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Development of an Integrated Water Quality Management Plan for the Vaal River System

Task 4

Integration of Resource Water Quality Objectives

September 2009

Development of an Integrated Water Quality Management Plan for the Vaal River System

TASK 4:

INTEGRATION OF RESOURCE WATER QUALITY OBJECTIVES

FINAL REPORT

Directorate National Water Resource Planning
Department of Water Affairs and Forestry

September 2009

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EXECUTIVE SUMMARY

Introduction

It is a given that it is impossible to meet the ideal water quality requirements in the Vaal River System as huge impacts from land developments, the extensive use of the resources and high regulation of the system already exists. Thus while Resource Water Quality Objectives (RWQOs) currently set are at levels which are achievable through sound management practices, in many instances the results of the status assessment task indicated that the RWQOs must be revised and integrated on a WMA and in a system context to enable the Vaal River to be managed sustainably and to cater for downstream users and uses. Thus while the emphasis is on improving water quality over time, the current situation has warranted, on one hand, that acceptable levels of impact are assimilated to maintain current water quality. However on the other hand improvement of water quality is the only option, but this comes at a cost. Both situations have economic implications – maintenance of current status (relaxation of RWQOs in some cases), would mean the downstream user would bear the cost, and improvement of current status (stricter RWQOs) would mean the discharger /polluter would bear the cost. Thus the integrated RWQOs proposed have considered the balance between the needs of users and uses, and reflects the realities that exist in such a regulated and impacted system.

The integration of the RWQOs, details the process and approach followed in determining an integrated set of RWQOs for the Vaal River System .

Process Followed

Based on the current water quality status of the system, the assessment of the situation with regard to the water users and various uses and the consideration of all water quality variables, an attempt was made to integrate, align and revise the RWQOs of the Vaal River main stem and its major tributaries.

The process followed to arrive at a proposed set of integrated RWQOs for the Vaal River System included the following:

Desk Top Assessment

As the first attempt, an assessment of all the existing RWQOs for the water resources in the catchment was undertaken by the study team. Based on their current understanding of the system and the results of the status assessment and salinity balance the study team, at a desktop level, identified proposed changes to the existing RWQOs. This exercise was aimed at identifying the key issues and focus areas that required attention. This analysis provided the basis for the iterations that followed. The results of this first order assessment are presented in Appendix B of the RWQOs report.

Workshops

Two workshops were held with key stakeholders in the Department to confirm a set of proposed RWQOs for the Vaal River System. The Department stakeholders that participated included representatives from the Department National Office (various Directorates) and Regional Offices

(Gauteng, Free State and Northern Cape). The first integration of RWQOs workshop was held on 12 October 2007 in Pretoria, at which the approach was confirmed, and set of RWQOs were proposed. These RWQOs were then modelled using the WRPM to determine what was achievable and possible based on the current operation and restraints in the system. A second workshop was then held on 1 November 2007 to present the outcome of these modelling runs, and to confirm a proposed set of integrated RWQOs for the Vaal River and its tributaries.

The integrated RWQOs proposed

Based on the criteria defined and considerations identified, as well as the key drivers, RWQOs for the selected water quality variables for the Vaal River were determined. A set of integrated RWQOs for total dissolved salts (TDS), phosphate and *E.coli* (microbiological) were defined for the Vaal River (main stem) for each of the 14 river reaches identified. The locations of the reaches are given in **Figure 8**. The proposed RWQOs are presented in Table E1, Table Table E2 and Table E3. Based on the model runs that were undertaken, RWQOs for TDS for the major tributaries of the Vaal River were also defined and these are presented in Table E1 as well.

Table E1 also includes the eco-specifications outputs related to the ecological protection levels for TDS determined using the water quality based TEACHA programme of the Reserve process. This assessment was undertaken to ensure that the RWQOs proposed were aligned to and took into consideration the level of ecological protection required for the various reaches of the Vaal River. The ecology is a key component of the system and in almost all instances the RWQOs proposed are stricter than the requirements specified by TEACHA.

Table E1: Proposed RWQOs for TDS for the Vaal River main for each river reach defined and for the major tributaries

VAAL RIVER SYSTEM: LEVEL 1 POINTS: RWQOS FOR TDS												
NO	REACH	WATER USERS	SOUTH AFRICAN WATER QUALITY GUIDELINES				PROTECTION (TEACHA OUTPUT - Preliminary Ion EcoSpecs)	CURRENT STATUS (95th %tile value)	RWQO SET (12th October 2007)	RWQO (1 November 2007) based on model runs	RESULTS OF MODEL RE-RUNS (December 2007)	TDS RWQO: Tributaries (1 November 2007) based on model runs
			TWQR (*1)	A (*2)	T (*3)	U (*4)						
1	Vaal River downstream Harts River confluence to Douglas Barrage	Irrigation#	260	585	1755	3510	1198 mg/l (average VS19 to VS20)	961 mg/l	600 mg/l	600 mg/l	800 mg/l	1500 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
2	Vaal river d/s Bloemhof Dam and u/s Harts confluence	Irrigation#	260	585	1755	3510	574 mg/l (average VS16, VS17 & VS18)	601 mg/l (average)	600mg/l	600mg/l	700 mg/l	no tributary
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
3	Makwassiespruit to Bloemhof Dam	Irrigation#	260	585	1755	3510	1167 mg/l	807 mg/l	600 mg/l	600 mg/l	700 mg/l	Vet River: 660 mg/l
		Recreation	No guideline prescribed									
4	Vaal River d/s Vals confluence to Sandspruit confluence	Irrigation#	260	585	1755	3510	1167 mg/l	807 mg/l	450 mg/l	600 mg/l	750 mg/l	Vals River: 700 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
5	Vaal River d/s Mooi confluence to Vals River confluence	Irrigation#	260	585	1755	3510	1526 mg/l (average VS 9, VS10, VS12)	673 mg/l	450mg/l	600mg/l	600 mg/l	Schoonspruit: 800mg/l Koekemoerspruit: 800mg/l Renoster: 200mg/l ; Mooi: 450mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
		Industry (*category)	100	200	450	1600						
6	Vaal River d/s Vaal Barrage u/s Mooi confluence	Irrigation#	260	585	1755	3510	845 mg/l	647 mg/l	600mg/l	To be determined (Need to model to reach 600mg/l in Middle Vaal River)	600 mg/l	no tributary
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
7	Vaal River d/s Lethabo weir to Vaal Barrage	Irrigation	260	585	1755	3510	845 mg/l	647 mg/l	To be determined (Driven by blending option to 300mg/)	To be determined (Need to model to reach 600mg/l in Middle Vaal River)	600 mg/l	Klip: 600 mg/l, Suikerbos: 650mg/l; Leeu: 455mg/l; Taai: 390 mg/l; Rietspruit: 550 mg/l; Kromelmboog: 195 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
		Industry (*category)	100	200	450	1600						
8	Vaal Dam to Lethabo weir	Irrigation#	260	585	1755	3510	245 mg/l	198 mg/l	180mg/l (Sulphate 30mg/l)	125mg/l (Sulphate 30mg/l)	125 mg/l	Wilge River: 110 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
		Industry (*category)	100	200	450	1600						
		Power Generation	175									
9	Vaal River Downstream Waterval Confluence to inflow Vaal Dam	Irrigation#	260	585	1755	3510	200 mg/l	413 mg/l	200mg/l	200mg/l	250 mg/l	450 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
10	D/S Grootdraai Dam to u/s Waterval confluence	Irrigation#	260	585	1755	3510	264 mg/l	200 mg/l	200mg/l	195 mg/l	200 mg/l	Klip River: 195 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
11	Vaal River d/s Blesbokspruit to Grootdraai Dam	Irrigation#	260	585	1755	3510	264 mg/l	256 mg/l	180mg/l (Sulphate 30mg/l)	180mg/l (Sulphate 30mg/l)	180 mg/l	Leeuspruit: 400 mg/l Blesbokspruit: 400 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
		Industry (*category)	100	200	450	1600						
12	Vaal River d/s Rietspruit u/s Blesbokspruit	Irrigation#	260	585	1755	3510	too little data (< 60)	313 mg/l	150mg/l (Sulphate 30mg/l)	150mg/l (Sulphate 30mg/l)	150 mg/l	no tributary
		Recreation	No guideline prescribed									
13	Vaal River u/s and d/s of Rietspruit	Irrigation#	260				too little data (< 60)	144 mg/l	150mg/l (Sulphate 30mg/l)	150mg/l (Sulphate 30mg/l)	150 mg/l	Rietspruit: 100 mg/l
		Recreation	No guideline prescribed									
14	Vaal River u/s Klein Vaal to origin of Vaal River	Irrigation#	260	585	1755	3510	too little data (< 60)	159 mg/l (average)	150mg/l (Sulphate 30mg/l)	100mg/l (Sulphate 30mg/l)	100 mg/l	Klein Vaal: 100 mg/l Witpuntspruit: 100 mg/l
		Domestic (informal)	450	1000	2400	3400						
		Recreation	No guideline prescribed									

u/s = upstream d/s = downstream Irrigation# - TDS values fo crop yield

Table E2: Proposed RWQOs for phosphate for the identified reaches in the Vaal River main stem

Vaal river system RWQO for Phosphate (PO_4-P)							
No	**Reach**	**Water users**	**Guidelines for trophic status of vaal river waters (ug/l)**				**RWQO set**
			Oligotrophic	**Mesotrophic**	**Eutrophic**	**Hypertrophic**	
1 - 3	**Vaal River, Bloemhof Dam to Douglas Barrage**	Irrigation, domestic, recreation, industry, aquatic ecosystem	< 10	10 - 50	50 -150	> 150	**30 ug/l**
4 - 5	**Vaal River d/s Mooi confluence to Sandspruit confluence**						**100 ug/l**
6 - 7	**Vaal River d/s Lethabo weir to u/s Mooi confluence**	Irrigation, domestic, recreation, industry, aquatic ecosystem	< 10	10 - 50	50 -150	> 150	**150 ug/l**
8 -14	**Vaal River, Vaal Dam to headwaters**						**50 ug/l**

Table E3: Proposed RWQOs for *E.coli* for all reaches in the Vaal River (main stem)

Vaal River System RWQOs for *Escherichia coli* (Microbiological)							
No	**Reach**	**Water users**	**South african water quality guidelines**				**RWQO set**
			TWQR	**A**	**T**	**U**	
1 - 14	**All reaches in Vaal River System**	Recreation - Full contact (counts per 100ml)	0 - 130	130 - 200	200 - 400	> 400	**< 300 (counts/100ml)**

These RWQOs above represent a set of integrated/revised RWQOs being presented as part of task 4 of this study. The revised set of RWQOs proposed, while aimed at maintaining and/or improving water quality is dependent on what is achievable and can be cost-effectively implemented. The RWQOs are also dependant on the flow requirements and related operating rules of the Vaal River System and thus are inter-dependant on the water quality management options and the reconciliation options in terms of what is achievable in terms of a system perspective.

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Reports as part of this project:

Bold type indicates this report.

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2	P RSA C000/00/2305/1	Water Quality Status Assessment
3	P RSA C000/00/2305/2	Salinity Balance
4	**P RSA C000/00/2305/3**	**Integration of Resource Water Quality Objectives**
5	P RSA C000/00/2305/4	Water Quality Economic Impact Modelling
6	P RSA C000/00/2305/5	Evaluation of Water Quality Management Scenarios
7	P RSA C000/00/2305/6	Monitoring Programme
8	P RSA C000/00/2305/7	Water Quality Management Strategy

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LIST OF ACCRONYMS AND ABBREVIATIONS

CMA	Catchment Management Agency
CMS	Catchment Management Strategy
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
ICM	Integrated Catchment Management
ISP	Internal Strategic Perspective
IWQMP	Integrated Water Quality Management Plan
IWRM	Integrated Water Resource Management
NWA	National Water Act
NWRS	National Water Resource Strategy
PES	Present Ecological State
RDM	Resource Directed Measures
RQOs	Resource Quality Objectives
RO	Regional Office
RWQO	Resource Water Quality Objectives
SAWQGs	South African Water Quality Guidelines
TDS	Total Dissolved Salts
TOR	Terms of Reference
TWQR	Target Water Quality Range
WMA	Water Management Area
WRPM	Water Resources Planning Model

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1 INTRODUCTION

1.1 Water Resource Management Studies in the Integrated Vaal River System

In terms of the National Water Act (NWA) (Act No. 36 of 1998) and in line with the Department of Water Affairs and Forestry's (DWAF) obligation to ensure that the country's water resources are fit for use on an equitable and sustainable basis, it has adopted the approach of the progressive development and implementation of catchment management strategies (CMS) to fulfil this mandate. Each CMA is responsible for the progressive development of a CMS for its respective WMA that is developed in consultation with stakeholders within the area. The Department's eventual aim is to hand over certain water resource management functions to these CMAs. Until such time as the CMAs are established and are fully operational the Regional Offices of the Department will continue managing the water resources in their areas of jurisdiction with the support of the national office.

In terms of meeting this obligation, the Department has initiated the development of management strategies for the various WMAs within South Africa in an attempt to provide the framework and constraints within which the water resources will be managed into the foreseeable future. These various strategies and plans that arose out of the Internal Strategic Perspective (ISP) development process which identified the relevant water resource management issues and concerns in each of the WMAs. The Vaal River System WMAs, which include the Upper, Middle and Lower Vaal and the Modder Riet catchment of the Upper Orange WMA, are four such catchments for which management strategies are currently being developed. At present three major studies are underway in the Vaal River System, which specifically aim to introduce overarching management measures to reconcile water requirements and availability, and to ensure the continued fitness-for-use of the water resources. These studies are the Development of Large Bulk Water Supply Reconciliation Strategies (LBWSRS), Water Conservation and Water Demand Management Potential Assessment and the Development of an Integrated Water Quality Management Plan (IWQMP). The immediate objectives of the individual studies are to:

- Develop strategies for meeting the growing water requirements of the industrial and urban sectors served by the Integrated Vaal River System (Large Bulk Water Supply Reconciliation Study).
- Determine the potential for, and benefits of Water Conservation and Water Demand Management (WC/WDM) in the various water use sectors with the focus on the Upper and Middle Vaal WMAs.
- Develop water quality management measures to ensure continued fitness for use in the Vaal River System for the planning period up to the year 2025 (IWQMP Study).

The management options identified through these studies aim to eventually feed into a reconciliation and water quality management strategy that will be determined for the Vaal River System. The strategy aims to support current and future water users and uses within the interdependent water resource systems of the Vaal WMAs and associated Modder Riet catchment (**Figure 1**).

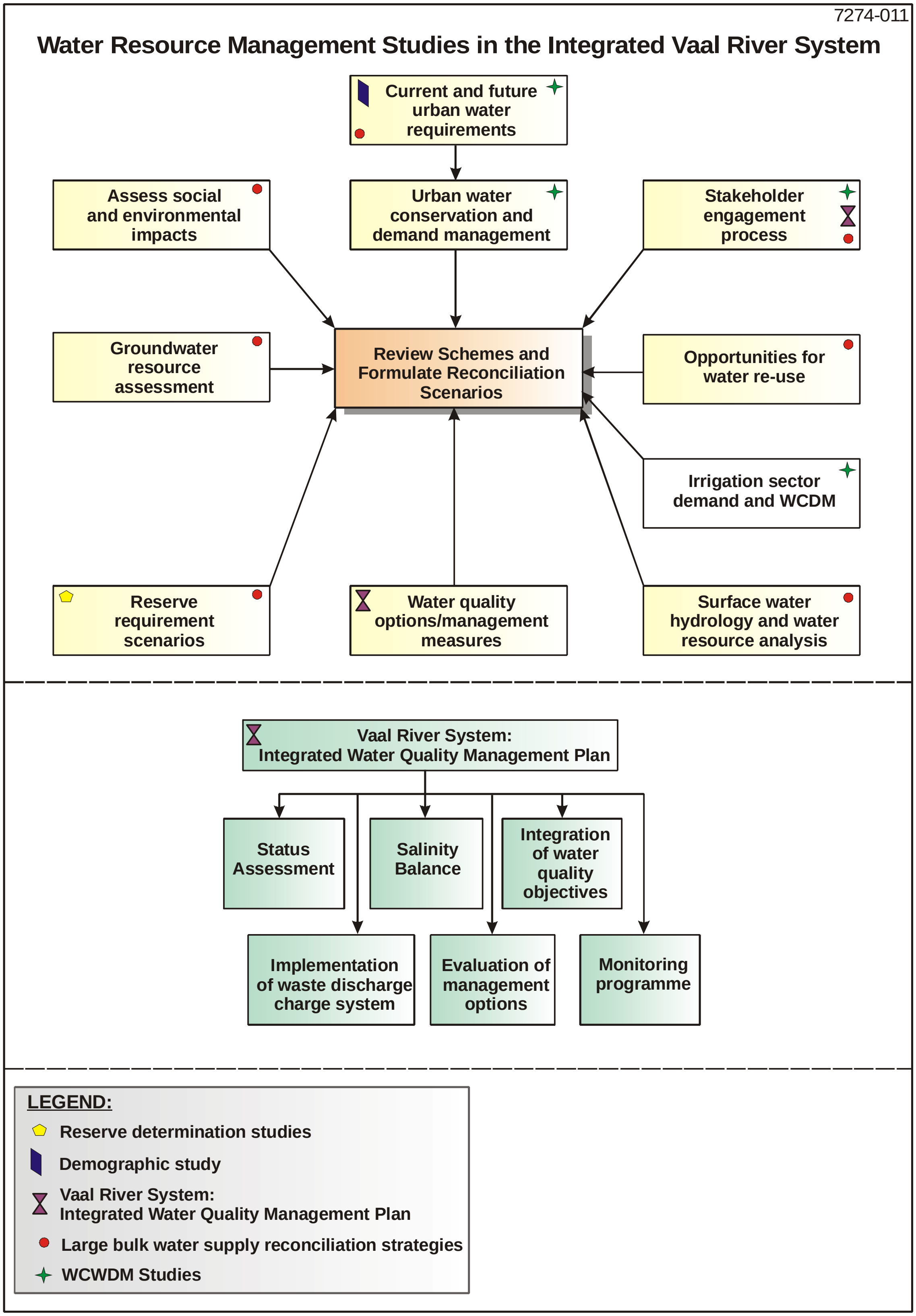


Figure 1: Water Resource Management Studies for the Integrated Vaal River System supporting the identification of reconciliation options (*adapted* DWAF, 2005a)

1.2 IWQMP Study description and context of the integration of the resource water quality objectives task

Having water of the right quality is just as important as having enough water. Integrated water resource management in the Vaal River System can only be achieved if water quality and quantity are managed together to meet the requirements of water users (including the aquatic ecosystem) and their needs in terms of use of the resource. The more the water resource is used and gets re-used, and as quantities get scarce and feedback loops within this highly exploited and utilised water resource system get even tighter, it is water quality that begins to take on a dominant role. The Department realises that just as planning and management are taking place to supplement and control water quantities, they also need to take place around water quality. In response to the need to meet the objectives of integrated water resource management (IWRM), the Department has initiated this process to address the management of the water quality in the Vaal River System. This need was identified through the ISP process that specifically highlighted the necessity for an integrated management plan to manage water quality within the Vaal River system. The purpose of this initiative is to eventually develop a management plan for the Vaal River System, which will serve as a coherent approach for water management institutions and stakeholders to manage the water resources in the interdependent Vaal WMAs. In essence the integrated management plan developed would serve as a holistic and comprehensive business-plan for water quality management in and among the WMAs of the Vaal River System. The plan will also feed into the NWRS as part of the national guiding framework.

The focus of this study is thus to develop an integrated water quality management plan (IWQMP) for the Vaal River System, which aims to identify management options that are technically, economically and socially feasible and which will support the continued fitness for use of the water resources for all users across the WMAs.

The proposed approach for the development of the IWQMP involves (DWAF, 2005b):

- The assessment of the Vaal River System to obtain a perspective of water quality (variables of concern), pollution sources and key water users. This will include the identification of existing Resource Water Quality Objectives (RWQOs) and their establishment where they are not available.
- Establishing how the system complies with the RWQOs, which will be determined through analysis of available data and undertaking modelling of possible future scenarios.
- Identifying and developing management measures that will improve the non-compliance cases, address water quality stresses and priorities and allow utilisation of available allocatable water quality to the benefit of the water users in the system. The management measures will be evaluated on the basis of their technical, environmental (range of aspects), social and economic feasibility.

The IWQMP study comprises seven tasks which are depicted in **Figure 2.**

In order that the Department is able to effectively manage the water resources of the Vaal River System catchment it is necessary that a set of integrated and balanced RWQOs are defined that will maintain or improve the systems water quality, using as a point of departure the existing RWQOs.

This task is therefore focussed on understanding and determining the existing RWQOs for the water resources in the Vaal River System, determining the applicability, alignment and balance and based on the results define a set of integrated RWQOs that will be achievable in terms of the management option analysis. This report focuses on the integration of the RWQOs which comprises task 4 of the study.

The output of this task is to identify a set of proposed integrated RWQOs for the Vaal River and its major tributaries for selected water quality variables.

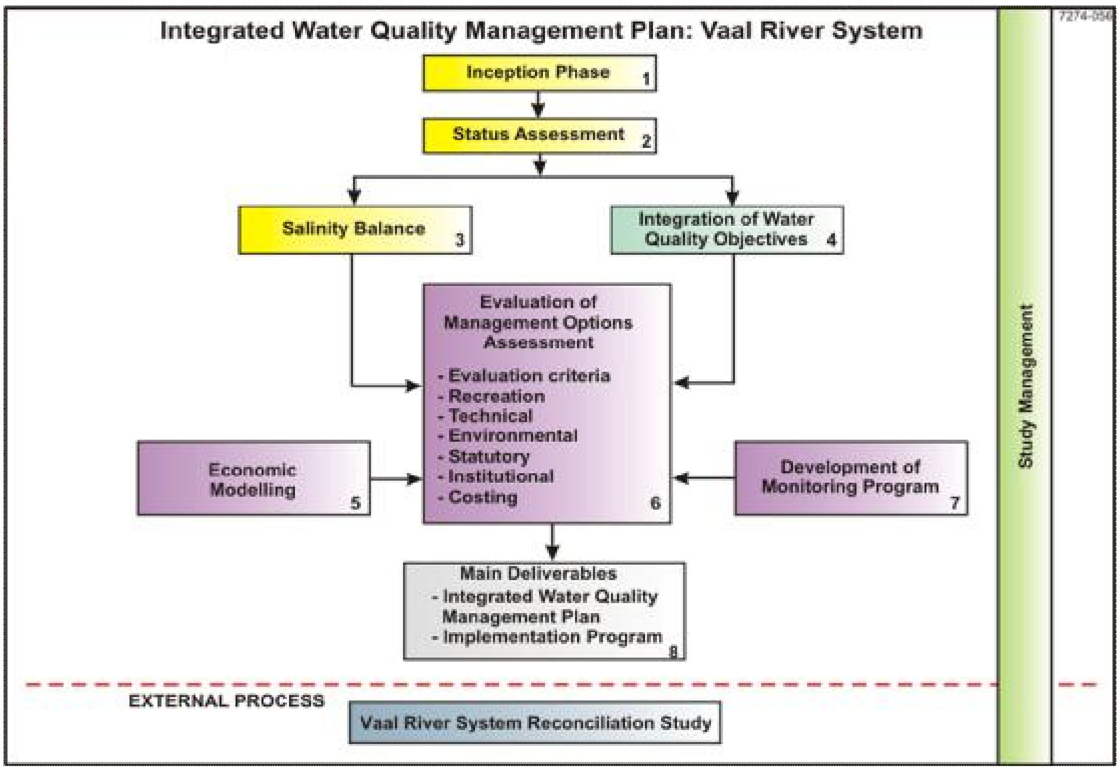


Figure 2: The study tasks comprising the development of the IWQM Plan for the Vaal River System (DWAF, 2005b)

1.3 Study Area

The study area for the IWQMP study includes the entire C drainage region within South Africa. This includes the Upper and Middle Vaal WMAs in their entirety, part of the Lower Vaal WMA (C31, C32, C33, C91 and C92 tertiary catchments), and part of the Upper Orange WMA (C51 and C52 tertiary catchments *i.e.* Modder Riet catchment) (**Figure 3**).

