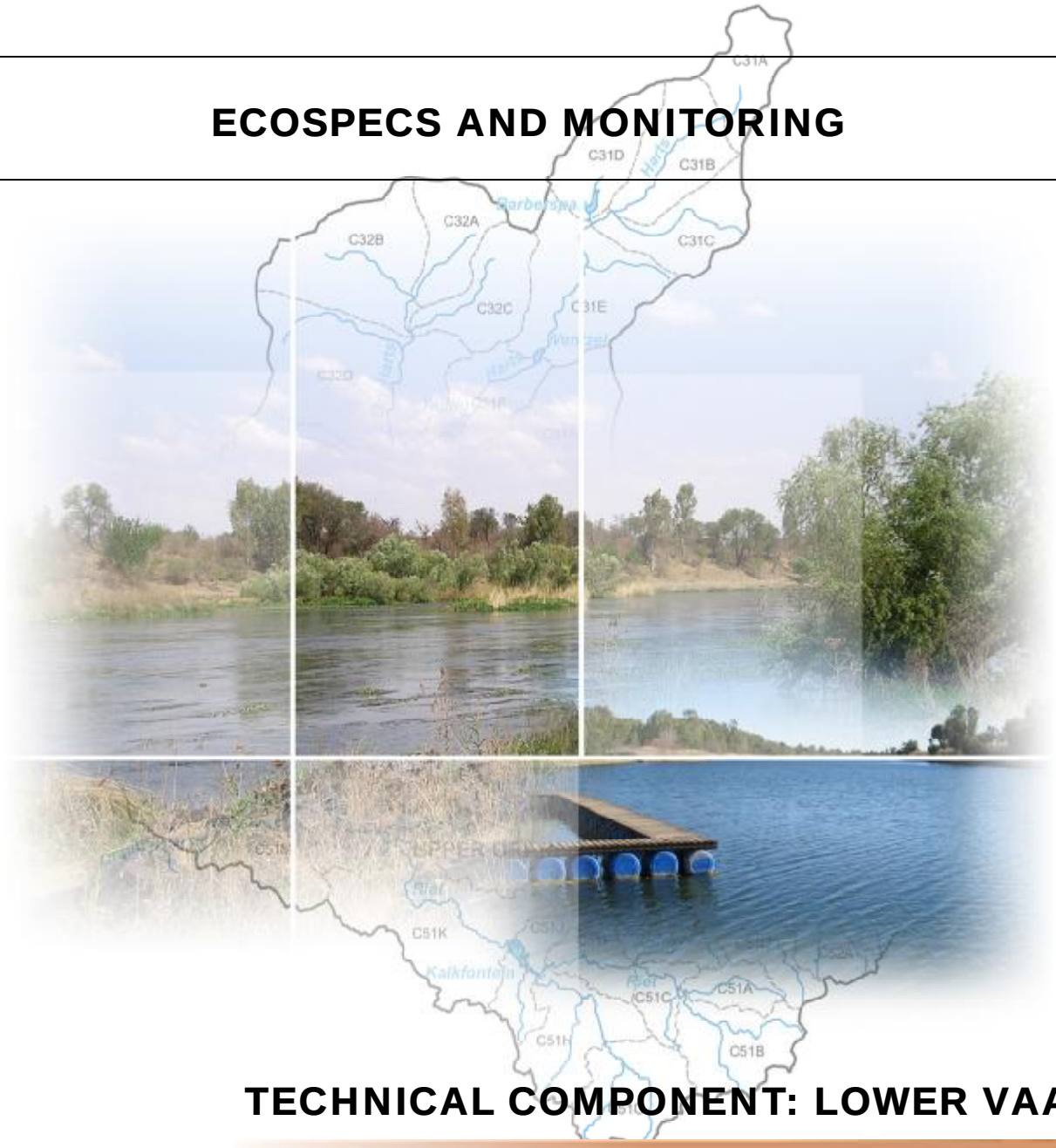
COMPREHENSIVE RESERVE DETERMINATION

INTEGRATED VAAL RIVER SYSTEM

SURFACE WATER

ECOSPECS AND MONITORING



TECHNICAL COMPONENT: LOWER VAAL

REPORT NO.: RDM/WMA10 C000/01/CON/0510
PROJECT NO.: 8829/1

water & forestry
Department:
Water Affairs & Forestry
REPUBLIC OF SOUTH AFRICA

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

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

This report should be cited as:

> Department of Water Affairs (DWA), 2010. Resource Directed Measures: Comprehensive Reserve determination study for the integrated Vaal River System, Lower Vaal Water Management Area. Ecological Specifications and Monitoring Report. Report no: RDM/ WMA10C000/ 01/CON/ 0510. Pretoria, South Africa.

Report produced and authored by:

Golder Associates Africa (Pty) Ltd

Golder Associates Africa (Pty) Ltd
Reg. No. 2002/007104/07

PO Box 6002 Halfway House 1685
South Africa
Thandanani Park, Matuka Close
Halfway Gardens, Midrand
Tel + (27) (0)11 254-4901
Fax + (27) (0)11 805-2100

DOCUMENT INDEX

Reports as part of this project:

Bold type indicates this report.

1.1	RDM/ WMA10C000/01/CON/0107	Lower Vaal Comprehensive Reserve determination: Surface Water Inception report
1.2	RDM/ WMA10C000/01/CON/ 0207	Lower Vaal Comprehensive Reserve determination: Surface Water Desktop EcoClassification report
1.3	RDM/ WMA10C000/ 01/CON/ 0108	Lower Vaal Comprehensive Reserve determination: Surface Water Basic Human Needs Reserve report
1.4	RDM/ WMA10C000/ 01/CON/ 0109	Lower Vaal Comprehensive Reserve determination: Surface Water Resource Units report
1.5	RDM/ WMA09/10C000/ 01/CON/ 0209	Lower and Lower Vaal Comprehensive Reserve determination: Surface Water Wetland/Pans Assessment report
1.6	RDM/ WMA10C000/ 01/CON/ 0110	Lower Vaal Comprehensive Reserve determination: Surface Water EcoClassification report
1.7	RDM/ WMA10C000/ 01/CON/ 0210	Lower Vaal Comprehensive Reserve determination: Surface Water Ecological Water Requirements report
1.8	RDM/ WMA10C000/ 01/CON/ 0310	Lower Vaal Comprehensive Reserve determination: Surface Water Operational scenarios and ecological consequences report
1.9	RDM/ WMA09/10C000/ 01/CON/ 0410	Lower Vaal Comprehensive Reserve determination: Surface Water Socio Economic consequences of operational scenarios report
1.10	RDM/ WMA10C000/ 01/CON/ 0510	Lower Vaal Comprehensive Reserve determination: Surface Water Ecospecs and monitoring report
1.11	RDM/ WMA10C000/ 01/CON/ 0610	Lower Vaal Comprehensive Reserve determination: Surface Water Main integration report
1.12	RDM/ WMA10C000/01/CON/ 0710	Lower Vaal Comprehensive Reserve determination: Surface Water Electronic information

APPROVAL

TITLE:	Resource Directed Measures: Comprehensive Reserve determination study for the integrated Vaal River System, Lower Vaal Water Management Area. Ecological Specifications and Monitoring Report.
DATE:	November 2010
AUTHORS:	R Heath, P Kimberg, A Koning, M. Rountree and Mushoni Makatu
REVIEWERS:	R Stassen
LEAD CONSULTANT:	Golder Consultants
FORMAT:	MSWord and PDF
WEB ADDRESS:	www.dwaf.gov.za

Approved for Golder Associates Africa (Pty) Ltd:

_____

Dr Ralph Heath
Study Leader and Manager

Approved for the Department of Water Affairs by:

_____

Ms R Stassen
Project Manager (PSP Project Management Team)

_____

Ms B Weston
Project Manager: Resource Directed Measures.

ACKNOWLEDGEMENTS

The following individuals are thanked for their contributions to the document:

Project Management Committee

Barbara Weston	Department of Water Affairs & Forestry	Project Manager
Daniel Masemola	Department of Water Affairs & Forestry	Assistant Project Manager
Retha Stassen	Blue Science Consulting	PSP Management team Leader
Owen Wilson	Arcus Gibb Consulting	Assistant PSP Project Manager
Ralph Heath	Golder Associates Africa	PSP Technical Study Leader and Manager

Study Team

Ralph Heath	Golder Associates Africa	Technical Project Leader and Manager
Trevor Coleman	Golder Associates Africa	Water Quality Specialist
Danie Otto	Golder Associates Africa	Pans/Wetlands Specialist
Anton Linstom	Golder Associates Africa	Pans/Wetlands Specialist
Angelina Jordanova	Golder Associates Africa	Hydraulics engineer
Peter Kimburg	Golder Associates Africa	Fish
Alvar Koning	Golder Associates Africa	Macroinvertebrate
Adrian Hudson	Golder Associates Africa	Riparian vegetation
Anelle Odendaal	Zitholele Consulting	Stakeholder awareness
Jennifer Molwantwa	Zitholele Consulting	Water Quality trainee
Rene Ford	Zitholele Consulting	Socio-economic
Justin du Toit	Golder Associates Africa	Trainee socio-economist
Ken Haumann	PD Naidoo and Associates	Spatsim and hydrology
Mark Rountree	Private Consultant	Geomorphologist
Lindo Hlongwane	Fluvial Environmental Consultants	Trainee geomorphologist
Mushoni Makatu	PD Naidoo and Associates	Spatsim and hydrology

Members of Project Steering Committee

Harrison Pienaar	Chief Directorate: Resource Directed Measures
Barbara Weston	Chief Directorate: Resource Directed Measures
Nancy Motebe	Chief Directorate: Resource Directed Measures
Wendy Ralekoa	Chief Directorate: Resource Directed Measures
Bonani Madekezela	Directorate: Resource Quality Services
Mamogale Kadiaka	Directorate: Water Abstraction and In-stream Use (Environment & Recreation)
Seef Rademeyer	Directorate: National Water Resources Planning
Niel van Wyk	Directorate: National Water Resources Planning
Jurgo van Wyk	Directorate: Water Resource Planning Systems
Peter Pyke	Directorate: Option Analysis
Churchill Mkwalo	Directorate: Stream flow Reduction
Marius Keet	Gauteng Regional Office
Delia Mare	Gauteng Regional Office
Walther van der Westhuizen	Gauteng Regional Office
Riana Munnik	Directorate: Resource Protection and Waste
Dawie Koekemoer	Gauteng Regional Office
Hanke Du Toit	Northern Cape Regional Office
Willem Grobler	Free State Regional Office
Retha Stassen	ARCUS GIBB/ Blue Science Consulting Project Management team

EXECUTIVE SUMMARY

The National Water Act (NWA, Act No. 36 of 1998, Section 3) requires that the Reserve be determined for rivers, i.e. the quantity, quality and reliability of water needed to sustain both human use and aquatic ecosystems, so as to meet the requirements for economic development without seriously impacting on the long-term integrity of ecosystems. It is therefore imperative that the Reserve be determined and requirements met before other economic activities can be satisfied.

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.

As the Department of Water Affairs (DWA) is the custodian of the nation's water resources, it is their responsibility to ensure the adequate protection and effective management of these resources. The Chief Directorate: Resources Directed Measures (CD: RDM) is the Directorate within the DWA tasked with the responsibility of ensuring that Reserve assessments take place before licensing can proceed.

The CD: RDM identified the Lower Vaal Water Management Area (WMA) as requiring a comprehensive Reserve assessment as to provide input to the Reconciliation studies and the integrated water quality management plan for the Vaal River undertaken by the National Water Resources Planning Directorate (D: NWRP) of the DWA. These studies require higher levels of confidence in the currently available Reserve determinations.

The CD: RDM initiated the Comprehensive Reserve Determination Study for selected water resources in the Lower Vaal Water Management Area (WMA). The purpose of the Comprehensive Reserve Determination Study for the selected water resources of the Lower Vaal WMA is to determine the ecological and basic human needs water quantity and quality Reserve at a comprehensive level of detail. This Reserve will assist the DWA to make informed decisions regarding the authorisation of future water use and assist with the implementation of the Classification System.

The study area for this Comprehensive Reserve determination is the Vaal catchment within the Lower Vaal and the Riet River within the Upper Orange WMAs (part of WMA 10 and 13). These catchment areas form part of the integrated Vaal River System, as they fall within the C drainage region of South Africa. The Lower Vaal WMA is the last of the three cascading WMAs in the Vaal River System, which includes the drainage area of the Vaal River from its headwaters to the confluence of the Vaal and Orange Rivers.

The Lower Vaal WMA is situated in the north-western part of the country and forms part of the Orange River watercourse. It covers a catchment area of 133 354 km^2, and includes parts of the Northern Cape and North-West Provinces, and a small part of the Free State Province. The Vaal River is the only major river in the WMA, as it flows in a westerly direction from Bloemhof Dam to the confluence with the Orange River. The largest part of the WMA falls within the catchment of the Molopo River, a tributary of the Orange River. The Molopo, Nossob and Kuruman rivers drain the remainder of the WMA but due to the very low rainfall in the WMA, the flow contribution of these rivers are insignificant. The WMA consists of the D41 (excluding D41A), parts of D42C and D42D, parts of D73A and D73C, C31, C32,

C33, C91, and C92 tertiary catchments. For the purpose of this study only the C drainage region is of relevance as it forms part of the Vaal River System, which includes the Harts River catchment and the Vaal River catchment. These two catchments as part of the Vaal River System cover a catchment area of 53 500km^2 within the Lower Vaal WMA. The C drainage region of the Lower WMA comprises four sub-catchments.

The Modder/Riet system forms part of the upper Orange River catchment and consists of tertiary catchments C51 and C52. The Orange River confluences with the Vaal River near the downstream outlet of the Lower Vaal WMA.

Four Ecological Water Requirement (EWR) sites (EWR 16 – 19) were selected for this Lower Vaal Reserve determination study.

The final step in the Reserve process is to define the Ecological Specifications (Ecospecs) and monitoring requirements for the maintenance of ecosystem integrity at each Ecological Water Requirement (EWR) site. The Ecospecs are intended to provide the quantifiable and enforceable descriptors of the quantity, quality and habitat and biotic integrity as they pertain to the ecological objectives for a particular water resource (in this case a particular river reach). These are the values of parameters (usually maximum concentrations) that should not be exceeded in order to meet the Ecological Category specified for the water resource.

This report details the EcoSpecifications and Thresholds of Potential Concern (TPC's) for the maintenance of the ecological Reserve for each EWR site for components consisting of the drivers (geomorphology, physico-chemical variables and hydrology) and the response (riparian vegetation, fish and macroinvertebrates).

The TPCs are "triggers" that indicate management action is required, and the monitoring activities that should be undertaken in order to measure the Ecospecs and TPCs are also described.

Monitoring activities that should be undertaken in order to measure the Ecospecs and TPCs are indicated per EWR site. These monitoring programmes should be rolled out as part of the implementation of the Vaal River catchment Reserve study.

The derived Ecospecs for the maintenance of the Reserve for each EWR site should not be exceeded in order to maintain the driver and response components of the Recommended Ecological Category (REC).

The following table is a summary of the proposed monitoring frequency for the Ecological Reserve for the Lower Vaal EWR sites 16 to 19.

Table A1 Summary of proposed monitoring frequency for the Ecological Reserve for the Lower Vaal.

Reserve component	**Monitoring Frequency**
Hydrology	Daily monitoring at closest DWA weir
Water Quality	Monthly, Quarterly (EC and Chlorophyll -a)
Geomorphology	• Every 2nd year: Daily hydrology and Fixed-point photography • Every 5 – 10 years: Bed material composition; Cross-sections and Aerial photographs
Fish	Monitoring should be conducted twice annually. If only once annually then the intermediate dry –wet season would be preferred.
Macroinvertebrates	Wet and dry season sampling
Riparian Vegetation	Monitoring should be conducted annually during the wet season (Spring to early Summer). Monitoring may be reduced to one survey every two to three years, however, any significant, change should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend

It is important to note that the proposed Rapid Habitat Monitoring Programme (RHAM) has not been tested in the Lower Vaal. If this programme is to be implemented then the suggested monitoring frequency in Table A1 would be altered and the RHAM monitoring would be used as a screening approach. If the TPCs are triggered then the proposed monitoring in Table A1 would then be initiated.

The use of RHAM should be a cost effective screening monitoring programme that could be used in Reserve monitoring. Furthermore the development of diatoms as biotic response indicators (Rapid Diatom Riverine Assessment Method (R-DRAM)) should be closely monitored and when there is sufficient scientific evidence this documented method should be included as an assessment tool for the water quality component of Reserve studies. The R-DRAM serves as a water quality screening tool and indicates which physico-chemical variable(s) require further monitoring and more detailed data analyses. This method could be a cost effective addition to the ongoing water quality monitoring and an early warning link to aquatic ecological impacts. It is recommended that this method be implemented in the Vaal catchment.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRYNOMS

CD: RDM	Chief Directorate: Resource Directed Measures
D: NWRP	Directorate: National Water Resource Planning
D: RQS	Directorate: Resource Quality Services
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
GDP	Gross Domestic Product
GGP	Gross Geographic Product
IHI	Index of Habitat Integrity
NWA	National Water Act
PES	Present Ecological State
QHI	Quick Habitat Integrity
REC	Recommended Ecological Category
RU	Resource Unit
SCI	Socio Cultural Importance
ToR	Terms of Reference
WMA	Water Management Area

GLOSSARY

DROUGHT FLOW	The minimum flow required facilitating the survival of the riverine ecosystem in a particular condition and over short, infrequent periods, when users are subject to water restrictions. Drought flows in the Vaal River will be defined as low-flows that occur less than x % of the time under natural conditions for each month.
ECOLOGICAL CATEGORY	A category indicating the potential management target for a river. Values range from Category A (unmodified, natural) to Category D (largely modified). This term replaces former terms used, namely: Ecological Reserve Category (ERC), Desired Future State (DFS) and Ecological Management Class (EMC). The reasons for these changes are explained in the proceedings of a workshop to clarify the terminology used in Reserve determinations (DWAF 2003). It should be noted that a distinction is made between Management Classes, which form part of the National Classification System, and Ecological Categories, which forms part of the Ecological Water Requirement assessment.
ECOSPECS	Clear and measurable specifications of ecological attributes (e.g. water quality, flow, biological integrity) that defines the Ecological Category. The purpose of ecospecs is to establish clear goals relating to resource quality (Kleynhans 2003).
ECOSTATUS	An overall assessment of the Ecological Category (A-F), based on rule-based integration of specialist indices (water quality, fish, etc). Ecostatus refers to the totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services" (Iversen ***et al.*** 2000, ***In*** IWR Environmental 2003).
ECOLOGICAL WATER REQUIREMENTS (EWR)	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.
INSTREAM FLOW REQUIREMENTS (IFR)	The flow patterns (magnitude, timing and duration) needed to maintain a riverine ecosystem in a particular

	condition. This term is used to refer to the quantity component only of Ecological Water Requirements.
MAINTENANCE FLOW	The flow required to meet the requirements of the riverine ecosystem at a particular site and maintain the resource base in a particular condition during "normal" climatic years. The distinction between "normal" and "drought" was based on an examination of monthly flow duration curves
PRESENT ECOLOGICAL STATE (PES)	The degree to which ecological conditions of an area have been modified from natural (reference) conditions. The measure is based on water quality variables, biotic indicators and habitat information collected 1 to 3 years prior to the assessment. Results are classified on a 6-poin scale, from Category A (*Largely Natural*) to Category F (*Critically Modified*).
REFERENCE CONDITION	Natural ecological conditions, prior to human development.
RESERVE	The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997), for people who are now or who will, in the reasonably near future, be (i) relying upon; (ii) taking water from; or (iii) being supplied from, the relevant water resource; and (b) to protect aquatic ecosystems under the National Water Act, 1998 (Act No. 36 of 1998) in order to secure ecologically sustainable development and use of the relevant water resource. The Reserve refers to the modified Ecological Water Requirement, where operational limitations, and stakeholder consultation are taken into account.
RESOURCE QUALITY OBJECTIVE	Quantitative and auditable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection. This term takes into account the management *classes* and the requirements of other users. These components are not addressed in this project
RESOURCE UNIT	Stretches of river that are sufficiently ecologically distinct to warrant their own specification of Ecological Water Requirements, and that can be practically managed as a single unit.

