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

WP10535

RESOURCE UNIT DELINEATION REPORT

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DOCUMENT INDEX

Reports as part of this project:

Index number	Report number	Report title
01	RDM/WMA10/00/CON/RQO/0112	Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10): INCEPTION REPORT
02	RDM/WMA10/00/CON/RQO/0212	Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10): GAP ANALYSIS REPORT
03	**RDM/WMA10/00/CON/RQO/0113**	**Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10): RESOURCE UNIT DELINEATION REPORT**
04	RDM/WMA10/00/CON/RQO/0213	Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10): RESOURCE UNIT PRIORITISATION REPORT
05	RDM/WMA10/00/CON/RQO/0114	Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10): SUB-COMPONENT PRIORITISATION AND INDICATOR SELECTION REPORT
06	RDM/WMA10/00/CON/RQO/0214	Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10): RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS REPORT
07	RDM/WMA10/00/CON/RQO/0314	Determination of Resource Quality Objectives in the Lower Vaal Water Management Area (WMA10): CLOSE OUT REPORT

Bold type indicates this report.

Title: *Resource Unit Delineation Report*

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

Resource Unit Delineation Report

Executive Summary

The Resource Quality Objectives (RQOs) determination procedures for the Lower Vaal Water Management Area (WMA) involved the application of the seven step framework established by the Department of Water Affairs in 2011 (DWA, 2011). Although the procedures involve defining the resource, setting a vision, determination of RQOs and Numerical Limits (NLs), gazetting this and then moving to implementation, monitoring and review before starting the process all over again, some of these steps were achieved in the Water Resource Classification (WRC) Study and were not repeated in this study. The procedural steps established for this case study to determine RQOs for rivers, groundwater, dams and wetland resources in the WMA include:

- Step 1. Delineate the Integrated Units of Analyses (IUAs) and Resource Units (RUs).
- Step 2. Establish a vision for the catchment and key elements for the IUAs.
- Step 3. Prioritise and select RU's and ecosystems for RQO determination.
- Step 4. Prioritise sub-components for RQO determination, select indicators for monitoring and propose the direction of change.
- Step 5. Develop draft RQOs and Numerical Limits.
- Step 6. Agree RUs, RQOs and NLs with stakeholders.
- Step 7. Finalise and Gazette RQOs.

Components of steps 1 and 2 were available from the WRC study to which this RQO determination process was aligned. This report documents the delineation of the IUAs and RUs for RQO determination in the Lower Vaal WMA (Step 1).

A total of 6 IUAs were already identified as part of the Lower Vaal WRC study and these existing IUAs were used in the development of RQOs for the Olifants WMA. The delineation process resulted in a total of 11 RUs selected for the rivers component which was also used for the groundwater component. Numerous wetlands and dams were delineated that will be prioritised during step 4 of the RQO process.

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

Resource Unit Delineation Report

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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.

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

Resource Unit Delineation Report

1 INTRODUCTION

The rationale for requiring RQOs, their components, their applicability and implementation procedures emanate from the National Water Act of South Africa (NWA, 1998). The Water Act (1998) requires that all water resources are protected in order to secure their future and sustainable use. It lays out a plan where each significant water resources (surface water, wetlands, groundwater and estuaries) are classified according to a WRC System. In the process, the Reserve is also determined for the water resource, i.e. the amount of water, and the quality of water, that is required to sustain both the ecosystem and provide for basic human needs. This Reserve then contributes to the Classification of the resource. This classification results in a Management Class and associated RQOs for water resources, which gives direction for future management activities in the WMA. According to the Water Act (NWA, 1998), the purpose of RQOs are to establish clear goals relating to the quality of the relevant water resources and stipulates that in determining RQOs a balance must be sought between the need to protect and sustain water resources and the need to use them (sensu DWA, 2011). Thus the "working part" of the Classification of water resources, is the RQOs that are produced. These 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:

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

This section of the RQO determination procedure includes the delineation of the IUAs and RUs for the Lower Vaal WMA (Step 1; DWA, 2011). Integrated Units of Analysis are finer-scale units aligned to watershed boundaries, in which socio-economic activities are likely to be similar. These homogenous units provide a useful indication of similar impacts in different areas of the catchment which should be considered in the determination of RQOs. A RU, on the other hand, is a stretch of river that is sufficiently ecologically distinct to warrant its own specification of Ecological Water Requirements (EWR). Resource Units are nested within IUAs and in the RQO process, are aligned to IUA boundaries.

2 SCOPE OF THE STUDY

The study entails the determination of Resource Quality Objectives (RQOs) for all significant water resources (rivers, wetlands, dams (or lakes) and groundwater ecosystems) in the Lower Vaal Water Management Area (WMA). The RQO determination procedure established by Department of Water Affairs (DWA) (2011) has been implemented to determine RQOs in this case study. The RQO determination procedure is based on a seven step framework including (DWA, 2011; Figure 1):

- Step 1. Delineate the Integrated Units of Analysis (IUAs) and define the Resource Units (RUs)
- Step 2. Establish a vision for the catchment and key elements for the IUAs
- Step 3. Prioritise and select preliminary RUs for RQO determination
- Step 4. Prioritise sub-components for RQO determination, select indicators for monitoring and propose the direction of change
- Step 5. Develop draft RQOs and Numerical Limits (NLs)
- Step 6. Agree RUs, RQOs and NLs with stakeholders
- Step 7. Finalise and Gazette RQOs

In 2013 the DWA completed the Water Resource Classification (WRC) study for the Lower Vaal WMA which included the delineation IUAs and established a vision for the catchment and key elements for the IUAs (DWA, 2012). This resulted in the determination of Management Classes for each IUA and Recommended Ecological Categories (REC) for biophysical nodes selected to represent the riverine ecosystem in the WMA. These outcomes met the IUA delineation requirements for the study and provided the vision information, including Management Classes for the study. As such this study did not include these components but rather adopted the outcomes from the WRC study (DWA, 2012). Apart from these components that were obtained from the WRC study; some developments/adaptations were made to the DWA (2011) RQO determination procedure to the groundwater, wetland and dam components of the study in particular. This report documents the approach adopted and the outcomes of the implementation of Step 1 of the RQO determination procedure (DWA, 2011).

3 METHODOLOGY

3.1 RESOURCE QUALITY OBJECTIVES METHODOLOGY OVERVIEW

The RQO determination procedure established by DWA (2011) has been implemented in the study. This includes the implementation of a seven step procedural framework (Figure 1), that is repeatable and as such forms allows for an adaptive management cycle with additional steps. Overall the procedure involves defining the resource, setting a vision, determination of RQOs and NLs, gazetting this and then moving to implementation, monitoring and review before starting the process all over again. A summary of the procedural steps established for this case study with some adaptations that were required to include groundwater, dams and wetland resources includes (Figure 1):

- **Step 1. Delineate the IUAs and RUs:** In this case study IUAs were obtained from the WRC (DWA, 2012) and applied to all water resources considered in the study (rivers, wetlands, dams and groundwater ecosystems). Three spatial levels for resources were considered for RQO determination in this case study including:
    - Regional (IUA) scale assessments were considered for rivers, wetlands and groundwater resources in the study.
    - Resource Unit scale assessments that were aligned to biophysical nodes obtained from the WRC study (DWA, 2012) were considered for river and groundwater resources alone.
    - Ecosystem scale assessments were considered for wetland and dam ecosystems/resources in the study.