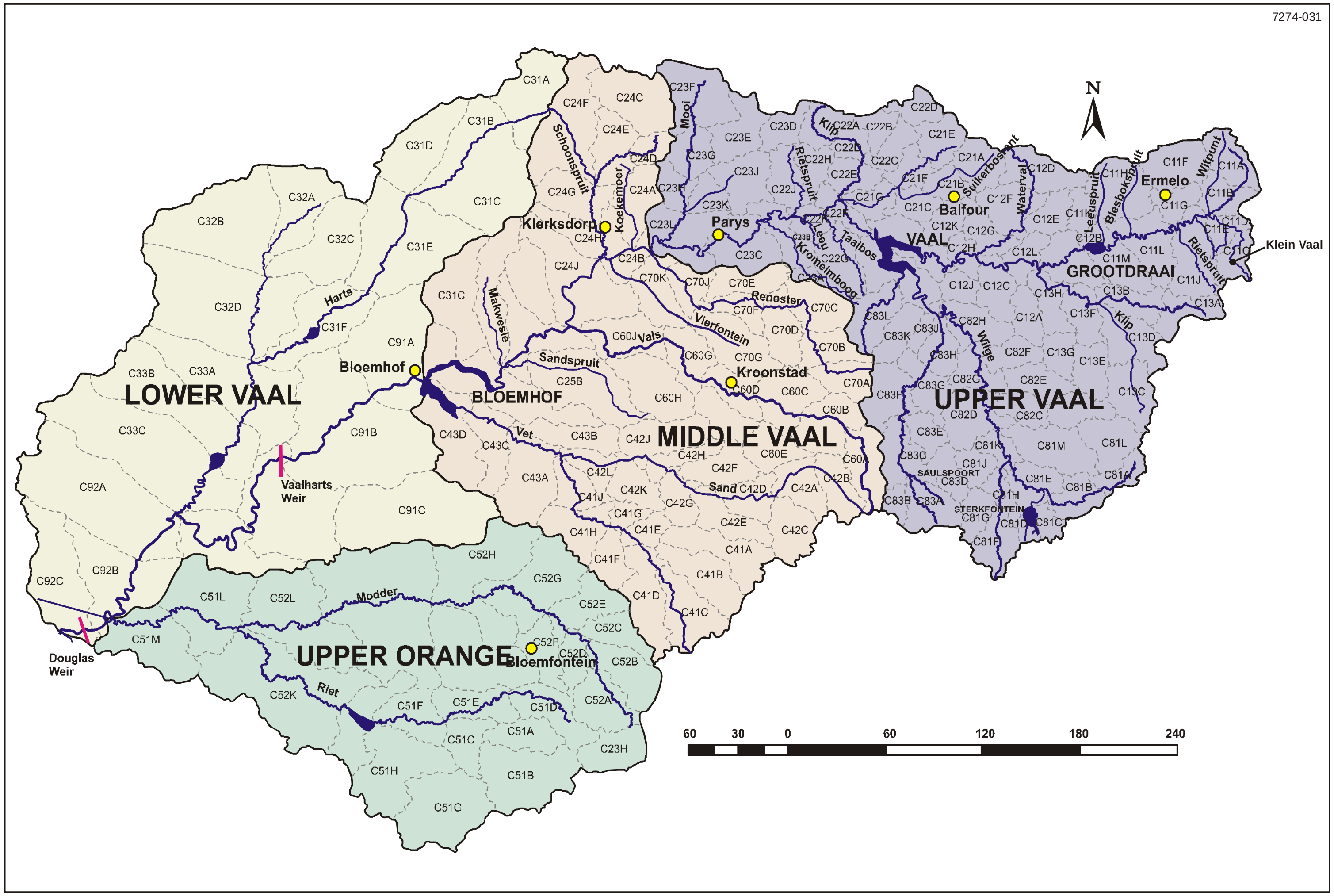


Figure 3: Study area of IWQMP study

The extent and approach of the study and this task is focussed on:

- The main stem of the Vaal River as it flows from its origin in the Drakensberg escarpment to Douglas Barrage;
- All the major tributaries to the Vaal River. The tributaries were considered just upstream of their confluences with the Vaal River. This did not include the upper reaches of the tributary catchments.

Although the study and the RWQOs task, considers the major tributaries, it does not look at the RWQOs for each of the sub-catchments. Rather the management options identified for the Vaal River will feed into the respective catchment management strategies and water quality management plans as they are developed or revised.

1.3.1 Strategic Monitoring Points

The extent of the study area and due to the high level nature of the analysis to be conducted necessitated the identification of monitoring points within the Vaal River System that would be strategically located and sufficiently widespread to provide an adequate indication of the prevailing water quality status.

Strategic monitoring points were identified at two levels:

- Level 1: Points on the Vaal River from its origin to Douglas Barrage; and
- Level 2: Points on the major tributaries of the Vaal River just upstream of their confluences.

Level 1 Points

The Level 1 strategic monitoring points refer to the monitoring points that are located on the Vaal River. Twenty Level 1 strategic points were identified and their locations are indicated on **Figure 4**.

The points are:

- numbered from 1 to 20 from the most upstream point to the most downstream point in the Vaal catchment; and
- preceded by the letters ‘VS’ which implies ‘Vaal System’ (for example VS 10).

Level 2 Points

The Level 2 strategic monitoring points refer to the monitoring points that are located on the major tributaries of the Vaal River, just upstream of their confluences. Twenty six level 2 strategic points were identified and their locations are indicated on **Figure 5.**

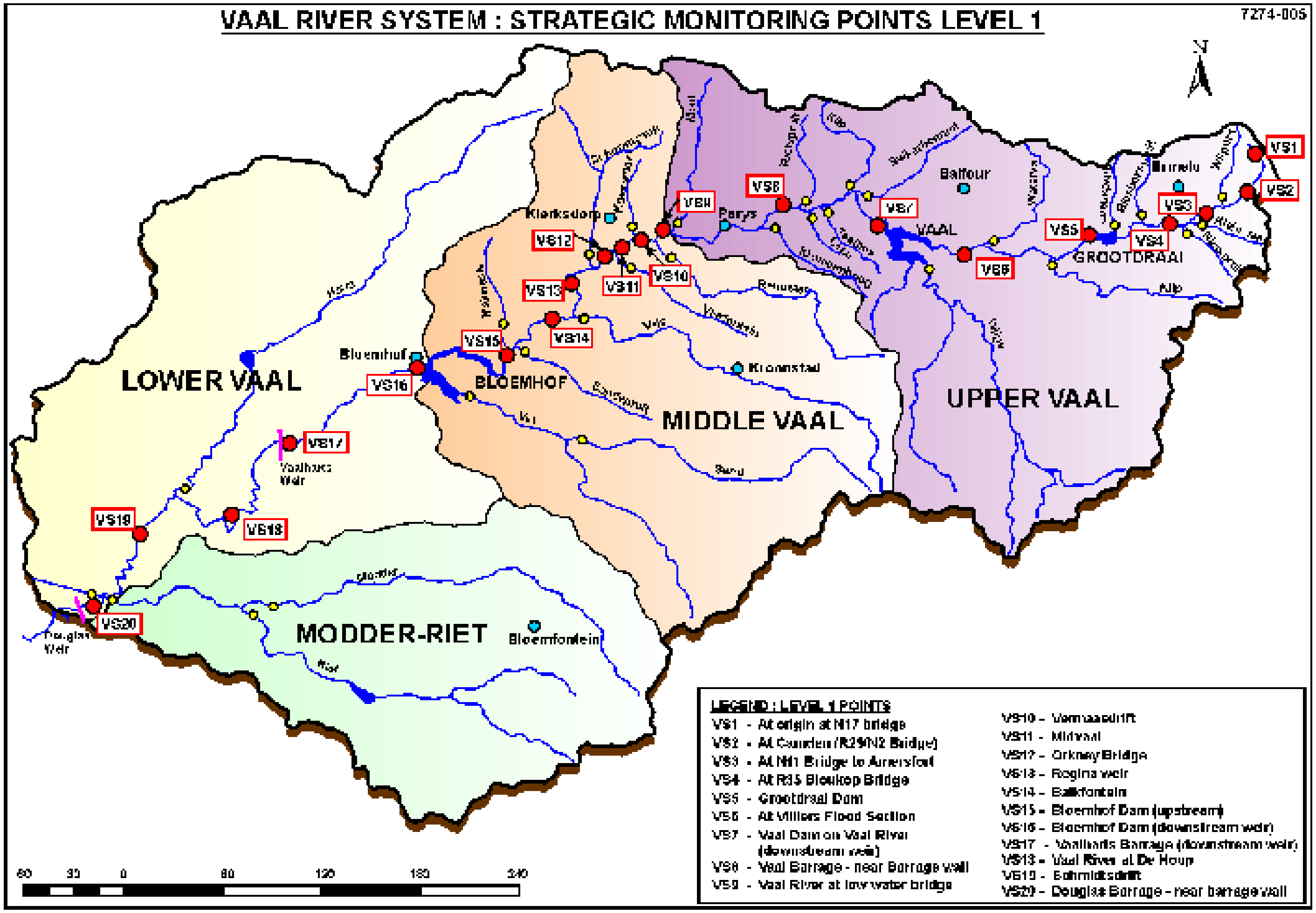


Figure 4: Location of Level 1 strategic monitoring points in Vaal River System

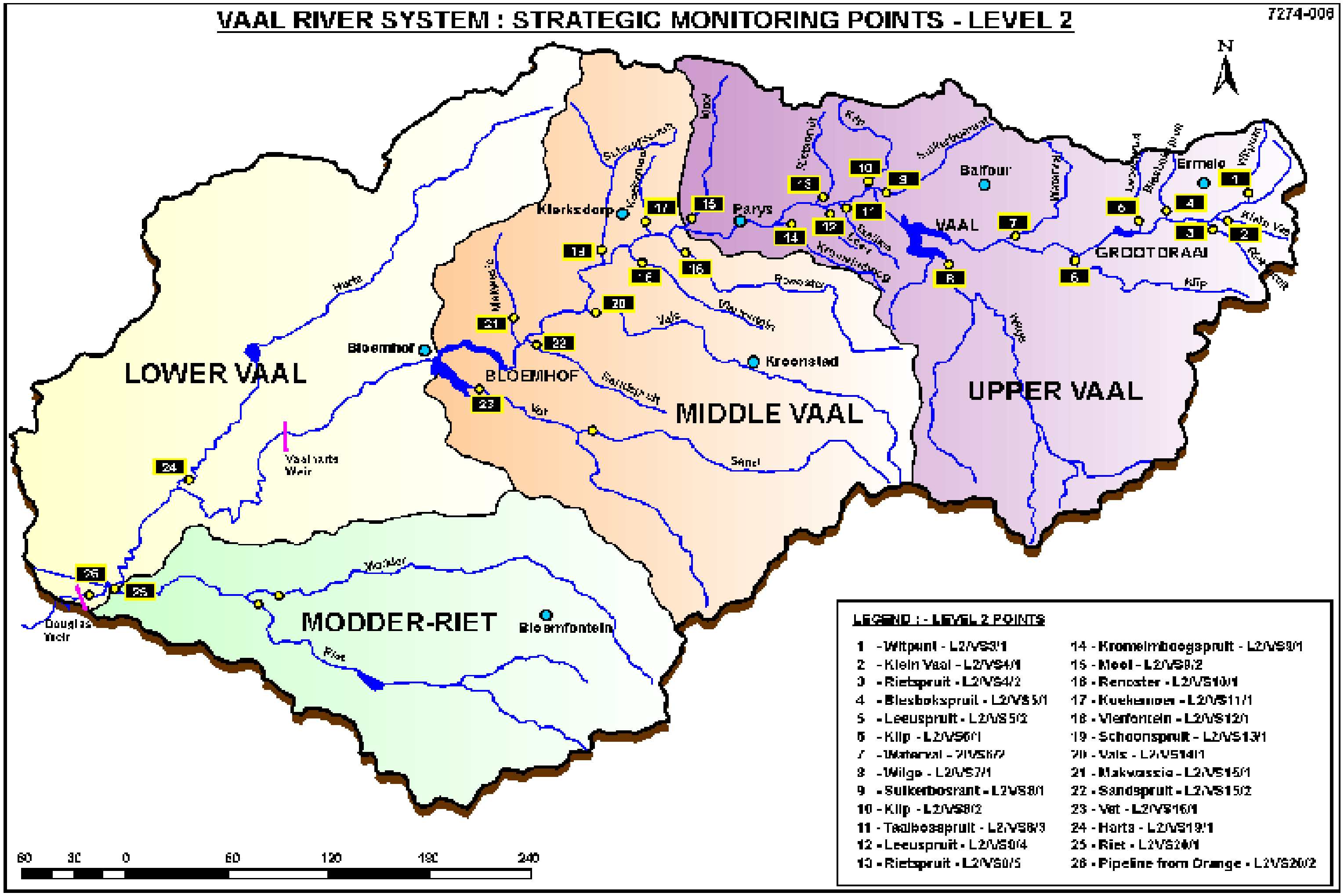


Figure 5: Location of Level 2 strategic monitoring points in Vaal River System

1.4 Objective of the integration of the resource water quality objectives task

As part of the Department's approach to the management of water quality, RWQOs have been set at a number of reaches in the Vaal River System. The RWQOs have been arrived at through discussions at the forums and with the water users. Typically RWQOs have been set defining ideal, acceptable, tolerable and unacceptable concentrations for different water quality variables for identified catchments/river reaches. These RWQOs have often been set in isolation without consideration of impacts on downstream RWQOs. The purpose of this task was to thus check the balance and alignment of the RWQOs set and in so doing look at ensuring their alignment and integration. This means that if the upstream RWQOs are met, the downstream RWQOs cannot be achieved assuming that the incremental catchment is not responsible for the non-compliance of the downstream RWQOs.

The objective of this task was to identify the RWQOs that are out of balance, find out the reasons for the setting of the RWQOs initially and to identify areas where particular attention will have to be given to the development of options in the management option analysis. This process also had to evaluate the catchment visions that have been set for the various catchments and ensure some degree of alignment to enable the realisation of the RWQOs. Catchment visioning was not undertaken as part of this project but the visions developed by the Department with the forums and project steering committees were sourced and used.

In this process particular attention was given to also incorporate RWQOs set as part of Reserve studies that have been determined as part of CMS development process for some of the sub-catchments within the Upper, Middle and Lower Vaal WMAs (e.g. Modder - Riet, Waterval, Schoon-Koekemoorspruit).

In terms of the Reserve for the Vaal main stem, this will only materialise by 2009 -2010, as the comprehensive Reserve determination process has only recently been initiated. The water quality Reserve was thus not available for the integration process of RWQOs for the Vaal River. However consideration was be given to aquatic system requirements as part of the process of setting and integrating the RWQOs. Available preliminary water quality component reserve determinations results for the Vaal River was incorporated, as well, information obtained through the River Health Programme and the DWAF's national monitoring programmes. However should the comprehensive reserve determination process for the Vaal River generate anything concrete before the conclusion of the study, this will be incorporated in the final IWQM plan. There will also be close liaison with the LBWSR study as meeting the environmental water requirement will be included in the reconciliation strategies. The meeting of the environmental water requirements will have an impact on water quality and will be included in the development of the water quality strategies.

It is anticipated that the RWQOs set on the main stem of the Vaal River at the boundaries between the WMAs could be used as a means of determining the transfer of monies obtained from the WDCS between WMAs. In order to implement such a scheme it will be necessary to have RWQOs at the WMA boundaries. For the calculation of such transfers the polluters and water abstractors will be classified according to the WMA within which they reside. The economic assessment and scenarios will be presented in **Task 6**.

2 RATIONALE FOR RESOURCE WATER QUALITY OBJECTIVES

Much of the Vaal River can be considered to be under water quality stress as it is unable to adequately meet the needs of the users in respect of their water quality requirements. The current state of the system shows unacceptably high nutrient and salt concentrations which is indicative of an unsustainable system. At present an imbalance exists between sustainable and optimal water use and protection of the water resource. Resource Water Quality Objectives (RWQOs) is a mechanism through which this balance between sustainable and optimal water use and protection of the water resource can be achieved.

RWQOs are the water quality components of the Resource Quality Objectives (RQOs) which are defined by the National Water Act as “clear goals relating to the quality of the relevant water resources” (DWAF, 2006a).

RWQOs are descriptive or quantitative, spatial or temporal, and ultimately allows realisation of the catchment vision by giving effect to the water quality component of the gazetted (RQOs). RWQOs at typically set at a finer resolution than RQOs to provide greater detail upon which to base the management of water quality. The catchment vision is a collective statement from all stakeholders of their future aspirations of the relationship between the stakeholders (in particular their quality of life) and the water resources in the catchment. The RWQOs form part of the strategy to attain that vision.

RWQOs are aimed at ensuring that local priorities are appropriately balanced with broader spatial and temporal perspectives (WMA and national level) and at meeting the objectives of the resource directed measures. They incorporate stakeholder needs, give effect to the Resource Directed Measures (RDM) and dictate the tolerable level of impact collectively produced by upstream users. RWQOs forms part of the mechanism to make the definition of pollution in terms of the National Water Act (Act No. 36 of 1998) operational in the current context of resource directed water quality management (DWAF, 2005b). As such, this allows for different levels of impact for different water resources though aligned with catchment visions. Particularly emphasis is given to effective stakeholder participation in the development of RWQOs. The levels at which RWQOs are set demand that they are practical and cost-effective as possible.

2.1 Overarching Policy

The policy of DWAF (DWAF, 2005b) regarding RWQOs is that they should:

- Ultimately allow realisation of the catchment vision;
- Give effect to the water quality component of gazetted RQOs;
- Express more detailed stakeholder needs than those accounted for by the RQOs (where necessary);
- May equal these gazetted RQOs, but may be set at a finer spatial/or temporal resolution;
- Dictate the tolerable level of impact collectively produced by upstream users.

The Department recognises the importance of a strong technical basis for defining RWQOs, and a heavy reliance on a catchment/situation assessment.

2.2 Guiding Principles

The determination of RWQOs is underpinned by the principle of sustainable development and is informed by the principles which formed the foundation for the following (DWAF, 2006a):

- The Precautionary Principle:
  - A risk averse and cautious approach that recognizes the limits of current knowledge about the environmental consequences of decisions or actions.

- The default rule described in the Resource Directed Measures documentation:

  The management class is determined in relation to the present state, but at a level which represents a goal of no further degradation for water resources which are slightly too largely modified, and at least a move toward improvement for water resources which are critically modified.

- The National Water Resource Strategy:

  Any water resource which demonstrates ‘Unacceptable’ conditions is deemed to be unsustainable. In these cases the management class will be determined as a minimum of ‘Heavily used/impacted’ (the lowest management class), and management will aim to rehabilitate the water resources to this state.

  Water required to meet basic human needs and to maintain environmental sustainability will be guaranteed as a right, whilst water use for all other purposes will be subject to a system of administrative authorisation.

- Environmental rights as described in the South African Constitution (Act 108 of 1996):

  Everyone has the right :

  a. To an environment that is not harmful to their health or well-being; and
  b. To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that:
     - Prevent pollution and ecological degradation;
     - Promote conservation; and

     Secure ecologically sustainable development and use of natural resources, while promoting justifiable economic and social development.

2.3 Balancing the needs of downstream water users with upstream water use and development

In setting RWQOs, the Department strives to achieve a balance between protecting the water resource for the downstream users and allowing use and development of the water resource upstream of the river reach selected for the RWQOs (**Figure 6**). For the downstream water users, the focus is on protecting the water quality in order to ensure a healthy functional aquatic ecosystem, while also meeting the water quality requirements of the other recognised water user groups (domestic, agricultural, industrial, recreation and aquatic ecosystems) downstream of the RWQOs point. However, the selected RWQO might also restrict the type and extent of water use upstream of the point. Water uses refer to those described in Section 21 of the NWA and includes uses such as the discharge of water containing waste (using some of the allocatable water quality) or taking water from a water resource (using some of the dilution capacity) (DWAF, 2006a).

In must also be borne in mind that in terms of DWAF policy the RQOs (and related RWQOs) will be used as the basis for the setting of waste discharge charges in each catchment. Thus the setting RQOs and RWQOs become central to balancing the needs of the upstream "impactors" with downstream user requirements.

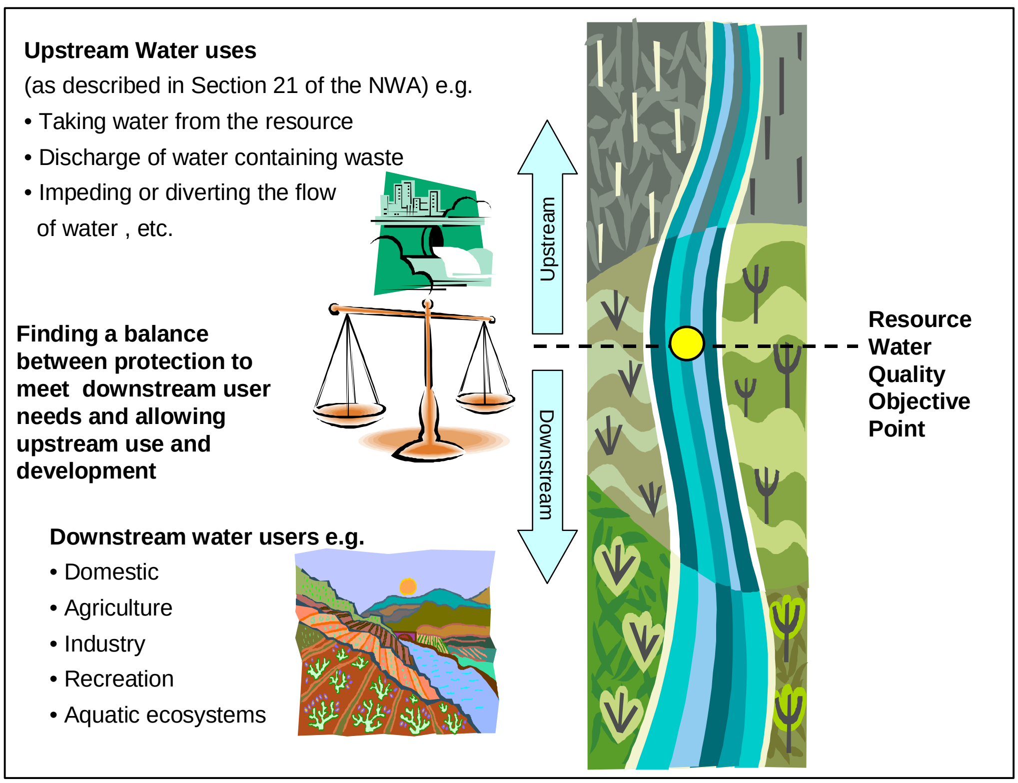


Figure 6: Balancing the needs of downstream water users with upstream water use and development (DWAF, 2006a)

2.4 Modification of Resource Water Quality Objectives

Based on the principles of flexibility and adaptive management RWQOs may be revised, following due process, in the following circumstances (DWAF, 2006a):

- The baseline ecological data upon which the RWQOs have been based change because new data has become available. RWQOs may thus be revised/modified based on the new information that has come to light.
- Significant changes to vision for the catchment have occurred (through due process), and the present RWQOs are inconsistent with that vision.
- Water treatment technology improves and becomes more cost effective. RWQOs can be made more stringent supporting protection of the water resource.
- Other driver's e.g. political decisions for socio-economic development or national or presidential imperatives could form the basis for RWQOs to be modified to support these.

