provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include, Baetidae, Coenagrionidae, Hydropsychidae, Leptoceridae and Simuliidae.

Table 42: Macroinvertebrate Ecological Category, MIRAI

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	71.2	*0.345*	24.5436	1	100
HABITAT	**H**	78.2	*0.310*	24.272	2	90
WATER QUALITY	**WQ**	70.5	*0.345*	24.2965	1	100
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						290
INVERTEBRATE EC				73.1121		
INVERTEBRATE EC CATEGORY				**C**		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for very fast flowing water had the highest rating of 2.5, being impacted the most from the reference condition.

The occurrence of taxa with a preference for loose cobbles and vegetation had been impacted the most from reference, with an allocated rating of 2 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site.

According to the water quality metrics, the SASS score has been impacted the most with an allocated rating of 3. The SASS and ASPT scores were ranked the highest along with the number of taxa and abundance and/or frequency of occurrence of taxa with a moderate requirement for unmodified physic-chemical conditions, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest.

Annexure 3 provides the detailed tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Waterkloofspruit was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in Table 43 and Table 44 respectively. The instream habitat integrity is in an A category and the riparian zone integrity is in an A/B category. The main impacts on the habitat integrity of the system are possible water quality deterioration due to the discharge of a lodge situated upstream of the site and the regular clearing of indigenous bush in the vicinity of the site.

Table 43: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	May 2012 (Waterkloofspruit EWR site)	COMMENT
VEGETATION REMOVAL (IMPACT 1-25)	4	Regular clearing of indigenous bush in vicinity of site
EXOTIC VEGETATION (IMPACT 1-25)	1	
BANK EROSION (IMPACT 1-25)	4	Localised at bridge
CHANNEL MODIFICATION (IMPACT 1-25)	0	
WATER ABSTRACTION (IMPACT 1-25)	0	
INUNDATION (IMPACT 1-25)	0	
FLOW MODIFICATION (IMPACT 1-25)	0	
WATER QUALITY (IMPACT 1-25)	0	

RIPARIAN VEGETATION INTEGRITY SCORE *	90.0	
RIPARIAN INTEGRITY CATEGORY	**A/B**	

* Weighted riparian integrity score

Table 44: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	May 2012 (Waterkloofspruit EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	2	Water use by lodge and farm
FLOW MODIFICATION (IMPACT 1-25)	2	Few road crossings
BED MODIFICATION (IMPACT 1-25)	2	Localised – bridge and some bank erosion
CHANNEL MODIFICATION (IMPACT 1-25)	1	Bridge
WATER QUALITY (IMPACT 1-25)	4	Possible impacts by upstream lodge development
INUNDATION (IMPACT 1-25)	1	Woody debris
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	
EXOTIC FAUNA (IMPACT 1-25)	0	
SOLID WASTE DISPOSAL (IMPACT 1-25)	1	General littering
IN STREAM HABITAT INTEGRITY SCORE *	93.2	
INSTREAM INTEGRITY CATEGORY	**A**	

* Weighted instream integrity score

(iv) Physico-chemical

The available physico-chemical data have been fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings have been used with the overall confidence as low since important constituents such as dissolved oxygen and temperature have insufficient data available.

The results have been determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the river based on the current condition of the resource.

Table 45 shows the results of this assessment for the Waterkloofspruit.

Table 45: PAI table for the Waterkloofspruit

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	0.00	50.00		55.00
Salts	0.00	NONE SPECIFIED	0.00	60.00		55.00
Nutrients	1.00	NONE SPECIFIED	0.00	55.00		70.00
Water Temperature	1.00	N	0.00	55.00		90.00
Water clarity	3.00	NONE SPECIFIED	0.00	65.00		50.00
Oxygen	2.50	N	0.00	75.00		80.00
Toxics	0.00	N	0.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	1.07	MEAN CONF ®	0.00			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	1.07					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	1.02					
FINAL PC MODIFICATION RATING	1.00					
P-C CATEGORY %	P-C CATEGORY					
80.00	B					

(v) Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in

Table 46. The main impacts on the Waterkloofspruitarefrom the lodge development upstream in the nature reserve.

Table 46: PES per component for the Waterkloofspruit

COMPONENT	PES	EXPLANATION
Fish	D/E	Expected species: 8 Previously recorded species: 3 Observed species: 3 Lower than expected species diversity and abundance. Individuals sparsely distributed throughout the river reach. Due to the time of year, downstream flow and habitat would have potentially formed a barrier for fish movement (i.e. the downstream wetland).
Macro-invertebrates	C	SASS5 score: 142 No of Taxa: 24 ASPT: 5.9 Key taxa expected but not observed were generally those that show preference for high water quality including Perlidae and Heptageniidae. Hydropsychidae >2spp., Leptoceridae and Dytiscidae were less abundant than expected.
Habitat Integrity: Instream	A	INSTREAM INTEGRITY: 93.2 Regular clearing of indigenous bush in vicinity of site Localised at bridge
Habitat Integrity: Riparian	A/B	RIPARIAN VEGETATION SCORE: 90 Water use by lodge and farm Few road crossings Localised – bridge and some bank erosion Bridge Possible impacts by upstream lodge development Woody debris
Physico-chemical	B	Localized upstream impacts from Lodge

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Waterkloofspruit are shown in

Table 47.

Table 47: Integrated results for the Waterkloofspruit

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	2	0.40	16.24
Confidence rating for **macro-invertebrate** information	3	0.60	48.72
	5	1.00	64.96
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**90.0**	**A/B**

ECOSTATUS	Confidence rating	Proporitons	Modified weights
Confidence rating for instream biological information	2.6	0.46	30.16
Confidence rating for riparian vegetation zone information	3	0.54	48.21
	5.6	1.00	78.37
ECOSTATUS	**EC**		**B/C**

Ecological Importance and Sensitivity (EIS)

The EIS for the Waterkloofspruit was determined as low as presented in Table 48.

Table 48: Ecological Importance and Sensitivity of the Waterkloofspruit

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	
Unique (endemic, isolated)	0	
Intolerant (flow and flow related water quality)	0	
Species/taxon richness	1	24 invertebrate families. ASPT= 5.9 3 of 8 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	2	SIC, SOC, MVIC, MVOOC, GSM, pools,

		riffle, runs
Refugia	1	All similar rivers in area dry
Sensitivity to flow changes	2	Small stream
Sensitivity to flow related water quality changes	1	
Migration route/corridor (instream and riparian)	0	
Importance of conservation and natural areas	3	Downstream of Rustenburg and Kgaswane nature reserve
MEDIAN OF DETERMINANTS	**1.0**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**LOW**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Waterkloofspruit is a B/C category and the EIS is low. No specific rare, endangered or unique species are present in the system. It is thus recommended that the REC for the Waterkloofspruit remains a B/C category.

3.3.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of B/C for the Waterkloofspruit at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for September and March. September is the lowest flow month and March the highest flow month based on the natural time series. May was used as the datum.

The water level in the Waterkloofspruit during the site visit on 31 May 2012 ($0.028 m^3/s$) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (Figure 13).

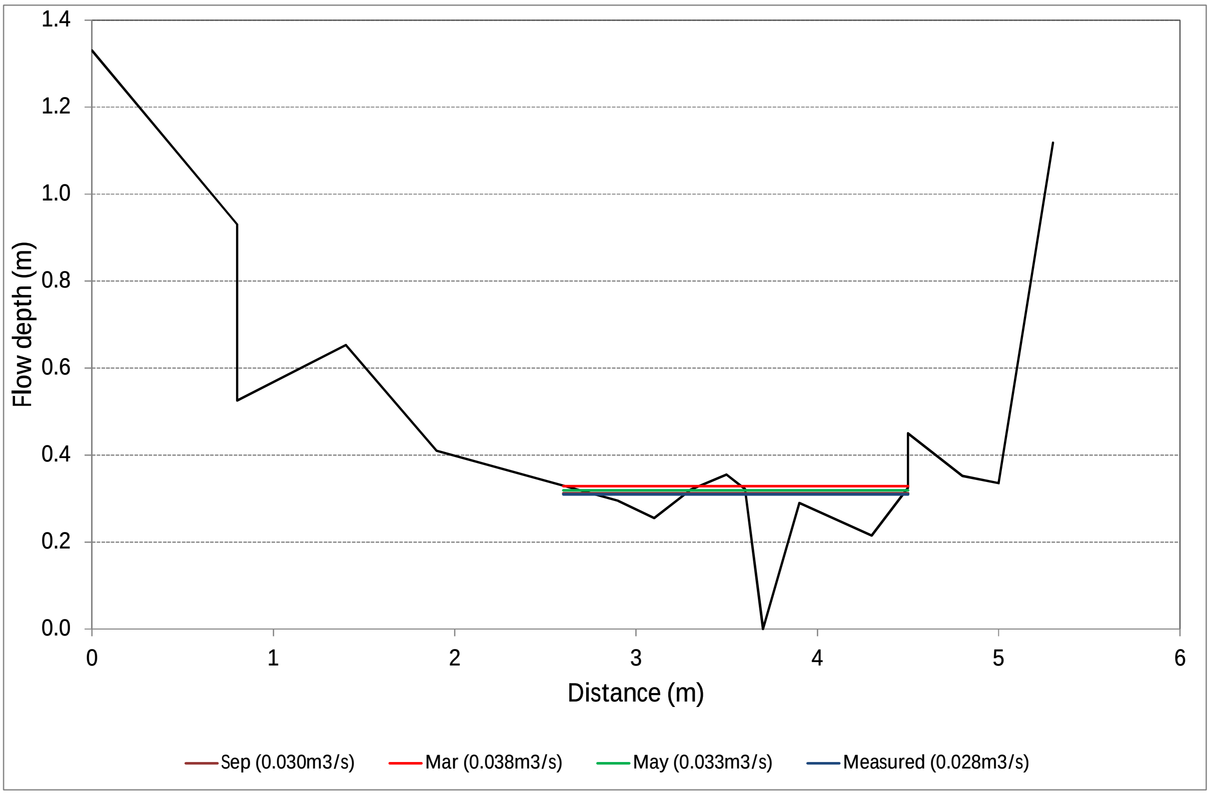

Figure 13: Calibrated cross-sectional profile of the Waterkloofspruit at the EWR site

The site-specific flow requirements were based mainly on the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of August was adequate to maintain the system in a B/C category. Table 49 gives the results of the DRM at the EWR site in the Waterkloofspruit in quaternary catchment A22H and

Table 50 provides a summary of the recommended requirements.

Table 49: Results of the DRM for the Waterkloofspruit (REC = B/C)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flow month	September	0.030	0.31	0.07	0.31
High flow month	March	0.038	0.33	0.07	0.31
Datum	May	0.033	0.32	0.07	0.31
Measured discharge at site visit (31May 2012)		0.028	0.31	0.07	0.31

Table 50: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	**A22H**
River	Waterkloofspruit
EWR Site Co-ordinates	S 25.7414°; E 27.2568°
Recommended Ecological Category	B/C
VMAR for Quaternary Catchment Area	5.469*
Total EWR	1.546 (28.27 %MAR)
Maintenance Low flows	1.013 (18.53 %MAR)
Drought Low flows	0.373 (6.81 %MAR)
Maintenance High flows	0.533 (9.74 %MAR)
Overall confidence	Low

* Based on observed data from A2H038 and adjusted for the EWR site

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Waterkloofspruit are provided in **Annexure 4**.

3.4 Magalies River (CROC15): Rapid 3

3.4.1 EWR site evaluation

The selected EWR site on the Magalies River falls in quaternary catchment A21F just before the confluence with the Klein River, a tributary of the Magalies River. The source of the Magalies River is a dolomitic Eye (Maloney's Eye) and the natural base flows would have been high. However, due to water use for irrigation in the upper catchment, these high base flows have been reduced significantly. No gauging weirs are present close to the EWR site.

The site is characterised by large and small boulder-dominated riffle with some cobbles, sparse marginal vegetation and limited gravel and sand. A run area is downstream of the surveyed cross-section.

Figure 14: View of the Magalies River EWR site in A21F

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in

Table 51.

Table 51: Magalies River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics			
Fish	3	• Good diversity of velocities present • Good instream habitat for fish.	• The Magalies River sampling station is located on a residential plot where it was noted that both *Micropterus salmoides* (Largemouth Bass) and *Cyprinus carpio* (Carp), both exotic species are caught on a regular basis. • Five of the 10 previously recorded species were present at the site but recorded in low abundances. • Excessive TDS concentrations were recorded at this sampling point (potentially due to upstream agricultural activities). • The excessive TDS concentrations and exotic fish species in this river reach may be the limiting factor to the low fish abundance and diversity in the area. • A weir is located approximately 50m from the sampling point, which has adverse effects on fish from migrating upstream of the river.
Macroinvertebrates	3	• Good diversity of instream biotopes present • Good diversity of SIC present • Good diversity of velocities present • MVIC and MVOOC abundant	• Limited diversity of gravel and sand biotope present • Algal presence on rocks • Sedimentation present

* Confidence scores: 0 = no confidence; 5 = high confidence

3.4.2 Information Availability

The available information for the EWR site is summarized in Table 52. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 52: Information availability for the Magalies River EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						Once-off monitoring
Hydrology						Updated monthly hydrology was used for the period 1920-2003.

Fish						Expected fish species lists obtained from Dr Neels Kleynhans at DWA (2007), Skelton (2001) and May 2012 data set.
Macroinvertebrates						May 2012 data set only.
Physico-chemical						Limited dataset from 2002 to 2010

3.4.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Magalies River per specialist component are summarized in Table 53.

Table 53: Description of reference conditions for the Magalies River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Barbus anoplus, Labeobarbus marequensis, Labeobarbus polylepis, Barbus paludinosus, Barbus trimaculatus, Barbus unitaeniatus, Chiloglanis pretoriae, Clarias gariepinus, Pseudocrenilabrus philander, Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 250 Average Score Per Taxon (ASPT): 7 List of taxa expected include: Perlidae, Baetidae >2pp., Heptageniidae, Tricorythidae, Gomphidae, Hydropsychidae >2spp., Psephenidae, Simuliidae.

The physic-chemical reference conditions for the Magalies River are presented in Table 16 as for the Crocodile (West) catchment.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the May 2012 survey the following fish species were present at the site:

- *Tilapia sparrmanii;*
- *Clarias gariepinus;*
- *Labeobarbus marequensis;*
- *Barbus anoplus; and*

- *Barbus paludinosus.*

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a C (64.4) present state. The following factors may be contributing factor to the low FRAI result:
The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

- The macroinvertebrate Ecological Category is a C (66). This means the river is in a moderately modified ecological condition. Poor water quality. The electrical conductivity and the TDS both exceeded the South African Guidelines for Aquatic Freshwater Ecosystems (DWAF, 1996);
- The resident residing adjacent to the river confirmed that both *Micropterus salmoides* (Largemouth Bass) and *Cyprinus carpio* (Carp), both exotic fish species are caught on a regular basis. These species have a reputation of altering the river's ecology and functionality, coupled with decreasing the diversity and abundance of indigenous fish species within the river reach; and
- A weir is located approximately 50m from the sampling point, which has adverse effects on fish from migrating upstream of the river.

The most impacted driver metric is that of water quality at 62.4%, followed by flow modificationat 75.1%, followed closely by the habitat metric at 76.6%.Table 54 provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include, Potamonautidae, Baetidae, Tricorythidae, Hydropsychidae, Elmidae and Simuliidae.

Table 54: Macroinvertebrate Ecological Category, MIRAI

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	75.1	*0.310*	23.3215	2	90
HABITAT	**H**	76.6	*0.345*	26.4224	1	100
WATER QUALITY	**WQ**	62.4	*0.345*	21.5317	1	100
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						290
INVERTEBRATE EC				71.2756		
INVERTEBRATE EC CATEGORY				C		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for very fast flowing water had the highest rating of 2.5, being impacted the most from the reference condition.

The occurrence of taxa with a preference for loose cobbles had been impacted the most from reference, with an allocated rating of 2.5 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with bedrock/boulders ranked as the least important instream habitat for this site.

The SASS and ASPT scores were ranked the highest along with the number of taxa and abundance and/or frequency of occurrence of taxa with a moderate requirement for unmodified physic-chemical conditions, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest.

Annexure 3 provides the detailed tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Magalies River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in Table 55 and Table 56 respectively. Both the instream habitat and riparian zone integrity is in a D category. The main impacts on the habitat integrity of the system are flow modifications due to abstractions, poor water quality (irrigation return flows), presence of exotic fauna and alien vegetation and bank erosion.

Table 55: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	May 2012 (Magalies EWR site)	COMMENT
VEGETATION REMOVAL (IMPACT 1-25)	15	Removal of riparian zone vegetation on right bank
EXOTIC VEGETATION (IMPACT 1-25)	10	Spanish reed, bugweed, mulberry, privet
BANK EROSION (IMPACT 1-25)	10	Localised at bridge due to removal of vegetation
CHANNEL MODIFICATION (IMPACT 1-25)	3	Localised
WATER ABSTRACTION (IMPACT 1-25)	4	Reduced flows
INUNDATION (IMPACT 1-25)	6	Downstream weir inundating riparian zone
FLOW MODIFICATION (IMPACT 1-25)	1	
WATER QUALITY (IMPACT 1-25)	1	
RIPARIAN VEGETATION INTEGRITY SCORE *	50.0	

RIPARIAN INTEGRITY CATEGORY	**D**	

* Weighted riparian integrity score

Table 56: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	**May 2012 (Magalies EWR site)**	**COMMENT**
WATER ABSTRACTION (IMPACT 1-25)	15	Upstream abstraction for irrigation and just below site
FLOW MODIFICATION (IMPACT 1-25)	15	Low and moderate flows impacted
BED MODIFICATION (IMPACT 1-25)	6	Sedimentation and bank disturbance upstream of bridge
CHANNEL MODIFICATION (IMPACT 1-25)	3	Localised
WATER QUALITY (IMPACT 1-25)	16	Increased nutrients due to irrigation and urban return flows
INUNDATION (IMPACT 1-25)	12	Small weir just below site will cause inundation during higher flows
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	2	
EXOTIC FAUNA (IMPACT 1-25)	16	Bass and carp possibly in river
SOLID WASTE DISPOSAL (IMPACT 1-25)	4	General littering on site and upstream
IN STREAM HABITAT INTEGRITY SCORE *	48.5	
INSTREAM INTEGRITY CATEGORY	**D**	

* Weighted instream integrity score

(iv) Physico-chemical

The available physico-chemical data have been fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings have been used with the overall confidence as low since important constituents such as dissolved oxygen and temperature have insufficient data available.

The results have been determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the river based on the current condition of the resource.

Table 57shows the results of this assessment for the Magalies River.

Table 57: PAI table for the Magalies River

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	2.50	**50.00**		**55.00**
Salts	2.00	NONE SPECIFIED	2.50	**50.00**		**55.00**
Nutrients	3.00	NONE SPECIFIED	2.50	**65.00**		**70.00**
Water Temperature	1.00	N	0.50	**55.00**		**90.00**
Water clarity	3.00	NONE SPECIFIED	0.50	**55.00**		**50.00**
Oxygen	3.50	N	0.50	**75.00**		**90.00**
Toxics	0.00	N	2.50	**100.00**		**100.00**
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	**1.73**	**MEAN CONF ®**	**1.64**			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	**1.73**					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	**1.72**					
FINAL PC MODIFICATION RATING	**1.70**					
P-C CATEGORY %	**P-C CATEGORY**					
66.00	**C**					

(v) Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in

Table 58. The main impacts on the Magalies River are from irrigation return flows.

Table 58: PES per component for the Magalies River

COMPONENT	PES	EXPLANATION
Fish	C	Expected species: 10 Previously recorded species: 0 Observed species: 5 Not all expected species were recorded in this reach for example Labeobarbus polylepis, *Barbus trimaculaturs*, *barbus unitaeniatus*, *Chiloglanis pretoriae* and *Pseudocrenilabrus philander*. This may be due to: • Poor water quality. The electrical conductivity and the TDS both exceeded the South African Guidelines for Aquatic Freshwater Ecosystems (DWAF, 1996); • The presence of the exotic *Micropterus salmoides* (Largemouth Bass) and *Cyprinus carpio* (Carp) in this river reach; • A weir located approximately 50m from the sampling point, which has adverse effects on fish from migrating upstream of the river.
Macro-invertebrates	C	SASS5 score: 143 No of Taxa: 23 ASPT: 6.2 Key taxa expected but not observed were generally those that show preference for moderate to high water quality including Perlidae and Psephenidae. Trocorythidae, Gomphida and Belostomatidae were less abundant than expected, while Leptophlebiidae and Heptageniidae were more abundant than expected.
Habitat Integrity: Instream	D	INSTREAM INTEGRITY: 48.5 Upstream abstraction for irrigation and just below site Low and moderate flows impacted Sedimentation and bank disturbance upstream of bridge Localised Increased nutrients due to irrigation and urban return flows Small weir just below site will cause inundation during higher flows Bass and carp possibly in river General littering on site and upstream
Habitat Integrity: Riparian	D	RIPARIAN VEGETATION SCORE: 50 Removal of riparian zone vegetation on right bank Spanish reed, bugweed, mulberry, privet Localised at bridge due to removal of vegetation Localised Reduced flows Downstream weir inundating riparian zone
Physico-chemical	C	Elevated nutrients from irrigation return flows

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Magalies River are shown in Table 59.

Table 59: Integrated results for the Magalies River

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	3	80		
2.What is the natural diversity of **fish** species with a preference for different cover types	3	80		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	4	100		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**64.4**	**C**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	4	100		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	90		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	90		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**10**	280	**71.3**	**C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		610	**68.5**	**C**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	3	0.50	32.20
Confidence rating for **macro-invertebrate** information	3	0.50	35.65
	6	1.00	67.85
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**50.0**	**D**

ECOSTATUS	Confidence rating	Proporitons	Modified weights

Confidence rating for instream biological information	3	0.50	33.93
Confidence rating for riparian vegetation zone information	3	0.50	25.00
	6	1.00	58.93
ECOSTATUS	**EC**		**C/D**

Ecological Importance and Sensitivity (EIS)

The EIS for the Magalies River was determined as low as presented in .