  The RU delineation procedure initially involved the identification of sub-quaternary reaches of rivers in the WMA for each biophysical node obtained from the WRC study (DWA, 2012; DWA, 2013a). The RU delineation process then involved amalgamating the upstream associated sub-quaternary reaches of riverine ecosystems, and their associated catchment areas, (DWA, 2013a). As a result, the number of RUs selected for the study is identical to and can later be aligned to the information associated with the biophysical nodes from the WRC study. The delineation procedure for ecosystem scale resource assessment involved the use of Geographical Information System (GIS) spatial ecosystem data. Refer to the delineation report (Step 1) for more information (DWA, 2013a).

- **Step 2. Establish a vision for the catchment and key elements for the IUAs:** The stakeholder requirements and their associated outcomes which includes the Management Classes for IUAs and RECs for RUs from the WRC study were adopted as the vision for this study (DWA, 2012). No further visioning process was appropriate as this could have conflicted with the WRC process. The WRC outcomes were skewed towards river resources in the WMA which necessitated obtaining additional information for the other resources considered in the study (wetlands, dams and groundwater ecosystems). This additional information is highlighted in the reports where applicable.

- **Step 3. Prioritise and select RUs and ecosystems for RQO determination:** Within this case study only 11 IUAs were delineated, as such the RU Prioritisation Tool for rivers (DWA, 2011) was not implemented. Priority RUs were selected during the following step (STEP 4) (DWA, 2013b).

- **Step 4. Prioritise sub-components for RQO determination, select indicators for monitoring and propose the direction of change:** This step included the hosting of a range of specialist workshops for rivers, dams and groundwater resources where RU Evaluation Tools were used to select sub-components for RQO determination, select indicators and propose the direction of change. The RU Evaluation Tools used in this section for wetlands, dams and groundwater were developed for this study. This information could then be used to develop draft RQOs and Numerical Limits in the next step (DWA, 2014). The relevant activities of this step are:
    - 4.1 Identify and assess the impact of current and anticipated future use on water resource components
    - 4.2 Identify requirements of important user groups
    - 4.3 Selection of sub-components for RQO determination

4.4 Establish the desired direction of change for selected sub-components
4.5 Complete the information sheet for the Resource Unit Evaluation Tool.

- **Step 5. Develop draft RQOs and Numerical Limits**: This step is based on the outcomes of the RU and ecosystem prioritisation step (Step 4). From the outcomes of the RU and ecosystem prioritisation step draft RQO were established and then provided to recognised specialists to establish NLs that are generally quantitative descriptors of the different components of the resource such as the water quantity, quality, habitat and biota. These descriptors were designed to give a quantitative measure of the RQOs (DWA, 2011). Although the NLs may have some uncertainty associated with them and were not originally intended for gazetting (DWA, 2011) the will be considered for gazetting in this case study at the request of the Department of Water and Sanitation (DWS) legal services. Consider the RQO and NL reports for more information. The relevant activities of this step are:
    5.1 Carry over sub-component and indicator information from the Resource Unit Evaluation Tool
    5.2 Extract available data to determine the present state for selected sub-components and indicators
    5.3 Assess the suitability of the data
    5.4 Where necessary, collect data to determine the Present State for selected indicators
    5.5 Determine the level at which to set RQOs
    5.6 Set appropriate draft RQOs
    5.7 Set appropriate draft Numerical Limits in line with the draft RQO
    5.8 Determine confidence in the RQOs and process

- **Step 6. Agree Resource Units, RQOs and Numerical Limits with stakeholders:** This component of the RQO determination process is carried out by the regulators of the WMA, assisted by the project team, and includes the consideration of RQO and NL outcomes with stakeholder, prior to the initiation of the gazetting process. The relevant activities of this step are:
    6.1 Notify stakeholders and plan the workshop
    6.2 Present and refine the Resource Unit selection with stakeholders
    6.3 Present the sub-components and indicators selected for the RQO determination
    6.4 Present the proposed direction of change and associated rationale
    6.5 Present and revise RQOs and Numerical Limits

- **Step 7. Finalise and Gazette RQOs:** This component of the RQO determination process is carried out by the regulators of the WMA assisted by the project team, and includes the development of gazette RQO and NL drafts for submission to legal services of the Department of Water and Sanitation for gazetting

