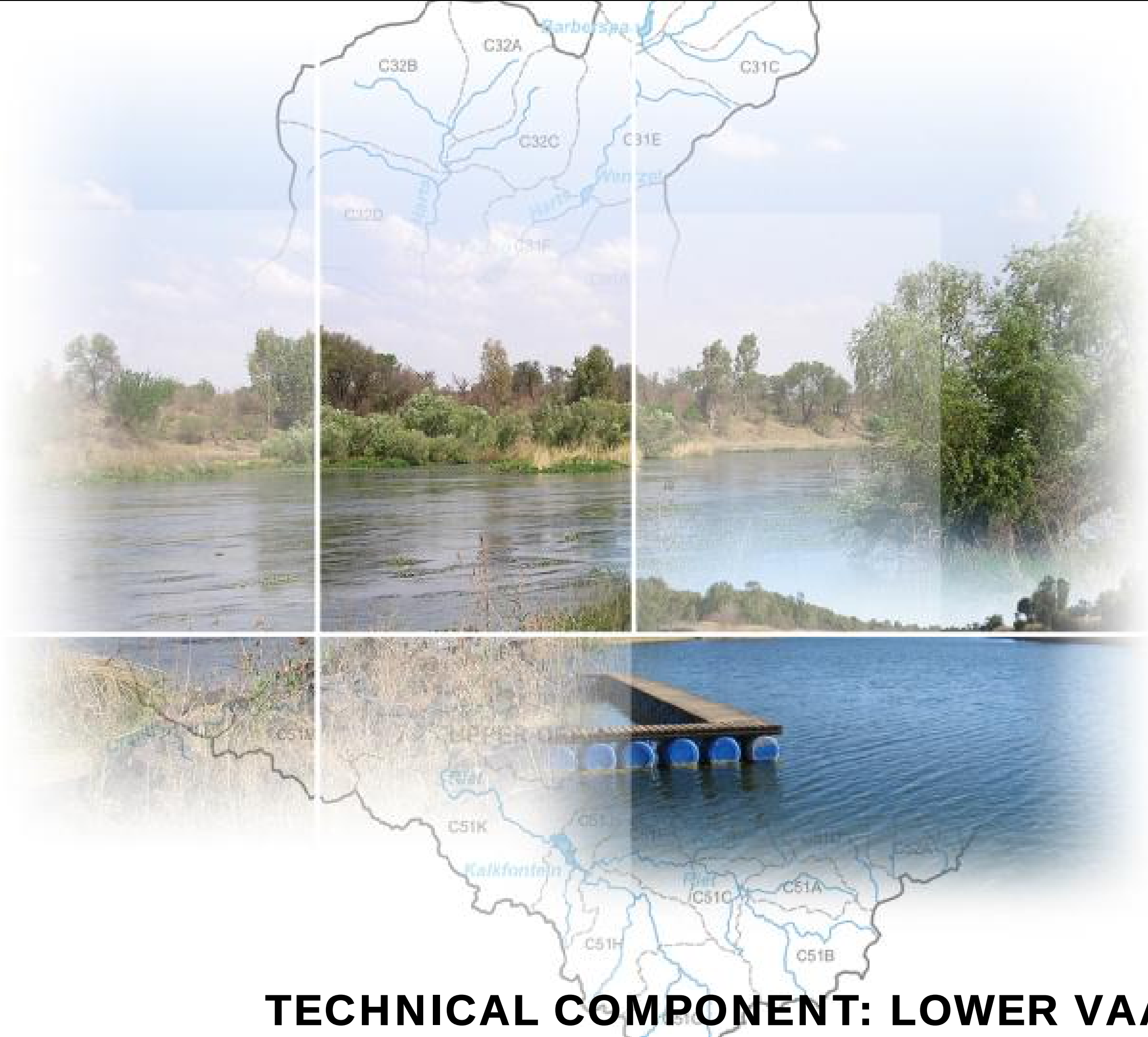
COMPREHENSIVE RESERVE DETERMINATION

INTEGRATED VAAL RIVER SYSTEM

SURFACE WATER

DESKTOP ECOCLASSIFICATION



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EXECUTIVE SUMMARY

Background

The CD: RDM identified the Integrated Vaal River System, with the focus of this study, the Lower Vaal Water Management Area (WMA) as requiring a comprehensive Reserve assessment as to provide input to the Reconciliation studies and the integrated water quality management plan for the Vaal River undertaken by the National Water Resources Planning Directorate (D: NWRP) of the 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:

§ C91A and C91B (Vaal River) due to Sandveld Nature Reserve and Rob Ferreira Reserve, high species diversity, including *Labeobarbus kimberlyensis* and *A. sclateri*
§ C31D (Barberspan/Leeupan)
§ C92A (Vaal River after confluence with Harts River)
§ C51A, C51B, C51C, C51D, C51E, and C51G (Riet River)

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., places of historical battles, Bushman paintings 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 tended to score relatively low in terms of SCI. An obvious exception is the recreational use of 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 (mainly alluvial diamonds) and industrialisation also scored generally low in terms of SCI. It should be emphasised that low SCI score does not indicate low economic importance.

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 the WMA are in a C, C/D and D category. Please note that this does not include all the smaller tributaries but only refer to the main rivers in the quaternaries. The rivers in a B category are the following:

- C91B: Vaal River at the Vaalharts weir
- C32B: Dry Harts River before the confluence with the Leeuspruit
- C33B and C33C: Harts River at Spitskop Dam and downstream of the dam.

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 alluvial diamond mining, irrigation, interbasin transfers for irrigation (Vaal Harts) and the return flows of poor water quality from mainly irrigated areas. Water quality issues (salts and nutrients) 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.

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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
PSP	Professional Service Provider
QHI	Quick Habitat Integrity
REC	Recommended Ecological Category
RU	Resource Unit
SCI	Socio Cultural Importance
ToR	Terms of Reference
WMA	Water Management Area

GLOSSARY

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

ECOLOGICAL WATER REQUIREMENTS (EWR)	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.
INSTREAM FLOW REQUIREMENTS (IFR)	The flow patterns (magnitude, timing and duration) needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to the quantity component only of Ecological Water Requirements.
MAINTENANCE FLOW	The flow required to meet the requirements of the riverine ecosystem at a particular site and maintain the resource base in a particular condition during "normal" climatic years. The distinction between "normal" and "drought" was based on an examination of monthly flow duration curves
PRESENT ECOLOGICAL STATE (PES)	The degree to which ecological conditions of an area have been modified from natural (reference) conditions. The measure is based on water quality variables, biotic indicators and habitat information collected 1 to 3 years prior to the assessment. Results are classified on a 6-poin scale, from Category A (*Largely Natural*) to Category F (*Critically Modified*).
REFERENCE CONDITION	Natural ecological conditions, prior to human development.
RESERVE	The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997), for people who are now or who will, in the reasonably near future, be (i) relying upon; (ii) taking water from; or (iii) being supplied from, the relevant water resource; and (b) to protect

aquatic ecosystems under the National Water Act, 1998 (Act No. 36 of 1998) in order to secure ecologically sustainable development and use of the relevant water resource. The Reserve refers to the modified Ecological Water Requirement, where operational limitations, and stakeholder consultation are taken into account.

RESOURCE QUALITY OBJECTIVE — Quantitative and auditable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection. This term takes into account the management *classes* and the requirements of other users. These components are not addressed in this project

RESOURCE UNIT — Stretches of river that are sufficiently ecologically distinct to warrant their own specification of Ecological Water Requirements, and that can be practically managed as a single unit.

Comprehensive Reserve Determination Study for the Integrated Vaal River System: Lower 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 Lower Vaal Water Management Area (WMA) as requiring a comprehensive Reserve assessment as to provide input to the Reconciliation studies and the integrated water quality management plan for the Vaal River 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 resuts as 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 WMA 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 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).

1.2 Study Area

The study area for the Reserve determination is the Lower Vaal system and is represented by WMA 10. WMA 10 is part of a larger water supply system, which includes adjacent WMAs, and Lesotho. The Lower 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 a and b, 2003, 2004, 2006).

The Lower Vaal WMA covers a catchment area of 133 354 km^2, and includes parts of the Northern Cape and North-West Provinces, and a small part of the Free State Province. It is situated in the north-western part of the country and forms part of the Orange River watercourse. The Vaal River is the only major river in the WMA, as it flows in a westerly direction from Bloemhof Dam to the confluence with the Orange River. The largest part of the WMA falls within the catchment of the Molopo River, a tributary of the Orange River. The Molopo, Nossob and Kuruman rivers drain the remainder of the WMA but due to the very low rainfall in the WMA, these rivers are insignificant. The WMA consists of the D41 (excluding D41A), parts of D42C and D42D, parts of D73A and D73C, C31, C32, C33, C91, and C92 tertiary catchments. For the purpose of this study only the C drainage region is of relevance as it forms part of the Vaal River System, which includes the Harts River catchment and the Vaal River catchment. These two catchments as part of the Vaal River System cover a catchment area of 53 500km^2 within the Lower Vaal WMA.

The Lower Vaal WMA has a population of about 1,3 million, with approximately 0,7 million being urban and 0,6 million being rural population (DWAF, 2004). The largest concentration of urban population is in Kimberley. There are large rural populations in areas west of Mafikeng, around Kuruman, Pampierstad and Lichtenberg.

The economy of the Lower Vaal WMA is relatively small, with the WMA generating about 2% of the Gross Domestic Product of South Africa (DWAF, 2003). The economy is still dominated by mining, however much of the beneficiation is done in other areas. Kimberley is the largest urban centre in the area. Most of the economic activity is concentrated in Kimberley and at other major mining areas. Manufacturing activities in the WMA include cement and cheese factories and relate to the agriculture sectors as well as items for local consumption. The trade sector is concentrated in wholesale of primary products and related services to the community. No significant changes to the economy of the WMA are foreseen over the medium term. The agricultural and mining sectors in the region are strong and will continue to make an important contribution to the regional economy.

The Lower Vaal WMA also shows minimal potential for strong economic growth, and thus a low population growth is projected. Consequently, limited growth in water requirements is expected.

1.3 The Modder Riet catchment

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

The Riet River generally flows in a north-westerly, to the confluence with the Vaal River. The Tierpoort dam which is used for irrigation purposes is situated on the tributary of the Riet River, and the Kalkfontein Dam which supplies water to the Riet River Government Water Scheme, is located just downstream of the confluence of the Kromellenboogspruit and Riet Rivers. The Modder River is the main tributary of the Riet River and joins the Riet River just upstream of Ritchie. The Modder River has its source in the high hills at the watershed near Dewetsdorp (1600m above mean sea level). The Krugersdrift Dam is located on the Modder River. Most of the natural runoff into the Modder River is from above the confluence of the Modder and Klein Modder Rivers. The rest of the Modder River catchment is very flat and very little runoff occurs (DWAF, 2002a).