Table 60.

Table 60: Ecological Importance and Sensitivity of the Magalies River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	
Unique (endemic, isolated)	0	
Intolerant (flow and flow related water quality)	2	Heptageniidae, Tricorythidae, Hydropsychidae more than 2
Species/taxon richness	1	23 invertebrate families. ASPT= 6.2 5 of 10 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	2	SIC, SOC, aquatic veg, MVIC, MVOOC, bedrock, GSM, riffle, pools, runs, rapids
Refugia	2	Riffle habitats acts as refugia for fish from bass
Sensitivity to flow changes	1	Small stream
Sensitivity to flow related water quality changes	1	
Migration route/corridor (instream and riparian)	1	Local movement
Importance of conservation and natural areas	0	
MEDIAN OF DETERMINANTS	**1.0**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**LOW**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Magalies River is a C/D category and the EIS is low. No specific rare, endangered or unique species are present in the system. It is thus recommended that the REC for the Magalies River remains a C/D category.

3.4.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of C/D for the Magalies River at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for September and February. September is the lowest flow month and February the highest flow month based on the natural time series. May was used as the datum.

The water level in the Magalies River during the site visit on 30 May 2012 ($0.144 m^3/s$) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (Figure 15 and Figure 16).

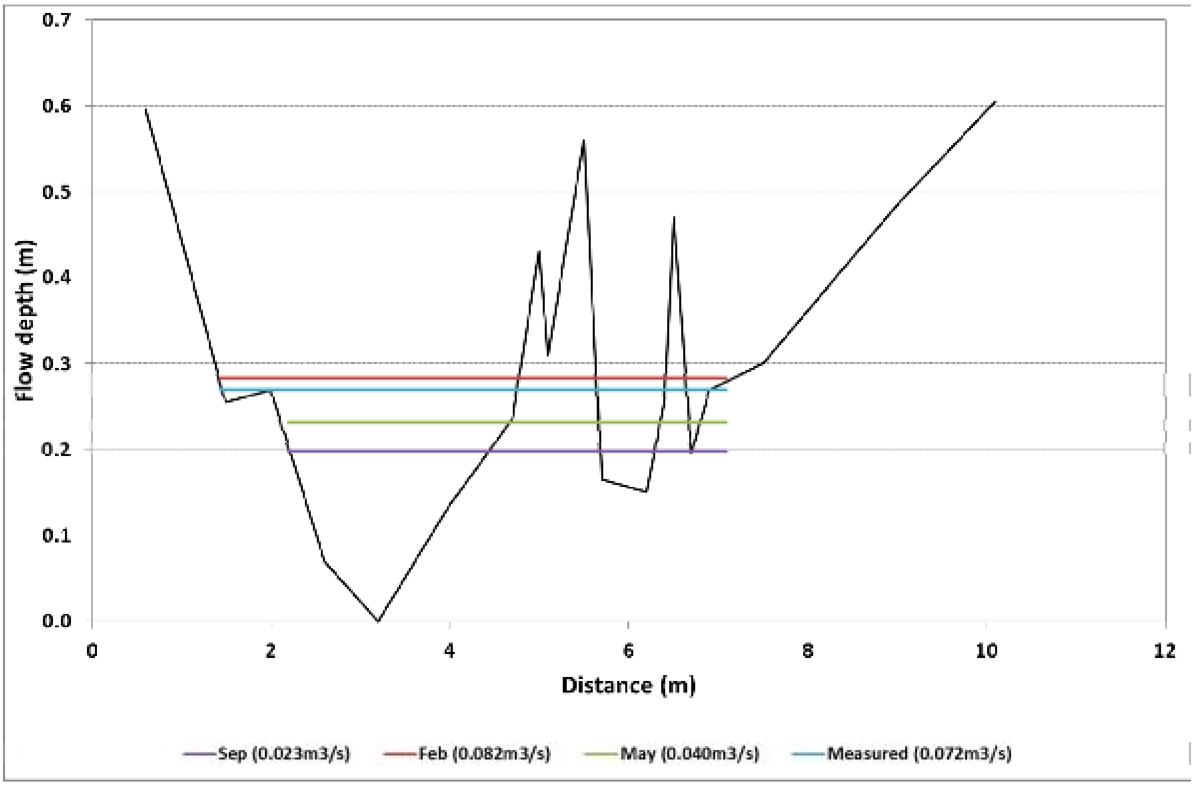

Figure 15: Calibrated cross-sectional profile of the Magalies River at the EWR site: Left Channel (based on the assumption that the flow is split 50/50 between the channels)

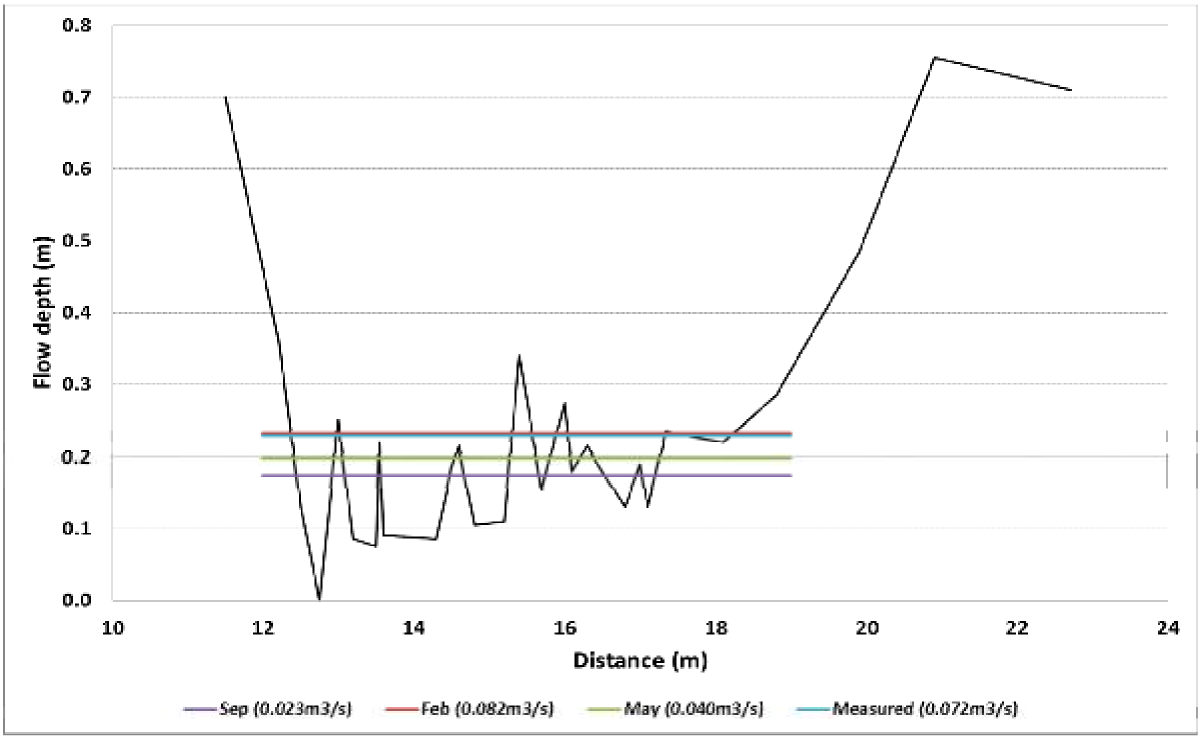

Figure 16: Calibrated cross-sectional profile of the Magalies River at the EWR site: Left Channel: Right Channel (based on the assumption that the flow is split 50/50 between the channels)

The site-specific flow requirements were based mainly on the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of September was not adequate to maintain the system in a C/D category. The maintenance low flows were adjusted as follows to provide the necessary velocities for macroinvertebrates:

May	0.047 - 0.080m^3/s
September	0.027 - 0.045m^3/s
February	0.096 - 0.163m^3/s

Table 61 gives the results of the DRM at the EWR site in the Magalies River in quaternary catchment A21F and Table 62 provides a summary of the recommended requirements.

Table 61: Results of the DRM for the Magalies River(REC = C/D)

	Month	**Discharge (m^3/s)**	**Depth (m)**		**Velocity (m/s)**
			Maximum	**Average**	**Average**
Maintenance low flows					
Low flow month	September	0.023	0.20	0.09	0.09
High flow month	February	0.082	0.28	0.12	0.14
Datum	May	0.040	0.23	0.11	0.11
Measured discharge at site visit (30May 2012)		0.072	0.27	0.12	0.14

Table 62: Results of the DRM for the Magalies River Right Channel (REC = C/D)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flow month	September	0.023	0.18	0.06	0.12
High flow month	February	0.082	0.23	0.08	0.18
Datum	May	0.040	0.20	0.07	0.14
Measured discharge at site visit (30 May 2012)		0.072	0.23	0.08	0.18

Table 63: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	A21F
River	Magalies
EWR Site Co-ordinates	S 25.8969°; E 27.5982°
Recommended Ecological Category	C/D
VMAR for Quaternary Catchment Area	21.899
Total EWR	4.639 (21.18 %MAR)
Maintenance Low flows	2.516 (11.49 %MAR)
Drought Low flows	0.802 (3.66 %MAR)
Maintenance High flows	2.123 (9.69 %MAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Magalies River are provided in **Annexure 4**.

3.5 Rietvlei (CROC16): Rapid 3

3.5.1 EWR site evaluation

The selected EWR site falls in quaternary catchment A21A and is situated downstream of an urban area. The Rietvlei Nature Reserve and dam is situated further downstream. No gauging weirs are situated close to the site.

The site is characterised by large and small boulder-dominated riffle with some cobbles, sparse marginal vegetation and limited gravel and sand. A run area is downstream of the surveyed cross-section.

Figure 17: View of the Rietvlei EWR site in A21A

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in Table 64**.**

Table 64: Rietvlei EWR site evaluation

Component	**Confidence Score***	**Advantages**	**Disadvantages**
Hydraulics			
Fish	3	-	• Only two species were observed in the Rietvlei River, of which one of the species was *Gambusia affinis*, an exotic fish species. • Thick filamentous algal growth on rocks and sediment. • Factors contributing to low fish diversity and abundance may be due to the following: o The TDS concentrations exceeded the South

			African Guidelines for Aquatic Freshwater Ecosystems. o A number of catchment activities namely, the Serengeti golf course, agriculture and industrial complexes may all be contributing to the nutrient load in the river reach.
Macroinvertebrates	2	• Fair diversity of MVIC and sand biotope present	• Thick filamentous algal growth on rocks • Limited diversity of SOOC, MVOOC and gravel present • Bank erosion

* Confidence scores: 0 = no confidence; 5 = high confidence

3.5.2 Information Availability

The available information for the EWR site is summarized in Table 65. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 65: Information availability for the Rietvlei EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						Once-off monitoring
Hydrology						Updated monthly hydrology was used for the period 1920-2003.
Fish						Expected fish species lists obtained from Dr Neels Kleynhans at DWA (2007), Skelton (2001), personal experience from the study area and May 2012 dataset.
Macroinvertebrates						31/05/2012 data set only.
Physico-chemical						Data available from 2002 to 2010

3.5.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Rietvlei per specialist component are summarized in Table 66.

Table 66: Description of reference conditions for the Rietvlei

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Barbus anoplus*, *Clarias gariepinus, Pseudocrenilabrus philander, Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 200 Average Score Per Taxon (ASPT): 6.5 List of taxa expected include: Baetidae >2pp., Heptageniidae, Hydropsychidae >2spp.

The physic-chemical reference conditions for the Rietvlei are presented in Table 16 as for the Crocodile (West) catchment.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the May 2012 survey the following fish species were present at the site:

Barbus anoplus; and

Gambusia aphinus

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a C/D (57.9) present state primarily due to poor water quality. Large quantities of algae were acknowledged in some parts of the river. This is mainly due to high levels of nutrient input into the water course. The TDS and electrical conductivity concentrations both exceeded the South African Guidelines for Aquatic Freshwater Ecosystems. The source of the impacts may be due to upstream catchment activities namely, the Serengeti golf course located approximately 2.5km upstream from the sampling point, surrounding agriculture practices and industrial complexes. Furthermore, the exotic fish species, *Gambusia aphinus* (Mosquito fish) was recorded. Although only a single individual was recorded, this provided evidence that these species reside in this river reach. These exotic fish species have a reputation of altering the river's ecology and functionality, coupled with decreasing the diversity and abundance of indigenous fish species within the river reach.

The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a C (The macroinvertebrate Ecological Category is a C/D (60.1%). This means the river is in a moderately modified ecological condition. This means the river is in a moderately modified to seriously modified ecological condition. The most impacted driver metric is that of water quality at 52.4%, followed by flow modification at 62.2%, followed by the habitat modification metric at 67.2%. Table 67 provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include, Baetidae, Hydropsychidae, Potamonautidae and Simuliidae.

Table 67: Macroinvertebrate Ecological Category, MIRAI

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	62.2	*0.333*	20.7292	2	90
HABITAT	**H**	67.2	*0.296*	19.905	3	80
WATER QUALITY	**WQ**	52.4	*0.370*	19.4229	1	100
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						270
INVERTEBRATE EC				60.0571		
INVERTEBRATE EC CATEGORY				C		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for standing water had the highest rating of 4, being impacted the most from the reference condition.

The occurrence of taxa with a preference for loose cobbles had been impacted the most from reference, with an allocated rating of 4 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with bedrock/boulders ranked as the least important instream habitat for this site.

The SASS and ASPT scores were ranked the highest along with the number of taxa and abundance and/or frequency of occurrence of taxa with a moderate requirement for unmodified physic-chemical conditions, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest. According to the water quality metrics, the SASS and ASPT scores, as well as the number of taxa with a moderate and low requirement for unmodified physic-chemical conditions has been impacted the most with an allocated rating of 4.

Annexure 3 provides the detailed tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Rietvlei was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in Table 68 and Table 69 respectively. The instream habitat integrity is in a D category and riparian zone integrity is in an A/B category. The main impacts on the habitat integrity of the system are bank erosion and collapsing of banks that cause sedimentation of the instream habitats. Increased flows and nutrient enrichment due to irrigation and urban return flows and storm water runoff further impacts on the instream habitats.

Table 68: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	**May 2012 (Rietvlei EWR site)**	**COMMENT**
VEGETATION REMOVAL (IMPACT 1-25)	3	Frequent burning
EXOTIC VEGETATION (IMPACT 1-25)	1	
BANK EROSION (IMPACT 1-25)	15	Undercut banks
CHANNEL MODIFICATION (IMPACT 1-25)	9	Collapsing of banks causing destruction of riparian zone
WATER ABSTRACTION (IMPACT 1-25)	1	
INUNDATION (IMPACT 1-25)	0	
FLOW MODIFICATION (IMPACT 1-25)	5	Increased flows (constant due to WWTW releases)
WATER QUALITY (IMPACT 1-25)	1	
RIPARIAN VEGETATION INTEGRITY SCORE *	92.0	
RIPARIAN INTEGRITY CATEGORY	**A**	

* Weighted riparian integrity score

Table 69: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	**May 2012 (Rietvlei EWR site)**	**COMMENT**
WATER ABSTRACTION (IMPACT 1-25)	5	Irrigation
FLOW MODIFICATION (IMPACT 1-25)	14	Increased flows - storm water, WWTW & irrigation return flows (Serengeti)
BED MODIFICATION (IMPACT 1-25)	15	Incised channel, sedimentation, trucks abstracting water for road works
CHANNEL MODIFICATION (IMPACT 1-25)	9	Increased flows
WATER QUALITY (IMPACT 1-25)	18	WWTW effluent, return flows, storm water, extensive algal growth

INUNDATION (IMPACT 1-25)	2	Localised from downstream bridge
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	
EXOTIC FAUNA (IMPACT 1-25)	1	
SOLID WASTE DISPOSAL (IMPACT 1-25)	2	General littering
IN STREAM HABITAT INTEGRITY SCORE *	53.0	
INSTREAM INTEGRITY CATEGORY	**D**	

* Weighted instream integrity score

(iv) Physico-chemical

The available physico-chemical data have been fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings have been used with the overall confidence as low since important constituents such as dissolved oxygen and temperature have insufficient data available.

The results have been determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the river based on the current condition of the resource. Table 70 shows the results of this assessment for the Rietvlei.

Table 70: PAI table for the Rietvlei

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	1.00	N	4.00	**60.00**		**55.00**
Salts	4.00	NONE SPECIFIED	4.00	**50.00**		**60.00**
Nutrients	4.00	NONE SPECIFIED	4.00	**75.00**		**100.00**
Water Temperature	1.00	N	0.50	**55.00**		**55.00**
Water clarity	4.00	NONE SPECIFIED	0.50	**50.00**		**50.00**
Oxygen	0.00	N	0.50	**65.00**		**50.00**
Toxics	0.00	N	4.00	**100.00**		**80.00**
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	**1.79**	**MEAN CONF ®**	**2.50**			

CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	**1.79**
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	**2.11**
FINAL PC MODIFICATION RATING	**2.10**
P-C CATEGORY %	**P-C CATEGORY**
58.00	**D**

(v) Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in Table 71. The main impacts on the Rietvlei are increased flows due to urban return flows as well as the poor water quality due to the discharges and urbanisation.

Table 71: PES per component for the Rietvlei

COMPONENT	PES	EXPLANATION
Fish	C/D	Expected species: 4 Previously recorded species: 5 Observed species: 2 Only 4 species are expected in this river reach, possibly due to the river being higher up in the catchment. Only 2 species were observed potentially due to channel and habitat alteration and upstream water quality impacts. Furthermore, one exotic *Gambusia aphinus* was observed.
Macro-invertebrates	C/D	SASS5 score: 61 No of Taxa: 14 ASPT: 4.4 Key taxa expected but not observed were generally those that show preference for moderate to high water quality including Heptageniidae, Hydropsychidae, Tricorythidae and Psephenidae. Ancylidae, Chironomidae and Turbellaria were less abundant than expected, while Baetidae were more abundant than expected.
Habitat Integrity: Instream	D	INSTREAM INTEGRITY: 53 Frequent burning Undercut banks Collapsing of banks causing destruction of riparian zone Increased flows (constant due to WWTW releases)
Habitat Integrity: Riparian	A	RIPARIAN VEGETATION SCORE: 92 Irrigation Increased flows - storm water, WWTW & irrigation return flows (Serengeti) Incised channel, sedimentation, trucks abstracting water for road works Increased flows WWTW effluent, return flows, storm water, extensive algal growth

		Localised from downstream bridge
Physico-chemical	D	Urbanization and return flows from wastewater treatment works

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Rietvlei are shown in Table 72.

Table 72: Integrated results for the Rietvlei

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	3	80		
2.What is the natural diversity of **fish** species with a preference for different cover types	4	90		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	3	80		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	5	100		
FISH ECOLOGICAL CATEGORY	15	350	**57.9**	**C/D**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	2	100		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	2	100		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	2	100		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**6**	300	**60.1**	**C/D**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		650	**58.8**	**C/D**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	3	0.50	28.95
Confidence rating for **macro-invertebrate** information	3	0.50	30.05
	6	1.00	59.00
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C/D**

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**71.7**	**C**

ECOSTATUS	Confidence rating	Proporitons	Modified weights
Confidence rating for instream biological information	3	0.60	35.40

Confidence rating for riparian vegetation zone information	2	0.40	28.68
	5	1.00	64.08
ECOSTATUS	**EC**		**C**

Ecological Importance and Sensitivity (EIS)

The EIS for the Rietvlei was determined as moderate as presented in Table 73**.**

Table 73: Ecological Importance and Sensitivity of the Rietvlei

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	
Unique (endemic, isolated)	0	
Intolerant (flow and flow related water quality)	0	
Species/taxon richness	1	14 invertebrate families. ASPT= 4.4 1 of 4 expected fish species, 1 exotic (GAFF)
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	2	SIC, SOC, MVIC, MVOOC, some boulders, GSM, riffle, pools, runs
Refugia	1	
Sensitivity to flow changes	1	Small stream
Sensitivity to flow related water quality changes	1	
Migration route/corridor (instream and riparian)	0	
Importance of conservation and natural areas	1	Upstream of Rietvlei Nature Reserve
MEDIAN OF DETERMINANTS	**1.0**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**LOW**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Rietvlei is a C category and the EIS is low. No specific rare, endangered or unique species are present in the system. It is thus recommended that the REC for the Rietvlei remains a C category.

3.5.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of C for the Rietvlei at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for September and February. September is the lowest flow month and February the highest flow month based on the natural time series. May was used as the datum.

The water level in the Rietvlei during the site visit on 31 May 2012 (0.028 m^3/s) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (Figure 18).