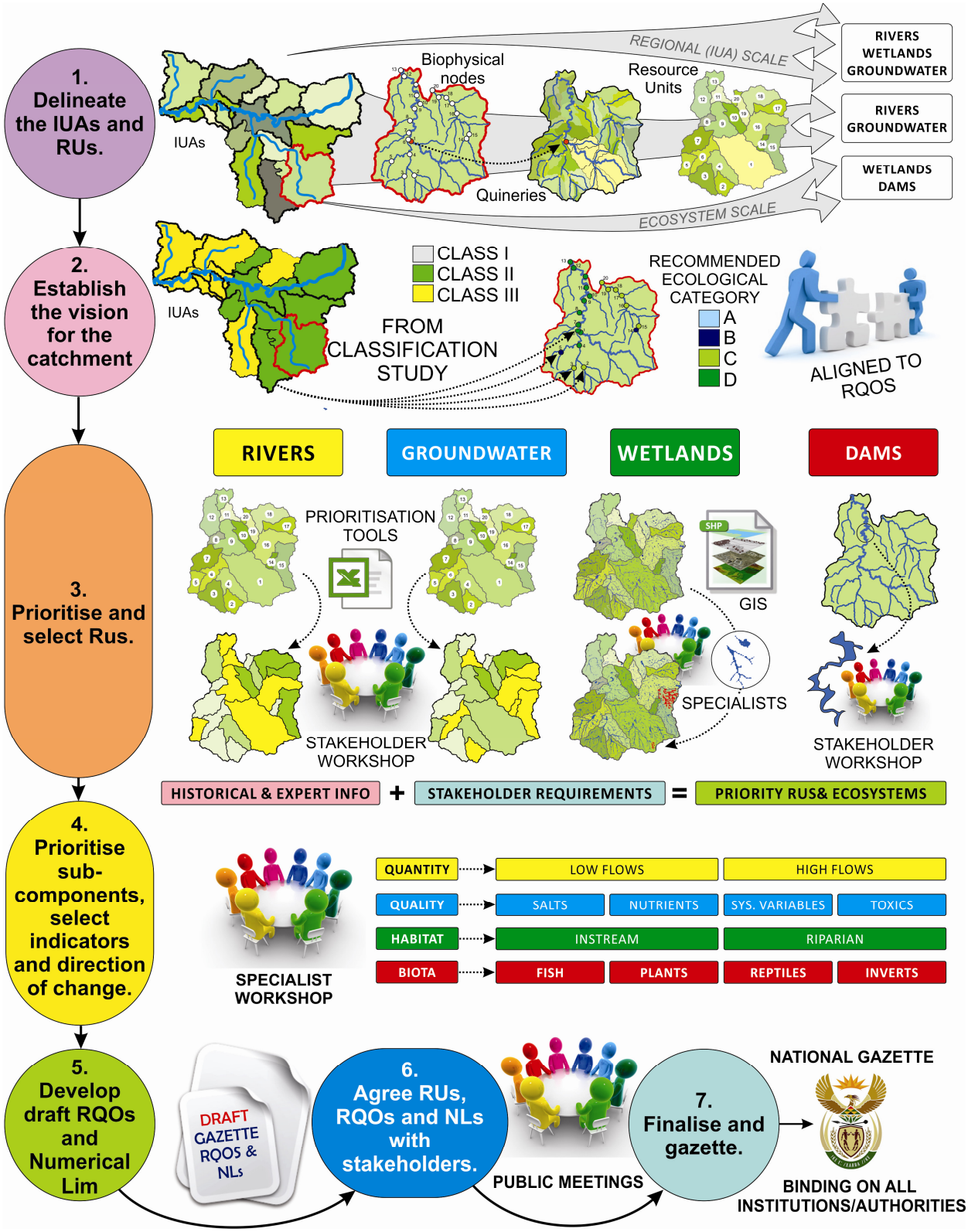

Figure 1: Schematic summary of the RQO determination procedure (adapted from DWA, 2011) which was implemented in this study.

3.2 RESOURCE UNIT DELINEATION OVERVIEW

The first step of the RQO process requires the delineation of IUAs and RUs. A total of six IUAs have already been identified as part of the Lower Vaal WRC study (Table 1 and

Figure 2). These existing IUAs have been used in the development of RQOs for the Lower Vaal WMA.

Table 1: IUAs and Nodes identified for the Lower Vaal WMA as part of the WRC study (DWA, 2012), and associated quaternary catchments

IUA	Nodes	Quaternary catchment
LV-A1	LA1.1, LA1.2	C31A – C31D
LV-A2	LA2.1	C31E
LV-A3	LA3.1	C32A – C32D
LV-A4	LA4.1, LA4.2, EWR17	C31F, C33A – C33C
LV-B	LB.1, EWR16, EWR18, DOUGLAS EWR	C91A – C91E, C92A – C92C
LV-C	Dolomite aquifer, Lichtenberg area	

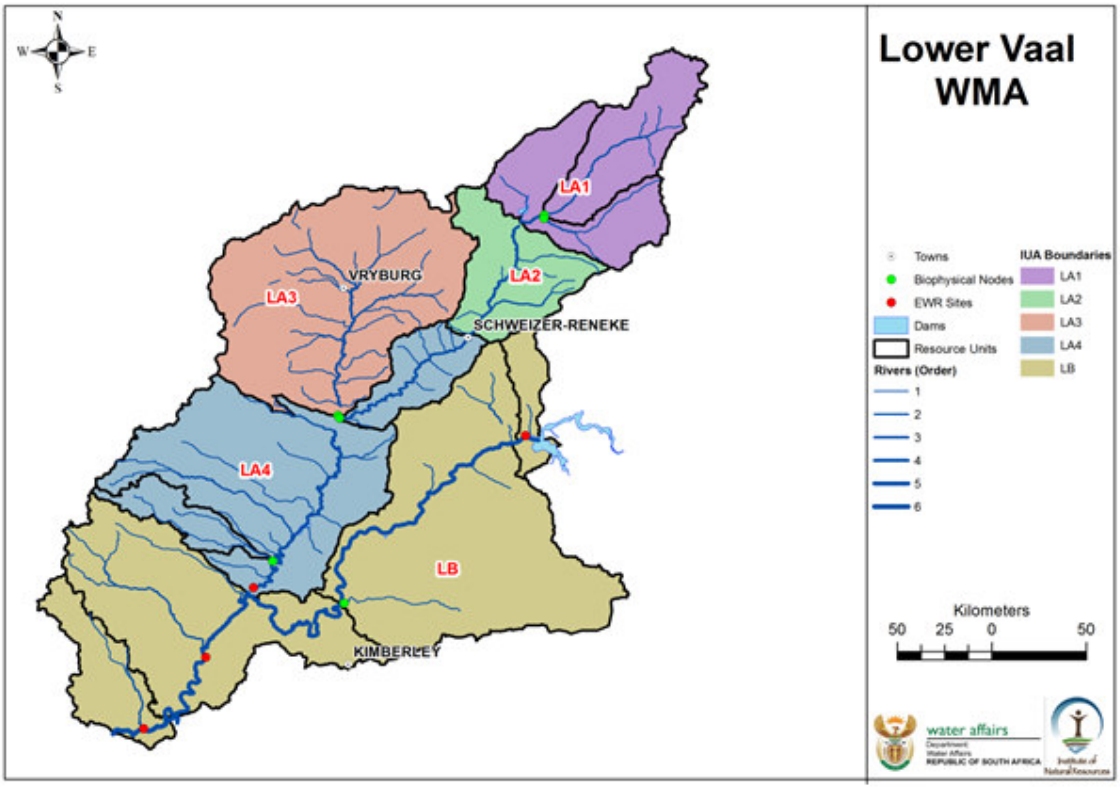

Figure 2: The location of IUAs in the Lower Vaal WMA

The following approaches have been applied in the delineation of RUs for rivers, wetlands, dams and groundwater.

3.3 RIVER RESOURCE UNIT DELINEATION FOR THE LOWER VAAL WMA

The WRC study has identified a total of 10 nodes for the Lower Vaal WMA including key nodes and desktop biophysical nodes (Table 1). 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 (NFEPA) study. The WRC study states that every effort was made to select nodes that fairly represent different conditions and operational procedures in the catchment.

For the purposes of the RQO study however, the terrestrial area associated with each of the desktop biophysical nodes was also delineated to provide an area based River Resource Unit. This was necessary to facilitate an assessment of the socio-economic data and associated users requirements as well as the potential impacts of different land uses on water resources. The following key steps were undertaken as part of this delineation process.

3.3.1 DATA GATHERING

Spatial data for the Lower Vaal WMA was obtained from Pieter van Rooyen (WRP Consulting Engineers (Pty) Ltd). This data was accompanied by an Ecological Database which provided detailed metadata for all biophysical nodes and EWR sites in the Upper, Middle and Lower Vaal WMAs. Table 2 shows a list of the data that was received as well as those data sets that were used in the delineation process. In addition to these data sets, the national sub-quaternary data layer (obtained from DWA) was also used.