1 INTRODUCTION

1.1 BACKGROUND

Chapter 3 of the National Water Act (NWA) (Act No. 36, 1998) provides for the protection of water resources of the country through the implementation of Resource Directed Measures (RDM), based on the guiding principles of sustainability and equity. In terms of the Act, before any 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. The Reserve can be defined as, 'the quantity, quality and reliability of water needed to sustain both basic human needs and aquatic ecosystems.

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 Chief Directorate: Resource Directed Measures (CD: RDM) is tasked with the responsibility of ensuring that the Reserve requirements, which have priority over other uses in terms of the Act, are determined before any new water uses are authorised. The Reserve requirements must be met, before the requirements for economic development or water uses are satisfied so as to ensure that the long-term integrity of ecosystems are not comprised or severely impacted upon'. As the Department of Water Affairs (DWA) is the custodian of the nation's water resources, it is their responsibility to ensure the adequate protection and effective management of these resources.

The CD: RDM initiated the Comprehensive Reserve Determination Study for selected water resources in the Lower Vaal Water Management Area (WMA). The purpose of the Comprehensive Reserve Determination Study for the selected water resources of the Lower Vaal WMA is to determine the ecological and basic human needs water quantity and quality Reserve at an intermediate level of detail. The final step in this process is to define the Ecological Specifications (Ecospecs) and monitoring requirements for the maintenance of the at each Ecological Water Requirement (EWR) site. The Ecospecs are intended to provide the quantifiable and enforceable descriptors of the quantity, quality and habitat and biotic integrity as they pertain to the ecological objectives for a particular water resource (in this case a particular river reach). These are the values of parameters (usually maximum concentrations) that should not be exceeded in order to meet the EC specified for the water resource.

The results of the Comprehensive Reserve determination study will assist the DWA to make more informed decisions regarding the authorization of future water uses, operation and management of the system and the evaluation of the magnitude of the impacts of present and proposed developments.

This report provides the results of step 7 (Quantify Ecological Specifications and Monitoring Requirements) of the 8-step Reserve determination process (see Figure 1.1) for the rivers of the Lower Vaal catchment area. This report describes the ecological specifications and monitoring requirements for maintenance of the preliminary Reserve in the rivers in the Lower Vaal WMA as they relate to hydrology, water quality, geomorphology, vegetation, macro-invertebrates and fish.

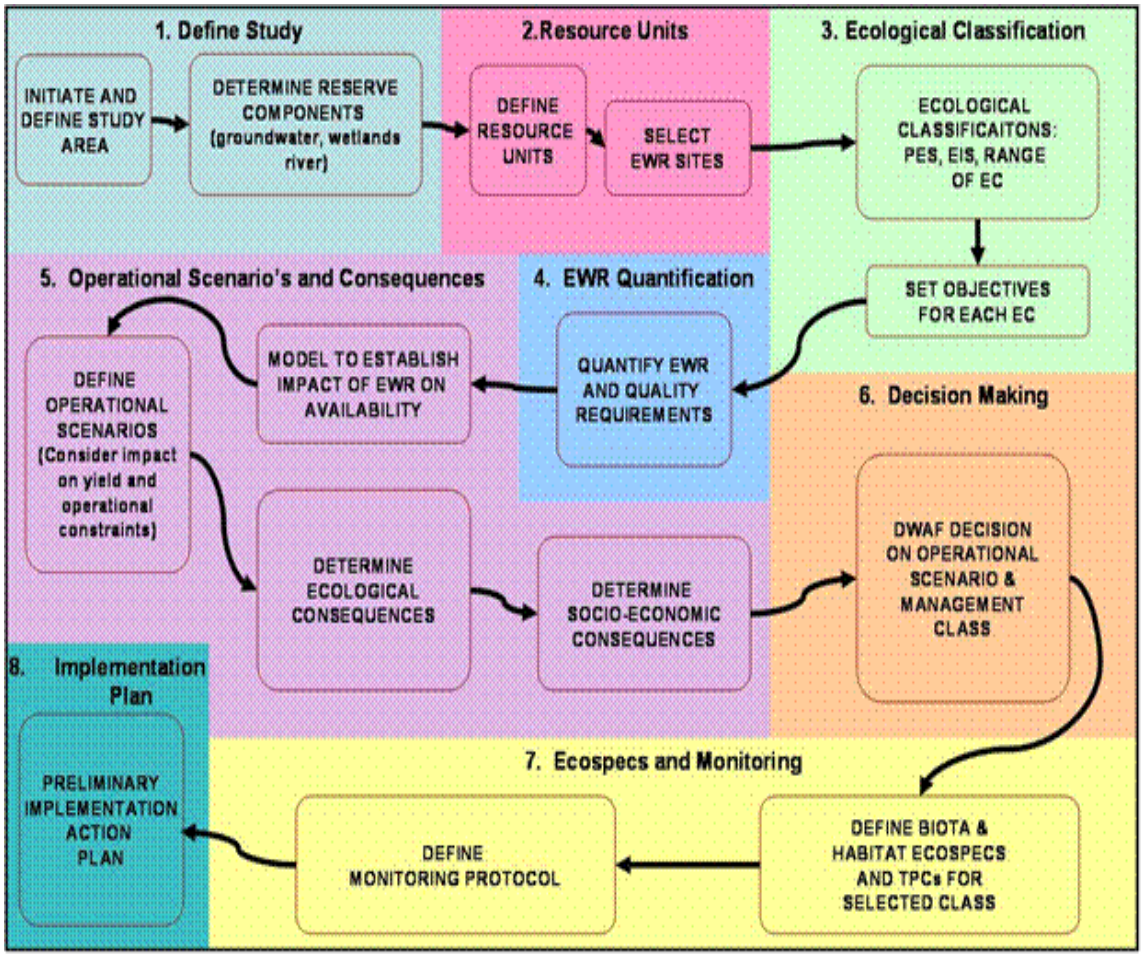


Figure 1.1: Generic procedure for the determination of the ecological Reserve

1.2 ECOLOGICAL SPECIFICATIONS AND THRESHOLDS OF POTENTIAL CONCERN

Ecological specifications (Ecospecs) are derived from the Resource Quality Objectives (RQOs) for the resource (specifically rivers, wetlands, estuaries and groundwater). RQOs are requirements for water quantity, quality and habitat and biotic integrity to be maintained in the resource. RQOs may encompass ecological, economic, social and political objectives. The Ecospecs are intended to provide the quantifiable and enforceable descriptors of the RQOs as they pertain to the ecological objectives for a particular resource (in this case a particular river reach).

Thresholds of Potential Concern (TPCs) are points along a continuum of change in selected Ecospecs, which prompt management action. Such action may involve attention to the causes of change or a reassessment of the validity of the Ecospecs or TPCs, as part of an adaptive management strategy.

A description of the theory behind Ecospecs, TPCs and monitoring is given in Kleynhans and Louw (2006).

1.3 STUDY AREA

The study area for the Comprehensive Reserve determination of the lower Vaal River is the Vaal catchment within the Lower Vaal and the Riet River in the Upper Orange WMAs (part of WMA 10 and 13) (Figure 1.2). These catchment areas form part of the integrated Vaal River System, as they fall within the C drainage region of South Africa. The Lower Vaal WMA is the last of the three cascading WMAs in the Vaal River System catchment, which includes the drainage area of the Vaal River from its headwaters to the confluence of the Vaal and Orange Rivers. The Lower Vaal WMA is situated in the north-western part of the country and forms part of the Orange River watercourse. It covers a catchment area of 133 354 km^2, and includes parts of the Northern Cape and North-West Provinces, and a small part of the Free State Province.

The Vaal River is the only major river in the WMA, as it flows in a westerly direction from Bloemhof Dam to the confluence with the Orange River. The largest part of the WMA falls within the catchment of the Molopo River, a tributary of the Orange River. The Molopo, Nossob and Kuruman rivers drain the remainder of the WMA but due to the very low rainfall in the WMA, these rivers are insignificant. The WMA consists of the D41 (excluding D41A), parts of D42C and D42D, parts of D73A and D73C, C31, C32, C33, C91, and C92 tertiary catchments. For the purpose of this study only the C drainage region is of relevance as it forms part of the Vaal River System, which includes the Harts River catchment and the Vaal River catchment. These two catchments as part of the Vaal River System cover a catchment area of 53 500km^2 within the Lower Vaal WMA.

The Modder/Riet system forms part of the upper Orange River catchment and consists of tertiary catchments C51 and C52. The Orange River confluences with the Vaal River near the downstream outlet of the Lower Vaal WMA. The C drainage region of the Lower WMA comprises four sub-catchments and the Upper Orange one catchment as listed in Table 1.1.

Table 1.1: Sub-catchments and related quaternary drainage regions within the C Drainage tertiary Catchment within the Lower Vaal WMA (DWAF, 2006)

PRIMARY CATCHMENT	SUB-CATCHMENT	QUARTENARY CATCHMENTS	AVERAGE GROSS AREA (km^2)
C	Dry Harts	C32A-D	10 205
	Harts	C31A-F	11 023
	Vaalharts	C33A-C	9843
	Vaal downstream Bloemhof	C91A-E, C92A-C	22 427
	Modder/Riet	C51A-M, C52A-L	34 795

Virtually all the surface flow of the Vaal River, the main source of water in the Lower Vaal WMA, originates from the Upper and Middle Vaal WMAs. Very little surface run-off originates within the WMA itself due to the low rainfall, flat topography and sandy soils. The groundwater resource is more substantial, supplying an estimated 128 million m^3/annum. The Vaal River is fed by the only tributary, the Harts River which drains a catchment area of 31 000km^2, with the Dry Harts being the major tributary of the Harts River joining it just downstream of Taung. The only lake and wetlands

of note are at Barberspan in the Upper Harts River catchment which has been given Ramsar status as a wildlife conservation area.

The development of the surface water resources occurring in the WMA has reached its potential, however all water is not being fully utilised. The water in Taung Dam and Spitskop Dam are currently not utilised and further studies are required to determine best how to utilise the water contained in these dams.

The selected Ecological Water Requirement (EWR) sites are listed in Table 1.2 and shown in Figure 1.2.

Table 1.2: Selected EWR sites for the Lower Vaal catchment

EWR Site number	EWR site name	River	National RHP[1] site	Coordinates		EcoRegion (Level II)	Geomorphic zone	Altitude (m)	RU[2]	Quaternary catchment	Hydrological gauge
				Latitude	Longitude						
EWR16	Downstream Bloemhof Dam	Vaal		S27.65541	E25.59564	11.08; 29.02	E: Lower Foothills	1211	MRU Vaal K	C91A	C9H021
EWR17	Lloyds weir on Harts River	Harts	C3HART-DELPO	S28.37694	E24.30305	29.02; 30.01	E: Lower Foothills	1114	MRU Harts C	C33C	C3H016
EWR18	Schmidtsdrift	Vaal	C9VAAL-SCHMI	S28.70480	E24.07601	29.02; 30.01	E: Lower Foothills	1239	MRU Vaal O	C92B	C9H024
EWR19	Lilydale Lodge	Riet		S29.03842	E24.50283	29.02	E: Lower Foothills	1107	MRU Riet D	C51L	C5H048

[1]: River Health Programme; [2]: Resource Unit

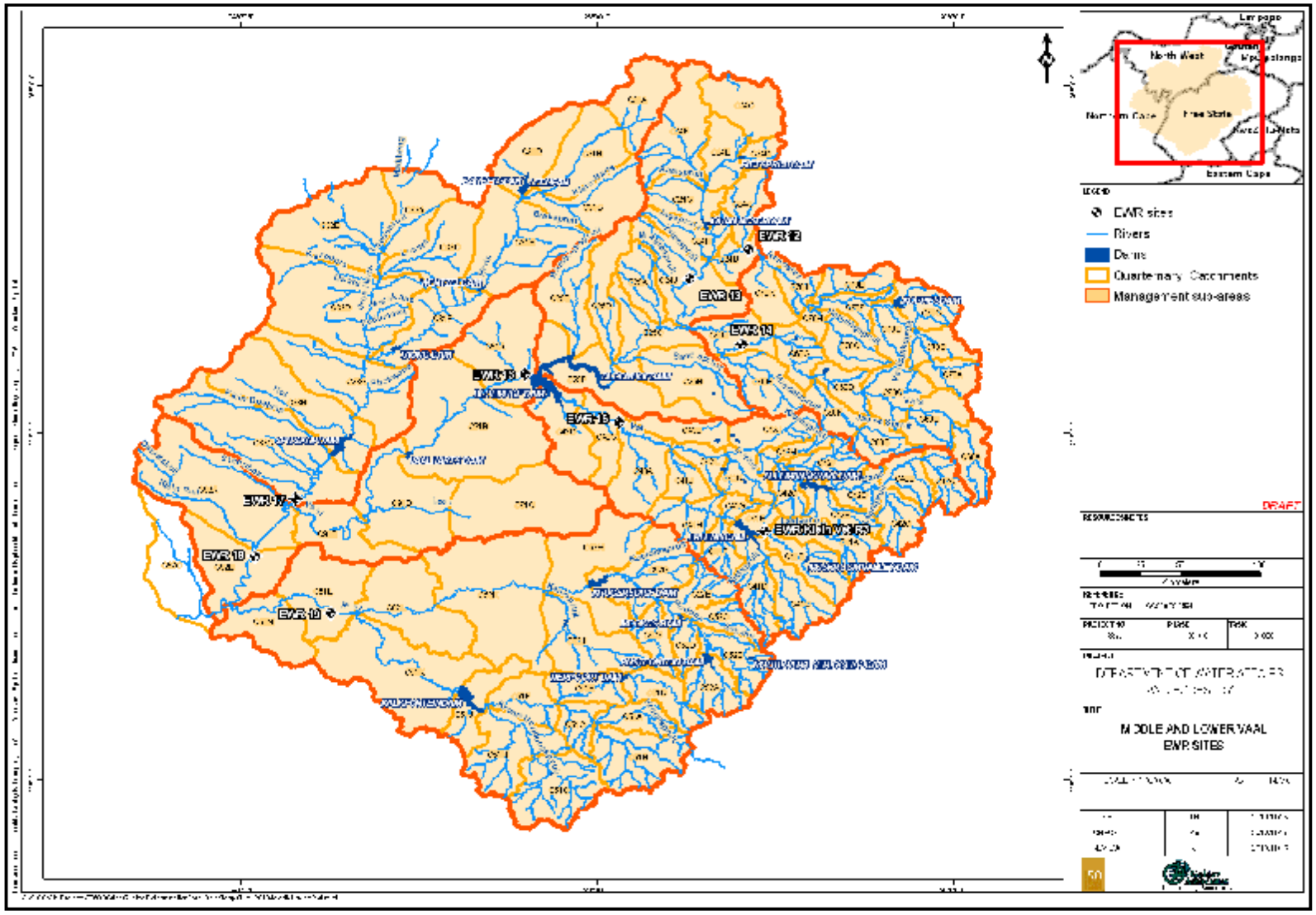


Figure 1.2: Resource Units and selected EWR sites for the Lower and Middle Vaal catchment

1.4 ECOLOGICAL CLASSIFICATION

The Present EcoStatus (PES), and the Recommended Ecological Category (REC) and Alternative Ecological Category (AEC) for which Reserves were determined for each of the sites are given in Table 1.3.

Table 1.3: The Present EcoStatus (PES), the Recommended Ecological Category (REC) and Alternative Ecological Category (AEC) for the Lower Vaal EWR sites

EWR Site	River	Quaternary Catchment	PES	Importance	Ecological Category		
				EIS	REC	Alternatives	
						AEC up	AEC down
EWR16	Vaal	C91A	E	Moderate	D	D	-
EWR17	Harts	C33C	D	Moderate	D	D	-
EWR18	Vaal	C92B	C/D	Moderate	C/D	C	D
EWR19	Riet	C51L	D	High	D	C	-

1.5 DESCRIPTORS OF ECOLOGICAL CONDITION FOR WHICH ECOSPECS ARE PROVIDED

In this report Ecospecs and TPCs are provided for the following disciplines:

- Hydrology
- Water Quality
- Geomorphology
- Fish
- Macroinvertebrates
- Vegetation.

1.5.1 Hydrology

The Lower Vaal WMA is dependent on the Upper Vaal and Middle Vaal WMAs for supply of utilisable surface water resources, with over 90% of the water required being sourced through releases from the Upper Vaal WMA and from Bloemhof Dam. More than 50% of the yield from natural water resources in the tributary catchments within the WMA is supplied from groundwater. Water use in the water management area is dominated by irrigation, which represent 80% of the local requirements for water. About 12% of the

requirements is for urban and industrial use, 7% for rural domestic supplies and stock watering, and the remainder for mining purposes. Over 85% of the requirements for irrigation are in the Harts sub-area, mainly at the Vaalharts irrigation scheme, abstracted at the Vaalharts Weir on the Vaal River, with the balance being along the Vaal River. Water is also transferred into the WMA from the Upper Orange WMA (abstracted at a pump station at Marksdrift) into Douglas Weir. The Vaalharts Irrigation scheme generates irrigation return flows which enter the Harts River upstream of Spitskop Dam. The return flows contribute salinity and nutrients to the Harts River and ultimately to the lower Vaal River.

There are several large dams that have been developed in the WMA. The main dams are listed below:

Dam name	Quaternary catchment	River	Purpose	Full Storage Capacity million m^3
Douglas Weir	C92B	Vaal	Irrigation	16.7
Spitskop	C33B	Harts	Irrigation	56.6
Taung Dam	C31F	Harts	Not utilised	6.6
Vaalharts Weir	C91B	Vaal	Irrigation (mainly) & Domestic	48.7
Wentzel	C31E	Harts	Domestic	6.6

General description of overall system operation

An important characteristic of the Integrated Vaal River System is the interdependencies that exist due to the numerous inter-basin transfers which form a complex network of interlinked reservoirs that are located in catchments with different hydrological characteristics. This necessitates that operation of the system is undertaken in an integrated manner to ensure the effects of operating rules are evaluated in a system context where the behaviour of all the components of the water resource system are evaluated and monitored. Therefore, as a general operation principle, the Integrated Vaal River System is operated as an integrated system irrespective of who owns or operate each component of the system.

The operation of the system is designed to maximise the long term water yield from the system. This is achieved by using water first from the most downstream impoundment in the system and only when depleted, water is released from upstream reservoirs to support the water requirements. The Integrated Vaal River System includes ten subsystems, seven transfer schemes and various internal supply schemes in the system, including the Vaal River Eastern Subsystem. The subsystems that form part of the Comprehensive Reserve Determination study area include the Lower Vaal Subsystem, Bloemhof Subsystem, Senqu Subsystem, Grootdraai Subsystem, Zaaihoek Subsystem, Heyshope Subsystem and Usutu subsystem.

The Lower Vaal WMA forms part of the Lower Vaal Subsystem of the Integrated Vaal River System, which extends from just downstream Bloemhof Dam to Douglas Weir. The main dams in the subsystem, Wentzel, Taung and Spitskop with a combined storage capacity of 69.8 million m^3, are all located in the Harts River and their function is to supply local water requirements. Vaalharts Weir, with a capacity of 49 million m^3, is

a regulation structure that diverts water into the canal system that feeds the Vaalharts Irrigation Scheme and releases water for the downstream users along the Vaal River.