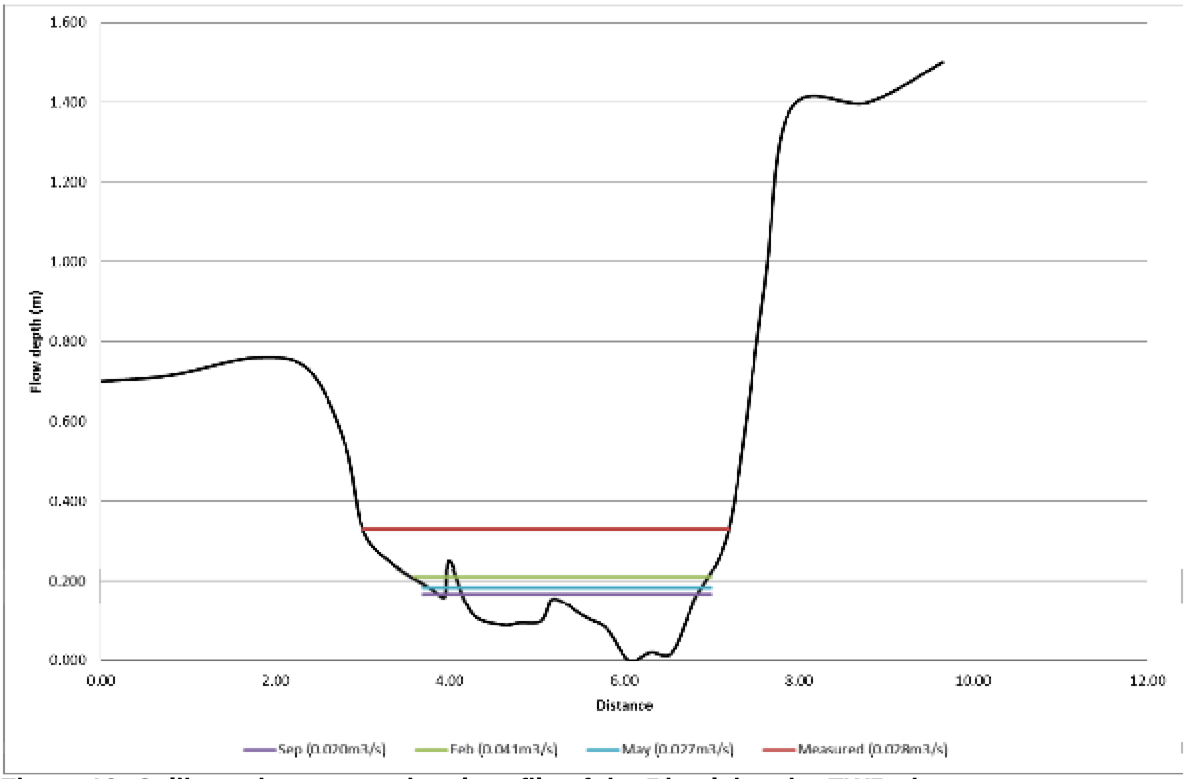

Figure 18: Calibrated cross-sectional profile of the Rietvlei at the EWR site

The site-specific flow requirements were based mainly on the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of September was not adequate to maintain the system in a C category. The maintenance low flows were adjusted as followsto provide the necessary velocities for macroinvertebrates:

May	0.016 - 0.027m^3/s
September	0.012 - 0.020m^3/s
February	0.024 - 0.041m^3/s

Table 74 gives the results of the DRM at the EWR site in the Rietvlei in quaternary catchment A21A and Table 75 provides a summary of the recommended requirements.

Table 74: Results of the DRM for the Rietvlei (REC = C)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flow month	September	0.020	0.17	0.08	0.09
High flow month	February	0.041	0.22	0.11	0.12
Datum	May	0.027	0.18	0.09	0.09
Measured discharge at site visit (31May 2012)		0.028	0.19	0.09	0.10

Table 75: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	A21A
River	Rietvlei
EWR Site Co-ordinates	S 26.0189°; E 28.3044°
Recommended Ecological Category	C
VMAR for Quaternary Catchment Area	4.788
Total EWR	1.331 (27.83 %MAR)
Maintenance Low flows	0.835 (17.45 %MAR)
Drought Low flows	0.166 (3.47 %MAR)
Maintenance High flows	0.496 (10.38 %MAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Rietvlei are provided in **Annexure 4**.

3.6 Polkadraaispruit (MAR6): Rapid 3

3.6.1 EWR site evaluation

The selected EWR site falls in quaternary catchment A31B and is situated downstream of a large dam at the road bridge. No gauging weirs are situated in close vicinity of the EWR site.

The site is characterised by large and small boulder-dominated riffle with some cobbles, sparse marginal vegetation and limited gravel and sand. A run area is downstream of the surveyed cross-section.

Figure 19: View of the Polkadraaispruit EWR site in A31B

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in Table 76.

Table 76: Polkadraaispruit EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics			
Fish	3	• Good diversity of velocities present. • Good instream habitat	• Five of the 12 expected fish species were recorded at Polkadraai River in low

		diversity for fish.	abundances. • Most of the fish species sampled at the site showed signs of abnormalities in the form of black spots all over the body and fins representing parasites. Therefore, the health of the species was not considered good and consequently, this could potentially be one of the influences limiting the diversity and abundance of fish species within this reach. • *Micropterus salmoides* (Largemouth Bass), an exotic fish species was recorded in this river reach.
Macroinvertebrates	3	• Good diversity of biotopes present • Good diversity of SIC present • Good diversity of velocities present • >10m of submerged SIC present for sampling •	• Site downstream of road bridge • Limited diversity of SOOC, MVIC and MVOOC present

* Confidence scores: 0 = no confidence; 5 = high confidence

3.6.2 Information Availability

The available information for the EWR site is summarized in Table 77. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 77: Information availability for the Polkadraaispruit EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics		X				Once-off monitoring
Hydrology		X				Updated monthly hydrology was used for the period 1920-2003.
Fish					X	Expected fish species lists obtained from Dr Neels Kleynhans at DWA (2007), Skelton (2001), personal experience at the study site and May 2012 data set.
Macroinvertebrates			X			Three SASS data sets used – 03 & 08/2007 and 05/2012.
Physico-chemical		X				Only 6 datasets

3.6.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Polkadraaispruit per specialist component are summarized in Table 78.

Table 78: Description of reference conditions for the Polkadraaispruit

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Amphilius uranoscopus, Labeobarbus marequensis, Barbus paludinosus, Barbus trimaculatus, Barbus unitaeniatus, Chetia flaviventris, Chiloglanis pretoriae, Clarias gariepinus, Labeobarbus polylepis, Pseudocrenilabrus philander, Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 250 Average Score Per Taxon (ASPT): 7 List of taxa expected include: Baetidae >2spp., Hydropsychidae >2spp., Hydroptilidae, Dytiscidae, Simuliidae.

The physic-chemical reference conditions for the Polkadraaispruit are presented in Table 79. As for the intermediate Reserve determination study for the Marico catchment the reference site chosen for the additioinal Rapid III is located on the upper reaches of the Koster River, upstream of Koster Dam. The Koster/Selons River unit is impacted mostly by water abstraction for irrigation and altered flow regimes due to impoundments. The River Health Programme has categorised the site as fair with a marginal/low EIS (River Health Programme, 2005). The report further stated that the water quality in the river is good, with low to intermediate nutrient levels and is free of significant organic pollution.

Table 79: Reference conditions for the Polkadraaispruit (WMS ID A2H036)

Component	**Description of Reference Conditions**		
Physio-chemico:	Physical Variables:	pH:	>= 7.32(5th percentile) and <= 7.98 (95th percentile)
		EC:	<= 16.58 mS/m (used as a surrogate for salts)
		Temperature:	Pristine river, catchment natural, no known problems with temperature. All temperature sensitive species present in abundances and frequencies of occurrence as expected for reference
		Clarity:	Some man-made modifications (up-stream dam) of the catchment, no known concerns

Component	Description of Reference Conditions		
			about turbidity, changes in turbidity appears to be natural and related to natural catchment processes such as rainfall runoff.
		Oxygen:	>8.0 mg/ ℓ
	Nutrients:	PO_4 Median	<0.016 mg/ ℓ
		TIN Median	<0.09 mg/ ℓ
	Toxins:	Ammonia	<3µg/ℓ

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the May 2012 survey the following fish species were present at the site:

- *Labeobarbus marequensis;*
- *Chiloglanis pretoriae;*
- *Amphilius uranoscopus;*
- *Labeobarbus polylepis; and*
- *Micropterus salmoides.*

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a C/D (60.3) present state. The primary contributing factor to a lack of fish diversity and abundance is due to the recording of *Micropterus salmoides* (Largemouth Bass). Although only a single individual was recorded, this provided evidence that these species reside in this river reach. These exotic fish species have a reputation of altering the river's ecology and functionality, coupled with decreasing the diversity and abundance of indigenous fish species within the river reach. Furthermore, several of the expected fish species no longer occur in this section of the river and upstream migration from refuge areas for re-establishment no longer available potentially due to the in-stream dam located upstream of the sample point.

The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a B (The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a B (82.0 %). This means the river is in a largely natural to moderately modified ecological condition. The most impacted driver metric is that of water quality at 77.3%, followed by instream habitat at 82.1%, followed by the flow modification metric at 84.0%. Table 80 provides a summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include, Baetidae, Tricorythidae, Gomphidae, Hydropsychidae, Elmidae and Simuliidae.

Table 80: Macroinvertebrate Ecological Category, MIRAI

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	84.0	*0.357*	29.9895	1	100
HABITAT	**H**	82.1	*0.321*	26.3898	2	90
WATER QUALITY	**WQ**	79.8	*0.321*	25.6339	2	90
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						280
INVERTEBRATE EC				82.0132		
INVERTEBRATE EC CATEGORY				B		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

According to the flow modification metric group, presence of taxa with a preference for very fast flowing water had the highest rating of 2.5, being impacted the most from the reference condition.

The occurrence of taxa with a preference for vegetation had been impacted the most from reference, with an allocated rating of 2.5 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with bedrock/boulders ranked as the least important instream habitat for this site.

According to the water quality metrics, the SASS score has been impacted the most with an allocated rating of 3.

Annexure 3 provides the detailed tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Polkadraaispruit was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in Table 81 and Table 82 respectively. The instream habitat is in a B category and the riparian zone integrity is in an A/B category. The main impacts on the habitat integrity of the system are the collapsing of the banks, flow modification due to the upstream dam and the presence of bass.

Table 81: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	May 2012 (Polkadraaispruit EWR site)	COMMENT
VEGETATION REMOVAL (IMPACT 1-25)	3	Clearing of vegetation
EXOTIC VEGETATION (IMPACT 1-25)	3	Seringa
BANK EROSION (IMPACT 1-25)	5	Bank collapse
CHANNEL MODIFICATION (IMPACT 1-25)	2	Localised by crossings and woody exotic species
WATER ABSTRACTION (IMPACT 1-25)	2	Localised irrigation
INUNDATION (IMPACT 1-25)	2	Upstream dam
FLOW MODIFICATION (IMPACT 1-25)	2	Narrowing of channel due to bridge
WATER QUALITY (IMPACT 1-25)	0	
RIPARIAN VEGETATION INTEGRITY SCORE *	88.0	
RIPARIAN INTEGRITY CATEGORY	**A/B**	

* Weighted riparian integrity score

Table 82: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	May 2012 (Polkadraaispruit EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	4	Small scale irrigation
FLOW MODIFICATION (IMPACT 1-25)	6	Dam upstream impacts on low and moderate flows
BED MODIFICATION (IMPACT 1-25)	6	Localised from road and bridge
CHANNEL MODIFICATION (IMPACT 1-25)	4	Localised collapse of banks, sedimentation
WATER QUALITY (IMPACT 1-25)	6	Increased phosphates – chicken farms
INUNDATION (IMPACT 1-25)	6	Woody debris and concrete slabs below road bridge
SECONDARY		

EXOTIC MACROPHYTES (IMPACT 1-25)	0	
EXOTIC FAUNA (IMPACT 1-25)	18	Presence of bass in the system
SOLID WASTE DISPOSAL (IMPACT 1-25)	1	General littering
IN STREAM HABITAT INTEGRITY SCORE *	83.2	
INSTREAM INTEGRITY CATEGORY	**B**	

* Weighted instream integrity score

(iv) Physico-chemical

The available physico-chemical data have been fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings have been used with the overall confidence as low since important constituents such as dissolved oxygen and temperature have insufficient data available.

The results have been determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the river based on the current condition of the resource. Table 83 shows the results of this assessment for the Polkadraaispruit.

Table 83: PAI table for the Polkadraaispruit

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	1.50	**50.00**		**55.00**
Salts	0.00	NONE SPECIFIED	1.50	**50.00**		**55.00**
Nutrients	3.00	NONE SPECIFIED	1.00	**65.00**		**70.00**
Water Temperature	1.00	N	0.50	**60.00**		**90.00**
Water clarity	3.00	NONE SPECIFIED	2.00	**50.00**		**50.00**
Oxygen	3.50	N	0.50	**75.00**		**90.00**
Toxics	0.00	N	1.50	**100.00**		**100.00**
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	**1.48**	**MEAN CONF ®**	**1.21**			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	**1.48**					

CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	**1.50**
FINAL PC MODIFICATION RATING	**1.48**
P-C CATEGORY %	**P-C CATEGORY**
70.40	**C**

(v) Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in Table 84. The main impacts on the Polkadraaispruit are due to the upstream dam at the road bridge.

Table 84: PES per component for the Polkadraaispruit

COMPONENT	PES	EXPLANATION
Fish	C/D	Expected species: 12 Previously recorded species: 3 Observed species: 5 Species observed were typically those associated with faster flowing waters and rocky habitats. The species absent (*Barbus paludinosus*, *Barbus trimaculatus*, *Barbus unitaeniatus*, *Tilapia sparrmanii* and *Pseudocrenilabrus philander* were absent in the larger pools where one would expect them. This is due to the presence of the alien invasive Largemouth Bass (*M.salmodies*)
Macro-invertebrates	B	2007/03/06 SASS5 score: 151 No of Taxa: 25 ASPT: 6 2007/08/27 SASS5 score: 160 No of Taxa: 28 ASPT: 5.7 2012/05/29 SASS5 score: 197 No of Taxa: 29 ASPT: 6.8 Key taxa expected but not observed were generally those that show preference for the vegetation biotope including Belostomatidae, Haliplidae, Naucoridae. Leptophlebiidae, Corixidae, Dytiscidae were less abundant than expected, while Veliidae were more abundant than expected.
Habitat Integrity: Instream	B	INSTREAM INTEGRITY: 83.2 Clearing of vegetation Seringa Bank collapse Localised by crossings and woody exotic species Localised irrigation Upstream dam Narrowing of channel due to bridge
Habitat Integrity: Riparian	A/B	RIPARIAM VEGETATION SCORE: 88 Small scale irrigation Dam upstream impacts on low and moderate flows Localised from road and bridge Localised collapse of banks, sedimentation Increased phosphates – chicken farms Woody debris and concrete slabs below road bridge Presence of bass in the system General littering
Physico-chemical	C	Elevated nutrients from extensive upstream agriculture

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Polkadraaispruit are shown in

Table 85.

Table 85: Integrated results for the Polkadraaispruit

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	3.5	90		
2.What is the natural diversity of **fish** species with a preference for different cover types	3	80		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	4	100		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12.5	340	**60.3**	**C/D**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	4	100		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	90		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	90		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**10**	280	**81.2**	**B/C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		620	**72.5**	**C**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	3	0.50	30.15
Confidence rating for **macro-invertebrate** information	3	0.50	40.60
	6	1.00	70.75
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**88.0**	**A/B**

ECOSTATUS	Confidence rating	Proporitons	Modified weights
Confidence rating for instream biological information	3	0.50	35.38
Confidence rating for riparian vegetation zone information	3	0.50	44.00
	6	1.00	79.38
ECOSTATUS	**EC**		**B/C**

Ecological Importance and Sensitivity (EIS)

The EIS for the Polkadraaispruit was determined as moderate as presented in Table 86.

Table 86: Ecological Importance and Sensitivity of the Polkadraaispruit

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	
Unique (endemic, isolated)	2	*Amphilius uranoscopus*
Intolerant (flow and flow related water quality)	2	Inverts: Tricorythidae, Hydropsychidae - more than 2 Fish: CPRE
Species/taxon richness	2	29 invertebrate families. ASPT= 6.8 4 of 12 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	2	Pools, riffles, runs, SIC, SOC, MVIC, MVOOC, GSM
Refugia	3	Riffle habitats acts as refugia for fish from bass moving up from Marico
Sensitivity to flow changes	2	Limited loss of riffle sections due to changes in low flows
Sensitivity to flow related water quality changes	2	Decrease in flow might concentrate algal growth
Migration route/corridor (instream and riparian)	0	
Importance of conservation and natural areas	1	Local conservancy
MEDIAN OF DETERMINANTS	**2.0**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**MODERATE**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Polkadraaispruit is a B/C category and the EIS is moderate. The unique species *Amphilius uranoscopus* is present in the system. A B category is thus recommended for the Polkadraaispruit.

3.6.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of B for the Polkadraaispruit at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for October and February. October is the lowest flow month and February the highest flow month based on the natural time series. May was used as the datum.

The water level in the Polkadraaispruit during the site visit on 29 May 2012 ($0.028m^3/s$) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge, Figure 20) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements.

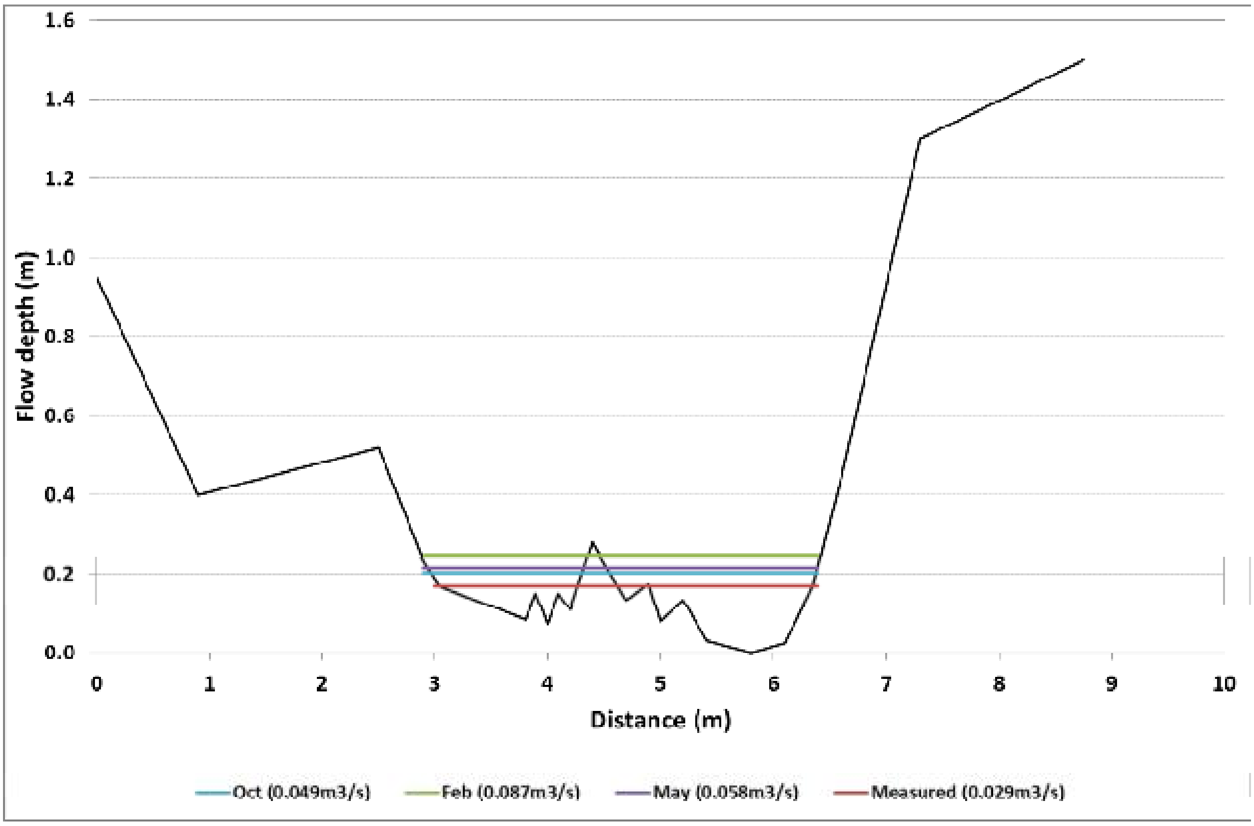

Figure 20: Calibrated cross-sectional profile of the Polkadraaispruit at the EWR site

The site-specific flow requirements were based mainly on the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of October was adequate to maintain the system in a B category.

Table 87 gives the results of the DRM at the EWR site in the Polkadraaispruit in quaternary catchment A31B and Table 88 provides a summary of the recommended requirements.

Table 87: Results of the DRM for the Polkadraaispruit (REC = B)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	**Average**	**Average**
Maintenance low flows					
Low flow month	October	0.049	0.21	0.10	0.15
High flow month	February	0.087	0.25	0.14	0.18
Datum	May	0.058	0.22	0.12	0.16
Measured discharge at site visit (28 May 2012)		0.0289	0.18	0.08	0.13

Table 88: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	A31B
River	Polkadraaispruit
EWR Site Co-ordinates	S 25.6469°; E 26.4893°
Recommended Ecological Category	B
VMAR for Quaternary Catchment Area	9.866
Total EWR	3.144 (31.87 %MAR)
Maintenance Low flows	1.949 (19.75 %MAR)
Drought Low flows	0.143 (1.45 %MAR)
Maintenance High flows	1.195 (12.11 %MAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Polkadraaispruit are provided in **Annexure 4**.