Table 2: Spatial data used in the Lower Vaal WMA resource unit delineation exercise

Folder	Shapefile (.shp)
Lower Vaal WMA	• **Biophysical Nodes*** • **EWR Sites*** • Lower Vaal catchment (x2) • Dams • **Integrated Units of Analysis*** • **Quaternary catchments*** • **Rivers*** • Provinces and international boundaries

***=data used for resource unit delineation**

3.3.2 SELECTION OF SCALE AND EXCLUSION OF SUB-CATCHMENTS

Resource Unit delineation was conducted at the sub-quaternary scale as this level of spatial representation provides greater resolution of the data. Furthermore, the sub-quaternary scale has been used in other projects by the DWA. Therefore, working at this scale ensures that data from various projects is transferrable thereby minimizing scale discrepancies and providing a homogenous platform for data analysis.

The Lower Vaal WMA in its western portion has rivers that feed into the Kuruman River which feeds the Molopo River, a tributary of the Orange River. The area covered by these catchments and rivers has been excluded from the resource unit delineation exercise as it does not form part of this study (see Figure 3).

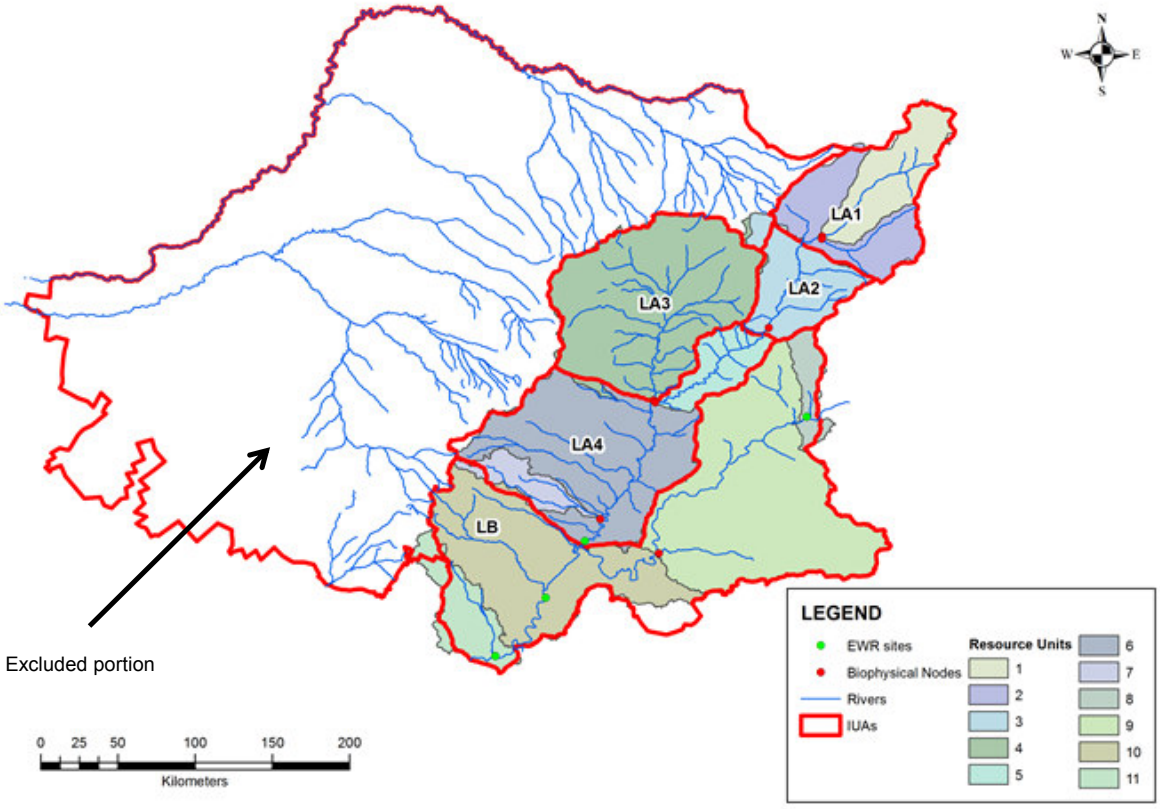

Figure 3: Overview of the Lower Vaal WMA.

3.3.3 DATA PROCESSING

Using ArcMap™ the above-mentioned layers (Table 2) were added into the document and symbolized accordingly. Thereafter, sub-quaternaries that intersected the IUAs were selected. The intersect function was used to ensure that adjacent sub-quaternary catchments that were part of the WMA were not excluded. The output of this step yielded sub-quaternary catchments that were within the IUAs. An edit session was entered into with the sub-quaternary layer as the layer to perform editing functions. Sub-quaternary catchments were merged to provide the RUs. The rivers and nodes within the IUAs provided the basis for resource unit delineation as the river catchments were followed i.e. the watershed area was included (quaternary catchments were also used to verify the validity of the delineated RU). The detailed steps undertaken as part of the River RU delineation process are detailed in Appendix 1.

3.4 WETLAND ECOSYSTEM DELINEATION FOR THE LOWER VAAL WMA

Step 1 of the RQO process includes defining RUs. The objective of the first step is to gather available information for the catchment of concern and then to delineate RUs. Guidance provided in the RQO manual suggests that the Decision Support System for Wetland Reserve Determinations (DWAF, 1999) should be used to inform the delineation of wetland RUs. This suggests that wetlands meeting the following criteria should be considered as a minimum:

- Ramsar wetlands or wetlands with potential Ramsar status;
- Wetlands with national or provincial protected status;
- Large wetlands providing important ecological services (*e.g.* flood attenuation, crop production etc.);
- Large freshwater Dams;

- Large wetlands fed by water sources on which major developments are planned, which could cause irreversible damage to the wetlands; and
- Wetlands supporting important populations of endangered species.

While some of these features can be identified from available spatial datasets, size of wetlands mapped, (which is one of the primary discriminators suggested) is largely a function of the scale of mapping and the level of classification applied. As a result, using size of mapped wetland units as a surrogate for importance is not a reliable attribute (at least from a GIS analysis perspective). At a coarse scale, clear wetland features may be identified as discrete units and mapped accordingly. With more detailed mapping, the connections between obvious wetland areas can be identified, and can result in the amalgamation of many smaller wetlands mapped at a courser scale. Equally, classification at increasingly fine levels helps to differentiate between wetland types but results in contiguous wetlands being cut into a number of sub-units which cannot be easily identified from available GIS datasets.