Hydrological Ecospecs

The hydrological Ecospecs are encompassed in the water quantity aspects of the Ecological Reserve (Riverine RDM Report). The following descriptors of the hydrological characteristics are used:

- Total Mean Annual Maintenance volume
- Monthly Mean Maintenance flow
- Monthly exceedance curves for the low flows
- Monthly exceedance curves for the complete flow regime
- Duration, magnitude (in daily average peak), volume and timing of intra-annual floods.

The Reserve information for the various rivers in the study area is provided in detail in the EWR report (RDM/ WMA10C000/ 01/CON/0210).

1.5.2 Water quality

The water quality Ecospecs are encompassed in the water quality aspects of the Ecological Reserve. The following water quality variables are included in the water quality Ecospecs either quantitatively or qualitatively:

- $MgSO_4$ (mg/L)
- Na_2SO_4 (mg/L)
- $MgCl_2$ (mg/L)
- $CaCl_2$ (mg/L)
- NaCl (mg/L)
- Total inorganic nitrogen (TIN) in mg/L
- Soluble Reactive Phosphorus (SRP) in mg/L
- pH
- Water temperature (°C)
- Dissolved oxygen (DO) in mg/L
- Turbidity (NTU)
- Electrical conductivity (mS/m)
- Chlorophyll a (Chl a) as periphyton algae (mg/m^2)
- Chlorophyll a as phytoplankton algae (µg/L)
- Toxic substances.

The Ecological Specifications (Ecospecs) for the maintenance of the Water Quality Reserve for each EWR site are the values of water quality parameters (usually maximum concentrations) that should not be exceeded in order to meet the water quality component of the Recommended Ecological Category (REC).

The Thresholds of Potential Concern (TPCs) which are "triggers" that indicate management action (further investigation into the cause of a potentially problematic water quality constituent) is required, and the monitoring activities that should be undertaken in order to measure the Ecospecs and TPCs are also described.

The water quality Ecospecs and TPCs were derived using methods from DWAF (2006); DWAF (2006b) and Muller and Scherman (2007).

The Present Ecological State for water quality (WQ PES), the Overall PES, the Ecological Importance and Sensitivity (EIS), and the Recommended Ecological Category (REC) for EWR sites at which comprehensive Reserve determinations were done are given in Table 1.4.

Table 1.4: Summary of the Lower Vaal EWR sites and the REC for water quality

Site (River)	EWR no.	EWR site and WQSU	Overall PES	WQ PES	EIS	Overall REC	REC for water quality
Vaal	EWR16	Downstream Bloemhof Dam WQSU 63	E	C	Moderate	D	C
Harts	EWR17	Lloyds weir on Harts River WQSU 67	D	D	Moderate	D	D
Vaal	EWR18	Schmidtsdrift WQSU 68	C/D	C	Moderate	C/D	C
Riet	EWR19	Lilydale Lodge WQSU 81	D	D	High	D	D

The approach followed in specifying the Ecospecs for the REC was to use the boundary value as given in the EWR Report for the current PES category for each variable. In cases where there was a negative trend for a water quality variable or where the variable was currently in a lower category than the REC, the Ecospecs was to improve by half or one category.

Since the hydrological regime under the REC is designed to maintain PES, major changes in water quality as a consequence of altered flow are not expected. Changes in water quality in the future are more likely to be a consequence of changes in land use (diffuse pollutants) or new point-sources of pollutants. Nevertheless it is important to keep in mind the following general relationships between flow and water quality:

- A decrease in flow is likely to result in increased concentrations of chemical constituents as a consequence of the reduced dilution capacity of the system.

- The range in daily in stream temperature is likely to increase if flow is reduced due a reduction in the buffering capacity. Thus during the summer, hotter day temperatures can be expected and during the winter, colder temperatures can be expected during the night.

- Dissolved oxygen (DO) concentrations will decrease as water temperature increases.

- Dissolved oxygen concentrations may also be lowered if flow is reduced due to reduction of aeration, a consequence of fewer riffle areas.

- pH is unlikely to show a marked change in response to changes in flow.

There are few data for the catchments under consideration for DO, temperature, turbidity or Chlorophyll *a*, and monitoring of these variables is highly recommended (possibly by installing data loggers for DO and temperature). As such, they have been included in the monitoring programme.

There was an incompatibility between water quality data obtained from the DWAF WMS database and the data format required to run the model "TEACHA." As a result, the theoretical concentrations of the salts that are normally examined during a water quality Reserve study ($MgSO_4$, Na_2SO_4, $MgCl_2$, $CaCl_2$, and NaCl) could not be calculated. TPCs are also set for physico-chemical parameters for the site, i.e. to monitor a deterioration from present state. TPCs are presented as 95^{th} percentiles, i.e. values not to be exceeded more than 5% of the time, for inorganic salts, physical variables and toxics; and 50^{th} percentiles for nutrients, i.e. Total Inorganic Nitrogen (TIN), Soluble Reactive Phosphorous (SRP) or ortho-phosphate and Chlorophyll-*a* (Chl-a). The TPC ranges are defined by the upper boundary of the PES category and 80% thereof for the lower boundary, e.g. if a B category for a PES EcoSpec is < 15 mg/L, the associated TPC would be 12 – 15 mg/L.

Percentiles should be calculated within the framework of the current assessment method (DWAF, 2008), i.e. using the PES monitoring point as shown on the table for the relevant EWR site, and the most recent 3 to 5 years of data, equivalent to a minimum of 60 data points. Data used from the DWA gauging weir must be requested from DWA's Water Management System's (WMS) database.

- EcoSpecs, i.e. water quality specifications or objectives for the Recommended Ecological Category (REC), are set for physico-chemical parameters only, i.e. quantifiable measurable parameters.

- EcoSpecs, i.e. water quality specifications or objectives for the Present Ecological State (PES), are set for physico-chemical parameters only, i.e. quantifiable measurable parameters.

Quality EcoSpecs are therefore related to attaining the water quality category of the overall REC or PES, and are presented as the range that each variable should be in to maintain the required category for that variable. The category specified per variable, and the composition of categories for all variables, will depend on the drivers of water quality per site.

1.5.3 Geomorphology

Reserve monitoring is required to assess the efficacy of the requested flows for the environment. Monitoring should thus be focussed on those descriptors of the system that are sensitive to flow alterations. However, the geomorphological condition at a monitoring or EWR site can be affected by both the upstream flow alterations as well as adjacent landuse activities. Thus there may not always be simple cause-effect relationships between geomorphological descriptors and flow conditions, and one should be aware of possible changes to river geomorphology that are not directly flow related. Additionally, antecedent events such as large natural flood events may temporarily create apparently undesirable changes that are not directly related to the provision of EWR flows at a site. Monitoring of the geomorphological conditions must therefore take into account the number and size of recent floods and the impacts of catchment and riparian landuse in addition to the flow record and provision (or lack) of the requested EWR flows.

The descriptors that were selected for geomorphology were chosen based on their assumed potential to indicate responses to flow changes. Three categories of descriptors were identified:

- Hydrology;
- Low flow season bed material composition, and;
- Channel form and gross morphology.

Once the descriptors were identified, the ranges of conditions expected for the Recommended Ecological Category were determined. The objectives or desired condition for the descriptor is described as an EcoSpec – a quantifiable and enforceable descriptor of the Resource Quality Objectives (RQOs) as they pertain to the ecological objectives for a river reach or site.

Thresholds of Probable Concern (TPCs) are provided to act as “red flags” which represent a level of concern of a particular EcoSpec whereby further change of that descriptor is likely to result in a new condition that does not satisfy the Resource Quality Objectives for that site or river reach. This approach is used to minimise monitoring costs, since only if the TPC’s are exceeded will more detailed discipline-specific assessments be required for the sites. It is assumed that if the TPC’s are not exceeded, then the EcoSpecs are achieved and thus the desired state (REC) of the reach is being achieved.

The EcoSpecs for geomorphology, described below for each of the EWR sites, are based on expert assumptions of the likely acceptable range of change for a variety of metrics. The expected critical, relatively rapid responding metrics or variables were selected for the generation of EcoSpecs and TPC’s. These needed to be

- Relevant for assessing and monitoring the condition of the river geomorphology, and/or represent critical habitats for instream biota, and
- Feasible and cost-effective to collect as part of a monitoring programme.

No RHAM monitoring baseline data are available for the Lower Vaal EWR sites, so no metrics related to this proposed Reserve monitoring approach could be identified or monitoring guidelines for this proposed. EcoSpecs and TPC's were thus determined from the EWR data collected in 2008. The Geomorphological TPC's provided thus relate to the baseline conditions observed at the time of the EWR site visits (the low flow season of August 2008).

In general, the Vaal River and associated tributaries in the Lower Vaal WMAs can be described as supply (sediment) limited systems, in that there is much more streampower available to erode than there is sediment available to be moved. Mobile sediment is composed predominantly of fines and suspended materials; with larger cobble and boulder components tending to be derived ***in situ*** rather than be representative of the general load of the system. Channel beds often have at least some bedrock component, indicating that the rivers have eroded down to base level (the underlying bedrock) and are not flowing across deposited alluvial material.

The bedrock influence and limited sediment storage and availability mean that the morphologies of these rivers are relatively resilient to moderate increases or decreases in overall flow. This is evident in the stable morphologies observed from the historical aerial photographs, and from the general absence of large-scale sedimentary features within the channels and along the banks.

Where relevant descriptors (such as hydrology, bed material composition and channel morphology) were identified, Ecospecs and where appropriate TPC's have been generated for each EWR site. These are presented in the tables below. These specifications were set based on a field and desktop assessment of the site undertaken during August (the low flow season) 2008.

Monitoring frequency is recommended at 2 (for hydrology/EWR flow verification) to 5 (for bed material, cross-sections and aerial photography assessments) year intervals. However, in the event of a 1:10-year or greater return period flood, it is recommended that the following dry season that the cross-section and bed material is resurveyed and fixed point photography is updated for the site.

It must be stressed however that rates and ranges of morphological adjustment that can be expected from the normal morphological descriptors for geomorphological monitoring (bed material composition and channel morphology) are likely to be relatively small due to the low slopes and resistant (often bedrock-controlled) nature of the river. In essence, the geomorphology of the rivers is extremely stable and thus cannot easily be monitored for the minor adjustments than can be expected. Some reduction in sediment load has occurred due to the trapping of sediment in upstream dams, but this cannot be ameliorated by flows. If funds or resources are limited, monitoring should be focussed on water quality and baseflow indicators (such as diatoms, invertebrates and fish) rather than riparian vegetation and geomorphology as these systems are relatively insensitive to large flows and floods and thus not likely to yield largescale changes in the geomorphology or riparian vegetation. Additionally, given the widespread encroachment of infrastructure into the riparian zone, it would be difficult to provide the larger floods required to improve riparian vegetation.

1.5.4 Fish

The fish communities will be affected in several ways by flow regulation. These include both beneficial and adverse effects. Some species may increase in abundance in the rivers whereas others may be lost from a specific reach. In particular, flow plays a critical role in mediating relative abundances of native and non-native species, with low, constant flows benefiting invasive alien species.

The species used as descriptors of the fish communities are given below:

- *Barbus anoplus* (Chubbyhead barb);
- *Labeobarbus aeneus* (Smallmouth yellowfish);
- *Labeobarbus kimberleyensis* (Largemouth yellowfish);
- *Labeo capensis* (Orange Vaal mudfish);
- *Labeo umbratus* (Moggel);
- *Clarias gariepinus* (Sharptooth catfish);
- *Tilapia sparrmanii* (Banded tilapia);
- *Pseudocrenilabrus philander* (Southern mouthbrooder);
- *Cyprinus carpio* (Carp) (exotic);
- *Gambusia affinis* (Mosquitofish) (exotic).

1.5.5 Macroinvertebrates

The descriptors for the invertebrates were derived from DWAF (2007, 2008) and Kleyhans and Louw (2006), and are based on a combination of target SASS5 scores and site-specific requirements for the presence of individual taxa. This approach was chosen because of the practicality of using existing biomonitoring practices, as well as the greater precision afforded by focusing on taxa with fairly well known habitat requirements.

The descriptors of the macroinvertebrates are given below:

- SASS5 Scores
- Average score per taxon (ASPT)

- Biotopes/habitats
- Taxa
    - *Elmidae*
    - *Hydrosychidae* 2spp
    - *Baetidae*
    - *Leptophlebiidae*
    - *Simulidae*
    - *Coenagrioenidae*
    - *Atyidae*
    - *Leptoceridae*.

1.5.6 Vegetation

The plant communities will respond to habitat changes related to changes in water level as follows:

- Changes in distribution of species along the vertical axis (*i.e.*, laterally up the banks), and along the rivers (*i.e.*, longitudinal zones);
- Changes in relative species abundance; and
- The loss of existing species or the gain of new species.

For this reason, descriptors of change consist of (1) a lateral zone and (2) species within the lateral zone. Details of the zonation of the riparian vegetation at the EWR sites are provided in the Riverine RDM Report.

The descriptors can usefully be divided into three main response groups, *viz*. those that are expected to decrease in response to adverse flow changes, and those that are expected to increase in response to adverse flow changes.

Change in response to flow change is also time dependent. The longer the period plus degree of change from natural, the greater the degree of the negative effect or the greater the likelihood of the change response occurring.

Function and timing of different flow classes

The periodicity of the different flood size classes is causal to the formation and maintenance of the different lateral vegetation zones. Floods size classes, by definition, have different periodicities and different lateral wetting heights (e.g., Class 1, 2, 3 and 4, which have an intra-annual occurrence, and the 1:2, 1:5, 1:10 and 1:20 year floods).

The physical environment shaping functions of each flow type is as important as the shaping of the vegetation by the flow. Certain smaller herbaceous plants would be reduced in size or numbers by smaller floods than trees, while large floods are clearly very important to clear channels of larger trees. The movement of depositional materials in floods is well known from debris lines left after floods.

Of lesser realized importance is the role played by different flow sizes to transport and bury reproductive material (seeds and portions of plants) through the different parts of the system. Similarly the regularity of wetting different parts of the riparian zone facilitates the growth and indeed survival of different species in each zone. The effects of these factors over the longer term are considered in the ratings given to the effects of flow reductions as assessed in a study of this nature.

1.6 PURPOSE OF THIS REPORT

The activities and tasks for step 7 (Ecological Specifications and Monitoring) of the 8 step Reserve determination process 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).
- EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2) of Kleynhans and Louw (2007).

This report serves to document the results of the Ecological Specification and Monitoring process and the determination of the ecological specification and monitoring requirements for the rivers in the Lower Vaal Water Management Area which were finalised at several specialist meetings held during June 2010.

The specialist components consist of the drivers (geomorphology, physico-chemical variables and hydrology) and the response (riparian vegetation, fish and macroinvertebrates).

1.7 REPORT STRUCTURE

This report is structured into the following sections:

Section 1: Introduction

This section.

Section 2: Determination of Ecological Specifications and Monitoring Requirements

This chapter provide results of different Ecospecs and monitoring requirements of the drivers and responses per EWR site.

Section 3: Conclusions and Recommendations

The results are summarised and recommendations are made.

Section 4: References

2 DETERMINATION OF ECOLOGICAL SPECIFICATIONS AND MONITORING REQUIREMENTS

2.1 EWR 16 VAAL RIVER: DOWNSTREAM OF BLOEMHOF DAM

2.1.1 Hydrology

The Lower Vaal Subsystem has limited local water resources and most of the water requirements in the subsystem are supplied through releases from Bloemhof Dam. The dam wall and outlet works are located within the Lower Vaal water management area immediately where the river enters the water management area from the Middle Vaal water management area. However most of the reservoir basin falls in the Middle Vaal water management area. The yield from the dam however, is available in the Lower Vaal water management area. Approximately 500 million m^3 of water per year is transferred from the Middle Vaal water management area to the Lower Vaal water management area.

Water stored in Bloemhof Dam is used to supply the downstream irrigation and urban users and only if Bloemhof Dam is empty will water be released from Vaal Dam to support those demands. Only sufficient releases are made from Vaal Barrage and Vaal Dam for users along the Middle Vaal Reach (between Vaal Barrage and Bloemhof Dam) to satisfy their requirements and to maintain the 600mg/l TDS concentration. These releases are mostly captured in Bloemhof Dam for subsequent supply to the downstream users.

The flow in this river reach is dominated by the releases made from Bloemhof Dam for the Vaalharts irrigation Scheme. Vaalharts Weir serves as the structure from where the irrigation water is diverted into the canal that feeds the Vaalharts Irrigation Scheme. Bloemhof Dam has substantial flow regulation capability. Due to the relative long river reach downstream of Bloemhof Dam and Vaalharts Weir, significant quantities of consumptive evaporative losses and non-consumptive operating losses are associated with releases in the river system.

Vaalharts Weir is the main diversion weir on the Vaal River located downstream of Bloemhof Dam. It serves as a control structure to divert water into a canal system that feeds the Vaalharts Irrigation Scheme. Vaalharts Weir has a capacity of 49 million m^3. Approximately 419 million m^3 of water is transferred per annum to the Harts River catchment as part of the irrigation scheme.

Water is released from Vaalharts Weir for irrigation and domestic users along this river reach. Vaalharts Weir has flow regulation capability of medium size freshets. Due to the negligible incremental runoff between Bloemhof Dam and Vaalharts Weir all water that has to be released from the Weir must be released from Bloemhof Dam. Any additional water released from the Weir will have an impact on the Integrated Vaal River System's water availability.

Water quality in the Vaal River is seriously impacted upon by urban and industrial use as well as mining activities in the Upper and Middle Vaal WMAs, and is of relative high salinity. The Vaalharts irrigation scheme serves the purpose of beneficially utilising lower quality water discharged from the Upper Vaal WMA and thus prevents the build up of salinity in the lower reaches of the Lower Vaal WMA.

To meet spiralling water demands within the basin, various importation schemes have been implemented. The predominant water use in this region of the catchment is for irrigation agriculture with minor urban and industrial demands of which the water use to Kimberley is the most significant. The Vaal River also provides water to other riparian towns and to the Gamagara pipeline serving the Kalahari (Hotazel-Postmasburg) mineral complex.

The hydrology Ecospecs for site EWR 16 is given in Table 2.1

Table 2.1: Hydrology Ecospecs for site EWR 16 (PES and REC =D)

MAR (present day)	Maintenance Low Flows (% MAR)	Drought Low Flows (% MAR)	High Flows (% MAR)	MCM Excluding Floods	Long Term Mean (% MAR) Excluding Floods	MCM Including Floods	Long Term Mean (% MAR) Including Floods
1699.32	12.42	8.78	9.64	543.33	31.97	635.88	37.42

2.1.2 Water quality

This assessment was made using data from the nearest weir is C9H021Q01. The Northern Cape DWA regional office also does monthly monitoring. Data was available from the Sedibeng Water Company which does a limited selection of water quality variables on a daily basis.

Water is released from Bloemhof Dam for use in the downstream irrigation (Vaal Harts system). Winter flows and concentrations of salts only 10% higher than the summer concentrations despite the 8.7 times lower flows.

The water quality Ecospecs and TPCs for EWR 16 are given in Table 2.2 as is the recommended frequency for monitoring. Additional recommendations with respect to monitoring are given below. The PES WQ at EWR 16 is a C category (high confidence) and the REC is a C (Table 2.1). It is recommended that the REC for water quality is maintained at a D category. Special attention should be paid to monitoring nutrient levels (Soluble reactive Phosphorus), which can be improved due to more stringent discharge standards. Furthermore:

- The River Health Programme (RHP) network of sites managed by the Northern Cape DWA should be continued. On-site water quality data should be collected as per standard RHP protocol (electrical conductivity (EC), temperature, dissolved oxygen (DO), turbidity if possible and a visual assessment (RHAM, 2009) should be done.

