DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE LOWER VAAL WATER MANAGEMENT AREA (WMA10)

WP10535

GAP ANALYSIS REPORT

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Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10) - WP10535

Gap Analysis Report

Executive Summary

This report presents the approach adopted and the findings of the synchronisation and gap analyses procedures undertaken within the RQO determination process for the lower Vaal WMA. The synchronisation phase presents the manner in which the RQO and WRC (Water Resource Classification) processes will be aligned so that RQOs and WRC classes can ultimately be gazetted together as integral parts of the South African Integrated Water Resource Management (IWRM) process for the Vaal Catchment. Thereafter the availability of information required to determine RQOs for rivers, dams, wetlands and groundwater components from the WRC study, and other sources of information, have been evaluated in the gap analyses sections of the report. The report also presents potential solutions, with time and budgetary implications, to mitigate identified information gaps which will allow the RQO process to be completed with moderate to high confidence.

The Institute of Natural Resources (INR) has been commissioned to determine the Resource Quality Objectives (RQO) for the Lower Vaal Water Management Area by the South African Department of Water and Sanitation. The scope of the study allows for five (step 3 to 7) of the seven procedural steps of the RQO procedure to be completed. Due to the availability of Management Classes and associated Nestled Ecological Category information for the study area through the completed Water Resource Classification (WRC) study, steps 1 and 2 of the RQO procedure should have been carried out with sufficient confidence to allow for the remaining steps (steps 3-7) of the RQO methodology to be completed with suitably high confidence. As such although the RQO determination study will make use of the outcomes of the WRC study, it is not dependent on the information from the study alone as various other sources of information (such as Reserve studies) exist which will be used in this RQO determination study. Should some information requirements for this RQO study however not be available from the WRC process, and or any other sources of information, the RQO process allows for this specific information to be collected through various processes, and incorporated into the RQO study without affecting the outcomes of the Water Resource Classification Study (WRC study) (DWA, 2011b). The scope of this Lower Vaal RQO determination study however does not allow for any additional information collection processes that may be required to complete the RQO process should the information from the WRC study and other sources prove to be insufficient.

The synchronisation process involves consideration of the outcomes of the WRC study which include MCs and NECs that have been generated for nodes within IUAs. The RQO process will allow for the MCs and NECs to be maintained so that ultimately both the WRC study classes and RQOs can be gazetted as integral parts of the South African Integrated Water Resource Management (IWRM) process for the Vaal Catchment without conflict.

A summary of the identified gaps in information and proposed solutions to these gaps which will affect the determine RQOs as well as solutions are presented in Table 1.

Table 1: Summary of the information gaps identified in the study as well as proposed solutions to address these gaps.

	Component			
	Rivers	Wetlands	Groundwater (GW)	Dams
Step 1. Delineating IUAs and RUs	• IUAs already delineated with biophysical nodes as foundation for RUs.			
	• Gap: RUs for rivers not delineated. • Solution: GIS assessment of nodes, contours vs. IUAs. RUs will be delineated, based on nodes and include associated terrestrial components delineated to catchment boundaries.	• Gap: No wetland RUs delineated. • Gap: Wetland RUs need to be delineated by type and aligned to IUAs boundaries. • Solution: Sufficient information available for wetland RU delineation.	• Gap: No GW RUs delineated. • GAP: GW RUs need to be delineated by type and aligned to IUAs boundaries. • Solution: GIS assessment of GW types vs. IUAs. GW RUs will then be delineated within existing IUAs.	• Gap: No dam RUs delineated. • Solution: Dam RUs to be delineated for large dams using available GIS data within existing IUAs and small dams (aka. Farm dams) will be considered within river RUs.
Step 2. Setting vision	• There was no formal visioning exercise that identifies the location of users and ecosystem components and their requirements in the WRC study. Management Classes and NECs will be used to generate vision information for IUAs. • Gap: IUA specific vision information for RU prioritisation and sub-component selection and prioritisation is required. • Gap: NEC data is largely specific to rivers and can only loosely be used to infer ecological state information for wetland, dams and groundwater components. • Solution: With broad IUA MC, NEC data and findings of additional studies, RQO steps 1-3 will be completed. Directed stakeholder engagement exercise is required during RQO step 4 to select and prioritise sub-components/criteria for prioritised RUs.			
Step 3. Prioritising RUs	• RU prioritisation tool will be used with ecosystem attribute criteria based on rivers. • Technical protection and use information required for RU prioritisation is available from WRC study • Gap: Additional ecological and user information is required from other sources.	• An amended RU prioritisation tool with wetland specific attribute criteria will be used.	• An amended RU prioritisation tool with GW specific attribute criteria will be used.	• An amended RU prioritisation tool with dams specific attribute criteria will be used. • Technical information pertaining to role of dams to maintain flows is available as well as water storage and associated IBT requirements.
		• Gap: Ecological and user information, not available in WRC study is needed for prioritisation.		
	• GAP: location specific vision information is unavailable to prioritise RUs. • Applicable visions generated from WRC study (see step 2) will be used to contribute to this step.			
Step 4. Prioritising sub-components and selecting indicators	• The Resource Unit Evaluation Tool will be used to evaluate river sub-components for the protection and use of ecosystem attributes. • Existing data from WRC study (for rivers) will contribute to the completion of this step. • Gap: Available information is insufficient to allow for important users and their requirements to be identified for prioritised RUs.	• The Resource Unit Evaluation Tool will be used to evaluate wetland sub-components for the protection and use of ecosystem attributes.	• Approach described by Colvin et al. (2004) to prioritise sub-components and to select GW specific indicators.	• The Resource Unit Evaluation Tool will be used to evaluate dam sub-components for the protection and use of ecosystem attributes.
		• Gap: Data pertaining to ecological state and user requirements of ecosystems (wetlands, GW & dams) and threats from WRC study is required. • Solution: Carry out desktop data gathering of ecological state and user requirement information and threats to ecosystems (wetlands, GW & dams) in Lower Vaal.		

	• Solution: Directed stakeholder engagement exercise required to identify use and protection requirements for prioritised RUs and identify sub-components for RQO determination and RQO indicators.
Step 5. Developing draft RQOs and Numerical Limits	• GAP: Information for the establishment of protection and use RQO numerical limits for rivers, wetlands, groundwater and dam ecosystems may be insufficient and or unavailable. This will not affect the RQOs but the numerical limits for the RQOs. • Solution: Following the establishment of RQOs (during step 5) and the identification of criteria for which numerical limits will be set, data requirements for setting numerical limits will be gathered through additional literature surveys, by extrapolation from other sites or by using scientific judgement.

The outcomes of the synchronisation and gap analyses shows that the RQO process can be aligned with the WRC study findings.

Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10) - WP10535

Gap Analysis Report

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ABBREVIATIONS

Acronym	Meaning
Al	Aluminium
As	Arsenic
$CaCO_3$	Calcium Carbonate
Cd	Cadmium
Chl-a	Chlorophyll a
Cl	Chlorine
Cr(VI)	Hexavalent chromium
Cu	Copper
DOC	Dissolved organic carbon
DRM	Desktop Reserve Model
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
F	Fluorine
FEPA	Freshwater Ecosystem Priority Areas
FRAI	Fish Response Assessment Index
GIS	Geographical Information Science
Hg	Mercury
□g/l	Micrograms per litre
IBA	Important Bird Areas
IRHI	Index of Reservoir Habitat Impairment
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resources Management Plan
KNP	Kruger National Park
m^3/s	Cubic meters per meter (cumecs)
MAR	Mean Annual Runoff
MC	Management Class
mg/l	Milligrams per litre
MIRAI	Macroinvertebrate Response Assessment Index
Mn	Manganese
NFEPA	National Freshwater Ecosystem Priority Areas
NL	Numerical Limit
NO_2	Nitrite
NO_3	Nitrate
NTU	Turbidity
NWA	National Water Act
NWRS	National Water Resource Strategy
O_2	Oxygen

Pb	Lead
PES	Present Ecological State
pH	power of hydrogen
PO_4	Phosphate
RDM	Resource Directed Measures
REC	Recommended Ecological Category
REC	Recommended ecological category
RHAM	Rapid Habitat Assessment Method
RHP	River Health Programme
RO	Regional Office
RQOs	Resource Quality Objectives
RR	Reporting rates
RU / RUs	Resource Unit/s
RUET	Resource Unit Evaluation Tool
RUPT	Resource Unit Prioritisation Tool
SASS5	South African Scoring System version 5
Se	Selenium
SPI	Specific Pollution sensitivity Index
TDS	Total Dissolved Solids
TIN	Total Inorganic Nitrogen
TPC	Threshold of Probable Concern
VEGRAI	Vegetation Response Assessment Index
VMAR	Virgin Mean Annual Runoff
WE	Water Ecosystems
WMA	Water Management Area
WRC	Water Resource Classification
WWTW	Waste Water Treatment Works
Zn	Zinc

DEFINITION OF PROJECT SPECIFIC ACRONYMS:

EWR – Ecological Water Requirements is synonymous with the ecological component of the Reserve as defined in the Water Act (1998).

IUA – Integrated Unit of Analysis or spatial units that will be defined as significant resources (as prescribed by the NWA).They are finer-scale units aligned to watershed boundaries, in which socio-economic activities are likely to be similar.

MC – The Management Class is set by the WRC and describes the degree of alteration that resources may be subjected to.

REC – Recommended Ecological Category – this is a recommendation purely from the ecological perspective designed to meet a possible future state.

RU – Resource Unit is a stretch of river that is sufficiently ecologically distinct to warrant its own specification of Ecological Water Requirements

WRC – Water Resources Classification is a procedure required by the Water Act 1998 that produces a MC per IUA for all water resources.