The major urban centres in the catchment are Bloemfontein, Botshabelo and Thabu Nchu whose collective population is 1.2 million people. The Modder River is a major source of water to these urban areas. Most industries in the Modder and Riet catchments are centred around Bloemfontein and use treated water from the municipal supply system. Only one industry that uses water directly out of the river is known. This is the diamond mining operation at Koffiefontein. The diamond mine at Koffiefontein is an underground mine that mines Kimberlite from a pipe. Aside from the ecological and domestic needs of the rivers, both rivers support recreational use at the dams.

1.4 Objectives of the Lower 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 10. 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 quarternary catchement 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.

1.5 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.

1.5.1 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 and 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 aesthetical 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.

1.6 Report Structure

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

1.6.1 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.

1.6.2 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.

1.6.3 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.

1.6.4 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.

1.6.5 . 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 10. A map illustrating areas of high Integrated Importance for WMA 10 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 INTRODUCTION

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.

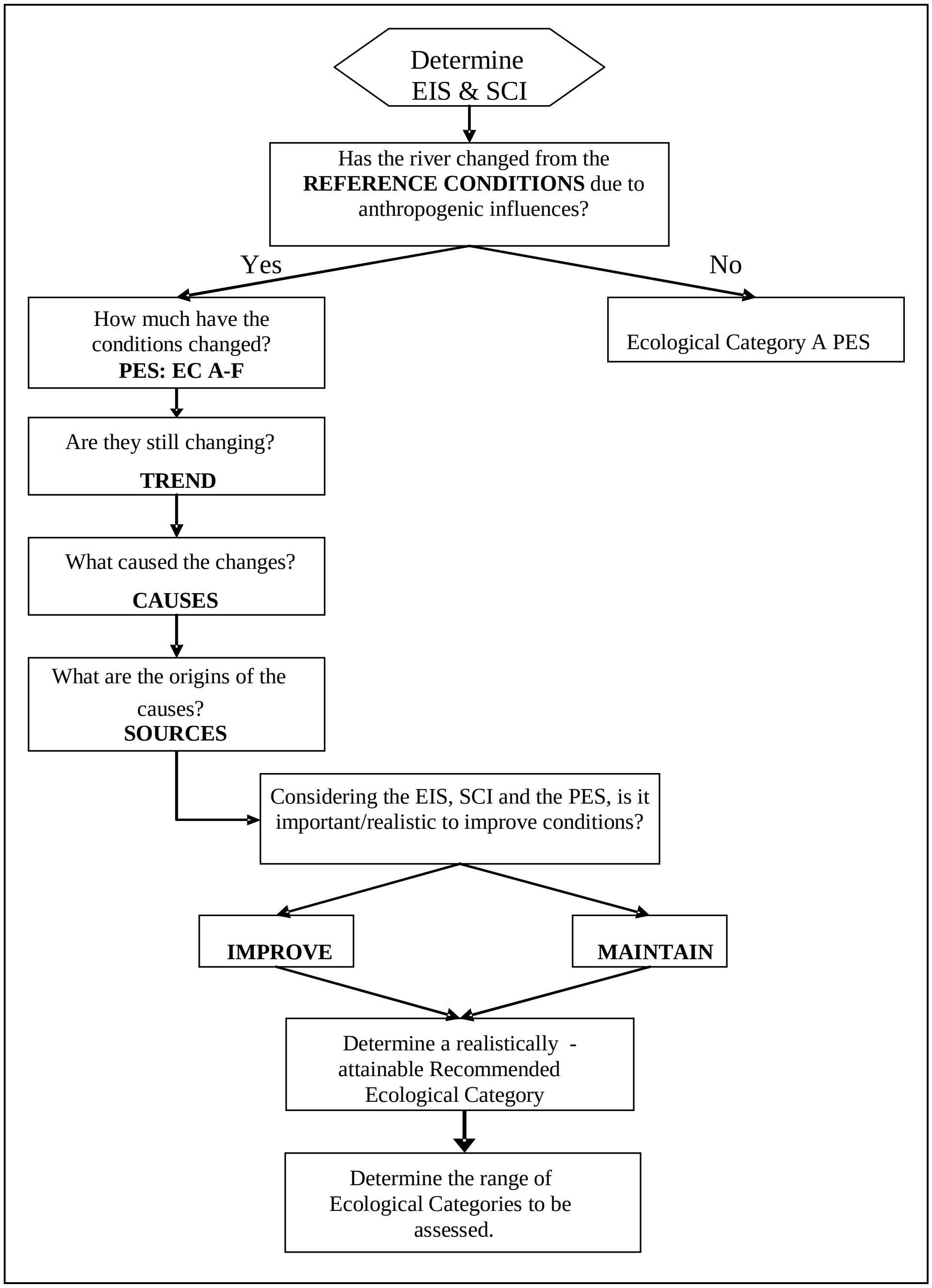


Figure 2-1: Flow diagram illustrating the information generated to determine the range of ECs for which EWRs will be determined

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 10. Various other rivers had 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 10;
- 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 10.

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.

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) and 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);

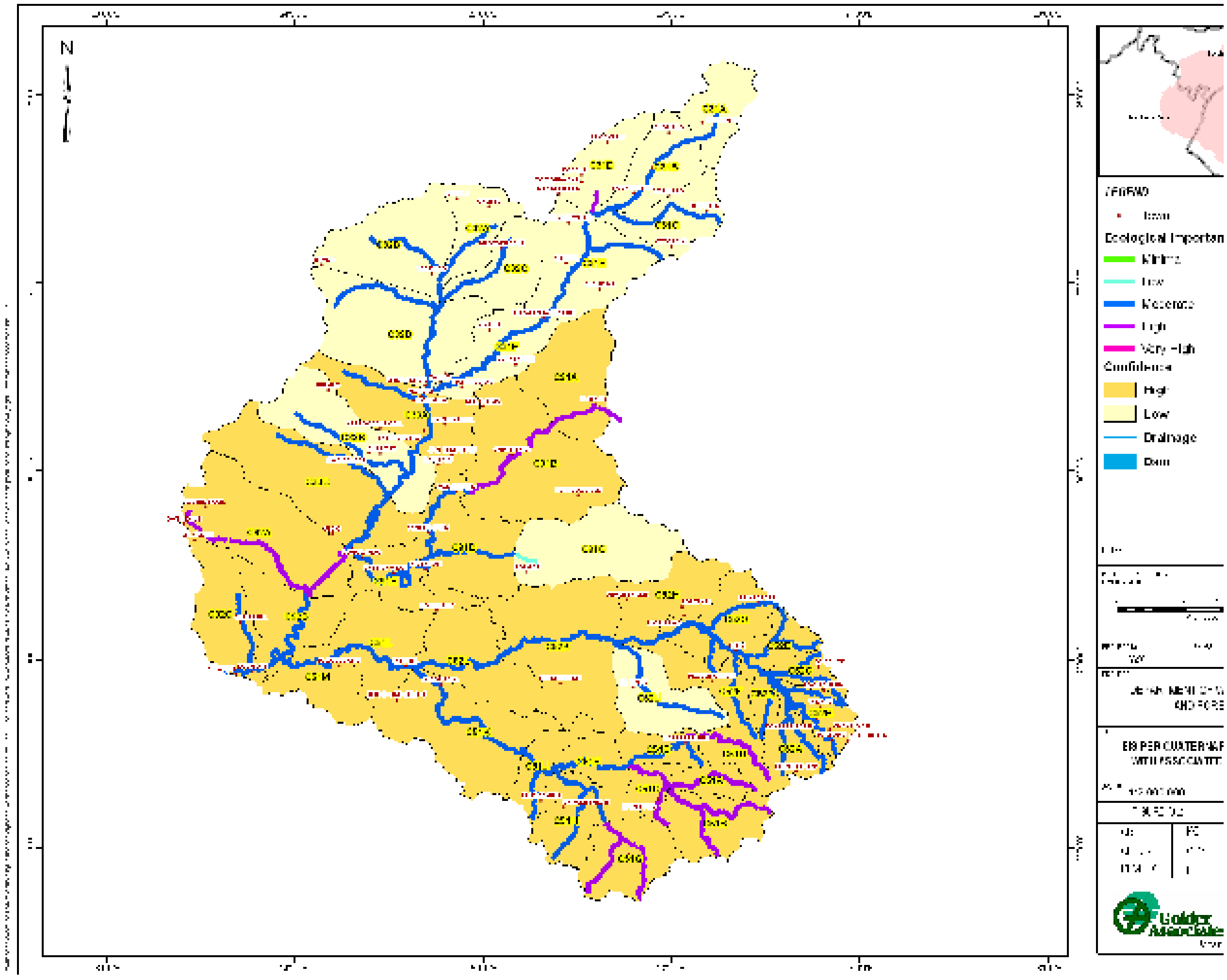
Column O Average confidence out of 5 (calculated in spreadsheet);

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 (



- Figure 3-2).

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

WMA, EcoRegions, Geomorphic zones, 1:50 000 rivers coverage.

