

COMPREHENSIVE RESERVE DETERMINATION INTEGRATED VAAL RIVER SYSTEM SURFACE WATER

DESKTOP ECOCLASSIFICATION



TECHNICAL COMPONENT: MIDDLE VAAL

REPORT NO.: RDM/WMA9 C000/01/CON/0207

PROJECT NO.: 8829/1



water & forestry

Department:
Water Affairs & Forestry
REPUBLIC OF SOUTH AFRICA

Published by

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

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

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This report should be cited as:

Department of Water Affairs and Forestry (DWAF), 2009. Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Middle Vaal Water Management Area Technical Component: Desktop EcoClassification Report. Report no: RDM/ WMA9 C000/ 01/CON/0207. Pretoria, South Africa.

Report produced and authored by:



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

JOHANNESBURG
PO Box 6001 Halfway House 1685
South Africa
Thandanani Park, Matuka Close
Halfway Gardens, Midrand
Tel + (27) (0)11 254-4800
Fax + (27) (0)11 315-0317
<http://www.golder.com>

DOCUMENT INDEX

Reports as part of this project:

Bold type indicates this report.

REPORT INDEX	REPORT NUMBER	REPORT TITLE
1.1	RDM/ WMA9C000/01/CON/0107	Middle Vaal Comprehensive Reserve determination: Inception report
1.2	RDM/ WMA9C000/01/CON/ 0207	Middle Vaal Comprehensive Reserve determination: Desktop EcoClassification report
1.3	RDM/ WMA9C000/ 01/CON/ 0307	Middle Vaal Comprehensive Reserve determination: BHNRR report
1.4	RDM/ WMA9C000/ 01/CON/ 0407	Middle Vaal Comprehensive Reserve determination: Resource Units report
1.5	RDM/ WMA9C000/ 01/CON/ 0507	Middle Vaal Comprehensive Reserve determination: Wetland/Pans Assessment report
1.6	RDM/ WMA9C000/ 01/CON/ 0607	Middle Vaal Comprehensive Reserve determination: EcoClassification report
1.7	RDM/ WMA9C000/ 01/CON/ 0707	Middle Vaal Comprehensive Reserve determination: EWR report
1.8	RDM/ WMA9C000/ 01/CON/ 0807	Middle Vaal Comprehensive Reserve determination: Operation scenarios and consequences report
1.9	RDM/ WMA9C000/ 01/CON/ 0907	Middle Vaal Comprehensive Reserve determination: Socio Economic Present State Evaluation Report
1.10	RDM/ WMA9C000/ 01/CON/ 1007	Middle Vaal Comprehensive Reserve determination: Ecospecs and monitoring report
1.11	RDM/ WMA9C000/ 01/CON/ 1107	Middle Vaal Comprehensive Reserve determination: Capacity building and audit report
1.12	RDM/ WMA9C000/ 01/CON/ 1207	Middle Vaal Comprehensive Reserve determination: Main integration report

APPROVAL

TITLE: Comprehensive Reserve determination study of the Integrated Vaal River System, Middle Vaal Water Management Area. Technical Component: Desktop EcoClassification Report

DATE: May 2009

AUTHORS: R Heath

REVIEWERS: R Stassen and B Weston

EDITORS: O Wilson and R Stassen

LEAD CONSULTANT: Golder Associates Africa

ISBN NO.:

FILE NO.: 26/8/3/10/10

FORMAT: MSWord and PDF

WEB ADDRESS: www.dwaf.gov.za

Approved for Golder Associates Africa:

Mr Ralph Heath
Study Leader and Manager

Approved for the Department of Water Affairs and Forestry 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 and Manager
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
Bruce Randell	Golder Associates Africa	Hydrology
Trevor Coleman	Golder Associates Africa	Water Quality Specialist
Danie Otto	Golder Associates Africa	Pans/Wetlands Specialist
Raina Hattingh	Golder Associates Africa	Trainee aquatic ecologist
Angelina Jordanova	Golder Associates Africa	Hydraulics engineer
Peter Kimburg	Golder Associates Africa	Fish
Alwa Koning	Golder Associates Africa	Macroinvertebrate
Niels Jacobson	Golder Associates Africa	Riparian vegetation
Anelle Odendaal	Zitholele Consulting	Stakeholder awareness
Jennifer Molwantwa	Zitholele Consulting	Water Quality trainee
Rene Ford	Zitholele Consulting	Socio-economic
Zwelibanzi Mahlangu	Zitholele Consulting	Trainee hydrologist
Ken Haumann	PD Naidoo and Associates	Spatsim and hydrology
Mark Rountree	Private Consultant	Geomorphologist

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

Background

The CD: RDM identified the Integrated Vaal River System, with the focus of this study, the Middle 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 studies undertaken by the National Water Resources Planning Directorate (D: NWRP) of the DWAF. These studies require higher levels of confidence in the Reserve determination results as is currently available. This will assist the DWAF to make informed decisions regarding the authorization of future water use and the magnitude of the impacts of the present and proposed developments.

A Desktop EcoClassification will serve as a scoping phase to investigate the WMA at a desktop level and at the scale of quaternary catchments and serves as the basis for most other tasks in the Reserve determination process. This scoping assessment provides an overview of the WMA and a better understanding when focussing on the EWR sites and the sections of rivers where comprehensive assessments will be undertaken. The output of the information also identifies areas of potential concern based on an integrated importance (combination of Ecological Importance and Sensitivity, Socio-Cultural Importance and Present Ecological State).

Approach

The objective of the EWR study is to provide information at two levels of detail, i.e. at scoping or desktop level, as well as a more detailed assessment. This report presents the results of the Desktop assessment of the EcoClassification process for each quaternary catchment. The term used for Ecological Classification "EcoClassification" (Kleynhans *et al.*, 2005) refers to the determination and categorisation of the Present Ecological State (PES) - or health or integrity - of various biophysical attributes of rivers, compared with the natural or close to natural reference condition. The purpose of EcoClassification is to gain insight into the causes and sources of the deviation of the PES from the reference condition. This provides the information needed to derive the desirable and attainable future ecological objectives for the river. The state of the river is described in terms of Ecological Categories (A to F).

The EcoClassification process also includes an assessment of Ecological Importance and Sensitivity (EIS), and Socio-Cultural Importance (SCI). These are described in terms of Low to Very High (EIS) and Minimal to Very High (SCI). All assessments include a confidence rating that may range from 1 (low confidence) to 5 (high confidence).

Ecological Importance and Sensitivity

The ecological importance of a river is an expression of its contribution to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or

fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Resh *et al.*, 1988; Milner, 1994).

Standard EIS models are used, irrespective of the level of assessment. The data which is used to populate the models vary, dependant on the level.

No areas of Very High EIS are present in the WMA. The few areas of high EIS are the following:

- § C70G, C70H, C70J and C70K (Renoster River system) due to the presence of the endangered rock catfish (*Austroglanis sclateri*)
- § C24B (Vaal River) due to the presence of the endangered rock catfish (*A. sclateri*).
- § C24D (Rietspruit River) due to the presence of the Schoonspruit provincial reserve, the location of the Schoonspruit dolomitic eye, and the presence of the endangered rock catfish (*A. sclateri*).
- § C25A (Klipspruit River) due to probable high species diversity, including rock catfish (*A. sclateri*) the site of the Wolfespruit Nature Reserve.

Most of the rest of the quaternary catchments were rated as moderate. The confidence of the evaluation ranged mostly from moderate to high with approximately 30% as low.

Socio-Cultural Importance

The SCI was determined from:

- § A site visit that covered points along the river; and
- § Extrapolation to sites not visited by reference to available literature, as well as to existing mapping.

The SCI was generated by scoring each quaternary, based on the following features:

- Ritual Use (e.g., ceremonial purposes, spiritual/religious activities.).
- Aesthetic Value.
- Resource Dependence (it refers to the goods and services delivered by the river system and peoples dependence on these components).
- Recreational Use.
- Historical/Cultural Value (e.g., sites of historic battles, craters dues to meteorites etc)).

Scores were then weighted to reflect the adjudged importance of each component relative to the other. The Resource Dependence component was given the highest weighting, because this component is designed to reflect the importance of a healthy riverine system to people who are often in the grips of poverty, and for whom the availability of such resources is a question of survival.

Areas dominated by relatively low population densities and given over to commercial farming enterprises (typically the upper parts of the catchment) as well as portions of the middle catchment tended to score relatively low in terms of SCI. An obvious exception is recreational use. Portions of the WMA with water related recreational activity scored slightly higher. Areas dominated by mining and industrialisation also scored generally low in terms of SCI. It should be emphasised that low SCI

score does not indicate low economic importance. In terms of economic importance the Middle Vaal catchment is obviously critical to the RSA due to the gold mining in the KOSH area.

Present Ecological State

The PES of the river is expressed in terms of various components, i.e., **drivers** (Physico-chemical variables, geomorphology, hydrology) and **biological responses** (fish, riparian vegetation and aquatic invertebrates), as well as an integrated state, the EcoStatus.

A Desktop Level EcoStatus assessment was designed for use when assessments for planning purposes on large scale have to be undertaken. As the name indicates, this is done at desktop level, and is therefore based on available information and expert judgement. However, due to the lack of relevant information in some of the areas, a site visit was undertaken during this study to provide additional information.

The bulk of the rivers in WMA 9 are in a B/C and C category. Please note again that this does not include all the smaller tributaries. The rivers in a B category are the following:

- C70K: Renoster River
- C24C: Upper Schoonspruit (including the Schoonspruit eye)

This means that there are very few rivers in this large WMA which are potentially still in a good condition. The reason for this is the high utilisation of the catchment due to mining, irrigation and the urban sprawl of Gauteng. Water quality issues are prevalent in many streams as well as increased flows, i.e. more than natural.

Recommendations

An evaluation has been undertaken comparing areas of Integrated Importance which consists of Ecological, Socio-Cultural and Present Ecological State, with an importance evaluation of Water Resource Use. All quaternary catchments with either a high (3) or very high (4) rating were identified and are illustrated in the map below. These quaternary catchments would require EWR of reasonably high confidence and detailed studies are therefore recommended. This information will play an important role in identifying the areas where EWR sites are to be selected.

TABLE OF CONTENTS

SECTION	PAGE
1. INTRODUCTION.....	1-1
1.1 Background.....	1-1
1.2 Study Area.....	1-1
1.2.1 Middle Vaal WMA.....	1-1
1.3 Objectives of the Middle Vaal Reserve Determination Study.....	1-2
1.4 Purpose of this Report.....	1-2
1.4.1 Desktop EcoClassification.....	1-3
1.5 Report Structure.....	1-3
1.5.1 EcoClassification (Chapter 2).....	1-3
1.5.2 Ecological Importance and Sensitivity (Chapter 3).....	1-3
1.5.3 Socio-Cultural Importance (Chapter 4).....	1-3
1.5.4 Present Ecological State (Chapter 5).....	1-4
1.5.5 Recommendations (Chapter 6).....	1-4
2. ECOCLASSIFICATION.....	2-1
2.1 Background.....	2-1
2.2 Process.....	2-1
2.3 Level of EcoClassification Assessment.....	2-3
2.3.1 Importance.....	2-3
2.3.2 Present Ecological State (PES).....	2-3
2.4 Confidence Levels.....	2-4
3. ECOLOGICAL IMPORTANCE AND SENSITIVITY.....	3-1
3.1 EIS Model.....	3-1
3.2 Electronic Database.....	3-2
3.3 EIS Results.....	3-3
3.4 Conclusions.....	3-8
4. SOCIO-CULTURAL IMPORTANCE.....	4-1
4.1 Overview.....	4-1
4.2 Social Environment.....	4-1
4.3 SCI Model.....	4-2
4.4 SCI Results.....	4-3
4.5 Conclusions.....	4-8
5. PRESENT ECOLOGICAL STATE.....	5-1
5.1 PES Model (Modified from Kleynhans <i>et al.</i> , 2005).....	5-1
5.2 Electronic Database.....	5-3
5.3 PES Results.....	5-4
5.4 Conclusions.....	5-9
6. RECOMMENDATIONS.....	6-1
6.1 Integrated (Ecological and Socio-Cultural) Importance.....	6-1
6.2 Recommendations.....	6-4
6.2.1 Importance of Water Resource Use.....	6-5
6.2.2 Determine level of EWR.....	6-5
7. REFERENCES.....	7-1

LIST OF TABLES

Table 3-1: EIS categories (Modified from DWAF 1999) 3-2

Table 3-2: Summarised EIS results per quaternary catchment..... 3-3

Table 4-1: SCI rating 4-3

Table 4-2: SCI results..... 4-3

Table 5-1: Summarised PES results per quaternary catchment..... 5-4

Table 6-1: Quaternaries of high and very high Integrated Importance 6-2

Table 6-2: Quaternary catchments of high Integrated Importance and/or high Water Resource Use Importance..... 6-6

Table 6-3: Summary of High priority areas..... 6-8

LIST OF FIGURES

Figure 2-1: Flow diagram illustrating the information generated to determine the range of ECs for which EWRs will be determined 2-2

Figure 3-1: EIS and confidence evaluation illustrated as bar graphs for the Middle Vaal WMA..... 3-6

Figure 3.2: EIS per quaternary catchment with associated confidence 3-7

Figure 4-1: SCI and confidence evaluation illustrated as bar graphs 4-6

Figure 4-2: SCI map illustrating SCI rating and confidence 4-7

Figure 5-1: Illustration of the distribution of ecological categories on a continuum 5-1

Figure 5-2: Desktop EcoStatus determination..... 5-2

Figure 5-3: Eco-Status desktop level..... 5-3

Figure 5-4: PES and confidence evaluation illustrated as bar graph 5-7

Figure 5.5: PES map illustrating PES categories and confidence 5-8

Figure 6-1 Matrix used to determine a combined EIS and PES value which provides an Integrated Importance value on a scale of 0 – 4..... 6-1

Figure 6.2: Map illustrating areas of high Integrated Importance 6-3

Figure 6-3: Matrix indicating the level of EWR assessments required 6-4

Figure 6-4 Sections in rivers which are important for Reserve assessment (Hotspots) (derived from overlaying Integrated Importance and Water Resource Use) 6-9

ACRONYMS

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-point 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.

***Comprehensive Reserve Determination Study for the Integrated Vaal River
System: Middle Vaal Water Management Area***

DESKTOP ECOCLASSIFICATION REPORT

1. INTRODUCTION

1.1 Background

The CD: RDM identified the Integrated Vaal River System, with the focus of this study, the Middle Vaal Water Management Area (WMA) and part of the Upper Orange 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 DWAF. These studies require higher levels of confidence in the Reserve determination results than is currently available. This will assist the DWAF to make informed decisions regarding the authorisation of future water use and magnitude of the impacts of the present and proposed developments.