- Nutrient monitoring should be undertaken more frequently on the Vaal River.

- Water use authorisations should be reviewed to ensure stricter phosphate standard compliance.

Table 2.2: Water Quality Ecospecs, TPCs and monitoring frequency for site EWR 16

RIVER		Vaal River	**WATER QUALITY MONITORING POINTS**			
WQSU		63	**DWAF WQ WMS**	C9H021Q01 1972 – 2008 (*n* = 2431)		
EWR SITE		EWR 16	**RHP**	Currently several monitoring sites		
Confidence in PES assessment		High				
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Inorganic salts (mg/L)	$MgSO_4$	F	The PES: F currently exceeds 45 mg/L	N/A	The PES: F currently exceeds 45 mg/L	Monthly
	Na_2SO_4	F	The PES: F currently exceeds 64 mg/L		The PES: F currently exceeds 64 mg/L	
	$MgCl_2$	A	0 – 15 mg/L		95th percentile to be <15 mg/L	
	$CaCl_2$	B	21 - 57 mg/L		95th percentile to be < 57 mg/L	
	NaCl	B	45 - 191 mg/L		95th percentile to be < 191 mg/L	
Nutrients (mg/L)	PO_4-P (SRP)	C	0.015 - 0.025mg/L		50th percentile to be < 0.025 mg/L	Monthly
	TIN	A	0 - 0.25 mg/L		50th percentile to be < 0.25 mg/L	Monthly
Physical Variables	pH	B	6.5 - 8.8	No	5th percentile to be > 6.5 and < 8.8	Monthly
	Temperature	Temperature modified as there is bottom release from the dam and heating up of the water. Good oxygen at site although close to the dam.	Maintain range	N/A	Maintain natural range	Monthly
	Dissolved oxygen		5 - 8 mg/L	N/A	5th percentile to be > 5 mg/L	Monthly
	Turbidity (NTU)	Seasonal variation but masked by dam..	Moderate change allowed	N/A	Moderate change allowed	Monthly
	Electrical conductivity (mS/m)	B	30.1 - 55 mS/m	No	95th percentile to be < 55 mS/m	Quarterly
Response variables	Chl a: periphyton	Category = D. Visual inspection indicates high algal concentrations on rocks and in pools	21 84 mg/m^2	N/A	50th percentile to be < 84 mg/ m^2	Quarterly
	Chl a: phytoplankton		20 - 30 µg/L		50th percentile to be < 30 µg/L	
	Macroinvertebrates (ASPT)	D	See Ecospecs for fish and invertebrates respectively			
	Fish community score	E				
	Instream toxicity	Once off instream toxicity results indicated no toxicity	Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown.			
Toxics	Ammonia	F - Currently extremely high concentrations present	The PES: F currently exceeds 129 ug/L	Yes to D/E	The PES: F currently exceeds 129ug/L	Monthly

2.1.3 Geomorphology

The Geomorphology Ecospecs for site EWR 16 is given in Table 2.3

Table 2.3: Geomorphology Ecospecs for site EWR 16

<table>
<tr><th colspan="2">Geomorphology PES = D/E</th></tr>
<tr><th>Ecospecs</th><th>Motivation and TPCs</th></tr>
<tr><td colspan="2">Daily Hydrology: requested flows must be provided
To ensure that the requested flows (specifically floods) are delivered to the site:
500 m3/s – at least a 1:3 year return interval</td></tr>
<tr><td colspan="2">Dry season bed material composition must be maintained

This site is below Bloemhof Dam and thus all sediment, except fines, is trapped in the dam. There are no significant tributaries between the dam and the EWR site to introduce sediments and thus ameliorate the dam’s impact. Bed material here can be expected to continue to coarsen as the smaller sediments are washed out from the reach and no replacement from upstream occurs. These impacts cannot be managed by flows; however bottom releases may present a problem by smothering available habitat with fine (silt) drapes.

The only flows set for this site are to provide occasional flushing events to remove accumulated fines. Sampling of the dry season bed material at the EWR site (using a sample size of not less than 500 points) should be undertaken at the prescribed intervals (every 5 years). At this site any fining of the bed – an increase in the percentage of fines along the bed and marginal areas in particular - would indicate a decline in the physical habitat diversity.</td></tr>
<tr><td colspan="2">Maintenance of channel form and gross morphology

Maintain the channel form and associated processes and habitats.</td></tr>
<tr><td>Cross-section scale</td><td>The site is immediately downstream of a large dam, with no significant tributaries between the dam and EWR site which could introduce sediment and thus ameliorate the sediment trapping impacts of the dam.

The banks are cut, since the clean-water releases from the dam are erosive. This trend is likely to at best stabilise, but more likely to continue in the future. Since this situation is not possible to manage with flows, it is not recommended that effort and resources be focussed in monitoring channel morphology. Therefore monitoring of the cross-section at this site is not required.</td></tr>
</table>

Geomorphology monitoring frequencies and interpretation

The monitoring frequencies and interpretation of for geomorphology are shown in Table 2.4.

Table 2.4: Geomorphology monitoring frequencies and interpretation

	Short-term monitoring (every 2nd year)	Interpretation (every 2nd year)	Long-term monitoring (every 5 to 10 years)	Interpretation (every 5 to 10 years)
HYDROLOGY	Daily hydrology: Update of the daily hydrological time series	Hydrological time series must be analysed to verify that the requested flood flows have been provided at the sites.	*Not applicable*	*Not applicable*
BED MATERIAL	*Not applicable* After any 1:10-year or greater return period flood: - re-survey cross-section - re-survey bed material distribution, and - take fixed point photographs.	*Not applicable*	Bed material composition: Resurvey the bed material (sediment in the active channel) after 5 years along the cross-section/s.	Analyse bed material distribution data and compare to previous and to TPCs provided for each site.
CHANNEL FORM	Fixed-point photography	Fixed point photography should be analysed for changes in channel geometry, islands and hydraulic habitat (comparing the condition between the monitoring intervals). Reduction in critical habitats, and generally of channel width, is undesirable. Interpret in line with the site-specific guidelines provided in tables above.	Cross-section: Re-survey of fixed cross-sections Aerial photographs: Analysis of aerial photographs or high resolution satellite imagery (if available)	Assess the re-surveyed cross-sections and aerial photographs for any significant planform changes. Interpret these in terms of short- medium- changes in hydrology and land use Assess both for signs of net aggradation (increase in the bed level) or net erosion/incision. Some EWR sites have narrowed channels, and further such reductions in available habitat are undesirable.

All information must be interpreted in terms of medium- to long-term trends and trajectories and the impact of flood(s)

2.1.4 Fish

Eight fish species would historically have occurred at the site in moderate abundance. A further 2 species *L. kimberleyensis* and *B. paludinosus* would have been expected at the site at lower abundances. *A. sclateri* may have occurred at specific sites in the vicinity where suitable habitat occurred for it at moderate abundances. Eight of the expected fish species have a high level of preference for either slow deep or slow shallow habitats suggesting that these would historically have been the predominant velocity depth classes at this site. Two fish species namely *Labeobarbus aeneus* and *Austroglanis sclateri* have a high level of preference for fast shallow habitats. *Labeobarbus kimberleyensis* has a high level of preference for fast deep habitats. Seven of the expected fish species are either moderately tolerant or tolerant of reduced flow levels. Four fish species are moderately intolerant of a lack of flow, indicating that these species would require periods of flow at some stage in their lifecycle. The expected fish assemblage show high levels of preference for a wide range of cover types. Ten of the expected fish species are either moderately tolerant or tolerant of modified water quality indicating that water quality at this site would fluctuate naturally along with seasonal flow patterns. *L. kimberleyensis* is moderately intolerant of modified water quality. Five species have a requirement for movement between reaches/ fish habitat segments. These are the species that are most likely to be impacted upon by the construction of dams and weirs that impede fish migration.

Six of the expected fish species were recorded at the site during the 2 Reserve determination surveys. The Present Ecological State (PES) of the site was rated as a E. Along with the indigenous fish species 3 exotic fish species were recorded at the site namely: *Gambusia affinis* (Mosquitofish), *Cyprinus carpio* (Carp) and *Ctenopharyngodon idella* (Grass carp).

It is recommended that the site be managed so that the current PES is improved to a D category. Table 2.5 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the PES Class and Threshold of Potential Concern (TPC).

Table 2.5: Fish Ecospecs and TPC for site EWR 16

Biota Ecospecs	**Biota TPC**
Labeobarbus aeneus - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. aeneus* - absent from the site for a single survey
Labeo capensis - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. capensis* - absent from the site for a single survey
Habitat Ecospecs	**Habitat TPC**
Maintenance of fast shallow and slow deep habitats	40% reduction in fast shallow habitats
Provision of adequate flow during the spawning season	Reduction in flow during the spawning season

Fish monitoring

Fish should be sampled by means of combined electrofishing and gillnetting. Electrofishing should be conducted for at least 60 minutes. Gillnets should be left for at least 4 hours either around sunrise or sunset. Monitoring should be conducted twice annually, once during the intermediate dry – wet season (spring) and once during the intermediate wet – dry season (autumn). If only once annually then the intermediate dry –wet season would be preferred. This would provide an indication of any spawning or recruitment events that tend to peak at that time of year.

All fish caught should be counted and identified. Depending on the size of the catch, all fish or a subsample should be measured. Length frequency sampling will provide an indication of spawning periods, longevity and the number of cohorts in the system. Indigenous species should be returned to the water as soon as possible whereas introduced species should be destroyed. All results and samples should be lodged with the appropriate national databases.

Any observations of *L. kimberleyensis* should be considered significant due to the widespread decline in the abundance of this species.

2.1.5 Macroinvertebrates

Two surveys were conducted (during October 2007 and April 2008) in order to gather information regarding the macro-invertebrate communities at the various EWR sites and to apply the MIRAI (Macro-invertebrate Response Assessment Index) in order to determine the PES (Present Ecological State) of the macro-invertebrate component of the EcoStatus.

The results obtained from RHP and DACE database, together with the data obtained during the two field surveys was interpreted using the above mentioned methods. The original SASS5 total score for the site was 73 with an ASPT of 4.29. The Recommended Ecological Category (REC) is C

The reference conditions used to derive the EcoStatus (MIRAI) were based on the Freshwater Conservation Plan. The reference total SASS5 score for the site is 140 with an ASPT of 5.6.

The PES for this site is a C/D (58.97%). The REC is a C (65%). The TPCs are set to alert managers that the PES of a C/D is in danger of not being maintained. The Ecospecs are described for the PES.

Suitable habitat (> 0.6 m/s over coarse substrate) is required to ensure that all the selected taxa can overwinter without significant detrimental impacts on the overall population. *Tricorythidae* and *Simuliidae* require velocities of > 0.6 m/s, but may persist at lower velocities (> 0.1 m/s). *Belostomatidae, Coenagrionidae* and *Atyidae* require velocities of <0.1 m/s. All three taxa occur on vegetation. The *Tricorythidae* and *Atyidae* are moderately sensitive to water quality conditions. These taxa are not expected to tolerate wide fluctuations in flow and water quality. *Physidae* and *Lymnaeidae* must be monitored so that their numbers does not increase significantly.

Although a variety of flow-dependent taxa were collected at this site there are basically 3 groups of indicator taxa (Table 2.6)

Table 2.6: The habitat preferences for the indicator taxa groups for site EWR 16

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	*Tricorythidae, Simuliidae*	>0.6	Cobbles	Moderate/Low
2	*Belostomatidae, Coenagrionidae, Atyidae*	<0.1	Vegetation	Moderate/Low
3	*Physidae, Lymnaeidae*	<0.1	Vegetation	None

Table 2.7 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the Ecospecs and Threshold of Potential Concern (TPC).

Table 2.7: Macroinvertebrate Ecospecs and TPCs for site EWR 16

HABITAT ECOSPECS	**HABITAT TPC**
To ensure that the maximum depth over the riffle area is greater than 30 cm.	The maximum depth over the riffle area is less than 32cm.
To ensure that the average depth over the riffle area is greater than 20cm.	The average depth over the riffle area is less than 22cm.
To ensure that the maximum velocity over the riffle area is greater than 0.6m/s.	The maximum velocity over the riffle area is less than 0.62m/s.
BIOTA ECOSPECS	**BIOTA TPC**
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >70; ASPT value: > 4.0.	SASS5 scores below 74 and ASPT below 4.3.
To ensure that the MIRAI score remains within the range of a C category (> 70), using the same reference data used in this study	A MIRAI score of 73 or less.
To maintain suitable flow velocity(maximum > 0.6m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the VFCS (Very fast flow over coarse sediment) biotope: • *Tricorythidae* (Abundance A) • *Simuliidae* (Abundance B)	Any one of these taxa missing or present as a single individual in any two consecutive surveys
To maintain suitable water quality, shading, temperature and habitat conditions for the following five key taxa: • *Belostomatidae* • *Tricorythidae*	Presence of less than three of the five key taxa listed in any survey.

• *Atyidae* • *Coenagrionidae* • *Simuliidae*	
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000).	Any taxon occurring in an abundance of >500 for two consecutive surveys
The REC: SASS5 scores ranging between 100 and 115, ASPT scores ranging between 5.2 and 6.0; MIRAI scores ranging between 65% and 68%.	

2.1.6 Riparian Vegetation

The Riparian Vegetation composition at EWR 16 should not differ significantly from that recorded during the study (Table 2.8).

Table 2.8: Riparian vegetation recorded at site EWR 16

Recorded species : 27	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
13 indigenous species	1	9	7	9	9	8
14 exotic species	1	5	3	7	3	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Acacia karroo			√		√	
Salix mucronata			√			
Ziziphus mucronata			√		√	
Rhus lancea			√		√	
Rhus pyroides					√	
Grewia flava					√	
Asparagus sauveolens					√	
Cynodon dactylon		√		√		√
Phragmites australis		√				
Eragrostis plana						√
Cyperus denudatus		√				
Cyperus longus		√				
Panicum coloratum		√				
Sporobulus africanus				√		√
Salix babylonica	√		√		√	
Populus X canescens			√		√	
Eucalyptus spp.			√		√	
Opuntia ficus-indica				√		√
Cirsium vulgare				√		√
Datura ferox				√		√
Xanthium strumarium		√		√		
Pennisetum clandestinum		√		√		

Recorded species : 27	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
13 indigenous species	1	9	7	9	9	8
14 exotic species	1	5	3	7	3	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Cirsium vulgare		√		√		√
Rorripa nasturtium-aquaticum		√				
Eichhornia crassipes		√				
Myriophyllum spicatum		√				
Verbena bonariensis		√				

As the Vaal River system (particularly the system falling within the Highveld Alluvial vegetation type) is highly degraded, due to the introduction of exotic species and other anthropogenic impacts, a hypothetical reference position was determined using existing historical data, as well as the data collected from all the sites within the study area. Reductions in exotic species diversity and abundance, as well as exotic species cover, were utilized in order to obtain a hypothetical reference site. Many of the decisions made in order to determine the hypothetical reference site were subjective decisions based on existing literature and field experience.

Current status: The area is currently considerably degraded due to the introduction of a number of exotic species and the removal of indigenous species for the purposes of development. The eastern bank of the river is dominated completely by ***Pennisetum clandestinum***, and the only woody trees are scattered *Acacia karoo* and *Searsia (Rhus) lancea*. The western bank is dominated by Eucalyptus spp. which due to the fact that they alter soil chemistry, have caused the denudation of large areas of the western bank. The diversity and abundance of indigenous species are very low with only 13 indigenous species recorded in the study area. Exotic species recorded amounted to 14 (over 50% of the species recorded) and dominated all three of the riparian zones within the study area and further up- and downstream. Due to removal of the indigenous vegetation and outcompeting of the indigenous vegetation by the exotic species in the area, the area can be considered as almost completely transformed.

Trajectory of change: Due to the factors mentioned above under the section “Current Status” and the fact that these factors are not currently being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Ecospecs and TPCs

Table 2.9 combines and summarises the information from previous sections, which was presented per discipline, and presents the information per river reach, each of which is represented by one EWR site.

Table 2.9: Riparian Vegetation Ecospecs and TPCs for site EWR 16

Metric Group	Metric	ECOSPECs	TCPs
Marginal zone	Vegetation abundance	Maintain marginal vegetation cover at greater than 30% Maintain cyperoid species density at 10 - 15%	Marginal vegetation cover reduced to less than 30% Cyperoid density greater than 15% or less than 10%
	Species Richness	Maintain species richness at 13 or more	Species richness drops below 13
Lower Non-marginal zone	Vegetation abundance	Maintain woody species cover at 0 - 5% Maintain *Panicum colloratum* cover at 20 - 25% Maintain exotic species species cover at 80 - 90%	woody species cover less than 5% *Panicum colloratum* cover less than 25% Terrestrial species cover greater than 90%
	Species Richness	Maintain species richness at 15 or more	Species richness drops below 15
Upper Non-marginal zone	Vegetation abundance	Maintain Indigenous Acacia species cover at 0 - 5% Maintain exotic species cover at 50 - 80%	Indigenous Acacia species cover less than 5% Exotic species cover greater than 80%
	Species Richness	Maintain species richness at 16 or more	Species richness drops below 16

Riparian Vegetation Monitoring

Monitoring should be conducted annually during the wet season (Spring to early Summer) following the national VEGRAI (Vegetation Response Assessment Index) riparian vegetation monitoring system (Kleynhans *et al.* 2006) to identify and quantify changes in the vegetation in respect of abundance and cover of the selected zones or species being monitored.

Vegetation zones should be identified along two fixed transects through the river at each of the EWR sites. The boundaries of the zones should be recorded on profiles, noting the distances between each zone margin with density counts of shrubs and trees within them done every second year.

Vertical (or as near vertical as possible) photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the EcoStatus table for each site. Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded. Sampling vegetation is best during Spring to early Summer as this makes access to and sampling of all vegetation zones better as although water levels are high, aquatic zone temporal species are still abundant (built up under low flow conditions),

temperatures are high thus plants grow and more species are in flower (this later aspect assists with their identification) under the longer day length. Geophytic species are present and flowering during this time.

Monitoring may be reduced to one survey every two to three years at this site if necessary, however, any significant, change as explained in Table 2.10, should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend.

Table 2.10: Interpretation of Riparian Vegetation results for site EWR 16

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Alien species marked with *					
Marginal Zone	Marginal vegetation cover	More than 30% of marginal zone is covered by marginal vegetation	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks. Undercutting of the banks has reduced the marginal vegetation.	Maintain the natural vegetation still occurring in the area. Prevent the spread of exotics by active management of exotic species.
Marginal Zone	Cyperoid species	Density 10 – 15%	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks.	Maintain the natural vegetation still occurring in the area. Prevent the spread of exotics by active management of exotic species.
Lower Non Marginal	Woody species cover	Moderate densities, Currently 0 – 5% cover	Increase	Due to removal of the indigenous vegetation and outcompeting of the indigenous vegetation by the exotic species in the area, the area can be considered as almost completely transformed. And the area should be managed in order to maintain the existing natural vegetation and prevent the spread of exotic species.	Maintain the natural vegetation still occurring in the area. Prevent the spread of exotics by active management of exotic species.