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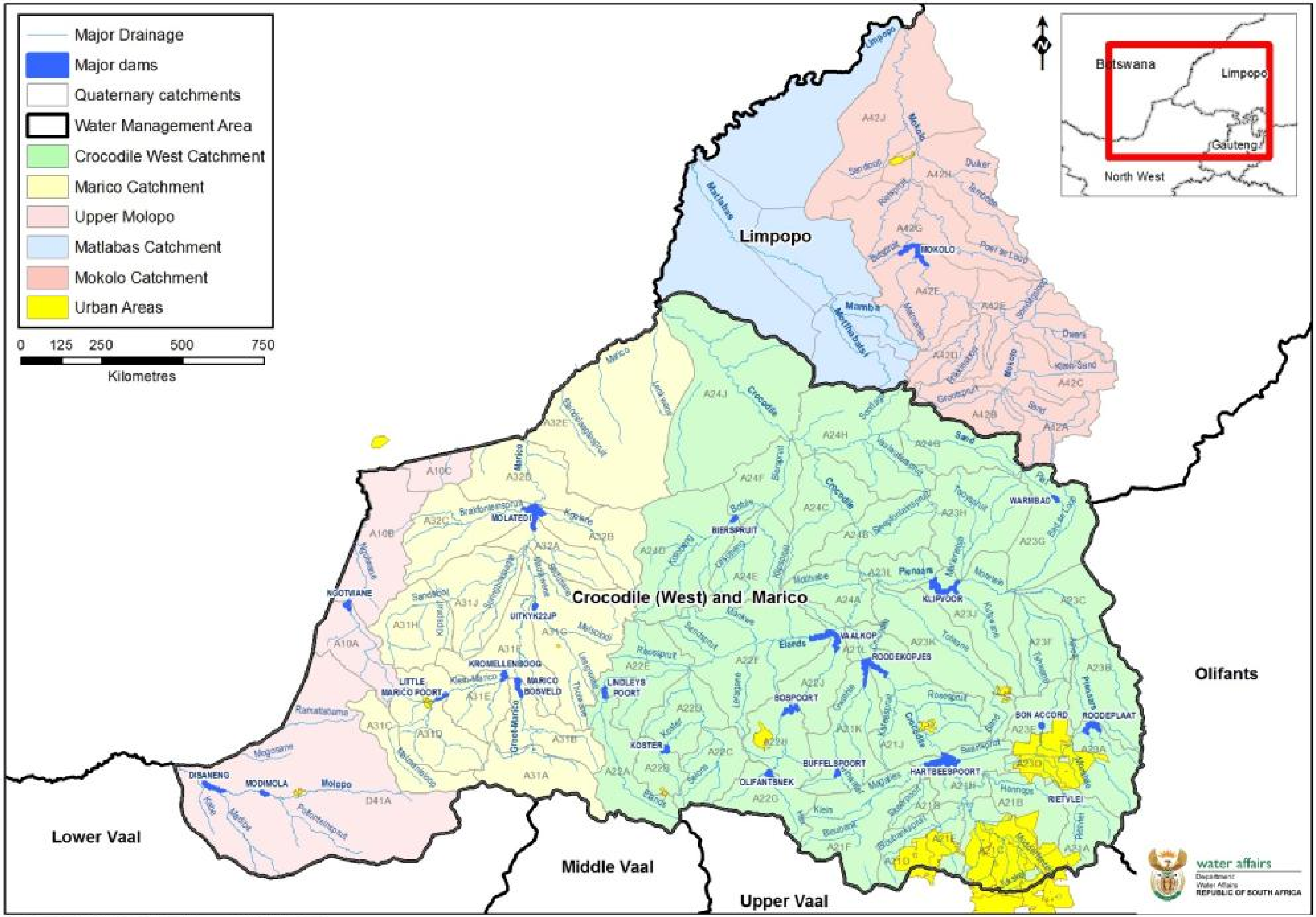
ANNEXURE 1

MAP OF STUDY AREA



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ANNEXURE 2

FISH: FRAI TABLES

Annexure 2.1: Buffels River

Summary of the metric group weighting for the Buffels River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	92.86
COVER	100.00
FLOW MODIFICATION	91.43
PHYSICO-CHEMICAL	75.71
MIGRATION	51.43
IMPACT OF INTRODUCED	22.86

Summary of the FRAI EC for the Buffels River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	**64.4**
EC: FRAI	**C**
ADJUSTED	
FRAI (%)	**64.4**
EC: FRAI	**C**

Frequency of Occurrence of Fish species for reference and present conditions for the Buffels River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
BARBUS BREVIPINNIS JUBB, 1966	3.00	3.00
LABEOBARBUS MAREQUENSIS SMITH, 1841	5.00	5.00
BARBUS PALUDINOSUS PETERS, 1852	5.00	0.00
BARBUS TRIMACULATUS PETERS, 1852	3.00	0.00
BARBUS UNITAENIATUS GÜNTHER, 1866	3.00	0.00
CHETIA FLAVIVENTRIS TREWAVAS, 1961	5.00	3.00
CLARIAS GARIEPINUS (BURCHELL, 1822)	3.00	0.00
LABEO CYLINDRICUS PETERS, 1852	1.00	0.00
LABEO MOLYBDINUS DU PLESSIS, 1963	1.00	0.00
OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	1.00	0.00
PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	4.00
TILAPIA SPARRMANII SMITH, 1840	5.00	5.00

Annexure 2.2: Lower Elands River

Summary of the metric group weighting for the Buffels River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	96.77
COVER	90.32
FLOW MODIFICATION	100.00
PHYSICO-CHEMICAL	83.87
MIGRATION	74.19
IMPACT OF INTRODUCED	32.26

Summary of the FRAI EC for the Buffels River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	**50.5**
EC: FRAI	**D**
ADJUSTED	
FRAI (%)	**59.5**
EC: FRAI	**C/D**

Frequency of Occurrence of Fish species for reference and present conditions for the Buffels River

Scientific Names: Reference Species (Introduced Species Excluded)	Reference Frequency Of Occurrence	Pes:Observed & Habitat Derived Frequency Of Occurrence
ANGUILLA MOSSAMBICA PETERS 1852	1.00	0.00
AMPHILIUS URANOSCOPUS (PFEFFER, 1889)	2.00	0.00
LABEOBARBUS MAREQUENSIS SMITH, 1841	3.00	5.00
BARBUS MOTEBENSIS STEINDACHNER, 1894	1.00	0.00
BARBUS PALUDINOSUS PETERS, 1852	3.00	5.00
LABEOBARBUS POLYLEPIS BOULENGER, 1907	3.00	0.00
BARBUS TRIMACULATUS PETERS, 1852	3.00	0.00
BARBUS UNITAENIATUS GÜNTHER, 1866	3.00	0.00

Annexure 2.3: Waterkloofspruit

Summary of the metric group weighting for the Buffels River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	100.00
COVER	92.59
FLOW MODIFICATION	96.30
PHYSICO-CHEMICAL	92.59
MIGRATION	92.59
IMPACT OF INTRODUCED	81.48

Summary of the FRAI EC for the Buffels River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	**40.7**
EC: FRAI	**D/E**
ADJUSTED	
FRAI (%)	**40.7**
EC: FRAI	**D/E**

Frequency of Occurrence of Fish species for reference and present conditions for the Buffels River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
LABEOBARBUS MAREQUENSIS SMITH, 1841	3.00	0.00
BARBUS MOTEBENSIS STEINDACHNER, 1894	1.00	0.00
BARBUS PALUDINOSUS PETERS, 1852	1.00	0.00
BARBUS TRIMACULATUS PETERS, 1852	3.00	3.00
BARBUS UNITAENIATUS GÜNTHER, 1866	3.00	3.00
CLARIAS GARIEPINUS (BURCHELL, 1822)	1.00	1.00
PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	1.00	1.00
TILAPIA SPARRMANII SMITH, 1840	1.00	2.00

Annexure 2.4: Magalies River

Summary of the metric group weighting for the Buffels River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	100.00
COVER	81.25
FLOW MODIFICATION	78.13
PHYSICO-CHEMICAL	62.50
MIGRATION	62.50
IMPACT OF INTRODUCED	78.13

Summary of the FRAI EC for the Buffels River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	**54.7**
EC: FRAI	**D**
ADJUSTED	
FRAI (%)	**64.4**
EC: FRAI	**C**

Frequency of Occurrence of Fish species for reference and present conditions for the Buffels River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
BARBUS ANOPLUS WEBER, 1897	3.00	5.00
LABEOBARBUS MAREQUENSIS SMITH, 1841	3.00	5.00
LABEOBARBUS POLYLEPIS BOULENGER, 1907	1.00	0.00
BARBUS PALUDINOSUS PETERS, 1852	3.00	3.00
BARBUS TRIMACULATUS PETERS, 1852	3.00	0.00
BARBUS UNITAENIATUS GÜNTHER, 1866	1.00	0.00
CHILOGLANIS PRETORIAE VAN DER HORST, 1931	3.00	0.00
CLARIAS GARIEPINUS (BURCHELL, 1822)	3.00	3.00
PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	3.00	0.00
TILAPIA SPARRMANII SMITH, 1840	3.00	4.00

Annexure 2.5: Rietvlei

Summary of the metric group weighting for the Buffels River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	81.25
COVER	90.63
FLOW MODIFICATION	84.38
PHYSICO-CHEMICAL	100.00
MIGRATION	68.75
IMPACT OF INTRODUCED	50.00

Summary of the FRAI EC for the Buffels River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	**57.9**
EC: FRAI	**C/D**
ADJUSTED	
FRAI (%)	**57.9**
EC: FRAI	**C/D**

Frequency of Occurrence of Fish species for reference and present conditions for the Buffels River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
BARBUS ANOPLUS WEBER, 1897	4.00	5.00
CLARIAS GARIEPINUS (BURCHELL, 1822)	3.00	0.00
PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	3.00	0.00
TILAPIA SPARRMANII SMITH, 1840	3.00	0.00

Annexure 2.6: Polkadraaispruit

Summary of the metric group weighting for the Buffels River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	90.00
COVER	83.33
FLOW MODIFICATION	88.33
PHYSICO-CHEMICAL	75.00
MIGRATION	56.67
IMPACT OF INTRODUCED	100.00

Summary of the FRAI EC for the Buffels River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	**56.8**
EC: FRAI	**D**
ADJUSTED	
FRAI (%)	**60.3**
EC: FRAI	**C/D**

Frequency of Occurrence of Fish species for reference and present conditions for the Buffels River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
AMPHILIUS URANOSCOPUS (PFEFFER, 1889)	3.00	3.00
LABEOBARBUS MAREQUENSIS SMITH, 1841	3.00	5.00
BARBUS PALUDINOSUS PETERS, 1852	3.00	0.00
BARBUS TRIMACULATUS PETERS, 1852	3.00	0.00
BARBUS UNITAENIATUS GÜNTHER, 1866	1.00	0.00
CHETIA FLAVIVENTRIS TREWAVAS, 1961	0.00	0.00
CHILOGLANIS PRETORIAE VAN DER HORST, 1931	3.00	5.00
CLARIAS GARIEPINUS (BURCHELL, 1822)	1.00	0.00
LABEOBARBUS POLYLEPIS BOULENGER, 1907	3.00	1.00
PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	1.00	0.00
TILAPIA SPARRMANII SMITH, 1840	1.00	0.00

ANNEXURE 3

MACROINVERTEBRATES: MIRAI TABLES

Annexure 3.1 Buffels River

FLOW MODIFICATION METRICS. WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% Weight
Presence of taxa with a preference for very fast flowing water	1	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1	2	90
Presence of taxa with a preference for moderately fast flowing water	1	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1.5	1	100
Presence of taxa with a preference for slow flowing water	1.5	3	70
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	1.5	3	70
Presence of taxa with a preference for standing water	2	4	60
Abundance and/or frequency of occurrence of taxa with a preference for standing water	0.5	4	60
Overall % change in flow dependence of assemblage			25

<u>**HABITAT MODIFICATION METRICS.**</u> **WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	5	50
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	5	50
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	2	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	0.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	2	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1	3	80
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	1	3	80
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	1	4	70
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	4	70
Overall % change in flow dependenceof assemblage			21

WATER QUALITY METRICS. WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% WEIGHT
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	0	2	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	2	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	2	1	100
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	1	100
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	2	3	80
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1.5	3	80
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	2	4	70
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	4	70
How does the total SASS score differ from expected?	0	1	100
How does the total ASPT score differ from expected?	1	1	100
Overall change to indicators of modified water quality			21

Annexure 3.2 Lower Elands River

FLOW MODIFICATION METRICS. WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% Weight
Presence of taxa with a preference for very fast flowing water	2.5	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1	2	90
Presence of taxa with a preference for moderately fast flowing water	2	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1	1	100
Presence of taxa with a preference for slow flowing water	1.5	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	1	3	80
Presence of taxa with a preference for standing water	2.5	4	70
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	70
Overall % change in flow dependence of assemblage			31

HABITAT MODIFICATION METRICS. WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	%WEIGHT
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	5	70
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	5	70
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	3	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	1.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	2	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1	3	85
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	1	3	85
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	1	4	80
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	4	80
Overall % change in flow dependenceof assemblage			25

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	2.5	3	80
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	3	80
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	3.5	2	90
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	2	2	90
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	2	4	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	2	4	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1.5	5	40
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	5	40
How does the total SASS score differ from expected?	3	1	100
How does the total ASPT score differ from expected?	3	1	100
Overall change to indicators of modified water quality			45

Annexure 3.3 Waterkloofspruit

<u>FLOW MODIFICATION METRICS.</u> WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% Weight
Presence of taxa with a preference for very fast flowing water	2.5	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1.5	2	90
Presence of taxa with a preference for moderately fast flowing water	1.5	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1	1	100
Presence of taxa with a preference for slow flowing water	1.5	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	3	80
Presence of taxa with a preference for standing water	2	4	70
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	70
Overall % change in flow dependence of assemblage			29

HABITAT MODIFICATION METRICS. WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	5	40
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	5	40
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	2	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	1.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2	3	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	3	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1	2	95
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	0.5	2	95
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	0.5	4	80
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	4	80
Overall % change in flow dependenceof assemblage			22

<u>WATER QUALITY METRICS.</u> **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	2	2	95
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	1	2	95
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	2	1	100
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	1	100
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	2	3	80
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1.5	3	80
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1.5	4	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	0.5	4	60
How does the total SASS score differ from expected?	3	1	100
How does the total ASPT score differ from expected?	2	1	100
Overall change to indicators of modified water quality			34

Annexure 3.4 Magalies River

<u>FLOW MODIFICATION METRICS.</u> WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% Weight
Presence of taxa with a preference for very fast flowing water	2	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	0.5	2	90
Presence of taxa with a preference for moderately fast flowing water	2	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	0.5	1	100
Presence of taxa with a preference for slow flowing water	1.5	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	3	80
Presence of taxa with a preference for standing water	2	4	70
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	70
Overall % change in flow dependence of assemblage			25

HABITAT MODIFICATION METRICS. WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	5	60
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0	5	60
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	2.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	0.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	2	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1	3	80
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	1	3	80
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	1.5	4	70
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	1	4	70
Overall % change in flow dependenceof assemblage			23

WATER QUALITY METRICS. WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	1	2	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	2	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	3	1	100
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	2	1	100
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	3	3	80
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1.5	3	80
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1.5	4	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	0.5	4	60
How does the total SASS score differ from expected?	3	1	100
How does the total ASPT score differ from expected?	2	1	100
Overall change to indicators of modified water quality			38

Annexure 3.5 Rietvlei

<u>FLOW MODIFICATION METRICS.</u> **WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	2.5	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	0.5	2	90
Presence of taxa with a preference for moderately fast flowing water	3.5	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1	1	100
Presence of taxa with a preference for slow flowing water	2.5	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	3	80
Presence of taxa with a preference for standing water	4	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	50
Overall % change in flow dependence of assemblage			38

<u>HABITAT MODIFICATION METRICS.</u> WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	%WEIGHT
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	5	50
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	5	50
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	4	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	0.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	3.5	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	2	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	2.5	3	80
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	0	3	80
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	2	4	70
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	4	70
Overall % change in flow dependenceof assemblage			33

<u>**WATER QUALITY METRICS.**</u> **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	2	2	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	2	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	4	1	100
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	0.5	1	100
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	4	3	80
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	0.5	3	80
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	2	4	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1.5	4	60
How does the total SASS score differ from expected?	4	1	100
How does the total ASPT score differ from expected?	4	1	100
Overall change to indicators of modified water quality			48

Annexure 3.6 Polkadraaispruit

FLOW MODIFICATION METRICS. WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% Weight
Presence of taxa with a preference for very fast flowing water	0.5	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1	2	90
Presence of taxa with a preference for moderately fast flowing water	0.5	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1	1	100
Presence of taxa with a preference for slow flowing water	1	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	3	80
Presence of taxa with a preference for standing water	1	4	70
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	70
Overall % change in flow dependence of assemblage			16

<u>**HABITAT MODIFICATION METRICS.**</u> **WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	5	20
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	5	20
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	0.5	1	10
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	1	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2	3	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	3	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	0.5	2	95
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	0.5	2	95
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	0.5	4	85
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	1	4	85
Overall % change in flow dependenceof assemblage			18

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	0	3	80
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	3	80
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	1	2	90
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	2	90
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	0.5	4	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	0.5	4	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	5	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	5	60
How does the total SASS score differ from expected?	3	1	100
How does the total ASPT score differ from expected?	2	1	100
Overall change to indicators of modified water quality			23

ANNEXURE 4

PHYSICO-CHEMICAL: ECOSPECS, TPCs & MONITORING REQUIREMENTS

Annexure 4.1 Buffels River

RIVER		**River**	**Buffels River**			
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Nutrients (mg/L)	SRP	**C**ategory = C/D	50th %tile ≤0.03 mg/L	Yes	50th percentile to be < 0.030 mg/L	Monthly
	TIN	Category = B/C	50th %tile ≤0.6 mg/L	Yes	50th percentile to be <0.6 mg/L	Monthly
Physical Variables	pH	Category = **B**	95th %tile <= 7.7 and 5th %tile >= 6.1	No	95th percentile to be <= 7.7 and 5th percentile >= 6.1	Monthly
	Temperature	Category = **C**	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = **B**	5th %tile > 6 mg/l	No	5th percentile to be > 6.5	Monthly
	Turbidity	Category = C	Change from natural should not be more than moderate (definition - DWAF 2008).	Yes	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = **B**	95th %tile ≤ 42.5mS/m	No	95th percentile to be <42.5mS/m	Monthly
Response variables	SASS (ASPT)	Category = B/C	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = **A**	95th %tile < 0.06mg/l	No	95th %tile < 0.06mg/l	Monthly
	Fluoride	Category = **A**	95th %tile < 0.7	No	No toxic component should be within 10% of the A/ B category boundary at its 95th percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.
	Manganese	Category = **A**				

Annexure 4.2 Lower Elands River

RIVER		**River**	**Lower Elands River**			
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Nutrients (mg/L)	SRP	**C**ategory = D	50^{th} %tile ≤0.05 mg/L	Yes	50^{th} percentile to be < 0.030 mg/L	Monthly
	TIN	Category = B	50^{th} %tile ≤0.3 mg/L	No	50^{th} percentile to be <0.3mg/L	Monthly
Physical Variables	pH	Category = **A**	95^{th} %tile <= 8.1 and 5^{th} %tile >= 7.5	No	95^{th} percentile to be <= 8.3 and 5^{th} percentile >= 7	Monthly
	Temperature	Category = **C**	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = **D**	5^{th} %tile > 6 mg/l	Yes	5^{th} percentile to be > 8 mg/l	Monthly
	Turbidity	Category = B	Change from natural should not be more than moderate (definition - DWAF 2008).	Yes	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = **A**	95^{th} %tile ≤ 21mS/m	No	95^{th} percentile to be <21mS/m	Monthly
Response variables	SASS (ASPT)	Category = C	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = **E**	95^{th} %tile < 0.42mg/l	Yes	95^{th} %tile < 0.07mg/l	Monthly
	Fluoride	Category = **A**	95^{th} %tile < 0.25 mg/l	No	No toxic component should be within 10% of the A/ B category boundary at its 95^{th} percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.
	Manganese	Category = **A**				

Annexure 4.3 Waterkloofspruit

RIVER		River	Waterkloofspruit			
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Nutrients (mg/L)	SRP	**C**ategory = B	50^{th} %tile ≤0.012 mg/L	No	50^{th} percentile to be < 0.012 mg/L	Monthly
	TIN	Category = A	50^{th} %tile ≤0.06mg/L	No	50^{th} percentile to be <0.1 mg/L	Monthly
Physical Variables	pH	Category = A	95^{th} %tile <= 7.6 and 5^{th} %tile >= 7.1	No	95^{th} percentile to be <= 7.6 and 5^{th} percentile >= 7.1	Monthly
	Temperature	Category = C	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = B	5^{th} %tile > 6 mg/l	No	5^{th} percentile to be > 6.5	Monthly
	Turbidity	Category = A	Change from natural should not be more than moderate (definition - DWAF 2008).	No	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = B	95^{th} %tile ≤ 42.5mS/m	No	95^{th} percentile to be <42.5 mS/m	Monthly
Response variables	SASS (ASPT)	Category = C	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = B	95^{th} %tile < 0.02mg/l	No	95^{th} %tile < 0.02mg/l	Monthly
	Fluoride	Category = A	95^{th} %tile < 0.16	No	No toxic component should be within 10% of the A/ B category boundary at its 95^{th} percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.
	Manganese	Category = **A**				

Annexure 4.4 Magalies River

RIVER		River	Magalies River			
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Nutrients (mg/L)	SRP	**C**ategory = D	50^{th} %tile ≤0.050 mg/L	Yes	50^{th} percentile to be < 0.030 mg/L	Monthly
	TIN	Category = A	50^{th} %tile ≤0.06 mg/L	No	50^{th} percentile to be <0.1 mg/L	Monthly
Physical Variables	pH	Category = **A**	95^{th} %tile <= 8.3 and 5^{th} %tile >= 7.2	No	95^{th} percentile to be <= 8.3 and 5^{th} percentile >= 7.2	Monthly
	Temperature	Category = **C**	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = **D**	5^{th} %tile > 6.6 mg/l	Yes	5^{th} percentile to be > 6.6	Monthly
	Turbidity	Category = D	Change from natural should not be more than moderate (definition - DWAF 2008).	Yes	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = **B/C**	95^{th} %tile ≤ 55.0mS/m	Yes	95^{th} percentile to be <55.0mS/m	Monthly
Response variables	SASS (ASPT)	Category = C	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = **E**	95^{th} %tile < 1mg/l	Yes	95^{th} %tile < 0.07mg/l	Monthly
	Fluoride	Category = **A**	95^{th} %tile < 0.16 mg/l	No	No toxic component should be within 10% of the A/ B category boundary at its 95^{th} percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.
	Manganese	Category = **A**				