A Desktop EcoClassification, will serve as a scoping phase to investigate the WMAs at a desktop level and at a scale of quaternary catchments and serves as the basis for most other tasks in the Reserve determination process. This scoping assessment provides an overview of the WMAs and a better understanding when focussing on the EWR sites and the sections of rivers where comprehensive assessments will be undertaken. The output of the information also identifies areas of potential concern based on an integrated importance (combination of Ecological Importance and Sensitivity, Socio-Cultural Importance and Present Ecological State).

1.2 Study Area

1.2.1 Middle Vaal WMA

The study area for the Reserve determination is the Middle Vaal system and is represented by WMA 9. WMA 9 is part of a larger water supply system, which includes adjacent WMAs, and Lesotho. The Middle Vaal WMA is one of the three WMAs in the Vaal River catchment, which is the drainage area of the Vaal River and its headwaters to the confluence of the Vaal and Orange Rivers (DWAF, 2002, 2003, 2004 and 2006).

The Middle Vaal WMA covers a catchment area of 52 563 km², and includes parts of the Free State and North-West Provinces. It is situated in the north-western part of the country and forms part of the Orange River watercourse. The Vaal River flows in a westerly direction to the Lower Vaal WMA. It is the middle WMA within the Vaal River System, with water being transferred *via* the Vaal River through this WMA to Bloemhof Dam, from the Upper Vaal WMA to the Lower Vaal WMA. The WMA consists of the C24, C25, C41, C42, C43, C60 and C70 tertiary catchments.

The surface flow of the Vaal River, most of which originates in the Upper Vaal WMA, represents the bulk of the surface water in the Middle Vaal WMA. The Vaal River is fed by a number of tributaries of which the most significant are the Renoster, Schoonspruit, Vals and Vet Rivers. Vlei areas occur along the lower Vet River and in the upper Schoonspruit catchment. The surface water flows that originate within the WMA are highly seasonal and intermittent.

1.3 Objectives of the Middle Vaal Reserve Determination Study

The overall aim of the project as described in the Terms of Reference (ToR) is to provide EcoClassification results and Reserves for WMA 9. The detailed aims, objectives and proposed outcomes of the study are as follows:

- Provide the typing, importance and habitat integrity for wetlands and make recommendations regarding Reserve assessments;
- Provide a Desktop assessment per quaternary catchment of the Present Ecological State (PES), Ecological Importance and Sensitivity (EIS) and Socio-cultural Importance (SCI) as part of the EcoClassification process;
- Provide a Level 4 EcoStatus assessment for the Resource Units (RUs) represented by comprehensive Ecological Water Requirements (EWRs) sites as part of the EcoClassification process;
- Identify other Ecological Categories (ECs) and provide implications / consequences of these categories;
- Determine EWRs for each of the ECs;
- Determine the impact of EWRs on the allocatable yield and, based on the impacts, devise additional scenarios;
- Provide the Ecological Specifications (EcoSpecs), as input into the Resource Quality Objectives (RQOs), associated with the Management Class provided to the Provisional Service Provider (PSP);
- Train selected specialist trainees in specific tasks relating to Reserve determinations.

1.4 Purpose of this Report

This report provides the outcomes of the following study:

A Desktop assessment per quaternary catchment of the Present Ecological State (PES), Ecological Importance and Sensitivity (EIS) and Socio-cultural Importance (SCI) as part of the EcoClassification process.

The objective of this report is to summarise the approach, document the results on a quaternary basis and provide recommendations on the level of EWR assessment.

1.4.1 Desktop EcoClassification

The more detailed objectives and approach to the Desktop EcoClassification was:

- Determining the Present Ecological Status (PES) of the system, applying a Quick Habitat Integrity (QHI), as well as considering the biota's responses within the EcoQuat model.
- Determining the Ecological Importance and Sensitivity (EIS): This assessment of the EIS uses indicators such as presence of rare and / or sensitive species and sensitive habitats to provide an evaluation.
- The Socio-Cultural Importance (SCI): This assessment of the importance of the river was undertaken in terms of sustainable utilisation of the ecological goods and services provided by the river, as well as assessing the cultural use and aesthetic values of the river.

Evaluations are provided on a quaternary scale with the degree of confidence in the evaluations attached to each quaternary. Note that the main rivers in the quaternaries were mostly assessed with the limited emphasis on the rivers at sub-quaternary level.

Various study sites will be selected during the course of the study. At these sites, Level 4 EcoClassification (Kleynhans *et al.*, 2007) will be applied. This refers to a more detailed process.

1.5 Report Structure

This report combines various aspects that relate to the Desktop EcoClassification. The chapters are summarised as follows.

1.5.1 EcoClassification (Chapter 2)

This chapter provides an overview of the purpose of the EcoClassification and the process. Detail on where information was sourced with specific emphasis on the PES, the EIS and the SCI is given. The level of EcoClassification and confidence levels are discussed.

1.5.2 Ecological Importance and Sensitivity (Chapter 3)

This chapter details the use and application of the EIS model, which ecological aspects were considered as the basis for the estimation of EIS, a description of the electronic database and the EIS results. The EIS per quaternary catchment with associated confidence is provided in map format.

1.5.3 Socio-Cultural Importance (Chapter 4)

This chapter provides an overview of the economic importance of the study area as well as the social environment. The chapter provides detail on how SCI scores were generated and the application of the SCI model. SCI results and a map illustrating SCI rating and confidence are provided.

1.5.4 Present Ecological State (Chapter 5)

This chapter deals with a description and application of the PES model, what level of detail was applied and what information was used in the desktop analysis. The electronic database is explained and the results are provided. A PES map illustrating the PES categories and confidence are provided.

1.5.5 Recommendations (Chapter 6)

This chapter discusses the results of the desktop assessment in terms of the Integrated Ecological Importance of the rivers assessed in the WMA 9. A map illustrating areas of high Integrated Importance for WMA 9 is provided. These areas are then compared to areas of high Water Resource Use and areas which require detailed EWR assessments are thus identified.

2. ECOCLASSIFICATION

2.1 Background

EcoClassification (Kleynhans *et al.*, 2007) is the term used for Ecological Classification. It refers to the determination and categorisation of the PES (in terms of health or integrity) of the various biophysical attributes of rivers as compared to the natural, or close to natural, reference condition. The purpose of undertaking the EcoClassification was to gain insight into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provided the information needed to derive desirable and attainable future ecological objectives for the river. The EcoClassification process also supports a scenario-based approach when a range of ecological endpoints have to be considered.

The state of the river is expressed in terms of biophysical components:

- Drivers (e.g. physico-chemical variables, geomorphology, hydrology), which provide a particular habitat template; and
- Biological responses (displayed by e.g. fish, riparian vegetation and aquatic invertebrates).

Different processes were followed for each component to assign a category from A→F (where A is natural, and F is critically modified) to each component. Ecological evaluation against the expected reference conditions followed by integration of the categories of each component, provides a description of the Ecological Status or EcoStatus of a river. Thus, the EcoStatus can be defined as the totality of the features and characteristics of the river and its riparian areas that influence its ability to support an appropriate natural flora and fauna (modified from: Iversen *et al.*, 2000). This ability relates directly to the capacity of the system to provide a variety of goods and services.

2.2 Process

The steps followed in EcoClassification are as follows:

- Determine the reference conditions for each component;
- Determine the PES for each component, as well as the EcoStatus;
- Determine the trend for each component, as well as the EcoStatus;
- Determine reasons for the PES and whether these are flow or non-flow related;
- Determine the EIS for the biota and habitat;
- Determine the SCI;
- Considering the PES, the EIS and the SCI; suggest a realistic Recommended Ecological Category (REC) for each component, as well as for the EcoStatus;
- Determine alternative Ecological Categories (ECs) for each component, as well as for the EcoStatus.

The flow diagram (Kleynhans *et al.*, 2007) (Figure 2-1) illustrates the process.

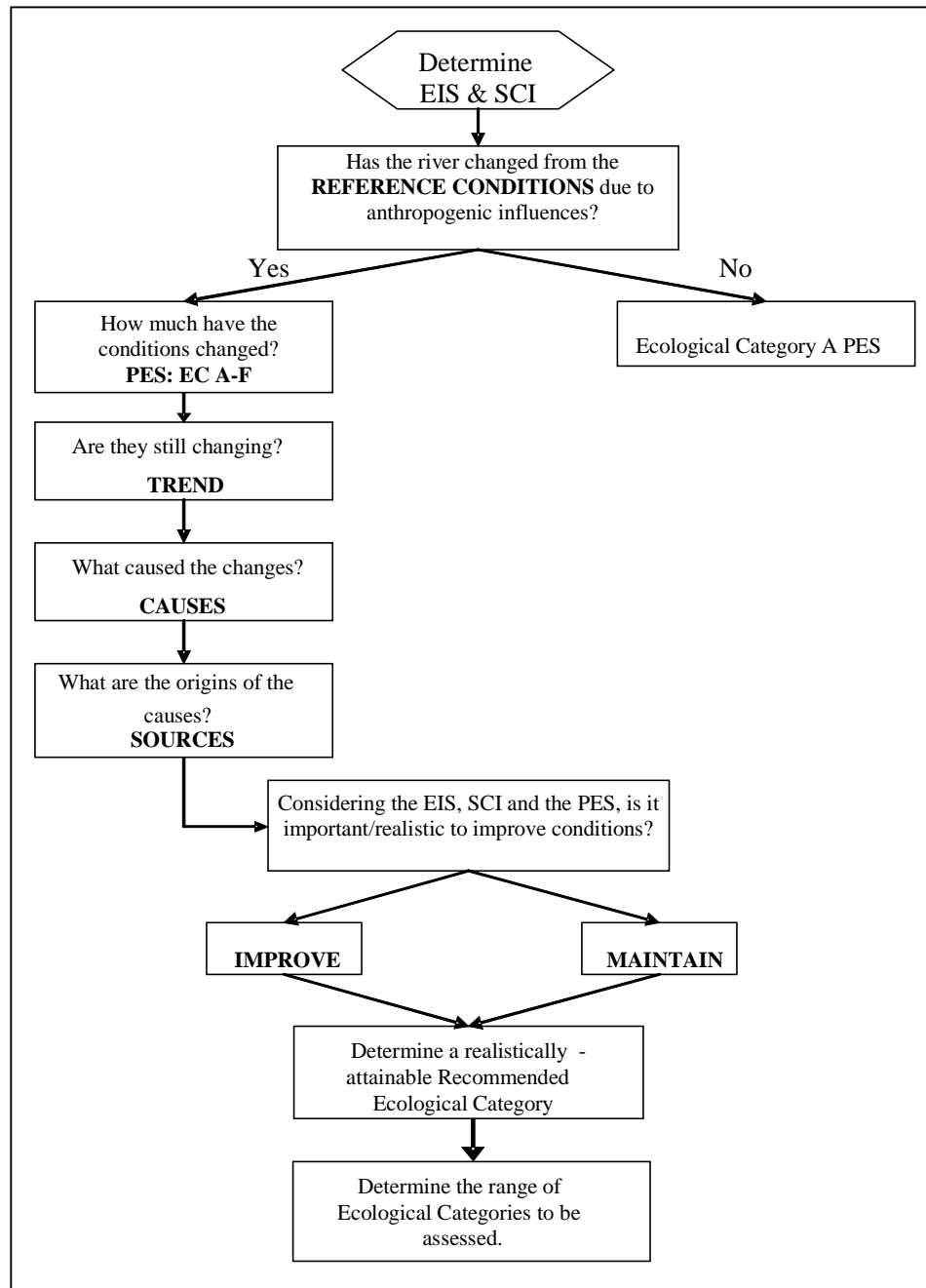


Figure 2-1: Flow diagram illustrating the information generated to determine the range of ECs for which EWRs will be determined

This study is aimed to collate all information pertaining to the EcoClassification with specific emphasis on the PES, the EIS and the SCI. Information on the EcoClassification for the study area was sourced from:

- Previous Ecological Reserve assessments;
- Extensive fish surveys covering the whole study area;
- Invertebrate surveys;
- Desktop PES and EIS database for South Africa and quaternary catchments (Kleynhans, 2000);
- Reconnaissance site visit. This included visiting at least 20 potential EWR points on the rivers of WMA 9. Various other rivers have also been visited during the River Health Programme and members of DWAF accompanied the project team on this site reconnaissance visit.
- Various aerial videos undertaken through Habitat Integrity surveys for the main rivers in WMA 9;
- Analysis of 1:50 000 topographical maps covering the region;
- Analysis of the Demarcation Board socio-economic database for the area and other relevant planning documentation at district and local municipality level.

The original PES-EIS database (Kleynhans, 2000) was updated with new information for all quaternary catchment, based either on expert input or recent studies undertaken, as well as by completing the process for the quaternary catchments in the Study area that were not previously assessed and is presented in this report.

The database is supplied in electronic format as Excel Spreadsheets. The spreadsheets are summarised in this document, using tables and maps.

2.3 Level of EcoClassification Assessment

2.3.1 Importance

Importance consists of Ecological and Socio-Cultural importance which is assessed separately. Standard importance models were used irrespective of the level of the assessment, although the information used to populate the models varied according to the level of assessment.

2.3.2 Present Ecological State (PES)

A range of EcoStatus levels, with tools of correspondingly different complexity were utilised in consideration of time and funding constraints. As EcoStatus levels become less complex, less complex tools must be used. The following tools were used to determine the PES within the EcoQuat Model:

- Quick Habitat Integrity (QHI);
- Desktop Fish Response Rating;
- Desktop Invertebrate Response Rating;

- Desktop Riparian Vegetation Response Rating.

These tools were used to generate a database which in turn provided a PES for the EcoStatus of the main rivers in the quaternary catchments of WMA 9.

2.4 Confidence Levels

The Confidence levels were evaluated as follows:

1. low confidence;
2. low to moderate confidence;
3. moderate confidence;
4. moderate to high confidence; and
5. high confidence.

Confidence was evaluated by considering the information available, the tools used and the expert knowledge available. For this level assessment, the expected confidence is between 1 and 3. The confidence is indicated in the database and summary tables.

Information from DWAF (2004a and b) reports were used for the Vals and Rhenoster rivers.

3. ECOLOGICAL IMPORTANCE AND SENSITIVITY

3.1 EIS Model

The EIS Model was developed by Dr CJ Kleynhans (DWAF, 1999a). The ecological importance of a river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Resh *et al.*, 1998; Milner, 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of Ecological Importance and Sensitivity (EIS).

This approach estimates and classifies the EIS of the streams in a catchment by considering a number of components surmised to be indicative of these characteristics. This procedure was originally developed for assessment of mainstream rivers in quaternary catchments (Schulze *et al.*, 1997). Although the delineation of quaternary catchments is not based on ecological principles, the EIS approach can be used for any river delineation. However, it must be realised that the EIS and the reality of the approach may be low due to the omission of an ecological typing framework.