1 INTRODUCTION

The Lower Vaal Water Management Area (WMA) extends across four of South Africa's provinces (Gauteng, Free State, North West and Mpumalanga), and constitutes the upper catchment area for the Vaal River, a major tributary of the Orange River. This WMA is of major national strategic and economic importance, contributing 20% of South Africa's Gross Domestic Product. Within the matrix of natural grassland are sprawling urban and industrial areas, with extensive coal and gold mining occurring in the region. Consequently, water resources in this area have been fully allocated for over three decades, and 54% of water requirements are met through inter-basin transfer schemes primarily from Lesotho and the Thukela catchment. Owing to such interdependencies between catchments, water infrastructure management is increasingly key to water supply.

Towards addressing integrated water resource management in this WMA, the approach set out in the Water Act (1998) prescribes the WRC and RQO processes. The purpose of RQOs are to establish clear goals relating to the quality of water resources that allow for the establishment of a balance between the use and protection of these resources (South African National Water Act, No. 36 of 1998). Resource Quality Objectives are numerical and narrative descriptors of conditions that need to be met in order to achieve the required management scenario as provided during the resource classification. Such descriptors relate to the:

- quantity, pattern, timing, water level and assurance of instream flow,
- water quality including the physical, chemical, and biological characteristics of the water resources,
- character and condition of the instream and riparian habitat; and
- characteristics, condition and distribution of the aquatic biota (DWA, 2011a).

For the establishment of suitable RQOs, the RQO process needs to be synchronized with the findings of the WRC process (DWA, 2011b). Thereafter the procedure used to determine the RQOs by DWA (2011a) is consequently applied.

The synchronisation component of this report focusses on the use of the existing water resource classes pertaining to the Integrated Unit of Analysis (IUAs) from the Water Resource Classification Study (WRC study) for the RQO process (DWA, 2011a; DWA, 2011b). This includes the use of defined RUs for the RQO determination within existing IUAs from the WRC. Thereafter the RQO process will be synchronised with vision, recommended ecological categories and management classes obtained from the WRC (DWA, 2011b). The Gap Analysis component of this report includes a review of the data and information gaps which may affect the determination of RQO and proposes actions or mitigation measures to address gaps identified for the RQO process to be competed.

2 SCOPE OF WORK

The Institute of Natural Resources (INR) has been commissioned by the Department of Water Affairs (DWA) to determine the Resources Quality Objectives (RQOs) for all significant water resources (rivers, wetlands, dams and groundwater) within the Lower Vaal Catchment. Following the outcome of the Water Resource Classification (WRC) process (DWA, 2011b) for the Vaal River that includes steps 1 and 2 of the RQO process (DWA, 2011a) the objectives established for the study include:

- select priority Resource Units (RUs) that have been identified by the relevant WRC process (part of step 1),
- applying steps 3 to 7 of the RQO process and,
- provision of final RQOs for the Lower Vaal WMA that can be gazetted by DWA.

The study was initiated in August 2012 and planned to be completed by September 2014. *Following the amendments the completion data is proposed to change to May 2014.* This report constitutes the gap analysis and synchronization report for the Inception Phase (Phase 1) of the project.

3 ESTABLISHING THE REQUIRMENTS FOR SETTING RESOURCE QUALITY OBJECTIVE: STEPS RELEVANT TO THE GAP ANALYSIS PROCESS

The seven step RQO determination procedure is being used as the basis for guiding the gap analysis component of this report, and specifically how this relates to the alignment with the classification process (Figure 1)(DWA, 2011a). This procedure will be applied to all significant resources including rivers, dams, wetlands and groundwater. The groundwater component will also incorporate the RQO process established by Colvin et al. (2004) and Parsons and Wentzel (2007). Steps relevant to the gap analysis of the RQO development process include steps 1 to 5 and are presented below. Where applicable information requirements of the RQO process that should be available from the WRC process according to the scope of work for this study has been highlighted.

Figure 1: Management of water resources using RQOs; incorporating the seven steps for determination of RQOs and three additional steps to implement the Adaptive Management Cycle (DWA, 2011a).

STEP 1. DELINEATE THE INTEGRATED UNITS OF ANALYSIS AND RESOURCE UNITS

The first step of the RQO procedure requires that the Integrated Units of Analysis IUAs and RUs are delineated. For this study, IUAs and RUs for all significant water resources (rivers, dams, wetlands and groundwater) should have been established through the WRC process (DWA, 2011b). The IUA and RU information will be obtained and related to river/hydrology etc. nodes or modelling points from the WRC study. This initial step is vital to ensure that the outputs of the WRC study can be correctly extrapolated within the RQO procedure to the various RUs which will ultimately result in RQOs that are synchronised with WRC study outputs.

STEP 2. ESTABLISH A VISION FOR THE CATCHMENT AND KEY ELEMENTS FOR THE IUAS

The visioning process provides stakeholders with an opportunity to voice their desires regarding the future state of water resource characteristics. The visioning process is undertaken at an IUA and WMA level and allows for RU specific visions to be established. The visioning information for the IUAs and RUs will be obtained from the WRC process. These visions should consider all significant

water resources including rivers, dams, wetlands and groundwater. The visioning process undertaken within the WRC process should simply be synchronised with the RQO process.

STEP 3. PRIORITISE AND SELECT PRELIMINARY RESOURCE UNITS FOR RQO DETERMINATION

Following the selection of RUs (Step 1), the prioritisation and selection of Resource Units for RQO determination will be undertaken for each component considered in the study independently. This process will make use of the Resource Unit Prioritisation Tool (DWA, 2011a) for rivers without amendment but will contain unique evaluation criteria for wetlands, dams and in particular groundwater components. Through this step available use requirements (based on social and economic values) and protection (ecological importance and sensitivity) information from the WRC study will be used to identify important RUs for each component. The effectiveness of this tool is dependent on a thorough understanding of the use and protection scenarios of each component within the catchment. This necessitates the involvement of local regulators, conservators and scientists (experts) for wetland, groundwater, dam and river in the study area.

STEP 4. PRIORITISE SUB-COMPONENTS FOR RQO DETERMINATION, SELECT INDICATORS FOR MONITORING AND PROPOSE THE DIRECTION OF CHANGE

For this step a technical workshop will be held with the RQO Project Team, ideally members of the WRC study Team and key stakeholders with specialist expertise to evaluate the RUs, develop the RQOs and Numerical Limits for RQOs. This workshop will include representative specialists for rivers, dams, wetlands and groundwater. This step makes use of the Resource Unit Evaluation Tool (DWA, 2011a) to determine the RQOs for the prioritised Resource Units. It is important to note that that while separate tools with unique criteria specific to the component being assessed will be used for each component, the process is essentially the same. RQO determination for groundwater will be undertaken by applying Steps 1 to 4 as detailed in Colvin et al. (2004). These include:

1. Broadly characterising the groundwater resource
2. Defining the aquifer attributes which support or limit the identified uses
3. Defining the risk to uses with respect to hazards present in the catchment and aquifer vulnerability
4. Selecting key measurable indicators which relate to the resource itself or landuse impacts

Of particular importance in this step is to understand the trade-offs that have been made in the WRC study between different social, ecosystem, and economic aspects. The involvement of the Water Resource Classification Project Team in this evaluation process will facilitate an understanding of these trade-offs and ensure that the outcomes of the two processes are aligned. It is also vital that the outcomes of the process, in respect of the proposed magnitude and direction of change, are aligned between RUs. This step will be undertaken in conjunction with Step 5 through a technical specialist workshop.

STEP 5. DEVELOP DRAFT RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS

This step involves developing draft RQOs and Numerical Limits for these RQOs. At this stage Present Ecological State (PES) information for the sub-components and indicators identified in the previous step (Step 4) will be extracted from the relevant documentation to facilitate this procedure. This process will draw on the known integrated ecological status or EcoSpecs for each Ecological Category (EC) for the resource produced in the Ecological Reserve for the Lower Vaal. This step will be undertaken for rivers, dams and wetlands. Groundwater will follow Step 5 of Colvin et al. (2004) which requires quantifying the reference conditions, present status, sustainability threshold and variability of the resource indicators. Step 6 and 7 of Colvin et al. (2004) will also be undertaken during this step and will include a description of the management actions that may be necessary to assure the maintenance of different levels of modification and setting the value for the RQO.

The RQO procedure recommends that directed field surveys/campaigns are undertaken to collect ecological information where not available. In this case substantial ecological state information

already exists for riverine ecosystems in particular which may necessitate the collection of ecological information for the establishment of numerical limits for wetlands and dams only. The scope of works for this study does not allow for any field surveys to collects ecological information. However, should the need arise for additional data collection; this will be discussed with DWA. The level at which to set the RQOs will be determined in line with the outcomes of the WRC study.

4 SYNCHRONISATION AND GAP ANALYSIS

4.1 SYNCHRONISATION OF THE WRC PROCEDURE WITH RQOS

The synchronisation process involves consideration of the outcomes of the WRC study which include MCs and NECs that have been generated for nodes within IUAs in the WRC study. The RQO process will allow for the MCs and NECs generated from the WRC to be maintained so that ultimately both the WRC study findings and RQOs can be gazetted together as integral parts of the South African Integrated Water Resource Management (IWRM) process for the Vaal Catchment.