Annexure 4.5 Rietvlei

RIVER		**River**	**ietvlei River**			
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Nutrients (mg/L)	SRP	**C**ategory = D	50^{th} %tile ≤0.05 mg/L	Yes	50^{th} percentile to be < 0.03mg/L	Monthly
	TIN	Category = B	50^{th} %tile ≤0.6 mg/L	No	50^{th} percentile to be <0.6 mg/L	Monthly
Physical Variables	pH	Category = A/**B**	95^{th} %tile <= 8.8 and 5^{th} %tile >= 7.2	No	95^{th} percentile to be <= 8.8 and 5^{th} percentile >= 7.2	Monthly
	Temperature	Category = **C**	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = **B**	5^{th} %tile > 8.1mg/l	No	5^{th} percentile to be > 8.0mg/L	Monthly
	Turbidity	Category = D	Change from natural should not be more than moderate (definition - DWAF 2008).	Yes	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = **B/C**	95^{th} %tile ≤ 55mS/m	Yes	95^{th} percentile to be <50 mS/m	Monthly
Response variables	SASS (ASPT)	Category = C/D	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = **E**	95^{th} %tile < 1.1mg/l	Yes	95^{th} %tile < 0.07mg/l	Monthly
	Fluoride	Category = **A**	95^{th} %tile < 0.3 mg/l	No	No toxic component should be within 10% of the A/ B category boundary at its 95^{th} percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.
	Manganese	Category = **A**				

Annexure 4.6 Polkadraaispruit

RIVER		**River**	**Polkadraaispruit**			
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Nutrients (mg/L)	SRP	**C**ategory = D	50^{th} %tile ≤0.03 mg/L	Yes	50^{th} percentile to be < 0.015 mg/L	Monthly
	TIN	Category = A	50^{th} %tile ≤0.04 mg/L	Yes	50^{th} percentile to be <0.6 mg/L	Monthly
Physical Variables	pH	Category = **A**	95^{th} %tile <= 7.8 and 5^{th} %tile >= 7.7	No	95^{th} percentile to be <= 8.0 and 5^{th} percentile >= 6.5	Monthly
	Temperature	Category = **C**	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = **B**	5^{th} %tile > 6 mg/l	No	5^{th} percentile to be > 6.5	Monthly
	Turbidity	Category = C	Change from natural should not be more than moderate (definition - DWAF 2008).	Yes	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = **A**	95^{th} %tile ≤ 16mS/m	No	95^{th} percentile to be <30 mS/m	Monthly
Response variables	SASS (ASPT)	Category = B/C	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = **B/C**	95^{th} %tile < 0.07mg/l	Yes	95^{th} %tile < 0.06mg/l	Monthly
	Fluoride	Category = **A**	95^{th} %tile < 0.2mg/l	No	No toxic component should be within 10% of the A/ B category boundary at its 95^{th} percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.
	Manganese	Category = **A**				

APPENDIX C

RAPID ECOLOGICAL RESERVE DETERMINATION STUDIES FOR THE MATLABAS CATCHMENT

TABLE OF CONTENTS

ANNEXURES

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

CD: RDM	Chief Directorate: Resource Directed Measures
DRM	Desktop Reserve Model
DWA	Department of Water Affairs
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FFHA	Fish Frequency Habitat Assessment
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurrence
GSM	Gravel, Mud and Sand
HI	Habitat Integrity
IFHA	Invertebrate Frequency Habitat Assessment
IHAS	Invertebrate Habitat Assessment System
MAR	Mean Annual Runoff
MIRAI	Macro-invertebrate Response Assessment Index
NWA	National Water Act
PES	Present Ecological State/Ecostatus
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
SASS5	South African Scoring System (Version 5)
SIC	Stones in Current
SOOC	Stones out of Current
TPC	Threshold of Potential Concern
VMAR	Virgin Mean Annual Runoff
WRCS	Water Resources Classification System

1. INTRODUCTION

1.1 Purpose

The purpose of the ecological Reserve determination studies undertaken for the Matlabas catchment was to provide higher confidence results than the current available desktop requirements to be used in the WRCS and to provide the necessary protection of the resource during the evaluation of water use license applications. The EWR sites selected for this study were in tributaries and on the main stem where limited EWR information is available.

This report provides the results of the determination of the quantity and quality requirements of the preliminary Reserve for the surface water component of the selected rivers in the Matlabas catchment on a rapid level of detail.

The following main tasks were undertaken:

- Undertake field surveys for the fish, macro-invertebrates and hydraulics (flow measurement and profiling) at the selected EWR sites.
- Describe the reference conditions; determine the Present Ecological State (PES), Ecological Importance and Ecological Sensitivity, the Recommended Ecological Category (REC) and the ecological water requirements of the rivers at the EWR sites.
- Prepare a report detailing the process followed, approaches, results and recommendations for the protection of the water resources and further analysis as part of the WRCS.

1.2 Study approach

The following main activities were undertaken to meet the objectives of the study:

- Field surveys were undertaken on 30, 31 January and 1 February 2013 to collect data on fish, macroinvertebrates and to undertake the hydraulic measurements. It is important to note that rapid studies should ideally be undertaken during the dry season as this will provide the critical information required to ensure protection of the water resources.
- Integration of the results from the field surveys, to determine the ecostatus and ecological water requirements of the rivers at the EWR sites were done during a specialist workshop.

The activities and tasks for this ecological Reserve determination study were undertaken in accordance with the appropriate approaches and methodologies for rivers as prescribed by the CD: RDM of DWA, namely:

- *The methodology as set out in DWAF (1999): Resource Directed Measures for Protection of Water Resources; Volume 3: River Ecosystems Version 1.0 (Revised water quality methodology, 2002).*

- *The revised methods as outlined in Louw and Hughes (2002), the Habitat Flow Stressor Response (HFSR) manual of IWR Source-to-Sea (2004) and the EcoClassification manual of Kleynhans et al (2005).*
- *Principles of a process to estimate and/or extrapolate environmental flow requirements, Kleynhans, Birkhead and Louw (2008).*
- *DWAF (2002): Hazard-based water quality ecological specifications for the Ecological Reserve in fresh water Resources. Report No. N/0000/REQ0000. Institute for Water Quality Studies, Department of Water Affairs and Forestry. Author: Jooste S.*
- *DWAF (2008): Methods for determining the water quality component of the Ecological Reserve. Report prepared for Department of Water Affairs and Forestry, Pretoria, South Africa by P-A Scherman. Draft 2, March 2008.*

1.3 Structure of the report

This report is divided into 5 main chapters and applicable annexures, where necessary.

The main chapters are:

- **Chapter 1** provides the purpose and the study approach;
- **Chapter 2** describes the study protocol followed for the assessment of the rivers at the EWR sites;
- **Chapter 3** provides the results of the field surveys and specialist workshop for the rivers assessed;
- **Chapter 4** provides the main conclusions and recommendations; and
- **Chapter 5** cites the references used in this report.

2. STUDY PROTOCOL

This section of the report provides the protocol followed for the determination of the EWRs of the Matlabas catchment.

2.1 Study team

The specialists involved in the assessment are listed in Table 1**.**

Table 1: Study team for the rapid ecological Reserve determination study

TEAM MEMBER	AFFILIATION	SPECIALIZATION/TASK
Stassen R	JMM Stassen	Co-ordination, SPATSIM
Kimberg, P	Golder Associates	Fish, habitat integrity
Farrell, K	Golder Associates	Macroinvertebrates
Naidoo, E	Golder Associates	Hydraulics
Boyd, L	Golder Associates	Physico-chemical

Dr Neels Kleynhans and Christa Thirion from the DWA RQS directorate assisted during the specialists' workshop and provided the relevant fish and macroinvertebrate requirements using the FFHA and IFHA models for further analysis with SPATSIM to determine the ecological water requirements at the EWR sites.

2.2 Study area and site visit

The Matlabas catchment falls within the Limpopo Water Management Area (WMA) and included the tributaries as well as the main stem river where limited data is available on EWRs to provide input to the WRCS.

Four EWR sites were selected for the Matlabas catchment during a previous survey in May 2012 by officials of the Department of Water Affairs. Surveys on fish and macroinvertebrates were undertaken during that visit, but no detailed hydraulics was done at any of these sites as only slopes and discharge were measured. The purpose of this field survey was to re-visit the existing EWR sites to undertake detail hydraulic cross-sections and to do another fish and macroinvertebrate sampling. Limited *in situ* water quality sampling would also be undertaken.

Table 2 provides information on the selected EWR sites and a map of the study area is provided in **Annexure 1**.

Table 2: EWR site information for the rivers in the Matlabas catchment

EWR site	Quaternary catchment	River	Level of determination	Latitude	Longitude	Eco-region level 2	MAR ($10^6 m^3$)
MATEWR1	A41A	Matlabas Zyn Kloof	Rapid 3	S 24.4120°	E 27.6034°	7.04	5.23
MATEWR2	A41B	Matlabas Haarlem Oos	Rapid 2	S 24.1601°	E 27.4797°	1.03	32.80
MATEWR3	A41B	Mamba	Rapid 2	S 24.2127°	E 27.5072°	1.02	9.54
MATEWR4	A41C	Matlabas Phofu	Rapid 1	S 24.0515°	E 27.3592°	1.02	35.58

* Based on WR2005 data and some additional modeling undertaken for MATEWR1

The surveys were undertaken after major floods in the system and the flows were high compared to the expected flows. Access to the sites was also a problem as most of the areas were fenced in for game farming. Due to the high flows and inaccessibility the following levels of assessments were undertaken:

i. MATEWR1 (Matlabas Zyn Kloof in Marakele National Park) – Rapid level 3 which include a hydraulic cross-section, discharge, fish and macroinvertebrates surveys;

ii. MATEWR2 (Matlabas at Haarlem Oos) – Rapid 2 as access was a problem due to game fences, instream dams, very high flows and locked gates at the gauging weir. The information on fish and macroinvertebrates from the May 2012 survey together with a desktop hydraulic cross-section was used;

iii. MATEWR3 (Mamba at the R512 bridge) – Rapid 2 as this reach of the river was not adequate to undertake a hydraulic cross-section due to the impact of the bridge on the river channel. No access to the reaches up or downstream due to fences. The information on fish and macroinvertebrates from the May 2012 survey together with a desktop hydraulic cross-section was used;

iv. MATEWR4 (Matlabas at Phofu) – Rapid 1 as this site could not be accessed due to locked gates and game fences. Only the information from the fish and macroinvertebrates surveys from May 2012 was used. No desktop hydraulics cross-section was available and the biological data from MATEWR3 (Haarlem Oos) was extrapolated for this site.

2.3 Hydrological data

The WR2005 hydrology for the period 1920 to 2004 was used for the EWR sites. The hydrology at Matlabas Zyn Kloof (MATEWR1) was revised after discussions with Dr Neels Kleynhans from DWA: RQS. This was due to zero flows in the long term flow record and the occurrence of the rare and unique *Amphilius uranoscopus* in this river that need flowing water during all life stages. The regional parameters that were used in WR2005 were changed to parameters for a similar catchment (Sterkstroom in quaternary catchment A42D). This change provided the specified flow conditions as required by the fish.

Table 3 provides the natural MAR at each EWR site.

Table 3: Natural MAR at the selected EWR sites

EWR site	Quaternary catchment	River	MAR ($10^6 m^3$)
MATEWR1	A41A	Matlabas Zyn Kloof	5.23
MATEWR2	A41B	Matlabas Haarlem Oos	32.80
MATEWR3	A41B	Mamba	9.54
MATEWR4	A41C	Matlabas - Phofu	35.58

2.4 Physico-chemical data

Water quality data for the catchment was sourced from various databases and studies previously undertaken in the area. *In situ* data was also collected during the field surveys.

Details of the water quality assessment and methods used for this rapid assessment are given in DWAF (2008). The Physio-Chemical Driver Assessment Index (PAI) model can be used to disaggregate the overall water quality category into individual scores for each variable (e.g., dissolved oxygen [DO] or nutrients). Available water quality data was used and linked to the findings of the ecologists. The water quality ecospecs and TPCs were derived using methods from DWAF (2006).

The coordinates of the selected EWR sites and water quality site are given in Table 4.

Table 4: Coordinates of the EWR sites and notes on the water quality sites

EWR site		River	Co-ordinates of EWR site	Notes for water quality sampling point
1	MATEWR1	Matlabas Zyn Kloof	-24.41203; 27.60324	No water quality site except in Matlabas, 30 kms downstream
2	MATEWR2	Matlabas Haarlem Oos	-24.16013889; 27.47971111	At EWR site
3	MATEWR3	Mamba	-24.2127; 27.50718	No water quality site except in Matlabas, 6kms downstream
4	MATEWR4	Matlabas at Phofu	-24.05159; 27.35922	No water quality site except in Matlabas approximateky 16kms upstream

Water quality data was selected according to the availability of data and the locality of the monitoring sites with respect to the EWR sites. It is important to note that the water quality data was on the whole very limited. The water quality data used is from the DWA WMS data base. The level of confidence for the water quality data is set out in Table 5.

Table 5: Water quality data confidence

Data availability	Number of samples	Confidence
Sampling point 90328 (AH004)	225	Moderate

The driving issues on water quality at the EWR sites are set out in Table 6 and the infield results are set out in Table 7.

Table 6: Water quality drivers

EWR site	Drivers
MATEWR1	Nutrients: National Park, game farming
MATEWR2	Nutrients: Game farming
MATEWR3	Nutrients: Game farming
MATEWR4	Nutrients: Game farming

Table 7: Field results for physic-chemical parameters

EWR site	WMS site	River	DO (mg/l)	Temp (°C)	pH	TDS (mg/l)	EC (mS/m)
MATEWR1	-	Matlabas Zyn Kloof	27.5	27	7.9	196	25.5

The statistical water quality data at the EWR sites is shown in Table 8.

Table 8: Statistical water quality data for the water quality sampling points

EWR site	Sampling point ID	River	5th per	95th per	Inorganic Salts (mg/l) 95th percentile					95th per	Toxics (µg/l) 95th percentile		Nutrients (mg/l) 50th percentile	
			pH		Na	Ca	Mg	Cl	SO_4	EC mS/m	NH_4	F	PO_4	TIN
EWR MAT	90328 N=29	Matlabas	6.87	7.96	20.2	6.71	4.62	16.8	nd	16.1	130	280	0.01	0.03

nd: no data

2.5 Specialist workshop (EcoClassification workshop)

The results of the field assessments of the various habitat and biotic components to obtain the Ecostatus and the recommended ecological category (REC) were compiled after the completion of the site visit. This assessment took place during the ecoclassification workshop with input from all the specialists. Information from the recently completed desktop PES study has been used for the PES, EI and ES. The ecostatus was determined using the ECOSTATUS4 model for each of the EWR sites. The process included the determination of the following:

Reference conditions: those conditions that occur under natural conditions before anthropogenic impacts.

Present Ecological State (PES) or ecostatus: the determination of the current state of the resource through rule-based models for the driver components (geomorphology – GAI, hydrology – HAI and water quality – PAI) and for the biological response components (fish – FRAI, macro-invertebrates – MIRAI and vegetation – VEGRAI). A rule-based model is then used to derive the ecostatus or overall/integrated condition/health of the resource by integrating the driver and response status. Only the FRAI and MIRAI models are used during a rapid ecological assessment. Where applicable, the PAI model is also used.

Ecological Importance (EI) and Ecological Sensitivity (ES): the ecological importance is defined by Kleynhans (1999), and is regarded as an expression of the water resource's ability to maintain the ecological diversity and functioning on local and wider scales. The ecological sensitivity refers to the river's ability to recover from disturbance. The EI and ES information was obtained from the desktop PES study.

Recommended ecological category (REC): the PES and EIS is used in the decision on the REC as well as the feasibility to realistically be able to maintain or improve the current condition of the water resource.

Ecological Water Requirements: the Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (quantity) for the recommended ecological category at the EWR sites. This EWR flow data were converted to hydraulic conditions at the EWR sites (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model to be evaluated by the ecologists. This information tohether with the optimum wet and dry season months were interpreted by the ecologists using the FFHA and IFHA models to determine the EWRs at the sites. These values were then used as a guide to determine the final EWR results through adjusting the Desktop Reserve Model where necessary.

Final ecological Reserve results: the EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curve. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3. RESULTS

The results of the ecological water requirements of the rivers of the Matlabas catchment at the selected EWR sites are presented in this section.

3.1 Matlabas Zyn Kloof (MATEWR1): Rapid 3

3.1.1 EWR site evaluation

The selected EWR site falls in quaternary catchment A41A and is on a tributary of the Matlabas River, situated in the Marakele National Park (see Figure 1). No gauging weirs are situated in close vicinity of the EWR site.

Figure 1: View of the Matlabas Zyn Kloof EWR site in A41A

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in Table 9

Table 9: Matlabas Zyn Kloof EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics	3	• Single channel	
Fish	3	• Diversity of velocities present • Diversity of instream	

Component	Confidence Score*	Advantages	Disadvantages
		habitats present	
Macroinvertebrates	3	• Good quality & quantity of cobble biotope present • Diversity of velocities present • Diversity of instream habitats present • Site situated in Marekele National Park	• No Marginal Vegetation in Current present • Very limited Marginal Vegetation out of current present • Very limited Gravel biotopes

* Confidence scores: 0 = no confidence; 5 = high confidence

3.1.2 Information availability

The available information for the EWR site is summarized in Table 10. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence

Table 10: Information availability for the EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						One surveyed cross-section and discharge
Hydrology						Updated monthly hydrology was used for the period 1920-2004.
Fish						Expected fish species lists obtained from Dr Neels Kleynhans (DWA, PES/EIS for A4 and May 2012 data set)
Macroinvertebrates						Two data sets available at the site, but historical data available from nearby tributary

3.1.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Matlabas Zyn Kloof specialist component are summarized in Table 11.

Table 11: Description of reference conditions for the EWR site/ river reach

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Macroinvertebrates	SASS5 scores: 200 Average Score Per Taxon (ASPT):7 List of taxa expected include: Perlidae, Baetidae>2spp.,Tricorythidae, Heptageniidae, Leptophlebiidae, Chlorocyphidae, Aeshnidae,

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
	Gomphidae, Libellulidae, all the Hemiptera, Hydropsychidae>2pp., Philopotamidae, Leptoceridae, Elmidae, Psephenidae, Simuliidae, Athericidae, Blepharoceridae, Dixidae, Ancylidae, Corbiculiidae and Sphaeriidae.

The water quality impacts at this site are limited to those from the Nature Reserve so that water quality is very good. The catchment is completely in Marakele National Park and is not listed on the sub-quaternary catchment (SQ) reach delineation. The river was classified as having a very high Ecological Importance (EI) and Ecological Sensitivity (ES). The physio-chemical reference conditions for the Matlabas Zyn Kloof site are presented in Table 12.

Table 12: Reference conditions for the Matlabas Zyn Kloof (WMS ID A4H4)

Component	Description of Reference Conditions		
Physio-chemico:	Physical Variables:	pH:	>= 6.8 (5th percentile) and <= 7.03 (95th percentile)
		EC:	<= 25.5 mS/m (used as a surrogate for salts)
		Temperature:	Pristine river, catchment natural, no known problems with temperature. All temperature sensitive species present in abundances and frequencies of occurrence as expected for reference
		Clarity:	Pristine River, no known man-made modifications of the catchment, no known concerns about turbidity, changes in turbidity appear to be natural and related to natural catchment processes such as rainfall runoff.
		Oxygen:	>8.0 mg/ ℓ
	Nutrients:	PO_4 Median	<0.006 mg/ ℓ
		TIN Median	<0.25 mg/ ℓ
	Toxins:	Ammonia	<131µg/ℓ
		Fluoride	< 280 µg/ℓ

Present Ecological State (PES) or ecostatus

The PES for the fish and macroinvertebrates were derived from the various available models. The details are provided below:

Fish

During the May 2012 and January 2013 surveys the following fish species were present at the site:

Based on the PES/EIS information (including data for Limpopo province) and the survey in May 2012, the following species are present:

Labeobarbus marequensis

Amphilius uranoscopus

Barbus trimaculatus

Labeo molybdinus

The FRAI for this site is an A category.

Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is an A (92.5%). This means the river is in a natural ecological condition. The most impacted driver metric is that of water flow modification at 91.5%, followed by Water Quality 92.8%, followed closely by the Instream habitat metric at 92.9%.

Table 13 provides a summary of the data interpretation and the PES for the macroinvertebrates. Taxa characterising this site include, Baetidae, Caenidae, Coenagrionidae, Gomphidae, Libellulidae, HydropsychidaeLeptoceridae.

Table 13: Summary of the data interpretation and the PES for the macroinvertebrates

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	91.5	*0.316*	28.9069	3	90
HABITAT	**H**	92.9	*0.351*	32.6059	1	100
WATER QUALITY	**WQ**	92.8	*0.333*	30.9498	2	95
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						285
INVERTEBRATE EC				92.4626		
INVERTEBRATE EC CATEGORY				**A**		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

Physico-chemical

The available physico-chemical data were fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings have been used with the overall confidence as low since important constituents such as dissolved oxygen and temperature had insufficient data availability.

The results were determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the river based on the current condition of the resource. Table 14 shows the results of this assessment for the Matlabas Zyn Kloof.

Table 14: PAI table for the Matlabas Zyn Kloof

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	3.00	60.00		55.00
Salts	0.00	NONE SPECIFIED	3.00	50.00		55.00
Nutrients	1.00	NONE SPECIFIED	3.00	75.00		70.00
Water Temperature	1.00	N	3.00	55.00		90.00
Water clarity	1.00	NONE SPECIFIED	3.00	50.00		50.00
Oxygen	1.00	N	3.00	65.00		90.00
Toxics	3.00	N	3.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	1.20	MEAN CONF ®	3.00			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	1.20					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	1.18					
FINAL PC MODIFICATION RATING	0.98					
P-C CATEGORY %	P-C CATEGORY					
80.40	B					

Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in Table 15. The main impacts on the Matlabas ZynKloof are due to the activities in the Nature Reserve.