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Lower Non Marginal	*Panicum colloratum*	Moderate densities. Currently 0 – 10%	Decrease	Due to removal of the indigenous vegetation and outcompeting of the indigenous vegetation by the exotic species in the area, the area can be considered as almost completely transformed. And the area should be managed in order to maintain the existing natural vegetation and prevent the spread of exotic species.	Maintain the natural vegetation still occurring in the area. Prevent the spread of exotics by active management of exotic species.
Lower Non Marginal	Percentage cover of exotic species	Currently 80-90%	Increase	Due to removal of the indigenous vegetation and outcompeting of the indigenous vegetation by the exotic species in the area, the area can be considered as almost completely transformed. And the area should be managed in order to maintain the existing natural vegetation and prevent the spread of exotic species.	Maintain the natural vegetation still occurring in the area. Prevent the spread of exotics by active management of exotic species.
Upper Non-marginal	Exotic Eucalyptus spp	Currently 50 – 80%	Increase	Due to removal of the indigenous vegetation and outcompeting of the indigenous vegetation by the exotic species in the area, the area can be considered as almost completely transformed. And the area should be managed in order to maintain the existing natural vegetation and prevent the spread of exotic species.	Maintain the natural vegetation still occurring in the area. Maintain the natural vegetation still occurring in the area.
Upper Non-marginal	Indigenous *Acacia,*	Currently 0 – 5%	Decrease	Due to removal of the indigenous vegetation and outcompeting of the indigenous vegetation by the exotic species in the area, the area can be considered as almost completely transformed. And the area should be managed in order to maintain the existing natural vegetation and prevent the spread of exotic species.	Prevent the spread of exotics by active management of exotic species. Maintain the natural vegetation still occurring in the area.

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Upper Non - marginal	% indigenous grass cover	Currently 5 – 10%	Decrease	Due to removal of the indigenous vegetation and outcompeting of the indigenous vegetation by the exotic species in the area, the area can be considered as almost completely transformed. And the area should be managed in order to maintain the existing natural vegetation and prevent the spread of exotic species.	Maintain the natural vegetation still occurring in the area. Maintain the natural vegetation still occurring in the area.

2.2 EWR 17 HARTS RIVER AT LLOYDS WEIR

2.2.1 Hydrology

The Harts River system is in the C3 drainage region of South Africa. Its source is near the town of Lichtenburg in the North West Province, although the larger part of the catchment is situated in the Northern Cape Province. The Harts River flows in a south-westerly direction via Barberspan, the Taung and Spitskop dams, after which it flows into the Vaal River near Delportshoop. The major water uses in the Harts River catchment are domestic and agriculture. Agriculture consists of irrigation and stock watering. Irrigation is the biggest water user with the majority of the irrigation located in the Vaalharts Irrigation Scheme. There is also irrigation located along the reach of the Harts River below Spitskop Dam**.** The only lake and wetlands of note are at Barberspan in the upper Harts River catchment, which has been given Ramsar status as a wildlife conservation area.

The Harts River reach upstream of Wentzel Dam has no upstream regulating storage and there are substantial irrigation abstractions that are already experiencing low assurance of supply. Water is also transferred from the Harts River (approximately from the outlet of C31B) into Barberspan (located in quaternary C31D). This transfer will result in some of the base flow being removed from the river reach. The exact operation of this transfer is unknown (capacity of the transfer infrastructure etc.) at this point in time and is currently been investigated.

Wentzel Dam is located at the outlet of quaternary C31E, and has limited release capability. The dam supplies water to the town of Schweizer-Reneke for domestic purposes. The available yield of Wentzel Dam is fully utilised and any further releases will result in a deficit in supply.

Water from Taung Dam is not utilised and investigations are currently underway to determine the feasibility of using the dam to supply domestic and/or irrigation water requirements from the dam. Taung Dam will have limited release capability (remedial civil works are being carried out on the release structures).

Significant flows occur in the Harts River reach upstream of Spitskop Dam from the return flows of the Vaalharts Irrigation Scheme. The return flows have substantially changed the flow regime compared to natural conditions. This river reach receives flows from the Dry Harts River (upstream of and including quaternary C32D), which has no regulating storage structure as well as from Taung Dam located in quaternary C31F.

The water available in Spitskop Dam is more than the water requirements supplied from the dam. This is due to the large volume of return flows generated by the Vaalharts Irrigation Scheme located upstream of the dam. Water is released from Spitskop Dam from where it is abstracted for irrigation along the downstream river reach. Spitskop Dam has the capability to regulate flow releases in this river reach. Investigations are in progress to identify potential further use of the excess water available in the dam.

An appropriate balance exists for the Harts River catchment as only enough water is transferred from the Vaal River into the area to meet the water requirements, while return flows from the catchment are available for use along the lower Vaal River.

According to the River Health Programme (2003), the overall water quality status of the lower Harts River is in a fair to poor condition while the upper region remains in a good to fair condition. The water quality and flows of the lower section of the Harts River between Taung Dam and Spitskop Dam is impacted by return flows from the Vaalharts Irrigation Scheme. The water is of exceptional high salinity as a result of saline leachate from the irrigation fields (± 1 100 mg/l salinity). The salinity and nutrient loads associated with the return flows has resulted in increased concentrations in the lower reaches of the Harts River and in Spitskop Dam. The quality of the water discharging from the Harts River into the Vaal River has been cited as a contributing factor to the blue-green algal blooms that sporadically occur in the lower reaches of the Orange River below the confluence with the Vaal River. Management of water quality (salinity) at the Vaalharts irrigation scheme and downstream of Spitskop Dam thus remains of primary importance.

Include the mining activities – although not a huge water user, they do have an impact on the Harts River upstream of Taung Dam.

The hydrology Ecospecs for site EWR 17 is given in Table 2.11

Table 2.11: Hydrology Ecospecs for site EWR 17 (PES and REC=D/E)

MAR (present day)	Maintenance Low Flows (% MAR)	Drought Low Flows (% MAR)	High Flows (% MAR)	MCM Excluding Floods	Long Term Mean (% MAR) Excluding Floods	MCM Including Floods	Long Term Mean (% MAR) Including Floods
124.72	56.71	0.02	13.07	32.02	21.54	38.698	26.02

2.2.2 Water quality

This assessment was made using data from the nearest weir is C3H016Q01. The Northern Cape DWA regional office also does monthly monitoring. Data was available from the Sedibeng Water Company which does a limited selection of water quality variables on a daily basis.

The maximum discharge capability of the outlet works of Spitskop Dam is dependent on the storage level within the dam. Releases for the irrigation water use downstream of Spitskop Dam are also made through the outlet works, irrigation water use results showed that supply failures occurred even though there was sufficient water available in the dam to meet the full irrigation water requirements. High salts concentrations (EC and SO_4) return from agriculture and diamond mining impacts. There are irrigation drainage channel which collects and discharges into the river. Low to moderate nutrients (moderate to high ammonia from degrading algal matter) as well as eutrophication (there are three dams upstream of the system) is present.

The water quality Ecospecs and TPCs for EWR 17 are given in Table 2.12 as is the recommended frequency for monitoring. Additional recommendations with respect to monitoring are given below. The PES WQ at EWR 17 is a D category (high confidence) and the REC is a D (Table 2.11). It is recommended that the REC for water quality is maintained at a D category. Special attention should be

paid to monitoring nutrient levels (Soluble reactive Phosphorus), which can be improved due to more stringent discharge standards. Furthermore:

- The River Health Programme (RHP) network of sites managed by the Northern Cape DWA should be continued. On-site water quality data should be collected as per standard RHP protocol (electrical conductivity (EC), temperature, dissolved oxygen (DO), turbidity if possible and a visual assessment (RHAM, 2009) should be done.

- Nutrient monitoring should be undertaken more frequently on the Harts River and main stem of the Vaal River.

- Water use authorisations should be reviewed to ensure stricter phosphate standard compliance.

Table 2.12: Water Quality Ecospecs, TPCs and monitoring frequency for site EWR 17

RIVER		Harts River	**WATER QUALITY MONITORING POINTS**			
WQSU		67	**DWAF WQ WMS**	C3H016Q01 1992 – 2008 (*n* = 268)		
EWR SITE		EWR 6	**RHP**	Currently several monitoring sites		
Confidence in PES assessment		High				
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Inorganic salts (mg/L)	$MgSO_4$	F	The PES: F currently exceeds 45 mg/L	Yes to D	The PES: F currently exceeds 45 mg/L	Monthly
	Na_2SO_4	F	The PES: F currently exceeds 64 mg/L		The PES: F currently exceeds 64 mg/L	
	$MgCl_2$	C	36 - 51 mg/L		95^{th} percentile to be < 51 mg/L	
	$CaCl_2$	F	The PES: F currently exceeds 141 mg/L		The PES: F currently exceeds 141 mg/L	
	NaCl	D	243 - 389 mg/L		95^{th} percentile to be < 389 mg/L	
Nutrients (mg/L)	PO_4-P (SRP)	C	0.015 - 0.025mg/L	Yes to D	50^{th} percentile to be < 0.025 mg/L	Monthly
	TIN	A	0 - 0.25 mg/L		50^{th} percentile to be < 0.25 mg/L	Monthly
Physical Variables	pH	B	6.5 - 8.8	No	95^{th} percentile to be >6.5 and <8.8	Monthly
	Temperature	Natural variation	Maintain range	N/A	Maintain natural range	Monthly
	Dissolved oxygen		6 - 8 mg/L	N/A	5^{th} percentile to be > 6.0 mg/L	Monthly
	Turbidity (NTU)	Seasonal but masked by upstream dams	Moderate change allowed	N/A	Moderate change allowed	Monthly
	Electrical conductivity (mS/m)	D	The PES: F currently exceeds 85 mS/m	Yes to C	The PES: F currently exceeds 85 mS/m	Quarterly
Response variables	Chl a: periphyton	Visual observation in both seasons indicated dense macrophytic growth from bank to bank	21 - 84 mg/m^2	N/A	50^{th} percentile to be < 84 mg/ m^2	Quarterly
	Chl a: phytoplankton		20 - 30 µg/L		50^{th} percentile to be < 30 µg/L	
	Macroinvertebrates (ASPT)	D	See Ecospecs for fish and invertebrates respectively			
	Fish community score	D				
	Instream toxicity	Once off instream toxicity results indicated no toxicity	Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown.			
Toxics	Ammonia	F - Currently high concentrations present	The PES: F currently exceeds 129 ug/L	Yes to D	The PES: F currently exceeds 129 ug/L	Monthly

2.2.3 Geomorphology

The Geomorphology Ecospecs for site EWR 17 is given in Table 2.13

Table 2.13: Geomorphology Ecospecs for site EWR 17

<table>
<tr><th colspan="2">Geomorphology PES = D</th></tr>
<tr><th>Ecospecs</th><th>Motivation and TPCs</th></tr>
<tr><td colspan="2">Daily Hydrology: requested flows must be provided

To ensure that the requested flows (specifically floods) are delivered to the site:

2 m3/s – at least 3 events per year

10 m3/s – at least 2 events per year</td></tr>
<tr><td colspan="2">Dry season bed material composition must be maintained

The channel is incised, with extensive cut banks and marginal vegetation almost absent. This is likely due to the effects of cattle trampling, constant baseflows and the dispersive nature of the soils at the site. The area has also been impacted by disturbance (small scale sand mining or alluvial diamond mining). Large cobbles are embedded within fine sands. The flows set for this site are to flush fines and maintain the movement of sand through the reach. The cobbles do not form part of the current active load of the river system and no flows have been set to manage these as it is more likely that these are derived locally (or from eroded gabions upstream).

To ensure that the bed composition and thus physical habitat diversity is maintained, sampling of the dry season bed material at the EWR site (using a sample size of not less than 500 points) should be undertaken at the prescribed intervals (every 5 years) to assess impacts of flow on the bed sediment and therefore as an indication of the change of available habitat for instream biota. At this site any fining of the bed – represented by a decrease in the percentage of the exposed cobble component due to smothering by sands - would indicate insufficient flows being delivered to the site to maintain the geomorphological condition.</td></tr>
<tr><td colspan="2">Maintenance of channel form and gross morphology

Maintain the channel form and associated processes and habitats.</td></tr>
<tr><td>Cross-section scale</td><td>The sand-dominated nature of the sediment could lead to bed aggradation if insufficient flows are provided for the reach. Aggradation of the bed (an increase in the level of the bed of the active channel) would represent an undesirable change for geomorphology as this would reduce in-channel habitat diversity.</td></tr>
</table>

Geomorphology monitoring frequencies and interpretation

The monitoring frequencies and interpretation of for geomorphology are shown in Table 2.14.

Table 2.14: Geomorphology monitoring frequencies and interpretation

	Short-term monitoring (every 2nd year)	Interpretation (every 2nd year)	Long-term monitoring (every 5 to 10 years)	Interpretation (every 5 to 10 years)
HYDROLOGY	Daily hydrology: Update of the daily hydrological time series	Hydrological time series must be analysed to verify that the requested flood flows have been provided at the sites.	*not applicable*	*not applicable*
BED MATERIAL	*not applicable* After any 1:10-year or greater return period flood: - re-survey cross-section - re-survey bed material distribution, and - take fixed point photographs.	*not applicable*	Bed material composition: Resurvey the bed material (sediment in the active channel) after 5 years along the cross-section/s.	Analyse bed material distribution data and compare to previous and to TPCs provided for each site.
CHANNEL FORM	Fixed-point photography	Fixed point photography should be analysed for changes in channel geometry, islands and hydraulic habitat (comparing the condition between the monitoring intervals). Reduction in critical habitats, and generally of channel width, is undesirable. Interpret in line with the site-specific guidelines provided in tables above.	Cross-section: Re-survey of fixed cross-sections Aerial photographs: Analysis of aerial photographs or high resolution satellite imagery (if available)	Assess the re-surveyed cross-sections and aerial photographs for any significant planform changes. Interpret these in terms of short- medium- changes in hydrology and land use Assess both for signs of net aggradation (increase in the bed level) or net erosion/incision. Some EWR sites have narrowed channels, and further such reductions in available habitat are undesirable.

All information must be interpreted in terms of medium- to long-term trends and trajectories and the impact of flood(s)

2.2.4 Fish

Eight fish species would historically have occurred at the site in low to moderate abundance. A further 3 indigenous fish namely *Barbus paludinosus, Labeobarbus kimberleyensis* and *Austroglanis sclateri* may sporadically have been present at the site in low to moderate abundances. Eight of the expected fish species have a high level of preference for either slow deep or slow shallow habitats suggesting that these would historically have been the predominant velocity depth classes at this site. Two fish species namely *Labeobarbus aeneus* and *Austroglanis sclateri* have a high level of preference for fast shallow habitats. *Labeobarbus kimberleyensis* has a high level of preference for fast deep habitats. Seven of the expected fish species are either moderately tolerant or tolerant of reduced flow levels. Four fish species are moderately intolerant of a lack of flow, indicating that these species would require periods of flow at some stage in their lifecycle. The expected fish assemblage show high levels of preference for a wide range of cover types. Ten of the expected fish species are either moderately tolerant or tolerant of modified water quality indicating that water quality at this site would fluctuate naturally along with seasonal flow patterns. *L. kimberleyensis* is moderately intolerant of modified water quality. Five species have a requirement for movement between reaches/ fish habitat segments. These are the species that are most likely to be impacted upon by the construction of dams and weirs that impede fish migration.

Eight of the expected fish species were recorded at the site during the 2 Reserve determination surveys. The PES of the site was rated as a D. Along with the indigenous fish species 1 exotic fish species was recorded at the site namely: *Gambusia affinis* (Mosquitofish).

It is recommended that the site be managed so that the current PES is maintained and doesn't decrease. Table 2.15 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the PES Class and Threshold of Potential Concern (TPC).

Table 2.15: Fish Ecospecs and TPC for site EWR 17

Biota Ecospecs	**Biota TPC**
Labeobarbus aeneus - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. aeneus* - absent from the site for a single survey
Labeo capensis - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. capensis* - absent from the site for a single survey
Habitat Ecospecs	**Habitat TPC**
Maintenance of fast shallow and slow deep habitats	40% reduction in fast shallow habitats
Provision of adequate flow during the spawning season	Reduction in flow during the spawning season

Fish monitoring

Fish should be sampled by means of combined electrofishing and gillnetting. Electrofishing should be conducted for at least 30 minutes. Gillnets should be left for at least 4hours either around sunrise or sunset. Monitoring should be conducted twice annually, once during the intermediate dry – wet season (spring) and once during the intermediate wet – dry season (autumn). If only once annually then the intermediate dry –wet season would be preferred. This would provide an indication of any spawning or recruitment events that tend to peak at that time of year.

All fish caught should be counted and identified. Depending on the size of the catch, all fish or a subsample should be measured. Length frequency sampling will provide an indication of spawning periods, longevity and the number of cohorts in the system. Indigenous species should be returned to the water as soon as possible whereas introduced species should be destroyed. All results and samples should be lodged with the appropriate national databases.

Any observations of *L. kimberleyensis* should be considered significant due to the widespread decline in the abundance of this species.

2.2.5 Macroinvertebrates

Two surveys were conducted (during October 2007 and April 2008) in order to gather information regarding the macro-invertebrate communities at the various EWR sites and to apply the MIRAI (Macro-invertebrate Response Assessment Index) in order to determine the PES (Present Ecological State) of the macro-invertebrate component of the EcoStatus.

The results obtained from RHP and DACE database, together with the data obtained during the two field surveys was interpreted using the above mentioned methods. The original SASS5 total score for the site was 91 with an ASPT of 4.33 with a Recommended Ecological Category (REC) of a B/C.

The reference conditions used to derive the EcoStatus (MIRAI) were based on the Freshwater Conservation Plan. The reference total SASS5 score for the site is 125 with an ASPT of 5.6.

The PES for this site is a C/D (58.75%). The REC is a C (65%). The TPCs are set to alert managers that the PES of a C/D is in danger of not being maintained. The Ecospecs are described for the PES.

Suitable habitat (> 0.6 m/s over coarse substrate) is required to ensure that all the selected taxa can overwinter without significant detrimental impacts on the overall population. *Tricorythidae* and *Simuliidae* require velocities of > 0.6 m/s, but may persist at lower velocities (> 0.1 m/s). *Belostomatidae, Coenagrionidae* and *Atyidae* require velocities of <0.1 m/s. All three taxa occur on vegetation. The *Tricorythidae* and *Atyidae* are moderately sensitive to water quality conditions. These taxa are not expected to tolerate wide fluctuations in flow and water quality. *Physidae* and *Lymnaeidae* must be monitored so that their numbers does not increase significantly.

Although a variety of flow-dependent taxa were collected at this site there are basically 3 groups of indicator taxa (Table 2.16).

Table 2.16: The habitat preferences for the indicator taxa groups for site EWR 17

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	*Tricorythidae, Simuliidae*	>0.6	Cobbles	Moderate/Low
2	*Belostomatidae, Coenagrionidae, Atyidae*	<0.1	Vegetation	Moderate/Low
3	*Physidae, Lymnaeidae*	<0.1	Vegetation	None

Table 2.17 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the Ecospecs and Threshold of Potential Concern (TPC).

Table 2.17: Macroinvertebrate Ecospecs and TPCs for site EWR 17

HABITAT ECOSPECS	**HABITAT TPC**
To ensure that the maximum depth over the riffle area is greater than 20 cm.	The maximum depth over the riffle area is less than 22cm.
To ensure that the average depth over the riffle area is greater than 10cm.	The average depth over the riffle area is less than 12cm.
To ensure that the maximum velocity over the riffle area is greater than 0.6m/s.	The maximum velocity over the riffle area is less than 0.62m/s.
BIOTA ECOSPECS	**BIOTA TPC**
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >90; ASPT value: > 4.0.	SASS5 scores below 94 and ASPT below 4.4.
To ensure that the MIRAI score remains within the range of a C/D category (> 55), using the same reference data used in this study	A MIRAI score of 58 or less.
To maintain suitable flow velocity(maximum > 0.6m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the VFCS (Very fast flow over coarse sediment) biotope: • *Tricorythidae* (Abundance A) • *Simuliidae* (Abundance B)	Any one of these taxa missing or present as a single individual in any two consecutive surveys
To maintain suitable water quality, shading, temperature and habitat conditions for the following five key taxa: • *Belostomatidae* • *Tricorythidae*	Presence of less than three of the five key taxa listed in any survey.