Table 3-2: Summarised EIS results per quaternary catchment

QUATERNARY CATCHMENT	RIVER	EIS	CONFIDENCE (0-4)
C91A	**Vaal (downstream from Bloemhof dam)**	**HIGH**	**2.75**
C91B	**Vaal (main) /Vaalharts weir at bottom of catchment)**	**HIGH**	**2.75**
C91C	Endorheic (no rivers)	LOW	0
C91D	Vaal main downstream Vaalharts weir (tributary - Leeu)	MODERATE	2.75
C91E	Vaal main (Barkly West) upstream Harts confluence	MODERATE	2.75

QUATERNARY CATCHMENT	RIVER	EIS	CONFIDENCE (0-4)
C31A	Coligny Dam/ eye of Harts	MODERATE	1
C31B	Groot Harts	MODERATE	1
C31C	Klein Harts	MODERATE	1
C31D	**Barberspan/Leeupan**	**HIGH**	**1.1**
C31E	Middle reaches of Groot Harts	MODERATE	1
C31F	Groot Harts upstream of confluence with Dry Harts/	MODERATE	1
C32A	Leeuspruit	MODERATE	1
C32B	Dry Harts before confluence with Leeuspruit	MODERATE	1
C32C	Losase River	MODERATE	1
C32D	Dry Harts lower reaches before confluence with Groot	MODERATE	1
C33A	Harts after confluence with Dry Harts	MODERATE	2
C33B	Groot Boetsap tributary and Spitskop Dam	MODERATE	0.9
C33C	Harts downstream Spitskop/ Klein Boetsap tributary	MODERATE	2.4
C92A	**Vaal after confluence with Harts River / Klein Riet**	**HIGH**	**1.8**
C92B	Vaal main upstream Douglas Barrage/Riet River	MODERATE	1.8
C92C	Douglas Barrage	MODERATE	2
C51A	**Tributary to Riet - upper reaches**	**HIGH**	**2.5**
C51B	**Riet River upper reaches**	**HIGH**	**2.5**
C51C	**Riet River upstream confluence Tierpoort tributary**	**HIGH**	**2.5**
C51D	**Major tributary to Riet/Tierpoort Dam**	**HIGH**	**2.5**
C51E	**Tributary downstream Tierpoort Dam upstream**	**HIGH**	**2.5**
C51F	Riet river	MODERATE	2
C51G	**Kromellenboogspruit (upper reaches)**	**HIGH**	**2.5**
C51H	Kromellenboogspruit (upstream confluence with Riet -	MODERATE	2
C51J	Kalkfontein Dam	MODERATE	2
C51K	Riet river downstream Kalkfontein Dam, upstream	MODERATE	2
C51L	Riet river after confluence with Modder river	MODERATE	2.1
C51M	Riet river upstream Douglas Barrage	MODERATE	2
C52A	Rustfontein /Rustfontein Dam - before confluence	MODERATE	2.2
C52B	Modder River (upper reaches)	MODERATE	2.2
C52C	Korannaspruit - tributary to Modder River	MODERATE	2.2
C52D	Modder	MODERATE	2.2
C52E	Middle Modder River (and tributary Klein Osspruit)	MODERATE	2.2

QUATERNARY CATCHMENT	RIVER	EIS	CONFIDENCE (0-4)
C52F	Renoster (upstream from Bloemspruit confluence and	MODERATE	2.2
C52G	Modder (after confluence, before Krugerdrif dam)	MODERATE	2.1
C52H	Middle Modder River - upstream confluence with	MODERATE	2.2
C52J	Kaalspruit tributary	MODERATE	1.6
C52K	Lower Modder River	MODERATE	2.2
C52L	Lower Modder River upstream Riet River confluence	MODERATE	2.2

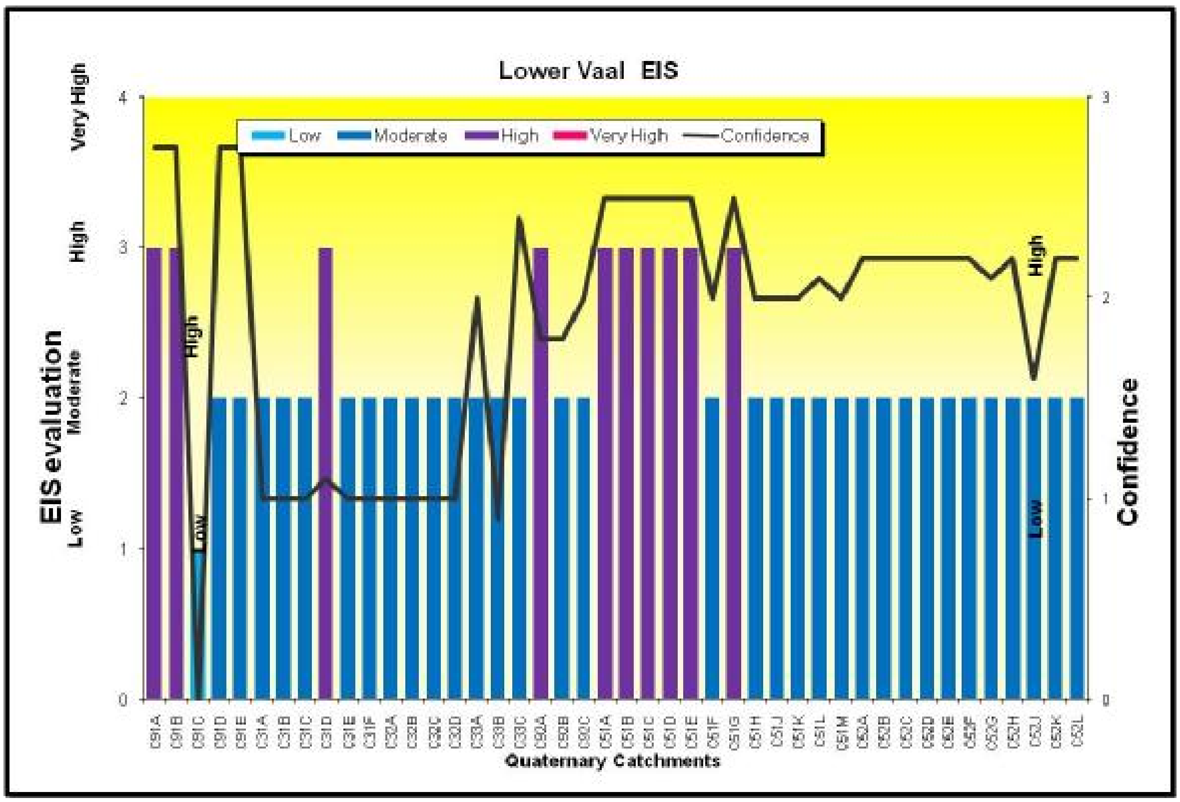


Figure 3-1: EIS and confidence evaluation illustrated as bar graphs for the Lower Vaal WMA

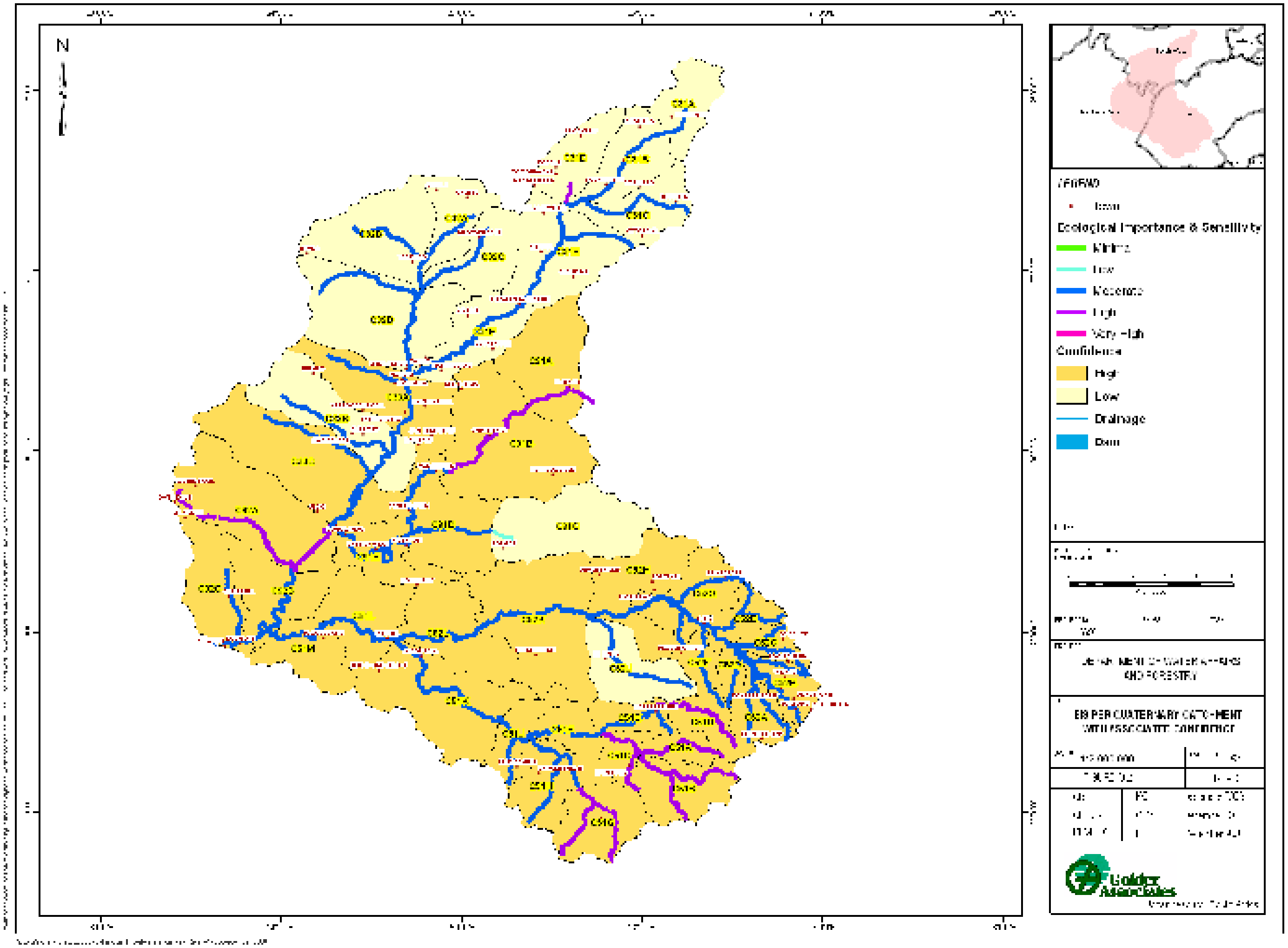


Figure 3-2: EIS per quaternary catchment with associated confidence

3.4 Conclusions

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

- C91A: Vaal River downstream of Bloemhof Dam due to a high species diversity and the presence of several rare and/or endemic fish species (e.g. *Austroglanis sclateri*).
- C91B: Vaal River and Vaalharts Weir due to the Rob Ferreira Provincial Reserve and the presence of *A. sclateri*.
- C31D: Barberspan/Leeupan due to the Barberspan Provincial Reserve (RAMSAR Site) and the presence of *A. sclateri*.
- C92A: Vaal River after confluence with Harts River and Klein Riet tributary due to the presence of *A. sclateri*.
- C51A to C51E and C51G: Riet River system due to species diversity, the importance of the pools as refugia and the presence of rare and/or endemic species such as *Labeobarbus kimberlyensis* and *A. sclateri*.