The NFEPA wetland layer was used as the base map of wetlands for the catchment. The attribute information available for the NFEPA wetland layer, in particular the ecological importance and sensitivity of wetland systems, was important for the prioritization and selection process (i.e. Step 3). Examples of the attributes from the NFEPA dataset for wetlands that may have specific relevance are indicated below:

- **Wetland condition**: This was modelled based on available Landcover data around wetland systems and informed by the condition of associated rivers where information was available.
- **Important provincial wetlands**: Here, important wetlands including peatlands will be identified by the provincial authorities.
- **Expert-identified important wetland systems**: This includes wetlands containing exceptional biodiversity importance, good intact examples of particular wetland types, and wetlands in which Working for Wetlands has undertaken rehabilitation work (based on available data).
- **Wetlands located in proximity to populations of threatened species**;
- **Wetlands within catchments highlighted for threatened species conservation**;
- **Rank of wetlands**: The final ranking of wetlands giving their relative importance based on available criteria; and
- **Wetland FEPAS**: Priority wetlands (Freshwater Ecosystem Priority Areas) identified for meeting National Freshwater Ecosystem Targets.

3.5 DAM ECOSYSTEM DELINEATION FOR THE LOWER VAAL WMA

Dams are single units within main stem rivers or tributaries. Off-channel dams are not associated with any rivers and are usually filled by the transfer of water from a nearby river system or dam. No specific tool was developed or used for the delineation of the dams of the Lower Vaal catchment. Various data bases and reports were used to identify the dams in the Lower Vaal catchment. Some of the main sources of information included:

- DWA Hydrological Information System (HIS)
- Water Situation Assessment Model (WSAM)
- Internal Strategic Perspective (ISP) study, 2004
- Any other relevant reports (Water Resources Classification study, Reserve studies, etc.)

The above information and the following rules were used to delineate the various dams:

i. Plotting of the larger dams (farm dams were excluded)
ii. Delineation using the full supply areas of the dams
iii. These delineations were overlaid with the resource units and all resource units associated with the dams were identified for further use in steps 4 and 5 of the RQO process
iv. The dam wall was used as the endpoint per dam.

3.6 GROUNDWATER RESOURCE UNIT AND ECOSYSTEM DELINEATION FOR THE LOWER VAAL WMA

The delineation of Resource Units was based on surface drainage areas. In general surface water reporting to DWA is based on quaternary catchment boundaries. This is done for various reasons which include:

- DWA In-house models utilise quaternary boundaries
- The WMA comprise of a subset of quaternary boundaries

Groundwater does not report to quaternary boundaries or resource units for the purpose of this document. This is due to the fact that aquifers are aligned with the geology rather than surface drainage regions. A comparison of the surface geology and the resource units are shown in Figure 4 which clearly illustrate the variability of the geology that occurs within the respective resource units.

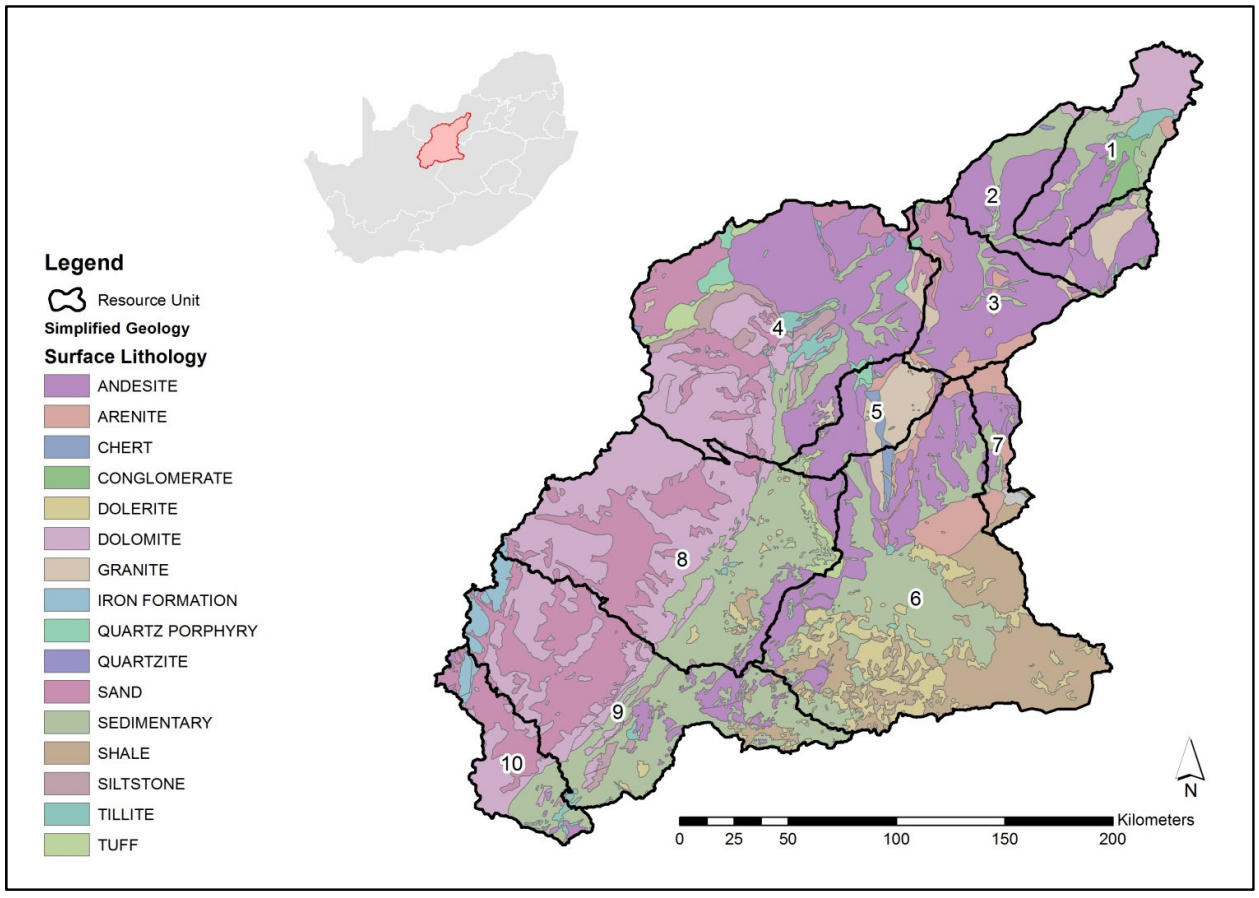

Figure 4: Surface geology vs. resource unit boundaries

General assumptions made to report groundwater within surface catchments (e.g. groundwater reserve determinations on quaternary boundary) are as follows:

- Shallow groundwater will follow the regional topography and surface water catchment boundaries will act as natural groundwater divides (Figure 5 (1)).
- Deeper groundwater will follow the deeper regional groundwater flow (Figure 5 (2) and (3)).
- The net groundwater flow through the surface catchment is assumed to be zero.