3 RESOURCE WATER QUALITY OBJECTIVES FOR THE VAAL RIVER SYSTEM

3.1 Background

Resource water quality objectives that are currently available for catchments in the Vaal River System reflect the water users and other stakeholders' needs with respect to the in-stream water quality of the water resources in their catchments' over and above those outlined in the NWRS, and include stakeholders' needs with respect to the disposal of water that contains waste to the resource. Together these RWQOs shape the goals for water quality management in the various catchments, and are among the key determinants of the unfolding Catchment Management Strategy development processes. As a wide range of substances can impact on the quality of water, RWQOs that are available have generally focused on the priority water quality concerns in the respective catchments.

The Department has developed a common basis from which to derive RWQOs through the development of the South African Water Quality Guidelines (SAWQGs) for different water user groups (DWAF, 1996). These guidelines offer a platform towards developing target RWQOs for water resources. Typically RWQOs have been set by defining ideal, acceptable, tolerable and unacceptable concentrations of different water quality variables.

While the effort to develop RWQOs is recognised, and the achievements made thus far especially in the Upper Vaal WMA is considered progressive, much of it has happened in isolation of the wider WMA and the Vaal River System context. Thus while catchment objectives are being met those of the Vaal River and cascading WMAs were found to be non compliant. In addition the deterioration of the water resources in some catchments of the system as well as in certain reaches of the Vaal River warranted an evaluation of RWQOs to determine their current applicability, appropriateness and effectiveness in achieving the desired water quality.

3.2 Status Quo of RWQOs

RWQOs for the Vaal River in the Upper Vaal WMA, Middle and Lower Vaal WMAs were available for the study.

3.2.1 Upper Vaal WMA

RWQOs for the Vaal River Catchment were available for the Vaal River and its sub-catchments in the Upper Vaal WMA. These RWQOs have been set through a consultative process between the Department's Regional Office and the water users in the various sub-catchments of the Upper Vaal WMA. This process has been facilitated over recent years by the various forums in the WMA and involved numerous workshops with all the relevant stakeholders in the respective catchments. The objectives have been set based on user requirements, current water uses, existing water quality at the time, detection limits of water quality variables and achievability. The RWQOs have been adopted by the users and have been applied in the management of the water quality in the Upper Vaal WMA for sometime now. However the RWQOs that have been set for the Vaal River in the sub-catchment downstream of the Vaal Barrage was done so between the Department's Gauteng South Regional Office and the Free State Regional Office water quality personnel through an in-house process and was not a consultative process as was for the setting of RWQOs for other sub-catchments.

The Upper Vaal WMA comprises 5 management sub-units for which RWQOs were set for the Vaal River (see **Figure 7**). These were based on the river sub-catchments and include the following:

- Sub-unit 1 and 2: Grootdraai Catchment
- Sub-unit 3: Vaal Dam Catchment
- Sub-unit 4: Vaal Barrage Catchment
- Sub-unit 5: Downstream Vaal Barrage

RWQOs for the Upper Vaal sub- units are listed in the tables below. While this study focus is on salinity and nutrient variables, a list of RWQOs for the Upper Vaal sub-catchments, which includes other additional variables (e.g. biological) are contained in **Appendix A**.

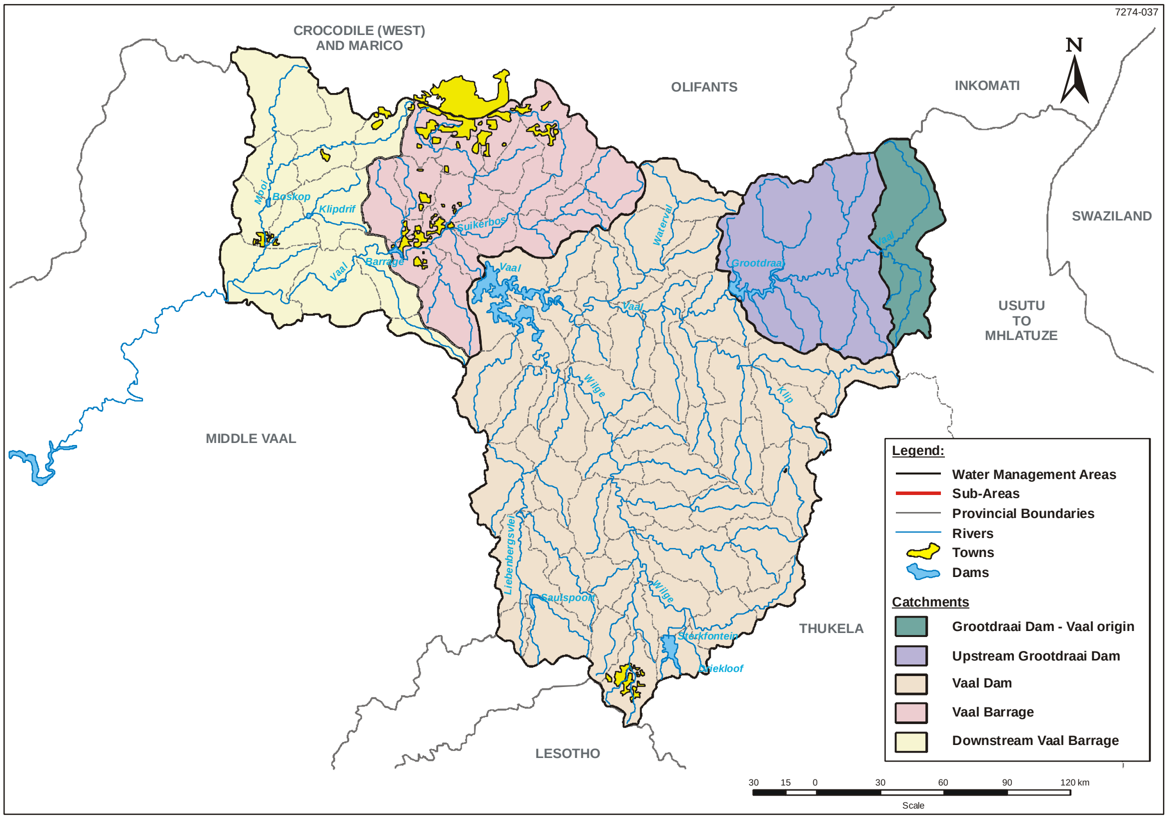


Figure 7: Sub-catchments of the Upper Vaal WMA as they relate to the management units for which RWQOs have been set

Table 1: RWQOs for the Vaal River in Grootdraai sub-catchment for Vaal origin (VS 1, VS 2 and VS 3)

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.05	0.05-0.25	0.25-0.5	>0.5
Ammonia	(mg/l) as N	<0.02	0.02-0.5	0.5-1	>1
Sulphate	(mg/l)	<10	10-20	20-30	>30
Chloride	(mg/l)	<10	10-15	15-20	>20
EC	(mS/m)	<10	10-15	15-25	>25
TDS	(mg/l)	65	65 -97.5	97.5-162.5	>162.5
Phosphate	(mg/l) as P	<0.05	0.05-0.08	0.08-1	>1

Table 2: RWQOs for the Vaal River in Grootdraai sub-catchment for upstream Grootdraai Dam (Point VS4)

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.05	0.05-0.25	0.25-0.5	>0.5
Ammonia	(mg/l) as N	<0.02	0.02-0.5	0.5-1	>1
Sulphate	(mg/l)	<15	15-35	35-50	>50
Chloride	(mg/l)	<10	10-20	20-30	>30
EC	(mS/m)	<15	15-30	30-50	>50
TDS	(mg/l)	<97.5	97.5-195	195-325	>325
Phosphate	(mg/l) as P	<0.05	0.05-0.25	0.25-0.5	>0.5

Table 3: RWQOs for the Vaal River in Vaal Dam sub-catchment in the Upper Vaal WMA

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.1	0.1-0.2	0.2-0.3	>0.3
Ammonia	(mg/l) as N	<0.2	0.2-0.5	0.5-1.0	>1
Sulphate	(mg/l)	<20	20-45	45-70	>70
Chloride	(mg/l)	<25	25-50	50-75	>75
EC	(mS/m)	<10	10-30	30-45	>45
TDS	(mg/l)	<65	65-195	195-293	>293
Phosphate	(mg/l) as P	<0.05	0.05-0.25	0.25-0.5	>0.5

Table 4: RWQOs for the Vaal River in Vaal Barrage sub-catchment in the Upper Vaal WMA

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.5	0.5-3	3-6	>6
Ammonia	(mg/l) as N	------	<0.5	0.5-1.0	>1
Sulphate	(mg/l)	<20	20-100	100-200	>200
Chloride	(mg/l)	<5	5-50	50-75	>75
EC	(mS/m)	<18	18-30	30-70	>70
TDS	(mg/l)	<117	117-195	195-455	>455
Phosphate	(mg/l) as P	------	<0.03	0.03-0.05	>0.05

Table 5: RWQOs for the Vaal River in Downstream Vaal Barrage sub-catchment in the Upper Vaal WMA

Variable	Units	Ideal	Acceptable
Nitrate	(mg/l) as N	<6	6
Ammonia	(mg/l) as N	0.015	0.1
Sulphate	(mg/l)	80	150
Chloride	(mg/l)	50	80
EC	(mS/m)	30	61
TDS	(mg/l)	195	397
Phosphate	(mg/l) as P	<0.26	0.26

Note: *No tolerable or unacceptable levels of RWQOs were set for the catchment downstream Vaal Barrage. The decision taken was to set a management target based on a combination of most stringent user requirements (ideal and acceptable), current status and a 20% improvement where necessary.*

3.2.2 Middle and Lower Vaal WMAs

RWQOs for the Vaal River in the Middle and Lower WMAs had not been determined at the start of this study. Thus it was necessary for the progress of the study that this process be initiated to ensure that there is benchmark against which water quality could be measured to identify where the issues of water quality concern exist. As part of the status assessment task (task 2), RWQOs were thus set for the Middle and Lower Vaal WMAs.

The process to set RWQOs for the Vaal River and its tributaries in the Middle and Lower Vaal WMA involved a one day workshop with each of the responsible Departmental Regional Offices. The respective workshops included the study team, the Department's Regional Office staff and Head Office personnel.

The RWQOs that were set were based on the expert knowledge of the Department's personnel responsible for water resources management in the WMA, the expertise of Departmental Head Office personnel, consideration of the water users in the catchment, the impacts being experienced and the consideration of the upstream and receiving catchments. The RWQOs Model developed by the Directorate Water Resources Planning Systems of Department was used as the basis to set the objectives. Only one set of RWQOs were set for the Vaal River in each WMA as it was agreed by the respective participants that it was not necessary to define management sub-units as the nature of the water users and uses were fairly uniform in each WMA. In addition, the RWQOs that were set were at this stage defined for an acceptable level of concentration only for the identified water quality variables.

The RWQOs for the Middle and Lower Vaal WMA tributaries were set through the same process as that described for the Vaal River main stem above. For the tributaries of the Middle Vaal WMA, the 95th percentile current status values were adopted as RWQOs and only acceptable levels of concentration were defined for all the sub-catchments, except for the Schoonspruit/Koekemoerspruit and Sand/Vet River Catchments. In the Lower Vaal the RWQOs for the Vaal River were adopted for the Harts River (acceptable level), and the RWQOs for the Modder Riet sub-catchment are awaited from a current study that is nearing completion.

This exercise was an in-house Departmental process and was not meant to be consultative in terms of inclusion of external stakeholders. The aim was establish a set of RWQOs that would serve as a starting point. The RWQOs that are eventually confirmed through this study will then have to be taken back to stakeholders and water users to ensure buy-in and implementation.

The RWQOs for the Middle Vaal WMA and Lower Vaal WMA are included in the tables below. While this study focus is on salinity and nutrient variables, a list of RWQOs for the Middle and Lower Vaal WMAs, which includes other additional variables (e.g. biological) are contained in **Appendix A**.

Table 6: RWQOs for the Vaal River in the Middle Vaal WMA

Variable	Units	Acceptable
Nitrate	(mg/l) as N	3
Ammonia	(mg/l) as N	0.1
Sulphate	(mg/l)	250
Chloride	(mg/l)	100
EC	(mS/m)	90
TDS	(mg/l)	630
Phosphate	(mg/l) as P	0.03

Table 7: RWQOs for the Vaal River in the Lower Vaal WMA

Variable	Units	Acceptable
Nitrate	(mg/l) as N	3
Ammonia	(mg/l) as N	0.1
Sulphate	(mg/l)	250
Chloride	(mg/l)	100
EC	(mS/m)	120
TDS	(mg/l)	**840**
Phosphate	(mg/l) as P	**0.04**

3.2.3 Tributaries of the Vaal River

The RWQOs for the tributaries of the Vaal River are listed in terms of 20 management sub-units over the three WMAs (see **Figure 8**). The RWQOs for the various tributary management units of the Vaal River are listed in the tables below.

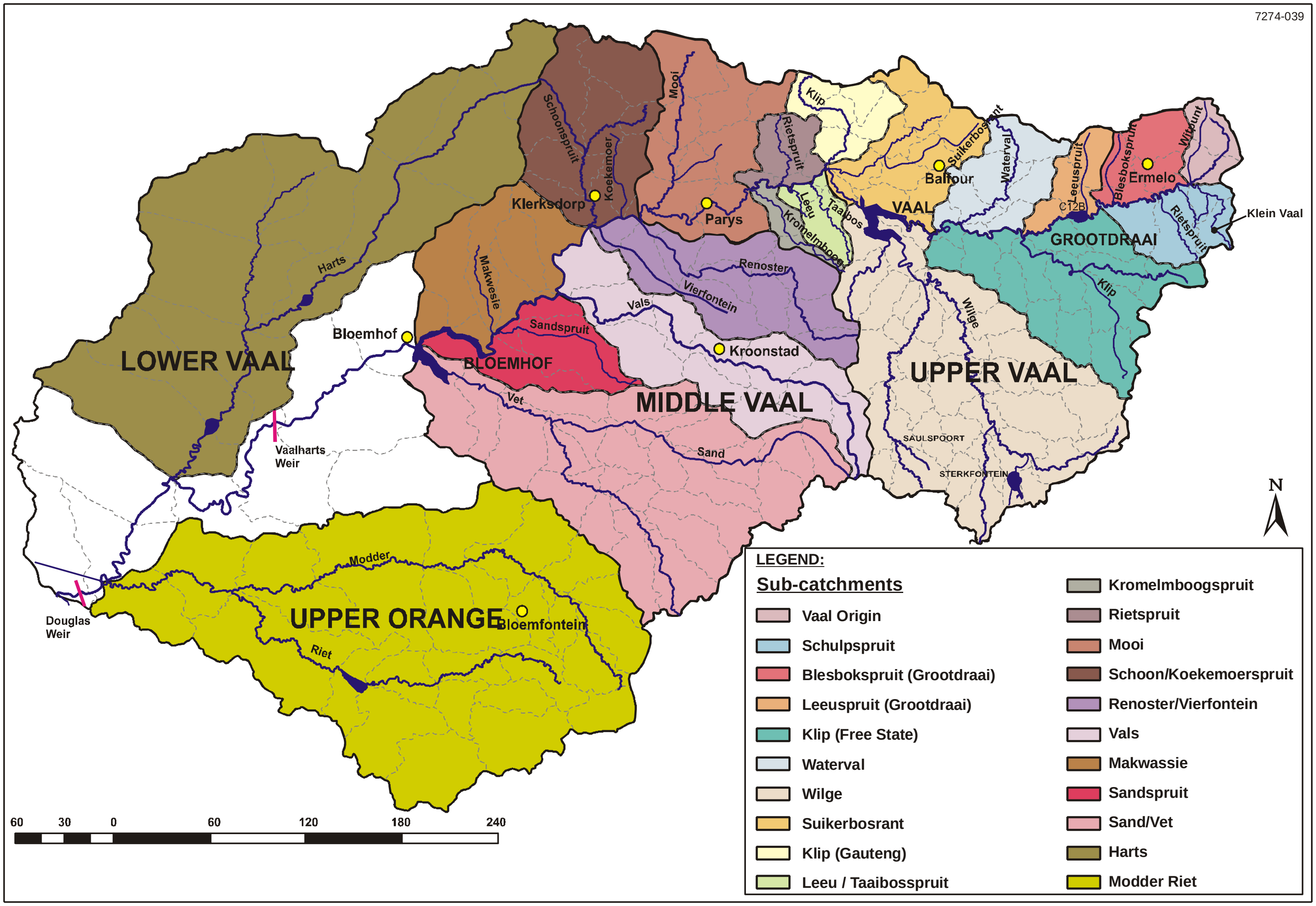


Figure 8: Tributary sub-catchments of the Vaal River System as they relate to the management units for which RWQOs have been set

Table 8: RWQOs for the Vaal Origin tributary catchment
Level 2: Sub-unit 1 - Vaal Origin Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.05	0.05-0.25	0.25-0.5	>0.5
Ammonia	(mg/l) as N	<0.02	0.02-0.5	0.5-1	>1
Sulphate	(mg/l)	<10	10-20	20-30	>30
Chloride	(mg/l)	<10	10-15	15-20	>20
EC	(mS/m)	<10	10-15	15-25	>25
TDS	(mg/l)	65	65 -97.5	97.5-162.5	>162.5
Phosphate	(mg/l) as P	<0.05	0.05-0.08	0.08-1	>1

Table 9: RWQOs for the Schulpspruit tributary catchment

Level 2: Sub-unit 2 - Schulpspruit Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.05	0.05-0.25	0.25-0.5	>0.5
Ammonia	(mg/l) as N	<0.02	0.02-0.5	0.5-1	>1
Sulphate	(mg/l)	<10	10-20	20-30	>30
Chloride	(mg/l)	<10	10-15	15-20	>20
EC	(mS/m)	<10	10-15	15-25	>25
TDS	(mg/l)	65	65 -97.5	97.5-162.5	>162.5
Phosphate	(mg/l) as P	<0.05	0.05-0.08	0.08-1	>1

Table 10: RWQOs for the Blesbokspruit tributary catchment (Grootdraai Dam catchment)
Level 2: Sub-unit 3 - Blesbokspruit Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.05	0.05-0.25	0.25-0.5	>0.5
Ammonia	(mg/l) as N	<0.02	0.02-0.5	0.5-1	>1
Sulphate	(mg/l)	<15	15-35	35-50	>50
Chloride	(mg/l)	<25	25-50	50-70	>70
EC	(mS/m)	<15	15-30	30-50	>50
TDS	(mg/l)	97.5	97.5-195	195-325	>325
Phosphate	(mg/l) as P	<0.05	0.05-0.25	0.25-0.50	>0.50

Table 11: RWQOs for the Leeuspruit tributary catchment (Grootdraai Dam catchment)
Level 2: Sub-unit 4 - Leeuspruit Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.05	0.05-0.25	0.25-0.5	>0.5
Ammonia	(mg/l) as N	<0.02	0.02-0.5	0.5-1	>1
Sulphate	(mg/l)	<15	15-35	35-50	>50
Chloride	(mg/l)	<10	10-20	20-30	>30
EC	(mS/m)	<15	15-30	30-50	>50
TDS	(mg/l)	97.5	97.5-195	195-325	>325
Phosphate	(mg/l) as P	<0.05	0.05-0.25	0.25-0.50	>0.50

Table 12: RWQOs for the Klip River tributary catchment (Free State)
Level 2: Sub-unit 5 - Klip Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.1	0.1-0.2	0.2-0.3	>0.3
Ammonia	(mg/l) as N	<0.2	0.2-0.5	0.5-1.0	>1
Sulphate	(mg/l)	<20	20-45	45-70	>70
Chloride	(mg/l)	<25	25-50	50-75	>75
EC	(mS/m)	<10	10-30	30-45	>45
TDS	(mg/l)	<65	65-195	195-293	>293
Phosphate	(mg/l) as P	<0.05	0.05-0.25	0.25-0.5	>0.5

Table 13: RWQOs for the Waterval River tributary catchment
Level 2: Sub-unit 6 - Waterval Catchment

Variable	Units	Ideal	Acceptable	Tolerable
Nitrate	(mg/l) as N	0.5	2.5	10
Ammonia	(mg/l) as N	0.025	0.3	0.8
Sulphate	(mg/l)	60	100	200
Chloride	(mg/l)	75	150	300
EC	(mS/m)	40	90	370
TDS	(mg/l)	260	585	
Phosphate	(mg/l) as P	<0.005	0.025	0.25

Table 14: RWQOs for the Wilge tributary catchment
Level 2: Sub-unit 7 - Wilge Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	0.1	0.1-0.2	0.2-0.3	>0.3
Ammonia	(mg/l) as N	<0.05	0.05-0.10	0.1-0.2	>0.2
Sulphate	(mg/l)	<5	5-10	10-15	>15
Chloride	(mg/l)	<5	5-10	10-15	>15
EC	(mS/m)	<10	10-30	30-45	>45
TDS	(mg/l)	65	65-195	195-292.5	>292.5
Phosphate	(mg/l) as P	<0.05	0.050.15	0.15-0.3	>0.3

Table 15: RWQOs for the Blesbokspruit tributary catchment (Vaal Barrage Catchment)
Level 2: Sub-unit 8 - Blesbokspruit Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.5	0.5-3.0	3.0-6.0	>6.0
Ammonia	(mg/l) as N	<0.1	0.1-1.5	1.5-5.0	>5.0
Sulphate	(mg/l)	<150	150-300	300-500	>500
Chloride	(mg/l)	80	80-150	150-200	>200
EC	(mS/m)	<45	45-70	70-120	>120
TDS	(mg/l)	292.5	292.5-455	455-780	>780
Phosphate	(mg/l) as P	<0.2	0.2-0.4	0.4-0.6	>0.6

Table 16: RWQOs for the Klip River tributary catchment (Gauteng)

Level 2: Sub-unit 9 - Klip River Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<2	2-4	4-7	>7.0
Ammonia	(mg/l) as N	<0.5	0.5-1.5	1.5-4.0	>4.0
Sulphate	(mg/l)	<200	200-350	300-500	>500
Chloride	(mg/l)	<50	50-75	75-100	>100
EC	(mS/m)	<80	80-100	100-150	>150
TDS	(mg/l)	<520	520-650	650-975	>975
Phosphate	(mg/l) as P	<0.2	0.2-0.5	0.5-1.0	>1.0

Table 17: RWQOs for the Taaibosspruit tributary catchment

Taaibosspruit

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.5	0.5-3.0	3.0-6.0	>6.0
Ammonia	(mg/l) as N	<0.25	0.25-0.50	0.50-1.0	>1.0
Sulphate	(mg/l)	<150	150-300	300-500	>500
Chloride	(mg/l)	<50	50-60	60-75	>75
EC	(mS/m)	<42	42-60	60-70	>70
TDS	(mg/l)	<273	273-390	390-455	>455
Phosphate	(mg/l) as P	<0.2	0.2-0.4	0.4-0.6	>0.6

Table 18: RWQOs for the Leeuspruit tributary catchment (Vaal Barrage catchment)

Leeuspruit

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.5	0.5-3.0	3.0-6.0	>6.0
Ammonia	(mg/l) as N	<0.1	0.1-1.5	1.5-5.0	>5.0
Sulphate	(mg/l)	<150	150-300	300-500	>500
Chloride	(mg/l)	<80	80-150	150-200	>200
EC	(mS/m)	<45	45-70	70-120	>120
TDS	(mg/l)	<293	293-455	455-780	>780
Phosphate	(mg/l) as P	<0.2	0.2-0.4	0.4-0.6	>0.6

Table 19: RWQOs for the Kromelmboogspruit tributary catchment

Kromelmboogspruit

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.5	0.5-3.0	3.0-6.0	>6.0
Ammonia	(mg/l) as N		<0.5	0.50-1.0	>1.0
Sulphate	(mg/l)	<20	20-100	100-200	>200
Chloride	(mg/l)	<5	5-50	50-75	>75
EC	(mS/m)	<18	18-30	30-70	>70
TDS	(mg/l)	<117	117-195	195-455	>455
Phosphate	(mg/l) as P		<0.03	0.03-0.05	>0.05