Most of the rest of the quaternary catchments were rated as moderate. The confidence of the evaluation as can be seen from

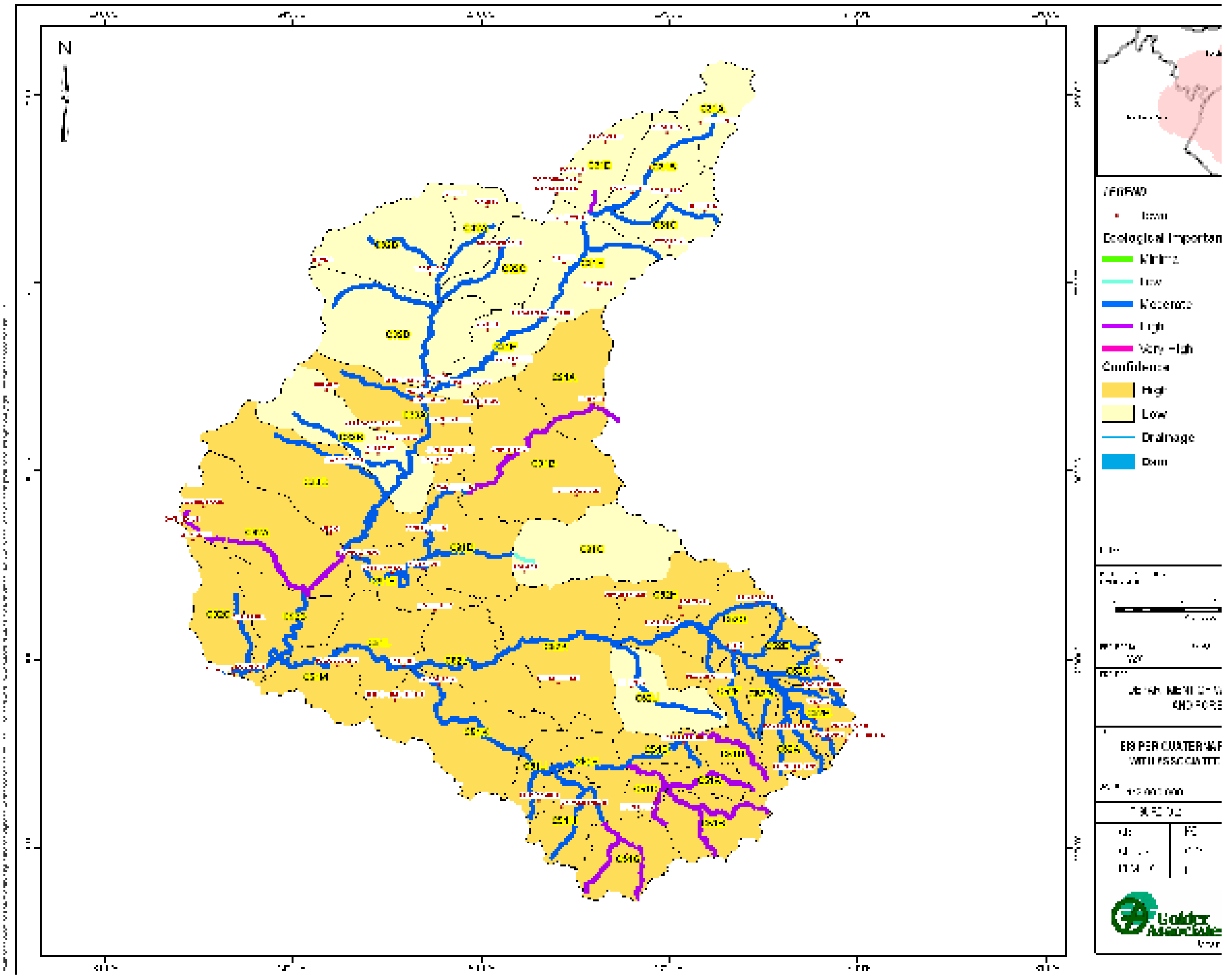


Figure **3-2: EIS per quaternary catchment with associated confidence**, ranged mostly from moderate to high with approximately 30% as low.

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 Lower Vaal WMA is relatively small, with the WMA generating about 2% of the Gross Domestic Product of South Africa (DWAF, 2003). The economy is still dominated by mining, however much of the beneficiation is done in other areas. Most of the economic activity is concentrated in Kimberley and at other major mining areas. Manufacturing activities in the WMA include cement and cheese factories and relate to the agriculture sectors as well as items for local consumption. The trade sector is concentrated in wholesale of primary products and related services to the community. No significant changes to the economy of the WMA are foreseen over the medium term. The agricultural and mining sectors in the region are strong and will continue to make an important contribution to the regional economy.

The Lower Vaal WMA also shows minimal potential for strong economic growth, and thus a low population growth is projected. Consequently, limited growth in water requirements is expected.

4.2 Social Environment

Current land use in the WMA, due to the arid climate is characterised by extensive livestock farming as the main activity and large scale dry land cultivation in the north eastern part of the WMA. Intensive irrigation (about 80% of water use) is practised at Vaalharts, as well as at locations along the Vaal River. The most significant urban area in the WMA is Kimberley to the South. Several towns as well as scattered rural settlements are found mainly in the central and eastern part of the WMA. Iron ore, diamonds and manganese are mined in the WMA. The poor in urban areas and rural villages are as important, in the consideration of the distribution and use of water resources, as the small (poor) rural subsistence farmer.

Livestock farming includes beef and dairy cattle, goats, non-wooled sheep, pigs and ostriches. In the east of the WMA, especially in the vicinity of Lichtenberg and Delareyville, dry-land crops (maize, sunflower, cotton, groundnuts and vegetables) are grown, but it is debatable whether or not this is commercially viable due to the low and erratic rainfall. There are large areas under irrigated crops in the Vaalharts area, but compared to the total area of the WMA, this area is small. The largest irrigation scheme is the Vaalharts Government Water Scheme, which is supplied via the Vaalharts weir with support from Bloemhof Dam.

The use of water for recreational purposes is one of the 11 water uses regulated in terms of the NWA (Act 36 of 1998). 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.

The area occurring within the Lower Vaal WMA exhibits very little urbanisation with the significant urban areas being Kimberley in the South, which lies only partly in the WMA, Lichtenburg in the north-east and Kuruman in the central part of the WMA. Other towns include Schweizer Reineke, Jan Kempdorp, Pampierstad, Christiana, Warrenton, Riverton, Delportshoop, Olifantshoek and Postmasburg. The Kalahari East Water Board and the North West Supply Authority are two water boards responsible for supplying bulk water to the users in the areas in the WMA. The large urban users are heavily dependent on water transferred into this WMA from the Upper and MiddleVaal WMAs.

4.3 SCI Model

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

- A site visit that covered points along the river; 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 –vely 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 Graphs (Figure 4-1)
- Catchment maps (Figure 4-2)

Table 4-2: SCI results

QUATERNARY CATCHMENT	RIVER	SCI	CONFIDENCE (0-5)
C91A	Vaal (downstream from Bloemhof dam)	LOW	2
C91B	Vaal (main) /Vaalharts weir at bottom of catchment)	LOW	2
C91C	Endorheic (no rivers)	MINIMAL	2
C91D	Vaal main downstream Vaalharts weir (tributary - Leeu)	LOW	2
C91E	Vaal main (Barkly West) upstream Harts confluence	MODERATE	2
C31A	Coligny Dam/ eye of Harts	MODERATE	4
C31B	Groot Harts	MODERATE	4

QUATERNARY CATCHMENT	RIVER	SCI	CONFIDENCE (0-5)
C31C	Klein Harts	LOW	2
C31D	Barberspan/Leeupan	MODERATE	2
C31E	Middle reaches of Groot Harts	LOW	2
C31F	Groot Harts upstream of confluence with Dry Harts/	MODERATE	2
C32A	Leeuspruit	LOW	2
C32B	Dry Harts before confluence with Leeuspruit	MODERATE	2
C32C	Losase River	LOW	2
C32D	Dry Harts lower reaches before confluence with Groot	LOW	2
C33A	Harts after confluence with Dry Harts	MODERATE	2
C33B	Groot Boetsap tributary and Spitskop Dam	MODERATE	2
C33C	Harts downstream Spitskop/ Klein Boetsap tributary	LOW	2
C92A	Vaal after confluence with Harts River / Klein Riet	LOW	3
C92B	Vaal main upstream Douglas Barrage/Riet River	MODERATE	2
C92C	Douglas Barrage	MODERATE	2
C51A	Tributary to Riet - upper reaches	LOW	2
C51B	Riet River upper reaches	LOW	3
C51C	Riet River upstream confluence Tierpoort tributary	MODERATE	1
C51D	Major tributary to Riet/Tierpoort Dam	MODERATE	2
C51E	Tributary downstream Tierpoort Dam upstream	LOW	3
C51F	Riet river	LOW	3
C51G	Kromellenboogspruit (upper reaches)	MODERATE	3
C51H	Kromellenboogspruit (upstream confluence with Riet -	MODERATE	2
C51J	Kalkfontein Dam	MODERATE	3
C51K	Riet river downstream Kalkfontein Dam, upstream	LOW	2
C51L	Riet river after confluence with Modder river	LOW	4
C51M	Riet river upstream Douglas Barrage	LOW	2
C52A	Rustfontein /Rustfontein Dam - before confluence	LOW	2
C52B	Modder River (upper reaches)	MODERATE	2
C52C	Korannaspruit - tributary to Modder River	MODERATE	2
C52D	Modder	LOW	2
C52E	Middle Modder River (and tributary Klein Osspruit)	LOW	4
C52F	Renoster (upstream from Bloemspruit confluence and	MODERATE	3
C52G	Modder (after confluence, before Krugerdrif dam)	LOW	2

QUATERNARY CATCHMENT	RIVER	SCI	CONFIDENCE (0-5)
C52H	Middle Modder River - upstream confluence with	LOW	3
C52J	Kaalspruit tributary	LOW	3
C52K	Lower Modder River	LOW	3
C52L	Lower Modder River upstream Riet River confluence	LOW	3