The following ecological aspects were considered as the basis for the estimation of EIS (Kleynhans in DWAF, 1999a):

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, intolerant species and species diversity were taken into account for both the instream and riparian components of the river;
- Habitat diversity was also considered. This includes specific habitat types such as reaches with a high diversity of habitat types, i.e. pools, riffles, runs, rapids, waterfalls, riparian forests, etc.

With reference to the points above, biodiversity in its general form (i.e., Noss, 1990) was taken into account as far as the available information allowed:

- The importance of a particular river or stretch of a river in providing connectivity between different sections of the river, i.e., whether it provided a migration route or corridor for species, was considered;
- The presence of conservation or relatively natural areas along the river section also served as an indication of Ecological Importance and Sensitivity; and
- The sensitivity (or fragility) of the system and its resilience (i.e., the ability to recover following disturbance) of the system to environmental changes was also considered. Consideration of both the biotic and abiotic components was included here.

This system is regarded as a guideline for the professional ecological judgement by individuals familiar with a particular area. The assessors scored a number of biotic and habitat determinants considered to be important for the determination of EIS. The median of these scores was calculated to

derive the EIS category (Table 3-1). This was only applicable to the main stem river in a quaternary catchment.

Table 3-1: EIS categories (Modified from DWAF 1999)

EIS Categories	General Description
Very High	Quaternaries/ delineations that are considered to be unique on a national or even international level, based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.
High	Quaternaries /delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications, but in some cases, may have a substantial capacity for use.
Moderate	Quaternaries / delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.
Low	Quaternaries / delineations that is not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use

3.2 Electronic Database

The electronic database is provided as a CD and explained below. The EIS information is on the Excel Sheet: EIS. The columns and colouration are explained below:

Colour coding: Light yellow in column A, E and G indicate the quaternaries which have been updated and the specific ratings (scores) which have changed from the Kleynhans database (Kleynhans, 2000).

- Column A: Quaternary catchment number;
- Column B: Main river per quaternary;
- Column C: EIS metrics;
- Column D: The original 1999 score;
- Column E: The revised or new 2008 score;
- Column F: The original 1999 confidences out of 4;
- Column G: The revised or new 2008 confidence out of 4;
- Column H: 1999 EIS score (calculated in spreadsheet);

- Column I 2008 EIS score (calculated in spreadsheet);
- Column J 1999 EIS evaluation (calculated in spreadsheet);
- Column K 2008 EIS evaluation (calculated in spreadsheet);
- Column L Comments;
- Column M Source: The source of any updated information;
- Column N Average confidence out of 4 (calculated in spreadsheet);
- Column O Average confidence out of 5 (calculated in spreadsheet);

3.3 EIS Results

The results are provided as follows:

- Summarised EIS per quaternary catchment (Table 3-2);
- Bar graph (Figure 3-1);
- Catchment map (Table 3-2).

Note that the following GIS coverages used in the maps were provided by D: RQS.

- WMA, EcoRegions, Geomorphic zones, 1:5 00 000 rivers coverage.

Table 3-2: Summarised EIS results per quaternary catchment

QUATERNARY CATCHMENT	RIVER	EIS	CONFIDENCE (0-4)
C70A	Renoster	MODERATE	2.4
C70B	Renoster	MODERATE	2.6
C70C	Renoster at Koppies Dam	MODERATE	2.6
C70D	Renoster system (downstream from Koppies dam)	MODERATE	2.6
C70E	Renoster system	MODERATE	2.6
C70F	Renoster (+ tributaries)	MODERATE	2.6
C70G	Renoster system	HIGH	2.6
C70H	Renoster system	HIGH	2.6
C70J	Renoster	HIGH	2.6
C70K	Renoster	HIGH	2.65

QUATERNARY CATCHMENT	RIVER	EIS	CONFIDENCE (0-4)
C24A	Koekemoerspruit	MODERATE	1.6
C24B	Vaal (main) (downstream Koekemoerspruit confluence/upstream Schoonspruit)	HIGH	3.8
C24C	Dry Harts (and tributaries)	MODERATE	1.5
C24D	Rietspruit/Rietspruit Dam	MODERATE	2.3
C24E	Rietspruit	MODERATE	1.3
C24F	Taaibosspruit (and Monamaladi)	MODERATE	3.8
C24G	Buisfonteinspruit/ Johan Nesor Dam	MODERATE	4.1
C24H	Schoonspruit (below dam upstream of Jagspruit confluence)	MODERATE	4.0
C24J	Vaal River (main)	MODERATE	1.4
C60A	Vals (upper reaches)	MODERATE	1.4
C60B	Vals (upper reaches)/Lindley Dam/Arlington Dam	MODERATE	1.3
C60C	Vals (middle reaches)	MODERATE	2.0
C60D	Vals (middle reaches) (upstream tributary/Serfontein Dam)	MODERATE	1.4
C60E	Upper Sand (upstream of dams)	MODERATE	2.0
C60F	Tributary	MODERATE	1.6
C60G	Vals River (upstream of tributary - C60H)	MODERATE	1.6
C60H	Tributary of Vals	MODERATE	2.5
C60J	Vals River (upstream confluence)	MODERATE	1.3
C25A	Klipspruit	HIGH	2.9
C25B	Sandspruit	MODERATE	3.8
C25C	Vaal main (minor tributary)	MODERATE	1.3
C25D	Makwassie spruit (Wolmaranstad Dam/Makwassie Dam)	MODERATE	1.3
C25E	Tributary into Bloemhof	MODERATE	3.8
C25F	Bloemhof Dam	MODERATE	1.4
C41A	Klein Vet	MODERATE	1.4
C41B	Upper Sand (upstream of dams)	MODERATE	1.4
C41C	Lengana	MODERATE	1.4
C41D	Leeuspruit /Saliba Dam	MODERATE	2.1
C41E	Erfenis Dam	MODERATE	1.3

QUATERNARY CATCHMENT	RIVER	EIS	CONFIDENCE (0-4)
C41F	Tributary to Vet (downstream of Erfenis Dam)	MODERATE	2.5
C41G	Tributary to Vet (downstream of Erfenis Dam)	MODERATE	2.5
C41H	Vet river	MODERATE	2.5
C41J	Vet river (upstream confluence)	MODERATE	1.4
C42A	Upper Sand (upstream of dams)	MODERATE	1.4
C42B	Upper Sand (upstream of dams)	MODERATE	1.4
C42C	Upper Sand (upstream of dams)	MODERATE	1.4
C42D	Upper reaches Sand (after confluence) upstream Allemanskraal Dam	MODERATE	1.4
C42E	Tributary to Sand river just upstream of Allemanskraal Dam	LOW	2.3
C42F	Tributary to Sand river just downstream of Allemanskraal Dam	LOW	2.3
C42G	Sand just downstream Allemanskraal Dam	MODERATE	2.3
C42H	Sand (middle reaches -upstream Virginia Dam)	MODERATE	2.3
C42J	Sand - Virginia Dam and tributary	MODERATE	2.3
C42K	Tributary to Sand river	MODERATE	2.3
C42L	Sand upstream of confluence with Vet	MODERATE	3.8
C43A	Vet River (downstream confluence with Sand /minor tributary)	MODERATE	3.8
C43B	Endoreic region	LOW	0
C43C	Vet (lower reaches)	MODERATE	3.6
C43D	Vet (just upstream to Bloemhof Dam)	MODERATE	2.5

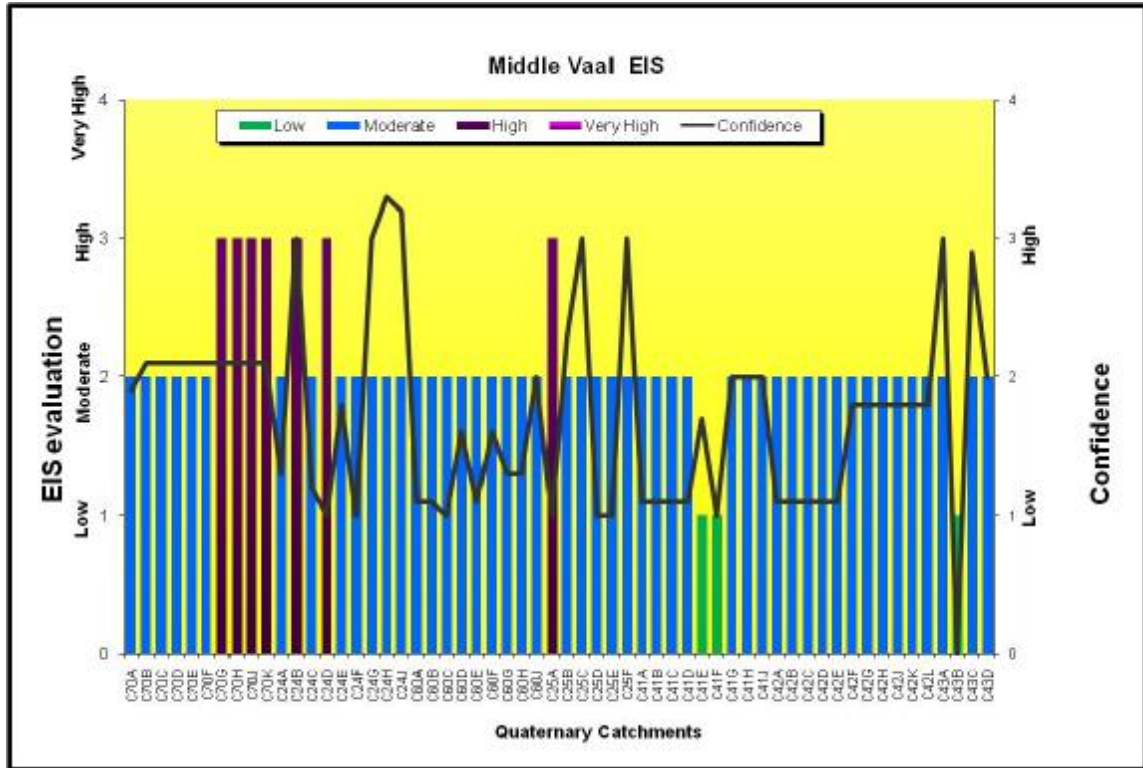


Figure 3-1: EIS and confidence evaluation illustrated as bar graphs for the Middle Vaal WMA

Middle Vaal EIS

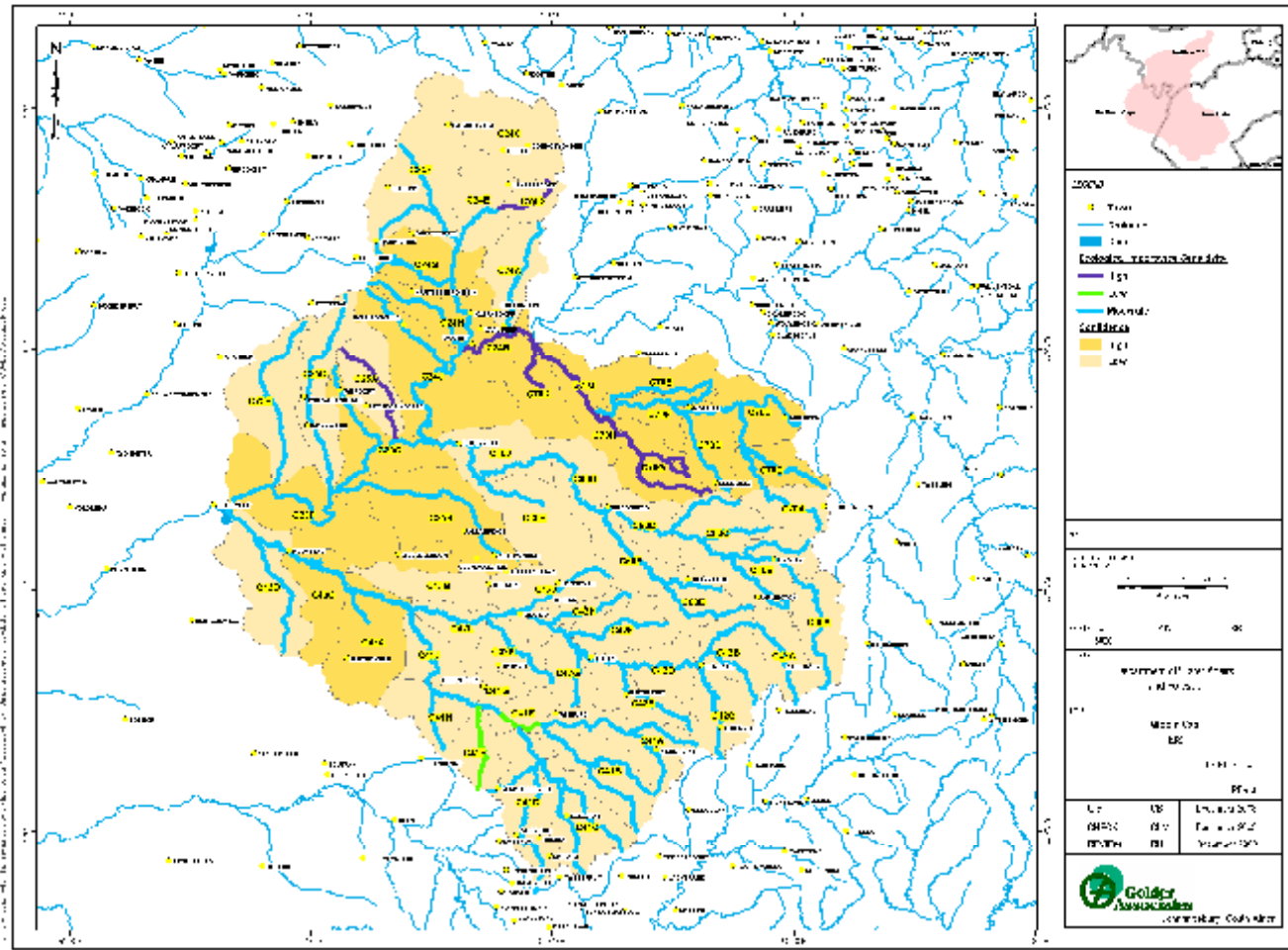


Figure 3.2: EIS per quaternary catchment with associated confidence

3.4 Conclusions

No areas of Very High EIS are present in the WMA. The few areas of high EIS are the following:

- § C70G, C70H, C70J and C70K (Renoster River system) due to the presence of the endangered rock catfish (*Austroglanis sclateri*)
- § C24B (Vaal River) due to the presence of the endangered rock catfish (*A. sclateri*).
- § C24D (Rietspruit River) due to the presence of the Schoonspruit provincial reserve, the location of the Schoonspruit dolomitic eye, and the presence of the endangered rock catfish (*A. sclateri*).
- § C25A (Klipspruit River) due to probable high species diversity, including rock catfish (*A. sclateri*) the site of the Wolvespruit Nature Reserve.