Table 20: RWQOs for the Rietspruit tributary catchment
Level 2: Sub-unit 11 - Rietspruit Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<1.0	1.0-3.0	3.0-6.0	>6.0
Ammonia	(mg/l) as N	<0.25	0.25-5.0	5.0-10.0	>10.0
Sulphate	(mg/l)	<100	100-200	200-300	>300
Chloride	(mg/l)	<50	50-100	100-150	>150
EC	(mS/m)	<30	30-70	70-100	>100
TDS	(mg/l)	<195	195-455	455-650	>650
Phosphate	(mg/l) as P	<0.25	0.25-0.50	0.50-1.0	>1.0

Table 21: RWQOs for the Mooi tributary catchment

Level 2: Sub-unit 12 - Mooi River Catchment

Variable	Units	RWQO
Nitrate	(mg/l) as N	0.3
Ammonia	(mg/l) as N	0.03
Sulphate	(mg/l)	75
Chloride	(mg/l)	36
EC	(mS/m)	57
TDS	(mg/l)	370.5
Phosphate	(mg/l) as P	0.4

Note: *No levels of RWQOs were Mooi River catchment. The decision taken was to set a management target based on a combination of most stringent user requirements (ideal and acceptable), current status and a 20% improvement where necessary.*

Table 22: RWQOs for the Schoonspruit/Koekemoerspruit tributary catchment
Level 2: Sub-unit 13 - Schoonspruit/Koekemoerspruit Catchment

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Nitrate	(mg/l) as N	<0.2	0.2-1.0	1-3	>3.0
Ammonia	(mg/l) as N	<0.25	0.25-1.0	1.0-5.0	>5.0
Sulphate	(mg/l)	<100	100-200	200-400	>400
Chloride	(mg/l)	<50	50-100	100-150	>150
EC	(mS/m)	<31	31-62	62-92	>92
TDS	(mg/l)	<200	200-400	400-600	>600
Phosphate	(mg/l) as P	<0.2	0.2-0.4	0.4-1.0	>1.0

Table 23: RWQOs for the Middle Vaal WMA tributary catchments: Renoster/Vierfontein, Vals, Makwassie, Sandspruit and Sand/Vet Catchments

Renoster/Vierfontein (1/2), Vals (3), Makwassie (4), Sandspruit (5) and Sand/Vet (6) Catchments

Variable	Units	Acceptable Range					
Management Unit		**1**	**2**	**3**	**4**	**5**	**6**
Nitrate	(mg/l) as N	0.2-1.0	0.6	2.0	3.5	0.9	Awaiting RWQOs from study
Ammonia	(mg/l) as N	0.25 -1.0	0.15	0.15	0.14	0.2	
Sulphate	(mg/l)	100-200	40	120	38	60	
Chloride	(mg/l)	50-100	30	100	52	107	
EC	(mS/m)	**31-62**	**45**	**98**	**69**	**94**	
TDS	(mg/l)	**200-400**	**293**	**637**	**449**	**611**	
Phosphate	(mg/l)	**0.2-0.4**	**0.2**	**1.0**	**0.1**	**0.4**	

Table 24: RWQOs for the Lower Vaal WMA tributary catchments: Harts and Modder Riet

Harts (1) and Modder Riet (2) Catchments

Variable	Units	Acceptable Range:	
Management Unit		**1**	**2**
Nitrate	(mg/l) as N	3	Awaiting RWQOs from study
Ammonia	(mg/l) as N	0.1	
Sulphate	(mg/l)	250	
Chloride	(mg/l)	100	
EC	(mS/m)	120	
TDS	(mg/l)	840	
Phosphate	(mg/l)	0.04	

The RWQOs listed above for the purposes of this study, contain the water quality variables related to salinity and nutrients. A list of RWQOs for the sub-catchment which includes other additional variables (e.g. biological) is contained in **Appendix A**.

3.3 Record of Decisions with respect to RWQOs set

3.3.1 Vaal Main Stem

In terms of this task *i.e.* integration of RWQOs and the parallel task - the identification of management options it was important to understand the rationale behind the setting of the RWQOs for the Vaal River. This is described below in **Table 25**.

Please take note: The rationales given in the table below were documented as provided by the DWAF Regional Office through the Record of Decisions noted during the RWQO development processes.

Table 25: Rationale for setting RWQOs at current levels (*source DWAF Regional Offices, Rand Water*)

Catchment /WMA	Rationale/Record of Decision	Date Adopted
Grootdraai Catchment	• Water quality should suit all user groups • 75th percentile is not the ideal value • RWQOs must be reasonably strict • RWQOs are liable to amendment from time to time • Ideal RWQOs are the ultimate goal • RWQOs based on in stream quality not effluent discharge standards	28 May 2002
Vaal Dam Catchment	Background water quality of Vaal Dam was adopted as the ideal RWQO level. The other RWQO levels were developed based on this background water quality.	Could not confirm
Vaal Barrage Catchment	• To safeguard domestic users who abstracted directly from the resource. • The ability of the existing conventional water treatment works to remove the identified water quality variables to meet potable water quality standards.	13 October 2001
Downstream Vaal Barrage	• Based on current water quality status (most conservative value), variables of concern and most sensitive downstream water user requirements (tolerant user requirement)	3 June 1998
Middle Vaal WMA	• Based on current water quality status, variables of concern and most sensitive downstream water user requirements	1 February 2006
Lower Vaal WMA	• Based on current water quality status, variables of concern and most sensitive downstream water user requirements	6 February 2006

3.3.2 Tributaries of the Vaal River

The rationale for the setting of the RWQOs for each of the Vaal River tributaries is described below in **Table 26**.

***Please take note*:** The rationales given in the table below were documented as provided by the DWAF Regional Office through the Record of Decisions noted during the RWQO development processes.

Table 26: Rationale for setting RWQOs at current levels (*source DWAF Regional Offices, Rand Water*)

Management Sub-Unit (Level 2)	Sub-Catchment Area	Rationale/Record of Decision	Date Adopted
1	Vaal Origin	• Water quality should suit all user groups • 75th percentile is not the ideal value • RWQOs must be reasonably strict • RWQOs are liable to amendment from time to time • Ideal RWQOs are the ultimate goal • RWQOs based on in stream quality not effluent discharge standards	28 May 2002
2	Schulpspruit		
3	Blesbokspruit		
4	Leeuspruit		
5	Klip River (Free State)	• Water quality should suit all user groups • 75th percentile is not the ideal value • RWQOs must be reasonably strict • RWQOs are liable to amendment from time to time • Ideal RWQOs are the ultimate goal • RWQOs based on in stream quality not effluent discharge standards	
6	Waterval	• Based on assessment classification system (current status and SA WQG) – " fitness for use"	19 October 2005
7	Wilge	• Water quality should suit all user groups • 75th percentile is not the ideal value • RWQOs must be reasonably strict • RWQOs are liable to amendment from time to time • Ideal RWQOs are the ultimate goal • RWQOs based on in stream quality not effluent discharge standards	May 2004
8	Blesbokspruit	• Current state 95th percentile values for WQ variables identified were used as a basis • Comparison was made to existing RWQOs and VBCEC guidelines (Vaal Barrage RWQOs). VBCEC guidelines were based on the assumption that water should be fit for recreational users as well as domestic use after some basic purification has been implemented for water taken directly from the river. Basic human needs and ecological guidelines could be used as a point of departure. • RWQOs were set at a level to allow for certain degree of impact	4 April 2003
9	Klip River	• Based on impact of WQ variable on the users and in-stream quality	December 1997

Management Sub-Unit (Level 2)	Sub-Catchment Area	Rationale/Record of Decision	Date Adopted
10	Leeuspruit/Taaiboschspruit	• Vaal Barrage RWQOs were used as a reference point • Current water quality status was used as basis	30 April 2003
11	Rietspruit		
12	Mooi River	• Ideal and acceptable water requirements for the most sensitive users were used as the basis (SA WQG Target water quality ranges) • Based on the current status of water quality at the time • 20% improvement on status over a five period was used as RWQO when current status did not comply with the ideal or acceptable ranges (If 20% was better than ideal or acceptable level for user requirements, the ideal or acceptable level was then used). • If the current status was better than the ideal or acceptable level, than current status concentrations were adopted as RWQOs to maintain water quality and prevent deterioration.	1999
13	Schoon/Koekemoer	• Based on SAWQG user requirements, stakeholder and expert knowledge of catchment	December 2001
14	Renoster/Vierfontein	• Current state 95th tile water quality used as RWQOs	1 Feb 2006
15	Vals		
16	Makwassie		
17	Sandspruit		
18	Sand/Vet	• Awaiting from RWQOs from RO	2006
19	Harts River	• Level 1 RWQOs for Vaal River adopted as RWQOs	6 Feb 2006
20	Modder Riet	• Study report unavailable at completion of this report	

3.4 Alignment of Status Quo Resource Water Quality Objectives

3.4.1 Vaal Main Stem – Level 1 Points

It was determined that generally alignment between RWQOs existed with a few minor exceptions.

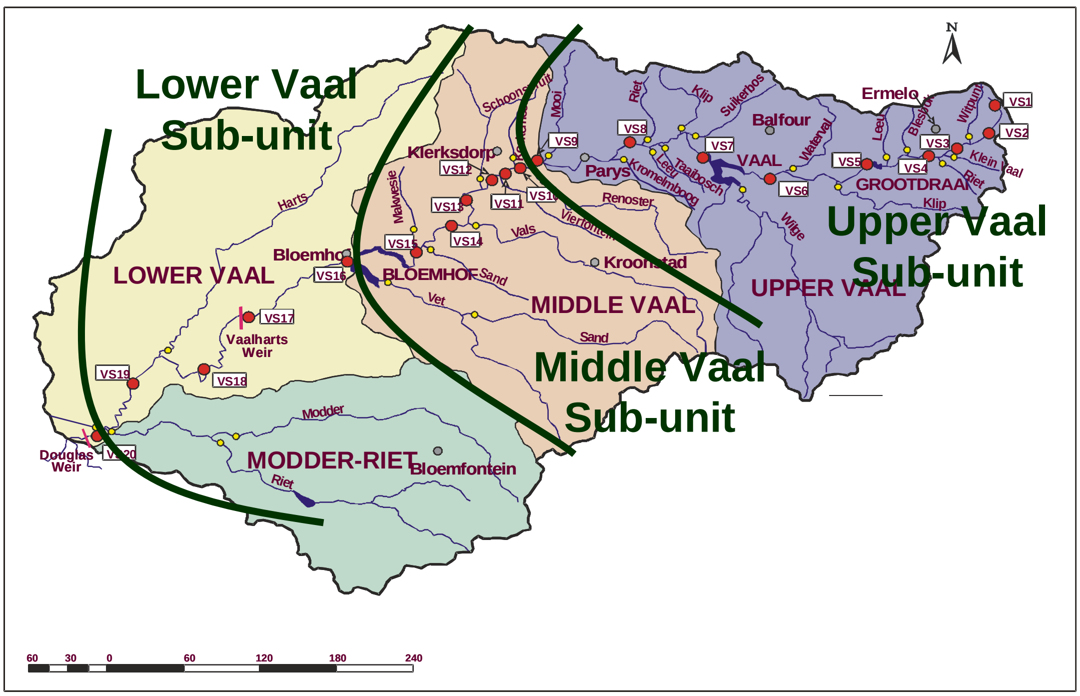
However, while the alignment existed – the realism in terms of achieving some of the RWQOs from a regulatory/management point of view and impact on water user (economic implications) was identified as a key issue..

A balance between current status and catchment vision/classification of the water resource was absent which resulted in the lack of direction in terms of what the final level of RWQOs were set at. However this was to be addressed to some degree through this task .

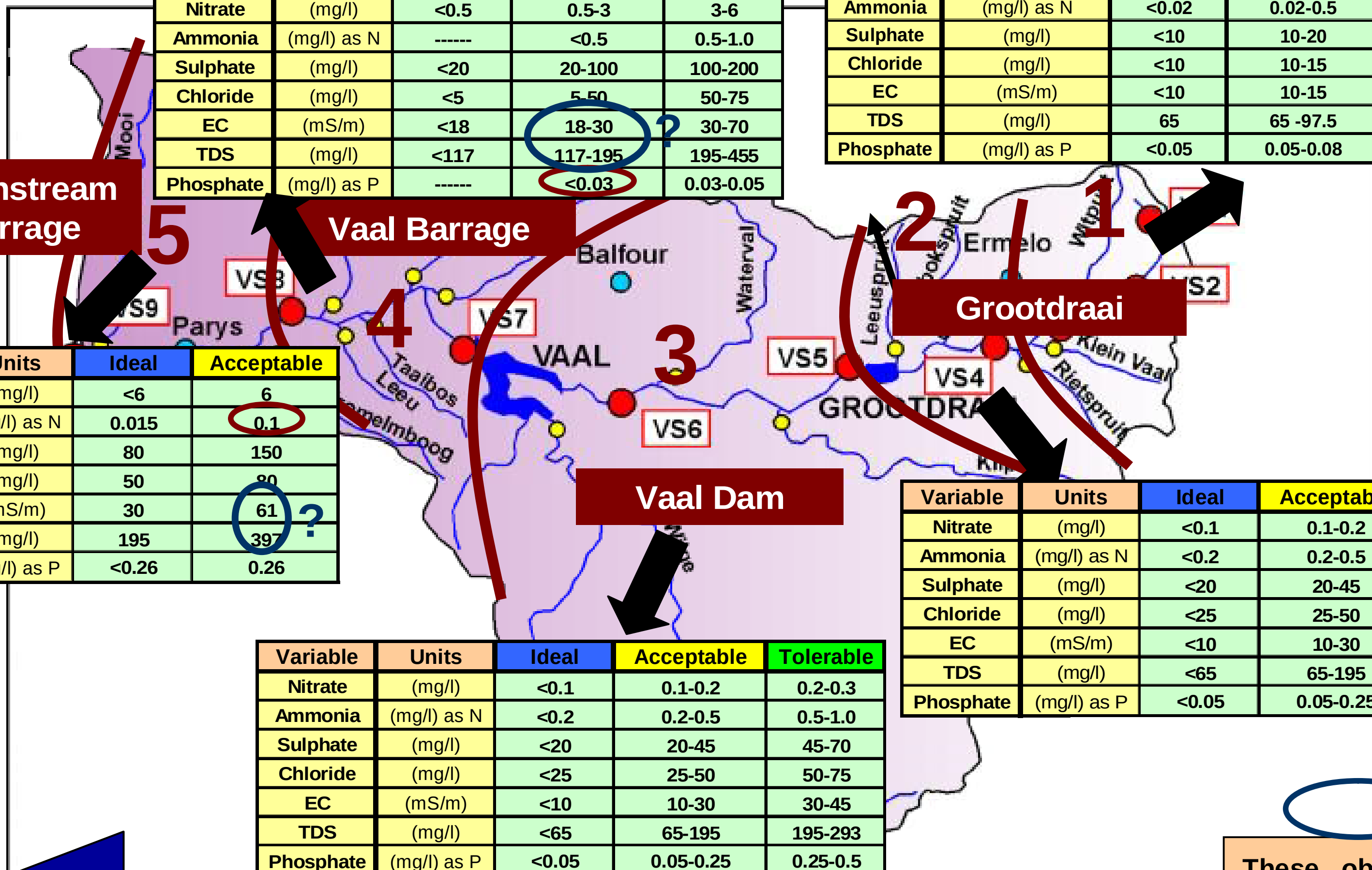
An evaluation of the alignment of the RWQOs currently set for the Vaal main stem in the three Vaal WMAs is depicted in the figures below.

Alignment of RWQOs for the Vaal River are depicted for the three WMAs as follows:

- Upper Vaal WMA as a sub-unit;
- Middle Vaal WMA as a sub-unit; and
- Lower Vaal WMA as a sub-unit.



UPPER VAAL WMA AS A SUB-UNIT: ALIGNMENT OF RWQOs OF MANAGEMENT UNITS



Variable	Units	Ideal	Acceptable	Tolerable
Nitrate	(mg/l)	<0.5	0.5-3	3-6
Ammonia	(mg/l) as N	------	<0.5	0.5-1.0
Sulphate	(mg/l)	<20	20-100	100-200
Chloride	(mg/l)	<5	5-50	50-75
EC	(mS/m)	<18	18-30	30-70
TDS	(mg/l)	<117	117-195	195-455
Phosphate	(mg/l) as P	------	<0.03	0.03-0.05

Variable	Units	Ideal	Acceptable	Tolerable
Nitrate	(mg/l)	<0.05	0.05-0.25	0.25-0.5
Ammonia	(mg/l) as N	<0.02	0.02-0.5	0.5-1
Sulphate	(mg/l)	<10	10-20	20-30
Chloride	(mg/l)	<10	10-15	15-20
EC	(mS/m)	<10	10-15	15-25
TDS	(mg/l)	65	65 -97.5	97.5-162.5
Phosphate	(mg/l) as P	<0.05	0.05-0.08	0.08-1

Variable	Units	Ideal	Acceptable
Nitrate	(mg/l)	<6	6
Ammonia	(mg/l) as N	0.015	0.1
Sulphate	(mg/l)	80	150
Chloride	(mg/l)	50	80
EC	(mS/m)	30	61
TDS	(mg/l)	195	397
Phosphate	(mg/l) as P	<0.26	0.26

Variable	Units	Ideal	Acceptable	Tolerable
Nitrate	(mg/l)	<0.1	0.1-0.2	0.2-0.3
Ammonia	(mg/l) as N	<0.2	0.2-0.5	0.5-1.0
Sulphate	(mg/l)	<20	20-45	45-70
Chloride	(mg/l)	<25	25-50	50-75
EC	(mS/m)	<10	10-30	30-45
TDS	(mg/l)	<65	65-195	195-293
Phosphate	(mg/l) as P	<0.05	0.05-0.25	0.25-0.5

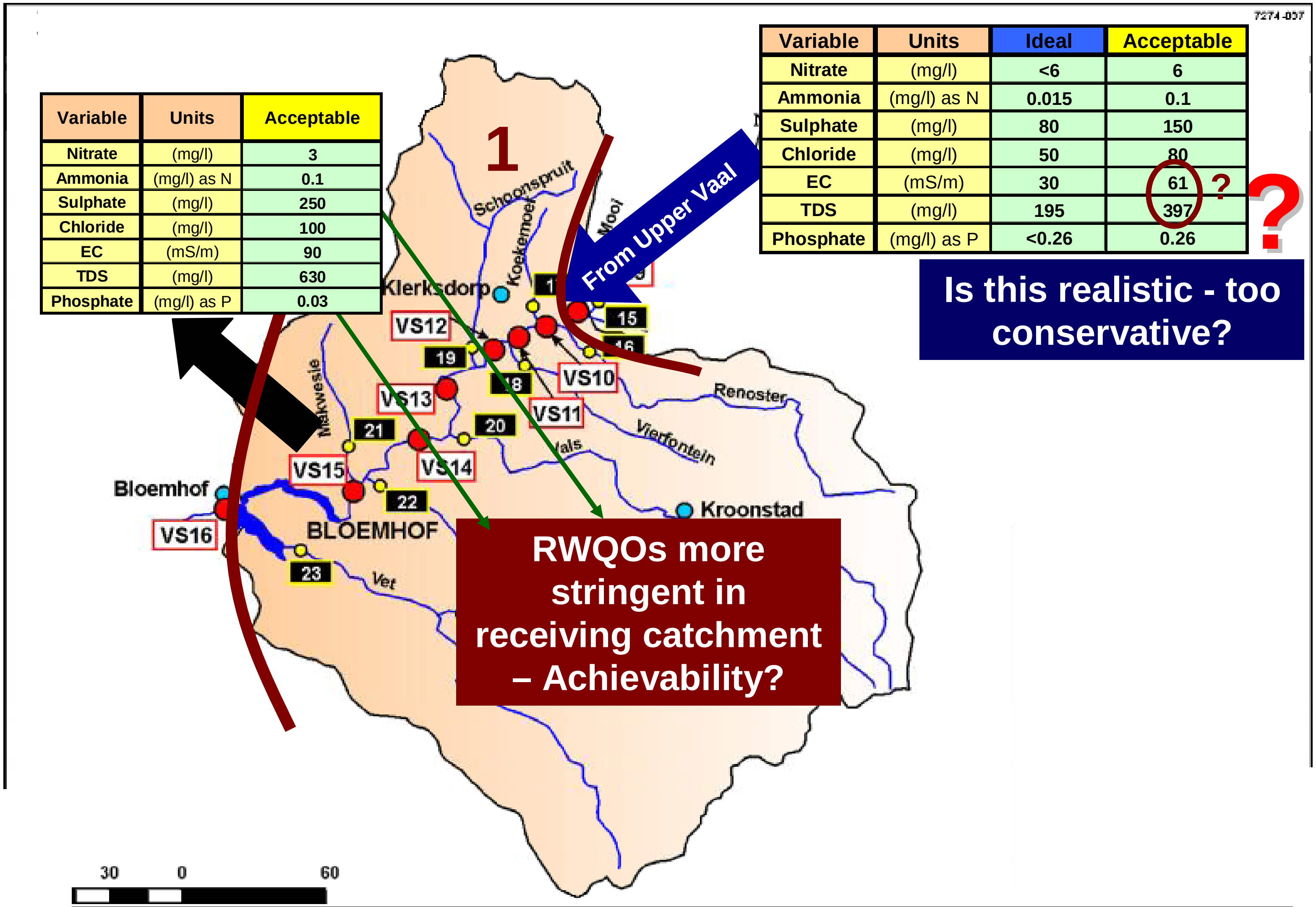
Variable	Units	Ideal	Acceptable	Tolerable
Nitrate	(mg/l)	<0.1	0.1-0.2	0.2-0.3
Ammonia	(mg/l) as N	<0.2	0.2-0.5	0.5-1.0
Sulphate	(mg/l)	<20	20-45	45-70
Chloride	(mg/l)	<25	25-50	50-75
EC	(mS/m)	<10	10-30	30-45
TDS	(mg/l)	<65	65-195	195-293
Phosphate	(mg/l) as P	<0.05	0.05-0.25	0.25-0.5

As you progress downstream RWQOs become less stringent *(with 2 exceptions)*

?

These objectives are ringed to highlight their applicability in terms of the current realities that exist in the Vaal Barrage and downstream.