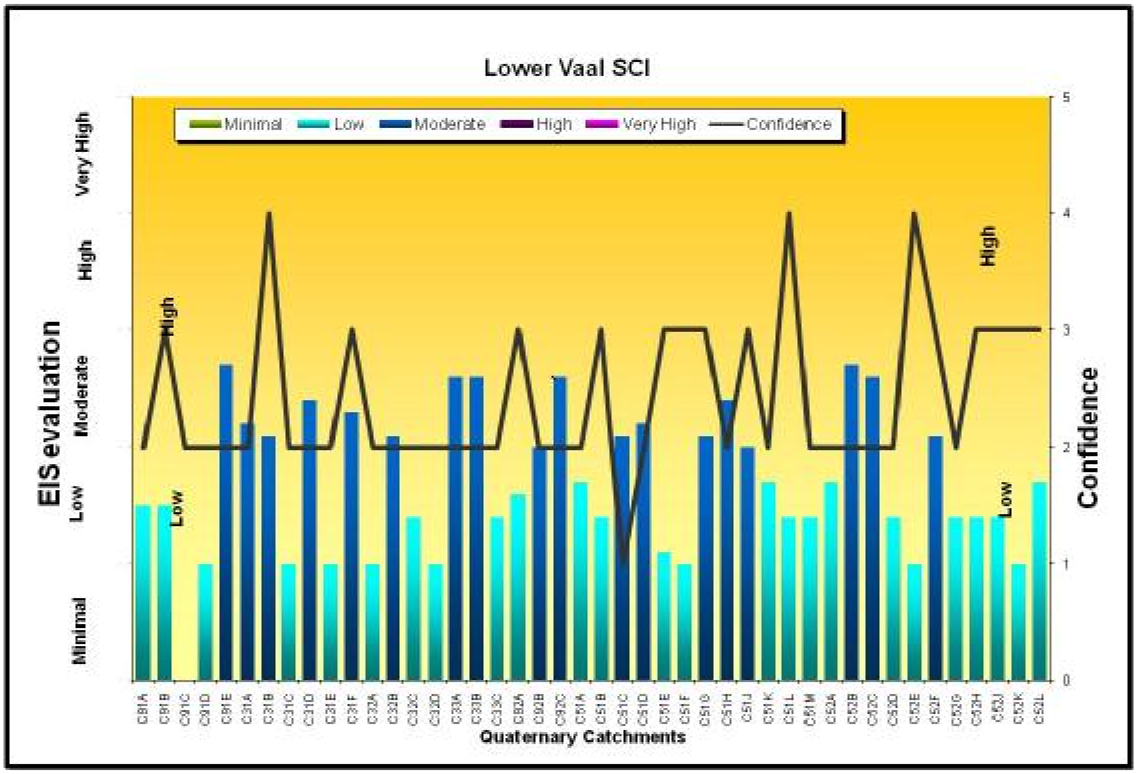


Figure 4-1: SCI and confidence evaluation illustrated as bar graph.

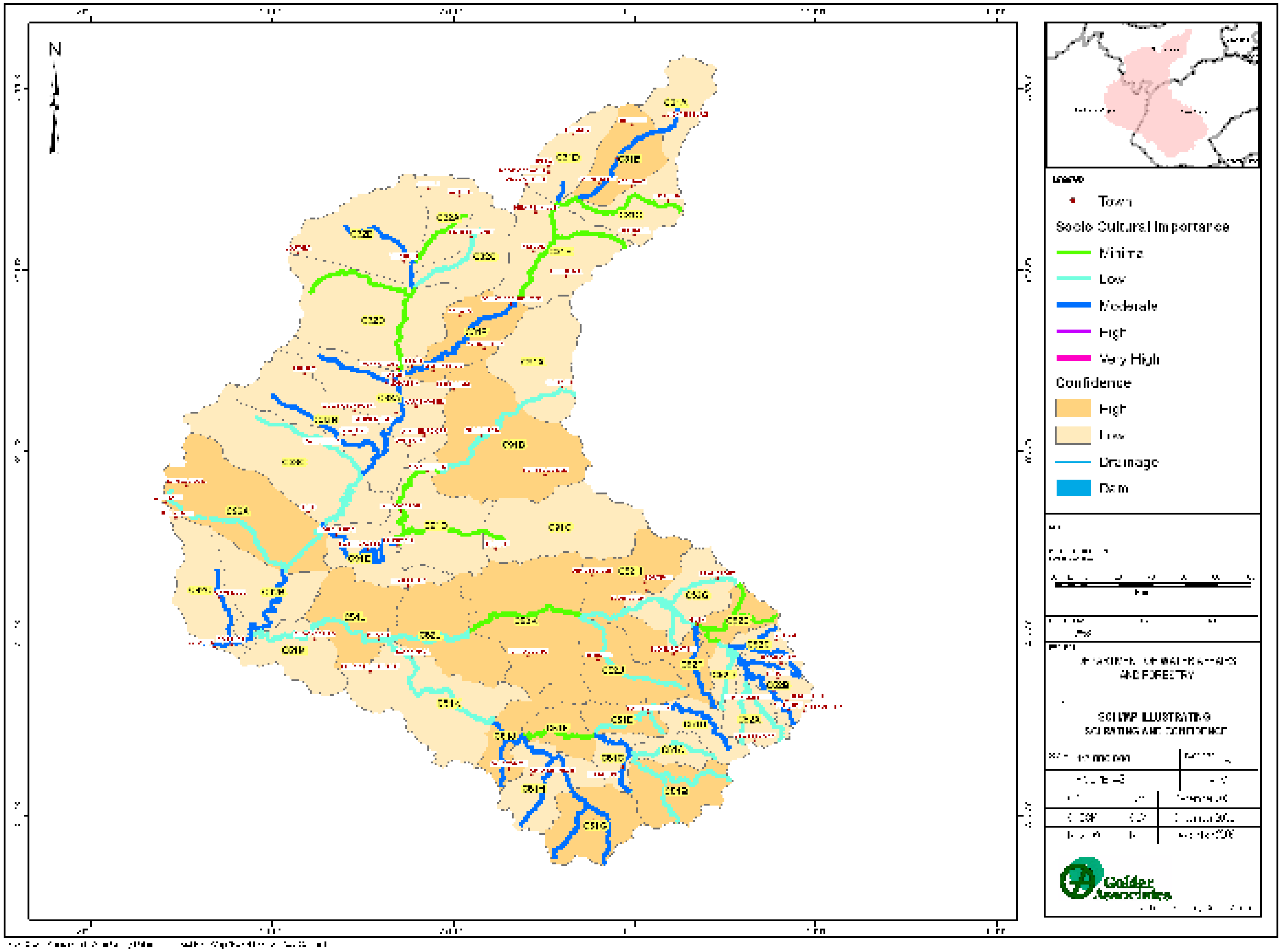


Figure 4-2: SCI map illustrating SCI rating and confidence

4.5 Conclusions

Areas dominated by relatively low population densities and given over to commercial farming enterprises tended to score relatively low in terms of SCI. An obvious exception is recreational use of the dams and main stem of the Vaal River. Portions of the WMA with water related recreational activity scored slightly higher. Areas dominated by alluvial diamond mining also scored generally low in terms of SCI. It should be emphasised that low SCI score does not indicate low economic importance. The Vaal Harts irrigation scheme is a case in point.

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, hyrdrology) 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.

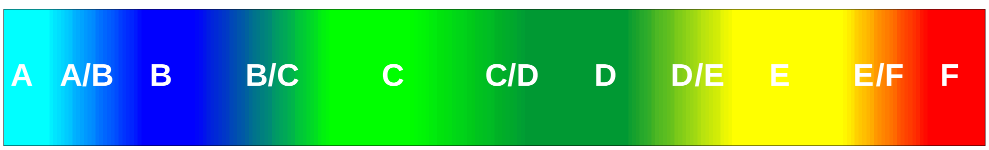


Figure 5-1: Illustration of the distribution of ecological categories on a continuum

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 a lack of relevant information in some of the study areas.

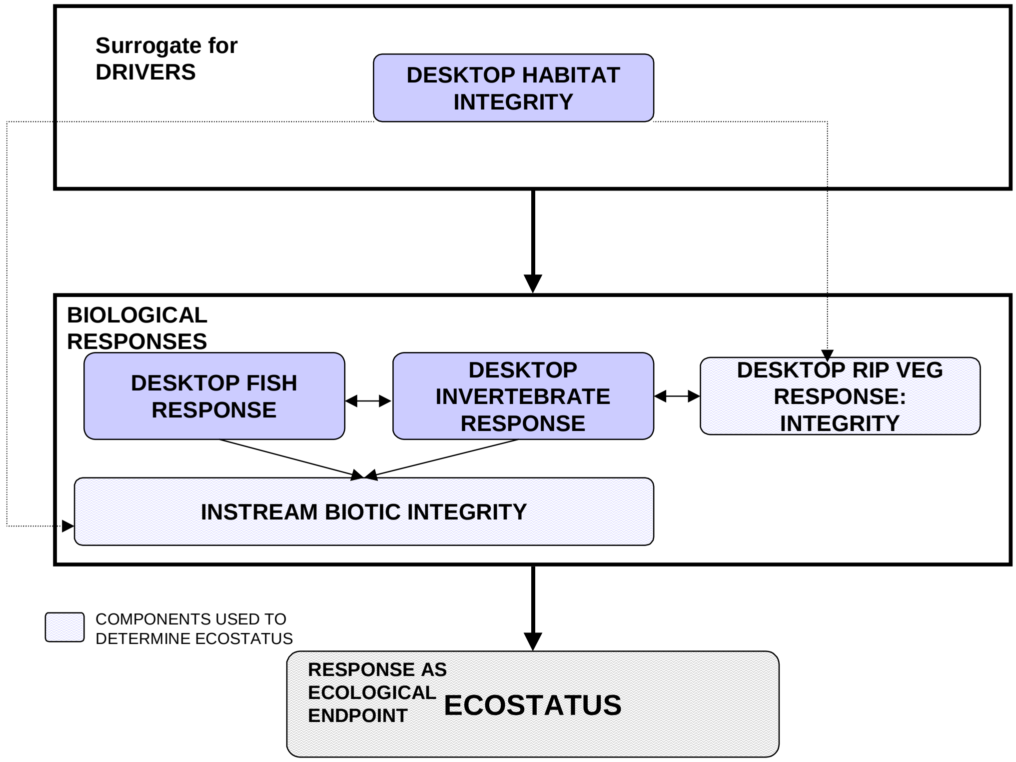


Figure 5-2: Desktop EcoStatus determination

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: Confindence 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 graph for the PES (Figure 5-4);
- Catchment map of the PES (Figure 5-5).