4.2 DATA AND INFORMATION GAPS WHICH MAY AFFECT THE DETERMINATION OF RQOS

The gap analysis component of the study is based on the first five steps of the RQO process as follows:

- Requirements for step 1: delineation of IUAs and RUs (for detailed overviews refer to APPENDICES
-
- Appendix 1 (rivers), Appendix 2 (dams), Appendix 3 (wetlands) and Appendix 4 (groundwater)).
- Requirements for step 2: catchment vision.
- Requirements for step 3: prioritise and select preliminary resource units for RQO determination (for detailed overviews refer to Appendix 5 (rivers), Appendix 6 (dams), Appendix 7 (wetlands) and

WETLANDS

Criteria	Sub-criteria	Data availability (WRCS)	Suitability	
Management Considerations				
	RUs with PES lower than a D Category	No	Insufficient	Ramsar m spec
Practical Considerations				
	RU with monitoring data/site/facility	No	Insufficient	Still
	Accessibility of resource unit for monitoring	No	Insufficient	Still
	Safety risk associated with monitoring RU	No	Insufficient	Still

- Appendix 8 (groundwater)).
- Requirements for step 4: prioritise sub-components for RQO determination and select indicators for monitoring (for detailed overviews refer to
-
-

- (rivers and dams) Appendix 10 (groundwater)).

- Requirements for step 5: develop draft RQOs and numerical limits

4.2.1 REQUIREMENTS FOR STEP 1: DELINEATION OF IUAS AND RUS

For each component (rivers, groundwater, wetlands and dams) considered in the RQO study a review of existing gaps is presented in this assessment. The first step of the RQO process requires the delineation of Integrated Units of Analysis (IUAs) and Resource Units (RUs). A total of 15 IUAs have already been identified as part of the Lower Vaal WRC study (

Table 2, Figure 2).These existing IUAs will be used in the development of RQOs for the Lower Vaal catchment to ensure alignment between the two processes.

Table 2: Integrated Units of Analysis (IUAs) and Nodes identified for the Lower Vaal WMA as part of the water resources classification (WRC) process, and associated quaternary catchments from DWA, 2011.

IUA	Nodes	Quaternary Catchment
UV-A	8VF5, C1VAAL-KVAAL, RE EWR 1, KIEINVAAL, UV9, C1RIET-AMERS, C1KVAA-UNSPE, UV17, EWR1, C1BLES-UNSPE, VC4, VC5	C11A, C11B, C11C, C11D, C11E, C11G C11H, C11J, C11K
UV-B	UV Uklip, C13C, C1KLIP-UNSPE1, EWR6 C13A, C1SAND-UNSPE, C13E, C1KLIP-UNSPE2, C13G, C13H	C13A, C13B, C13C, C13D, C13E, C13F, C13G, C13H
UV-C1	EWR7, 8WF1, 8WF3, UV25, UV28, UV Cor, C82B_N	C81A, C81B, C81L, C81M, C82A, C82B
UV-C2	8EF4, C81G, GG, C81J, C81C, C8NUWE-CONFL, EWR8, C82D	C81C, C81E, C81F, C81G, C81J, C82C, C82D
UV-C3	UV31, VC8, UV35, VC9	C82G, C82F, C82H
UV-D	VC15, C83D, C83E_N, VC16, VC17	C83A, C83D, C83E, C83G, C83H
UV-E	VC6, WA1, VC7, WA2, UV WV	C12D, C12F, C12G
UV-F	UV45, C8KLIP-VAALD	C83K, C83L
UV-G	EWR2, 8VF3, C12A, EWR3, C12K, C12J	C11M, C12A, C12H, C12K, C12J
UV-H	C21A, EWR 9	C21A, C21C
UV-I	EWR10, EWR11,VC11, VC12, VC13, VC14	C21G, C21F, C22C, C22D, C22E, C22J
UV-J	C22G	C22G
UV-K	UV53	C23B
UV-L	C23F, RE EWR 2 MOOI, VC19, M2, VC20	C23E, C23F, C23G, C23K, C23L
UV-M	EWR4, EWR5	C22F, C23L

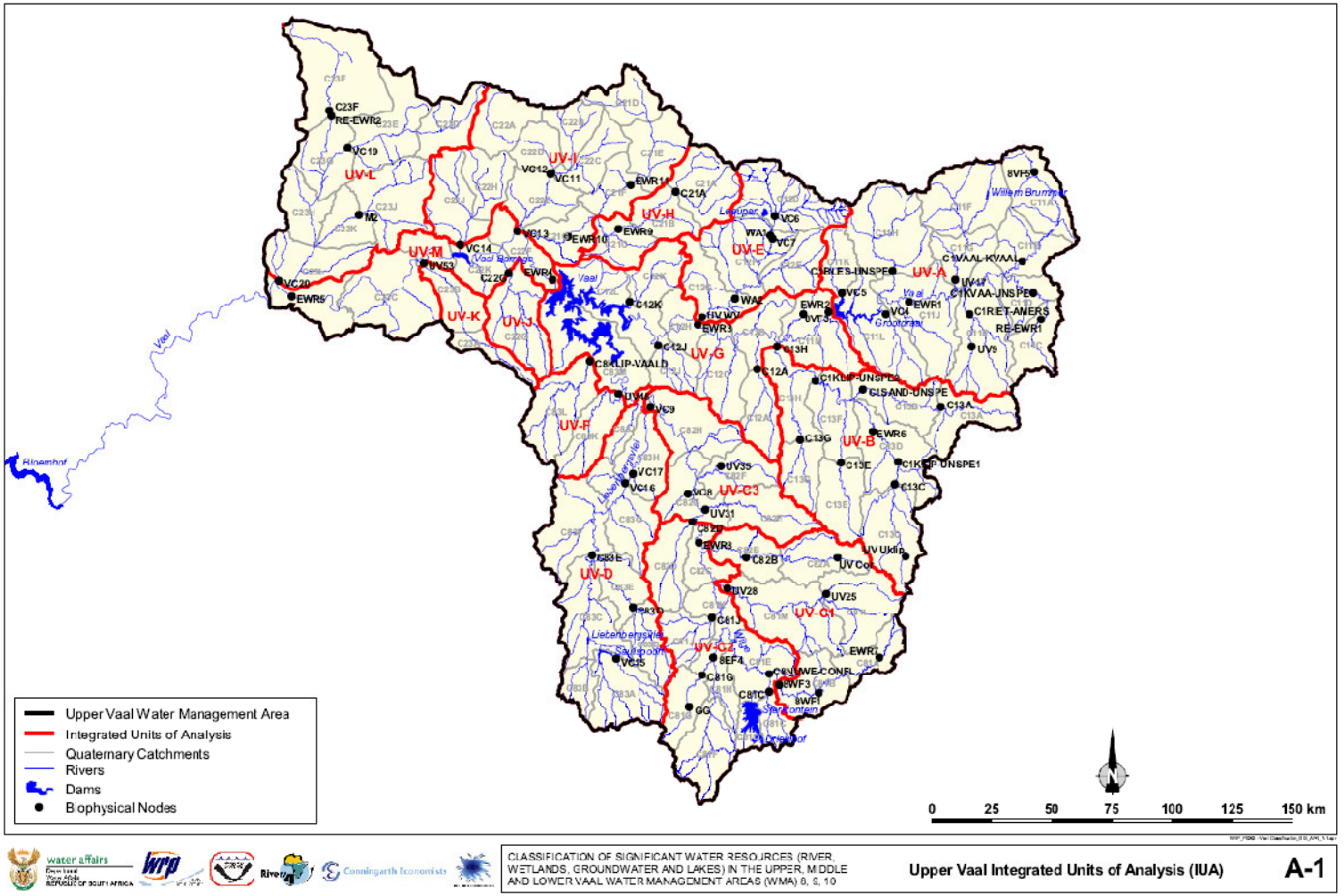

Figure 2: The Lower Vaal River Catchment with Integrated Units of Analysis (IUAs) demarcated and associated quaternary catchments (DWA, 2011).

RIVERS

The WRC study has identified a total of 75 nodes for the Lower Vaal WMA including key nodes and desktop biophysical nodes. Key nodes equate to the EWR sites and the selection process of these sites followed the Reserve site selection process. The WRC study however noted that large sections of the catchment were still unaccounted for and therefore selected additional desktop biophysical nodes. The selection of these desktop biophysical nodes was informed by information such as the Desktop EcoClassification results generated during the recent Reserve studies and the National Freshwater Ecosystem Priority Areas. The WRC study states that every effort was made to select nodes that fairly represent different conditions and operational procedures in the catchment.

The area between the nodes along a river reach together with the surrounding terrestrial area represents a Resource Unit. While the WRC study has clearly identified the aquatic component of the RU (i.e. the area between the nodes along a river reach), it did not demarcate the RUs as applicable to wetlands and groundwater i.e. the adjacent terrestrial landscape making up the entire river basin. These RUs will be captured spatially using a Geographical Information Systems (GIS) approach in the RQO process (Appendix). This RU delineation process will be achieved by dividing the quaternary catchment along the contours which intersect the nodes. Sufficient information exists to undertake this task. Thus, the information relevant to RUs for rivers is largely sufficient however RUs for wetlands, groundwater and dams still need to be explicitly delineated.

WETLANDS

Wetland RUs have not been defined for the Lower Vaal management area in the WRC study (Appendix 7). The Vaal classification reports reference a few wetland systems and areas that are dominated by wetlands, but they do not define these wetlands or any other wetlands as RUs. The wetlands mentioned in the Vaal classification reports include:

- The Seekoeivlei RAMSAR wetland on the Klip River;
- The Blesbokspruit RAMSAR wetland on the Blesbokspruit; and
- The wetlands that dominate the upper reaches of Vaal River; and
- The wetlands that dominate the upper reaches of Wilge River.