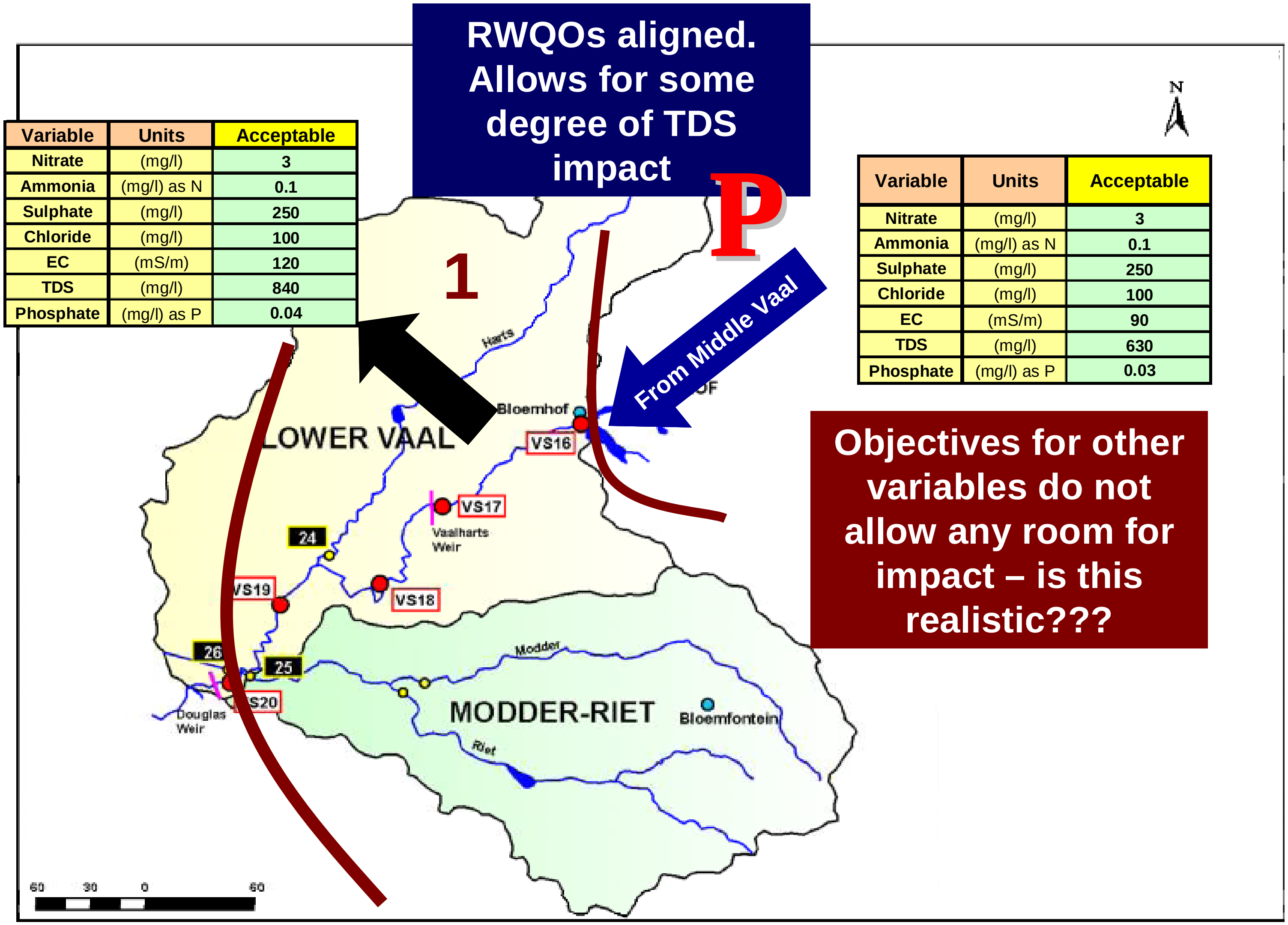
MIDDLE VAAL WMA AS A SUB-UNIT: ALIGNMENT OF RWQOs WITH UPPER VAAL



Variable	Units	Acceptable
Nitrate	(mg/l)	3
Ammonia	(mg/l) as N	0.1
Sulphate	(mg/l)	250
Chloride	(mg/l)	100
EC	(mS/m)	90
TDS	(mg/l)	630
Phosphate	(mg/l) as P	0.03

Variable	Units	Ideal	Acceptable
Nitrate	(mg/l)	<6	6
Ammonia	(mg/l) as N	0.015	0.1
Sulphate	(mg/l)	80	150
Chloride	(mg/l)	50	80
EC	(mS/m)	30	61
TDS	(mg/l)	195	397
Phosphate	(mg/l) as P	<0.26	0.26

LOWER VAAL WMA AS A SUB-UNIT: ALIGNMENT OF RWQOs WITH MIDDLE VAAL



Variable	Units	Acceptable
Nitrate	(mg/l)	3
Ammonia	(mg/l) as N	0.1
Sulphate	(mg/l)	250
Chloride	(mg/l)	100
EC	(mS/m)	120
TDS	(mg/l)	840
Phosphate	(mg/l) as P	0.04

Variable	Units	Acceptable
Nitrate	(mg/l)	3
Ammonia	(mg/l) as N	0.1
Sulphate	(mg/l)	250
Chloride	(mg/l)	100
EC	(mS/m)	90
TDS	(mg/l)	630
Phosphate	(mg/l) as P	0.03

3.4.2 RWQOs of tributaries – alignment with Vaal main stem RWQOs

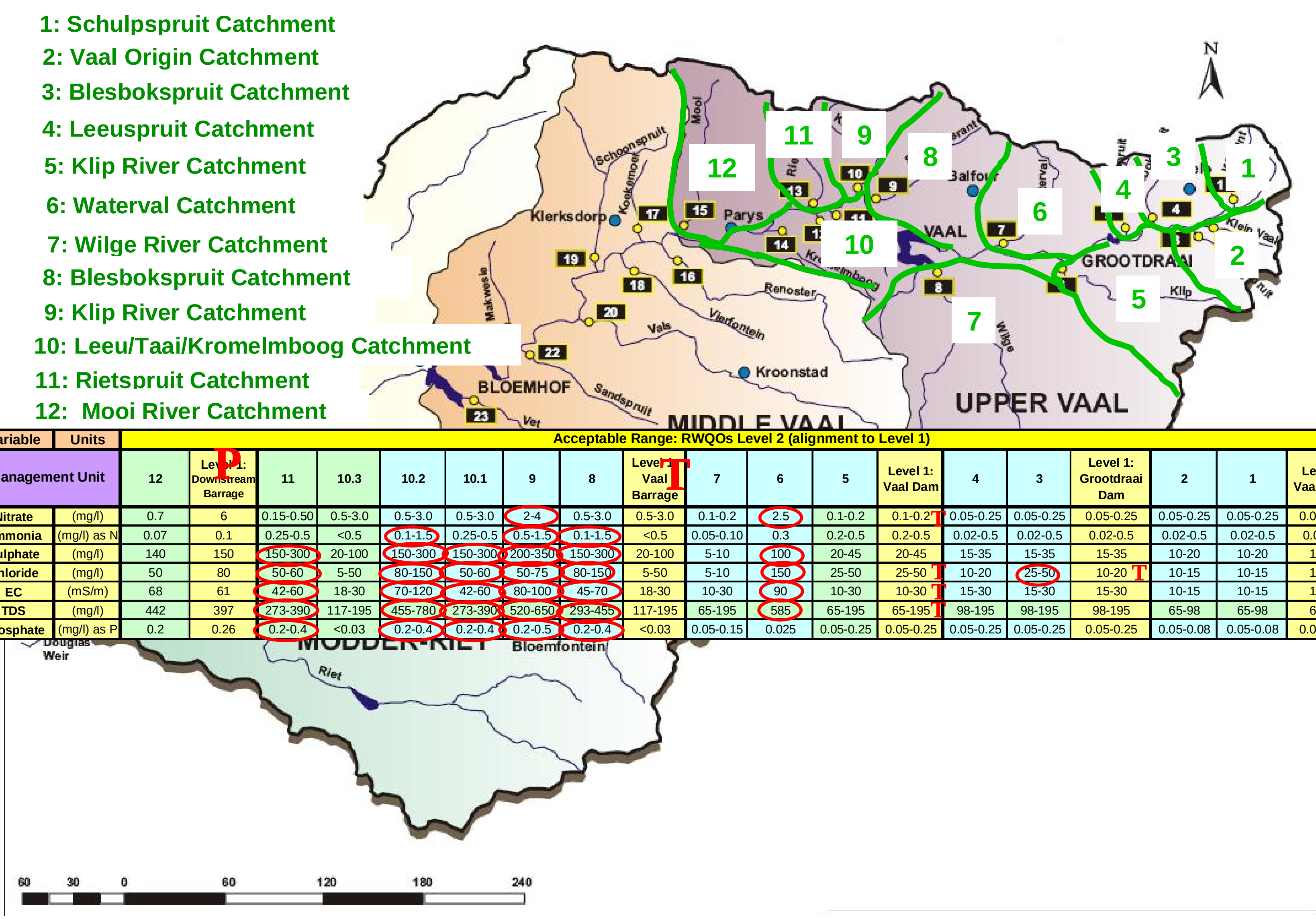
Generally it was found that there is a fair degree of alignment between Level 1 and Level 2 RWQOs.

However:

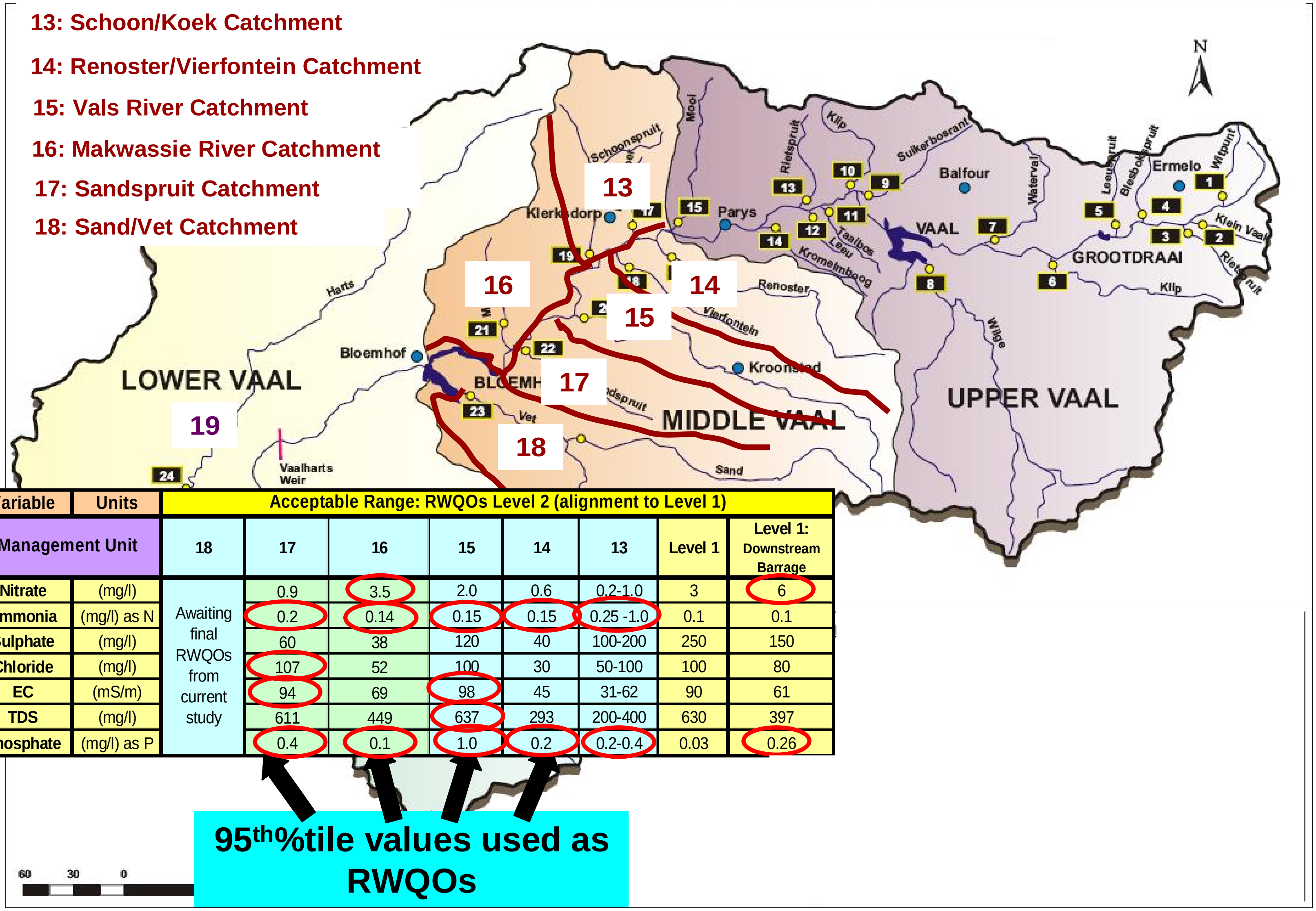
- **Upper Vaal WMA**
  - Lack of alignment of RWQOs in the sub-catchments of the Vaal Barrage was identified as a issue that needed addressing.
  - The Waterval Catchment RWQOs were found to be not aligned to Vaal Dam RWQOs.
- **Middle Vaal WMA**
  - RWQOs of specific variables were identified as an issue in terms of alignment (e.g. ammonia and phosphate)
  - RWQOs set for many of the tributary catchments were 95th %tile values. The effectiveness of balancing use with protection and needs of users was identified as a issue that required consideration in terms of using the 95th percentile value as the RWQO.
- **Lower Vaal WMA**
  - RWQOs were found to be aligned between tributary and Vaal main stem.

An evaluation of the alignment of the RWQOs currently set for the tributaries with the RWQOs of the Vaal main stem is depicted in the figures below.

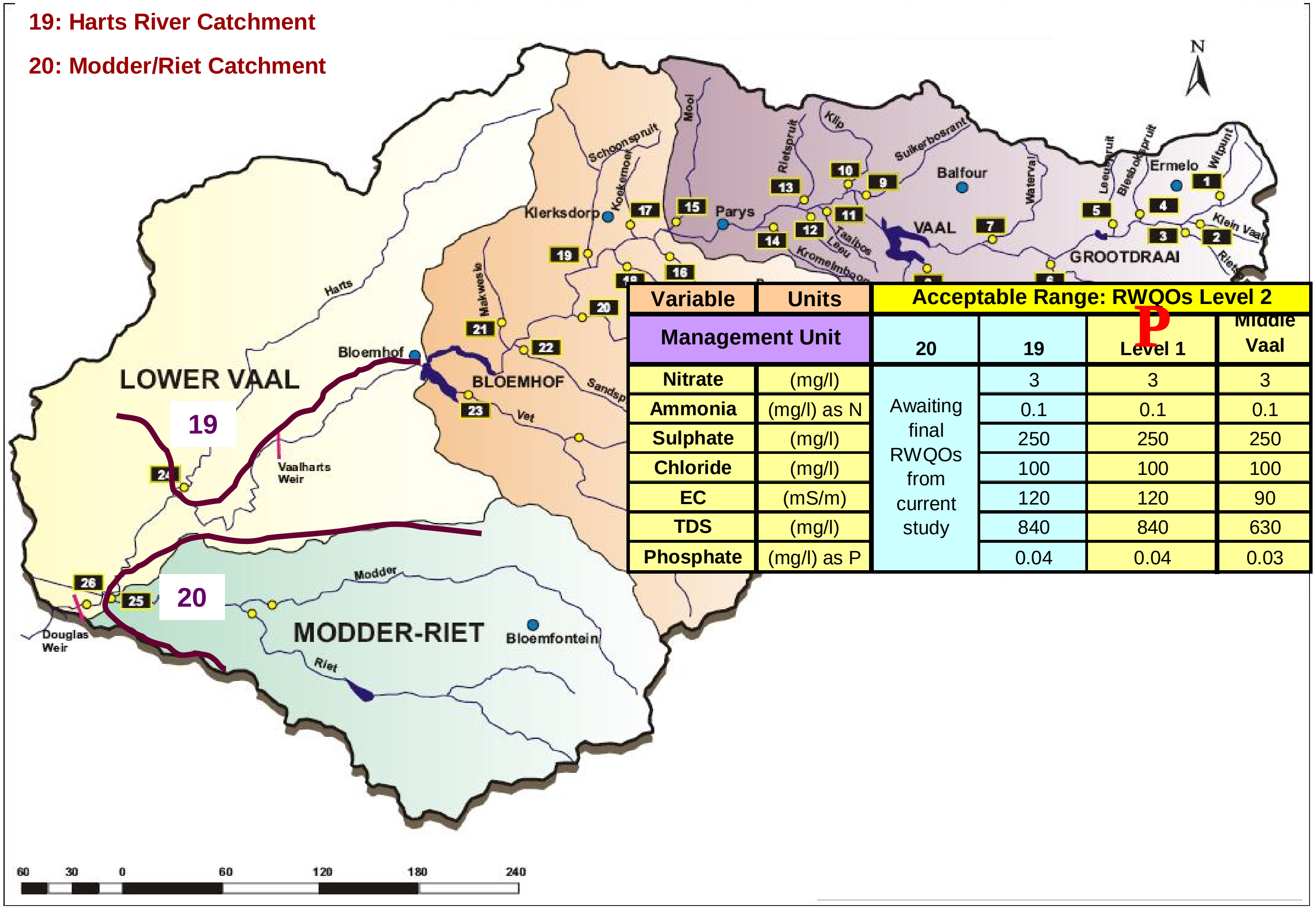
RWQOs for the tributaries of the Vaal River are depicted in terms of 20 management units.



Variable	Units	Acceptable Range: RWQOs Level 2 (alignment to Level 1)																	
Management Unit		12	Level 1: Downstream Barrage	11	10.3	10.2	10.1	9	8	Level 1: Vaal Barrage	7	6	5	Level 1: Vaal Dam	4	3	Level 1: Grootdraai Dam	2	1	Level 1: Vaal origin
Nitrate	(mg/l)	0.7	6	0.15-0.50	0.5-3.0	0.5-3.0	0.5-3.0	2-4	0.5-3.0	0.5-3.0	0.1-0.2	2.5	0.1-0.2	0.1-0.2	0.05-0.25	0.05-0.25	0.05-0.25	0.05-0.25	0.05-0.25	0.05-0.25
Ammonia	(mg/l) as N	0.07	0.1	0.25-0.5	<0.5	0.1-1.5	0.25-0.5	0.5-1.5	0.1-1.5	<0.5	0.05-0.10	0.3	0.2-0.5	0.2-0.5	0.02-0.5	0.02-0.5	0.02-0.5	0.02-0.5	0.02-0.5	0.02-0.5
Sulphate	(mg/l)	140	150	150-300	20-100	150-300	150-300	200-350	150-300	20-100	5-10	100	20-45	20-45	15-35	15-35	15-35	10-20	10-20	10-20
Chloride	(mg/l)	50	80	50-60	5-50	80-150	50-60	50-75	80-150	5-50	5-10	150	25-50	25-50	10-20	25-50	10-20	10-15	10-15	10-15
EC	(mS/m)	68	61	42-60	18-30	70-120	42-60	80-100	45-70	18-30	10-30	90	10-30	10-30	15-30	15-30	15-30	10-15	10-15	10-15
TDS	(mg/l)	442	397	273-390	117-195	455-780	273-390	520-650	293-455	117-195	65-195	585	65-195	65-195	98-195	98-195	98-195	65-98	65-98	65-98
Phosphate	(mg/l) as P	0.2	0.26	0.2-0.4	<0.03	0.2-0.4	0.2-0.4	0.2-0.5	0.2-0.4	<0.03	0.05-0.15	0.025	0.05-0.25	0.05-0.25	0.05-0.25	0.05-0.25	0.05-0.25	0.05-0.08	0.05-0.08	0.05-0.08



Variable	Units	Acceptable Range: RWQOs Level 2 (alignment to Level 1)							
Management Unit		18	17	16	15	14	13	Level 1	Level 1: Downstream Barrage
Nitrate	(mg/l)	Awaiting final RWQOs from current study	0.9	3.5	2.0	0.6	0.2-1.0	3	6
Ammonia	(mg/l) as N		0.2	0.14	0.15	0.15	0.25 -1.0	0.1	0.1
Sulphate	(mg/l)		60	38	120	40	100-200	250	150
Chloride	(mg/l)		107	52	100	30	50-100	100	80
EC	(mS/m)		94	69	98	45	31-62	90	61
TDS	(mg/l)		611	449	637	293	200-400	630	397
Phosphate	(mg/l) as P		0.4	0.1	1.0	0.2	0.2-0.4	0.03	0.26



Variable	Units	Acceptable Range: RWQOs Level 2			
Management Unit		20	19	Level 1	Middle Vaal
Nitrate	(mg/l)	Awaiting final RWQOs from current study	3	3	3
Ammonia	(mg/l) as N		0.1	0.1	0.1
Sulphate	(mg/l)		250	250	250
Chloride	(mg/l)		100	100	100
EC	(mS/m)		120	120	90
TDS	(mg/l)		840	840	630
Phosphate	(mg/l) as P		0.04	0.04	0.03

4 INTEGRATION/REVISION OF RWQOS

4.1 Point of Departure

It is a given that it is impossible to meet the ideal water quality requirements in the Vaal River System as huge impacts from land developments, the extensive use of the resources and high regulation of the system already exists. Thus while objectives currently set are at levels which are achievable through sound management practices, in many instances the results of the status assessment task indicate that the RWQOs must be revised and integrated on a WMA and in a system context to enable the Vaal River to be managed sustainably and to cater for downstream users and uses. Thus while the emphasis is on improving water quality over time, the current situation may warrant on one hand that acceptable levels of impact are assimilated to maintain current water quality. However in other instances improvement of water quality is the only option, but this comes at a cost which still needs to be interrogated. Both situations have economic implications – maintenance of current status (relaxation of RWQOs in some cases), would mean the downstream user would bear the cost, and improvement of current status (stricter RWQOs) would mean the discharger /polluter would bear the cost. Thus the RWQOs defined would have to ensure a balance of the needs of users and uses, and be a reflection of the realities that exist in such a regulated and impacted system.

4.2 Process Followed

Based on the current water quality status of the system, the assessment of the situation with regard to the water users and various uses and the consideration of all variables, an attempt has been made to integrate, align and revise the RWQOs of the Vaal River main stem and its tributaries.

The process followed to arrive at a proposed set of integrated RWQOs for the Vaal River System included the following:

4.2.1 Desk Top Assessment

As the first attempt, an assessment of all the existing RWQOs for the water resources in the catchment was undertaken by the study team. Based on their current understanding of the system and the results of the status assessment and salinity balance the study team at a desktop level identified proposed changes to the existing RWQOs. This exercise was aimed at identifying the key issues and focus areas that required attention. This analysis provided the basis for the iterations that followed. The results of this first order assessment are presented in **Appendix B**.

The proposed changes to RWQOs as they currently existed per sub-catchment for the Level 1 and 2 points in the Vaal River system and the reasoning behind these are indicated in the tables in **Appendix B**. The acceptable range RWQO was used as the "reference" as in most instances the acceptable level RWQO was used as the management target for the catchment. The suggested concentrations given in the tables were based on data available (past 10 years), field observations, professional expertise and knowledge, gut feeling, and literature. These recommended changes/proposals were the presented to DWAF for discussion.

4.2.2 Workshops

Following on from the draft discussion document, two workshops were held with key stakeholders in the Department to confirm a set of proposed RWQOs for the Vaal River System. The DWAF stakeholders that participated included representatives from the DWAF National Office (various Directorates) and Regional Offices (Gauteng, Free State and Northern Cape). The first integration of RWQOs workshop was held on 12 October 2007 in Pretoria, at which the approach was confirmed, and set of RWQOs were proposed. These RWQOs were then modelled using the WRPM to determine what was achievable and possible based on the current operation and restraints in the system. A second workshop was then held on 1 November 2007 to present the outcome of these modelling runs, and to confirm a proposed set of integrated RWQOs for the Vaal River and its tributaries.

4.3 Record of Decisions

The results/ record of decisions of the workshops regarding the approach and process followed and the integrated RWQOs proposed are discussed below.

4.3.1 Approach and process

The approach to the process followed was agreed upon by all stakeholders present. The key components of the approach were identified key drivers and reality check factors that were considered integral to the process. These components as listed below with the identified criteria for each:

Reality check factors:

The factors identified that the RWQOs were based on/tested against included:

- Bottom up approach
- Defined River Reaches
- Vision for the Vaal River
- Selected Water Quality Variables
- Single management objective
- Principles for setting the Level 2 RWQOs

Key Drivers:

The RWQOs in addition to being guided by the reality check factors were also dependent on key drivers for the river reaches of the system. These included**:**

- Water User requirements
- Protection level
- Status quo

The criteria (reality check factors), decisions taken and considerations regarding the approach and process followed are presented below in **Table 27**.

4.3.2 The integrated RWQOs proposed

Based on the criteria (reality check factors) defined and considerations identified, as well as the key drivers per river reach, RWQOs for the selected water quality variables were then set. A set of integrated RWQOs for total dissolved salts (TDS), phosphate, and *E.coli* (microbiological) were defined for the Vaal River (main stem) for each of the 14 river reaches identified (**Table 28**).