Table 5-1: Summarised PES results per quaternary catchment

QUATERNARY CATCHMENT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)	SOURCE
C91A	Vaal (downstream from Bloemhof dam)	C	2	Knowledge based on Google Earth and historical fish records
C91B	Vaal (main) /Vaalharts weir at bottom of catchment)	B	2	Knowledge based on Google Earth and historical fish records
C91C	endorheic no rivers	C	1	Google Earth only
C91D	Vaal main downstream Vaalharts weir (tributary - Leeu)	B/C	2	Knowledge based on Google Earth and historical fish records
C91E	Vaal main (Barkly West) upstream Harts confluence	C	2	Knowledge based on Google Earth and historical fish records
C31A	Coligny Dam/ eye of Harts	D	2	Knowledge based on Google Earth and historical fish records
C31B	Groot Harts	D	3	Google Earth, historical and recent biota surveys, personal knowledge

QUATERNARY CATCHMENT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)	SOURCE
C31C	Klein Harts	C/D	2	Knowledge based on Google Earth and historical fish records
C31D	Barberspan/Leeupan	D	2	Knowledge based on Google Earth and historical fish records
C31E	Middle reaches of Groot Harts	C	3	Google Earth, historical and recent biota surveys, personal knowledge
C31F	Groot Harts upstream of confluence with Dry Harts/ Taung Dam	C	2	Google Earth, access problems, some fish and invert records.
C32A	Leeuspruit	B/C	2	0
C32B	Dry Harts before confluence with Leeuspruit	B	2	Knowledge based on Google Earth and historical fish records
C32C	Losase River	B/C	2	Google Earth, access problems, some fish and invert records.
C32D	Dry Harts lower reaches before confluence with Groot Harts. Includes Korobela and Dwars tributaries	B/C	2	Google Earth, access problems.
C33A	Harts after confluence with Dry Harts	C	4	Bivane IFR site, fish and invertebrate information
C33B	Groot Boetsap tributary and Spitskop Dam	B	2	Google Earth, limited information
C33C	Harts downstream Spitskop/ Klein Boetsap tributary	B	2	Google Earth, limited information
C92A	Vaal after confluence with Harts River / Klein Riet tributary	C	2	Google Earth, some fish information
C92B	Vaal main upstream Douglas Barrage/Riet River confluence into Douglas Barrage	C/D	3	Visited, Google Earth, some fish information
C92C	Douglas Barrage	C	2	Google Earth, derived information from area visited, fish records.
C51A	Tributary to Riet - upper reaches	C	2	Google Earth, derived information from area visited, fish records.
C51B	Riet River upper reaches	C/D	3	Google Earth, area visited, fish records.
C51C	Riet River upstream confluence Tierpoort tributary	D	4	Google Earth, area visited, fish records.
C51D	Major tributary to Riet/Tierpoort Dam	D/E	4	Google Earth, area visited, fish records.
C51E	Tributary downstream Tierpoort Dam upstream confluence with Riet	D/E	4	Google Earth, area visited, fish records.
C51F	Riet river	D	3	Area visited, Google Earth, extensive fish and invertebrate information
C51G	Kromellenboogspruit (upper reaches)	C	3	Area visited, Google Earth, extensive fish and invertebrate information

QUATERNARY CATCHMENT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)	SOURCE
C51H	Kromellenboogspruit (upstream confluence with Riet - includes Prosesspruit tributary)	C	3	Area visited, Google Earth, extensive fish and invertebrate information
C51J	Kalkfontein Dam	C	3	Area visited, Google Earth, extensive fish and invertebrate information
C51K	Riet river downstream Kalkfontein Dam, upstream confluence with Modder river	C	2	Google Earth, some fish and invertebrate information
C51L	Riet river after confluence with Modder river	C	3	Area visited, Google Earth, extensive fish and invertebrate information
C51M	Riet river upstream Douglas Barrage	C	4	Area known to specialists, Google Earth, fish survey information
C52A	Rustfontein /Rustfontein Dam - before confluence	C	3	Google Earth, river known to specialists
C52B	Modder River (upper reaches)	D	4	Present surveys, area visited, EFR 2 situated in quat, Google Earth.
C52C	Korannaspruit - tributary to Modder River	B/C	2	Google Earth only
C52D	Modder	C	2	Google Earth and some limited fish surveys
C52E	Middle Modder River (and tributary Klein Osspruit)	C	3	Google Earth, some fish sruveys
C52F	Renoster (upstream from Bloemspruit confluence and informal settlement)	C	4	Google Earth, EFR3 situated in quat, extensive surveys, historical fish surveys.
C52G	Modder (after confluence, before Krugerdrif dam)	C	2	Google Earth, limited personal knowledge
C52H	Middle Modder River - upstream confluence with Kaalspruit	D	3	Google Earth, specialist knowledge, fish surveys
C52J	Kaalspruit tributary	B/C	3	Google Earth, specialist knowledge, fish surveys
C52K	Lower Modder River	B/C	2	Google Earth, some limited knowledge
C52L	Lower Modder River upstream Riet River confluence	C	3	Google Earth, specialist knowledge

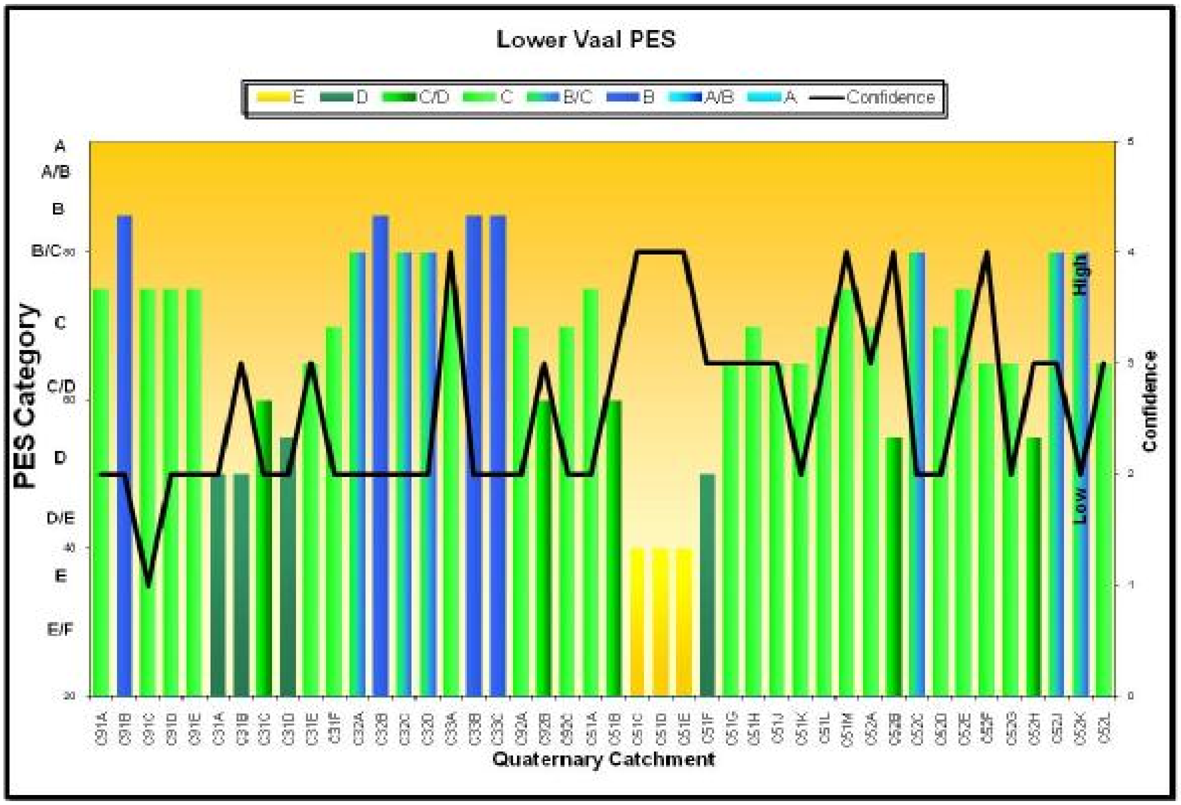


Figure 5-4: PES and confidence evaluation illustrated as bar graphs

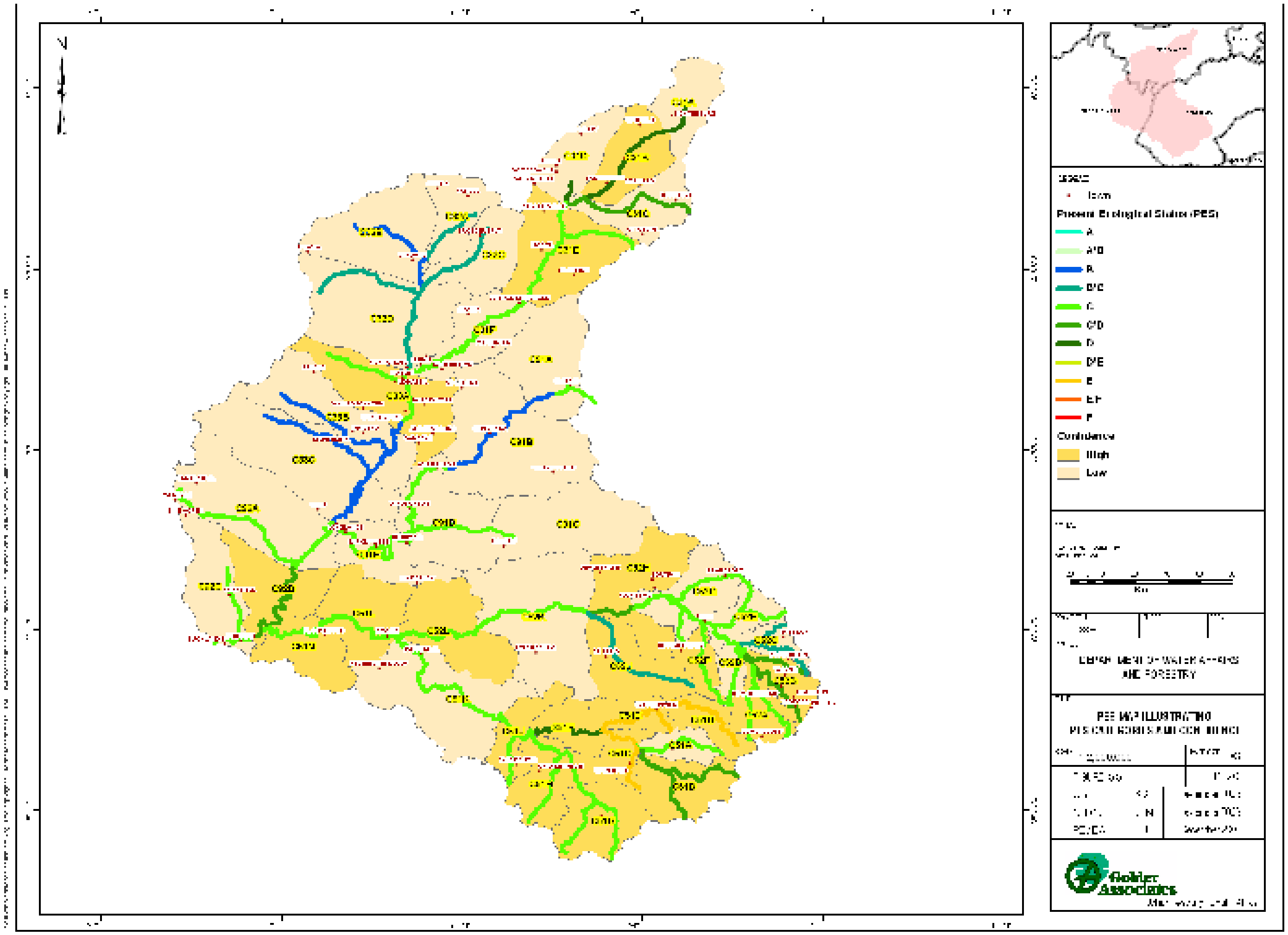


Figure 5-5: PES map illustrating PES categories and confidence

5.4 Conclusions

The bulk of the rivers in WMA 10 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:

- C91B: Vaal (main) and Vaalharts Weir.
- C32B: Dry Harts before confluence with Leeuspruit.
- C33B: Groot Boetsap tributary and Spitskop Dam.
- C33C: Harts River downstream of Spitskop Dam.