• *Atyidae* • *Coenagrionidae* • *Simuliidae*	
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000).	Any taxon occurring in an abundance of >500 for two consecutive surveys
The REC: SASS5 scores ranging between 110 and 118, ASPT scores ranging between 5.2 and 6.0; MIRAI scores ranging between 65% and 68.	

2.2.6 Riparian Vegetation

The Riparian Vegetation composition at EWR 17 should not differ significantly from that recorded during the study (Table 2.18).

Table 2.18: Riparian vegetation recorded at site EWR 17

Recorded species : 39	**Marginal**		**Lower**		**Upper**	
39 indigenous species	**W**	**NW**	**W**	**NW**	**W**	**NW**
24 exotic species	1	9	7	9	9	8
	1	5	3	7	3	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Acacia karroo			√		√	
Salix mucronata					√	
Diospyros lycoides			√		√	
Melianthus comosus			√		√	
Rhus pyroides			√		√	
Asparagus setaceus			√		√	
Asparagus sauveolens			√		√	
Clematis brachiata			√		√	
Lycium arenicola			√		√	
Rubia cordifolia			√		√	
Phragmites australis		√		√		√
Melica decumbens		√		√		√
Cineraria dregeana		√		√		√
Cineraria lobata		√		√		√
Gleditsia triacanthos		√		√		√
Morus alba			√		√	
Eucalyptus spp.			√		√	
Salix babylonica			√		√	
Populus X canescens			√		√	
Melia azedarach			√		√	
Ricinus communis			√		√	
Cestrum laevigatum		√		√		√

Cestrum parqui		√		√		√
Opuntia ficus-indica				√		√
Arundo donax				√		√
Pennisetum clandestinum		√		√		√
Cirsium vulgare		√		√		√
Datura ferox		√		√		√
Datura stramonium		√		√		√
Xanthium strumarium		√		√		√
Xanthium spinosum		√		√		√
Arundo donax		√		√		√
Pennisetum clandestinum		√		√		√
Cirsium vulgare		√		√		√
Rorripa nasturtium-aquaticum		√		√		√
Azolla filiculoides		√		√		√
Eichhornia crassipes		√		√		√
Myriophyllum aquaticum		√		√		√
Myriophyllum spicatum		√		√		√

Current status: The area is currently considerably degraded due to the construction and mining activities that have disturbed much of the riparian vegetation and the introduction of a number of exotic species. The exotic species in the area contribute to a significant number of the total number of species identified during the surveys as well as a considerable percentage approximately 30% of the abundance recorded during the survey. The most significant reason for the low PES at this site is due to the degradation of the site as well as the invasion of the site by exotic species.

Trajectory of change: Due to the factors mentioned above under the section “Current Status” and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Reasons for PES

This was the first site in the study that did not fall within the Highveld Alluvial vegetation type and, in fact falls within the Upper Gariep Alluvial vegetation type. This vegetation type appears to be less impacted by the invasion of exotic species than the Highveld Alluvial vegetation type, possibly due to less agriculture in the surrounding areas due to a lower rainfall. Exotic species occur especially in areas where disturbance has taken place as is the case with this site. The area has been impacted by construction of bridges and other infrastructure as well as some mining activities. In these areas along the banks of the river the disturbed riparian vegetation has been invaded by some exotic species and pioneer grasses. Reductions in exotic species diversity and abundance, as well as exotic species cover, were utilised in order to obtain a hypothetical reference site. Many of the decisions made in order to determine the hypothetical reference site were subjective decisions based on existing literature and field experience. The area is currently considerably degraded due to the construction and mining activities that have disturbed much of the riparian vegetation and the introduction of a number of exotic species.

The exotic species in the area contribute to a significant number of the total number of species identified during the surveys as well as a considerable percentage approximately 30% of the

abundance recorded during the survey. The most significant reason for the low PES at this site is due to the degradation of the site as well as the invasion of the site by exotic species. Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Ecospecs and TPCs

Table 2.19 combines and summarises the information from previous sections, which was presented per discipline, and presents the information per river reach, each of which is represented by one EWR site.

Table 2.19: Riparian Vegetation Ecospecs and TPCs for site EWR 17

Metric Group	Metric	ECOSPECs	TCPs
Marginal zone	Vegetation abundance	• Maintain marginal vegetation cover at greater than 60% • Maintain Cyperoid species density at 30 - 35% • Maintain *Phragmites australis* cover at 50%	• Marginal vegetation cover reduced to less than 60% • Cyperoid density greater than 35% or less than 30% • *Arundo donax* cover greater than 50%
	Species Richness	Maintain species richness at 9 or more	Species richness drops below 9
Lower Non-marginal zone	Vegetation abundance	• Maintain woody species cover at 20 - 30% • Maintain *Cenchrus cilliarus* cover at 20 - 25% • Maintain terrestrial species cover at 40 - 45%	• woody species cover greater than 30% or less than 20% • *Cenchrus cilliarus* cover greater than 75% or less than 50% • Terrestrial species cover greater than 45%
	Species Richness	Maintain species richness at 14 or more	• Species richness drops below 14
Upper Non-marginal zone	Vegetation abundance	• Maintain Indigenous Acacia species cover at 20 - 45% • Maintain indigenous grass cover at 50 - 60%	• Indigenous Acacia species cover less than 30% • Indigenous grass cover less than 50%
	Species Richness	• Maintain species richness at 18 or more • Maintain terrestrial species at 50 - 55% or less	• Species richness drops below 18 • Terrestrial species increase above 55%
	Vegetation Structure	Maintain woody cover between 40 and 45 %	Woody cover greater than 60%

Riparian Vegetation Monitoring

Monitoring should be conducted annually during the wet season (Spring to early Summer) following the national VEGRAI (Vegetation Response Assessment Index) riparian vegetation monitoring system (Kleynhans et al. 2006) to identify and quantify changes in the vegetation in respect of abundance and cover of the selected zones or species being monitored.

Vegetation zones should be identified along two fixed transects through the river at each of the EWR sites. The boundaries of the zones should be recorded on profiles, noting the distances between each zone margin with density counts of shrubs and trees within them done every second year.

Vertical (or as near vertical as possible) photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the Ecostatus table for each site.

Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded. Sampling vegetation is best during Spring to early Summer as this makes access to and sampling of all vegetation zones better as although water levels are high, aquatic zone temporal species are still abundant (built up under low flow conditions), temperatures are high thus plants grow and more species are in flower (this later aspect assists with their identification) under the longer day length. Geophytic species are present and flowering during this time.

Monitoring may be reduced to one survey every two to three years at this site if necessary, however, any significant, change as explained in Table 2.21, should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend.

Table 2.20: Interpretation of Riparian Vegetation results for site EWR 17

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Alien species marked with *					
Marginal Zone	Marginal vegetation cover	More than 60% of marginal zone is covered by marginal vegetation	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks. Undercutting of the banks has reduced the marginal vegetation.	Increase density by introducing variability in flow. Introduce lower flows during dry months
Marginal Zone	Cyperoid species	Density 30 – 35%	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks.	Increase density by introducing variability in flow. Introduce lower flows during dry months.
Marginal Zone	*Phragmites australis*	Lining parts of river and stream floodplains, Currently 50% cover at the site but may encroach on the site area.	Increase	Reduction of indigenous species and denudation of the banks leads to areas that can be colonised by *Arundo donax*. Canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks, *Arundo donax* is able to colonise these areas better than the indigenous species leading to the increase in cover of this species.	Decrease density by introducing variability in flow. Introduce lower flows during dry months. Physical removal

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Lower Non Marginal	Woody species cover	Low densities, Currently 20 – 30% cover	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones. Many of the terrestrial species in this area are woody species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	*Cenchrus ciliaris*	Moderate densities. Currently 20 – 25%	Decrease	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	Percentage cover of Terrestrial species	High densities Currently 40-45%	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Increase flow rate and moderate flood events
Upper Non-marginal	Indigenous *Acacia,*	Currently 30 – 45%	Decrease	An increase in exotic tree species will cause a decrease in percentage of indigenous species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Upper Non - marginal	% indigenous grass cover	Currently 50 – 60%	Decrease	Increase in exotic trees cause a reduction of indigenous grass species due to increased crown cover.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.

2.3 EWR 18 VAAL RIVER SCHMIDTSDRIFT

2.3.1 Hydrology

In this part of the catchment the quality of surface water in the Vaal River is highly impacted upon by irrigation return flows of the Vaalharts Irrigation Scheme as well as by water use in the Upper and Middle Vaal WMAs, which limits the usability of water in the lower reaches of the river. Water quality in the lower reaches of the Vaal River is also impacted upon by irrigation return flows from the Riet/Modder River necessitating further blending with low salinity water from the Orange River at the Douglas weir.

Douglas Weir falls just outside the Lower Vaal WMA, immediately upstream of the Vaal River confluence with the Orange River. This is the most downstream section of the Vaal River before the confluence with the Orange River. Douglas Weir has limited flow-regulating capability. Currently the river reach below the weir has no flow for most of the time, except during floods and is operated to minimise flow in the reach. The river reach length is only 1 km.

Water (18 million m^3/a) is also transferred into the water management area at Douglas Weir, from the upper Orange WMA (at Marksdrift) for water quality management purposes. The Douglas Irrigation Scheme is supplied from the Douglas Weir and, in addition to the runoff entering Douglas Weir from the upstream incremental catchments, water is transferred (pumped) from the Orange River into Douglas Weir. No releases are made from storage structures in the Vaal, Harts or Riet/Modder river systems to support the water requirements in Douglas Weir.

Since the inception of the Douglas irrigation scheme water quality in the Lower Vaal River has deteriorated dramatically. The layout of the scheme as well as the position where the water transferred from the Orange River is discharged upstream of the weir, are poorly suited for water quality management purposes and the continued feasibility of the scheme is unclear. Without excess releases from Bloemhof Dam the scheme would not be sustainable. Douglas weir is operated such that no water apart from spills flows into the Orange River.

The hydrology Ecospecs for site EWR 18 is given in Table 2.21

Table 2.21: Hydrology Ecospecs for site EWR 18 (PES and REC=C)

MAR (present day)	Maintenance Low Flows (% MAR)	Drought Low Flows (% MAR)	High Flows (% MAR)	MCM Excluding Floods	Long Term Mean (% MAR) Excluding Floods	MCM Including Floods	Long Term Mean (% MAR) Including Floods
1177.28	2.84	1.51	4.85	82.35	2.59	198.80	6.07

2.3.2 Water quality

This assessment was made using data from the nearest weir is C9H024Q01. The Northern Cape DWA regional office also does monthly monitoring. Data was available from the Sedibeng Water Company which does a limited selection of water quality variables on a daily basis.

Water is released from Bloemhof Dam for use in the downstream irrigation (Vaal Harts system). High salts concentrations (EC and SO_4) return from agriculture and diamond mining impacts mainly in the Harts River released from the Spitskop Dam. There are irrigation drainage channel which collects and discharges into the river. Low to moderate nutrients (moderate to high ammonia from degrading algal matter). Eutrophication (there are three dams upstream of the system) as well as the intensive irrigated Vaal Hartz irrigation system. Winter flows and concentrations of salts similar for the scenarios and higher concentrations than those of the summer.

Winter salt concentrations are only 9 % higher than the summer concentrations despite the 30 times lower flows. Extra water is released from the Vaal Dam in winter and this is used for the dilution of salts in the middle and lower Vaal. Slightly increased winter flow results in increased winter turbidity. There is a settling of salts in Bloemhof Dam as well as Spitskop Dam in the Harts River.

The water quality Ecospecs and TPCs for EWR 18 are given in Table 2.22 as is the recommended frequency for monitoring. Additional recommendations with respect to monitoring are given below. The PES WQ at EWR 18 is a C category (high confidence) and the REC is a C (Table 2.21). It is recommended that the REC for water quality is maintained at a C category. Special attention should be paid to monitoring nutrient levels (Soluble reactive Phosphorus), which can be improved due to more stringent discharge standards. Furthermore:

- The River Health Programme (RHP) network of sites managed by the Northern Cape DWA should be continued. On-site water quality data should be collected as per standard RHP protocol (electrical conductivity (EC), temperature, dissolved oxygen (DO), turbidity if possible and a visual assessment (RHAM, 2009) should be done.

- Nutrient monitoring should be undertaken more frequently on the Harts River and main stem of the Vaal River.

- Water use authorisations should be reviewed to ensure stricter phosphate standard compliance.

Table 2.22: Water Quality Ecospecs, TPCs and sampling frequency for EWR 18

RIVER		Vaal River	**WATER QUALITY MONITORING POINTS**			
WQSU		68	**DWAF WQ WMS**	C9H024Q01 1995 – 2008 (*n* = 163)		
EWR SITE		EWR 7	**RHP**	Currently several monitoring sites		
Confidence in PES assessment		High				
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Inorganic salts (mg/L)	$MgSO_4$	F	The PES: F currently exceeds 45 mg/L	N/A	The PES: F currently exceeds 45 mg/L	Monthly
	Na_2SO_4	F	The PES: F currently exceeds 64 mg/L		The PES: F currently exceeds 64 mg/L	
	$MgCl_2$	B	15 - 30 mg/L		95^{th} percentile to be < 30 mg/L	
	$CaCl_2$	C	69 - 105 mg/L		95^{th} percentile to be < 105 mg/L	
	NaCl	B	45 - 191 mg/L		95^{th} percentile to be < 191 mg/L	
Nutrients (mg/L)	PO_4-P (SRP)	B	0.005 – 0.015 mg/L	Yes to C	50^{th} percentile to be < 0.015 mg/L	Monthly
	TIN	A	0.25 – 0.7 mg/L	No	50^{th} percentile to be < 0.7 mg/L	Monthly
Physical Variables	pH	B	6.5 - 8.8	No	95^{th} percentile to be >6.5 and <8.8	Monthly
	Temperature	Natural variation but also impacted by upstream dams	Maintain range	N/A	Maintain natural range	Monthly
	Dissolved oxygen		4 - 6 mg/L	N/A	5^{th} percentile to be > 4 mg/L	Monthly
	Turbidity (NTU)	Seasonal variation	Moderate change allowed	N/A	Moderate change allowed	Monthly
	Electrical conductivity (mS/m)	C	55.1 - 85 mS/m	No	95^{th} percentile to be < 85 mS/m	Quarterly
Response variables	Chl a: periphyton	Visual observation in both seasons indicated dense macrophytic growth from bank to bank	21 - 84 mg/m^2	N/A	50^{th} percentile to be < 84 mg/ m^2	Quarterly
	Chl a: phytoplankton		20 - 30 µg/L		50^{th} percentile to be < 30 µg/L	
	Macroinvertebrates (ASPT)	C/D	See Ecospecs for fish and invertebrates respectively			
	Fish community score	C				
	Instream toxicity	Once off instream toxicity results indicated no toxicity	Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown.			
Toxics	Ammonia	B/C	15 – 72.5 ug/L	No	95^{th} percentile to be <72.5 ug/L	Monthly

2.3.3 Geomorphology

The Geomorphology Ecospecs for site EWR 18 is given in Table 2.23

Table 2.23: Geomorphology Ecospecs for site EWR 18

Geomorphology PES = C/D	
Ecospecs	**Motivation and TPCs**
Daily Hydrology: requested flows must be provided To ensure that the requested flows (specifically floods) are delivered to the site: 120 m3/s – at least a 1:1 year return interval 560 m3/s – at least a 1:2 year return interval	
Dry season bed material composition must be maintained The flows set for this site are to provide flushing events to remove accumulated fines from the bed of the river. Fining of the bed would indicate insufficient flows being delivered to the site to maintain the geomorphological condition. To ensure that the bed composition and thus physical habitat diversity is maintained, sampling of the dry season bed material at the EWR site (using a sample size of not less than 500 points) should be undertaken at the prescribed intervals (every 5 years) to assess impacts of flow on the bed sediment and therefore as an indication of the change of available habitat for instream biota. At this site any fining of the bed – represented by an increase in the percentage of fine sand - would indicate insufficient flows being delivered to the site to maintain the geomorphological condition.	
Maintenance of channel form and gross morphology Maintain the channel form and associated processes and habitats.	
Cross-section scale	This site has extensive cut banks, suggestion that the river is incising. There must be no further incision of the mainstem channel since this reduces the effectiveness of high flows and floods for maintaining the bed and banks. Incision of the channel can be monitored through resurveyed cross-sections. TPC: -Any deepening or widening of the active channel

Geomorphology monitoring frequencies and interpretation

The monitoring frequencies and interpretation of for geomorphology are shown in Table 2.24.

Table 2.24: Geomorphology monitoring frequencies and interpretation

	Short-term monitoring (every 2nd year)	Interpretation (every 2nd year)	Long-term monitoring (every 5 to 10 years)	Interpretation (every 5 to 10 years)
HYDROLOGY	Daily hydrology: Update of the daily hydrological time series	Hydrological time series must be analysed to verify that the requested flood flows have been provided at the sites.	*Not applicable*	*Not applicable*
BED MATERIAL	*Not applicable* After any 1:10-year or greater return period flood: - re-survey cross-section - re-survey bed material distribution, and - take fixed point photographs.	*Not applicable*	Bed material composition: Resurvey the bed material (sediment in the active channel) after 5 years along the cross-section/s.	Analyse bed material distribution data and compare to previous and to TPCs provided for each site.
CHANNEL FORM	Fixed-point photography	Fixed point photography should be analysed for changes in channel geometry, islands and hydraulic habitat (comparing the condition between the monitoring intervals). Reduction in critical habitats, and generally of channel width, is undesirable. Interpret in line with the site-specific guidelines provided in tables above.	Cross-section: Re-survey of fixed cross-sections Aerial photographs: Analysis of aerial photographs or high resolution satellite imagery (if available)	Assess the re-surveyed cross-sections and aerial photographs for any significant planform changes. Interpret these in terms of short- medium- changes in hydrology and land use Assess both for signs of net aggradation (increase in the bed level) or net erosion/incision. Some EWR sites have narrowed channels, and further such reductions in available habitat are undesirable.

All information must be interpreted in terms of medium- to long-term trends and trajectories and the impact of flood(s)

2.3.4 Fish

Eight fish species would historically have occurred at the site in moderate abundance. *Barbus paludinosus* and *Labeobarbus kimberleyensis* would have occurred at the site in low abundances. *Austroglanis sclateri* may sporadically have been present at the site in moderate abundance. Eight of the expected fish species have a high level of preference for either slow deep or slow shallow habitats suggesting that these would historically have been the predominant velocity depth classes at this site. Two fish species namely *Labeobarbus aeneus* and *Austroglanis sclateri* have a high level of preference for fast shallow habitats. *Labeobarbus kimberleyensis* has a high level of preference for fast deep habitats. Seven of the expected fish species are either moderately tolerant or tolerant of reduced flow levels. Four fish species are moderately intolerant of a lack of flow, indicating that these species would require periods of flow at some stage in their lifecycle. The expected fish assemblage show high levels of preference for a wide range of cover types. Ten of the expected fish species are either moderately tolerant or tolerant of modified water quality indicating that water quality at this site would fluctuate naturally along with seasonal flow patterns. *L. kimberleyensis* is moderately intolerant of modified water quality. Five species have a requirement for movement between reaches/ fish habitat segments. These are the species that are most likely to be impacted upon by the construction of dams and weirs that impede fish migration.

Nine of the expected fish species were recorded at the site during the 2 Reserve Determination surveys. The Present Ecological State (PES) of the site was rated as a C category. In addition to the indigenous fish species the exotic species *Gambusia affinis* was abundant at the site. The exotic species *Cyprinus carpio* was also recorded at the site.

It is recommended that the site be managed so that the current PES is maintained and doesn't decrease. Table 2.25 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the PES Class and Threshold of Potential Concern (TPC).