Table 15: PES per component for the MatlabasZynKloof EWR site

COMPONENT	PES	EXPLANATION
Macro-invertebrates	A	SASS5 score:128, 174 No of Taxa: 22, 28 ASPT: 5.8, 6.2 Key taxa expected but not observed were generally those that show preference for the vegetation biotope, such as Lestidae,Atyiidae and Pyralidae and the Gastropoda as well as some of the more sensitive cobble dwelling taxa such as Heptageniidae, Psephenidae and Blepharoceridae
Physico-chemical	B	Elevated nutrients and fluoride (toxic)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Matlabas Zyn Kloof are shown in Table 16.

Table 16: Integrated results for the Matlabas Zyn Kloof

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	4	100		
2.What is the natural diversity of **fish** species with a preference for different cover types	3	80		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	3	80		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	4	100		
FISH ECOLOGICAL CATEGORY	14	360	**100.0**	**A**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	4.5	90		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	4.5	90		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	5	100		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**14**	280	**92.5**	**A**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		640	**95.2**	**A**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	5	0.56	55.56
Confidence rating for **macro-invertebrate** information	4	0.44	41.11
	9	1.00	96.67
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**A**

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**100.0**	**A**

ECOSTATUS	Confidence rating	Proporitons	Modified weights
Confidence rating for instream biological information	4.55556	0.53	51.47
Confidence rating for riparian vegetation zone information	4	0.47	46.75
	8.55556	1.00	98.23
ECOSTATUS	**EC**		**A**

Ecological Importance (EI) and Ecological Sensitivity (ES)

The EI and ES for the Matlabas Zyn Kloof was determined as very high during the desktop PES/EIS study in 2012.

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Matlabas Zyn Kloof is an A category and the EIS is very high. An A category is thus recommended for the Matlabas Zyn Kloof.

3.1.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of A for the Matlabas Zyn Kloof at the EWR site. The maximum baseflows for the months representing the wet and dry seasons (June and September) were identified from the natural flow time series and the recommended flows for an A category.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The water level (discharge = 0.082 m^3/s) in the Matlabas Zyn Kloof during the site visit on 30 January 2013 was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (Figure 2).

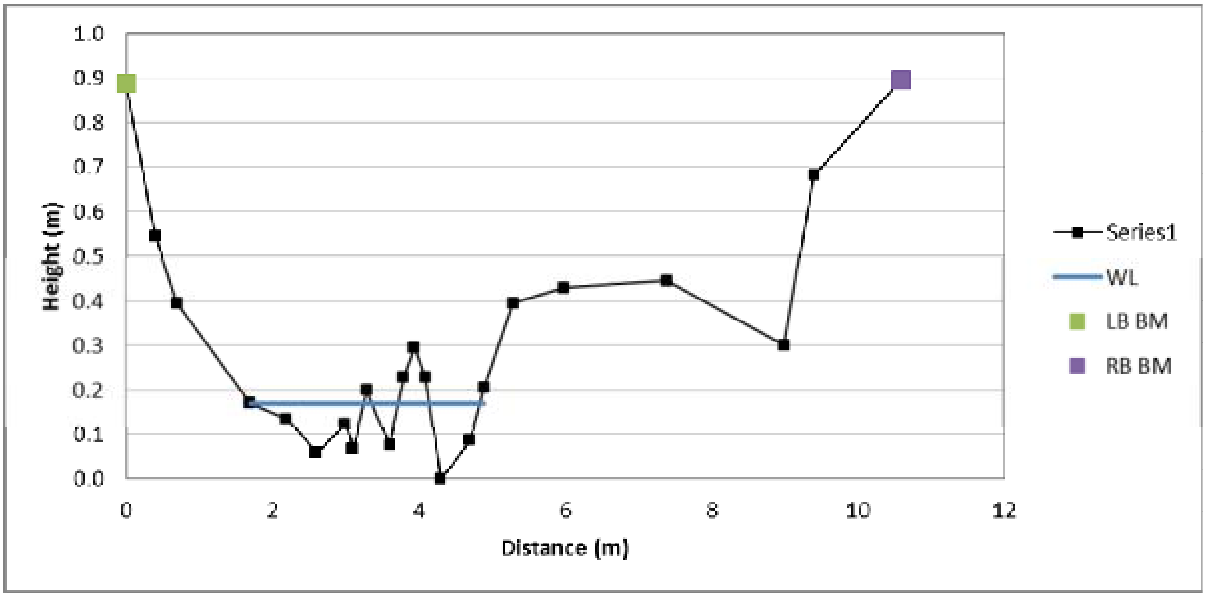


Figure 2: Calibrated cross-sectional profile of the Matlabas Zyn Kloof at the EWR site

The fish and macroinvertebrate specialists further assessed the ecological water requirements using the identified maximum baseflows and the hydraulic cross-section with the FFHA and IFHA models to determine the water requirements based on flow sensitive fish and macroinvertebrates. The site-specific flow requirements were based mainly on the rare and sensitive fish *Amphilius uranoscopus.* The following changes were made to the DRM to represent the final EWR as determined with the FFHA and IFHA models:

Drought flows: September change from 0.009m^3/s – 0.030m^3/s

Maintenance low flows: June change from 0.057m^3/s – 0.065m^3/s

Maintenance high flows: January change from 0.018m^3/s – 0.022m^3/s

The above changes resulted in an overall change from 49.12% to 57.07% for an A category. The final EWRs for the Matlabas Zyn Kloof is presented in Table 17.

Table 17: Matlabas Zyn Kloof (MATEWR1): Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	**A41A**
River	Matlabas Zyn Kloof
EWR Site Co-ordinates	S 24.4120; E 27.6034
Recommended Ecological Category	A
VMAR (10^6m^3)	5.23
Total EWR	2.983 x10^6m^3 (57.07 %MAR)
Maintenance Low flows	2.126 x10^6m^3 (40.67 %MAR)
Drought Low flows	1.001 x10^6m^3 (19.16 %MAR)
Maintenance High flows	0.857 x10^6m^3 (16.40 %MAR)
Overall confidence	Low to medium

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Matlabas, Zyn Kloof site are provided in **Annexure 4**.

3.2 Matlabas Haarlem Oos (A4H004) (MAT 2): Rapid 2

3.2.1 EWR site evaluation

The selected EWR site falls in quaternary catchment A41B situated in the Haarlem Oos Game Park. It is located at the DWA A4H004 weir (see Figure 3).

Figure 3: View of the Matlabas (Haarlem Oos) MATEWR2 site in A41B

3.2.2 Information availability

Table 18: MATEWR2 site evaluation (Haarlem Oos)

Component	Confidence Score*	Advantages	Disadvantages
Macroinvertebrates	3	• Good quality & quantity of cobble biotope present • Diversity of velocities present • Diversity of instream habitats present • Good quality and quantity of vegetation	• Limited Marginal Vegetation in Current present • Very limited Gravel, Sand and Mud biotopes • Situated just downstream of a weir resulting in altered habitat
Hydraulics	3	• Single channel	No measured cross-section, only a desktop cross-section was developed
Fish	3	• Diversity of velocities present • Diversity of instream habitats present	

* Confidence scores: 0 = no confidence; 5 = high confidence

The available information for the EWR site is summarized in Table 18. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence

Table 19: Information availability for theEWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						Only slope and discharge available from May 2012 survey
Hydrology						Updated monthly hydrology was used for the period 1920-2004.
Fish						Expected fish species lists obtained from Dr Neels Kleynhans (DWA, PESEIS for A4 and May 2012 data set) as well as data collected during 2010 and 2011 and 1980
Macroinvertebrates						Only one data set available. Information regarding taxa expected to be present in the SQ reach as determined for the PES EI Es project available

3.2.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site 2 in the Matlabas River at Haarlem Oos per specialist component are summarized in Table 20**.**

Table 20: Description of reference conditions for the EWR site 2/ river reach

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Macroinvertebrates	SASS5 scores: 200 Average Score Per Taxon (ASPT):7 List of taxa expected include: Perlidae, Baetidae>2spp.,Tricorythidae, Heptageniidae, Leptophlebiidae, Chlorocyphidae, Aeshnidae, Gomphidae, Libellulidae, all the Hemiptera, Hydropsychidae>2pp., Philopotamidae, Leptoceridae, Elmidae, Psephenidae, Simuliidae, Athericidae, , Dixidae, Ancylidae, Corbiculiidae and Sphaeriidae.
Fish	Expected fish species: BARBUS ANNECTENS BARBUS BIFRENATUS (#) LABEOBARBUS MAREQUENSIS (#) BARBUS PALUDINOSUS (#) BARBUS TRIMACULATUS (#) BARBUS UNITAENIATUS BARBUS VIVIPARUS CLARIAS GARIEPINUS (#) LABEO CYLINDRICUS LABEO MOLYBDINUS (#) MARCUSENIUS PONGOLENSIS(#) OREOCHROMIS MOSSAMBICUS(#) PETROCEPHALUS WESSELSI PSEUDOCRENILABRUS PHILANDER (#) TILAPIA SPARRMANII (#)

Present Ecological State (PES) or ecostatus

The PES for the fish and macroinvertebrates were derived from the various available models. The details are provided below:

Macroinvertebrates

The four modification metrics of the MIRAI, namely flow modification, habitat, water quality and connectivity and seasonality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a C 71.9%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water quality at 69.9%, followed by Flow Modification 71.9%, followed closely by the Instream habitat metric at 73.5% with Connectivity and Seasonality at 80%.

Table 21 provides a summary of the data interpretation and the PES for the macroinvertebrates.Taxa characterising this site include Perlidae, Baetidae, Leptophleniidae, Tricorythidae, Coenagrionidae, Libellulidae, Chlorocyphidae, Hydropsychidae and Simuliidae.

Table 21: Summary of the data interpretation and the PES for the macroinvertebrates

		INVERTEBRATE EC: BASED ON WEIGHTS OF METRIC GROUPS				
INVERTEBRATE EC METRIC GROUP		**METRIC GROUP CALCULATED SCORE**	**CALCULATED WEIGHT**	**WEIGHTED SCORE OF GROUP**	**RANK OF METRIC GROUP**	**%WEIGHT FOR METRIC GROUP**
FLOW MODIFICATION	**FM**	71.9	*0.310*	22.3248	3	90
HABITAT	**H**	73.5	*0.345*	25.3352	1	100
WATER QUALITY	**WQ**	69.9	*0.328*	22.892	2	95
CONNECTIVITY & SEASONALITY	**CS**	80.0	*0.017*	1.37931	4	5
						290
INVERTEBRATE EC				71.9314		
INVERTEBRATE EC CATEGORY				C		

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

Annexure 2 provides the detailed tables for the flow, habitat and water quality modification metrics.

Fish

The fish species collected during May 2012 and during 2010-2011 surveys are indicated with a (#) in Table 20. The FRAI for this reach of the river is in a C category.

Physico-chemical

The available physico-chemical data have been fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings have been used with the overall confidence as low since important constituents such as dissolved oxygen and temperature have insufficient data available.

The results have been determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the river based on the current condition of the resource. Table 14Table 22 shows the results of this assessment for the Matlabas Haarlem Oos site (MATEWR2).

Table 22: PAI table for the Matlabas Haarlem Oos (MATEWR2)

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	3.00	60.00		55.00
Salts	0.00	NONE SPECIFIED	3.00	50.00		55.00
Nutrients	1.00	NONE SPECIFIED	3.00	75.00		70.00
Water Temperature	1.00	N	3.00	55.00		90.00
Water clarity	1.00	NONE SPECIFIED	3.00	50.00		50.00
Oxygen	1.00	N	3.00	65.00		90.00
Toxics	3.00	N	3.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	1.20	MEAN CONF ®	3.00			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	1.20					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	1.18					
FINAL PC MODIFICATION RATING	0.98					
P-C CATEGORY %	P-C CATEGORY					
80.40	B					

Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in Table 23. The main impact on the Matlabas Haarlem Oos site is the upstream dams.

Table 23: PES per component for the Matlabas Haarlem Oos EWR site 2

COMPONENT	PES	EXPLANATION
Macro-invertebrates	C	SASS5 score: 164 No of Taxa: 30 ASPT: 5.5 Key taxa expected but not observed were generally those that show preference for the GSM biotope such as Gomphidae

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Matlabas Haarlem Oos site are shown in Table 24.

Table 24: Integrated results for the Matlabas Haarlem Oos (MATEWR2)

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	1	5		
2.What is the natural diversity of **fish** species with a preference for different cover types	4	100		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	2	5		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2	50		
FISH ECOLOGICAL CATEGORY	9	160	**72.8**	**C**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	3	80		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	80		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	4	100		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**10**	260	**71.9**	**C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		420	**72.3**	**C**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	4	0.57	41.58
Confidence rating for **macro-invertebrate** information	3	0.43	30.81
	7	1.00	72.39
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**

RIPARIAN VEGETATION	EC %	EC

RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**80.0**	**C/B**

ECOSTATUS	**Confidence rating**	**Proporitons**	**Modified weights**
Confidence rating for instream biological information	3.57143	0.51	36.56
Confidence rating for riparian vegetation zone information	3.5	0.49	39.60
	7.07143	1.00	76.16
ECOSTATUS	**EC**		**C**

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Matlabas Haarlem Oos is a C category. Due to the high EI and ES for the reach, a B/C category is thus recommended for the Matlabas Haarlem Oos.

3.2.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of B/C for the Matlabas Haarlem Oos at the EWR site. The maximum baseflows for the months representing the wet and dry seasons (June and September) were identified from the natural flow time series and the recommended flows for a B/C category.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a desktop hydraulic model. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (Figure 4).

The fish and macroinvertebrate specialists further assessed the ecological water requirements using the identified maximum baseflows and the hydraulic cross-section with the FFHA and IFHA models to determine the water requirements based on flow sensitive fish and macroinvertebrates. The site-specific flow requirements were based mainly on flow sensitive species in the reach. The following changes were made to the DRM to represent the final EWR as determined with the FFHA and IFHA models:

Drought flows: June change from $0.041m^3/s$ – $0.070m^3/s$

Maintenance low flows: June change from $0.123m^3/s$ – $0.193m^3/s$

The above changes resulted in an overall change from 25.45% to 33.23% for a B/C category. The final EWRs for the Matlabas Haarlem Oos (MATEWR2) are presented in Table 25.

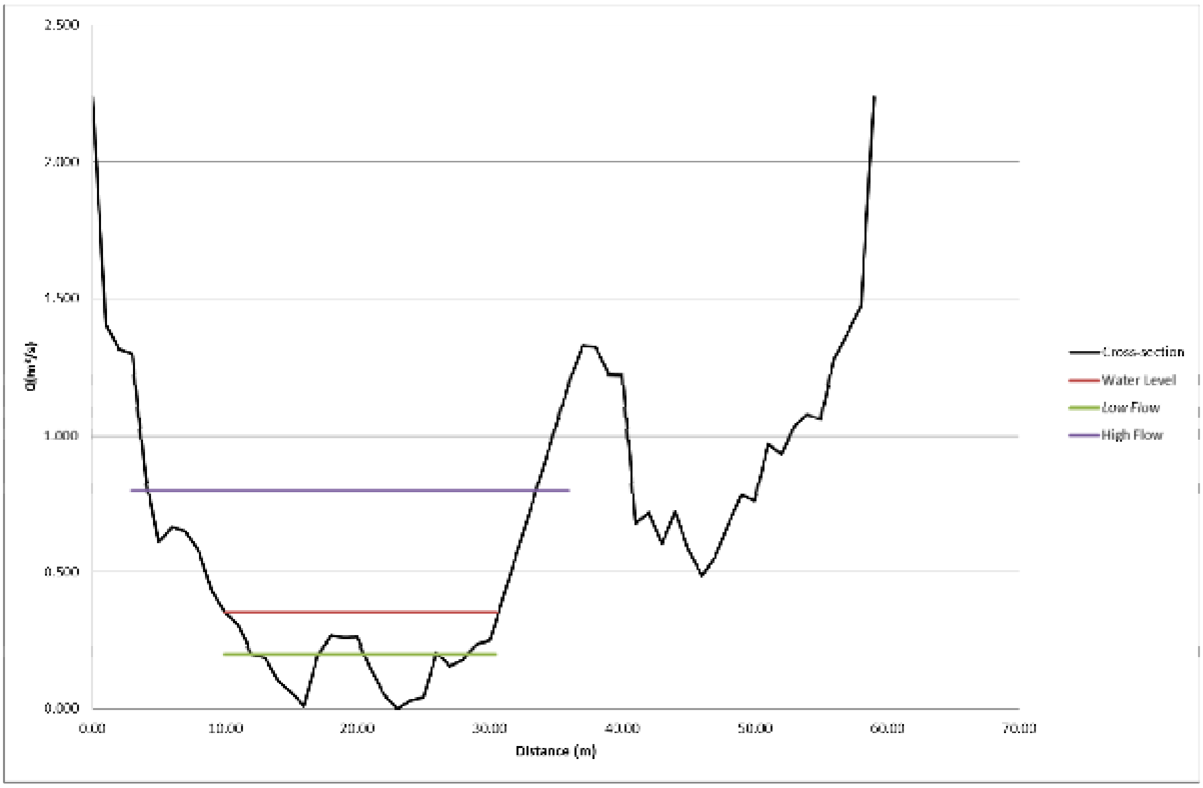


Figure 4: Modelled cross-sectional profile of the Matlabas Haarlem Oos at the EWR site

Table 25: Matlabas Haarlem Oos (MATEWR2): Summary of the EWR results (flows in 10^6m^3 per annum)

Quaternary Catchment	A41B
River	Matlabas Haarlem Oos
EWR Site Co-ordinates	S 24.1601; E 27.4797
Recommended Ecological Category	B/C
VMAR (10^6m^3)	32.80
Total EWR	10.898 x10^6m^3 (33.23 %MAR)
Maintenance Low flows	7.070 x10^6m^3 (21.56 %MAR)
Drought Low flows	1.931 x10^6m^3 (5.89 %MAR)
Maintenance High flows	3.828 x10^6m^3 (11.67 %MAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Matlabas Haarlem Oos site are provided in **Annexure 4**.

3.3 Mamba River Bridge (MATEWR3): Rapid 2

3.3.1 EWR site evaluation

The selected EWR site falls in quaternary catchment A41B and is on a tributary of the Matlabas River. The site is situated at the R510 bridge crossing the Mamba River (see Figure 5 and is bordered on either side by game fences. No gauging weirs are situated in close vicinity of the EWR site.

Figure 5: View of the Mamba River Bridge EWR site in A41B

Table 26: EWR3 site evaluation (Mamba River)

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics	0		• Site is under a bridge; • Game fences on either side of the bridge
Macroinvertebrates	1	• Good quality and quantity of vegetation out of current • Good sand biotope	• No Stones biotope available • No Marginal Vegetation in Current

			present during survey • Very limited Gravel and Mud biotopes at higher flows only • Site limited to section below the bridge and is not representative of the Mamba River as a whole

* Confidence scores: 0 = no confidence; 5 = high confidence

3.3.2 Information availability

The available information for the EWR site is summarized in Table 27. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 27: Information availability for the Mamba EWR site (MATEWR3)

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Fish						Expected fish species lists obtained from Dr Neels Kleynhans (DWA, PESEIS for A4 and May 2012 data set)
Macroinvertebrates						Two data sets available at the site and historical data available at an upstream site. Information regarding taxa expected to be present in the SQ reach as determined for the PES EI ES project available

3.3.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site 3 in the Mamba River per specialist component are summarized in Table 28**.**

Table 28: Description of reference conditions for the EWR site/ river reach

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Fish expected for the reach: AMPHILIUS URANOSCOPUS BARBUS ANNECTENS BARBUS BIFRENATUS LABEOBARBUS MAREQUENSIS BARBUS BREVIPINNIS BARBUS PALUDINOSUS BARBUS TRIMACULATUS BARBUS UNITAENIATUS BARBUS VIVIPARUS CLARIAS GARIEPINUS CLARIAS THEODORAE LABEO CYLINDRICUS LABEO MOLYBDINUS MARCUSENIUS PONGOLENSIS

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
	OREOCHROMIS MOSSAMBICUS PETROCEPHALUS WESSELSI PSEUDOCRENILABRUS PHILANDER TILAPIA SPARRMANII Fish expected for the site: OREOCHROMIS MOSSAMBICUS(#) BARBUS TRIMACULATUS (#) Labeomolybdinus BARBUS UNITAENIATUS BARBUS VIVIPARUS CLARIAS GARIEPINUS (#) PSEUDOCRENILABRUS PHILANDER TILAPIA SPARRMANII (#) BARBUS bifrenatus (#) BARBUS PALUDINOSUS (#) MARCUSENIUS PONGOLENSIS(#)
Macroinvertebrates	SASS5 scores: 180 Average Score Per Taxon (ASPT):6 List of taxa expected include: Perlidae, Baetidae>2spp.,Heptageniidae, Leptophlebiidae, Coenagrioniidae, Aeshnidae, Corduliidae, Gomphidae, Libellulidae, all the Hemiptera, Hydropsychidae>2pp., Philopotamidae, Leptoceridae, Dytiscidae, Elmidae, Psephenidae, Simuliidae, Athericidae, , Dixidae, Ancylidae, Corbiculiidae and Sphaeriidae.

Present Ecological State (PES) or ecostatus

The PES for the fish and macroinvertebrates were derived from the various available models. The details are provided below:

Fish

The fish species collected during May 2012 and other surveys are indicated with a (#) in Table 28. The FRAI for this reach of the river is in a B category.

Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a B/C (78.2%). This means the river is in a minimally to moderately modified ecological condition. The most impacted driver metric is that of Flow modificationat 75.5%, followed by Habitat Modification 77.8% with Water Quality at 81.3%.