The proposed RWQOs are presented in **Table 29**, **Table 30** and **Table 31**. Based on the model runs that were undertaken RWQOs for TDS for the major tributaries of the Vaal River were also defined and these are presented in **Table 29**.

These RWQOs are the set of integrated/revised RWQOs being presented as part of this study. While these RWQOs are considered what is most appropriate and achievable at present the final RWQOs will be confirmed in the strategy report which is to integrate the reconciliation and water quality management options while also taking account of the economic implications.

Table 27: Approach followed in integration/setting of RWQOs for the Vaal River

CRITERIA	DECISION	CONSIDERATION
BOTTOM UP	**Bottom up approach - Start at Douglas Barrage and move up the system**	• Need to test impact – "sea" – bottom up on Orange River • Top-down and Bottom up - both have some implications for drivers and users
RIVER REACHES	**14 River Reaches were agreed upon for setting of RWQOs (see Figure 9 and Table 28)**	• Reserve needs to be taken account of • Need to consider management approach • Criteria to apply: - Water user profiles - Ecoregions - Hydrodynamics – tributaries entering - Discontinuity e.g. discharges • Middle Vaal - 1 reach for Schoon / Koekemoerspruit area is sufficient. Management will dictate / direct outcomes. • Lethabo weir – accepted as end of Vaal Dam Reach
VISION	**Three catchment areas defined**: - Upstream Grootdraai Dam - Downstream Grootdraai Dam to Vaal Dam - Below Vaal Dam to Douglas Barrage	• Two definitions to agree on vision - Uses – Heavily used catchment areas - State of catchment no use: Background WQ • Need to consider economics and social issues and impacts • Reality check must be done with Reserve process and links must be made with ecological water requirements • Ecological scenarios should also consider water quality needs and issues that prevail in the catchment • Collective for visions need to be derived • Qualitative statement for protection required

CRITERIA	DECISION	CONSIDERATION
	Visions (Main Stem) o **Upstream Grootdraai** - Good state – keep as is – ecologically functioning - Not highly modified • **Upstream Vaal Dam to Grootdraai Dam** - Highly modified area - Maintain at a C category ecologically - Preserve Wilge River o Consider trade offs if deterioration observed o Moderately impacted river • **Below Vaal Dam to Douglas Barrage** - Workhorse catchment that is overworked - Have to improve current state - Need to ensure an acceptable state that is sustainable	

CRITERIA	DECISION	CONSIDERATION
OBJECTIVE (RWQOs)	• **Set at level that should not be exceeded** • **95^{th}% tile management objective set** • **Set maximum limit** • **Range / or single number may be set**	
WATER QUALITY VARIABLES	• **TDS** • **TP** • **TN** • ***E. coli* (Microbiological)**	**TDS: Indicator of issue** • Salinity management is required • Sulphate (most and problematic). Causes: - Corrosion - Diarrhoea (health impact) • Sulphate salts – impact on the aquatic ecosystem (some are toxic) • **Ask sulphate question along each reach – to determine if RWQO is needed** **NUTRIENTS** • **TP – as PO_4** • **TN – as N/NO_3** • Immediate objective for Phosphate can be set • Long term management option for total phosphorus and total nitrogen must be available. **MICROBIOLOGICAL** • Indicator organism selected – *E.coli* • Current problem being faced relates to analysis – issues related to accuracy of analysis

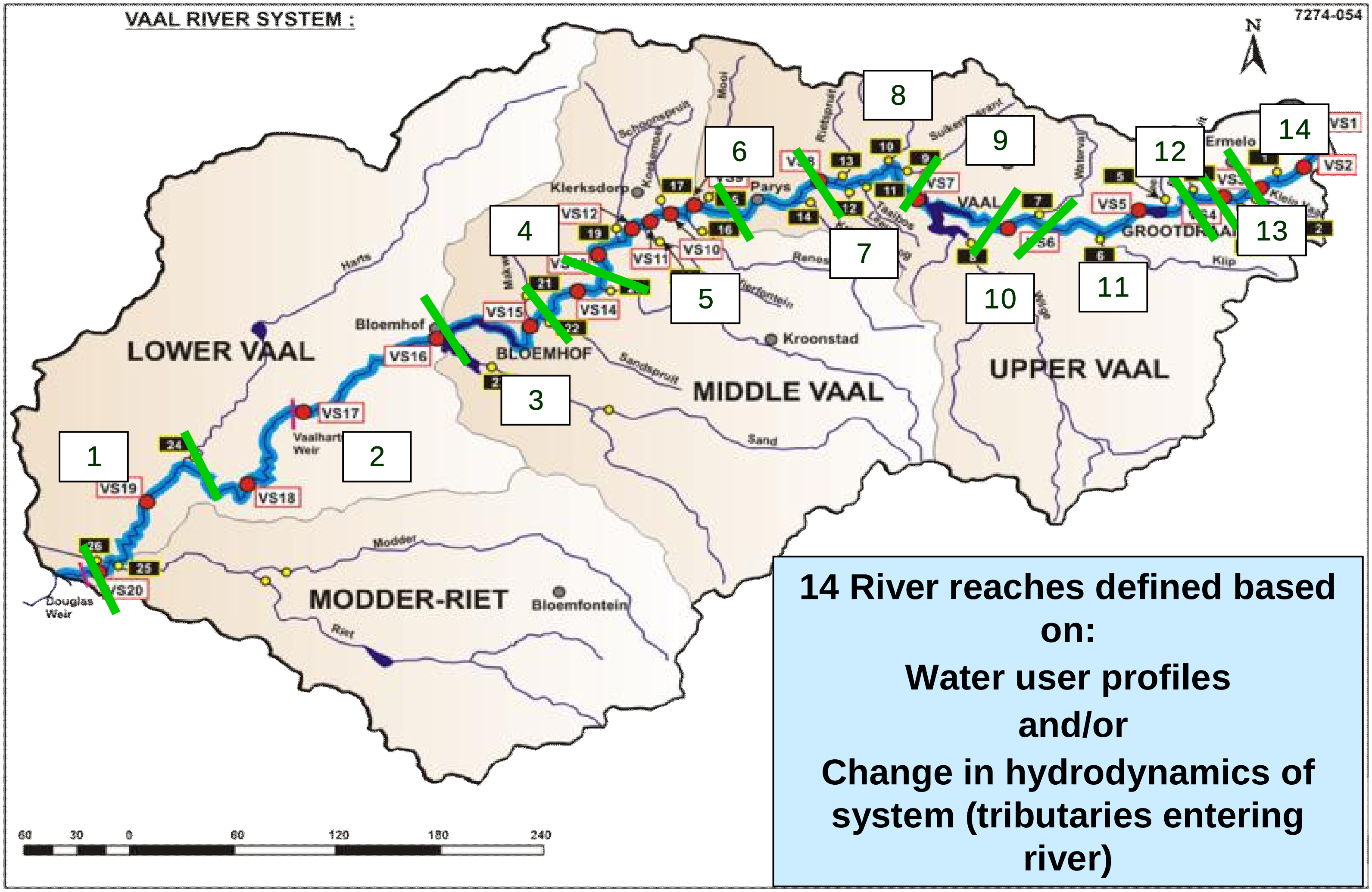


Figure 9: River reaches defined for the Vaal River main stem

Table 28: River reaches identified for the Vaal River main stem

Reach no (map)	Reach (Bottom up)
1	Vaal River downstream Harts River confluence to Douglas Barrage
2	Vaal river d/s Bloemhof Dam and u/s Harts confluence
3	Makwassiespruit to Bloemhof Dam
4	Vaal River d/s Vals confluence to Sandspruit confluence
5	Vaal River d/s Mooi confluence to Vals River confluence
6	Vaal River d/s Vaal Barrage u/s Mooi confluence
7	Vaal River d/s Lethabo weir to Vaal Barrage
8	Vaal Dam to Lethabo weir
9	Vaal River Downstream Waterval Confluence to inflow Vaal Dam
10	D/S Grootdraai Dam to u/s Waterval confluence
11	Vaal River d/s Blesbokspruit to Grootdraai Dam
12	Vaal River d/s Rietspruit u/s Blesbokspruit
13	Vaal River u/s and d/s of Rietspruit
14	Vaal River u/s Klein Vaal to origin of Vaal River

Table 29: Proposed RWQOs for TDS for the Vaal River main for each river reach defined and for the major tributaries

VAAL RIVER SYSTEM: LEVEL 1 POINTS: RWQOS FOR TDS

NO	REACH	WATER USERS	SOUTH AFRICAN WATER QUALITY GUIDELINES				PROTECTION (TEACHA OUTPUT - Preliminary Ion EcoSpecs)	CURRENT STATUS (95th %tile value)	RWQO SET (12th October 2007)	RWQO (1 November 2007) based on model runs	RESULTS OF MODEL RE-RUNS (December 2007)	TDS RWQO: Tributaries (January 2008) based on model runs
			TWQR (*1)	A (*2)	T (*3)	U (*4)						
1	Vaal River downstream Harts River confluence to Douglas Barrage	Irrigation#	260	585	1755	3510	1198 mg/l (average VS19 to VS20)	961 mg/l	600 mg/l	600 mg/l	800 mg/l	1500 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
2	Vaal river d/s Bloemhof Dam and u/s Harts confluence	Irrigation#	260	585	1755	3510	574 mg/l (average VS16, VS17 & VS18)	601 mg/l (average)	600mg/l	600mg/l	700 mg/l	no tributary
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
3	Makwassiespruit to Bloemhof Dam	Irrigation#	260	585	1755	3510	1167 mg/l	807 mg/l	600 mg/l	600 mg/l	700 mg/l	Vet River: 660 mg/l
		Recreation	No guideline prescribed									
4	Vaal River d/s Vals confluence to Sandspruit confluence	Irrigation#	260	585	1755	3510	1167 mg/l	807 mg/l	450 mg/l	600 mg/l	750 mg/l	Vals River: 700 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
5	Vaal River d/s Mooi confluence to Vals River confluence	Irrigation#	260	585	1755	3510	1526 mg/l (average VS 9, VS10, VS12)	673 mg/l	450mg/l	600mg/l	600 mg/l	Schoonspruit: 800mg/l Koekemoerspruit: 800mg/l Renoster: 200mg/l Mooi: 450mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
		Industry (*category)	100	200	450	1600						
6	Vaal River d/s Vaal Barrage u/s Mooi confluence	Irrigation#	260	585	1755	3510	845 mg/l	647 mg/l	600mg/l	To be determined (Need to model to reach 600mg/l in Middle Vaal River)	600 mg/l	no tributary
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
7	Vaal River d/s Lethabo weir to Vaal Barrage	Irrigation	260	585	1755	3510	845 mg/l	647 mg/l	To be determined (Driven by blending option to 300mg/)	To be determined (Need to model to reach 600mg/l in Middle Vaal River)	600 mg/l	Klip: 600 mg/l, Suikerbos: 650mg/l; Leeu: 455mg/l; Taai: 390 mg/l; Rietspruit: 550 mg/l; Kromelmboog: 195 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
		Industry (*category)	100	200	450	1600						
8	Vaal Dam to Lethabo weir	Irrigation#	260	585	1755	3510	245 mg/l	198 mg/l	180mg/l (Sulphate 30mg/l)	125mg/l (Sulphate 30mg/l)	125 mg/l	Wilge River: 110 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
		Industry (*category)	100	200	450	1600						
		Power Generation	175									
9	Vaal River Downstream Waterval Confluence to inflow Vaal Dam	Irrigation#	260	585	1755	3510	200 mg/l	413 mg/l	200mg/l	200mg/l? (To be confirmed. Model needs to be rerun for Waterval River)	250 mg/l	450 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
10	D/S Grootdraai Dam to u/s Waterval confluence	Irrigation#	260	585	1755	3510	264 mg/l	200 mg/l	200mg/l	195 mg/l	200 mg/l	Klip River: 195 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
11	Vaal River d/s Blesbokspruit to Grootdraai Dam	Irrigation#	260	585	1755	3510	264 mg/l	256 mg/l	180mg/l (Sulphate 30mg/l)	180mg/l (Sulphate 30mg/l)	180 mg/l	Leeuspruit: 400 mg/l Blesbokspruit: 400 mg/l
		Domestic	450	1000	2400	3400						
		Recreation	No guideline prescribed									
		Industry (*category)	100	200	450	1600						
12	Vaal River d/s Rietspruit u/s Blesbokspruit	Irrigation#	260	585	1755	3510	too little data (< 60)	313 mg/l	150mg/l (Sulphate 30mg/l)	150mg/l (Sulphate 30mg/l)	150 mg/l	no tributary
		Recreation	No guideline prescribed									
13	Vaal River u/s and d/s of Rietspruit	Irrigation#	260				too little data (< 60)	144 mg/l	150mg/l (Sulphate 30mg/l)	150mg/l (Sulphate 30mg/l)	150 mg/l	Rietspruit: 100 mg/l
		Recreation	No guideline prescribed									
14	Vaal River u/s Klein Vaal to origin of Vaal River	Irrigation#	260	585	1755	3510	too little data (< 60)	159 mg/l (average)	150mg/l (Sulphate 30mg/l)	100mg/l (Sulphate 30mg/l)	100 mg/l	Klein Vaal: 100 mg/l Witpuntspruit: 100 mg/l
		Domestic (informal)	450	1000	2400	3400						
		Recreation	No guideline prescribed									

u/s = upstream

d/s = downstream

Irrigation# - TDS values fo crop yield

Table 30: Proposed RWQOs for phosphate for the identified reaches in the Vaal River main stem

VRFAAL RIVER SYSTEM RWQO for Phosphate (PO_4-P)							
NO	REACH	WATER USERS	GUIDELINES FOR TROPHIC STATUS OF VAAL RIVER WATERS (ug/l)				RWQO SET
			Oligotrophic	Mesotrophic	Eutrophic	Hypertrophic	
1 - 3	Vaal River, Bloemhof Dam to Douglas Barrage	Irrigation, domestic, recreation, industry, aquatic ecosystem	< 10	10 - 50	50 -150	> 150	30 ug/l
4 - 5	Vaal River d/s Mooi confluence to Sandspruit confluence						100 ug/l
6 - 7	Vaal River d/s Lethabo weir to u/s Mooi confluence	Irrigation, domestic, recreation, industry, aquatic ecosystem	< 10	10 - 50	50 -150	> 150	150 ug/l
8 -14	Vaal River, Vaal Dam to headwaters						50 ug/l

Table 31: Proposed RWQOs for *E.coli* for all reaches in the Vaal river (main stem)

VAAL RIVER SYSTEM RWQOs FOR *Escherichia coli* (Microbiological)							
NO	REACH	WATER USERS	SOUTH AFRICAN WATER QUALITY GUIDELINES				RWQO SET
			TWQR	A	T	U	
1 - 14	All reaches in Vaal River System	Recreation - Full contact (counts per 100ml)	0 - 130	130 - 200	200 - 400	> 400	< 300 (counts/100ml)

4.4 General Considerations/Conclusions on the RWQOs

4.4.1 Salinity (Total Dissolved Salts)

- The current RWQOs for salinity are appropriate in some catchments while in others requires revision (which would mean either relaxation or more stringent RWQOs). Consideration was given to the protection of the system, the users (abstractors), and the uses (discharges).
- Relaxation is only proposed to maintain current water quality status where current RWQOs appear to be unrealistic at this stage, and where it is believed that assimilative capacity does exist.
- More stringent objectives are generally proposed where reaches are under threat or where the use of the resource is impeded due to current quality (especially in the case of downstream of the Vaal Barrage).
- RWQOs for TDS were also weighed against the dilution capacity that exists in terms of the current stringent regulation of the system that occurs.
- RWQOs set are at levels which are achievable through sound management practices, and will require investment and commitment from the Department and stakeholders.
- The suggested RWQOs concentrations are based on data available (past 10 years), catchment assessments and observations, modelling, professional knowledge and experience and gut feeling.

The following summary can be made regarding TDS RWQOs for the Vaal River System:

<u>Grootdraai Dam Catchment</u>

- TDS concentrations are generally acceptable. RWQOs can be maintained however this requires a concerted effort in terms of stricter source management in tributary catchments.
- The upstream RWQOs (upper part of Grootdraai) must be maintained to ensure current good quality of the Upper reaches of the Vaal River
- RWQOs need to be set based on water quality required for transfers.
- Some tributaries (Witpuntspruit, Leeuspruit and Blesbokspruit) are problematic requiring some change to existing RWQOs.

<u>Frankfort</u>

- Current RWQOs can be maintained.
- RWQOs are aligned with Vaal Dam RWQOs.

- Transfer of water from Katse Dam will ensure compliance to RWQOs as it continuously provides dilution capacity.

- There is however a need to protect the quality of Katse Dam water by managing local impacts.

Vaal Dam

- Vaal Dam meets RWQO of 10 to 30 mS/m. Water users are adequately satisfied at this stage.

- Lesotho (Katse Dam) provides dilution water which dilutes any impacts from the upper parts of the catchment.

- The Waterval tributary is an impacting tributary and stricter RWQOs are proposed.

- VS6 point into Vaal Dam on Vaal River does not meet RWQO. The RWQO at this point is aligned to RWQO of Vaal Dam, however at a current quality (95^{th} percentile) of 52 mS/m it is non-compliant. This reach of Vaal River from the confluence of Waterval river to Vaal Dam is of relatively poor water quality. While the impact of the Waterval River is diluted in Vaal Dam needs of the water users in this part of the catchment have to be considered (drinking, irrigation, Grootvlei Power station). The recommissioning of the Grootvlei Power Station is a future user to be considered if the water supply source is to be the Vaal River in this reach.

Vaal Barrage

- Upstream Lethabo weir the current RWQO can be maintained

- Downstream of Lethabo weir: Economic evaluation of two proposed RWQOs of 450 mg/L and 600 mg/L is underway as part of the evaluation of the management options. Practical achievement and cost to achieve are considerations.

- Based on above RWQOs for the tributaries will have to be evaluated.

- The proposed range of RWQOs in for the Vaal Barrage catchment needs to meet the water quality requirements of the users in the Middle Vaal WMA and Lower Vaal WMA.

Middle and Lower Vaal

- Consideration of achieving 500 mg/L to 600 mg/L RWQO to meet the drinking water quality treatment requirements of the Water Boards is a key consideration.

- This will also require a focus on source reduction within Middle and Lower Vaal WMAs.

- The RWQOs in these WMAs are however highly dependent on upstream RWQOs set at Vaal Barrage.

4.4.2 Nutrients

The nutrient concentration ranges (Nitrogen and Phosphate) for most existing RWQOs were found to be unacceptable high and would not protect the river environment against eutrophication, excessive algal growth and associated problems. The current status of the Vaal River reflects clearly reflects this situation.

The Vaal River system is also under huge stress because of an excess sewage (purified and raw) entering the aquatic ecosystem.

Limiting nutrient:

It is generally recognised that an increase in nutrient loading is a prerequisite of increased eutrophication in rivers. In general, the nutrient elements limiting the primary production in freshwater is phosphorus (mainly phosphate) while that in the marine environment is nitrogen (mainly nitrate).

However, the current consensus in Australia is that both, nitrogen and phosphorus, rather than just one supposedly limiting nutrient, need to be considered when developing management strategies to reduce nutrient inputs to waters (Davis & Koop, 2006).

Nevertheless, phosphorus is the major nutrient controlling the occurrence of water blooms of cyanobacteria in many regions of the world (WHO, 1999). Thus, the TP concentrations in the aquatic system are usually strongly associated with trophic level and cyanobacteria (blue-green algae) increase with an increase in TP concentration.

In the Vaal River, the phosphate concentrations were generally high (mean >100 µg/ℓ) and show an increasing trend during the past ten years. The annual chlorophyll-***a*** concentration was positively correlated with phosphorus. Consequently, the high concentrations of P (mostly as phosphate) in the Vaal River, promotes the excessive growth of algae.

Dissolved orthophosphate is evidently the major source of phosphorus for phytoplankton. Phosphate loading of natural waters occurs mainly through the introduction of man-made detergents, fertilisers, and sewage.

How much is too much?

The most common symptom of eutrophication is excessive algal growth, thus excess amounts of nutrients have been linked to algal blooms – usually defined as conditions with chlorophyll-a levels >50 µg/ℓ. During 2005 the average chl-a in the Vaal Barrage was 62 µg/ℓ.

It is generally accepted that chl-*a* concentrations persistently in excess of 30 µg/ℓ, pose problems for the treatment of raw potable water. An annual average chl-a concentration of 30 µg/ℓ is also considered to be hypertrophic (unacceptable).

Usually it is the peaks of algal development (the blooms) that cause the management problems in most rivers and reservoirs. The maximum chl-a in the Vaal Barrage was 232 µg/ℓ. In severely enriched (eutrophic to hypertrophic) systems the problem worsens in that the duration of the blooms is extended.

It was established in the Vaal Barrage that the maximum chl-*a* concentration during a specific annual cycle was related statistically significantly to the mean chl-*a* of the same year. The importance of this relationship lies in the fact that it might allow the prediction of extreme nuisance conditions that could be expected with increased mean annual chlorophyll-*a* concentrations in the Vaal River.

Vaal River system – Status Quo:

Water quality data collected during the past ten years in the middle Vaal River, indicated the flow in the river has decreased, the total dissolved salts, alkalinity and phosphates have increased, however, the nitrate concentrations showed an decreasing trend.

The upper Vaal River, i.e. from the origin to the Grootdraai Dam, is in a fairly good condition with slight modification from natural conditions. Based on the mean annual chlorophyll-*a* concentration, Grootdraai Dam (mean, 9.7 µg/ℓ) can be classified as oligo-mesotrophic.

In the Vaal River (main stream), the annual average phosphate (PO_4-P) concentrations were high and ranged between 29 and 317 µg/ℓ (mean, 112 µg/ℓ). In addition, the PO_4-P concentration in the Vaal River has increased significantly during the last ten years. As a result of excessive nutrient loading, growth of algae progresses exponentially.

However, the Middle Vaal River has been classified as hypertrophic (nutrient over-enriched). The average chlorophyll-*a* concentration in the Middle Vaal River ranged between 35 and 66 µg/ℓ.

Phytoplankton biomass in middle Vaal River has increased significantly over the last 30 years, e.g.:

- In 1973, 92 % of the samples from the Vaal Barrage had Chl-a levels below 5 µg/ℓ.
- By 1982, 87 % of samples had Chl-a levels exceeding 15 µg/ℓ, while 34 % of samples exceeded 35 µg/ℓ.
- In 2005, 92 % of samples had Chl-a levels exceeding 15 µg/ℓ, while 57 % of samples exceeded 35 µg/ℓ.

The eutrophication effects and problems are profound in the Vaal River and have become a matter of major concern to all water users. The impacts are ecological, social and economical.

The middle Vaal River ecosystem is seriously impaired and continues to degrade at alarming rates. The scale of nutrient inputs far exceeds the capacity of the natural environment to assimilate the waste.

Predictive relationship approach – Vaal River:

The relationship between external nutrient loading and algal biomass is one of the best established patterns in limnology. Clearly, excessive densities of algal biomass first and foremost require high nutrient levels to produce that biomass. The essence of the quantification of the effect of eutrophication is to determine ‘how much phytoplankton’ for ‘how much nutrients’.

Few studies are available which relate phosphorus and eutrophication trends in rivers. In the Vaal River, the relationship between phosphate and chlorophyll (empirical regression) is best illustrated by data from the Vaal Barrage (**Figure 10**). Phosphate is the dominant P fraction (mean 71 % of TP). Unfortunately only limited TP data for the Vaal Barrage is available.

The average phosphate in the Vaal Barrage during the last three years was 375 µg/ℓ and the annual average chlorophyll-a was 53 µg/ℓ, i.e. hypertrophic conditions (red drop line in **Figure 10**), which correspond very well with the predicted line (blue line) in **Figure 10**. Therefore, if the average phosphate in the Barrage is reduced to 250 µg/ℓ (34 %), then we can predict that the average chlorophyll-***a*** concentration will probably drop to about 30 µg/ℓ (± 10 µg/ℓ), i.e. still eutrophic conditions.