All of these wetlands would be delineated as wetland RUs. Other data sources that contain spatial referenced wetland inventory data including the National Freshwater Ecosystem Priority Areas (NFEPA) and wetland inventory data for conservation planning will be used to delineate wetland RUs within existing IUA (DWA, 2011) for the RQO assessment.

For this step we recommend that a limited number of key wetlands are selected for RQO determination, however consideration should also be given to setting quaternary catchment level RQO's in line with the management class for the IUAs i.e. to synchronise the condition of the wetlands within an IUA with the overall MC for that IUA. This could include setting quaternary level related targets for wetland management / rehabilitation (See Table 1)

GROUNDWATER

Groundwater RUs were not explicitly delineated as part of the WRC study process and no spatial groundwater information related to existing IUAs is available (Appendix 8). The Zuurbekom dolomitic aquifer is the only aquifer described in the classification document. The Zuurbekom karst aquifer straddles across multiple quaternary catchments C22A and C23D and IUAs. The aquifer is subdivided into compartments separated by dolerite dykes. Groundwater within the karst environment is forced upwards along the impermeable dolerite dykes to emanate as springs. The RU delineation procedure for groundwater will involve an evaluation process where available data including the aquifer regions (DWA, 2001), 1:250 000 geological maps (CGS, 1986), 1:500 000 hydrogeological maps (DWA, 1999) (DWA, 2003), DWA NGA raw data and DWA GRA II (DWA, 2005) will be considered. Thus the RUs will be delineated in a manner that allows for the classification of water resources in the catchment within each IUA to be applied to the groundwater RUs.

DAMS

Within this study large formal (licenced by DWA) manmade dams and farm dams will be considered. Depending on the location and importance of these dams, large dams will usually all form one dam RU while a group of smaller farm dams may be grouped into one dam RU if appropriate. Although the major dams, which will be considered in the RQO study, have largely been considered within the delineation process of the IUAs, where sample nodes have generally been positioned below the major dams, no dam specific RUs are available from the WRC study (Appendix 6) (DWA, 2011). Sufficient information is available however for the dams to be defined within the study area using available DWA-RQS spatial dam data & dam management information where available (DWAF, 1999; DWA, 2013a; DWA, 2013b). In the absence of any direction from the WRC study, the dams will be positioned within existing IUAs to maintain the classification of water resources in the catchment i.e. the same MC applied to the rivers will apply to the dams.

4.2.2 REQUIREMENTS FOR STEP 2: CATCHMENT VISION

Within the RQO process, a key step is to align the diverse and competing interests in the resource into a collective desired future state. “A catchment vision is a collective statement from all stakeholders of their future aspirations of the relationship between the stakeholders and the water resources in the catchment” (DWAF, 2009b). It is important to note that no specific visioning exercise was undertaken as part of the WRC process for the Vaal River and that IUA specific visions that can be used to infer visions for RUs are not available. The WRC does however stipulate a Management Class (MC) per IUA and a Recommended Ecological Category per IUA. This could be accepted as the vision at a broad level although they were determined with minimal stakeholder consultation. In the RQO procedure (DWA, 2011a), provision is made for a visioning exercise, which would be undertaken in the absence of a visioning process in the WRC study. However, because the MC has already been determined, at the request of DWA the visioning process has been excluded from the RQO determination process (this study). There are however a number of information gaps/issues and concerns pertaining to the establishment of the RQOs as follows:

- The MC provides a very minimal vision for a catchment. Most of the IUAs in the catchment fall into a Class II Management Class which implies that the vision for the large part of the catchment is to maintain a balance of ecological function and integrity (DWA, 2012c). The rest of the catchment is designated to extensive alteration of the water resource possibly limiting water based recreation activities and requiring monitoring to guard against further degradation (DWA, 2012c).
- No specific MCs are prescribed for wetlands, dams and groundwater. No information on specific components or attributes of these components can be inferred from the MC. For example, the WRC study may indicate that in order to achieve a required MC, 40% of the RUs should be in a B ecological category while the remainder should be in a C ecological category. These ecological categories essentially represent the EcoStatus which in turn is comprised of sub-components in a particular state (e.g. Fish in a B category, Water quality in a C category etc.) While this information can be extracted from the Ecological Reserve for EWR sites, it is not available in the WRC study for the remainder of the Resource Units. This information is required for the setting RQOs as the state of the individual components can vary significantly but cumulatively can still result in the desired EcoStatus and/or MC.

A directed stakeholder engagement process for this study would facilitate the collection of information necessary for the development of RQOs and ensure that stakeholder needs are being met. This information would feed into the following steps of the RQO process.

- Step 3: Prioritize Resource Units
  - Rivers
    - Importance for users (Current & anticipated future use)
  - Dams

- Importance for users (Current & anticipated future use)
- Threat posed to users
- Ecological Importance
- Threat faced by ecological component of the RU

- Wetlands
  - Importance for users (Current & anticipated future use)
  - Threat posed to users
  - Ecological Importance
  - Threat faced by ecological component of the RU
  - Management Considerations
  - Practical Considerations
- Ground Water
  - Importance for users (Current & anticipated future use)
  - Practical Considerations

- Step 4: Prioritise sub-components for RQO determination, select indicators & propose the direction of change
  - Rivers
    - Identify requirements of important user groups
    - Selection of sub-components for RQO determination
    - Establish the desired direction of change for selected sub-components
  - Dams
    - Identify requirements of important user groups
    - Selection of sub-components for RQO determination
    - Establish the desired direction of change for selected sub-components
  - Wetlands
    - Identify and assess current and anticipated future catchment-level impacts on wetlands and where possible impacts on a sub-set of wetlands for site-based RQO determination
    - Identify requirements of important user groups
  - Groundwater
    - Broadly characterise the groundwater resource:
    - Define the critical characteristics or attributes of groundwater which support or limit the identified uses.
    - Define the risk to uses with respect to hazards present in the catchment and aquifer vulnerability.
    - From the critical attributes, select key measurable indicators which relate to the resource itself or land-use impacts, and which will enable sustainable management of groundwater.

- In the absence of this data, the validity of the RQOs will be greatly reduced and the risk of negative feedback once they are published may be high.
- Visions from previous alternative processes do exist and could potentially be used to inform the RQOs visions for the upper reaches of the Lower Vaal main stem. However, these visions are not officially part of the WRC study process and will need to be carefully considered to ensure that they do not conflict with the MC. The primary vision to be considered is that from the determination of RWQOs. DWA (2009b) integrated and revised existing RWQOs for various sections of the Vaal WMAs (upper, middle and lower), including the Vaal main stem and tributaries. This included a visioning process based on a desktop study and workshop involving key DWA personnel only, and applies to three catchment areas of the Vaal (upstream of Grootdraai Dam = Lower Vaal; Grootdraai Dam to Vaal Dam = Lower Vaal; and Vaal Dam to

Douglas Barrage = Lower Vaal and remainder of Vaal downstream). These were informed by an earlier process of setting RWQOs for the Lower Vaal, upstream of the Vaal Barrage (not referenced), which included a comprehensive consultative process with stakeholders. The project team is not aware of any other visions that exist for the Lower Vaal WMA.

4.2.3 REQUIREMENTS FOR STEP 3: PRIORITISE AND SELECT PRELIMINARY RESOURCE UNITS FOR RQO DETERMINATION

Currently within the RQO methodology the RU prioritisation tool has been established to prioritise RUs for riverine ecosystems and wetlands. The criteria that this tool is based on can also be adapted to allow for a dam prioritisation process. However, currently no methodology is available within the RQO process for the prioritisation of groundwater ecosystems. It is proposed that a similar approach as that developed and used for other resources in the RQO process be followed. This would entail the identification of suitable ecosystem use, protection and process criteria to facilitate the prioritisation process. In consideration of the availability of data from the WRC study for this step, each component can be reviewed as follows.

RIVERS

The prioritisation of Resource Units with respect to rivers requires the consideration of a range of criteria including:

- The importance of each Resource Unit to users
- The level of threat posed to water resource quality for users
- The importance of each Resource Unit to ecological components
- The level of threat posed to water resource quality for the environment
- The identification of Resource Units for which management action should be prioritised
- An assessment of practical considerations associated with RQO determination for each Resource Unit

Details of the specific data requirements and suitability of the available data to assess each of these criteria has been provided in the appendix. A summary of the data suitability is provided below.

In considering the importance of a RU to users, each RU is assessed to determine whether or not it provides or supports:

- Important cultural services
- Livelihoods of vulnerable communities
- Strategic requirements or international obligations
- Supporting and/or regulating services
- Activities contributing to the economy

Sufficient information, in respect of strategic requirements, is provided in the WRC Status Quo report to enable an assessment of this criterion at a RU scale. This includes information in respect of inter-basin transfers per RU. The Status Quo Report also provides a breakdown of important economic sectors. However, this information is presented at a very coarse scale for the entire Lower Vaal WMA and will need to be extrapolated to an IUA level and then a RU level. This will significantly decrease the confidence in the data.

The Classification provides information per RU for selected ecosystem goods and services including:

- Recreational Fishing
- Subsistence Fishing
- Other recreational aspects associated with the rivers
- Riparian vegetation usage

- Waste water dilutions
- Floodplain agricultural usage of subsistence purposes

These ecosystem services were identified from an analysis of the available Reserve Determination reports. This analysis was supported by primary fieldwork to critical areas together with a second analysis of the typology of settlements in the area and their likely dependence on goods and services for livelihoods. In addition information in respect of people's dependence on services is reflected through a socio-cultural importance (SCI) score. 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. This score was originally provided out of 5 and but has been modified to be out of 4 so that it is comparable to the EIS. It is important to note that the extrapolation process has decreased the confidence in the data and very few regulating and supporting services have been considered. However, sufficient information is available to enable an assessment of the importance of RUs for users to be undertaken.