Table 29 provides a summary of the data interpretation and the PES for the macroinvertebrates. Taxa characterising this site include, Baetidae, Caenidae, Coenagrionidae, Corduliidae, Gomphidae, Hydropsychidae and Simuliidae.

Table 29: Summary of the data interpretation and the PES for the macroinvertebrates

INVERTEBRATE EC:
BASED ON WEIGHTS OF

METRIC GROUPS

INVERTEBRATE EC METRIC GROUP		**METRIC GROUP CALCULATED SCORE**	**CALCULATED WEIGHT**	**WEIGHTED SCORE OF GROUP**	**RANK OF METRIC GROUP**	**%WEIGHT FOR METRIC GROUP**
FLOW MODIFICATION	**FM**	75.5	*0.316*	23.837	3	90
HABITAT	**H**	77.8	*0.351*	27.2846	1	100
WATER QUALITY	**WQ**	81.3	*0.333*	27.1032	2	95
CONNECTIVITY & SEASONALITY	**CS**	100.0	*0.000*	0	4	0
INVERTEBRATE EC				78.2248		285
INVERTEBRATE EC CATEGORY				**B/C**		

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

Annexure 2 provides the detailed tables for the flow, habitat and water quality modification metrics.

Physico-chemical

The available physico-chemical data have been fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings have been used with the overall confidence as low since important constituents such as dissolved oxygen and temperature have insufficient data available.

The results have been determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the river based on the current condition of the resource. Table 30 shows the results of this assessment for the Mamba River Bridge site.

Table 30: PAI table for the Mamba River Bridge EWR site

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	3.00	60.00		55.00
Salts	0.00	NONE SPECIFIED	3.00	50.00		55.00
Nutrients	1.00	NONE SPECIFIED	3.00	75.00		70.00
Water Temperature	1.00	N	3.00	55.00		90.00
Water clarity	1.00	NONE SPECIFIED	3.00	50.00		50.00
Oxygen	1.00	N	3.00	65.00		90.00
Toxics	3.00	N	3.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	1.20	MEAN CONF ®	3.00			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	1.20					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	1.18					
FINAL PC MODIFICATION RATING	0.98					
P-C CATEGORY %	P-C CATEGORY					
80.40	B					

Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in Table 31. The main impacts on the Mamba River are small dams, over-grazing and vegetation removal in the upper catchment.

Table 31: PES per component for the Mamba River Bridge

COMPONENT	PES	EXPLANATION
Macro-invertebrates	B/C	SASS5 score: 134 No of Taxa: 24 ASPT: 5.6 Key taxa expected but not observed were generally those that show preference for the cobbles biotope such as Perlidae, Tricorythidae and Psephenidae.

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Mamba River Bridge EWR site are shown in Table 32.

Table 32: Integrated results for the Mamba River Bridge EWR site (MATEWR3)

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	1	5		
2.What is the natural diversity of **fish** species with a preference for different cover types	4	100		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	2	5		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2	50		
FISH ECOLOGICAL CATEGORY	9	160	**85.0**	**B**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	4	80		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	4	80		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	5	100		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**13**	260	**78.2**	**B/C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		420	**80.6**	**B/C**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	3.5	0.54	45.78
Confidence rating for **macro-invertebrate** information	3	0.46	36.09
	6.5	1.00	81.87
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**B/C**

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**80.0**	**B/C**

ECOSTATUS	Confidence rating	Proporitons	Modified weights
Confidence rating for instream biological information	3.26923	0.52	42.70
Confidence rating for riparian vegetation zone information	3	0.48	38.28
	6.26923	1.00	80.98
ECOSTATUS	**EC**		**B/C**

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Mamba River Bridge is a B/C category with a moderate ecological importance and sensitivity. Thus, the final REC for the Mamba EWR site is a B/C category.

3.3.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of B/C for the Mamba River at the EWR site. The maximum baseflows for the months representing the wet and dry seasons (June and September) were identified from the natural flow time series and the recommended flows for a B/C category.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a desktop hydraulic model. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (Figure 6).

The fish and macroinvertebrate specialists further assessed the ecological water requirements using the identified maximum baseflows and the hydraulic cross-section with the FFHA and IFHA models to determine the water requirements based on flow sensitive fish and macroinvertebrates. The site-specific flow requirements were based mainly on flow sensitive species in the reach. The following changes were made to the DRM to represent the final EWR as determined with the FFHA and IFHA models:

Drought flows: June change from $0.006m^3/s$ – $0.011m^3/s$

Maintenance low flows: June change from $0.022m^3/s$ – $0.045m^3/s$

The above changes resulted in an overall change from 24.19% to 35.49% for a B/C category. The final EWRs for the Mamba River (MATEWR3) are presented in Table 33.

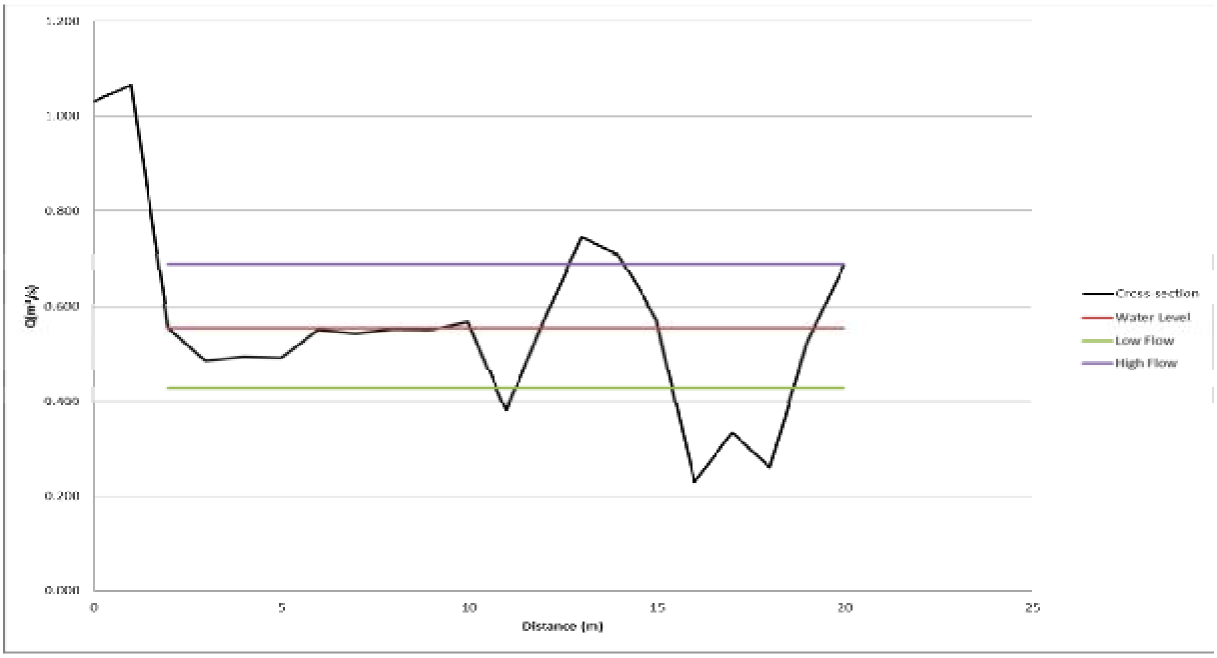


Figure 6: Modelled cross-sectional profile of the Mamba River at the EWR site

Table 33: Mamba (MATEWR3): Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	**A41B**
River	Mamba
EWR Site Co-ordinates	S 24.2127; E 27.5072
Recommended Ecological Category	B/C
VMAR (10^6m^3)	9.54
Total EWR	3.387 $x10^6m^3$ (35.49 %MAR)
Maintenance Low flows	2.175 $x10^6m^3$ (22.79 %MAR)
Drought Low flows	0.336 $x10^6m^3$ (3.52 %MAR)
Maintenance High flows	1.212 $x10^6m^3$ (12.70 %MAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Mamba River are provided in **Annexure 4**.

3.4 Matlabas at Phofu (MATEWR 4): Rapid 1

3.4.1 EWR site evaluation

The selected EWR site falls in quaternary catchment A41C and is on the Matlabas River downstream of Haarlem Oos at Phofu (see Figure 7).

Figure 7: View of the Matlabas EWR site at Phofu in A41C

Table 34: EWR4 site evaluation (Matlabas River at Phofu)

Component	Confidence Score*	Advantages	Disadvantages
Macroinvertebrates	1	• Good quality and quantity of vegetation out of current • Good sand biotope • Good Stones-out-of-current biotope	• No Marginal Vegetation in Current present during survey • No Stones-in-current biotope available at time of survey • River barely flowing and very shallow at time of sampling
Fish	4	• Representative of habitat in reach	• Requirements difficult to derive during no flow

* Confidence scores: 0 = no confidence; 5 = high confidence

3.4.2 Information availability

The available information for the EWR site is summarized in Table 35. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 35: Information availability for the EWR site at Phofu

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Fish						Surveys in 2010-2011, May 2012 and previously by Limpopo province
Macroinvertebrates						Two data sets available at the site and historical data available at another site. Information regarding taxa expected to be present in the SQ reach as determined for the PES EI ES project available

3.4.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site 4 in the Matlabas River per specialist component are summarized in Table 36**.**

Table 36: Description of reference conditions for the EWR site 4/ river reach

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Macroinvertebrates	SASS5 scores: 150 Average Score Per Taxon (ASPT):6 List of taxa expected include: Potamonautidae, Baetidae>2spp., Caenidae, Heptageniidae, Leptophlebiidae, Coenagrioniidae, Aeshnidae, Gomphidae, Libellulidae, all the Hemiptera, Hydropsychidae., Philopotamidae, Leptoceridae, Dytiscidae, Gyrinidae, Hydrophilidae, Simuliidae, Tabanidae, Tipulidae, Planorbidae, Corbiculiidae and Sphaeriidae.
Fish	Expected fish species are: ANGUILLA MOSSAMBICA BARBUS ANNECTENS BARBUS BIFRENATUS (#) LABEOBARBUS MAREQUENSIS BARBUS PALUDINOSUS (#) BARBUS TRIMACULATUS (#) BARBUS UNITAENIATUS BARBUS VIVIPARUS CLARIAS GARIEPINUS (#) LABEO CYLINDRICUS LABEO MOLYBDINUS LABEO ROSAE (#) MICRALESTES ACUTIDENS MARCUSENIUS PONGOLENSIS OREOCHROMIS MOSSAMBICUS(#) PETROCEPHALUS WESSELSI

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
	SCHILBE INTERMEDIUS(#) SYNODONTIS ZAMBEZENSIS (#) TILAPIA RENDALLI(#) TILAPIA SPARRMANII (#) PSEUDOCRENILABRUS PHILANDER (#)

Present Ecological State (PES) or ecostatus

The PES for the fish and macroinvertebrates were derived from the various available models. The details are provided below:

Fish

The fish species collected during May 2012 and other surveys are indicated with a (#) in Table 36. The FRAI for this reach of the river is in an A/B category.

Macroinvertebrates

The four modification metrics of the MIRAI, namely flow modification, habitat, water quality and connectivity and seasonality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a B (83.2%). This means the river is in a minimally modified ecological condition. The most impacted driver metrics are that of Habitat modification at 81.9% and Water Quality Modification at 82%, followed by Flow modification at 85.4 with Connectivity and Seasonality the least impacted at 90%.

Table 37 provides a summary of the data interpretation and the PES for the macroinvertebrates. Taxa characterising this site include Oligochaeta, Baetidae, Caenidae, Coenagrionidae, Gomphidae, Leptoceridae and Chironomidae.

Table 37: Summary of the data interpretation and the PES for the macroinvertebrates

INVERTEBRATE EC: BASED ON WEIGHTS OF METRIC GROUPS

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	85.4	*0.310*	26.4901	3	90
HABITAT	**H**	81.9	*0.345*	28.2536	1	100
WATER QUALITY	**WQ**	82.0	*0.328*	26.8742	2	95
CONNECTIVITY &SEASONALITY	**CS**	90.0	*0.017*	1.55172	4	5
INVERTEBRATE EC				83.1697		290
INVERTEBRATE EC CATEGORY				**B**		

Annexure 2 provides the detailed tables for the flow, habitat and water quality modification metrics.

Physico-chemical

The available physico-chemical data have been fed into the PAI model and adjusted based on supplementary information to derive an overall physico-chemical condition for this site.

For this assessment, the PAI model's default weightings have been used with the overall confidence as low since important constituents such as dissolved oxygen and temperature have insufficient data available.

The results have been determined using the limited available data supplemented by bio-indicator data and catchment observations. The PAI model aggregates the condition score from each determinant and generates an overall state for the water quality in the river based on the current condition of the resource. Table 38 shows the results of this assessment for the Matlabas River at Phofu.

Table 38: PAI table for the Matlabas at Phofu

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	3.00	60.00		55.00
Salts	0.00	NONE SPECIFIED	3.00	50.00		55.00
Nutrients	1.00	NONE SPECIFIED	3.00	75.00		70.00
Water Temperature	1.00	N	3.00	55.00		90.00
Water clarity	1.00	NONE SPECIFIED	3.00	50.00		50.00
Oxygen	1.00	N	3.00	65.00		90.00
Toxics	3.00	N	3.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	1.20	MEAN CONF ®	3.00			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	1.20					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	1.18					
FINAL PC MODIFICATION RATING	0.98					
P-C CATEGORY %	P-C CATEGORY					
80.40	B					

Ecostatus

A summary of the PES per component as derived from the various available models and the rationale is provided in Table 39. The main impacts on the Matlabas River at Phofu are due to numerous roads, abstraction of water from the river, inundation by small instream dams, over-grazing and vegetation removal.

Table 39: PES per component for the Matlabas River at the Phofu EWR site

COMPONENT	PES	EXPLANATION
Macro-invertebrates	B	SASS5 score: 128 No of Taxa: 25 ASPT: 5.1 Key taxa expected but not observed were generally those that show preference for the cobbles biotope such as Philopotamidae,

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. The integrated results for the Matlabas River at the Phofu EWR site (MATEWR4) are shown in Table 40.

Table 40: Integrated results for the Matlabas River at Phofu

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	1	5		
2.What is the natural diversity of **fish** species with a preference for different cover types	4	100		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	2	5		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2	50		
FISH ECOLOGICAL CATEGORY	9	160	**90.4**	**A/B**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	2.5	70		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	80		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	4	100		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**9.5**	250	**83.2**	**B**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		410	**86.2**	**B**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	4	0.57	51.63
Confidence rating for **macro-invertebrate** information	3	0.43	35.66
	7	1.00	87.29
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**B**

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**80.0**	**B/C**

ECOSTATUS	Confidence rating	Proporitons	Modified weights
Confidence rating for instream biological information	3.57143	0.54	47.44
Confidence rating for riparian vegetation zone information	3	0.46	36.52
	6.57143	1.00	83.96
ECOSTATUS	**EC**		**B**

Recommended Ecological Category (REC)

This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The ecostatus of the Matlabas River at Phofu is a B category with a moderate ecological importance and sensitivity. Thus, the final REC for the Matlabas River at the EWR site is a B category.

3.1.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of B for the Matlabas River at Phofu (MATEWR4). The maximum baseflows for the months representing the wet and dry seasons (June and September) were identified from the natural flow time series and the recommended flows for a B category.

No hydraulic data was available for this site and the fish and macroinvertebrate specialists further assessed the ecological water requirements using the identified maximum baseflows. Although this site is not morphologically similar to MATEWR2 (Matlabas Haarlem Oos), hard substrate and coarse gravel are present in some sections. Thus, the flows for the categories were derived using a proportional approach where the ratio of the natural flow at a percentile from MATEWR2 were applied to the corresponding percentiles at this site. The assumption was that although the assessment was not based on hydraulics, it does provide some indication of the flow requirements at the site.

The following changes were made to the DRM to represent the final EWR as determined with the FFHA and IFHA models:

Drought flows: June change from $0.042m^3/s$ – $0.061m^3/s$

Maintenance low flows: June change from $0.159m^3/s$ – $0.192m^3/s$

The above changes resulted in an overall change from 30.42% to 33.42% for a B category. The final EWRs for the Matlabas River at Phofu (MATEWR4) are presented in Table 41

Table 41: Matlabas at Phofu (MATEWR4): Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	A41C
River	Matlabas at Phofu
EWR Site Co-ordinates	S 24.0515; E 27.3592
Recommended Ecological Category	B
VMAR (10^6m^3)	35.58
Total EWR	11.891 $x10^6m^3$ (33.42 %MAR)

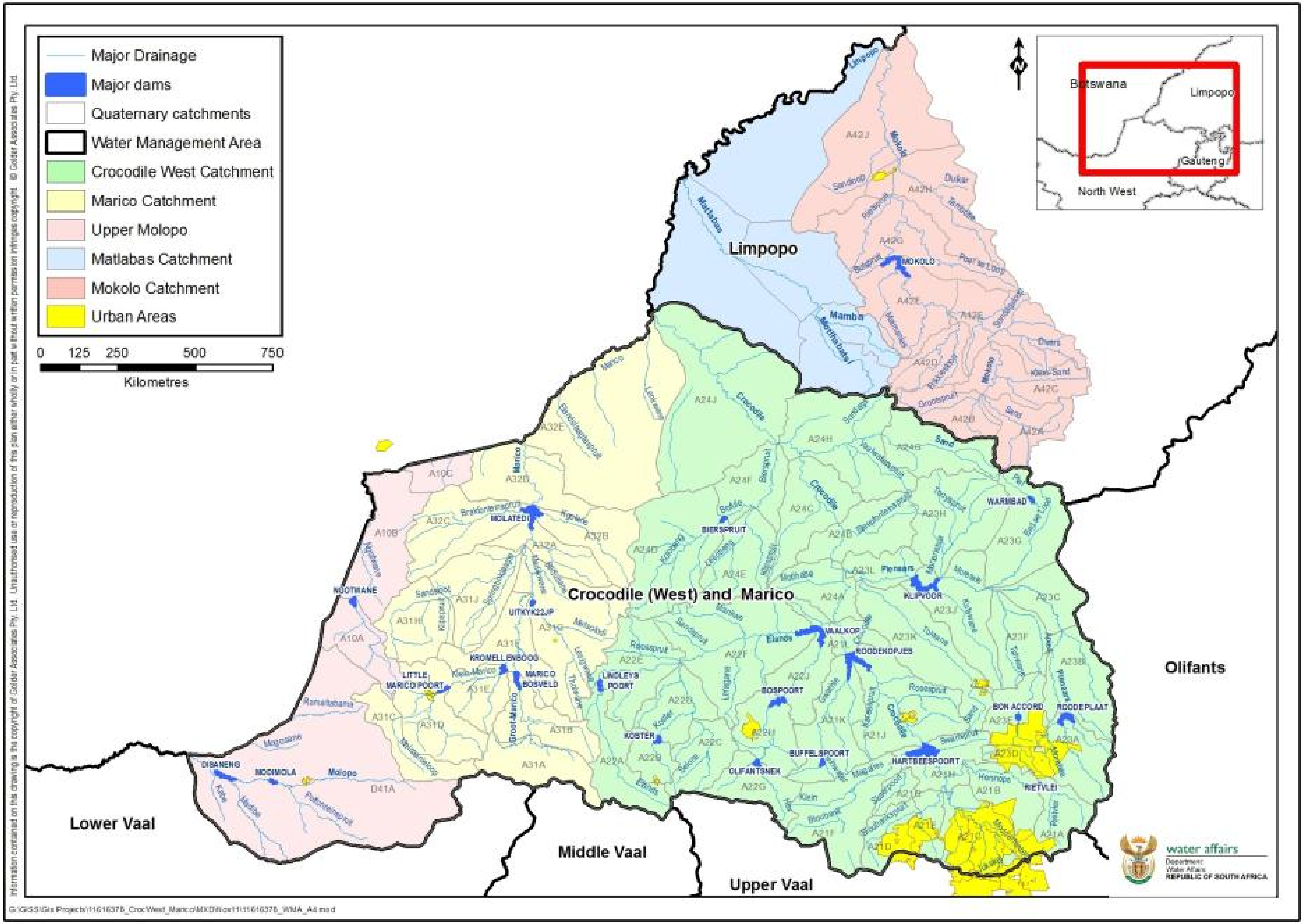
Maintenance Low flows	7.162 x10^6m^3 (20.13 %MAR)
Drought Low flows	1.831 x10^6m^3 (5.14 %MAR)
Maintenance High flows	4.728 x10^6m^3 (13.29 %MAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve. These requirements are available electronically.