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 alluvial diamond mining, irrigation and interbasin water transfers (Vaal Harts irrigation system). Water quality issues (salts and nutrients) are prevalent in many streams as well as increased flows, i.e. more than natural (due to interbasin transfers for irrigation areas).

Approximately 40% of the quaternaries have a moderate to high confidence.

6 RECOMMENDATIONS

Recommendations have been made using two matrices (Figure 6-1 and Figure 6-2) 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 a very high overall importance, but is in a 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 a 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 a 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).

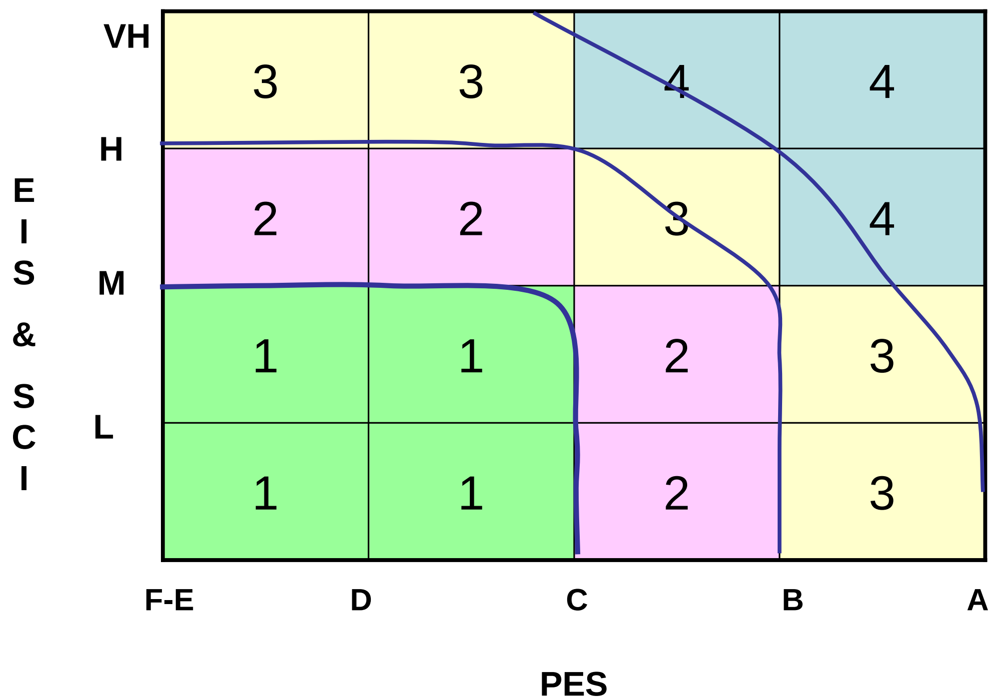


Figure 6-1: Matrix used to determine a combined EIS and PES value which provides an Integrated Importance value on a scale of 0 – 4

The results of the evaluation are listed in the 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. The additional information provided in Figure 6.2 are the quaternary catchment where specific EIS or SCI metrics have rated a 4. These are illustrated as lines on the rivers.

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

Quaternary Catchment	River	Importance Rating (0 – 4)	Reasons for Evaluation
C91A	Vaal (downstream from Bloemhof Dam)	3	High EIS Bloemhof release required for Vaal integrity.
C91B	Vaal (main)/Vaalharts Weir at bottom of catchment)	3	High EIS and B PES Bloemhof release required for Vaal integrity
C91D	Vaal main downstream Vaalharts Weir (tributary Leeu)	3	Bloemhof release required for Vaal integrity
C31D	Barberspan/Leeupan	3	High EIS and Moderate SCI Barberspan
C33C	Harts downstream Spitskop/Klein Boetsap tributary	3	B PES Releases from Spitskop maintain integrity of Harts River
C92B	Vaal main upstream Douglas Barrage/Riet River confluence into Douglas Barrage	3	Maintain integrity of Vaal system
C51K	Riet River downstream Kalkfontein Dam, upstream confluence with Modder River	3	Maintain integrity of Riet River
C51L	Riet River after confluence with Modder River	3	Maintain integrity of Riet River
C51M	Riet River upstream Douglas Barrage	3	Maintain integrity of Riet River
C52L	Lower Modder River upstream Riet River confluence	3	Maintain integrity of Modder River

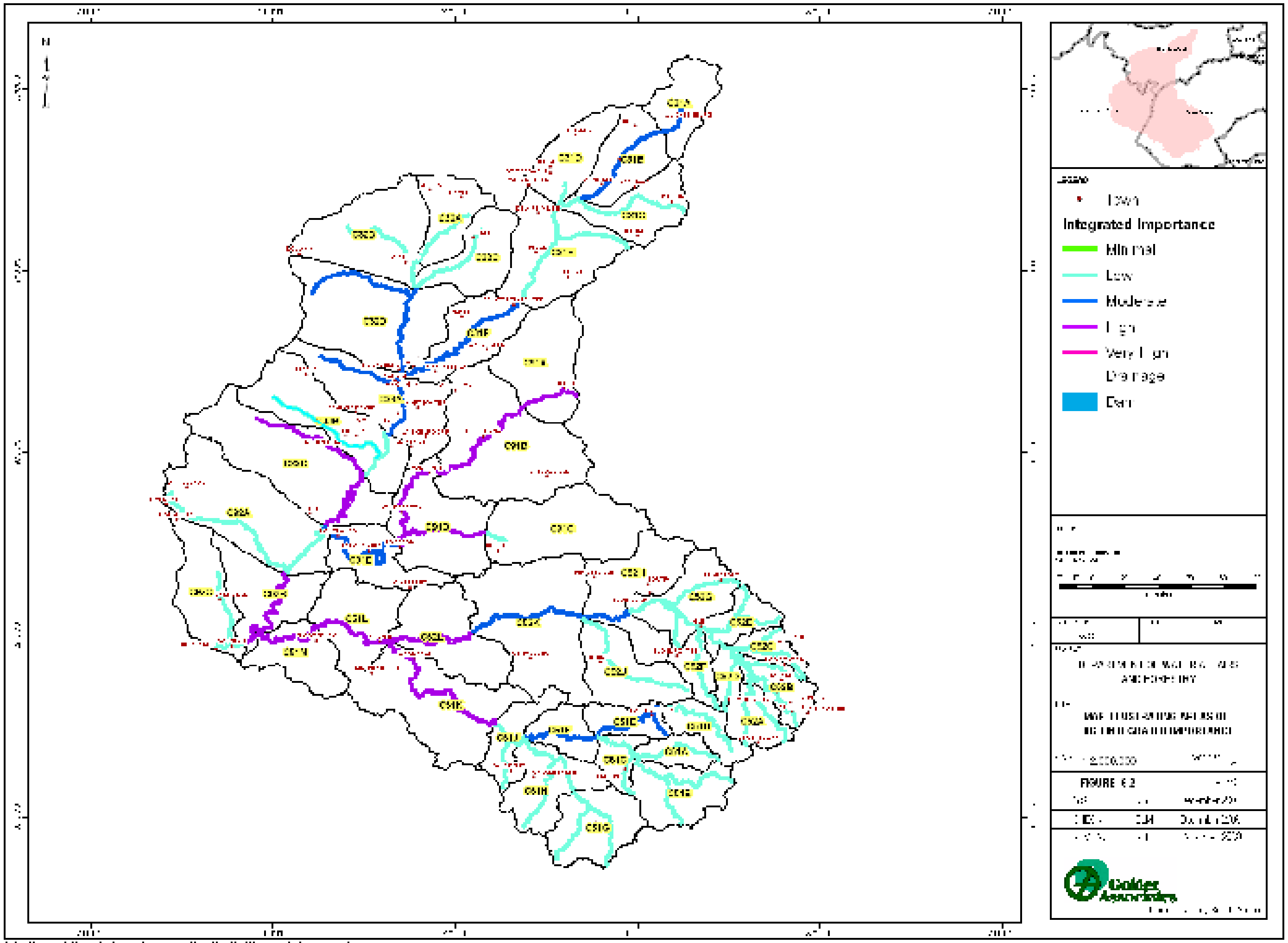


Figure 6-2: Map illustrating areas of high Integrated Importance

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 6-4). 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).