Most of the rest of the quaternary catchments were rated as moderate. The confidence of the evaluation as can be seen from Figure 3.2 ranged mostly from moderate to low with approximately 30% as high.

This EIS evaluation was only undertaken for the main rivers in the quaternaries. Evaluation is still required to identify those rivers of high and very high importance on a sub-quaternary scale.

4. SOCIO-CULTURAL IMPORTANCE

Sections 4.1 and 4.2 have been adapted from DWAF, 2004.

4.1 Overview

The economy of the Middle Vaal WMA contributes about 4% of the GDP of South Africa with the most dominant economic activity being the mining sector, contributing more than 45% of the GDP in the WMA, trade (12.3%), and agriculture (8.9%) (DWAF, 2003). Due to a decline in gold mining activity, a decline in population is also projected for the WMA, with a concomitant effect on the regional economy. Manufacturing activities in the WMA relate to the mining and agriculture sectors as well as items for local consumption. No dramatic changes to the economy of the WMA are foreseen for the medium term. The agricultural sector in the region is relatively stable and will continue to make an important contribution to the regional economy. A minimal change in water requirements is therefore projected.

The Middle Vaal WMA is rural in nature with the land use typically characterised by extensive livestock farming, dry land agriculture and some irrigation farming.

The Middle Vaal WMA's water quality and flow is mainly controlled by activities that take place in the Upper Vaal WMA. The Middle Vaal WMA is dependant on the Upper Vaal WMA for meeting the bulk water requirements of its mining, industrial and urban sectors. Large quantities of water are transferred into the WMA to augment local water resources. These upstream activities include releases from the Vaal Dam and Vaal River Barrage, waste water treatment works discharges, urban runoff and gold mining activities on the Witwatersrand. In the Middle Vaal WMA discharges and decants from gold mining activities in the Mooi and Koekemoer Spruits have an impact on the continued salinity build up in the Vaal River. These impacts are subject to many catchment studies that have been undertaken by DWAF as well as a current Integrated Water Quality Management Plan for the Vaal River system. Management of water quality and quantity in the Middle Vaal WMA is therefore integrally linked to both the Upper and Lower Vaal WMAs.

4.2 Social Environment

Current land use in the WMA is characterised by extensive dry land cultivation in the central parts of the WMA. The largest urban areas are Welkom, Klerksdorp (North West Goldfields) and Kroonstad (Free State Goldfields). Irrigation is practiced downstream of dams and along the main tributaries and at locations along the Vaal River. The WMA is characterised by a large number of goldmines.

The poor in urban areas and rural villages are as important, in the consideration of the distribution and use of water resource, as the small (poor) rural subsistence farmer.

The use of water for recreational purposes is one of the 11 water uses regulated in terms of the NWA. Water resources offer a very significant recreational outlet and that recreation is an important public and social asset necessary for national health and productivity. Recreational use can take many forms

and only occasionally has any direct impact on the water resource. Most obvious are activities such as power-boating, which can have quality / pollution impacts.

4.3 SCI Model

The Socio-Cultural Importance (SCI) was determined from:

- A site visit that covered points along the river;
- Discussions with the regional DWAF offices: and
- Extrapolation to unvisited sites by reference to available literature, as well as to existing mapping.

Given the size of the budget and the geographical scope of the work most of the information used to influence the score was derived from direct observation and consideration of the literature available. A limited number of direct interviews were held with people who are resident proximate to the river.

The SCI was generated by scoring each quaternary catchment based on the following features discussed below.

Ritual Use: This was scored between 0 – 5 by asking the question “How much ritual use of the river takes place?” Typically, ritual use would be for ceremonial purposes or for spiritual / religious activities, for example using pools for traditional initiation purposes.

Aesthetic Value: this was scored between 0 – 5 by asking the questions “How important is the aesthetic value to people? Does the river stretch add value to peoples’ lives as an object of natural beauty? Would changing flows detract from this value?”

Resource Dependence: This was scored between 0 – 5. This refers to the goods and services delivered by the river system and peoples dependence on these components. This is usually a critical element of the SCI score and is designed to cater for river resource dependence by those who rely directly on such aspects for their survival. It should be noted that commercial or “for financial gain” usage of resources is excluded from consideration in this instance.

Recreational Use: this was scored between 0 – 5 by asking the question “Does the river stretch provide recreational facilities to people and would this be affected by changing flows?”

Historical / Cultural Value: This was scored between 0 – 5 by asking the question “Does the river have a strong cultural or historical value?”

Scores were then weighted to reflect the adjusted importance of each component relative to the other. The Resource dependence component was given the highest weighting, given that this component is designed to reflect the importance of a healthy riverine system to people who are often in the grips of poverty and for whom the availability of such resources are a question of survival.

The weighted scores were then combined to generate an overall score between 0 and 5. The meaning of the score is as set out in Table 4-1 below.

Table 4-1: SCI rating

0-1	Minimal	Of little or no socio-cultural importance.
1-2	Low	Of some importance. PES not critical, but caution should be displayed with regard to –ve impact on dependent communities.
2-3	Moderate	Of moderate importance. PES should not be allowed to be –ve affected without strong motivation.
3-4	High	Of high importance. A score in this range motivates for maintain or potentially +ve change to PES.
4-5	Very High	Of extreme importance. A score in this range motivates for +ve change to PES.

4.4 SCI Results

The model is provided in the electronic database on the worksheet labelled SCI.

The results are provided as follows:

- SCI per quaternary catchment (Table 4-2)
- Bar Graph (Figure 4-1)
- Catchment map (Figure 4-2)

Table 4-2: SCI results

QUATERNARY CATCHMENT	RIVER	SCI	CONFIDENCE (0-5)
C70A	Renoster	LOW	2
C70B	Renoster	LOW	2
C70C	Renoster at Koppies Dam	MODERATE	2
C70D	Renoster system (downstream from Koppies dam)	LOW	2
C70E	Renoster system	LOW	2
C70F	Renoster (+ tributaries)	LOW	4
C70G	Renoster system	LOW	4
C70H	Renoster system	LOW	2
C70J	Renoster	LOW	2
C70K	Renoster	LOW	2
C24A	Koekemoerspruit/Kromdraaispruit (before confluence)	LOW	2

QUATERNARY CATCHMENT	RIVER	SCI	CONFIDENCE (0-5)
	Koekemoerspruit (downstream confluence)	MINIMAL	2
C24B	Vaal (main) (downstream Koekemoerspruit confluence/unstream Schoonspruit)	MODERATE	2
C24C	Dry Harts (and tributaries)	LOW	2
C24D	Rietspruit/Rietspruit Dam	MODERATE	2
C24E	Rietspruit	LOW	2
C24F	Taaibosspruit (and Monamaladi)	LOW	2
C24G	Buisfonteinspruit/ Johan Nesor Dam	MODERATE	2
C24H	Schoonspruit (below dam upstream of Jagspruit confluence)	LOW	3
C24J	Vaal River (main)	MODERATE	3
C60A	Vals (upper reaches)	LOW	3
C60B	Vals (upper reaches)/Lindley Dam/Arlington Dam	MODERATE	3
C60C	Vals (middle reaches)	LOW	3
C60D	Vals (middle reaches) (upstream tributary/Serfontein Dam)	MODERATE	2
C60E	Upper Sand (upstream of dams)	LOW	3
C60F	Tributary	LOW	3
C60G	Vals River (upstream of tributary - C60H)	LOW	3
C60H	Tributary of Vals	LOW	3
C60J	Vals River (upstream confluence)	LOW	2
C25A	Klipspruit	LOW	3
C25B	Sandspruit	LOW	2
C25C	Vaal main (minor tributary)	MODERATE	4
C25D	Makwassie spruit (Wolmaranstad Dam/Makwassie Dam)	MODERATE	2
C25E	Tributary into Bloemhof	LOW	2
C25F	Bloemhof Dam	MODERATE	2
C41A	Klein Vet	LOW	2
C41B	Upper Sand (upstream of dams)	LOW	2
C41C	Lengana	LOW	4
C41D	Leeuspruit /Saliba Dam	MODERATE	3
C41E	Erfenis Dam	MODERATE	2
C41F	Tributary to Vet (downstream of Erfenis Dam)	LOW	3
C41G	Tributary to Vet (downstream of Erfenis Dam)	LOW	3
C41H	Vet river	LOW	3

QUATERNARY CATCHMENT	RIVER	SCI	CONFIDENCE (0-5)
C41J	Vet river (upstream confluence)	LOW	3
C42A	Upper Sand (upstream of dams)	LOW	2
C42B	Upper Sand (upstream of dams)	LOW	2
C42C	Upper Sand (upstream of dams)	LOW	3
C42D	Upper reaches Sand (after confluence) upstream Allemanskraal	MODERATE	2
C42E	Tributary to Sand river just upstream of Allemanskraal Dam	MODERATE	3
C42F	Tributary to Sand river just downstream of Allemanskraal Dam	LOW	3
C42G	Sand just downstream Allemanskraal Dam	MODERATE	2
C42H	Sand (middle reaches -upstream Virginia Dam)	MODERATE	2
C42J	Sand - Virginia Dam and tributary	LOW	2
C42K	Tributary to Sand river	LOW	3
C42L	Sand upstream of confluence with Vet	LOW	3
C43A	Vet River (downstream confluence with Sand /minor tributary	LOW	2
C43B	Endoreic region	MINIMAL	2
C43C	Vet (lower reaches)	LOW	2
C43D	Vet (just upstream to Bloemhof Dam)	MODERATE	2

4.5 Conclusions

Areas dominated by relatively low population densities and given over to commercial farming enterprises (typically the middle Vaal, and the middle and lower parts of the Vet, Vals, Schoonspruit and Sand catchments) tended to score relatively low in terms of SCI. An obvious exception is recreational use associated with dams and the main stem of the Vaal River. Portions of the WMA with water related recreational activity scored slightly higher. Areas dominated by mining and industrialisation also scored generally low in terms of SCI. It should be emphasised that low SCI score does not indicate low economic importance. In terms of economic importance the catchment is obviously important to the RSA with the gold mining activities in the KOSH area.

5. PRESENT ECOLOGICAL STATE

5.1 PES Model (Modified from Kleynhans *et al.*, 2005)

The PES of a river is expressed in terms of various components, i.e. drivers (Physico-chemical variables, geomorphology, hydrology) and biological responses (fish, riparian vegetation and aquatic invertebrates), as well as in terms of an integrated state, the EcoStatus. The ecological state of the components and the EcoStatus are categorised from A to F. It must be emphasised that the scale represents a continuum, and that the boundaries between categories are notional, artificially-defined points along the continuum. There may therefore be cases where there is uncertainty as to which category a particular entity belongs. The situation falls within the concept of a fuzzy boundary, where a particular entity may potentially have membership of both classes (Robertson *et al.*, 2004). For practical purposes, these situations are referred to as boundary categories and are denoted B/C, C/D and so on. The B/C boundary category, for example, is indicated as the dark-blue to light green area in Figure 5-1.



Figure 5-1: Illustration of the distribution of ecological categories on a continuum

A Desktop Level EcoStatus assessment (Figure 5-2) was designed for use when assessments for planning purposes on large scale have to be undertaken. As the name indicates, this method is usually carried out at desktop level, and is therefore based on available information and expert judgement. In this instance, however, a site visit was undertaken to provide additional information due to lack of relevant information in some of the study area.

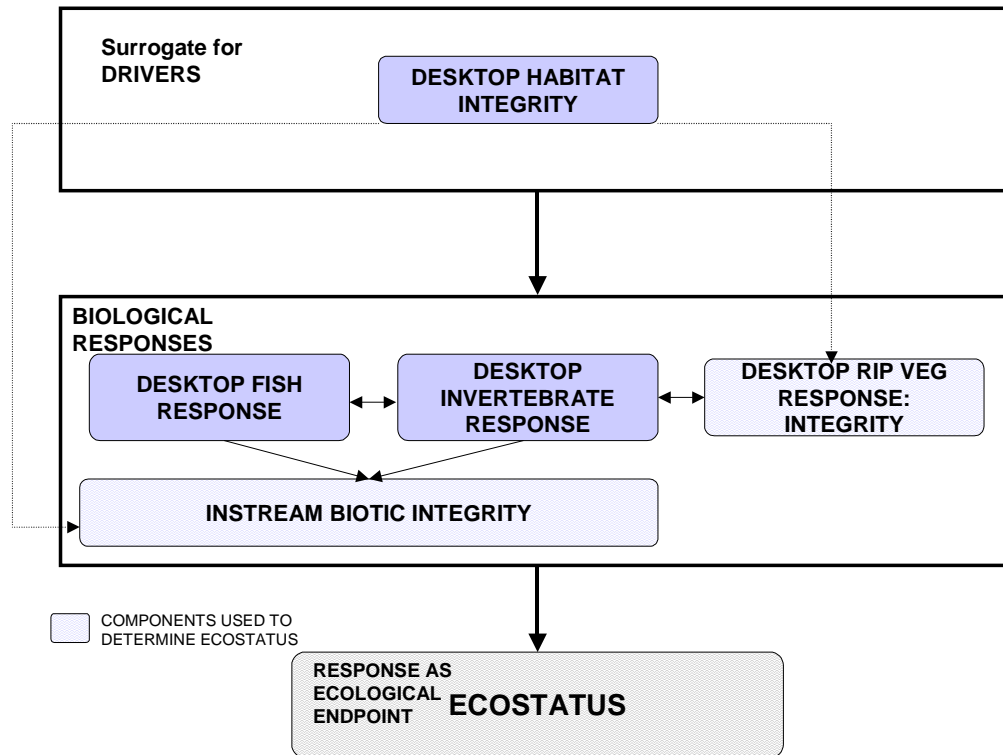


Figure 5-2: Desktop EcoStatus determination

To accommodate the less-detailed process, the following deviations from the detailed EcoStatus level method were required: Note: the detailed level will be applied to river reaches in which the EWR sites are situated.

- A Quick Habitat Integrity was developed. This approach allows for a coarse assessment and rates the habitat according to a scale of 0 (close to natural) to 5 (critically modified), according to the following metrics:
 - Bed Modification;
 - Flow Modification;
 - Introduced instream biota;
 - Inundation;
 - Riparian / bank condition; and
 - Water quality modification.
- This Quick Habitat Integrity approach serves as a substitute for the drivers, as well as playing a role in assessing the EcoStatus. This is necessary because the response information is of low confidence;
- To accommodate the lack of fish and invertebrate response information, the Quick Habitat Integrity results are brought into the equation to calculate the Instream Ecological Category (EC). The instream EC is therefore a combination of the Desktop Habitat Integrity and the Desktop fish, invertebrate and riparian vegetation ECs.