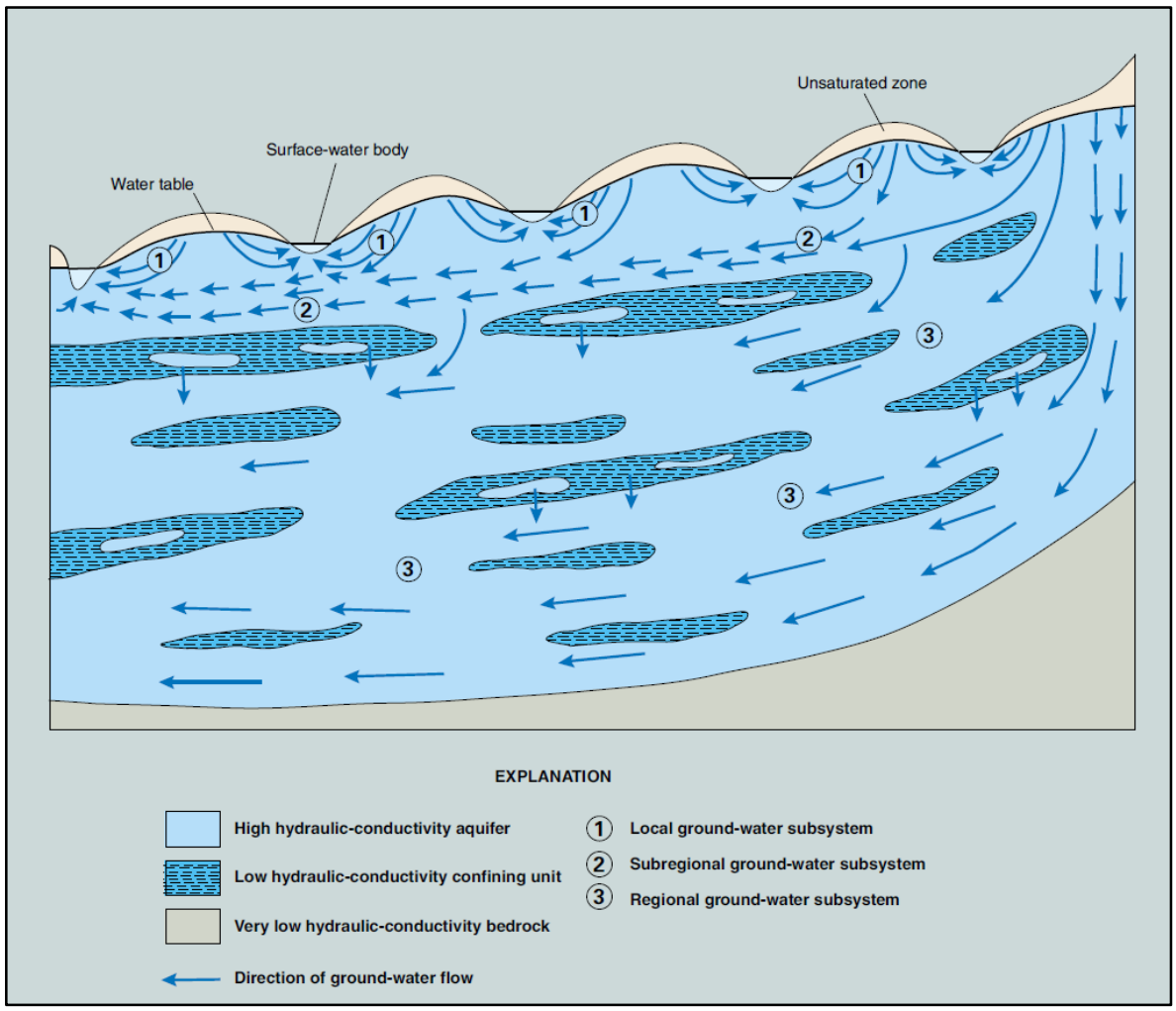

Figure 5: Groundwater flow systems (USGS, 1999)

4 FINDINGS

4.1 RIVER RESOURCE UNITS FOR THE LOWER VAAL WMA

A total of 11 River RUs were delineated for the Lower Vaal WMA. The location of these River RUs and associated biophysical nodes is shown in Figure 6. The IUA, biophysical node and corresponding river as well as the present ecological state, recommended ecological category (as required by the WRC) and the management class for each RU is detailed in

Table 3.