The assessment of the importance of each Resource Unit to ecological components requires the consideration of the following criteria:

- Does the RU have a high EIS?
- Does the RU have an A/B Recommended Ecological Category and / or PES?
- Is the RU categorised as a support or priority area in NFEPA?
- Has the RU been identified as a priority in terms of provincial or fine-scale aquatic biodiversity conservation plans?

Present Ecological Sate (PES) and Ecological Importance and Sensitivity (EIS) data per node is available from both the Reserve and WRC studies. During the Reserve studies, the PES was determined for all EWR sites using the EcoClassification Level 4. In addition, the WRC study determined the PES and the EIS for all nodes (excluding NFEPA nodes) using the basic EcoQuat Model and EIS models respectively. Information relevant to the Recommended Ecological Category is available in the WRC reports and data regarding NFEPA priority and support areas can be extracted from the NFEPA data sheets. The Lower Vaal WMA spans Mpumalanga, Gauteng, Free State and North West Provinces. Fine-scale aquatic biodiversity conservation plans (C-plan) do exist for Mpumalanga and Gauteng, and Free State are in the process of updating their C-plan. It is unlikely that there will be any information in this regard for North West. In summary, sufficient detailed ecological information exists at a fine enough scale to enable the assessment of the ecological importance of each RU.

Available information related to threats posed to water resource quality for both users and the environment will be extracted from the WRC study and any other source. The ecological database provided by the WRC study contains information for each biophysical node including a list of about 30 metrics on land-based impacts and scores.

Within the prioritisation tool, RUs are also assessed against a range of suitable ecosystem use, protection and process criteria in relation to management. These criteria include whether a Resource Unit is in a D category or lower and/or whether the accepted NEC is higher than the PES. This assessment therefore requires both PES and NEC information. This information is readily available from both the Reserve and WRC studies. Practical considerations require an assessment of whether data is available for the Resource Unit; whether the Resource Unit can be accessed; and whether the Resource Unit is safe to monitor. Sufficient information is available from the WRC study to undertake this assessment. Both the management and practical considerations can therefore be assessed.

Following this approach the prioritisation of RUs for the Lower Vaal catchment can be undertaken.

WETLANDS

For wetlands suitable ecosystem use, protection and process criteria will be considered for use in the prioritisation of wetlands. These criteria include the importance of the resource for users and the environment, the level of threat posed to the resource, and management and practical considerations. Detail of the initial data requirements, based on these criteria, together with the suitability of the available data to assess each of these criteria, has been provided in Appendix 5. Wetland specific criteria will however be established and will be based on the ecological processes and ecosystem services associated with wetlands. Data requirements for this process will be obtained from available literature. This information is likely to be largely lacking for wetlands in the study area unless wetlands were selected as part of previous assessments e.g. Wetlands rehabilitated by WFWetlands. While information on the PES of most wetlands in the catchment exists (DWAF, 2008; DWAF, 2009a; DWAF, 2009b; Sullivan, *et al*., 2008; Macfarlane and Muller, 2011; NFEPA, 2011), Ecospecs are likely to be lacking for prioritised wetland areas and this information is not available in the WRC study. For the wetlands associated with major rivers in the study area information on quantity and quality of water can potentially be extrapolated and used for these ecosystems (except for pan ecosystems for example that have no outlet (endorheic)). In the case of wetlands, users are often directly linked to the wetland (e.g. farmers grazing on the wetland or local communities harvesting natural resources from the wetland). Understanding user requirements for the prioritised wetlands is likely to require direct engagement with these users.

Following the collection of information, for wetlands a GIS multi-layered analysis approach will be followed which will allow for the determination of priority wetland RUs. The analysis would allow for the filtering of wetland RUs by considering important data such as: NFEPA, Ramsar status, size, protected status, presence of threatened species or suitable habitat, etc (DWAF, 2008; DWAF, 2009a; DWAF, 2009b; Sullivan, *et al*., 2008; Macfarlane and Muller, 2011; NFEPA, 2011). Thereafter a filtering process will be established for the RUs to identify the priority wetlands.

GROUNDWATER

Currently no groundwater component specific RU prioritisation methodology is available. It is proposed that a similar approach to that used for the prioritisation of other resources within the RQO process be followed. This would entail the identification of suitable ecosystem use, protection and process criteria against which groundwater resource units could be evaluated for prioritisation. An initial assessment of possible data for the current criteria is detailed below:

- The importance of each ground water RU to users. Suitable information (WRC study) and other sources (DWAF, 2004) exists to allow for the assessment of groundwater Userspecs. This information can be evaluated to allow for the initial prioritisation of groundwater RUs.
- The level of threat posed to water resource quality for users. Although very little information pertaining to the state of groundwater RUs is available from the WRC, other sources of information (DWA, 2005), should allow for a low confidence assessment of the quality of groundwater RUs which would contribute to the prioritisation of these systems.
- The level of threat posed to water resource quality for the environment. Similarly limited information pertaining to the level of threats to groundwater ecosystems is available from the WRC. A desktop threat assessment of groundwater RUs for the study area can however be undertaken to contribute to this step.
- An assessment of practical considerations associated with each groundwater ecosystems RUs are dynamic ecosystems that are relatively (compared with surface aquatic ecosystems) difficult to monitor and manage. Practical considerations for the determination of RQOs for these ecosystems are of great importance which will be carried out in this step.

Details of the specific data requirements and suitability of the available data to assess each of these criteria have been provided in Appendix 5. A summary of the data suitability is provided below:

- The potential of a groundwater RU to support a range of criteria pertaining to ecosystem services and ecological processes is used to evaluate the importance of RUs. These criteria will be established in the study based on available information.
- Insufficient information, in respect of strategic requirements, is provided in the WRC Status Quo report for groundwater ecosystems to enable an assessment of this criterion at a RU Scale. A desktop survey is required to allocate available information to delineated groundwater RUs and then to established RU specific information for other groundwater RUs.
- For groundwater RUs, limited ecosystem services information is available from the WRC however there are other sources of information which can be used to establish UserSpec information for groundwater RUs.

To establish an acceptable balance between the use and protection of groundwater ecosystems, through the establishment of appropriate RQOs for this component, information pertaining to the desired protection of these ecosystems is required. Currently only the MCs and NECs that are based on surface ecosystems are available for IUAs in the study area. This information may be indirectly related to the state of groundwater resources but case specific information for prioritised groundwater resources may be required.

DAMS

Within this step dam RUs will be prioritised according to their relative importance within each IUA. Within each IUA, the prioritisation of RUs with respect to dams requires the consideration of a range of dam component appropriate criteria (adapted from riverine ecosystems) including:

- The importance of each RU to users
- The level of threat posed to water resource quality for users
- The importance of each RU to ecological components
- The level of threat posed to water resource quality for the environment
- The identification of RU for which management action should be prioritised
- An assessment of practical considerations associated with RQO determination for each RU

Details of the specific data requirements and suitability of the available data to assess each of these criteria has been provided in (Appendix 5). A summary of the data suitability is provided below. Similarly to rivers, in consideration of the importance of RUs to users, each RU is assessed to determine whether or not it provides or supports:

- Important cultural services
- Livelihoods of vulnerable communities
- Strategic requirements or international obligations
- Supporting and/or regulating services
- Activities contributing to the economy
- Other dam specific criteria

Sufficient information pertaining to the role of dams for; the maintenance of ecological flow requirements and for water supply (domestic, environmental (including Reserve), agricultural and industrial use) is generally provided in the WRC and or available dam operating rules and other sources of information (DWAF, 1999a; DWA, 2011; DWA, 2013a; DWA, 2013b). Although the WRC specifically addresses the storage and supply of water services of dams, many other ecosystem services including supply of additional natural products (e.g. vegetation and fish) and ecological services (assimilation capacity of wastes and associated water quality mitigation, sediment trapping services and maintenance of ecologically important aquatic animals) have not been addressed in the

WRC. This information is generally available from other sources (DWAF, 1999b; DWA, 2011; DWA, 2013a; DWA, 2013b for example), and will be considered for this study.

The assessment of the importance of each dam RU to the ecological component would require a desktop evaluation of available biophysical information from dam ecosystems which should include stakeholder engagement to verify and update available biophysical information. With this information, consideration of a range of dam ecosystem specific criteria will contribute to the prioritisation process.

Following this approach the prioritisation of dam RUs for the Lower Vaal catchment can be undertaken, but only following the addition of information not available in the WRC.

4.2.4 REQUIREMENTS FOR STEP 4: PRIORITISE SUB-COMPONENTS FOR RQO DETERMINATION AND SELECT INDICATORS FOR MONITORING

This step of the RQO process entails the prioritisation of sub-components for RQO determination and the selection of appropriate indicators. This requires the use of the Resource Unit Evaluation Tool. In consideration of the data availability from the WRC study for this step each component can be reviewed as follows.

RIVERS

For riverine ecosystems, two key criteria are assessed during this step:

- The impact of current and anticipated future use on water resource components
- The requirements of important user groups

This information is ultimately used to facilitate the selection of sub-components for RQO determination and to establish the desired direction of change for selected sub-components. The impact of current and anticipated future use requires:

- Assessing the importance of activities in driving resource change
- Determining the anticipated level of impact on each sub-component
- Determining the cumulative level of impact on each sub-component
- Determining the anticipated consequences of the impacting activities on each sub-component.