The best case scenario would be if the mean phosphate concentration can be reduced to 150 µg/ℓ (by 60 %), then the predicted average chlorophyll-***a*** concentration in the Vaal Barrage could be ideal at 20 µg/ℓ (± 5 µg/ℓ), i.e. mesotrophic conditions.

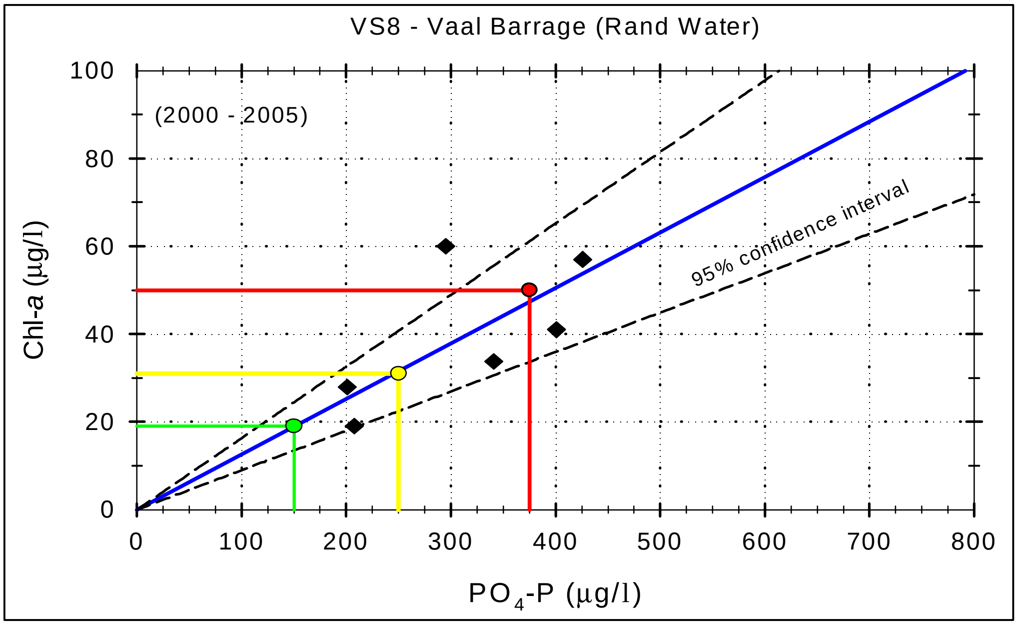


Figure 10: Relationship between the average phosphate (annual) and chlorophyll-*a* concentration in the Vaal Barrage (2000 – 2005).

<u>Recommendations</u>

The purpose of the RWQO's for nutrients is to develop nutrient criteria to address cultural eutrophication (waters enriched with nutrients because of human activities) and associated impacts in the Vaal River.

The nutrient targets were set to keep mean Chl-a concentrations below 30 µg/ℓ because this value is generally considered undesirable (hypertrophic).

Because phytoplankton biomass tends to be highly variable, changing from upstream to downstream within a river system, it is not possible to develop a single criteria value for phosphorus applicable to the whole river.

Pragmatic management targets vary between 30 and 100 µg/ℓ phosphate (soluble reactive phosphorus) with an interim target of 150 µg/ℓ for the heavily enriched sections of the Vaal River. However, it is recommended that monitoring for both total and soluble forms of phosphorus and nitrogen to continue the study of point and non-point source impacts on the river.

Under these conditions, it is foreseen that the eutrophication status (nutrient quality) of the Vaal River will significantly improve and be acceptable for general uses such as drinking water, recreation and irrigation.

5 CONCLUSION

From the assessment conducted, a revised set of RWQOs have been recommended. The key river reaches and tributaries that require revision of the RWQOs are apparent and the water quality variables requiring attention have been highlighted. In order to ensure that the water quality of the Vaal River System is maintained or improved, the RWQOs proposed will have to be adopted. In addition to manage the poor water quality that is observed in the Middle and Lower Vaal reaches some stringent control is required in the Vaal Barrage, downstream Barrage catchment and KOSH area in order to alleviate the impacts that are faced by the downstream users and by the river system itself. While salinity is still a problem and an acceptable RWQO for all users in the system still needs to be agreed upon, the threatening issue currently is the nutrients in the system that is causing severe eutrophication. The final RWQOs that are adopted are also dependent on the flow requirements and related operating rules of the Vaal River System. Thus once the modelling runs for the reconciliation strategy are complete incorporating various proposed water quality management options, the RWQOs that could be holistically and realistic achieved can be confirmed. While change is definitely a necessity, the level to which this can happen is dependent on the viable options that can be cost-effectively implemented. Thus the economic implications for achievement and the impact on the downstream user also needs to be considered. The economic impact modelling related to the final management options and operating rules would also be a key determinant in the RWQOs that are adopted.

Setting the RWQOs is one component; the second more important component is its implementation and compliance, which extends beyond the study. Thus the formation of an implementation task team to take these RWQOs forward is critical to ensuring that effective management of the Vaal River does occur into the future.

While this study aims to set integrated, an acceptable level and realistic RWQOs for managing water quality, other initiatives to be undertaken by DWAF such as catchment visioning and water resource classification would have to take these RWQOs forward and refine them accordingly to meet the goals of these processes and that of the respective Catchment Management Strategies. However the flaw with current processes is that it lacked an “integrated” stakeholder grouping/team that considered the Vaal River System as a whole. Thus for these future water resource management initiatives it is imperative that the implementation task team or a formal institutional structure that is borne out of the task team be established to ensure that the integration and alignment is maintained between the WMAs into the future so that all users and the system itself benefits.

6 WAY FORWARD

A number of proposed changes and recommendations to existing RWQOs have been made. The Department as the custodian of the RWQOs has accepted these recommendations and the RWQOs now have to be sanctioned by the Project Steering Committee for the study. These revised set of RWQOs would then be the output of the study, and it would then be the responsibility of the relevant DWAF Directorates and Regional Offices to take back final agreed upon RWQOs to the relevant institutional structures in their management areas to ensure implementation. The revised RWQOs would then form the basis for management in the various sub-catchments of the Vaal River.

A further related component to the RWQOs is the current Comprehensive Vaal River Reserve determination study that is underway. The Reserve requirements (water quality ecospecs determined through TEACHA) and the water user requirements (existing and proposed RWQOs) will have to integrated to define the final integrated RWQOs for the system which is also dependent on the modelling runs and flow requirements of the system. The final RWQOs proposed will thus be confirmed once all these processes are complete.

Once the Reserve is determined for the Vaal River (by 2010) the RWQOs that are established through this study could be gazetted as part of the RQOs that are set as part of the classification process for the Vaal River System.

7 REFERENCES

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APPENDIX A

RESOURCE WATER QUALITY OBJECTIVES

Level 1: Sub-unit 1 - Grootdraai catchment (VS1, VS2 and VS3)

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Conductivity	mS/m	< 10	10 - 15	15 - 25	> 25
Alkalinity ($CaCO_3$)	mg/l	< 20	20 - 45	45 - 75	> 75
pH	pH units				< 6.4 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.08	0.08 - 1	> 1
Sulphate (SO_4)	mg/l	< 10	10 - 20	20 - 30	> 30
Nitrate (NO_3)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Ammonia (NH_4)	mg/l	< 0.02	0.02 - 0.5	0.5 - 1	> 1
SAR		< 4	4 - 8	8 - 12	> 12
Chloride (Cl)	mg/l	< 10	10 - 15	15 - 20	> 20
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 15	15 - 25	> 25

Level 1: Sub-unit 2 - Grootdraai catchment (VS4)

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Conductivity	mS/m	< 15	15 - 30	30 - 50	> 50
Alkalinity ($CaCO_3$)	mg/l	< 40	40 - 70	70 - 100	> 100
pH	pH units				< 6.4 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Sulphate (SO_4)	mg/l	< 15	15 - 35	35 - 50	> 50
Nitrate (NO_3)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Ammonia (NH_4)	mg/l	< 0.02	0.02 - 0.5	0.5 - 1	> 1
SAR		< 4	4 - 8	8 - 12	> 12
	mg/l	< 10	10 - 20	20 - 30	> 30
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 20	20 - 35	> 35

Level 1: Sub-unit 3 - Vaal Dam (VS 5 and VS6)

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Ammonia (NH_4)	mg/l	< 0.2	0.2 - 0.5	0.5 - 1.0	> 1.0
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 15	15 - 20	> 20
Chloride (Cl)	mg/l	< 25	25 - 50	50 - 75	> 75
Conductivity	mg/l	< 10	10 - 30	30 - 45	> 45
Faecal coliforms	per 100 ml	< 10	10 - 60	60 - 120	> 120
Fluoride (F)	mg/l	< 0.05	0.05 - 0.20	0.20 - 0.40	> 0.40
M - Alkalinity ($CaCO_3$)	mg/l	< 40	40 - 75	75 - 120	> 120
Nitrate (NO_3)	mg/l	< 0.1	0.1 - 0.2	0.2 - 0.3	> 0.3
pH	pH units	6.5 - 8.5			< 6.5 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
SAR		< 4	4 - 8	8 - 12	> 12
Sulphate (SO_4)	mg/l	< 20	20 - 45	45 - 70	> 70

Level 1: Sub-unit 4 - Vaal Barrage (VS7 and VS8)

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Physical					
Conductivity	mS/m	< 18	18 - 30	30 - 70	> 70
Dissolved Oxygen (O_2)	mg/l		> 6	5 - 6	< 5
pH	mg/l	7.0 - 8.4	6.5 - 8.5	9.0 - 9.0	< 6.0 & > 9.0
Suspended Solids	mg/l	< 20	20 - 30	30 - 55	> 55
Organic					
Atrazine	ug/l	< 5	5 -10	10 - 20	> 20
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 20	20 - 30	> 30
Phenols	mg/l		< 0.01	0.01 - 0.1	> 0.1
Macro Elements					
Aluminium (Al)	mg/l		< 0.3	0.3 - 0.5	> 0.5
Ammonia (NH_4)	mg/l		< 0.5	0.5 - 1.0	> 1.0
Chloride (Cl)	mg/l	< 5	5 - 50	50 - 75	> 75
Fluoride (F)	mg/l	< 0.19	0.19 - 0.70	0.70 - 1.00	> 1.00
Iron (Fe)	mg/l		< 0.5	0.5 - 1.0	> 1.0
Magnesium (Mg)	mg/l	< 8	8 - 30	30 - 70	> 70
Manganese (Mn)	mg/l		< 0.15	0.15 - 0.20	> 0.20
Nitrate (NO_3)	mg/l	< 0.5	0.5 - 3.0	3.0 - 6.0	> 6.0
Phosphate (PO_4)	mg/l		< 0.03	0.03 - 0.05	> 0.05
Sodium (Na)	mg/l	< 15	15 - 50	50 - 100	> 100
Sulphate (SO_4)	mg/l	< 20	20 - 100	100 - 200	> 200
Bacteriological					
Faecal coliforms	counts/100 ml		< 126	126 - 1000	< 1000
Biological					
Daphnia	% survival	100	90 - 100	80 - 90	< 80

Level 1: Sub-unit 5 - Downstream Vaal Barrage (VS9)

Variable	Measured as	Ideal	Tolerable
Conductivity	mS/m	30	68
Sodium (Na)	mg/l	40	50
Sulphate (SO_4)	mg/l	80	140
Chloride (Cl)	mg/l	50	50
Nitrate (NO_3)	mg/l	0.7	0.7
Phosphate (PO_4)	mg/l	0.077	0.2
Boron (B)	mg/l	0.12	0.2
Fluoride (F)	mg/l	0.5	0.5
Manganese (Mn)	mg/l	0.1	0.15
Phenols	mg/l	0.004	0.01
pH	pH units	6.5 - 8.4	6.5 - 8.4
Ammonia (NH_4)	mg/l	0.015	0.07

Iron (Fe)	mg/l	0.1	0.2
Aluminium (Al)	mg/l	0.03	0.15

Level 1: Sub-unit 6 - Middle Vaal (VS10 to VS15)

Variable	Measured as	Acceptable
Physical		
Conductivity	mS/m	90
pH	pH units	6.5 - 8.4
Suspended Solids	mg/l	75
Organic		
Chemical Oxygen Demand (COD)	mg/l	75
Macro Elements		
Aluminium (Al)	mg/l	0.01
Ammonia (NH_4)	mg/l	0.1
Chloride (Cl)	mg/l	100
Nitrate (NO_3)	mg/l	3
Phosphate (PO_4)	mg/l	0.03
Sodium (Na)	mg/l	70
Silica (diatoms)		To be determined
Sulphate (SO_4)	mg/l	250
Total Dissolved Salts (TDS)	mg/l	630
Bacteriological		
Faecal coliforms	counts/100 ml	1
Biological		
Daphnia	% survival	90 - 100
Algae	mg/l Chl-a	0.001*

* to be confirmed through eutrophication assessment task

Level 1: Sub-unit 7 - Lower Vaal (VS 16 - VS 20)

Variable	Measured as	Acceptable
Physical		
Conductivity	mS/m	120
pH	pH units	6.5 - 8.4
Suspended Solids	mg/l	75
Organic		
Chemical Oxygen Demand (COD)	mg/l	75
Macro Elements		
Aluminium (Al)	mg/l	0.01
Ammonia (NH_4)	mg/l	0.1
Calcium (Ca)	mg/l	53
Chloride (Cl)	mg/l	100

Magnesium (Mg)	mg/l	41
Nitrate (NO_3)	mg/l	3
Phosphate (PO_4)		0.04
Sodium (Na)	mg/l	70
Sulphate (SO_4)	mg/l	250
Total Dissolved Salts (TDS)	mg/l	840
Bacteriological		
Faecal coliforms	counts/100 ml	1
Biological		
Daphnia	% survival	90 - 100
Algae	mg/l Chl-a	0.001*

* to be confirmed through eutrophication assessment task

Level 2: Sub-unit 1 - Vaal Origin

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Conductivity	mS/m	< 10	10 - 15	15 - 25	> 25
Alkalinity ($CaCO_3$)	mg/l	< 20	20 - 45	45 - 75	> 75
pH	pH units				< 6.4 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.08	0.08 - 1	> 1
Sulphate (SO_4)	mg/l	< 10	10 - 20	20 - 30	> 30
Nitrate (NO_3)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Ammonia (NH_4)	mg/l	< 0.02	0.02 - 0.5	0.5 - 1	> 1
SAR		< 4	4 - 8	8 - 12	> 12
Chloride (Cl)	mg/l	< 10	10 - 15	15 - 20	> 20
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 15	15 - 25	> 25

Level 2: Sub-unit 2 - Schulpspruit

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Conductivity	mS/m	< 10	10 - 15	15 - 25	> 25
Alkalinity ($CaCO_3$)	mg/l	< 20	20 - 45	45 - 75	> 75
pH	pH units				< 6.4 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.08	0.08 - 1	> 1
Sulphate (SO_4)	mg/l	< 10	10 - 20	20 - 30	> 30
Nitrate (NO_3)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Ammonia (NH_4)	mg/l	< 0.02	0.02 - 0.5	0.5 - 1	> 1
SAR		< 4	4 - 8	8 - 12	> 12
Chloride (Cl)	mg/l	< 10	10 - 15	15 - 20	> 20
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 15	15 - 25	> 25

Level 2: Sub-unit 3 - Blesbokspruit

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Conductivity	mS/m	< 15	15 - 30	30 - 50	> 50
Alkalinity ($CaCO_3$)	mg/l	< 40	40 - 80	80 - 120	> 120
pH	pH units				< 6.4 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Sulphate (SO_4)	mg/l	< 15	15 - 35	35 - 50	> 50
Nitrate (NO_3)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Ammonia (NH_4)	mg/l	< 0.02	0.02 - 0.5	0.5 - 1	> 1
SAR		< 4	4 - 8	8 - 12	> 12
Chloride (Cl)	mg/l	< 25	25 - 50	50 - 70	> 70
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 20	20 - 35	> 35

Level 2: Sub-unit 4 - Leeuspruit

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Conductivity	mS/m	< 15	15 - 30	30 - 50	> 50
Alkalinity ($CaCO_3$)	mg/l	< 40	40 - 70	70 - 100	> 100
pH	pH units				< 6.4 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Sulphate (SO_4)	mg/l	< 15	15 - 35	35 - 50	> 50
Nitrate (NO_3)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Ammonia (NH_4)	mg/l	< 0.02	0.02 - 0.5	0.5 - 1	> 1
SAR		< 4	4 - 8	8 - 12	> 12
Chloride (Cl)	mg/l	< 10	10 - 20	20 - 30	> 30
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 20	20 - 35	> 35

Level 2: Sub-unit 5 - Klip River Catchment (Free State)

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Ammonia (NH_4)	mg/l	< 0.2	0.2 - 0.5	0.5 - 1.0	> 1.0
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 15	15 - 20	> 20
Chloride (Cl)	mg/l	< 25	25 - 50	50 - 75	> 75
Conductivity	mg/l	< 10	10 - 30	30 - 45	> 45
Faecal coliforms	per 100 ml	< 10	10 - 60	60 - 120	> 120
Fluoride (F)	mg/l	< 0.05	0.05 - 0.20	0.20 - 0.40	> 0.40
M - Alkalinity ($CaCO_3$)	mg/l	< 40	40 - 75	75 - 120	> 120
Nitrate (NO_3)	mg/l	< 0.1	0.1 - 0.2	0.2 - 0.3	> 0.3
pH	pH units	6.5 - 8.5			< 6.5 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
SAR		< 4	4 - 8	8 - 12	> 12
Sulphate (SO_4)	mg/l	< 20	20 - 45	45 - 70	> 70

Level 2: Sub-unit 6 - Waterval River Catchment

Variable	Measured as	Ideal	Acceptable	Tolerable
Conductivity	mS/m	40	90	370
pH upper	pH units	8.4	9	10
pH lower	pH units	6.5	5	4
Nitrate (NO_3)	mg/l	0.5	2.5	10
Fluoride (F)	mg/l	0.7	1	1.5
Sulphate (SO_4)	mg/l	60	100	200
Sodium (Na)	mg/l	50	100	200
Potassium (K)	mg/l	25	50	100
Magnesium (Mg)	mg/l	23	50	70
Calcium (Ca)	mg/l	80	150	300
Chloride (Cl)	mg/l	75	150	300
Ammonia (NH_4)	mg/l	0.025	0.3	0.8
Nitrite	mg/l	0.06	0.25	5
Orthophosphate	mg/l	0.005	0.025	0.25
Total Hardness	CaCO3 mg/l	200	300	600
Sodium Adsorption Ratio	units	3	6	12
Faecal Coliforms	CFU/100ml	1	600	2000

Level 2: Sub-unit 7 - Wilge River

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Conductivity	mS/m	< 10	10 - 30	30 - 45	> 45
Alkalinity ($CaCO_3$)	mg/l	< 30	30 - 80	80 - 120	> 120
pH	pH units	> 6.4 - 8.5	> 6.4 - 8.5	> 6.4 - 8.5	> 6.4 - 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.15	0.15 - 0.3	> 0.3
Sulphate (SO_4)	mg/l	< 5	5- 10	10 - 15	> 15
Nitrate (NO_3)	mg/l	< 0.1	0.1 - 0.2	0.2 - 0.3	> 0.3
Ammonia (NH_4)	mg/l	< 0.05	0.05 - 0.1	0.1 - 0.2	> 0.2
Fluoride (F)	mg/l	< 0.05	0.05 - 0.1	0.1 - 0.2	> 0.2
Chloride (Cl)	mg/l	< 5	5 - 10	10 - 15	> 15
Chemical Oxygen Demand (COD)	mg/l	< 5	5 - 15	15 - 25	> 25

Level 2: Sub-unit 8 - Blesbokspruit Catchment

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Physical					
Conductivity	mS/m	< 45	45 - 70	70 - 120	> 120
Dissolved Oxygen (O_2)	mg/l		> 6	5 - 6	> 5

pH	mg/l	6.5 - 8.5			< 6.5 & > 8.5
Suspended Solids	mg/l	< 20	20 - 30	30 - 55	> 55
Organic					
Chemical Oxygen Demand (COD)	mg/l	< 20	20 - 35	35 - 55	> 55
Macro Elements					
Aluminium (Al)	mg/l		< 0.3	0.3 - 0.5	> 0.5
Ammonia (NH_4)	mg/l	< 0.1	0.1 - 1.5	1.5 - 5.0	> 5.0
Chloride (Cl)	mg/l	< 80	80 - 150	150 - 200	> 200
Fluoride (F)	mg/l	< 0.19	0.19 - 0.70	0.70 - 1.00	> 1.00
Iron (Fe)	mg/l	< 0.1	0.1 - 0.5	0.5 - 1.0	> 1.0
Magnesium (Mg)	mg/l	< 8	8 - 30	30 - 70	> 70
Manganese (Mn)	mg/l	< 0.2	0.2 - 0.5	0.5 - 1.0	> 1.0
Nitrate (NO_3)	mg/l	< 0.5	0.5 - 3.0	3.0 - 6.0	> 6.0
Phosphate (PO4)	mg/l	< 0.2	0.2 - 0.4	0.4 - 0.6	> 0.6
Sodium (Na)	mg/l	< 70	70 - 100	100 - 150	> 150
Sulphate (SO_4)	mg/l	< 150	150 - 300	300 - 500	> 500
Bacteriological					
Faecal coliforms	counts/100 ml		< 126	126 - 1000	> 1000
Biological					
Daphnia	% survival	100	90 - 100	80 - 90	< 80

Level 2: Sub-unit 9 - Klip River Catchment (Gauteng)

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Physical					
Conductivity	mS/m	< 80	80 - 100	100 - 150	> 150
Dissolved Oxygen (O_2)	mg/l		> 6	5 - 6	< 5
pH	mg/l	6.0 - 9.0			< 6.0 & > 9.0
Suspended Solids	mg/l	< 20	20 - 30	30 - 55	> 55
Organic					
Chemical Oxygen Demand (COD)	mg/l	< 15	15 - 30	30 - 40	> 40
Macro Elements					
Ammonia (NH_4)	mg/l	< 0.5	0.5 - 1.5	1.5 - 4.0	> 4.0
Chloride (Cl)	mg/l	< 50	50 - 75	75 - 100	> 100
Fluoride (F)	mg/l	< 0.19	0.19 - 0.70	0.70 - 1.00	> 1.00
Iron (Fe)	mg/l	< 0.5	0.5 -1.0	1.0 - 1.5	> 1.5
Manganese (Mn)	mg/l	< 1	1.0 - 2.0	2.0 - 4.0	> 4
Nitrate (NO_3)	mg/l	< 2	2.0 - 4.0	4.0 - 7.0	> 7
Phosphate (PO_4)	mg/l	< 0.2	0.2 - 0.5	0.5 - 1.0	> 1.0
Sodium (Na)	mg/l	< 50	50 - 80	80 - 100	> 100
Sulphate (SO_4)	mg/l	< 200	200 - 350	350 - 500	> 500
Bacteriological					

Faecal coliforms	counts/100 ml	< 1000	1000 - 5000	5000 - 10 000	> 10 000
Biological					
Daphnia	% survival	> 95	95 - 90	90 - 80	< 80