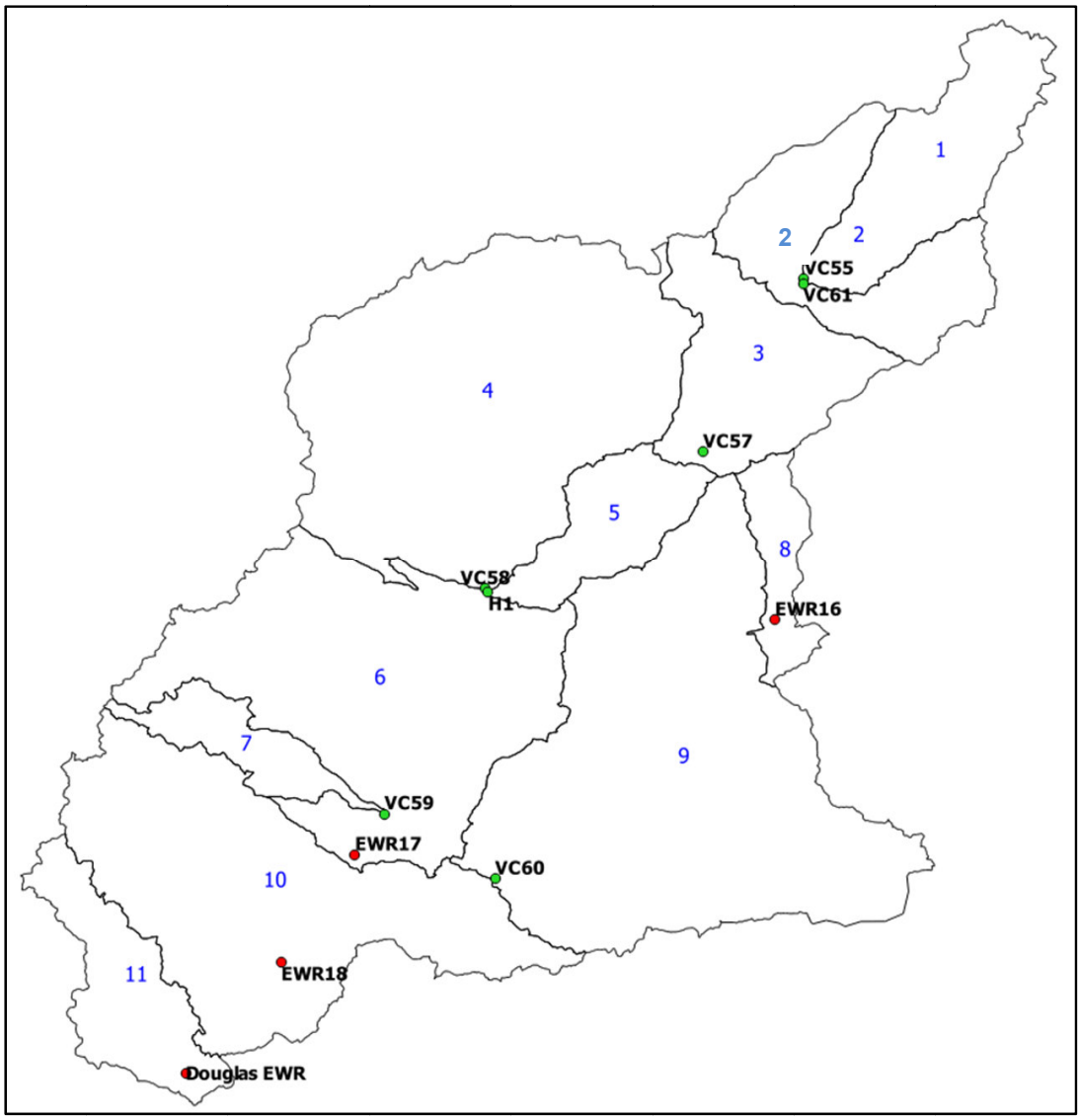

Figure 6: River Resource Units delineated for the Lower Vaal WMA

Table 3: Summary data for each River Resource Unit delineated in the Lower Vaal WMA

IUA Name	Class for IUA	RU	Original node name (WRC study)	New node name (WRC study)	River Name	PES*	REC*
LA1. Upper Harts River	II	1	VC55	LA1.1	Harts River	C	C
		2	VC61	LA1.2	Klein Harts	C	C
LA2. Middle Harts River	II	3	VC57	LA2.1	Harts River	C	C
LA3. Dry Harts River	III	4	VC58	LA3.1	Dry harts	D	D
LA4. Lower Harts River	II	5	H1	#	Harts River	#(C)	#(C)
		6	EWR 17	EWR17	Harts River	D	D
		7	VC59	LA4.2	Unnamed trib	A/B	A/B
LB. Vaal River from downstream of Bloemhof Dam to Douglas Weir	III	8	EWR 16	EWR16	Vaal River	D	D
		9	VC60	LB.1	Leeu River	A/B	A/B
		10	EWR 18	EWR18	Vaal River	C	C
		11	IFR1	Douglas EWR	Vaal River	C/D	C

* The Present Ecological State (PES) and Recommended Ecological Category (REC) were extracted from DWA (2012).

Note that H1 has not been included in the determination of the Management Class for this IUA (as per DWA, 2012) however a PES and REC of a C is detailed in the metadata table for the WRC study.

4.2 WETLAND ECOSYSTEMS FOR THE LOWER VAAL WMA

The NFEPA wetland base layer for the catchment is illustrated in Figure 7 below.

Table 4 provides an indication of the number of different wetland types throughout the IUAs, and the approximate areas for each of the wetland types.

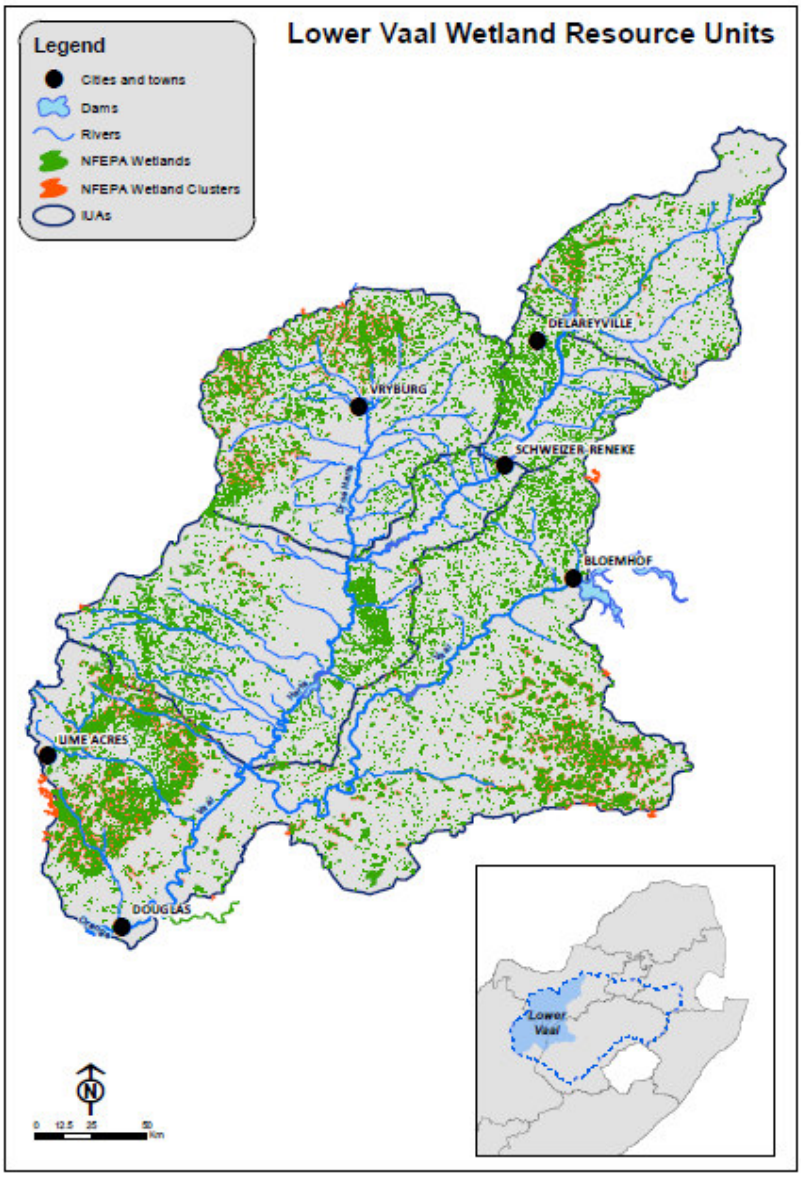

Figure 7: Lower Vaal wetland resource units

Table 4: Lower Vaal wetland resource units, number and area of wetland types

IUAs	Wetland Type	Channelled valley-bottom wetland	Depression	Flat	Floodplain wetland	Seep	Unchannelled valley-bottom wetland	Valleyhead seep	Total
LA1	No. of Wetlands	200	818	174	11	373	121	106	1803.0
	Area (Ha)	2551.3	5393.2	1017.9	2723.6	933.2	679.0	1132.0	14430.2
LA2	No. of Wetlands	33	565	359	10	276	89	42	1374.0
	Area (Ha)	415.6	2829.5	1874.7	1526.3	1129.1	338.6	244.9	8358.7
LA3	No. of Wetlands	230	1871	722	37	895	504	215	4474.0
	Area (Ha)	661.2	6588.5	2472.2	1350.8	3554.4	1261.5	583.4	16472.1
LA4	No. of Wetlands	251	1153	899	64	906	765	417	4455.0
	Area (Ha)	3426.2	6080.3	3975.0	7396.6	4025.5	1184.2	1017.2	27105.0
LB	No. of Wetlands	440	5584	1853	96	1599	963	478	11013.0
	Area (Ha)	6546.0	44180.6	6892.0	11328.2	6007.8	3898.9	2041.4	80895.0
TOTAL	No. of Wetlands	1154	9991	4007	218	4049	2442	1258	23119
	Area (Ha)	13600.4	65072.1	16231.9	24325.5	15650.1	7362.2	5018.9	147261.0

4.3 DAM ECOSYSTEMS FOR THE LOWER VAAL WMA

The approach resulted in a large number of dams being delineated that will be prioritised during step 4 of the RQO process. These delineated dams are listed in the following tables below:

- Dams delineated from the DWAHIS database as presented in Table 5.
- Major dams delineated using WSAM as presented in Table 6.
- Minor dams delineated using WSAM as presented in Table 7.
- Dams delineated based on the ISP study as presented in Table 8.