Information on impacting activities will be extracted from the WRC study. This information is presented at RU level and is therefore adequate to enable the assessment to be undertaken at a suitable scale. Where necessary, additional data may be extracted from land-use maps and other reports such as the Water Reconciliation Strategy, the RWQO's, rapid PES/EIS assessment and the ISPs. However, these alternative sources of data were not incorporated into the WRC and thus will not have the official status they require.

The second sub-step in prioritising sub-components for RQO determination entails identifying which groups are using the resource, classifying the importance of these groups and determining which sub-components are important to them. These user group types include both 'protection of the water resource' and 'water resource dependent activities'. This sub-step will be aligned with the outputs of the WRC study. Careful consideration will therefore be given to those user groups which were identified as important within the WRC study. There may however be specific user groups at a RU level, for which an RQO should be set, that are not provided in the WRC study. Information in respect of 'protection of the resource' will be extracted from a range of reports and data sources. These include Ecological Reserve studies which contribute to the WRC study, the PES/EIS desktop study, NFEPA and available fine-scale aquatic conservation plans. Various levels of information are available from these reports and include:

- Detailed information on some of the components from both recent and historic Reserve studies in which the EcoClassification Level 4 method were used. However, this information is only available for the EWR sites. In addition, the WRC study generated additional information

pertaining to the ecological importance and sensitivity of instream and riparian habitat and biota for all nodes.

- Information in respect of quantity requirements is available for selected biophysical desktop nodes from the WRC study. This information was generated using a low confidence high resolution network configuration of the Water Resource Yield Model (WRYM) to undertake a cursory quantitative evaluation of the water availability (and consequential implications) at small catchment scale for the selected nodes.
- A recent DWA/WRC PES and Ecological Importance-Ecological Sensitivity also provides some useful information specifically regarding the sub-quaternary (SQ) reaches of extensive river coverage of the area.

Information contained in conservation plans and NFEPA may relate to specific components within a Resource Unit.

Although information in respect of 'water resource dependent activities' has partially been gathered during the visioning exercise of the WRC, RU specific information was not provided. To obtain this information a focused stakeholder engagement exercises will be undertaken to the study area to specifically generate information pertaining to water resource dependent activities and or requirements for prioritised RUs (refer to step 3). In addition the identification and subsequent rating of the importance of users groups as well as the aspirations of each user group will be validated using a variety of other information. These include the following:

- Resource Water Quality Objectives (RWQOs) for the Lower Vaal. Based on a comprehensive consultative process, RWQOs have been determined for the Lower Vaal (main stem and tributaries) for nitrate, ammonia, sulphate, chloride, electrical conductivity, TDS and phosphate (no reference or date). These informed a more recent project (DWAF 2009b,c) to integrate and revise RWQOs for the Vaal system, and to develop an integrated water quality management plan. This process defined 14 river reaches, and defined RWQOs for the Vaal main stem only, working progressively upstream from the most downstream site. Here, the Lower Vaal was divided into nine reaches, and RWQOs were defined for TDS, nutrients (total nitrogen and total phosphorus) and microbes (E. coli) based on 95th percentile values. Associated management strategies exist for these RWQOs (DWAF 2009c), which were partly informed by five modelling scenarios for salinity (TDS) and net present values for each scenario.
- The Status Quo Report of the WRC study and associated ecological worksheets study provides information on ecosystem goods and services per node. Although a socio-cultural importance score is provided, no information on the value or quantification of ecosystem services is given.

WETLANDS

Following the establishment and prioritisation of RUs for wetlands within IUAs, the identification of sub-components and their prioritisation requires an understanding of ecological processes, use requirements and the threats of these activities to prioritised RUs. This information is not available on a RU scale from the WRC process and requires a revision of available information and a directed stakeholder engagement exercise. The focused stakeholder engagement exercises planned here can also be used in this section to obtain RU specific use requirements for prioritised RUs (refer to step 3). Within this step it may be necessary to broaden the information review of wetland ecosystem processes from the study area to national and possibly international sources so that the importance of sub components can be evaluated and used to establish RQOs for the prioritised wetlands in the study area. In addition, some site specific biophysical information may be required to establish suitable RQOs based on the Socio-cultural importance (SIC) and ecologically important wetland RUs.

GROUNDWATER

Similarly, following the establishment of RUs for groundwater and the prioritisation of these RUs within IUAs, an understanding of potential impacts and user requirements for groundwater RUs is required to prioritise sub-components within groundwater RUs. Although this information is not available from the WRC it may be generated from other sources of information including findings of existing assessments being undertaken by groundwater socio-economists and ecologists. The focused stakeholder engagement exercises planned for other parts of this project can also be used in this section to obtain RU specific use requirements for prioritised RUs (refer to step 3). Within this step it may also be necessary to broaden the information review of groundwater ecosystem processes from the study area to national and possibly international sources so that the importance of sub components can be evaluated and used to establish RQOs for the prioritised wetlands in the study area.

DAMS

For dam RUs, step 4 of the RQO process also entails the prioritisation of sub-components for RQO determination and the selection of appropriate indicators. This requires the use of a modified Resource Unit Evaluation Tool for dam RUs. Two key criteria are assessed during this step:

- The impact of current and anticipated future use on the dam RU
- The requirements of important user groups

This information is ultimately used to facilitate the selection of sub-components for RQO determination and to establish the desired direction of change for selected sub-components.

The impact of current and anticipated future use requires:

- Assessing the importance of activities in driving resource change
- Determining the anticipated level of impact on each sub-component
- Determining the cumulative level of impact on each sub-component
- Determining the anticipated consequences of the impacting activities on each sub-component.

Information on impacting activities from the WRC study will be evaluated and used for this section. This information is presented at RU level and is therefore adequate to enable the assessment to be undertaken at a suitable scale. Similarly to rivers, additional data may be extracted from land-use maps and other reports such as the Water Reconciliation Strategy, the RWQO's, rapid PES/EIS assessment and the ISPs where available will be incorporated, however it must be acknowledged that this information will not have the credibility associated with the WRC process and was not considered by that process.

The second sub-step in prioritising sub-components for RQO determination entails identifying which groups are using the resource, classifying the importance of these groups and determining which sub-components are important to them. These user group types include both 'protection of the water resource' and 'water resource dependent activities'. This sub-step will be aligned with the outputs of the WRC study. Careful consideration will therefore be given to those user groups which were identified as important within the WRC study. There may however be specific user groups at a Resource Unit level, for which an RQO should be set, that are not explicitly listed within the WRC study. Available information from other sources, in respect of the 'protection of the resource will be evaluated in this step.

Although information in respect of 'water resource dependent activities' has partially been gathered during the visioning exercise of the WRC, RU specific information is not available. To obtain this information a focused stakeholder engagement exercises will be undertaken to the study area to

specifically generate information pertaining to water resource dependent activities and or requirements for prioritised RUs (refer to step 3).

4.2.5 REQUIREMENTS FOR STEP 5: DEVELOP DRAFT RQOS AND NUMERICAL LIMITS

Draft RQOs and associated Numerical Limits will be recommended for the selected-sub-components. These should relate directly to a characteristic of the water resource. It is difficult at this stage to assess whether sufficient information is available to set these RQOs and associated Numerical Limits for all of the rivers, wetlands, dams and groundwater as the required information and data is very specific to particular components and associated user groups. For example, an RQO may need to be set in support of a yellowfish dependent angling industry in a particular RU however data in respect to the size of the yellowfish population required to maintain this RQO may not be available. To address this gap an assessment of the size of the angling industry with allowance for future growth and the associated population size of yellowfish in RU needs to be established to set numerical limits for the RQO. Additional data collection will be required at that stage which is not included within the scope of this study. A potential data source to set numerical limits for some RQOs and the possible need for additional data collection is detailed per component type which follows.

RIVERS

Data in respect of user specifications is available from the WRC study in the form of ecosystem service information. This information is detailed per RU in the form of a socio-cultural importance (SCI) score. The likely use of selected ecosystem services is also provided in broad terms however no quantification of ecosystem services is given. Additional user data may be extracted from the RWQOs, water availability studies and reconciliation strategies however further data collection may be required.

In respect of ecological specifications, the WRC process does not make allowance for field assessments beyond those undertaken previously for the EWR sites. The remaining biophysical nodes in the WRC study were all assessed at a desktop level using specialist input. Nevertheless, a substantial amount of useful data is contained in the ecological database spreadsheets associated with the WRC study. These include:

- Present Ecological State (PES) information per node including scores for each of the metrics used to calculate the quick habitat integrity namely bed modification, flow modification, inundation, riparian bank condition, and water quality modification. Each of these metrics is rated between 0 – 5 with 5 indicating a severe change from natural. A score is also given for the response of the instream and riparian biota to the habitat changes and is derived from ratings for fish, aquatic invertebrate and riparian vegetation. These ratings are based on a 0 – 5 scale with 0 inferring a pristine state (Class A) and a 5 a critically modified state (Class F).
- The Instream EC and the EcoStatus per node as well as a confidence scores 1 – 5 (5 = very high confidence).
- The EIS per node including scores for a range of metrics associated with both instream and riparian habitat and biota.

Detailed information on water quality, geomorphology, fish, macroinvertebrates, instream and riparian habitat and water quality is also available for the EWR sites from the Ecological Reserve studies. Where necessary, consideration will be given to whether this data can be extrapolated to other Resource Units however it may also be appropriate to limit this detailed information to the EWR sites, and to use generic type information for the other RUs.

WETLANDS, GROUND WATER AND DAMS

For wetlands, groundwater and dam ecosystems limited desktop information of the PES or related integrated ecological state information is available. In some cases some information can be extrapolated from existing river studies. In most cases however a survey of available research,

management and conservation literature needs to be carried out to establish numerical limits for wetland, groundwater and dam RQOs. Furthermore, information generated to characterise the structure and function of the ecosystems of prioritised RUs may need to be obtained if meaningful RQOs are to be set.