As the EcoStatus is primarily targeted towards the Instream Integrity, and as the derived vegetation EC is inherently of lower confidence, the instream EC comprises two thirds of the EcoStatus. The model is illustrated in Figure 5-3.

DESKTOP LEVEL	
	RATING
Bed modification	2.0
Flow modification	1.0
Introduced instream biota	3.0
Inundation	1.0
Riparian/bank condition	3.0
Water quality modification	1.0
HABITAT INTEGRITY	1.8
DESKTOP INVERTEBRATE RATING	3.0
DESKTOP FISH RATING	3.0
INSTREAM EC%	56.9
INSTREAM EC%	D
DESKTOP VEGETATION	2.0
	0.7
ECOSTATUS %	60.7
ECOSTATUS EC	C
BOUNDARY EC	

Figure 5-3: Eco-Status desktop level

5.2 Electronic Database

The electronic database is available on a CD.

The columns are explained below:

- Column A: Quaternary catchment number;
- Column B: Main river per quaternary, according to the Kleynhans database, and corrected, where required;
- Column D-O: Quick Habitat Integrity metrics;
- Column Q: Quick Habitat Integrity (calculated in spreadsheet);
- Column R: Desktop Invertebrate rating (value provided from 0 – 5);
- Column S: Desktop Invertebrate % (calculated in spreadsheet);
- Column T: Desktop Fish rating (value provided from 0 – 5);
- Column U: Desktop Fish % (calculated in spreadsheet);
- Column V: Instream EC % (calculated in spreadsheet);

- Column X: Instream EC (calculated in spreadsheet);
- Column Y: Desktop Riparian vegetation rating (value provided from 0 -5)
- Column Z: Desktop Riparian vegetation % (calculated in spreadsheet)
- Column AA: EcoStatus percentage (calculated in spreadsheet)
- Column AC: EcoStatus EC (calculated in spreadsheet)
- Column AD: Confidence evaluation out of 5
- Column AE: Source and relevant comments

5.3 PES Results

The results are provided as follows:

- Summarised PES per quaternary catchment (Table 5-1);
- Bar graphs for the PES (Figure 5-4);
- Catchment maps of the PES (Figure 5.5).

Table 5-1: Summarised PES results per quaternary catchment

QUATERNARY CATCHMENT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)	SOURCE
C70A	Renoster	C	2	Knowledge based on Google Earth and historical fish records
C70B	Renoster	B/C	2	Knowledge based on Google Earth and historical fish records
C70C	Renoster; Koppies Dam	C	1	Google Earth only
C70D	Renoster system (downstream from Koppies dam)	C	2	Knowledge based on Google Earth and historical fish records
C70E	Renoster system	C	2	Knowledge based on Google Earth and historical fish records
C70F	Renoster (+ tributaries)	C	2	Knowledge based on Google Earth and historical fish records
C70G	Renoster system	C	3	Google Earth, historical and recent biota surveys, personal knowledge
C70H	Renoster system	C	2	Knowledge based on Google Earth and historical fish records
C70J	Renoster	B	2	Knowledge based on Google Earth and historical fish records
C70K	Renoster	B	3	Google Earth, historical and recent biota surveys, personal knowledge

QUATERNARY CATCHMENT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)	SOURCE
C24A	Koekemoerspruit/Kromdaaispruit (before confluence)	B/C	2	Google Earth, access problems, some fish and invert records.
	Koekemoerspruit (downstream confluence)	C	2	0
C24B	Vaal (main) (downstream Koekemoerspruit confluence/upstream Schoonspruit)	B	2	Survey data also visual assessment on Google Earth and historical fish records
C24C	Upper Schoonspruit (including Schoonspruit eye)	C	2	Google Earth, access problems, some fish and invert records.
C24D	Rietspruit/Rietspruit Dam	C	2	Google Earth, access problems,.
C24E	Schoonspruit main stem and Rietspruit	C	4	Bivane IFR site, fish and invertebrate information
C24F	Taaibosspruit (and Monamaladi)	C	2	Google Earth, limited information
C24G	Buisfonteinspruit/ Johan Naser Dam	C	2	Google Earth, limited information
C24H	Schoonspruit (below dam upstream Jagspruit confluence)/Jagspruit	C	2	Google Earth, some fish information
C24J	Vaal River (main)	D	3	Visited, Google Earth, some fish information
C60A	Vals (upper reaches)	D	2	Google Earth, derived information from area visited, fish records.
C60B	Vals (upper reaches)/Lindley Dam/Arlington Dam	C	2	Google Earth, derived information from area visited, fish records.
C60C	Vals (middle reaches)	D	3	Google Earth, area visited, fish records.
C60D	Vals (middle reaches) (upstream tributary/Serfontein Dam	E	4	Google Earth, area visited, fish records.
C60E	Upper Sand (upstream of dams)	D/E	4	Google Earth, area visited, fish records.
C60F	Trib	D	4	Google Earth, area visited, fish records.
C60G	Vals River (upstream of tributary - C60H)	E	3	Area visited, Google Earth, extensive fish and invertebrate information
C60H	Trib. of Vals	C/D	3	Area visited, Google Earth, extensive fish and invertebrate information
C60J	Vals River (upstream confluence)	C	3	Area visited, Google Earth, extensive fish and invertebrate information
C25A	Klipspruit	C	3	Area visited, Google Earth, extensive fish and invertebrate information
C25B	Sandspruit	C	2	Google Earth, some fish and invertebrate information
C25C	Vaal main (minor tributary)	C	3	Area visited, Google Earth, extensive fish and invertebrate information

QUATERNARY CATCHMENT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)	SOURCE
C25D	Makwassie spruit (Wolmaranstad Dam/Makwassie Dam)	C	4	Area known to specialists, Google Earth, fish survey information
C25E	Tributary into Bloemhof	C	3	Google Earth, river known to specialists
C25F	Bloemhof Dam	C	4	Present surveys, area visited, EFR 2 situated in quat, Google Earth.
C41A	Klein Vet	C	2	Google Earth only
C41B	Upper Sand (upstream of dams)	C/D	2	Google Earth and some limited fish surveys
C41C	Lengana	C/D	3	Google Earth, some fish surveys
C41D	Leeuspruit /Saliba Dam	D	4	Google Earth, EFR3 situated in quat, extensive surveys, historical fish surveys.
C41E	Erfenis Dam	C	2	Google Earth, limited personal knowledge
C41F	Tributary to Vet (downstream Erfenis)	C	3	Google Earth, specialist knowledge, fish surveys
C41G	Tributary to Vet (downstream Erfenis)	C	3	Google Earth, specialist knowledge, fish surveys
C41H	Vet river	C	2	Google Earth, some limited knowledge
C41J	Vet river (upstream confluence)	B/C	3	Google Earth, specialist knowledge
C42A	Upper Sand (upstream of dams)	D	2	Google Earth & Kleynhans <i>et al.</i> , 2007 & extrapolation
C42B	Upper Sand (upstream of dams)	D	2	Google Earth & Kleynhans <i>et al.</i> , 2007 & extrapolation
C42C	Upper Sand (upstream of dams)	D	2	Google Earth & Kleynhans <i>et al.</i> , 2007 & extrapolation
C42D	Upper reaches Sand (after confluence) upstream Allemanskraal Dam	D	3	Google Earth & Kleynhans <i>et al.</i> , 2007 & extrapolation
C42E	tributary to Sand river just upstream of Allemanskraal Dam	D	3	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation
C42F	tributary to Sand river just downstream of Allemanskraal Dam	C/D	1	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation
C42G	Sand just downstream Allemanskraal Dam	C/D	3	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation
C42H	Sand (middle reaches -upstream Virginia Dam/)	C/D	1	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation
C42J	Sand - Virginia Dam and tributary	C	1	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation
C42K	tributary to Sand river	C	1	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation
C42L	Sand upstream of confluence with Vet	C	3	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation
C43A	Vet River (downstream confluence with Sand /minor tributary	C	1	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation
C43B	Endoreic region	B/C	0	No data found, no record of streams

QUATERNARY CATCHMENT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)	SOURCE
C43C	Vet (lower reaches)	C	2	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation
C43D	Vet (just upstream to Bloemhof Dam)	C/D	1	Google Earth, Kleynhans <i>et al.</i> , 2007 & extrapolation

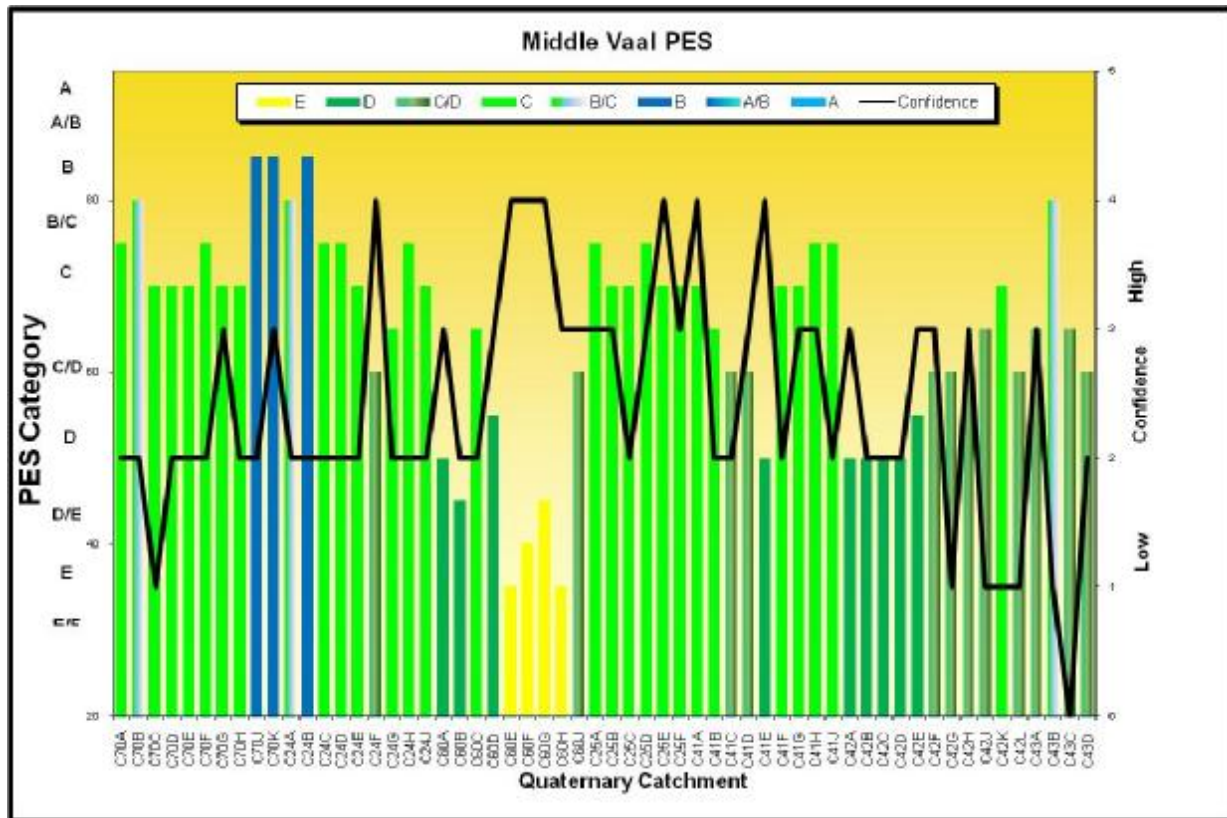


Figure 5-4: PES and confidence evaluation illustrated as bar graph

Middle Vaal PES

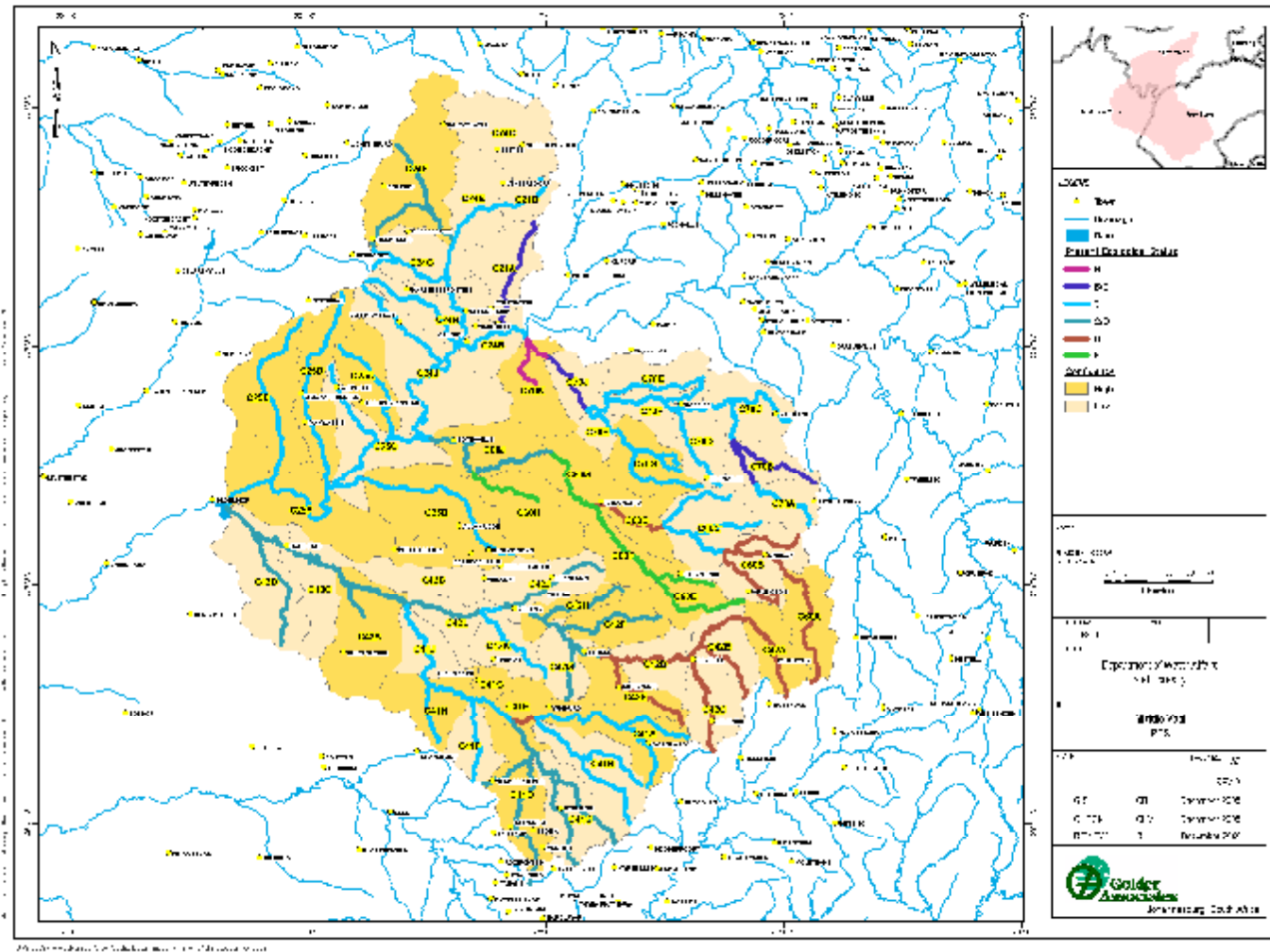


Figure 5.5: PES map illustrating PES categories and confidence

5.4 Conclusions

The bulk of the rivers in WMA 9 are in a B/C and C category. Please note again that this does not include all the smaller tributaries. The rivers in a B category are the following:

- C70K: Renoster River
- C24C: Upper Schoonspruit (including the Schoonspruit eye)

This means that there are very few rivers in this large WMA which are potentially still in a good condition. The reason for this is the high utilisation of the catchment due to mining, irrigation and the urban sprawl of Gauteng. Water quality issues are prevalent in many streams as well as increased flows, i.e. more than natural.