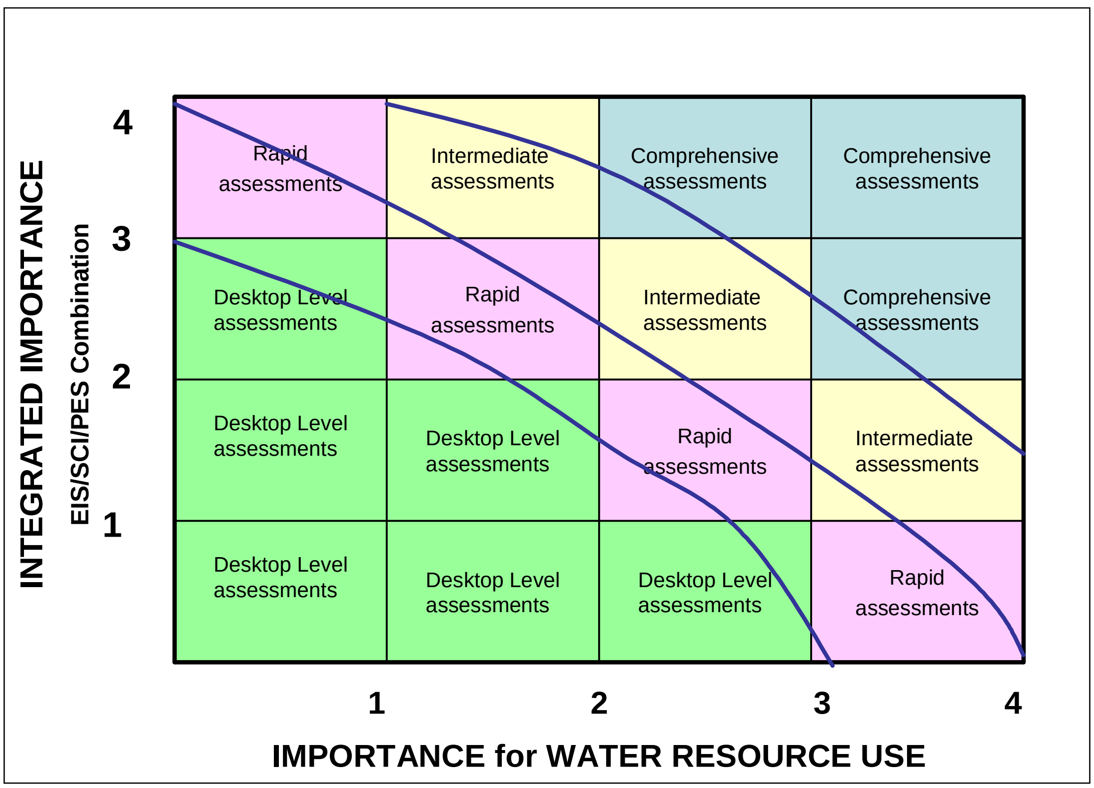


Figure 6-3: Matrix indicating the level of EWR assessments required

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, Appendix A). 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 quantatively 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 thereof 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	Recommendations PRIORITY RATING	Reasons for Evaluation
C91A	Vaal (downstream from Bloemhof dam)	3	3	3	High EIS Bloemhof release required for Vaal integrity
C91B	Vaal (main) /Vaalharts weir at bottom of catchment)	3	3	3	High EIS and B PES Bloemhof release required for Vaal integrity
C91C	endorheic no rivers	1	0	1	
C91D	Vaal main downstream Vaalharts weir (tributary - Leeu)	3	3	3	Moderate EIS and B/C PES Bloemhof release required for Vaal integrity
C91E	Vaal main (Barkly West) upstream Harts confluence	2	3	3	Need to keep environmental flows for yellow fish movement
C31A	Coligny Dam/ eye of Harts	2	2	2	
C31B	Groot Harts	2	2	2	
C31C	Klein Harts	2	1	1	
C31D	Barberspan/Leeupan	3	2	1	High EIS and Moderate SCI
C31E	Middle reaches of Groot Harts	2	2	1	
C31F	Groot Harts upstream of confluence with Dry Harts/ Taung Dam	2	2	2	
C32A	Leeuspruit	2	1	1	
C32B	Dry Harts before confluence with Leeuspruit	1	1	1	

Quaternary Catchment	River	Importance Rating (0 – 4)	Water Resource Stress Rating	Recommendations PRIORITY RATING	Reasons for Evaluation
C32C	Losase River	1	1	1	
C32D	Dry Harts lower reaches before confluence with Groot Harts. Includes Korobela and Dwars tributaries	2	2	2	
C33A	Harts after confluence with Dry Harts	2	2	2	
C33B	Groot Boetsap tributary and Spitskop Dam	2	1	1	
C33C	Harts downstream Spitskop/ Klein Boetsap tributary	3	3	3	B PES Releases from Spitskop Dam maintain the integrity of the Harts River
C92A	Vaal after confluence with Harts River / Klein Riet tributary	2	1	1	
C92B	Vaal main upstream Douglas Barrage/Riet River confluence into Douglas Barrage	3	3	3	Important for integrity of Vaal system
C92C	Douglas Barrage	2	3	1	Managed to not release poor water quality into the Orange River
C51A	Tributary to Riet - upper reaches	2	1	1	
C51B	Riet River upper reaches	1	1	1	
C51C	Riet River upstream confluence Tierpoort tributary	2	2	1	
C51D	Major tributary to Riet/Tierpoort Dam	1	2	1	
C51E	Tributary downstream Tierpoort Dam upstream confluence with Riet	2	2	2	
C51F	Riet river	2	2	2	
C51G	Kromellenboogspruit (upper reaches)	2	2	1	
C51H	Kromellenboogspruit (upstream confluence with Riet - includes Prosesspruit tributary)	1	1	1	
C51J	Kalkfontein Dam	2	2	1	
C51K	Riet river downstream Kalkfontein Dam, upstream confluence with Modder river	3	2	3	Maintain integrity of Riet River

Quaternary Catchment	River	Importance Rating (0 – 4)	Water Resource Stress Rating	Recommendations PRIORITY RATING	Reasons for Evaluation
C51L	Riet river after confluence with Modder river	3	2	3	Maintain integrity of Riet River
C51M	Riet river upstream Douglas Barrage	3	2	3	Maintain integrity of Riet River
C52A	Rustfontein /Rustfontein Dam - before confluence	2	2	1	
C52B	Modder River (upper reaches)	1	2	1	
C52C	Korannaspruit - tributary to Modder River	2	1	1	
C52D	Modder	1	1	1	
C52E	Middle Modder River (and tributary Klein Osspruit)	2	2	1	
C52F	Renoster (upstream from Bloemspruit confluence and informal settlement)	2	3	1	
C52G	Modder (after confluence, before Krugerdrif dam)	2	2	1	
C52H	Middle Modder River - upstream confluence with Kaalspruit	1	3	2	Migratory corridor from Vaal to Modder-Riet
C52J	Kaalspruit tributary	2	2	1	
C52K	Lower Modder River	2	3	2	Migratory corridor from Vaal to Modder-Riet
C52L	Lower Modder River upstream Riet River confluence	3	3	2	Maintain the integrity of the Modder River

These areas are illustrated spatially on a map (Figure 6-4). Pink (very high) and purple (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 Lower Vaal WMA there are no pink classified quaternaries and only a few purple (high priority) quaternaries (Table 6-3).

This assessment guided the selection of EWR sites (See the Resource Unit report). It will be attempted to place most of the 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 and areas with a high demand for licenses.

Table 6-3: Summary of high priority areas

High priority quaternary catchment	River	Suggested EWR level	EWR site
C91A	Vaal (downstream of Bloemhof dam)	Intermediate/Comprehensive	EWR 5
C91B	Vaal (main)/Vaalharts weir at bottom of catchment	Intermediate/Comprehensive	
C91D	Vaal main downstream Vaalharts weir (tributary-Leeu)	Intermediate/Comprehensive	
C91E	Vaal main (Barkly West) Upstream Harts confluence	Rapid/Intermediate	
C33C	Harts downstream Spitskop/Klein Boetsap tributary	Intermediate/Comprehensive	EWR 6
C92B	Vaal main upstream Douglas Barrage/Riet River confluence into Douglas Barrage	Intermediate/Comprehensive	EWR 7
C51K	Riet River downstream Kalkfontein Dam, upstream confluence with Modder River	Rapid/Intermediate	
C51L	Riet River after confluence with Modder River	Rapid/Intermediate	EWR 8
C51M	Riet River upstream Douglas Barrage	Rapid/Intermediate	

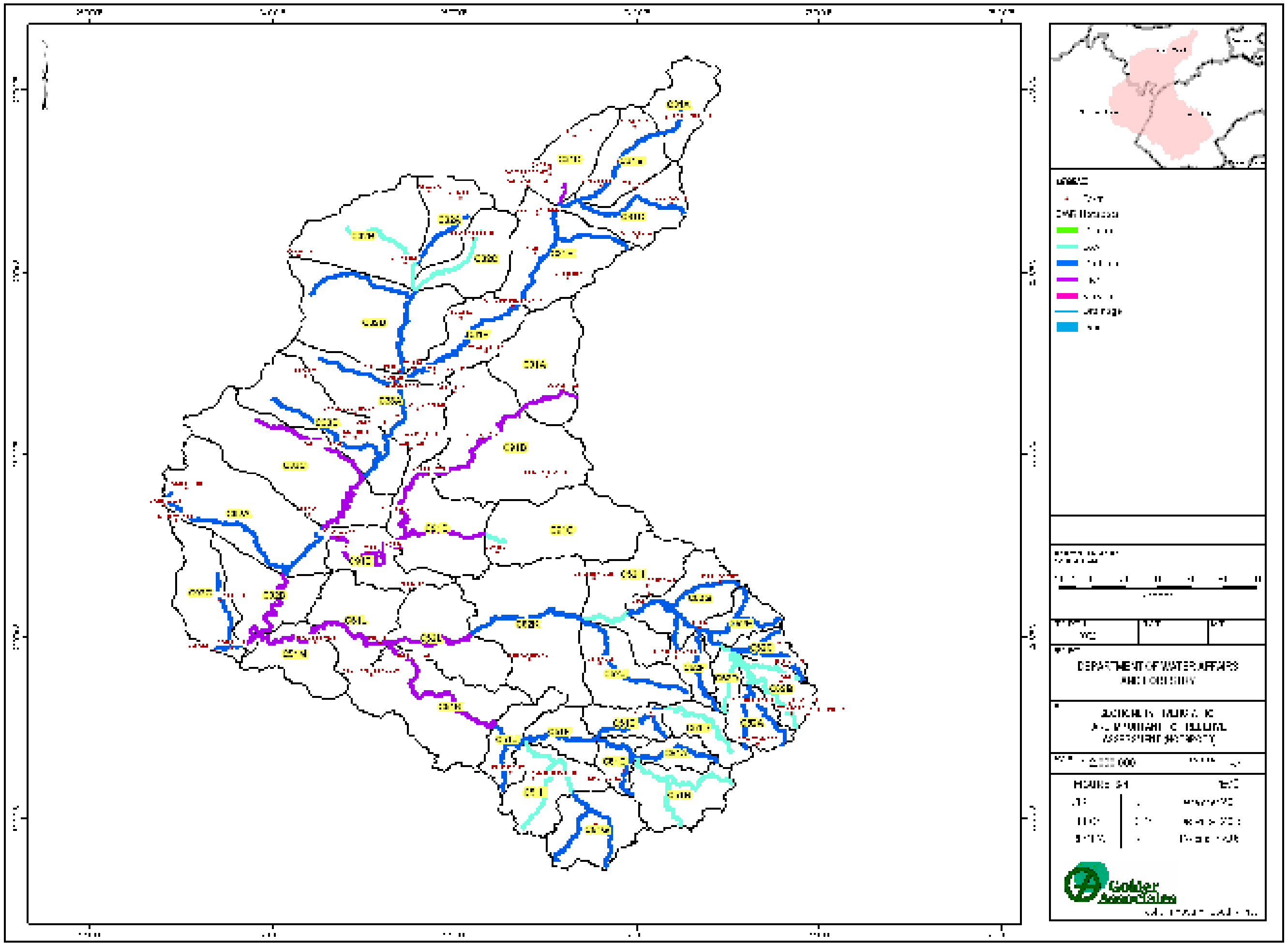


Figure 6-4: Sections in rivers which are important for Reserve assessment (Hotspots) (derived from overlaying Integrated Importance and Water Resource Use

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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

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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 m^3/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 is 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 form 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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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 m^3/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.

Taaibosspruit 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 rives 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 m^3/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
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 been 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