5 GENERAL CONCLUSIONS & IMPLICATIONS FOR RQOS DETERMINATION PROCESS

The outcomes of the synchronisation and gap analyses show that the RQO process can be aligned with the WRC study findings

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7 APPENDICES

Appendix 1: GAP analyses summary for Step 1 of the RQO process for the Lower Vaal River Catchment: River component.

RIVERS			
Criteria	Data availability (WRCS)	Other sources	Suitability
Existence of IUAs	Yes	NA	Sufficient: high confidence
Node locations within IUAs	Available	NA	Sufficient: high confidence
Demarcate RU's	Available	NA	Sufficient: high confidence

Appendix 2: GAP analyses summary for Step 1 of the RQO process for the Lower Vaal River Catchment: Dams component.

DAMS			
Criteria	Data availability (WRCS)	Other sources	Suitability
Existence of IUAs	Available	NA	Sufficient: high confidence
Node locations associated with dams within IUAs	Nodes usually located upstream or downstream of all major dams.	Additional DWA-RGS data & dam management information available	Sufficient: high confidence
Demarcate RU's	Limited	DWA-RGS data & dam management plans can be used	Sufficient: low confidence

Appendix 3: GAP analyses summary for Step 1 of the RQO process for the Lower Vaal River Catchment: Wetlands component.

WETLANDS			
Criteria	Data availability (WRCS)	Other sources	Suitability
List own criteria for delineation, consider any criteria in WRCS (Vaal)	Wetland RUs haven't been delineated as part of the WRC process. There is mention of two RAMSAR wetlands (the Barbers Pan and Leeu Pan), both of which would be wetland RUs	NFEPA, wetland inventory data for conservation planning, etc. Note: Wetland RUs can be delineated but this process was not included in the initial budget.	Sufficient: medium confidence

Appendix 4: GAP analyses summary for Step 1 of the RQO process for the Lower Vaal River Catchment: Groundwater component.

GROUND WATER			
Criteria	Data availability (WRCS)	Other sources	Suitability
1. Primary delineation	Limited	DWA Quaternary Catchments	Sufficient: high confidence
2. Secondary delineation	No	Vegter groundwater maps; 1:500 000 hydrogeological maps	Sufficient: high confidence
3. Tertiary delineation			
(a) Physical criteria	Limited	Vegter groundwater maps; 1:250 000 geological maps, 1:500 000 hydrogeological maps, DWA NGA, DWA GRA II	Sufficient: high confidence
(b) Management criteria	Limited	Consultant's reports, ISP	Sufficient: medium confidence
(c) Functional criteria	No	Technical reports, DWA NGA, DWA GRA II data	Sufficient: medium to high confidence

Appendix 5: GAP analyses summary for Step 3 of the RQO process for the Lower Vaal River Catchment: River component.

RIVERS				
Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Position of resource unit within IUA				
	RU location	Yes	Sufficient: H	
Importance for users (Current & anticipated future use)				
	Cultural service provision of RU	Yes	Sufficient: H	
	NB Rus that support livelihoods of communities	Yes	Sufficient: H	
	RUs for strategic requirements/ int. obligations	Yes	Sufficient: H	
	RUs with supporting and regulating services	Yes	Sufficient: L	PES studies/ Valuation of resources in the Lower Vaal Reports
	Economically NB RUs	Yes	Sufficient: H	
Threat posed to users				
	Level of threat posed to users	Yes	Insufficient	
Ecological Importance				
	RU with high EIS	Yes	Sufficient: H	
	RUs with A/B NEC and / or PES	Yes	Sufficient: H	
	RUs identified with NFEPA	Yes	Sufficient: H	
	RUs with other biodiversity conservation plans	No	Insufficient	Conservation Plans
Threat faced by ecological component of the RU				
	RUs with threats to ecological components	Yes	Sufficient: H	
Management Considerations				
	RUs with PES lower than a D Category	Yes	Sufficient: H	
Practical Considerations				
	RU with monitoring data/site/facility	Yes	Sufficient: H	
	Accessibility of resource unit for monitoring	Yes	Sufficient: L	WRCS Team, LocaL Knowledge and Google Earth
	Safety risk associated with monitoring RU	No	Sufficient: L	WRCS Team and Local Knowledge

Appendix 6: GAP analyses summary for Step 3 of the RQO process for the Lower Vaal River Catchment: Dams component.

DAMS				
Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Position of resource unit				
	RU location	Yes	Sufficient: H	DWA-RQS data and dam operation plans
Importance for users (Current & anticipated future use)				
	NB RUs that durectly support livelihoods of communities	Limited	Sufficient: L	Dam operation rules and limited additional userspec information specific to some dams
	RUs for strategic requirements/ int. obligations	Yes	Sufficient: H	Dam operation rules/requirements
	RUs that contribute to instream flows	Yes	Sufficient: L	
	Economically NB RUs	Limited	Insufficient	
Threat posed to users				
	Level of threat posed to users	Limited	Insufficient	Published literature
Ecological Importance				
	RU with high EIS	No	Insufficient	Regional conservation plans
	RUs with A/B NEC and / or PES	No	Insufficient	
	RUs identified with NFEPA	Yes	Sufficient: L	
	RUs with other biodiversity conservation plans	Limited	Sufficient: L	
Threat faced by ecological component of the RU				
	RUs with threats to ecological components	Limited	Sufficient: L	
Management Considerations				
	RUs with PES lower than a D Category	Limited	Sufficient: L	
Practical Considerations				
	RU with monitoring data/site/facility	Yes	Sufficient: L	
	Accessibility of resource unit for monitoring	Yes	Sufficient: L	
	Safety risk associated with monitoring RU	Yes	Sufficient: L	

Appendix 7: GAP analyses summary for Step 3 of the RQO process for the Lower Vaal River Catchment: Wetlands component.

WETLANDS				
Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Position of resource unit				
	RU location	No	Insufficient	NFEPA, reserve, conservation plans, Ramsar mgt. plans, etc.
Importance for users (Current & anticipated future use)				
	NB RUs that directly support livelihoods of communities	No	Insufficient	Ramsar mgt. plans, wetland prioritisation report, reserve, other specialist studies, etc.
	RUs for strategic requirements/ int. obligations	No	Insufficient	Ramsar mgt. plans, wetland prioritisation report, reserve, other specialist studies, etc.
	RUs that contribute to instream flows	No	Insufficient	Ramsar mgt. plans, wetland prioritisation report, reserve, other specialist studies, etc.
	Economically NB RUs	No	Insufficient	Ramsar mgt. plans, wetland prioritisation report, reserve, other specialist studies, etc.
Threat posed to users				
	Level of threat posed to users	No	Insufficient	Ramsar mgt. plans, wetland prioritisation report, reserve, other specialist studies, etc.
Ecological Importance				
	RU with high EIS	No	Insufficient	Ramsar mgt. plans, wetland prioritisation report, reserve, other specialist studies, etc.
	RUs with A/B NEC and / or PES	No	Insufficient	Ramsar mgt. plans, wetland prioritisation report, reserve, other specialist studies, etc.
	RUs identified with NFEPA	No	Insufficient	NFEPA
	RUs with other biodiversity conservation plans	No	Insufficient	Ramsar mgt. plans, other specialist studies, etc.
Threat faced by ecological component of the RU				

	RUs with threats to ecological components	No	Insufficient	Ramsar mgt. plans, other specialist studies, etc.
WETLANDS				
Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Management Considerations				
	RUs with PES lower than a D Category	No	Insufficient	Ramsar mgt. plans, reserve, other specialist studies, etc.
Practical Considerations				
	RU with monitoring data/site/facility	No	Insufficient	Still to be determined
	Accessibility of resource unit for monitoring	No	Insufficient	Still to be determined
	Safety risk associated with monitoring RU	No	Insufficient	Still to be determined

Appendix 8: GAP analyses summary for Step 3 of the RQO process for the Lower Vaal River Catchment: Groundwater component.

GROUND WATER				
Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Position of resource unit				
	RU location	No	Insufficient	Technical reports, DWA NGA, DWA GRA II data
Importance for users (Current & anticipated future use)				
	NB RUs that durectly support livelihoods of communities	No	Insufficient	Technical reports, DWA NGA, DWA GRA II data
	RUs for strategic requirements/ int. obligations	No	Insufficient	Technical reports, DWA NGA, DWA GRA II data
	RUs that contribute to instream flows	No	Insufficient	Technical reports, DWA NGA, DWA GRA II data
	Economically NB RUs	No	Insufficient	WUA's, Technical reports, Municipalities
Threat posed to users				
	Level of threat posed to users	No	Insufficient	Technical reports, DWA NGA, DWA GRA II data

GROUND WATER

Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Ecological Importance				
	RU with high EIS	Yes	Sufficient	
	RUs with A/B NEC and / or PES	Yes	Sufficient	
	RUs identified with NFEPA	Yes	Sufficient	
	RUs with other biodiversity conservation plans	Yes	Sufficient	
Threat faced by ecological component of the RU				
	RUs with threats to ecological components	Yes	Sufficient	
Management Considerations				
	RUs with PES lower than a D Category	Yes	Sufficient	
Practical Considerations				
	RU with monitoring data/site/facility	No	Insufficient	WUA's, Technical reports, DWA NGA, DWA GRA II data
	Accessibility of resource unit for monitoring	No	Insufficient	WUA's, Municipalities, Property owners
	Safety risk associated with monitoring RU	No	Insufficient	WUA's, Municipalities, Property owners

Appendix 9: GAP analyses summary for Step 4 of the RQO process for the Lower Vaal River Catchment: River and Lakes component.