Approximately 45% of the quaternaries have a moderate to high confidence.

6. RECOMMENDATIONS

Recommendations have been made using two matrices (Figure 6-1 and Figure 6-3) to provide consistent answers.

6.1 Integrated (Ecological and Socio-Cultural) Importance

The first matrix illustrates a combination of EIS, SCI, and PES, to provide an indication of overall / integrated importance with the emphasis on the restoration potential. The restoration potential refers to the probability of achieving the rehabilitation of the river to an improved state. For example, if a river has very high overall importance, but is in bad condition, the restoration potential is often low.

However, rivers in good condition are scarce, and therefore important in their own right. A river that is in very good condition, but of low EIS, and/or SCI; might still be important from an ecological perspective, as it could be one of a limited number of that type of river that is still in good condition.

According to the matrix (note, the curves have not been fitted, but have been 'hand drawn'), an Integrated Importance value is estimated from 1 (low importance, to 4 high importance).

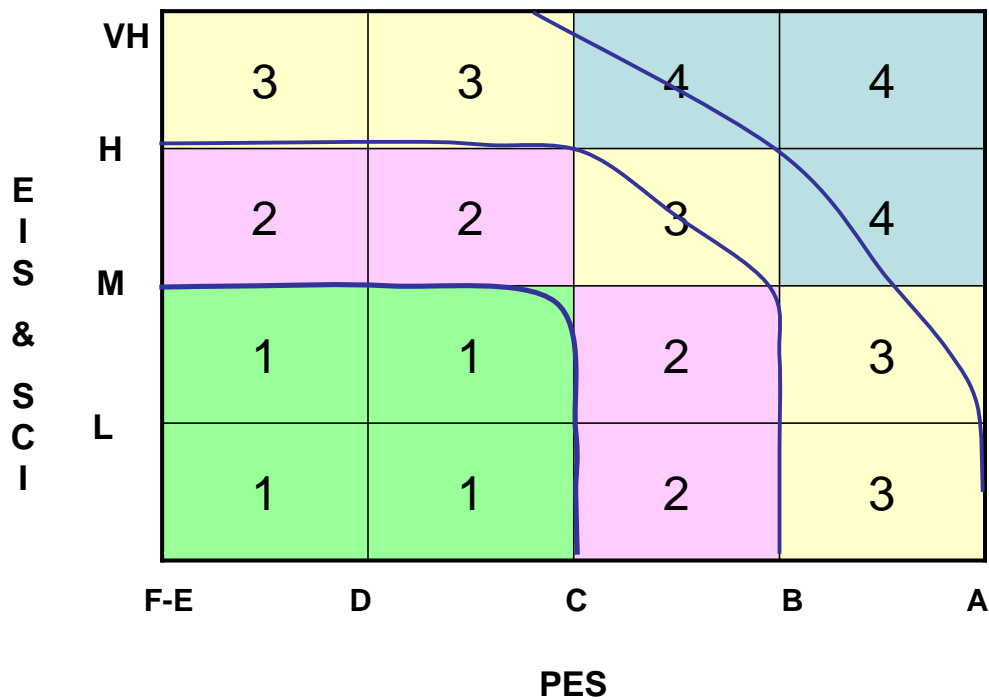


Figure 6-1 Matrix used to determine a combined EIS and PES value which provides an Integrated Importance value on a scale of 0 – 4

The results of the evaluation are listed in Table 6-1 and illustrated in Figure 6.2. This depicts the areas of high (3) and very high (4) Integrated Importance in the quaternary catchments on a spatial scale.

Table 6-1: Quaternaries of high and very high Integrated Importance

Quaternary Catchment	River	Importance Rating (0 – 4)	Reasons for Evaluation
C70J	Renoster	3	High EIS and B PES
C70K	Renoster	3	High EIS and B PES
C24B	Vaal (main) (downstream Koekemoerspruit confluence/upstream Schoonspruit)	3	Moderate EIS and B PES Maintain sustainability of the Vaal system upstream of Bloemhof Dam
C24C	Upper Schoonspruit (including Schoonspruit eye)	3	High EIS and C PES
C24H	Schoonspruit (below dam upstream Jagspruit confluence)/Jagspruit	3	Important for management of Schoonspruit system
C24J	Vaal River (main)	3	Maintain sustainability of the Vaal system upstream of Bloemhof Dam
C60J	Vals River (upstream confluence)	3	Maintain integrity of Vals River
C25C	Vaal main (minor tributary)	3	Moderate EIS and SCI
C43C	Vet (lower reaches)	3	Maintain integrity of Vet River

6.2 Recommendations

The second matrix has two axes (Figure 6-3). The X-axis is based on the Integrated Importance value derived from the first matrix (Figure 6-1, Table 6-1 and results illustrated in Figure 6.2). The Y-axis depicts an estimate of water resource use (DWAf, 2007), with a 0 being of no importance and 4 being of very high importance (cf 6.2.1)

This second matrix was used to identify quaternary catchments which are so called ‘hotspots’. A biodiversity/ecological hotspot is a biogeographic region which is a significant reservoir of biodiversity which is threatened with destruction (http://en.wikipedia.org/wiki/Biodiversity_hotspot). In the context used in the Desktop EcoClassification, the hotspot represents a quaternary catchment with a high Integrated Importance which could be under threat due to its importance for water resource use. These hotspots indicate areas where Reserve assessments should ideally result in high confidence recommendations. This then guides the initial estimate of the level of the assessments required, and indicates areas where detailed investigations would be required if development was being considered. It must be noted that a detailed Reserve assessment does not necessarily provide high confidence results. This is usually due to constraints such as lack of available data (hydrology, biota etc).

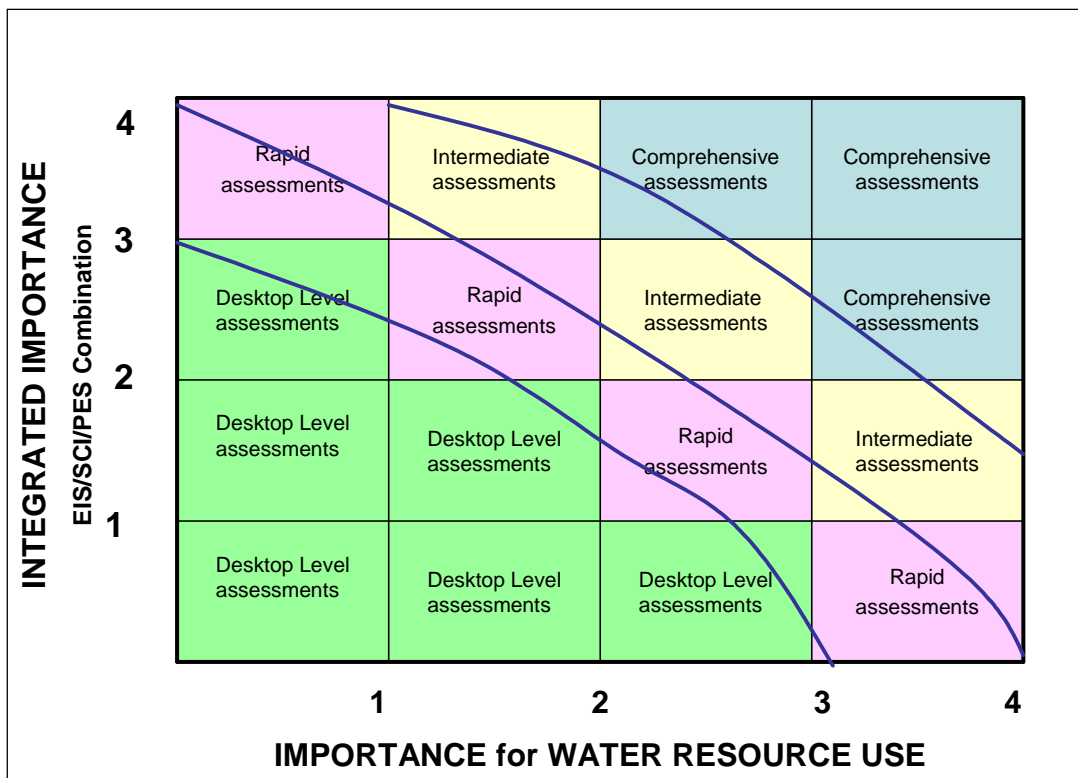


Figure 6-3: Matrix indicating the level of EWR assessments required

6.2.1 Importance of Water Resource Use

The priority rating method consists of assigning a qualitative score to a river reach for four variables or factors that represent the status of the instream flow. The scores of the four variables are combined to determine (qualitatively) an overall score which represents the importance of the river reach in terms of the water resource use and guides decision making with regard to what level of assessment is needed (DWAF, 2007). These ratings are an indication of possible impacts in the area that can affect the PES. They are not applied in the actual models and do not contribute quantitatively to the PES, EIS or SCI.

6.2.2 Determine level of EWR

The matrix was used to compare the Integrated importance with the Water Resource Use importance and the results are provided in Table 6-2 and Figure 6-4.

Table 6-2: Quaternary catchments of high Integrated Importance and/or high Water Resource Use Importance

Quaternary Catchment	River	Importance Rating (0 – 4)	Water Resource Stress Rating	PRIORITY RATING	Reasons for Evaluation
C70A	Renoster	2	2	1	
C70B	Renoster	2	2	1	
C70C	Renoster; Koppies Dam	2	2	2	
C70D	Renoster system (downstream from Koppies dam)	2	2	1	
C70E	Renoster system	2	2	1	
C70F	Renoster (+ tributaries)	2	2	2	
C70G	Renoster system	2	2	1	
C70H	Renoster system	2	2	1	
C70J	Renoster	3	2	2	High EIS and B PES
C70K	Renoster	3	2	2	High EIS and B PES
C24A	Keokemoerspruit/Kromdraaispruit before confluence AND Koekemoerspruit downstream confluence	2	1	2	
C24B	Vaal (main) (downstream Koekemoerspruit confluence/upstream Schoonspruit)	3	1	3	Moderate EIS and B PES Maintain sustainability of Vaal system upstream of Bloemhof Dam
C24C	Upper Schoonspruit (including Schoonspruit eye)	3	1	2	High EIS
C24D	Rietspruit/Rietspruit Dam	2	1	2	
C24E	Schoonspruit main stem and Rietspruit	2	2	2	
C24F	Taaibospruit (and Monamaladi)	2	1	1	
C24G	Buisfonteinspruit/Johan Nesor Dam	2	3	3	Moderate EIS and SCI
C24H	Schoonspruit (below dam upstream Jagspruit confluence)/Jagspruit	3	4	3	Important for management of Schoonspruit system
C24J	Vaal River (main)	3	1	3	Maintain sustainability of Vaal system upstream of Bloemhof Dam
C60A	Vals (upper reaches)	2	1	1	
C60B	Vals (upper reaches)/Lindley Dam/Arlington Dam	2	1	1	
C60C	Vals (middle reaches)	2	1	1	
C60D	Vals (middle reaches) (upstream tributary/Serfontein Dam	2	2	2	
C60E	Upper Sand (upstream of dams)	1	1	1	
C60F	Trib	1	1	1	
C60G	Vals River (upstream of tributary – C60H)	2	3	2	

Quaternary Catchment	River	Importance Rating (0 – 4)	Water Resource Stress Rating	PRIORITY RATING	Reasons for Evaluation
C60H	Trib. of Vals	1	3	1	
C60J	Vals River (upstream confluence)	3	2	3	Maintain integrity of Vals River
C25A	Klipspruit	1	1	1	
C25B	Sandspruit	2	2	1	
C25C	Vaal main (minor tributary)	3	1	3	Moderate EIS and SCI
C25D	Makwassiespruit (Wolmaranstad Dam/Makwassie Dam)	2	3	1	Makwassie Dam
C25E	Tributary into Bloemhof	2	2	1	
C25F	Bloemhof Dam	2	1	1	
C41A	Klein Vet	1	1	1	
C41B	Upper Sand (upstream of dams)	1	1	1	
C41C	Lengana	1	1	1	
C41D	Leeuspruit /Saliba Dam	1	1	1	
C41E	Erfenis Dam	2	2	1	
C41F	Tributary to Vet (downstream Erfenis)	1	1	1	
C41G	Tributary to Vet (downstream of Erfenis Dam)	1	3	2	Downstream of Erfenis Dam
C41H	Vet River	1	3	2	
C41J	Vet River (upstream confluence)	2	3	2	
C42A	Upper Sand (upstream of dams)	1	1	1	
C42B	Upper Sand (upstream of dams)	1	1	1	
C42C	Upper Sand (upstream of dams)	1	1	1	
C42D	Upper reaches Sand (after confluence) upstream Allemanskraal Dam	2	1	1	
C42E	tributary to Sand river just upstream of Allemanskraal Dam	1	1	1	
C42F	tributary to Sand river just downstream of Allemanskraal Dam	1	2	2	
C42G	Sand just downstream Allemanskraal Dam	2	1	1	
C42H	Sand (middle reaches -upstream Virginia Dam/)	2	1	1	
C42J	Sand - Virginia Dam and tributary	1	1	1	
C42K	tributary to Sand river	1	2	2	
C42L	Sand upstream of confluence with Vet	2	2	2	

Quaternary Catchment	River	Importance Rating (0 – 4)	Water Resource Stress Rating	PRIORITY RATING	Reasons for Evaluation
C43A	Vet River (downstream confluence with Sand /minor tributary)	2	2	2	
C43B	Endoreic region	1	1	1	
C43C	Vet (lower reaches)	3	2	2	Maintain integrity of Vet River
C43D	Vet (just upstream to Bloemhof Dam)	1	1	1	

These areas are illustrated spatially on a map (Figure 6-4). Red (very high) and blue (high) quaternaries represent the main river reaches where considerable care should be taken when considering development and which would require intermediate or comprehensive EWR assessment. In the Middle Vaal WMA there were no quaternaries of very high priority, with most classified as medium to low priority.