Table 2.25: Fish Ecospecs and TPC for site EWR 18

Biota Ecospecs	**Biota TPC**
Labeobarbus aeneus - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. aeneus* - absent from the site for a single survey
Labeo capensis - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. capensis* - absent from the site for a single survey
Habitat Ecospecs	**Habitat TPC**
Maintenance of fast shallow and slow deep habitats	Reduction in fast shallow habitats
Provision of adequate flow during the spawning season	Reduction in flow during the spawning season

Fish monitoring

Fish should be sampled by means of combined electrofishing and gillnetting. Electrofishing should be conducted for at least 60 minutes. Gillnets should be left for at least 4 hours either around sunrise or sunset. Monitoring should be conducted twice annually, once during the intermediate dry – wet season (spring) and once during the intermediate wet – dry season (autumn). If only once annually then the intermediate dry –wet season would be preferred. This would provide an indication of any spawning or recruitment events that tend to peak at that time of year.

All fish caught should be counted and identified. Depending on the size of the catch, all fish or a subsample should be measured. Length frequency sampling will provide an indication of spawning periods, longevity and the number of cohorts in the system. Indigenous species should be returned to the water as soon as possible whereas introduced species should be destroyed. All results and samples should be lodged with the appropriate national databases.

Any observations of *L. kimberleyensis* should be considered significant due to the widespread decline in the abundance of this species.

2.3.5 Macroinvertebrates

Two surveys were conducted (during October 2007 and April 2008) in order to gather information regarding the macro-invertebrate communities at the various EWR sites and to apply the MIRAI (Macro-invertebrate Response Assessment Index) in order to determine the PES (Present Ecological State) of the macro-invertebrate component of the EcoStatus.

The results obtained from RHP and DACE database, together with the data obtained during the two field surveys was interpreted using the above mentioned methods. The original SASS5 total score for the site was 77 with an ASPT of 4.28 with a Recommended Ecological Category of a C.

The reference conditions used to derive the EcoStatus (MIRAI) were based on the Freshwater Conservation Plan. The reference total SASS5 score for the site is 125 with an ASPT of 5.6.

The PES for this site is a C/D (58.3%). The REC is a C (65%). The TPCs are set to alert managers that the PES of a C/D is in danger of not being maintained. The Ecospecs are described for the PES.

Suitable habitat (> 0.6 m/s over coarse substrate) is required to ensure that all the selected taxa can overwinter without significant detrimental impacts on the overall population. *Tricorythidae* and *Simuliidae* require velocities of > 0.6 m/s, but may persist at lower velocities (> 0.1 m/s). *Belostomatidae, Coenagrionidae* and *Atyidae* require velocities of <0.1 m/s. All three taxa occur on vegetation. The *Tricorythidae* and *Atyidae* are moderately sensitive to water quality conditions. These taxa are not expected to tolerate wide fluctuations in flow and water quality. *Physidae* and *Lymnaeidae* must be monitored so that their numbers does not increase significantly.

Although a variety of flow-dependent taxa were collected at this site there are basically 3 groups of indicator taxa (Table 2.26).

Table 2.26: The habitat preferences for the indicator taxa groups at site EWR 18

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	*Tricorythidae, Simuliidae*	>0.6	Cobbles	Moderate/Low
2	*Belostomatidae, Coenagrionidae, Atyidae*	<0.1	Vegetation	Moderate/Low
3	*Physidae, Lymnaeidae*	<0.1	Vegetation	None

Table 2.27 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the Ecospecs and Threshold of Potential Concern (TPC).

Table 2.27: Macroinvertebrate Ecospecs and TPCs for site EWR 18

HABITAT ECOSPECS	**HABITAT TPC**
To ensure that the maximum depth over the riffle area is greater than 30 cm.	The maximum depth over the riffle area is less than 34cm.
To ensure that the average depth over the riffle area is greater than 20cm.	The average depth over the riffle area is less than 25cm.
To ensure that the maximum velocity over the riffle area is greater than 0.6m/s.	The maximum velocity over the riffle area is less than 0.62m/s.
BIOTA ECOSPECS	**BIOTA TPC**
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >75; ASPT value: > 4.0.	SASS5 scores below 77 and ASPT below 4.5.
To ensure that the MIRAI score remains within the range of a C/D category (> 55), using the same reference data used in this study	A MIRAI score of 57 or less.
To maintain suitable flow velocity(maximum > 0.6m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the VFCS (Very fast flow over coarse sediment) biotope: • *Tricorythidae* (Abundance A) • *Simuliidae* (Abundance B)	Any one of these taxa missing or present as a single individual in any two consecutive surveys
To maintain suitable water quality, shading, temperature and habitat conditions for the following five key taxa: • *Belostomatidae* • *Tricorythidae* • *Atyidae*	Presence of less than three of the five key taxa listed in any survey.

• *Coenagrionidae* • *Simuliidae*	
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000).	Any taxon occurring in an abundance of >500 for two consecutive surveys
The REC: SASS5 scores ranging between 100 and 115, ASPT scores ranging between 4.5 and 5.0; MIRAI scores ranging between 65% and 68%.	

2.3.6 Riparian Vegetation

The vegetation composition at EWR 18 should not differ significantly from that recorded during the study (Table 2.28).

Table 2.28: Riparian vegetation recorded at site EWR 18

Recorded species : 99	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
99 indigenous species	1	9	7	9	9	8
54 exotic species	1	5	3	7	3	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Acacia karroo			√		√	
Salix mucronata	√					
Diospyros lycoides	√		√			
Melianthus comosus	√					
Rhus pyroides	√		√		√	
Asparagus sauveolens	√		√			
Lycium arenicola			√		√	
Phragmites australis		√				
Cineraria dregeana		√		√		
Gleditsia triacanthos		√		√		
Eucalyptus spp.	√					
Salix babylonica	√					
Populus X canescens	√					
Melia azedarach	√					
Ricinus communis	√					
Cestrum laevigatum		√		√		√
Phragmites australis		√		√		√
Pennisetum clandestinum		√				

Cirsium vulgare				√		√
Datura ferox				√		√
Xanthium strumarium				√		√
Pennisetum clandestinum		√				
Cirsium vulgare		√				
Rorripa nasturtium-aquaticum		√				
Azolla filiculoides		√				
Myriophyllum aquaticum		√				
Verbena bonariensis		√				

The site at Schmidtsdrif on the Vaal River consists of a broad area of flow with moderately sloping banks, on which vegetation would easily colonise and recruit. Vegetated sand banks indicate that few flood events take place in this reach of the river and the creation of patches for the colonisation of species due to floods is seldom encountered. Disturbance in the area is mainly due to anthropogenic impacts such as the utilisation of the vegetation in the area for grazing, fuel and possibly medicinal plant species and mining activities that are widespread along the banks of the river. Erosion is also visible on the banks and much of the area has been degraded due to the mining activities on the banks of the river. Although the site selection at this site is not ideal as the vegetation in the area has been disturbed, it is representative of much of the vegetation along this reach of the Vaal River as land use in the area is predominantly mining with some agricultural and pastoral farming also occurring in the area.

Current status: The area is currently considerably degraded due to the mining activities on the banks of the river resulting in an inflow of silt and the introduction of exotic species in the area. Although the number of exotic species occurring in the area is considerably less than many of the other sites the exotic species only contribute to approximately 20% of the species recorded in the area. The exotic species that appears to be having the greatest impact on the area is the aquatic weed *Myriophyllum spicatum* which has colonised and taken over the aquatic habitat. This species, if it remains unchecked may cause considerable damage in future. Furthermore, the lack of stochastic events, such as flooding may be aiding the colonisation by this species at site EWR 18.

Trajectory of change: Due to the factors mentioned above under the section “Current Status” and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Reasons for PES

This site did not fall within the Highveld Alluvial vegetation type and, in fact falls within the Upper Gariep Alluvial vegetation type. This vegetation type appears to be less impacted by the invasion of exotic species than the Highveld Alluvial vegetation type, possibly due to less agriculture in the surrounding areas due to a lower rainfall. Exotic species occur especially in areas where disturbance has taken place as is the case with this site. The area has been impacted by construction of bridges and other infrastructure as well as some mining activities. In these areas along the banks of the river the

disturbed riparian vegetation has been invaded by some exotic species and pioneer grasses. Reductions in exotic species diversity and abundance, as well as exotic species cover, were utilised in order to obtain a hypothetical reference site. Many of the decisions made in order to determine the hypothetical reference site were subjective decisions based on existing literature and field experience.

The area is currently considerably degraded due to the mining activities on the banks of the river resulting in an inflow of silt and the introduction of exotic species in the area. Although the number of exotic species occurring in the area is considerably less than many of the other sites the exotic species only contribute to approximately 20% of the species recorded in the area. The exotic species that appears to be having the greatest impact on the area is the aquatic weed *Myriophyllum spicatum* which has colonised and taken over the aquatic habitat. This species, if it remains unchecked may cause considerable damage in future. Furthermore, the lack of stochastic events, such as flooding may be aiding the colonisation by this species at this site. Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Ecospecs and TPCs

Table 2.29 combines and summarises the information from previous sections, which was presented per discipline, and presents the information per river reach, each of which is represented by one EWR site.

Table 2.29: Riparian Vegetation Ecospecs and TPCs for site EWR 18

Metric Group	Metric	ECOSPECs	TCPs
Marginal zone	Vegetation abundance	• Maintain marginal vegetation cover at greater than 70% • Maintain Cyperoid species density at 40 - 55% • Maintain *Phragmites australis* cover at 40%	• Marginal vegetation cover reduced to less than 75% • Cyperoid density less than 40% • *Phragmites australis* cover greater than 40%
	Species Richness	Maintain species richness at 13 or more	Species richness drops below 13
Lower Non-marginal zone	Vegetation abundance	• Maintain woody species cover at 10 - 15% • Maintain *Cenchrus cilliarus* cover at 30 - 35% • Maintain terrestrial species cover at 40 - 45%	• woody species cover greater than 10% or less than 15% • *Cenchrus cilliarus* cover less than 35% • Terrestrial species cover greater than 45%

Metric Group	Metric	ECOSPECs	TCPs
	Species Richness	Maintain species richness at 17 or more	Species richness drops below 17
Upper Non-marginal zone	Vegetation abundance	• Maintain Indigenous Acacia species cover at 80 - 90% • Maintain indigenous grass cover at 40 - 50%	Indigenous Acacia species cover less than 80% 0r more than 90% Indigenous grass cover less than 40%
	Species Richness	• Maintain species richness at 14 or more • Maintain terrestrial species at 80% or less	• Species richness drops below 14 • Terrestrial species increase above 80%
	Vegetation Structure	Maintain woody cover between 80 and 95 %	Woody cover greater 95 than or less than 80%

Riparian Vegetation Monitoring

Monitoring should be conducted annually during the wet season (Spring to early Summer) following the national VEGRAI (Vegetation Response Assessment Index) riparian vegetation monitoring system (Kleynhans *et al.* 2006) to identify and quantify changes in the vegetation in respect of abundance and cover of the selected zones or species being monitored. Vegetation zones should be identified along two fixed transects through the river at each of the EWR sites. The boundaries of the zones should be recorded on profiles, noting the distances between each zone margin with density counts of shrubs and trees within them done every second year.

Vertical (or as near vertical as possible) photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the EcoStatus table for each site. Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded. Sampling vegetation is best during Spring to early Summer as this makes access to and sampling of all vegetation zones better as although water levels are high, aquatic zone temporal species are still abundant (built up under low flow conditions), temperatures are high thus plants grow and more species are in flower (this later aspect assists with their identification) under the longer day length. Geophytic species are present and flowering during this time. Monitoring may be reduced to one survey every two to three years at this site if necessary, however, any significant, change as explained in Table 2.32, should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend.

Table 2.30: Interpretation of Riparian Vegetation results for site EWR 18

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Alien species marked with *					
Marginal Zone	Marginal vegetation cover	More than 70% of marginal zone is covered by marginal vegetation	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks. Undercutting of the banks has reduced the marginal vegetation.	Increase density by introducing variability in flow. Introduce lower flows during dry months
Marginal Zone	Cyperoid species	Density 40 – 55%	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks.	Increase density by introducing variability in flow. Introduce lower flows during dry months.
Marginal Zone	*Phragmites australis*	Lining parts of river and stream floodplains, Currently 40% cover at the site but may encroach on the site area.	Increase	Reduction of indigenous species and denudation of the banks leads to areas that can be colonised by *Phragmites australis*. Canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks, *Phragmites australis* is able to colonise these areas better than the indigenous species leading to the increase in cover of this species.	Decrease density by introducing variability in flow. Introduce lower flows during dry months. Physical removal

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Lower Non Marginal	Woody species cover	Low densities, Currently 10 – 15% cover	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones. Many of the terrestrial species in this area are woody species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	*Cenchrus ciliaris*	Moderate densities. Currently 30 – 35%	Decrease	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	Percentage cover of Terrestrial species	Currently 40-45%	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Increase flow rate and moderate flood events
Upper Non-marginal	Indigenous *Acacia,*	Currently 80 – 90%	Decrease	An increase in exotic tree species will cause a decrease in percentage of indigenous species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Upper Non - marginal	% indigenous grass cover	Currently 40 – 50%	Decrease	Increase in exotic trees cause a reduction of indigenous grass species due to increased crown cover.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.

2.4 EWR 19 RIET RIVER AT LILYDALE LODGE

2.4.1 Hydrology

The Modder/Riet catchment is situated in the Free State and Northern Cape Provinces. It is part of the Upper Orange WMA, but forms part of the C drainage region (Vaal River System). It covers a catchment area of 35 000 km^2. The Modder and Riet Rivers are the only major rivers in the catchment, which drain into the Vaal River which subsequently flows into the Orange River. The catchment includes Kalkfontein, Rustfontein, Tierpoort, Groothoek and Krugersdrift Dams.

The Riet River generally flows in a north-westerly direction to the confluence with the Vaal River. The Tierpoort dam which is used for irrigation purposes is situated on the tributary of the Riet River, and the Kalkfontein Dam which supplies water to the Riet River Government Water Scheme, is located just downstream of the confluence of the Kromellenboogspruit and Riet Rivers. The Modder River is the main tributary of the Riet River and joins the Riet River just upstream of Ritchie. The Modder River has its source in the high hills at the watershed near Dewetsdorp (1600m above mean sea level). The Krugersdrift Dam is located on the Modder River. Most of the natural runoff into the Modder River is from above the confluence of the Modder and Klein Modder Rivers. The rest of the Modder River catchment is very flat and very little runoff occurs.

Current land use in the catchment is related agricultural activities, urbanisation and mining and industrial activities. In the Modder and Riet River catchments agricultural use comprises primarily the irrigation of crops. Agricultural activities are concentrated around the dams in the catchment. Livestock watering also occurs, but to a lesser extent. The major urban centres in the catchment are Bloemfontein, Botshabelo and Thabu Nchu. The Modder River is a major source of water to these urban areas. Most industries in the Modder and Riet catchments are centred around Bloemfontein and use treated water from the municipal supply system. Only one industry that uses water directly out of the river is known.

The hydrology Ecospecs for site EWR 19 is given in Table 2.31

Table 2.31: Hydrology Ecospecs for site EWR 19 (PES and REC=D)

MAR (present day)	Maintenance Low Flows (% MAR)	Drought Low Flows (% MAR)	High Flows (% MAR)	MCM Excluding Floods	Long Term Mean (% MAR) Excluding Floods	MCM Including Floods	Long Term Mean (% MAR) Including Floods
247.67	13.44	0.08	15.39	117.04	28.98	148.33	35.17

2.4.2 Water quality

This assessment was made using data from the nearest weir is C5H048Q01. The Northern Cape DWA regional office also does monthly monitoring. Data was available from the Sedibeng Water Company which does a limited selection of water quality variables on a daily basis.

Extremely high salts (agricultural activity even on the river banks) and moderate to high nutrients (agricultural return flows) are present. There are dams upstream used for irrigation (trapping the nutrients and salts), but most nutrients measured are due to diffuse pollution rather than point source.

The water quality Ecospecs and TPCs for EWR 19 are given in Table 2.32 as is the recommended frequency for monitoring. Additional recommendations with respect to monitoring are given below. The PES WQ at EWR 19 is a D category (high confidence) and the REC is a D (Table 2.31). It is recommended that the REC for water quality is maintained at a D category. Special attention should be paid to monitoring nutrient levels (Soluble reactive Phosphorus), which can be improved due to more stringent discharge standards. Furthermore:

- The River Health Programme (RHP) network of sites managed by the Northern Cape DWA should be continued. On-site water quality data should be collected as per standard RHP protocol (electrical conductivity (EC), temperature, dissolved oxygen (DO), turbidity if possible and a visual assessment (RHAM, 2009) should be done.

- Nutrient monitoring should be undertaken more frequently on the Harts River and main stem of the Vaal River.

- Water use authorisations should be reviewed to ensure stricter phosphate standard compliance.

Table 2.32: Water Quality Ecospecs, TPCs and sampling frequency for EWR 19

RIVER		Riet River	**WATER QUALITY MONITORING POINTS**			
WQSU		81	**DWAF WQ WMS**	C5H048Q01 1990 – 2008 (*n* = 789)		
EWR SITE		EWR 8	**RHP**	Currently several monitoring sites		
Confidence in PES assessment		High				
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Inorganic salts (mg/L)	$MgSO_4$	F	The PES: F currently exceeds 45 mg/L	Yes to D	The PES: F currently exceeds 45 mg/L	Monthly
	Na_2SO_4	F	The PES: F currently exceeds 64 mg/L		The PES: F currently exceeds 64 mg/L	
	$MgCl_2$	F	The PES: F currently exceeds 66 mg/L		The PES: F currently exceeds 66 mg/L	
	$CaCl_2$	F	The PES: F currently exceeds 141 mg/L		The PES: F currently exceeds 141 mg/L	
	NaCl	D	389 - 535 mg/L		95^{th} percentile to be < 535 mg/L	
Nutrients (mg/L)	PO_4-P (SRP)	B	0.025 – 0.125 mg/L	No	50^{th} percentile to be < 0.125 mg/L	Monthly
	TIN	B	1.0 – 4.0 mg/L	No	50^{th} percentile to be < 4.0 mg/L	Monthly
Physical Variables	pH	B	6.5 – 8.8	Yes to good	95^{th} percentile to be >6.5 and <8.8	Monthly
	Temperature	Natural variation	Maintain range	N/A	Maintain natural range	Monthly
	Dissolved oxygen		5 – 8 mg/L	N/A	5^{th} percentile to be > 5 mg/L	Monthly
	Turbidity (NTU)	Seasonal variation	Moderate change allowed	N/A	Moderate change allowed	Monthly
	Electrical conductivity (mS/m)	F	The PES: F currently exceeds 85 mS/m	Yes to D	The PES: F currently exceeds 85 mS/m	Quarterly
Response variables	Chl a: periphyton	Visual inspection indicates high algal concentrations on rocks and in pools	21 - 84 mg/m^2	N/A	50^{th} percentile to be <84 mg/ m^2	Quarterly
	Chl a: phytoplankton		20 - 30 µg/L		50^{th} percentile to be <30 µg/L	
	Macroinvertebrates (ASPT)	C	See Ecospecs for fish and invertebrates respectively			
	Fish community score	D				
	Instream toxicity	Visual inspection indicates high algal concentrations on rocks and in pools.	Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown.			
Toxics	Ammonia	C/D	72.5 – 128.75 ug/L	Yes to D	95^{th} percentile to be <100 ug/L	Monthly

2.4.3 Geomorphology

The Geomorphology Ecospecs for site EWR 19 is given in Table 2.33

Table 2.33: Geomorphology Ecospecs for site EWR 19

Geomorphology PES = C	
Ecospecs	**Motivation and TPCs**
Daily Hydrology: requested flows must be provided To ensure that the requested flows (specifically floods) are delivered to the site: 2 m3/s – at least 5 events per year 20 m3/s – at least a 1:1 year return interval 100 m3/s – at least a 1:2 year return interval 230 m3/s – at least a 1:5 year return interval	
Dry season bed material composition must be maintained The channel here has a bedrock floor with occasional cobbles and boulders overlying this. Fines and gravels are, under the current condition, almost absent from the site – only being found in the lee areas and along channel margins. This near absence of alluvial sediments indicates the high energy environment of this site. To ensure that the bed composition and thus physical habitat diversity is maintained, sampling of the dry season bed material at the EWR site (using a sample size of not less than 500 points) should be undertaken at the prescribed intervals (every 5 years) to assess impacts of flow on the bed sediment and therefore as an indication of the change of available habitat for instream biota. At this site any fining of the bed (i.e gravels or fines becoming the dominant sediment type) would indicate insufficient flows being delivered to the site to maintain the geomorphological condition.	
Maintenance of channel form and gross morphology Maintain the channel form and associated processes and habitats.	
The bedrock nature of the site makes it resistant to large-scale morphological adjustment. Therefore monitoring of the cross-section or aerial photographs for gross changes in morphology is not required.	