RIVERS & LAKES					
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
1. Identify and assess the impact of current and anticipated future use on water resource components (Impacting activities tab)					
	a. Assess the importance of activities in driving resource change	List of the associated activities per RU	Yes	ISP, RWQO, Water Reconciliation Strategy	Sufficient: High
	b. Determine the anticipated level of impact on each sub-component	Rating/Score	Yes	ISP, RWQO, Water Reconciliation Strategy	Sufficient: High
	c. Determine the cumulative level of impact on each sub-component	Subcomponents assessed and ratings	Yes	ISP, RWQO, Water Reconciliation Strategy	Sufficient: High
	d. Determine the anticipated consequences of the impacting activities on each sub-component	Breakdown of activity and sub-component degrader	Yes	Details of the Lower Vaal Water Conservation and Water Demand Management and Integrated Water Quality Management Plan	Sufficient: Low
2. Identify requirements of important user groups					
	a. Identify important user groups within the 'protection of the water resource' and 'water resource dependent activity' user group types	List of the protection users (conservation largely) and sectors/developments dependent on the water resource	Partial: Yes for protection users and scant for dependent activity	l/use maps, IDP, Conservation Plans EIS in w/sheet and G&S spread sheets	Sufficient: Low
	b. Rate the importance of sub-components for the 'protection of the water resource' and 'water resource dependent activities'	Fish and bird species mentioned in certain IUAs& Rus but no ratings	No	FRAI Reports, Biodiversity Conservation plans etc. and users such as ESKOM and SASOL. Specialist consultation required.	Insufficient
	c. Summarise the aspirations of each important user group	Aspirations/Vision	No	Provincial conservation targets/visions. Specialist consultation required.	Insufficient
	d. Review Present State information		YES		Sufficient: High
	e. Propose the desired direction and magnitude of change for each sub-component for important user-groups	Detailed sub-component changes/ vision for the water resource	No	Sector Development Plans, IDP, Conservation targets. Specialist consultation required.	Insufficient

RIVERS & LAKES (CONTINUED)					
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
3. Selection of sub-components for RQO determination					
	a. Review the Ecosystem and User Prioritisation ratings	Quality, Quantity, Habitat and Biota Indicators	Yes for Ecosystem	PES/EIS, Reserve, Socio-economic reports	Insufficient
	b. Select sub-components and associated indicators for RQO determination		No	Reports detailing water quality and biological issues in the Lower Vaal WMA. Specialist consultation required.	Insufficient

Appendix 10: GAP analyses summary for Step 4 of the RQO process for the Lower Vaal River Catchment: Dams component.

DAMS					
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
1. Identify and assess the impact of current and anticipated future use on water resource components (Impacting activities tab)					
	a. Assess the importance of activities in driving resource change	List of the associated activities per RU	Limited	ISP, RWQO, Water Reconciliation Strategy	Sufficient: Low
	b. Determine the anticipated level of impact on each sub-component	Rating/Score	Limited	ISP, RWQO, Water Reconciliation Strategy	Sufficient: Low
	c. Determine the cumulative level of impact on each sub-component	Subcomponents assessed and ratings	Limited	ISP, RWQO, Water Reconciliation Strategy	Sufficient: Low
	d. Determine the anticipated consequences of the impacting activities on each sub-component	Breakdown of activity and sub-component degrader	Yes	Details of the Lower Vaal Water Conservation and Water Demand Management and Integrated Water Quality Management Plan	Sufficient: High

DAMS

Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
2.	**Identify requirements of important user groups**				
	a. Identify important user groups within the 'protection of the water resource' and 'water resource dependent activity' user group types	List of the protection users (conservation largely) and sectors/developments dependent on the water resource	Limited	l/use maps, IDP, Conservation Plans EIS in w/sheet and G&S spread sheets. Specialist consultation required.	Insufficient
	b. Rate the importance of sub-components for the 'protection of the water resource' and 'water resource dependent activities'	Ecological state of dams.	Limited	FAI Reports, Biodiversity Conservation plans etc. and users such as ESKOM and SASOL. Specialist consultation required.	Insufficient
	c. Summarise the aspirations of each important user group	Aspirations/Vision	No	Provincial conservation targets/visions. Specialist consultation required.	Insufficient
	d. Review Present State information	Ecological state of dams.	YES	FRAI Reports, Biodiversity Conservation plans etc. and users such as ESKOM and SASOL. Specialist consultation required.	Sufficient: High
	e. Propose the desired direction and magnitude of change for each sub-component for important user-groups	Detailed sub-component changes/ vision for the water resource	No	Sector Development Plans, IDP, Conservation targets. Specialist consultation required.	Insufficient
3.	**Selection of sub-components for RQO determination**				
	a. Review the Ecosystem and User Prioritisation ratings	Quality, Quantity, Habitat and Biota Indicators	No	Current ecological state of dams.	Insufficient
4.	**Establish the desired direction of change for selected sub-components**				
	a. Where applicable, understand the trade-offs that have been made between user groups in the Water Resource Classification	Unavailable	No	Use "Impacts" info as surrogate. Specialist consultation required.	Insufficient
	b. Propose an acceptable direction of change for each selected sub-component c. Align the outcomes of each RU assessment across the catchment	Dep on selected sub-component, see text in report	No	Current ecological state of dams. Specialist consultation required.	Insufficient

Appendix 11: GAP analyses summary for Step 4 of the RQO process for the Lower Vaal River Catchment: Wetlands component.

WETLANDS					
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
1.	**Identify and assess the impact of current and anticipated future use on water resource components (Impacting activities tab)**				
	a. Assess the importance of activities in driving resource change		Insufficient	WET-Win "Pressure Levels" outputs, Land cover dataset, Mining licences & potential Google Earth analysis and WARMS database	Sufficient: Low
	b. Determine the anticipated level of impact on each sub-component		Insufficient	As above	Sufficient: Low
	c. Determine the cumulative level of impact on each sub-component		Insufficient	Desktop PES / EIA tables, Available water quality data and Available wetland assessment information	Sufficient: Low
	d. Determine the anticipated consequences of the impacting activities on each sub-component		Insufficient	Expert interpretation	Sufficient: Low
2.	**Identify requirements of important user groups**				
	a. Identify important user groups within the 'protection of the water resource' and 'water resource dependent activity' user group types		Insufficient	Land cover dataset Google Earth analysis. Specialist consultation required.	Insufficient
	b. Rate the importance of sub-components for the 'protection of the water resource' and 'water resource dependent activities'		Insufficient	Conservation: Can be informed by available data (e.g. Desktop PES/EIS, Conservation Plans etc.) User Groups: Can be informed by a basic understanding of sectors but will require local consultation. Specialist consultation required.	Insufficient
	c. Summarise the aspirations of each important user group		Insufficient	Specialist consultation required.	Insufficient
	d. Review Present State information		Insufficient	NFEPA. Specialist consultation required.	Insufficient
	e. Propose the desired direction and magnitude of change for each sub-component for important user-groups		Insufficient	Specialist consultation required.	Insufficient
3.	**Selection of sub-components for RQO determination**				
	a. Review the Ecosystem and User Prioritisation ratings		Insufficient	Specialist consultation required.	
	b. Select sub-components and associated indicators for RQO determination		Insufficient	Select based on importance of sub-components and an understanding of financial constraints associated with implementing a monitoring programme	
4.	**Establish the desired direction of change for selected sub-components**				
	a. Where applicable, understand the trade-offs that have been made between user groups in the WRC		Sufficient: L	Could base this on the wetland related objectives proposed at a catchment level	
	b. Propose an acceptable direction of change for each selected sub-component		Insufficient	N/A	Insufficient
	c. Align the outcomes of each RU assessment across the catchment		Insufficient	Wetland Specialist & Project team	

Appendix 12: GAP analyses summary for Step 4 of the RQO process for the Lower Vaal River Catchment: Groundwater component.

GROUND WATER					
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
Broadly characterise the groundwater resource:					
	The flow system as defined by climate and geology, with recharge and discharge areas	Vegter groundwater maps; 1:250 000 geological maps, 1:500 000 hydrogeological maps, DWA NGA, DWA GRA II	No	Vegter groundwater maps; 1:250 000 geological maps, 1:500 000 hydrogeological maps, DWA NGA, DWA GRA II	Sufficient: low
	Present status and degree of impact	DWA NGA, DWA GRAII, WMS, WARMS	No	DWA NGA, DWA GRAII, WMS, WARMS	Sufficient: low
	Reference conditions	DWA NGA, DWA GRAII, WMS, WARMS	No	DWA NGA, DWA GRAII, WMS, WARMS	Sufficient: low
	Current and future uses	WARMS, DWA GRAII, ISP	No	WARMS, DWA GRAII, ISP	Sufficient: low
Define the critical characteristics or attributes of groundwater which support or limit the identified uses.					
	Sub-steps	DWA NGA, DWA GRAII, WMS, Technical reports	No	DWA NGA, DWA GRAII, WMS, Technical reports	Sufficient: low
Define the risk to uses with respect to hazards present in the catchment and aquifer vulnerability.					
	Sub-steps	DWA NGA, DWA GRAII, WMS, Technical reports	No	DWA NGA, DWA GRAII, WMS, Technical reports	Sufficient: low
From the critical attributes, select key measurable indicators which relate to the resource itself or land-use impacts, and which will enable sustainable management of groundwater.					
	Sub-steps	DWA NGA, DWA GRAII, WMS, Technical reports	No	DWA NGA, DWA GRAII, WMS, Technical reports	Sufficient: low