This assessment guided the selection of EWR sites (See the Resource Unit report). It will be attempted to place most of the EWR sites within the ‘Very High’ and ‘High’ areas. The selection of EWR sites is also dependant on other factors such as the suitability of potential sites for EWR assessments (available habitat, accessibility etc) and areas with a high demand for water use licenses (as determined by the RDM current licence applications as well as those licences applied for via the Regional Offices).

The areas classified as “High” priority are listed in Table 6-3. These areas will be where EWR sites will be considered. The table also indicates what level of study will be considered at that area.

Table 6-3: Summary of High priority areas.

High priority quaternary catchment	River	EWR level	EWR site
C24B	Vaal (main) (downstream Keokemoerspruit confluence/upstream Schoonspruit)	Desktop/Rapid	EWR 1
C24G	Buisfonteinspruit/Johan Nesor Dam	Rapid/Intermediate	
C24H	Schoonspruit (below dam upstream Jagspruit confluence)/ Jagspruit	Comprehensive	
C24J	Vaal River (main)	Desktop/Rapid	EWR 2
C60J	Vals River (upstream confluence)	Rapid/Intermediate	
C25C	Vaal main (minor tributary)	Desktop/Rapid	

Two other EWR sites were selected within the Middle Vaal WMA (see Resource Unit Report). These were in quaternary catchments C60G and C43A.

Middle Vaal EWR hotspots

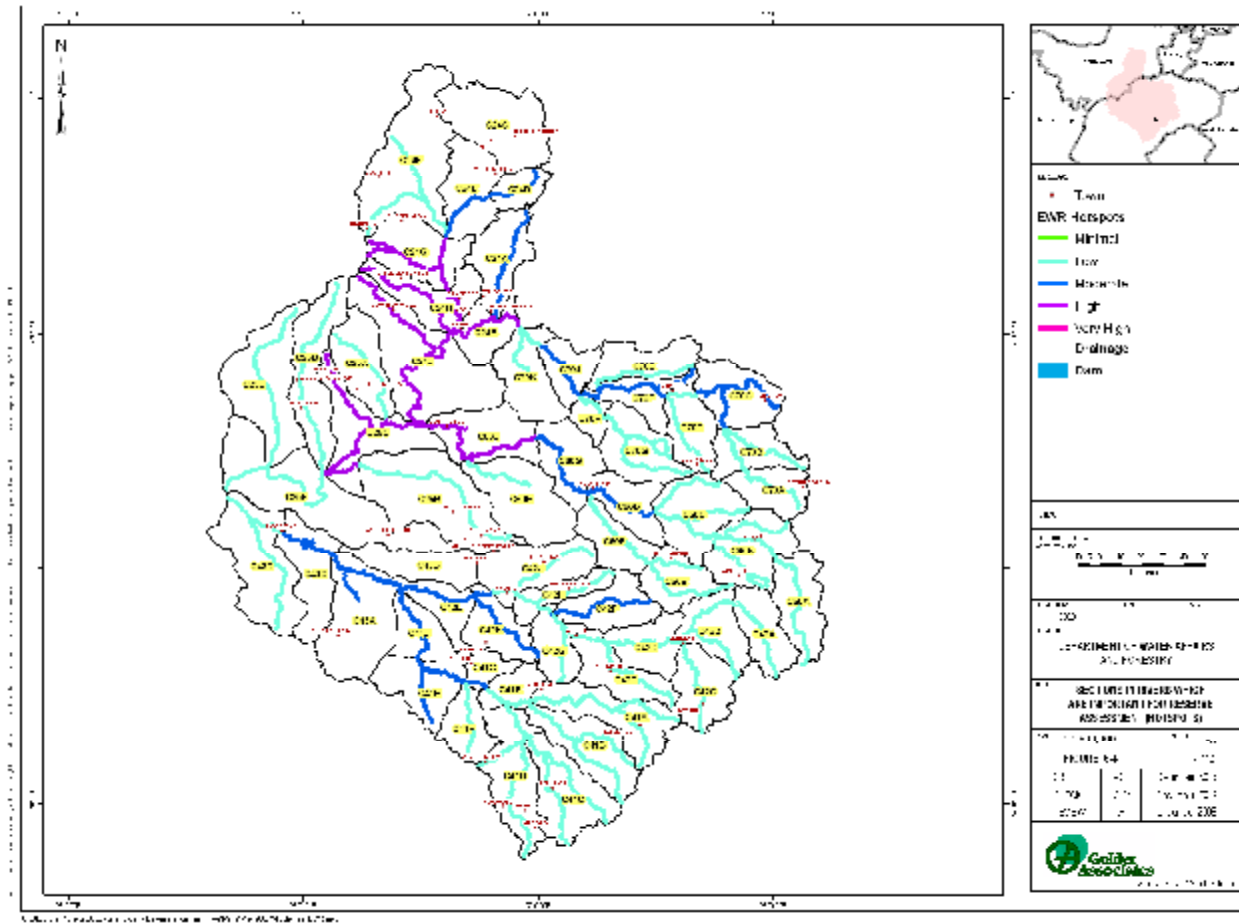


Figure 6-4 Sections in rivers which are important for Reserve assessment (Hotspots) (derived from overlaying Integrated Importance and Water Resource Use)

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APPENDIX A

**COMPREHENSIVE RESERVE DETERMINATION
STUDY FOR THE INTEGRATED VAAL RIVER
SYSTEM: WATER RESOURCE MODELLING
TECHNICAL COMPONENT**

**Water Resource Use Priority Rating of the River Reaches
in the Vaal River System**

Report No. RDM/C000/00/CON/0607

STATUS OF REPORT: FIFTH DRAFT

Document distribution and version history		
Status	Date	Person/Group
First Draft	6 June 2007	D Louw/R Heath
Second Draft	11 June 2007	D Louw
Third Draft	18 July 2007	Presented at meeting.
Fourth Draft	25 July 2007	D Louw/R Heath
Fifth Draft	13 August 2007	D Louw/R Heath

TABLE OF CONTENTS

	Page
1. INTRODUCTION	A3
2. WATER RESOURCE USE PRIORITY RATING METHOD FOR RIVER REACHES	A3
3. RIVER REACH DESCRIPTION AND WATER RESOURCE USE PRIORITY SCORE	A5

1. INTRODUCTION

The purpose of this document is to describe and apply a procedure to identify the tributaries and river reaches of Vaal River where Ecological Water Requirements (EWR) should be determined from a water resource utilisation and management perspective. The water resource use rating system also guides the selection of the appropriate EWR determination method (comprehensive, intermediate, rapid or desktop) to be carried out for the tributaries and river reaches.

The Reserve Determination Study Teams will use the assigned water resource use rating in conjunction with a rating of the ecological importance to select the location and define the Ecological Water Requirement determination method for each site.

Chapter 2 of the document describes the water resource use rating system and **Chapter 3** presents the scores assigned to the indicated river reaches. A brief description of the function and operation of each river reach is also provided.

2. WATER RESOURCE USE PRIORITY RATING METHOD FOR RIVER REACHES

The priority rating method consists of assigning a qualitative score to a river reach for four variables or factors that represent the status of the in-stream flow. The scores of the four variables are combined to determine (qualitatively) an overall score which represents the importance of the river reach in terms of the water resource use and guide the selection of the EWR determination method to be applied.

The variables or factors included in the rating method aim to represent the status and function of the river reach. The variables and the associated characteristics associated with a score ranging from zero to four are presented in **Table 2-1** below.

Table 2-2 presents the meaning of the overall score, which indicates the EWR determination method that is recommended for the river reach in terms of the water resource use. It is important to note that the final decision in terms of the required level of detail of the Reserve Study will be based on the overall water resource use score in combination with the ecological importance of the relevant river reach.

Table 2-1: Water Resource Use Priority rating variables and scoring characteristics

Variables	Score range and associated characteristic descriptions	
	0	4
Current water balance of catchment contributing flow to the river reach.	Very little water use occurs in the upstream catchment. Low, maintenance and high flow is largely natural.	Significant utilisation of water from the upstream catchment. Low and maintenance flows have been reduced and/or there exists significant regulating storage in the catchment.
Utilisation of river reach for operational purposes.	Minimum changes in the river flow due to operational purposes.	The river reach is utilised as a conveyance conduit.
Possible future developments and/or water use expected in the catchment.	No known development planned in the catchment that could change the flow in the river reach.	It is expected that future developments which could change the flow in the river could occur.
Water quality related problems, assimilative capacity.	The water quality in the river reach is excellent and large assimilative capacity is present.	The river contains very high loads of pollutants.
Overall score.	There is no reason to determine the EWR in the river reach from a water resource management perspective.	A comprehensive EWR determination is necessary from a water use point of view.

Table 2-2: Meaning of Overall Score

Overall score	Importance in terms of Water Resource Use	Typical EWR determination method ^(#)
0	Very low.	There is no reason to determine the EWR in the river reach from a water resource management perspective.
1	Low.	Desktop EWR determination is recommended.
2	Moderate.	Rapid EWR determination is recommended.
3	High.	Intermediate EWR determination is recommended.
4	Very high.	A Comprehensive EWR determination is recommended.

Note: (#) The final EWR determination method depends on a combination of the water resource use rating and the ecological importance.

3. RIVER REACH DESCRIPTION AND WATER RESOURCE USE PRIORITY SCORE

Little Vaal River (C11C)

Water is transferred from Heyshope Dam into the Little Vaal River (i.e. into the lower part of quaternary C11C). The normal operating rule is to transfer water to the Vaal River system if Grootdraai Dam's storage decreases below 90%. The maximum transfer rate is 4.6 m³/s. There may be limited flexibility in the transfer rate (lower than the maximum) if one or two of the three pump sets are used.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	0
Utilisation of river reach for operational purposes. ⁽¹⁾	2
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	2

Notes: (1) Transfers from Heyshope into river reach are regulated by storage within Grootdraai Dam.

Skulpspruit River (C11E)

The transfer from Zaaihoek Dam discharges water into the Perdewaterspruit, which is a tributary of the Skulpspruit. The water is released in the river system upstream of Amersfoort Dam, which is a small storage dam providing water to the town. The transfer from Zaaihoek Dam is mainly for the purpose of supplying water to Majuba Power Station and the releases to Grootdraai Dam (into Perdewaterspruit) is only the excess yield that is available in Zaaihoek Dam after Majuba's water requirement has been supplied. The water transferred into Grootdraai Dam has decreased over time due to the increasing usage from Majuba Power Station, and as the different generation units were commissioned.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	0
Utilisation of river reach for operational purposes. ⁽¹⁾	2
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	2

Notes: (1) Frequency of transfers from Zaaihoek into river reach are regulated by storage within Grootdraai Dam, whilst the transfer volumes are determined by the excess yield available from the Zaaihoek Dam Sub-system.

Rietspruit River (C11F)

Msukaligwa Local Municipality (former Ermelo TLC) is situated within this catchment. There are two dams, Willem Brummer and Douglas dams, in this river system supplying water to Msukaligwa (Based on information received from Trevor Coleman). There are also coal mining activities in the catchment upstream of these dams. These dams are small storage structures and it is unlikely that they have any release capabilities. The town of Msukaligwa uses all the available water from these dams and in dry periods the dams are frequently depleted. Msukaligwa also receives water from the Rietspruit-Davel pipeline (i.e. the pipeline from Jericho Dam providing water to the Usutu-Vaal Eskom Power Stations).

Variables	Score
Current water balance of catchment contributing flow to the river reach.	2
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	2

Vaal River reach between C11M and Grootdraai Dam

The Vaal River reach downstream of Grootdraai Dam receives compensation water from Grootdraai Dam. This is a variable flow (dependant on the inflow) and this water is used by Lekwa LM (former Standerton TLC) as well as downstream irrigators. The yield balance of Grootdraai Dam is such that all available water is used to supply Sasol (Secunda Complex) and Eskom Power Stations. Any additional water released from the dam would result in a negative yield balance and will have an impact on the Eastern Sub-system of the Integrated Vaal River System.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	4

Sandspruit River (C13A and C13B)

The Sandspruit, which is a tributary of the Klip River, should be mostly natural without any regulating storage and only minor water abstractions.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	0
Utilisation of river reach for operational purposes. ⁽¹⁾	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	0

Klip River (including and upstream of C13H)

The Klip River is largely natural and there is no large regulating storage in the catchment. The yield balance of the river system is positive. This catchment is contributing a large portion of the incremental runoff to Vaal Dam and is an important tributary of the Vaal River, in terms of providing natural variable flow downstream of Grootdraai Dam. There is a possibility (has been investigated in past studies) of constructing a dam on the Klip River. The most feasible option was found to be a dam in quaternary catchment C13F (just downstream of the tributary from quaternary C13E) from where water will be transferred (pumped) to Grootdraai Dam.

Current (June 2007) information on the projected water requirements of Sasol Secunda and Eskom points to the need for further augmentation to the Eastern Vaal River Sub-system by approximately the year 2014. This required intervention is in addition to the Vaal River Eastern Sub-system Augmentation Project (VRESAP) pipeline from Vaal Dam that is currently being constructed. It is, therefore, possible that the dam on the Klip River could provide this additional water. This option will, however, have to be investigated further.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	0
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment. ⁽¹⁾	2
Water quality related problems, assimilative capacity.	0
Overall score.	2

Notes: (1) .Possible construction of dam on Klip to augment water supply to Sasol Secunda and Eskom

Wilge River System (upstream of quaternary catchment C82H)

This river system has Sterkfontein Dam (located in C81D) as the only regulating storage. Sterkfontein Dam receives water from the Thukela-Vaal Transfer Scheme and contains the “reserve” water for the Integrated Vaal River System. The operating rule of Sterkfontein Dam is such that water is only released from the dam when Vaal Dam is at low levels.

Eskom is planning the Braamhoek Pump-storage Scheme that will result in the construction of a dam in the upper part of quaternary C81A. According to available information, there was a EWR determination study done for this proposed dam.

In the upper portion of quaternary C81F water is abstracted from Fika Patso and Metsi Matso dams to supply the Phuthaditjaba area. Currently there are plans to further support the Phuthaditjaba area with water from Sterkfontein Dam, which is an indication that the water resources of the above-mentioned two dams are fully utilised.