Table 5: Dams delineated from the DWAHIS database

Number	River and Dam Name
C3R001	Harts River @ Krugers Post (Wentzel Dam)
C3R002	Harts River @ Spitskop Dam
C3R003	Babers Pan @ Babers Pan
C3R006	Harts River @ Taung Dam
C9R001	Vaal River @ Vaalharts Storage We
C9R002	Vaal River @ Bloemhof Dam
C9R003	Vaal River @ Douglas Storage Weir

Table 6: Major dams delineated using WSAM

Dam Name	Quaternary catchment	Full Supply Capacity ($10^6 m^3$)	Full Supply Area (ha)
WENTZEL DAM	C31E	6578	299
TAUNG DAM	C31F	58900	465
SPITSKOP DAM	C33B	56630	2508
BLOEMHOF DAM	C91A	1269000	23066.5
VAALHARTS-STUWAL	C91B	48700	2118.9
DOUGLAS WEIR	C92B	16104	781

Table 7: Minor dams delineated using WSAM

Dam Name	Quaternary catchment	Full Supply Capacity ($10^6 m^3$)	Full Supply Area (ha)
DAUTH ROODE DAM	C31A	297	2
EEUFEES DAM	C31A	440	2
FINSCH SLIMES DAM NO.1	C92C	307	62
FINSCH SLIMES DAM NO.2	C92C	176	35
FINSCH SLIMES DAM NO.3	C92C	175	175

Table 8: Dams delineated based on the ISP study

Dam Name	Quaternary catchment	River
Wentzel	C31E	Harts
Taung	C31F	Harts
Spitskop	C33B	Harts
Vaalharts	C91B	Vaal
Douglas	C92B	Vaal

5 LIMITATIONS AND UNCERTAINTIES

SOME OF THE KEY LIMITATIONS WHICH MAY INFLUENCE THE CONFIDENCE OF THE DELINEATION PROCESS WHICH SHOULD BE CONSIDERED WHEN IMPLEMENTING THESE PRIORITY RUS AND ECOSYSTEMS INCLUDE:

5.1 RIVERS

- There is an observed conflict between the IUA and RU boundaries. To address this problem, it is recommended that in future the delineation of IUAs be based on sub-quaternary (quinery) catchment boundaries.

5.2 WETLANDS

- Delineation was largely dependent on available NFEPA wetland data. While this was the only publically available dataset for the study area, it is known to substantially under-represent the distribution of wetlands in the catchment[1].
- Whilst a wide range of wetland assessments (including wetland delineation) have been undertaken by consultants in the catchment, this information is not readily available due to (i) confidentiality clauses with clients and (ii) the disaggregated nature of the data that makes data acquisition difficult.

5.3 GROUNDWATER

- Very little information is available to adequately delineate confined groundwater ecosystems in particular in the study area.
- The delineation process demonstrates how groundwater ecosystems do not conform to surface ecosystems which were used as a template for groundwater delineation.

1 Based on extensive work in the catchment, Wetland Consulting Services have found that hillslope seepage wetlands are under-represented by up to 60% in some areas of the catchment (Gary Marnerwick, *pers. comm*..)

6 WAY FORWARD

The RUs provide the smallest discrete, manageable unit and are therefore important in the context of all other steps of the RQO process. However, given the large number of RUs within a selected catchment it is not possible to monitor all of these. The next step (Step 3) of the RQO process therefore entails a rationalisation process to prioritise and select the most useful RUs for RQO determination. The RUs detailed in the current report will therefore form the basis of this prioritisation process.

Selecting a sub-set of wetlands to take forward into further steps in the RQO process is likely to be a challenging process given the large number of wetlands in the study area. However, it is important to note that selection is undertaken again in Step 3 of the RQO process. This involves the prioritization and selection of RUs for RQO determination. Rather than following a tiered approach to selection (Step 1 then Step 3), a GIS analysis will be undertaken as part of Step 3 in order to evaluate the relative importance of all wetland units in the catchment. This analysis will be informed by the RU prioritization tool criteria (DWA, 2011) but will also need to be customised and refined based on available data. Additional criteria including the importance of wetlands to users and various practical considerations will be integrated into the prioritization process.

7 ACKNOWLEDGEMENTS

Contributions to this section of the RQO determination study were made by specialists from the Department of Water Affairs who provided spatial data and direction to the study team.

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9 APPENDIX

APPENDIX 1: SUMMARY OF THE DETAILED STEPS APPLIED IN DELINEATING RIVER RESOURCE UNITS.

Preparation

1) Open ArcMap 10 ™ and select new map
2) Add the following layers: sub-quaternaries, quaternary catchments, IUAs, Nodes, EWR sites and Rivers
3) Select> Select by location> select features from sub-quaternary catchments >source layer: IUA> Spatial selection method: Target layer (s) features intersect the Source layer feature > OK
4) Close dialog box
5) Right click the sub-quaternary catchment layer > Selection> Create layer from selected features (this creates a new layer in the table of contents)
6) Right click on the new layer and export the data to a shapefile with the name of the WMA as the prefix e.g. LVaal_SubQuats
7) Add the data as a layer in the map

Editing (*ensure that the layers are in the correct projection before editing)

1) Right click on the WMA_SubQuats layer > Edit Features> Start Editing
2) Using the river pattern and nodes, select sub-quaternaries that form the river catchment. Note: This step can involve integrating more than one river catchment to a resource unit.
3) When the sub-quaternaries feeding to hydronode x have been selected click Editor > Merge (do this step as necessary for resource unit delineation)
4) Delete subquats that do not fall within the IUA or have a significant portion of their area outside the WMA.
5) Editor > Save Edits Stop editing.

Resource Units have now been delineated.

Attribute table

Once the resource units were delineated, the following fields were added to the table: resource unit number (RU_Num), IUA, Area (km2) and Perimeter (km). The resource number was assigned by the hydro node in the particular resource unit.