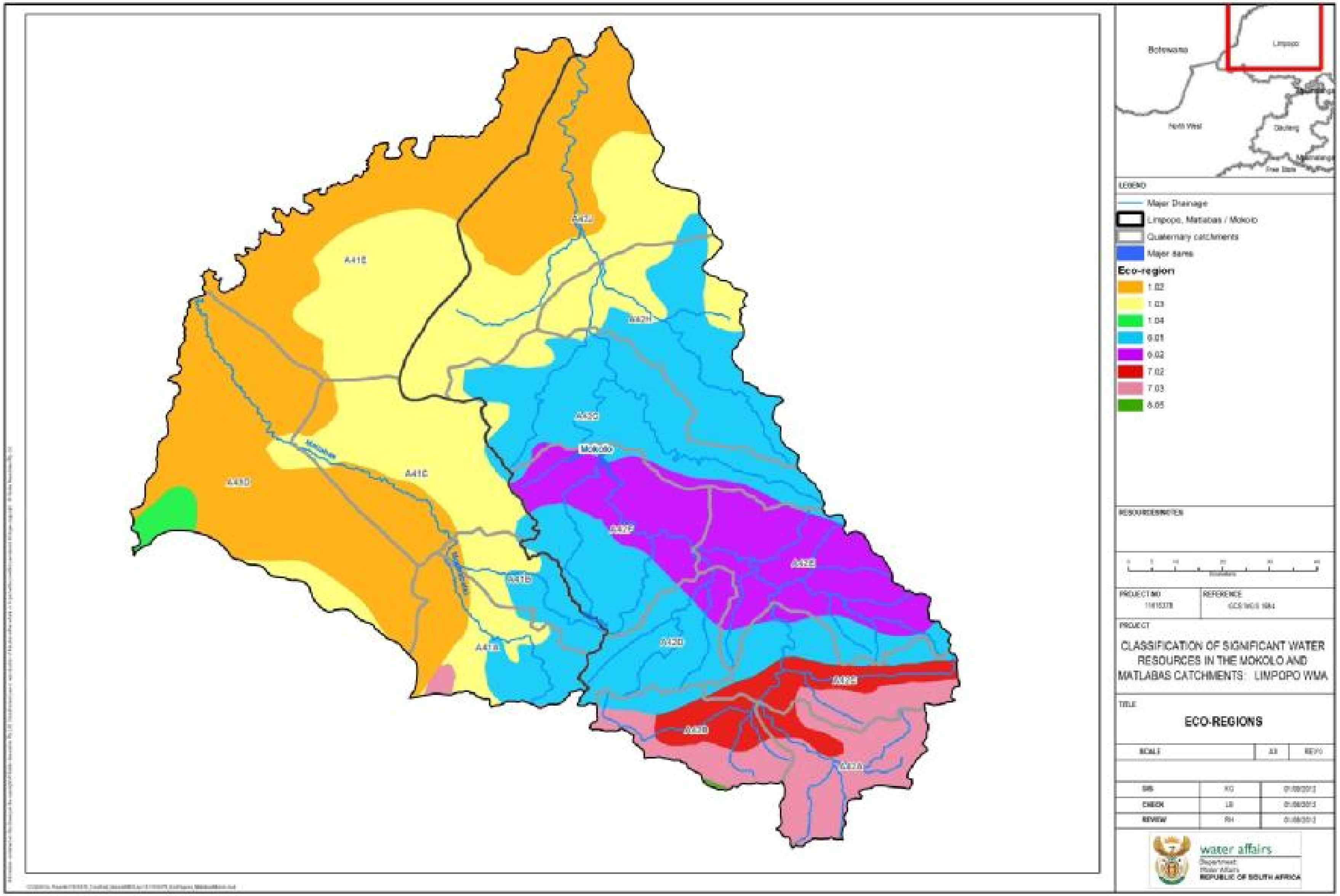
The physico-chemical ecospecs, Thresholds of Potential Concern (TPCs) and monitoring requirements for the Matlabas River (Phofu site) are provided in **Annexure 4**.

ANNEXURE 1

MAP OF STUDY AREA



Major Drainage
Major dams
Quaternary catchments
Water Management Area
Crocodile West Catchment
Marico Catchment
Upper Molopo
Matlabas Catchment
Mokolo Catchment
Urban Areas
0 125 250 500 750
Kilometres
Botswana
Limpopo
Gauteng
North West
Limpopo
Crocodile (West) and Marico
Olifants
Lower Vaal
Middle Vaal
Upper Vaal
MOKOLO
MOLATEDI
NGOTWANE
UITKYK
KROMELLENBOOG
LITTLE MARICO POORT
MARICO BOSVELD
LINDLEY'S POORT
BIERSPRUIT
KLIPVOOR
VAALKOP
ROODEKOPJES
BOSPOORT
KOSTER
BUFFELSPOORT
OLIFANTSNEK
HARTBEESPOORT
BON ACCORD
ROODEPLAAT
RIETVLEI
WARMBAD
DISANENG
MODIMOLA
water affairs
Department: Water Affairs REPUBLIC OF SOUTH AFRICA


Botswana
Limpopo
North West
Gauteng
Free State
A41E
A41C
A41D
A41B
A41A
A42J
A42H
A42G
Mokolo
Matlabas
A42F
A42E
A42D
A42C
A42B
A42A
LEGEND
Major Drainage
Limpopo, Matlabas / Mokolo
Quaternary catchments
Major dams
Eco-region
1.02
1.03
1.04
6.01
6.02
7.02
7.03
8.05
RESOURCES/NOTES
PROJECT NO
REFERENCE
PROJECT
CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE MOKOLO AND MATLABAS CATCHMENTS: LINPOPO WMA
TITLE
ECO-REGIONS
SCALE
A3
GIS
CHECK
REVIEW
water affairs
Department: Water Affairs
REPUBLIC OF SOUTH AFRICA

ANNEXURE 2

FISH: FRAI TABLES

Annexure 2.1: Matlabas Zyn Kloof, FRAI=A

FRAI (%)	100.0
EC: FRAI	A
ADJUSTED	
FRAI (%)	100.0
EC: FRAI	A

ABBREVIATIONS: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	SCIENTIFIC NAMES: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	REFERENCE FREQUENCY OF OCCURRENCE	EC:OBSERVED & HABITAT DERIVED FREQUENCY OF OCCURRENCE
AURA	AMPHILIUS URANOSCOPUS (PFEFFER, 1889)	5.00	5.00
bmar	LABEOBARBUS MAREQUENSIS SMITH, 1841	5.00	5.00
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	5.00
BTRI	BARBUS TRIMACULATUS PETERS, 1852	0.00	0.00

Annexure 2.2: SQ REACH A41C-00279 (SITE: HARLEM OOS)

AUTOMATED			
FRAI (%)	**69.5**		
EC: FRAI	**C**		
ADJUSTED			
FRAI (%)	**72.8**		
EC: FRAI	**C**		
ABBREVIATIONS: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	**SCIENTIFIC NAMES: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)**	**REFERENCE FREQUENCY OF OCCURRENCE**	**EC:OBSERVED & HABITAT DERIVED FREQUENCY OF OCCURRENCE**
BANN	**BARBUS ANNECTENS GILCHRIST & THOMPSON, 1917**	**3.00**	**2.00**
BBIF	**BARBUS BIFRENATUS FOWLER, 1935**	**3.00**	**2.00**
BMAR	**LABEOBARBUS MAREQUENSIS SMITH, 1841**	**3.00**	**2.00**
BPAU	**BARBUS PALUDINOSUS PETERS, 1852**	**3.00**	**2.00**
BTRI	**BARBUS TRIMACULATUS PETERS, 1852**	**3.00**	**2.00**
BUNI	**BARBUS UNITAENIATUS GÜNTHER, 1866**	**3.00**	**2.00**
BVIV	**BARBUS VIVIPARUS WEBER, 1897**	**3.00**	**2.00**

CGAR	**CLARIAS GARIEPINUS (BURCHELL, 1822)**	**3.00**	**2.00**
LCYL	**LABEO CYLINDRICUS PETERS, 1852**	**3.00**	**2.00**
LMOL	**LABEO MOLYBDINUS DU PLESSIS, 1963**	**3.00**	**2.00**
MMAC	**MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)**	**3.00**	**2.00**
OMOS	**OREOCHROMIS MOSSAMBICUS (PETERS, 1852)**	**3.00**	**2.00**
PCAT	**PETROCEPHALUS WESSELSI KRAMER & VAN DER BANK, 2000**	**3.00**	**2.00**
PPHI	**PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)**	**3.00**	**2.00**
TSPA	**TILAPIA SPARRMANII SMITH, 1840**	**3.00**	**2.00**

Annexure 2.3: FRAI SQ REACH A41B-00334 (SITE MAMBA BRIDGE)

AUTOMATED			
FRAI (%)	**89.3**		
EC: FRAI	**A/B**		
ADJUSTED			
FRAI (%)	**85.0**		
EC: FRAI	**B**		
ABBREVIATIONS: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	**SCIENTIFIC NAMES: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)**	**REFERENCE FREQUENCY OF OCCURRENC E**	**EC:OBSERVED & HABITAT DERIVED FREQUENCY OF OCCURRENCE**
AURA	**AMPHILIUS URANOSCOPUS (PFEFFER, 1889)**	**2.80**	**2.80**
BANN	**BARBUS ANNECTENS GILCHRIST & THOMPSON, 1917**	**2.20**	**2.20**
BBIF	**BARBUS BIFRENATUS FOWLER, 1935**	**4.10**	**4.10**
BBRI	**BARBUS BREVIPINNIS JUBB, 1966**	**2.80**	**2.80**
BMAR	**LABEOBARBUS MAREQUENSIS SMITH, 1841**	**4.70**	**4.70**
BPAU	**BARBUS PALUDINOSUS PETERS, 1852**	**4.70**	**4.70**

BTRI	**BARBUS TRIMACULATUS PETERS, 1852**	**4.70**	**4.70**
BUNI	**BARBUS UNITAENIATUS GÜNTHER, 1866**	**4.70**	**4.70**
BVIV	**BARBUS VIVIPARUS WEBER, 1897**	**4.10**	**4.10**
CGAR	**CLARIAS GARIEPINUS (BURCHELL, 1822)**	**4.10**	**4.10**
CTHE	**CLARIAS THEODORAE WEBER, 1897**	**2.80**	**2.80**
LCYL	**LABEO CYLINDRICUS PETERS, 1852**	**4.10**	**4.10**
LMOL	**LABEO MOLYBDINUS DU PLESSIS, 1963**	**4.10**	**4.10**
MMAC	**MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)**	**4.10**	**4.10**
OMOS	**OREOCHROMIS MOSSAMBICUS (PETERS, 1852)**	**4.10**	**4.10**
PCAT	**PETROCEPHALUS WESSELSI KRAMER & VAN DER BANK, 2000**	**4.10**	**4.10**
PPHI	**PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)**	**4.70**	**4.70**
TSPA	**TILAPIA SPARRMANII SMITH, 1840**	**4.70**	**4.70**

Annexure 2.4: FRAI SQ REACH A41D-00206 (PHOFU SITE)

AUTOMATED			
FRAI (%)	**94.3**		
EC: FRAI	**A**		
ADJUSTED			
FRAI (%)	**90.4**		
EC: FRAI	**A/B**		
ABBREVIATIONS: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	**SCIENTIFIC NAMES: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)**	**REFERENCE FREQUENCY OF OCCURRENC E**	**EC:OBSERVED & HABITAT DERIVED FREQUENCY OF OCCURRENCE**
AMOS	**ANGUILLA MOSSAMBICA PETERS 1852**	**1.00**	**1.00**
BANN	**BARBUS ANNECTENS GILCHRIST & THOMPSON, 1917**	**1.00**	**1.00**
BBIF	**BARBUS BIFRENATUS FOWLER, 1935**	**1.00**	**1.00**
BMAR	**LABEOBARBUS MAREQUENSIS SMITH, 1841**	**1.00**	**1.00**
BPAU	**BARBUS PALUDINOSUS PETERS, 1852**	**1.00**	**1.00**
BTRI	**BARBUS TRIMACULATUS PETERS, 1852**	**1.00**	**1.00**

BUNI	**BARBUS UNITAENIATUS GÜNTHER, 1866**	**1.00**	**1.00**
BVIV	**BARBUS VIVIPARUS WEBER, 1897**	**1.00**	**1.00**
CGAR	**CLARIAS GARIEPINUS (BURCHELL, 1822)**	**1.00**	**1.00**
LCYL	**LABEO CYLINDRICUS PETERS, 1852**	**1.00**	**1.00**
LMOL	**LABEO MOLYBDINUS DU PLESSIS, 1963**	**1.00**	**1.00**
MACU	**MICRALESTES ACUTIDENS (PETERS, 1852)**	**1.00**	**1.00**
MMAC	**MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)**	**1.00**	**1.00**
OMOS	**OREOCHROMIS MOSSAMBICUS (PETERS, 1852)**	**1.00**	**1.00**
PCAT	**PETROCEPHALUS WESSELSI KRAMER & VAN DER BANK, 2000**	**1.00**	**1.00**
PPHI	**PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)**	**1.00**	**1.00**
SINT	**SCHILBE INTERMEDIUS RÜPPELL, 1832**	**1.00**	**1.00**
SZAM	**SYNODONTIS ZAMBEZENSIS PETERS, 1852**	**1.00**	**1.00**
TSPA	**TILAPIA SPARRMANII SMITH, 1840**	**1.00**	**1.00**

ANNEXURE 3

MACROINVERTEBRATES: MIRAI TABLES

Annexure 3.1 Matlabas Zyn Kloof

FLOW MODIFICATION METRICS. **WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	0.5	2	95
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	0.5	2	95
Presence of taxa with a preference for moderately fast flowing water	0	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	0.5	1	100
Presence of taxa with a preference for slow flowing water	0.5	3	70
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	3	70
Presence of taxa with a preference for standing water	0.5	4	60
Abundance and/or frequency of occurrence of taxa with a preference for standing water	0.5	4	60
Overall % change in flow dependance of assemblage			8

HABITAT MODIFICATION METRICS. **WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	2	90
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	0.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	0.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	0	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	0.5	2	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	0.5	3	70
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	0.5	3	70

Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	0	4	60
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	4	60
Overall % change in flow dependence of assemblage			7

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	0	2	95
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	2	95
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	0.5	1	100
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	0.5	1	100
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	0	3	90
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	0.5	3	90
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	0	4	80
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	0.5	4	80
How does the total SASS score differ from expected?	0.5	1	100
How does the total ASPT score differ from expected?	0.5	1	100
Overall change to indicators of modified water quality			7

Annexure 3.2 Mamba River (at bridge)

FLOW MODIFICATION METRICS. WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	3	3	70
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1	3	70
Presence of taxa with a preference for moderately fast flowing water	0.5	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1	1	100
Presence of taxa with a preference for slow flowing water	2.5	2	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	2	80
Presence of taxa with a preference for standing water	1	4	60
Abundance and/or frequency of occurrence of taxa with a preference for standing water	0.5	4	60
Overall % change in flow dependance of assemblage			25

HABITAT MODIFICATION METRICS. WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	3	5	10
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	3	5	10
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	1.5	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	1	2	90
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	1.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	1	100
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1.5	3	75
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	0.5	3	75

Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	0.5	4	60
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	4	60
Overall % change in flow dependanceof assemblage			22

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	2	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	2	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	1.5	1	100
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	1	100
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	0.5	3	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1	3	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	0.5	4	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	4	60
How does the total SASS score differ from expected?	1.5	1	100
How does the total ASPT score differ from expected?	1	1	100
Overall change to indicators of modified water quality			19

Annexure 3.3 Matlabas Haarlem Oos

FLOW MODIFICATION METRICS. **WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	0.5	2	80
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1	2	80
Presence of taxa with a preference for moderately fast flowing water	1	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	2	1	100
Presence of taxa with a preference for slow flowing water	2	3	70
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	1	3	70
Presence of taxa with a preference for standing water	2	4	60
Abundance and/or frequency of occurrence of taxa with a preference for standing water	2	4	60
Overall % change in flow dependance of assemblage			28

HABITAT MODIFICATION METRICS. **WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	1	3	60
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	1	3	60
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	1.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	1.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	2	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	2.5	4	50
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	1	4	50

Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	0.5	3	60
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	1	3	60
Overall % change in flow dependanceof assemblage			27

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	2	2	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	1	2	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	2	1	100
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	1	100
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	1.5	3	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1	3	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	4	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	4	60
How does the total SASS score differ from expected?	1	1	100
How does the total ASPT score differ from expected?	3	1	100
Overall change to indicators of modified water quality			30

Annexure 3.4 Matlabas at Phofu

FLOW MODIFICATION METRICS. **WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	0.5	2	60
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	0.5	2	60
Presence of taxa with a preference for moderately fast flowing water	0	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	0.5	1	100
Presence of taxa with a preference for slow flowing water	1.5	2	70
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	1	2	70
Presence of taxa with a preference for standing water	1.5	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	50
Overall % change in flow dependance of assemblage			15

FLOW MODIFICATION METRICS. **WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	0.5	2	60
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	0.5	2	60
Presence of taxa with a preference for moderately fast flowing water	0	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	0.5	1	100
Presence of taxa with a preference for slow flowing water	1.5	2	70
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	1	2	70
Presence of taxa with a preference for standing water	1.5	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	50

Overall % change in flow dependance of assemblage			15

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	2	75
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	1	2	75
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	0.5	1	100
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	1	100
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	0.5	3	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1	3	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	0.5	4	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	0.5	4	60
How does the total SASS score differ from expected?	1	1	100
How does the total ASPT score differ from expected?	2	1	100
Overall change to indicators of modified water quality			18

ANNEXURE 4

PHYSICO-CHEMICAL: ECOSPECS, TPCs & MONITORING REQUIREMENTS

Annexure 4.1 Matlabas Zyn Kloof

RIVER		**River**	**Tributary of the Matlabas River**			
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Nutrients (mg/L)	SRP	**C**ategory = B	50th %tile ≤0.015 mg/L	No	50th percentile to be < 0.015 mg/L	Monthly
	TIN	Category = A	50th %tile ≤0.25 mg/L	No	50th percentile to be <0.25 mg/L	Monthly
Physical Variables	pH	Category = A	95th %tile <= 7.96 and 5th %tile >= 6.87	No	95th percentile to be <= 8 and 5th percentile >= 6.8	Monthly
	Temperature	Category = A	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = A	5th %tile > 8 mg/l	No	5th percentile to be > 8	Monthly
	Turbidity	Category = A	Change from natural should not be more than moderate (definition - DWAF 2008).	No	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = A	95th %tile ≤ 16 mS/m	No	95th percentile to be <30 mS/m	Monthly
Response variables	SASS (ASPT)	Category = A	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = F	95th %tile < 0.13 mg/l	No	95th %tile < 0.1 mg/l	Monthly
	Fluoride	Category = A	95th %tile < 0.3	No	No toxic component should be within 10% of the A/ B category boundary at its 95th percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.

Annexure 4. 2 Mamba River (at bridge)

RIVER		River	Mamba River			
Water Quality constituents		PES Category	WQ Ecospecs	Improvement required?	TPC	Monitoring frequency
Nutrients (mg/L)	SRP	Category = B	50th %tile ≤0.015 mg/L	No	50th percentile to be < 0.015 mg/L	Monthly
	TIN	Category = A	50th %tile ≤0.25 mg/L	No	50th percentile to be <0.25 mg/L	Monthly
Physical Variables	pH	Category = A	95th %tile <= 7.96 and 5th %tile >= 6.87	No	95th percentile to be <= 8 and 5th percentile >= 6.8	Monthly
	Temperature	Category = A	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = A	5th %tile > 8 mg/l	No	5th percentile to be > 8	Monthly
	Turbidity	Category = A	Change from natural should not be more than moderate (definition - DWAF 2008).	No	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = A	95th %tile ≤ 16 mS/m	No	95th percentile to be <30 mS/m	Monthly
Response variables	SASS (ASPT)	Category = A	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = F	95th %tile < 0.13 mg/l	No	95th %tile < 0.1 mg/l	Monthly
	Fluoride	Category = A	95th %tile < 0.3	No	No toxic component should be within 10% of the A/ B category boundary at its 95th percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.

Annexure 4.3 Matlabas Haarlem Oos

RIVER		**River**	**Matlabas River**			
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Nutrients (mg/L)	SRP	Category = B	50^{th} %tile ≤0.015 mg/L	No	50^{th} percentile to be < 0.015 mg/L	Monthly
	TIN	Category = A	50^{th} %tile ≤0.25 mg/L	No	50^{th} percentile to be <0.25 mg/L	Monthly
Physical Variables	pH	Category = A	95^{th} %tile <= 7.96 and 5^{th} %tile >= 6.87	No	95^{th} percentile to be <= 8 and 5^{th} percentile >= 6.8	Monthly
	Temperature	Category = A	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = A	5^{th} %tile > 8 mg/l	No	5^{th} percentile to be > 8	Monthly
	Turbidity	Category = A	Change from natural should not be more than moderate (definition - DWAF 2008).	No	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = A	95^{th} %tile ≤ 16 mS/m	No	95^{th} percentile to be <30 mS/m	Monthly
Response variables	SASS (ASPT)	Category = A	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = F	95^{th} %tile < 0.13 mg/l	No	95^{th} %tile < 0.1 mg/l	Monthly
	Fluoride	Category = A	95^{th} %tile < 0.3	No	No toxic component should be within 10% of the A/ B category boundary at its 95^{th} percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.

Annexure 4.4 Matlabas at Phofu

RIVER		**River**	**Matlabas River**			
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Nutrients (mg/L)	SRP	Category = B	50^{th} %tile ≤0.015 mg/L	No	50^{th} percentile to be < 0.015 mg/L	Monthly
	TIN	Category = A	50^{th} %tile ≤0.25 mg/L	No	50^{th} percentile to be <0.25 mg/L	Monthly
Physical Variables	pH	Category = A	95^{th} %tile <= 7.96 and 5^{th} %tile >= 6.87	No	95^{th} percentile to be <= 8 and 5^{th} percentile >= 6.8	Monthly
	Temperature	Category = A	No more than a 2 degree deviation from current range	N/A	No more than a 1 degree deviation from current range	Monthly
	Dissolved oxygen	Category = A	5^{th} %tile > 8 mg/l	No	5^{th} percentile to be > 8	Monthly
	Turbidity	Category = A	Change from natural should not be more than moderate (definition - DWAF 2008).	No	Change from natural should not approach moderate (definition - DWAF 2008).	Monthly
	Electrical conductivity (mS/m)	Category = A	95^{th} %tile ≤ 16 mS/m	No	95^{th} percentile to be <30 mS/m	Monthly
Response variables	SASS (ASPT)	Category = A	-	-	-	Baseline quarterly monitoring to be initiated
	Diatoms	Category = no data	-	-	-	Baseline quarterly monitoring to be initiated
Toxics	Ammonia	Category = F	95^{th} %tile < 0.13 mg/l	No	95^{th} %tile < 0.1 mg/l	Monthly
	Fluoride	Category = A	95^{th} %tile < 0.3	No	No toxic component should be within 10% of the A/ B category boundary at its 95^{th} percentile value (DWAF 2008)	Bi-Annual monitoring for all toxics listed in DWAF 2008. If TPC exceeded for any component, then monthly monitoring to be initiated for that component.