The remainder of the Wilge River System is largely unregulated with only small dams for water supply to local users. Water users within this catchment comprise of both urban and irrigation user groups. The available network models simulate the Wilge River System as a unit and it is therefore not possible to give yield balances for the individual tributary catchments.

The Wilge River may in future be the transfer conduit to convey water from the proposed Thukela Water Project (TWP) to Vaal Dam. This proposed transfer scheme is an alternative to a possible further phase of the Lesotho Highlands Water Project.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	2
Utilisation of river reach for operational purposes. ⁽¹⁾	4
Possible future developments and/or water use expected in the catchment. ⁽²⁾	1
Water quality related problems, assimilative capacity.	0
Overall score.	4

Notes: (1) *Transfer conduit for proposed Thukela Water Project.*

(2) *Support from Sterkfontein to Phuthaditjaba area.*

Liebenbergsvlei River (including and upstream of C83H)

The flow in the Liebenbergsvlei River is dominated by the transfer from the Lesotho Highlands Water Project (LHWP). The LHWP water is discharged into the river system upstream of Saulspoort Dam (located in quaternary catchment C83A). Saulspoort Dam supplies water to the town of Bethlehem as well as to irrigation farmers. There are significant irrigation abstractions along the Liebenbergsvlei River, of which a significant portion is considered to be unlawful.

Variables	Score
Current water balance of catchment contributing flow to the river reach. ⁽¹⁾	4
Utilisation of river reach for operational purposes.	4
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	4

Notes: (1) *Initiatives to eradicate unlawful irrigation water use should be implemented as a matter of urgency.*

Waterval River (including C12G and upstream)

The Waterval River receives discharges from the Sasol Secunda Complex as well as treated urban wastewater. From the salinity balance done by Chris Herald as part of the Vaal River System Analysis Update (VRSAU) study, there is also evidence of mine water seepage and runoff from the paved urbanised areas contributing to the flow in the river. There are irrigators situated downstream of the above-mentioned discharges. Since the existing water resource models do not simulate this river system as a separate unit, information on the yield balance of this river system is not available. It would, therefore, be necessary to refine the modeling of this river system based on information from

studies done by others (Van Veelen and/or Coleman). It is proposed that the results based on the most recent EWR study be adopted for this catchment.

Vaal River, reach from Vaal Barrage to Vaal Dam

The water body created by the Vaal Barrage dam wall dominates this river reach. Management of the flow into this reach is from Vaal Dam and is influenced by the water users in and downstream of the Vaal Barrage, the urban return flows and mine dewatering discharges as well as the releases from Vaal Dam to maintain the TDS concentration at 600 mg/l. The three main tributaries (Suikerbosrand, Klip and Rietspruit rivers) discharging into the Vaal Barrage, each convey significant volumes of treated wastewater and mine discharge water.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4
Utilisation of river reach for operational purposes. ⁽¹⁾	4
Possible future developments and/or water use expected in the catchment. ⁽²⁾	2
Water quality related problems, assimilative capacity.	4
Overall score.	4

Notes: (2) River reach receives regulated releases from Vaal Dam.

(3) Potential re-use of wastewater and mine discharges that could impact on water quality and inflow to river reach.

Klip River (including and upstream of C22E)

This river reach receives about 200 million m³/annum of treated urban wastewater which significantly changed the flow pattern from natural conditions. There is also significant runoff from the paved urbanised areas contributing to the flow in the Klip River and discharges from the mines are estimated at approximately 10 million m³/annum. There are no storage structures that can regulate the flow in this river reach.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	1
Utilisation of river reach for operational purposes. ⁽¹⁾	4
Possible future developments and/or water use expected in the catchment. ⁽²⁾	2
Water quality related problems, assimilative capacity.	4
Overall score.	4

Notes: (1) *The wastewater discharges have altered the natural flow regime of the river reach significantly*

(2) *Potential re-use of wastewater and mine discharges that could impact on water quality and inflow to river reach.*

Suikerbosrand River (C21C, C21B and C21A)

This portion of the Suikerbosrand River catchment is largely natural, there are no significant abstractions or discharges influencing the river flow, and there are no storage structures that can regulate the flow in this river reach.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	0
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	0

Suikerbosrand and Blesbokspruit rivers (including C21G, C21F, C21E and C21D)

About 50 million m³/annum of treated urban wastewater is discharged into this river system as well as mine water discharges from Grootvlei Mine (now referred to as Petrex) of approximately 27 million m³/annum. Furthermore, runoff from the paved urbanised areas within the Suikerbosrand catchment also contributes to the flow in the river. There are no storage structures that can regulate the flow in this river reach.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	1
Utilisation of river reach for operational purposes. ⁽¹⁾	3
Possible future developments and/or water use expected in the catchment. ⁽²⁾	2
Water quality related problems, assimilative capacity.	3
Overall score.	3

Notes: (1) Mine and wastewater discharges as well as urbanised runoff have changed the natural flow regime of the river reach.

(2) Potential re-use of wastewater and mine discharges that could impact on water quality and inflow to river reach.

Rietspruit (including and upstream of C22J)

This river system receives in the order of 35 million m³/annum treated urban wastewater with the result that high base flows are present in the river. Discharges from the Far West Basin Mines that are in the order of 18 million m³/annum are made to the Rietspruit and runoff from the paved urbanised areas also contributes to the flow in the river.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	1
Utilisation of river reach for operational purposes. ⁽¹⁾	3
Possible future developments and/or water use expected in the catchment. ⁽²⁾	2
Water quality related problems, assimilative capacity.	3
Overall score.	3

Notes: (1) Mine and wastewater discharges as well as urbanised runoff have changed the natural flow regime of the river reach.

(2) Potential re-use of wastewater and mine discharges that could impact on water quality and inflow to river reach.

Taibosspruit River (C22K and C22G)

These catchments contain the Sasolburg industrial complex including coal-mining areas. There is no regulating storage structure and water quality is a concern in this river system. More detailed information on these catchments should be available from Catchment Management Strategy studies or detailed water quality studies.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	1
Utilisation of river reach for operational purposes.	1
Possible future developments and/or water use expected in the catchment. ⁽¹⁾	2
Water quality related problems, assimilative capacity.	3
Overall score.	3

Notes: (1) Future changes in the water use and operations at the Sasol plant will affect this river reach.

Kromdraai River – (C23A and part of C23B)

The Kromdraai River catchment down to its confluence with the Vaal River is largely natural. With the exception of relatively small irrigation water use, there are no significant abstractions or discharges influencing the river flow. There are no storage structures that can regulate the flow in this river reach.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	0
Utilisation of river reach for operational purposes. ⁽¹⁾	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	0

Mooi River– (C23H, Boskop and Klerkskraal dams)

Boskop Dam is located upstream of this river reach and has currently limited excess water available. This is due to significant mine water discharges into the river system. The catchment upstream of Boskop Dam is partly underlain by dolomite. The Wonderfonteinspruit is the most significant tributary of the Mooi River. Water from the Gerhard Minnebron eye is used for irrigation purposes. Urban return flows from the Flip Human Wastewater Treatment Works are also discharged into the Mooi River upstream of Boskop Dam. Potchefstroom Town is supplied from a small storage dam, Lakeside Dam, which is supported from Boskop Dam. Boskop Dam also supplies water to the Mooi River Irrigation Scheme. Klerkskraal Dam is located upstream of Boskop Dam in quaternary catchment C23F. There are irrigation water users supplied directly from Klerkskraal Dam. Under certain conditions, water is released from Klerkskraal Dam to support Boskop Dam. In order to minimise river losses these releases are, however, made via the concrete lined Klerkskraal canal

system. Portions of the natural spills from Klerkskraal Dam are also routed through the right bank canal that spills into Boskop Dam.

There is currently an application for additional irrigation to supply resource poor farmers. It should be noted that there is a significant canal and pipe infrastructure conveying the urban return flows, mine discharges and irrigation water supply in this area.

It is proposed that EWR sites be assessed downstream of both dams.

Variables	Score
Current water balance of catchment contributing flow to the river reach. ⁽¹⁾	4
Utilisation of river reach for operational purposes. ⁽²⁾	2
Possible future developments and/or water use expected in the catchment. ⁽³⁾	2
Water quality related problems, assimilative capacity.	2
Overall score.	4

Notes: (1) The assurance of supply is dependant on mine water discharges.

(2) Releases made from Boskop Dam to Lakeside Dam.

(3) Licence applications to supply resource poor farmers.

Loopspruit River – (C23K, Klipdrift Dam)

Klipdrift Dam is located upstream of this river reach and provides water to irrigators. There is significant mine dewatering entering the river system upstream of the dam. The yield balance indicates that the water available and the water requirements are in balance (this is with the mine discharges included).

Variables	Score
Current water balance of catchment contributing flow to the river reach. ⁽¹⁾	4
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	2
Overall score.	4

Notes: (1) The assurance of supply is dependant on mine water discharges.

Rhenoster River downstream of Koppies Dam (C70J, most downstream quaternary)

Koppies Dam provides flow regulating capability. The yield balance situation is such that the water available from the dam is fully utilised. There is also significant water use from the river downstream of the dam to the extent that there is not excess water available. The Voorspoed Mine has recently purchased water rights from irrigators that were supplied from Koppies Dam as part of the Koppies Government Water Scheme.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	4

Schoonspruit River (including and upstream of C24H)

This river has been the subject of a Catchment Management Strategy Study which also included a Reserve Determination Study. It is proposed that the information from that study be consulted and used in order to prevent duplication.

Vals River (including and upstream of C61J)

This river system does not have storage regulation capability with release capabilities, with the result that high flow control and management is not possible. Moqhaka (previously known as Kroonstad) is supplied from Serfontein Dam, which has a small storage relative to the runoff. The yield balance situation is such that there are deficits in supply as was recently experienced in restrictions to the town of Moqhaka.

The only management measure to supply the EWRs in this system would be to reduce the water use.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	4

Sand/Vet rivers (upstream of C43D)

The available water resources in this river system are fully utilised. Allemanskraal Dam (located in quaternary C42E) on the Sand River and Erfenis Dam (located in quaternary C41E) on the Vet River have flow release regulating capabilities. It is recommended that EWRs be determined downstream of each of these two dams.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	4

Vaal River reach between the Vaal Barrage (C22K) and C25C

The main flow regulating capability for this reach is from Vaal Barrage with support from Vaal Dam. There are obviously contributing flows from the Schoonspruit, Mooi, Vals and Rhenoster tributary rivers. The flow in this river reach is influence by various factors as listed below:

- Return flows from mine dewatering and treated urban wastewater into this reach and upstream of the Vaal Barrage contribute to the flow in this river reach.
- In the past years a flow dilution operating rule has been applied where water is released from Vaal Dam to maintain the Total Dissolved Solids (TDS) concentration in the Vaal Barrage not to exceed 600 mg/l. This results in “spills” from Vaal Barrage and in some years can be as much as 200 million m³/annum.
- There are significant evaporative losses in this river reach.

The location of Bloemhof Dam, at the downstream end of this river reach, provides operating flexibility in that water released from the Vaal Barrage is not necessarily a loss from the Integrated Vaal River System. There are however constraints in the volume of releases that can be made.

Variables	Score
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Current water balance of catchment contributing flow to the river reach.	1
Utilisation of river reach for operational purposes.	4
Possible future developments and/or water use expected in the catchment. ⁽¹⁾	2
Water quality related problems, assimilative capacity.	4
Overall score.	4

Notes: (1) Any additional water use will have a direct impact on the Vaal River System Yield. Potential re-use of wastewater and mine discharges could impact on water quality.

Vaal River reach downstream of Bloemhof Dam (C91B)

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.

Note:

Since Bloemhof Dam is the main regulating storage structure for the lower portion of the Vaal River, it is proposed that the flow management plan be defined in the form of releases from Bloemhof Dam. It may therefore be possible to develop EWR only for one site downstream of Bloemhof Dam and to use those results to determine the required releases from Bloemhof Dam.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4
Utilisation of river reach for operational purposes.	4
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	4

Vaal River reach downstream of Vaalharts Weir (C91D)

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.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4
Utilisation of river reach for operational purposes.	4
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	4

Harts River upstream of Wentzel Dam (C31E and upstream quaternaries)

This river reach 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 being investigated. The ecological benefits of not transferring the water to Barberspan should be weighed against the benefits of having the water in Barberspan. **Barberspan Nature Reserve** is positioned 16 km north east of Delareyville. It has been identified as a RAMSAR site and is a sanctuary for waterfowl.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	4

Harts River downstream of Wentzel Dam (C31F)

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

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4

Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	4

Harts River downstream of Taung Dam (C31F)

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). The EWR downstream of the dam will have a direct influence on the water that will be available to supply the proposed water uses.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	1
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment. ⁽¹⁾	2
Water quality related problems, assimilative capacity.	0
Overall score.	2

Notes: (1) Investigations under way to assess potential domestic and irrigation water supply from the dam.

Dry Harts River (upstream of and including quaternary C32D)

No regulation storage is present in this catchment and the flow is largely natural.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	0
Utilisation of river reach for operational purposes.	0

Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	0
Overall score.	0

Harts River reach upstream of Spitskop Dam (C33A,C33B)

Significant flows occur in this river reach 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.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	1
Utilisation of river reach for operational purposes. ⁽¹⁾	4
Possible future developments and/or water use expected in the catchment.	2
Water quality related problems, assimilative capacity.	3
Overall score.	4

Notes: (1) River reach receiving unregulated return flows from the irrigated areas.

Harts River reach downstream of Spitskop Dam (C33C)

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 river reach.

Spitskop Dam has the capability to regulate flow releases in this river reach. Investigations are in progress to identify potential further user of the excess water available in the dam.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	1
Utilisation of river reach for operational purposes.	2
Possible future developments and/or water use expected in the catchment.	4
Water quality related problems, assimilative capacity.	3
Overall score.	4

Riet/Modder Rivers (upstream of quaternary C51M)

These catchments were part of a comprehensive reserve determination study and it is assumed that the site selection will be based on the work of that study.

Vaal River reach downstream of Douglas Weir (C92C)

This is the most downstream section of the Vaal River before the confluence with the Orange River. Douglas Weir is the upstream storage structure, which has limited flow-regulating capability. Currently this river reach has no flow for most of the time and is operated to minimise flow in the reach. The river reach length is only 1 km.

This river reach is downstream of the Riet/Modder and Harts tributary rivers and would therefore receive EWR flows from these rivers. Any additional EWR in this river reach (over and above what is received from the Riet/Modder and Harts rivers) will have to be released from Bloemhof Dam via the Vaalharts Weir and will impact on the water availability of the Integrated Vaal River System.

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.

Variables	Score
Current water balance of catchment contributing flow to the river reach.	4
Utilisation of river reach for operational purposes.	0
Possible future developments and/or water use expected in the catchment.	0
Water quality related problems, assimilative capacity.	2
Overall score.	4