Geomorphology monitoring frequencies and interpretation

The monitoring frequencies and interpretation of for geomorphology are shown in Table 2.34.

Table 2.34: Geomorphology monitoring frequencies and interpretation

	Short-term monitoring (every 2nd year)	Interpretation (every 2nd year)	Long-term monitoring (every 5 to 10 years)	Interpretation (every 5 to 10 years)
HYDROLOGY	Daily hydrology: Update of the daily hydrological time series	Hydrological time series must be analysed to verify that the requested flood flows have been provided at the sites.	*not applicable*	*not applicable*
BED MATERIAL	*not applicable* After any 1:10-year or greater return period flood: - re-survey cross-section - re-survey bed material distribution, and - take fixed point photographs.	*not applicable*	Bed material composition: Resurvey the bed material (sediment in the active channel) after 5 years along the cross-section/s.	Analyse bed material distribution data and compare to previous and to TPCs provided for each site.
CHANNEL FORM	Fixed-point photography	Fixed point photography should be analysed for changes in channel geometry, islands and hydraulic habitat (comparing the condition between the monitoring intervals). Reduction in critical habitats, and generally of channel width, is undesirable. Interpret in line with the site-specific guidelines provided in tables above.	Cross-section: Re-survey of fixed cross-sections Aerial photographs: Analysis of aerial photographs or high resolution satellite imagery (if available)	Assess the re-surveyed cross-sections and aerial photographs for any significant planform changes. Interpret these in terms of short- medium- changes in hydrology and land use Assess both for signs of net aggradation (increase in the bed level) or net erosion/incision. Some EWR sites have narrowed channels, and further such reductions in available habitat are undesirable.

All information must be interpreted in terms of medium- to long-term trends and trajectories and the impact of flood(s)

2.4.4 Fish

Eight fish species would historically have occurred at the site in moderate abundance. *Barbus paludinosus* and *Labeobarbus kimberleyensis* would have occurred at the site in low abundances. *Austroglanis sclateri* may sporadically have been present at the site in moderate abundance. Eight of the expected fish species have a high level of preference for either slow deep or slow shallow habitats suggesting that these would historically have been the predominant velocity depth classes at this site. Two fish species namely *Labeobarbus aeneus* and *Austroglanis sclateri* have a high level of preference for fast shallow habitats. *Labeobarbus kimberleyensis* has a high level of preference for fast deep habitats. Seven of the expected fish species are either moderately tolerant or tolerant of reduced flow levels. Four fish species are moderately intolerant of a lack of flow, indicating that these species would require periods of flow at some stage in their lifecycle. The expected fish assemblage show high levels of preference for a wide range of cover types. Ten of the expected fish species are either moderately tolerant or tolerant of modified water quality indicating that water quality at this site would fluctuate naturally along with seasonal flow patterns. *L. kimberleyensis* is moderately intolerant of modified water quality. Five species have a requirement for movement between reaches/ fish habitat segments. These are the species that are most likely to be impacted upon by the construction of dams and weirs that impede fish migration.

Five of the expected indigenous fish species were recorded at the site during the 2 Reserve Determination surveys. The Present Ecological State (PES) of the site was rated as a D category. The exotic fish species *Cyprinus carpio* was also recorded at the site during the surveys.

It is recommended that the site be managed so that the current PES is maintained and doesn't decrease any further. Table 2.35 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the PES Class and Threshold of Potential Concern (TPC).

Table 2.35: Fish Ecospecs and TPC for site EWR 19

Biota Ecospecs	**Biota TPC**
Labeobarbus aeneus - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. aeneus* - absent from the site for a single survey
Labeo capensis - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. capensis* - absent from the site for a single survey
Barbus anoplus - Present in moderate abundance and present at most sites (> 50 - 75%)	*B. anoplus* - absent from the site for a single survey
Habitat Ecospecs	**Habitat TPC**
Maintenance of fast shallow and slow deep habitats	40% reduction in fast shallow habitats
Provision of adequate flow during the spawning season	Reduction in flow during the spawning season

Fish monitoring

Fish should be sampled by means of combined electrofishing and gillnetting. Electrofishing should be conducted for at least 30 minutes. Gillnets should be left for at least 4hours either around sunrise or sunset. Monitoring should be conducted twice annually, once during the intermediate dry – wet season (spring) and once during the intermediate wet – dry season (autumn). If only once annually then the intermediate dry –wet season would be preferred. This would provide an indication of any spawning or recruitment events that tend to peak at that time of year.

All fish caught should be counted and identified. Depending on the size of the catch, all fish or a subsample should be measured. Length frequency sampling will provide an indication of spawning periods, longevity and the number of cohorts in the system. Indigenous species should be returned to the water as soon as possible whereas introduced species should be destroyed. All results and samples should be lodged with the appropriate national databases.

Any observations of *L. kimberleyensis* should be considered significant due to the widespread decline in the abundance of this species.

2.4.5 Macroinvertebrates

Two surveys were conducted (during October 2007 and April 2008) in order to gather information regarding the macro-invertebrate communities at the various EWR sites and to apply the MIRAI (Macro-invertebrate Response Assessment Index) in order to determine the PES (Present Ecological State) of the macro-invertebrate component of the EcoStatus.

The results obtained from RHP and DACE database, together with the data obtained during the two field surveys was interpreted using the above mentioned methods. The original SASS5 total score for the site was 140 with an ASPT of 4.67 with the Recommended Ecological Category of a B/C.

The reference conditions used to derive the EcoStatus (MIRAI) were based on the Freshwater Conservation Plan. The reference total SASS5 score for the site is 160 with an ASPT of 5.6.

The PES for this site is a C (70.0%). The REC is a B/C (75%). The TPCs are set to alert managers that the PES of a C is in danger of not being maintained. The Ecospecs are described for the PES.

Suitable habitat (> 0.6 m/s over coarse substrate) is required to ensure that all the selected taxa can overwinter without significant detrimental impacts on the overall population. *Tricorythidae* and *Simuliidae* require velocities of > 0.6 m/s, but may persist at lower velocities (> 0.1 m/s). *Belostomatidae, Coenagrionidae* and *Atyidae* require velocities of <0.1 m/s. All three taxa occur on vegetation. The *Tricorythidae* and *Atyidae* are moderately sensitive to water quality conditions. These taxa are not expected to tolerate wide fluctuations in flow and water quality. *Physidae* and *Lymnaeidae* must be monitored so that their numbers does not increase significantly.

Although a variety of flow-dependent taxa were collected at this site there are basically 3 groups of indicator taxa (Table 2.36).

Table 2.36: The habitat preferences for the indicator taxa groups for site EWR 19

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	*Tricorythidae, Simuliidae*	>0.6	Cobbles	Moderate/Low
2	*Belostomatidae, Coenagrionidae, Atyidae*	<0.1	Vegetation	Moderate/Low
3	*Physidae, Lymnaeidae*	<0.1	Vegetation	None

Table 2.37 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the Ecospecs and Threshold of Potential Concern (TPC).

Table 2.37: Macroinvertebrate Ecospecs and TPCs for site EWR 19

HABITAT ECOSPECS	**HABITAT TPC**
To ensure that the maximum depth over the riffle area is greater than 25 cm.	The maximum depth over the riffle area is less than 28cm.
To ensure that the average depth over the riffle area is greater than 18cm.	The average depth over the riffle area is less than 22cm.
To ensure that the maximum velocity over the riffle area is greater than 0.6m/s.	The maximum velocity over the riffle area is less than 0.62m/s.
BIOTA ECOSPECS	**BIOTA TPC**
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >135; ASPT value: > 4.5.	SASS5 scores below 140 and ASPT below 5.0
To ensure that the MIRAI score remains within the range of a C category (>68%), using the same reference data used in this study	A MIRAI score of 70% or less.
To maintain suitable flow velocity(maximum > 0.6m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the VFCS (Very fast flow over coarse sediment) biotope: • *Tricorythidae* (Abundance A) • *Simuliidae* (Abundance B)	Any one of these taxa missing or present as a single individual in any two consecutive surveys
To maintain suitable water quality, shading, temperature and habitat conditions for the following five key taxa: • *Belostomatidae* • *Tricorythidae*	Presence of less than three of the five key taxa listed in any survey.

• *Atyidae* • *Coenagrionidae* • *Simuliidae*	
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000).	Any taxon occurring in an abundance of >500 for two consecutive surveys
The REC: SASS5 scores ranging between 145 and 155, ASPT scores ranging between 5.2 and 6.0; MIRAI scores ranging between 75% and 78%.	

2.4.6 Riparian Vegetation

The Riparian Vegetation composition at EWR 19 should not differ significantly from that recorded during the study (Table 2.38).

Table 2.38: Riparian vegetation recorded at site EWR 19

Recorded species : 27	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
13 indigenous species	1	9	7	9	9	8
14 exotic species	1	5	3	7	3	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Acacia karroo	√		√		√	
Salix mucronata	√					
Diospyros lycoides	√		√		√	
Melianthus comosus			√		√	
Asparagus sauveolens	√		√		√	
Phragmites australis		√				
Cineraria dregeana		√		√		√
Eucalyptus spp.	√		√		√	
Salix babylonica	√		√			
Populus X canescens	√		√			
Ricinus communis	√		√			
Cenchrus ciliaris		√		√		
Cynodon dactylon		√		√		
Eragrostis sp.		√		√		
Themeda triandra				√		√
Cyperus spp.		√				

Recorded species : 27	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
13 indigenous species	1	9	7	9	9	8
14 exotic species	1	5	3	7	3	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Opuntia ficus-indica				√		√
Pennisetum clandestinum		√		√		√
Cirsium vulgare				√		√
Datura ferox		√		√		√
Xanthium strumarium		√		√		√
Pennisetum clandestinum		√				
Cirsium vulgare		√				
Rorripa nasturtium-aquaticum		√				
Myriophyllum aquaticum		√				

The site at Lillydale Lodge on the Riet River consists of a relatively broad area of flow with moderately sloping banks on the western side which are considerably impacted by previous mining activities and the introduction of exotic species. On the eastern bank there is a very small bank with a shallow slope before rising to a steep cliff which would not allow for easy colonisation and recruitment. The site selection at this site is, however, ideal as the vegetation in the area has been disturbed on much of this reach of the river by mining activities and stock grazing in the past. This area has recently been declared a national park, but much degradation is still evident from previous activities. Land use in the area is nature reserve at the moment but was previously pastoral farming and mining.

Current status: The area is currently degraded due to the introduction of a number of exotic species and the previous mining and farming impacts. The exotic species in the area, in fact, contribute to a total of only 20% of the total number of species identified during the surveys, but do make up a considerable amount of the local biomass.

Trajectory of change: Due to the factors mentioned above under the section “Current Status” and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Reasons for PES

This site also does not fall within the Highveld Alluvial vegetation type and falls within the Upper Gariep Alluvial vegetation type. This vegetation type appears to be less impacted by the invasion of exotic species than the Highveld Alluvial vegetation type, possibly due to less agriculture in the surrounding areas due to a lower rainfall. Exotic species occur especially in areas where disturbance has taken place as is the case with this site. The area has been declared a national park but has been previously impacted by mining activities and farming activities. In these previously mined areas along the banks of the river the disturbed riparian vegetation has been invaded by some exotic species and pioneer grasses. Reductions in exotic species diversity and abundance, as well as exotic species cover, were utilised in order to obtain a hypothetical reference site. Many of the decisions made in order to determine the hypothetical reference site were subjective decisions based on existing literature and field experience.

The area is currently degraded due to the introduction of a number of exotic species and the previous mining and farming impacts. The exotic species in the area, in fact, contribute to a total of only 20% of the total number of species identified during the surveys, but do make up a considerable amount of the local biomass. Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Ecospecs and TPCs

Table 2.39 combines and summarises the information from previous sections, which was presented per discipline, and presents the information per river reach, each of which is represented by one EWR site.

Table 2.39: Riparian Vegetation Ecospecs and TPCs for site EWR 19

Metric Group	Metric	ECOSPECs	TCPs
Marginal zone	Vegetation abundance	• Maintain marginal vegetation cover at greater than 40% • Maintain Cyperoid species density at 30 - 35% • Maintain Phragmites australis cover at 20%	• Marginal vegetation cover reduced to less than 40% • Cyperoid density greater than 35% or less than 30% • Phragmites australis cover greater than 20%
	Species Richness	Maintain species richness at 18 or more	Species richness drops below 18

Metric Group	Metric	ECOSPECs	TCPs
Lower Non-marginal zone	Vegetation abundance	• Maintain woody species cover at 40 - 45% • Maintain *Cynodon dactylon* cover at 30 - 35% • Maintain terrestrial species cover at 20 - 25%	• woody species cover greater than 40% or less than 45% • *Cynodon dactylon* cover less than 30% • Terrestrial species cover greater than 25%
	Species Richness	Maintain species richness at 15 or more	• Species richness drops below 15
Upper Non-marginal zone	Vegetation abundance	Maintain Indigenous Acacia species cover at 10 - 15% Maintain indigenous grass cover at 40 - 50%	Indigenous Acacia species cover less than 10% Indigenous grass cover greater than 40% or less than 50%
	Species Richness	Maintain species richness at 12 or more Maintain terrestrial species at 70% or less	Species richness drops below 12 Terrestrial species increase above 70 %
	Vegetation Structure	Maintain woody cover between 50 and 55 %	Woody cover greater than 55%

Riparian Vegetation Monitoring

Monitoring should be conducted annually during the wet season (Spring to early Summer) following the national VEGRAI (Vegetation Response Assessment Index) riparian vegetation monitoring system (Kleynhans *et al.* 2006) to identify and quantify changes in the vegetation in respect of abundance and cover of the selected zones or species being monitored.

Vegetation zones should be identified along two fixed transects through the river at each of the EWR sites. The boundaries of the zones should be recorded on profiles, noting the distances between each zone margin with density counts of shrubs and trees within them done every second year.

Vertical (or as near vertical as possible) photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the EcoStatus table for each site. Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded. Sampling vegetation is best during Spring to early Summer as this makes access to and sampling of all vegetation zones better as although water levels are high, aquatic zone temporal species are still abundant (built up under low flow conditions), temperatures are high thus plants grow and more species are in flower (this later aspect assists with

their identification) under the longer day length. Geophytic species are present and flowering during this time. Monitoring may be reduced to one survey every two to three years at this site if necessary, however, any significant, change as explained in Table 2.40, should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend.

Table 2.40: Interpretation of Riparian Vegetation results for site EWR 19

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Alien species marked with *					
Marginal Zone	Marginal vegetation cover	More than 40% of marginal zone is covered by marginal vegetation	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks. Undercutting of the banks has reduced the marginal vegetation.	Increase density by introducing variability in flow. Introduce lower flows during dry months
Marginal Zone	Cyperoid species	Density 30 – 35%	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks.	Increase density by introducing variability in flow. Introduce lower flows during dry months.
Marginal Zone	*Phragmites australis*	Lining parts of river and stream floodplains, Currently 20% cover at the site but may encroach on the site area.	Increase	Reduction of indigenous species and denudation of the banks leads to areas that can be colonised by *Phragmites australis*. Canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks, *Phragmites australis* is able to colonise these areas better than the indigenous species leading to the increase in cover of this species.	Decrease density by introducing variability in flow. Introduce lower flows during dry months. Physical removal

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Lower Non Marginal	Woody species cover	Moderate densities, Currently 40 – 45% cover	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones. Many of the terrestrial species in this area are woody species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	*Cynodon dactylon*	Moderate densities. Currently 30 – 35%	Decrease	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	Percentage cover of Terrestrial species	Currently 20-25%	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Increase flow rate and moderate flood events
Upper Non-marginal	Indigenous *Acacia,*	Currently 10 – 15%	Decrease	An increase in exotic tree species will cause a decrease in percentage of indigenous species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Upper Non -marginal	% indigenous grass cover	Currently 40 – 50%	Decrease	Increase in exotic trees cause a reduction of indigenous grass species due to increased crown cover.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.

3 CONCLUSIONS

The following table is a summary of the proposed monitoring frequency for the Ecological Reserve for the Lower Vaal EWR sites 16 to 19 (Table 3.1).

Table 3-1 Summary of proposed monitoring frequency for the Ecological Reserve for the Lower Vaal.

Reserve component	**Monitoring Frequency**
Hydrology	Daily monitoring at closest DWA weir
Water Quality	Monthly, Quarterly (EC and Chlorophyll a)
Geomorphology	• Every 2nd year: Daily hydrology and Fixed-point photography • Every 5 – 10 years: Bed material composition; Cross-sections and Aerial photographs
Fish	Monitoring should be conducted twice annually. If only once annually then the intermediate dry –wet season would be preferred.
Macroinvertebrates	Wet and dry season sampling
Riparian Vegetation	Monitoring should be conducted annually during the wet season (Spring to early Summer). Monitoring may be reduced to one survey every two to three years, however, any significant, change should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend

It is important to note that the proposed Rapid Habitat Monitoring Programme (RHAM) has not been tested in the Lower Vaal.

If this programme is to be implemented then the suggested monitoring frequency in Table 3.1 would alter and the RHAM monitoring would be used as a screening approach. If the TPCs are triggered then the proposed monitoring would be initiated.

4 REFERENCES

Department of Water Affairs and Forestry (DWAF). 1999: Resource Directed Measures for Protection of Water Resources; Volume 3: River Ecosystems Version 1.0 (Revised water quality methodology, 2002).

Department of Water Affairs and Forestry. (2006). Ecological Reserve Monitoring: Preliminary Generic Guidelines. February 2006. Prepared by CJ Kleynhans (Resource Quality Services, DWA) and MD Louw (Water For Africa).

Department of Water Affairs and Forestry (DWAF). 2008. Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Resource Unit. Report produced by Koekemoer Aquatic Services and Water for Africa. Authored by Louw, D. Report no: RDM/ WMA8 C000/01/CON/0507.

Kleynhans and Louw (2007) EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2)

Kleynhans, C J, Louw, M D and Moolman, J. 2007. Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission. Pretoria, South Africa : s.n., 2007.

Kleynhans, CJ, Thirion, C and Moolman, J. (2005). A Level I River EcoRegion classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Kleynhans, CJ, Thirion, C, Moolman, J and Gaulana, L. (2007). A Level II River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/000/00/REQ0XXX. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Louw MD, Kemper N and Birkhead AL. (1999). Procedure for selecting sites in intermediate and comprehensive determination of the ecological reserve (water quantity component). Appendix 18 in Resource Directed Measures for Protection of Water Resources: River Ecosystems. Published by Department of Water Affairs, South Africa.

Muller and Scherman (2007) The water quality Ecospecs and TPCs were derived using methods from.

National Water Act. Act No. 36 of 1998.

RHAM, 2009 Visual assessment.