Level 2: Sub-unit 10.1 - Taaibosspruit Catchment

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Physical					
Conductivity	mS/m	< 42	42 - 60	60 - 70	> 70
Dissolved Oxygen (O_2)	mg/l		> 6	5 - 6	< 5
pH	mg/l		7.0 - 8.5	7.0 - 9.0	< 7.0 & > 9.0
Suspended Solids	mg/l	< 27	27 - 50	50 - 90	> 90
Organic					
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 15.0	15 - 20	> 20
Macro Elements					
Aluminium (Al)	mg/l	< 0.15	0.15 - 0.50	0.50 - 1.00	> 1.00
Ammonia (NH_4)	mg/l	< 0.25	0.25 - 0.50	0.50 - 1.00	> 1.00
Chloride (Cl)	mg/l	< 50	50 - 60	60 - 75	> 75
Fluoride (F)	mg/l	< 0.40	0.40 - 0.70	0.70 - 1.00	> 1.00
Iron (Fe)	mg/l	< 0.4	0.4 - 0.5	0.5 - 0.8	> 0.8
Magnesium (Mg)	mg/l	< 8	8 - 30	30 - 70	> 70
Manganese (Mn)	mg/l	< 0.2	0.2 - 0.5	0.5 - 1.0	> 1.0
Nitrate (NO_3)	mg/l	< 0.5	0.5 - 3.0	3.0 - 6.0	> 6.0
Phosphate (PO_4)	mg/l	< 0.2	0.2 - 0.4	0.4 - 0.6	> 0.6
Sodium (Na)	mg/l	< 70	70 - 100	100 - 150	> 150
Sulphate (SO_4)	mg/l	< 150	150 - 300	300 - 500	> 500
Bacteriological					
Faecal coliforms	counts/100 ml		< 126	126 - 1000	> 1000
Biological					
Daphnia	% survival	100	90 - 100	80 - 90	< 80

Level 2: Sub-unit 10.2 - Leeuspruit Catchment

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Physical					
Conductivity	mS/m	< 45	45 - 70	70 - 120	> 120
Dissolved Oxygen (O_2)	mg/l		> 6	5 - 6	< 5
pH	mg/l	6.5 - 8.5			< 6.5 & > 8.5
Suspended Solids	mg/l	< 20	20 - 30	30 - 55	> 55
Organic					

Chemical Oxygen Demand (COD)	mg/l	< 20	20 - 35	35 - 55	> 55
Macro Elements					
Aluminium (Al)	mg/l		< 0.3	0.3 - 0.5	> 0.5
Ammonia (NH_4)	mg/l	< 0.1	0.1 - 1.5	1.5 - 5.0	> 5.0
Chloride (Cl)	mg/l	< 80	80 - 150	150 - 200	> 200
Fluoride (F)	mg/l	< 0.19	0.19 - 0.70	0.70 - 1.00	> 1.00
Iron (Fe)	mg/l	< 0.1	0.1 - 0.5	0.5 - 1.0	> 1.0
Magnesium (Mg)	mg/l	< 8	8 - 30	30 - 70	> 70
Manganese (Mn)	mg/l	< 0.2	0.2 - 0.5	0.5 - 1.0	> 1.0
Nitrate (NO_3)	mg/l	< 0.5	0.5 - 3.0	3.0 - 6.0	> 6.0
Phosphate (PO_4)	mg/l	< 0.2	0.2 - 0.4	0.4 - 0.6	> 0.6
Sodium (Na)	mg/l	< 70	70 - 100	100 - 150	> 150
Sulphate (SO_4)	mg/l	< 150	150 - 300	300 - 500	> 500
Bacteriological					
Faecal coliforms	counts/100 ml		< 126	126 - 1000	> 1000
Biological					
Daphnia	% survival	100	90 - 100	80 - 90	< 80

Level 2: Sub-unit 10.3 - Kromelemboogspruit Catchment

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Physical					
Conductivity	mS/m	< 18	18 - 30	30 - 70	> 70
Dissolved Oxygen (O_2)	mg/l		> 6	5 - 6	< 5
pH	mg/l	7.0 - 8.4	6.5 - 8.5	9.0 - 9.0	< 6.0 & > 9.0
Suspended Solids	mg/l	< 27	27 - 50	50 - 90	> 90
Organic					
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 20	20 - 30	> 30
Macro Elements					
Aluminium (Al)	mg/l		< 0.3	0.3 - 0.5	> 0.5
Ammonia (NH_4)	mg/l		< 0.5	0.5 - 1.0	> 0.1
Chloride (Cl)	mg/l	< 5	5 - 50	50 - 75	> 75
Fluoride (F)	mg/l	< 0.19	0.19 - 0.70	0.70 - 1.00	> 1.00
Iron (Fe)	mg/l		< 0.5	0.5 - 1.0	> 1.0
Magnesium (Mg)	mg/l	< 8	8 - 30	30 - 70	> 70
Manganese (Mn)	mg/l		< 0.15	0.15 - 0.20	> 0.20
Nitrate (NO_3)	mg/l	< 0.5	0.5 - 3.0	3.0 - 6.0	> 6.0
Phosphate (PO_4)	mg/l		< 0.03	0.03 - 0.05	> 0.05
Sodium (Na)	mg/l	< 15	15 - 50	50 - 100	> 100
Sulphate (SO_4)	mg/l	< 20	20 - 100	100 - 200	> 200
Bacteriological					
Faecal coliforms	counts/100		< 126	126 - 1000	< 1000

	ml				
Biological					
Daphnia	% survival	100	90 - 100	80 - 90	< 80

Level 2: Sub-unit 11 - Rietspruit Catchment

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
Aluminium (Al)	mg/l	< 0.15	0.15 - 0.30	0.30 - 0.50	> 0.50
Ammonia (NH_4)	mg/l	< 0.25	0.25 - 5.0	5 - 10	> 10
Chemical Oxygen Demand (COD)	mg/l	< 20	20 - 30	30 - 55	> 55
Chloride (Cl)	mg/l	< 50	50 - 100	100 - 150	> 150
Conductivity	mg/l	< 30	30 - 70	70 - 100	> 100
Faecal coliforms	per 100 ml	< 131	131 - 4000	4000 - 10 000	> 10 000
Fluoride (F)	mg/l	< 0.2	0.2 - 0.4	0.4 - 0.8	> 0.8
Iron (Fe)	mg/l	< 0.1	0.1 - 0.5	0.5 - 1.0	> 1.0
Manganese (Mn)	mg/l	< 0.1	0.1 - 0.3	0.3 - 0.5	> 0.5
Nitrate (NO_3)	mg/l	< 1	1 - 3	3 - 6	> 6
pH	pH units	6.5 - 8.5			< 6.5 & > 8.5
Phosphate (PO_4)	mg/l	< 0.25	0.25 - 0.50	0.50 - 1.00	> 1.00
Sodium (Na)	mg/l	< 40	40 - 70	70 - 100	> 100
Sulphate (SO_4)	mg/l	< 100	100 - 200	200 - 300	> 300

Level 2: Sub-unit 12 - Mooi River

Variable	Measured as	Water Quality Objective
pH	pH units	8
Conductivity	mg/l	57
Total Dissolved Salts (TDS)	mg/l	370.5
Ammonia (NH_4)	mg/l	0.03
Nitrate (NO_3)	mg/l	0.3
Fluoride (F)	mg/l	0.25
Sodium (Na)	mg/l	47
Magnesium (Mg)	mg/l	30
Phosphate (PO_4)	mg/l	0.4
Sulphate (SO_4)	mg/l	75
Chloride (Cl)	mg/l	36
Calcium (Ca)	mg/l	47
Aluminium (Al)	mg/l	0.18
Manganese (Mn)	mg/l	0.03
Iron (Fe)	mg/l	0.35

Level 2: Sub-unit 13 - Middle Vaal, Schoonspruit and Koekemoerspruit Catchments

Variable	Measured as	Ideal	Acceptable	Tolerable	Unacceptable
pH	pH units	6.5 - 8.5			< 6.5 & > 8.5
Sulphate (SO_4)	mg/l	< 100	100 - 200	200 - 400	> 400
Total Dissolved Salts (TDS)	mg/l	< 200	200 - 400	400 - 600	> 600
Sodium (Na)	mg/l	< 70	70 - 100	100 - 200	> 200
Chloride (Cl)	mg/l	< 50	50 - 100	100 - 150	> 150
Manganese (Mn)	mg/l	< 0.05	0.05 - 0.1	0.1 - 0.3	> 0.3
Magnesium (Mg)	mg/l	< 30	30 - 100	100 - 500	> 500
Aluminium (Al)	mg/l	< 0.15	0.15 - 0.30	0.30 - 0.5	> 0.5
Ammonia (NH_4)	mg/l	< 0.25	0.25 - 1.0	1.0 - 5.0	> 5.0
Phosphate (PO_4)	mg/l	< 0.2	0.2 - 0.4	0.4 - 1.0	> 1.0
Faecal coliforms	counts/100 ml	< 150	150 - 200	200 - 1000	> 1000
Fluoride (F)	mg/l	< 0.7	0.7 - 1.0	1.0 - 2.0	> 2.0
Nitrate (NO_3)	mg/l	< 0.2	0.2 - 1.0	1.0 - 3.0	> 3.0
Iron (Fe)	mg/l	< 0.1	0.1 - 0.5	0.5 - 1.0	> 1.0
SAR		< 1.5	1.5 - 3.0	3.0 - 5.0	> 5.0

Level 2: Sub-units 14,15,16,17 and 18

Rhenoster/Vierfontein (14), Vals (15), Makwassie (16), Sandspruit (17) and Sand/Vet (18) Catchments

Variable	Units	Acceptable Range					
Management Unit		13	14	15	16	17	18
Nitrate	(mg/l)	0.2-1.0	0.6	2.0	3.5	0.9	Awaiting RWQOs from study
Ammonia	(mg/l)	0.25 -1.0	0.15	0.15	0.14	0.2	
Sulphate	(mg/l)	100-200	40	120	38	60	
Chloride	(mg/l)	50-100	30	100	52	107	
EC	(mS/m)	31-62	45	98	69	94	
TDS	(mg/l)	200-400	293	637	449	611	
Phosphate	(mg/l)	0.2-0.4	0.2	1.0	0.1	0.4	

Level 2: Sub-units 19 and 20

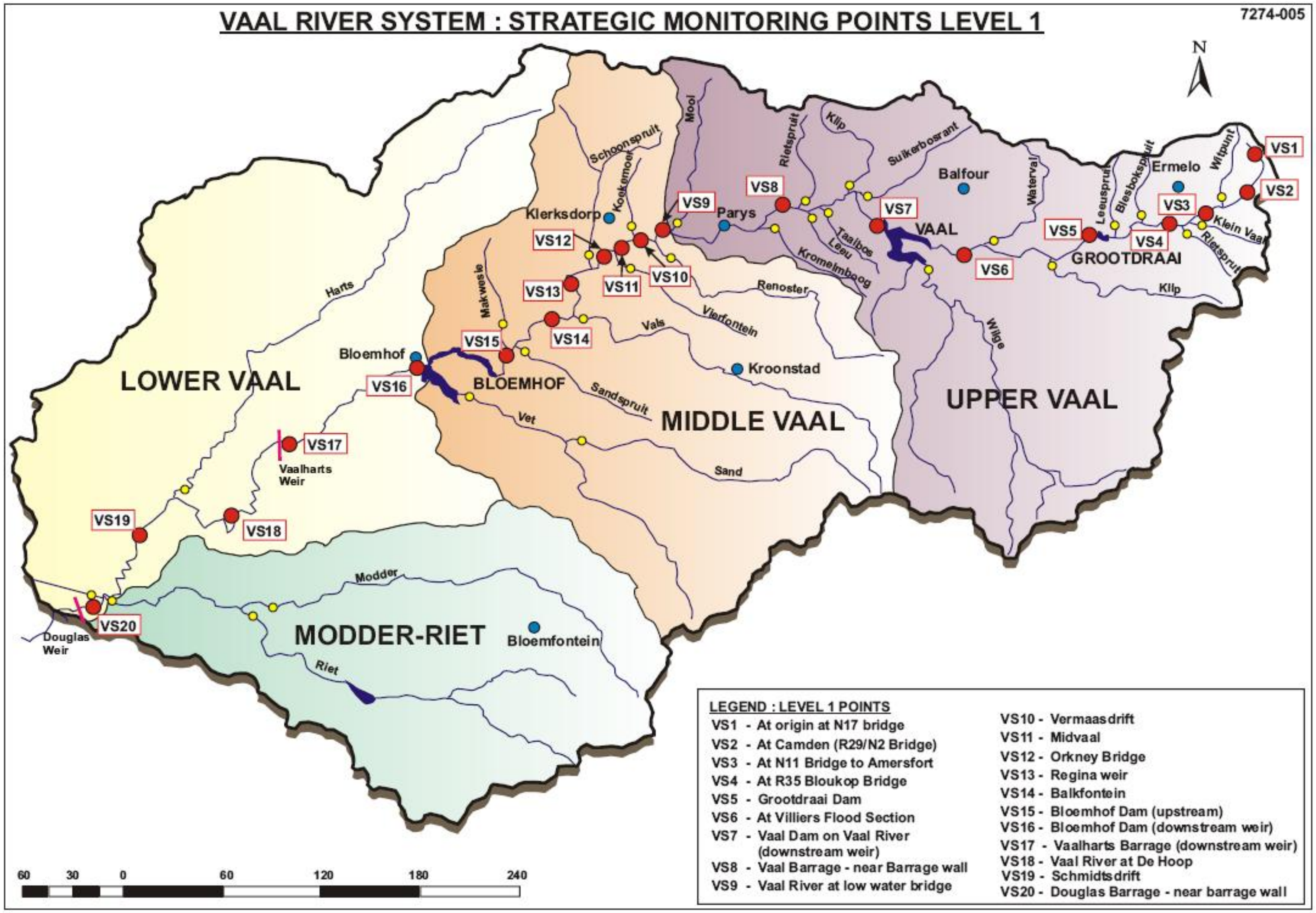
Harts (19) and Modder Riet (20) Catchment

Variable	Units	Acceptable Range:	
Management Unit		19	20
Nitrate	(mg/l)	3	Awaiting RWQOs from study
Ammonia	(mg/l)	0.1	
Sulphate	(mg/l)	250	
Chloride	(mg/l)	100	
EC	(mS/m)	120	
TDS	(mg/l)	840	
Phosphate	(mg/l)	0.04	

APPENDIX B

FIRST ORDER ASSESSMENT OF THE EXISTING RESOURCE WATER QUALITY OBJECTIVES

LEVEL 1


VAAL RIVER SYSTEM : STRATEGIC MONITORING POINTS LEVEL 1
7274-005
N
LOWER VAAL
MIDDLE VAAL
UPPER VAAL
MODDER-RIET
VS1
VS2
VS3
VS4
VS5
VS6
VS7
VS8
VS9
VS10
VS11
VS12
VS13
VS14
VS15
VS16
VS17
VS18
VS19
VS20
Ermelo
Balfour
Parys
Klerksdorp
Kroonstad
Bloemhof
BLOEMHOF
Bloemfontein
VAAL
GROOTDRAAI
Vaalharts Weir
Douglas Weir
Harts
Makwassie
Schoonspruit
Koekemoer
Mooi
Rietspruit
Klip
Suikerbosrant
Waterval
Leeuspruit
Blesbokspruit
Witpunt
Klein Vaal
Taaibos
Leeu
Kromelmboog
Renoster
Vierfontein
Vals
Wilge
Sandspruit
Vet
Sand
Modder
Riet
LEGEND : LEVEL 1 POINTS
VS1 - At origin at N17 bridge
VS2 - At Camden (R29/N2 Bridge)
VS3 - At N11 Bridge to Amersfort
VS4 - At R35 Bloukop Bridge
VS5 - Grootdraai Dam
VS6 - At Villiers Flood Section
VS7 - Vaal Dam on Vaal River (downstream weir)
VS8 - Vaal Barrage - near Barrage wall
VS9 - Vaal River at low water bridge
VS10 - Vermaasdrift
VS11 - Midvaal
VS12 - Orkney Bridge
VS13 - Regina weir
VS14 - Balkfontein
VS15 - Bloemhof Dam (upstream)
VS16 - Bloemhof Dam (downstream weir)
VS17 - Vaalharts Barrage (downstream weir)
VS18 - Vaal River at De Hoop
VS19 - Schmidtsdrift
VS20 - Douglas Barrage - near barrage wall
60 30 0 60 120 180 240

VS1: VAAL RIVER ORIGIN AT N17 BRIDGE									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.05	0.05	0.05	0.05	0.3	**0.05-0.25**	**0.03-0.10**	No need to change TDS (EC) RWQO. Current status within existing limits. Can protect current good water quality that exists. However nutrient levels must be more strictly controlled as indicated to maintain fairly natural conditions in catchment.
Ammonia	(mg/l) as N	0.05	0.05	0.2	0.2	2.1	**0.02-0.5**	**0.05-0.15**	
Sulphate	(mg/l)	5	5	12	16	24	**10-20**	**None**	
Chloride	(mg/l)	7.8	12	13	14	20	**10-15**	**None**	
EC	(mS/m)	8	9	10	12	16	**10-15**	**None**	
Phosphate	(mg/l) as P	0.05	0.05	0.05	0.05	0.1625	**0.05-0.08**	**0.03-0.08**	
Aluminium	mg/l							**0.05 - 0.10**	
TP	mg/l							**0.05 -0.15**	
TN	mg/l							**0.30-0.75**	
Algae	ug/l Chl-a							**10-20**	

VS2: VAAL RIVER AT R29/N2 BRIDGE AT CAMDEN									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.024	0.05	0.05	0.18	0.4	**0.05-0.25**	**0.03-0.10**	No need to change TDS (EC) RWQO, as upper part of catchment has water quality of fairly good quality. However some local impact source control/reduction is required to improve current status. Can achieve good quality that exists in rest of sub-catchment. However nutrient levels must be more stringent as indicated, as current status does indicate some nutrient pollution source.
Ammonia	(mg/l) as N	0.02	0.05	0.05	0.2	0.64	**0.02-0.5**	**0.05-0.15**	
Sulphate	(mg/l)	5	10	16	25.25	45.75	**10-20**	**None**	
Chloride	(mg/l)	6.3	10	13	17	20.7	**10-15**	**None**	
EC	(mS/m)	12	16	17	21	35.15	**10-15**	**None**	
TDS	(mg/l)	78	104	110.5	136.5	228.475	**65 -97.5**	**None**	
Phosphate	(mg/l) as P	0.05	0.05	0.075	0.2375	0.6225	**0.05-0.08**	**0.03-0.08**	
Aluminium	mg/l							**0.05 - 0.10**	
TP	mg/l							**0.05 -0.15**	
TN	mg/l							**0.30-0.75**	
Algae	ug/l Chl-a							**10-20**	

VS3: VAAL RIVER ON N11 BRIDGE TO AMERSFORT									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.05	0.05	0.05	0.2	0.315	**0.05-0.25**	**0.03-0.10**	No need to change TDS (EC) RWQO, as current water quality is fairly good quality. Can maintain current status. Some source control/reduction is required to bring current quality within the acceptable target range. Less stringent objectives for sulphate and chloride are however proposed in order to absorb the impact of the Witpuntspruit and Klein Vaal tributaries. These proposed objectives are within the limits for Grootdraai Dam. Management at source is also required to address current status. Nutrient levels must also be more stringent as indicated to protect fairly good quality observed.
Ammonia	(mg/l) as N	0.05	0.05	0.2	0.2	0.995	**0.02-0.5**	**0.05-0.15**	
Sulphate	(mg/l)	5	12.25	14.5	21.75	37.65	**10-20**	**20-30**	
Chloride	(mg/l)	5.25	7.75	10	12.25	15.5	**10-15**	**None**	
EC	(mS/m)	10.85	12.25	16.5	18.75	22.3	**10-15**	**15-20**	
TDS	(mg/l)	70.525	79.625	107.25	121.875	144.95	**65 -97.5**	**None**	
Phosphate	(mg/l) as P	0.05	0.05	0.05	0.05	0.6	**0.05-0.08**	**0.03-0.08**	
Aluminium	mg/l							**0.05 - 0.10**	
TP	mg/l							**0.05 -0.15**	
TN	mg/l							**0.30-0.75**	
Algae	ug/l Chl-a							**10-20**	

VS4: VAAL RIVER AT R35 BLOUKOP BRIDGE									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.05	0.10	0.30	0.74	**0.05-0.25**	**0.05-0.15**	No need to change TDS (EC) RWQO, as current water quality is fairly good and can be managed to acceptable range target objectives. Some source management is required to bring current quality within this range. This level of protection is required at VS4 in order to assimilate the impacts of the Leeuspruit and Blesbokspruit downstream, while at the same time maintaining good WQ in Grootdraai Dam. Nutrient RWQOs levels must be more stringent as indicated. Phosphate concentrations are high which could account for algal biomass observed.
Ammonia	(mg/l) as N	0.03	0.05	0.05	0.25	0.62	**0.02-0.5**	**0.05-0.15**	
Sulphate	(mg/l)	9.2	23.0	31.0	45.5	70.5	**15-35**	**None**	
Chloride	(mg/l)	9.3	11.3	16.0	19.0	28.3	**10-20**	**None**	
EC	(mS/m)	14.0	20.8	25.0	36.3	48.3	**15-30**	**None**	
TDS	(mg/l)	91	134.875	162.5	235.625	313.625	**97.5-195**	**None**	
Phosphate	(mg/l) as P	0.05	0.05	0.05	0.19	1.00	**0.05-0.25**	**0.03-0.01**	
Aluminium	mg/l							**0.05-0.10**	
TP	mg/l							**0.05-0.20**	
TN	mg/l							**0.5-0.75**	
Algae	ug/l Chl-a							**10-20**	

VS5: GROOTDRAAI DAM ON VAAL RIVER: NEAR DAM WALL									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.12	0.21	0.31	0.56	0.1-0.2	0.05-0.15	No need to change TDS (EC) RWQO. Current status within existing RWQOs limits. Can protect current good quality that exists. However need to determine long term influence of transfers (WQ deterioration picked up in donating catchments), as well as monitor impact of tributaries (further deterioration). Nutrient levels must be more strictly controlled as indicated. Impact of the Leeuspruit tributary could pose a threat to the nutrient status of Grootdraai Dam.
Ammonia	(mg/l) as N	0.04	0.04	0.04	0.06	0.09	0.2-0.5	0.02-0.05	
Sulphate	(mg/l)	14.5	18.9	22.7	26.8	32.3	20-45	None	
Chloride	(mg/l)	6.5	8.7	10.1	12.3	16.5	25-50	None	
EC	(mS/m)	17.5	21.6	23.5	25.6	28.5	10-30	None	
TDS	(mg/l)	119	154	167	180	200	65-195	None	
Phosphate	(mg/l) as P	0.01	0.01	0.02	0.03	0.07	0.05-0.25	0.02-0.05	
Aluminium	mg/l							0.3-0.10	
TP	mg/l							0.05-0.10	
TN	mg/l							0.5-1.00	
Algae	ug/l Chl-a							10-20	

VS6: VAAL RIVER AT VILLIERS FLOOD SECTION									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.04	0.11	0.26	0.79	0.1-0.2	0.05-0.15	Point is fairly impacted due to the confluence of the Waterval tributary. Need to change TDS RWQO at this point in order to assimilate this consistent impact. The Waterval tributary has a higher RWQO set for TDS thus the proposed changed to an upper limit of 50 is considered acceptable and a target that can be managed. This level RWQO is also suitable for local users (irrigation/power station). However local catchment source management is still required. Nutrients levels must also be managed more stringently. Stricter RWQOs proposed. High total phosphorus concentrations pose a serious threat for algal productivity.
Ammonia	(mg/l) as N	0.03	0.04	0.04	0.05	0.11	0.2-0.5	0.02-0.05	
Sulphate	(mg/l)	17.0	23.9	30.3	36.0	46.0	20-45	None	
Chloride	(mg/l)	7.8	11.3	15.7	22.8	32.0	25-50	None	
EC	(mS/m)	20.4	26.9	36.3	46.5	52.9	10-30	20-50	
TDS	(mg/l)	128	178	227.5	324	413	65-195	None	
Phosphate	(mg/l) as P	0.02	0.03	0.04	0.07	0.13	0.05-0.25	0.02-0.05	
Aluminium	mg/l							0.3-0.10	
TP	mg/l							0.05-0.10	
TN	mg/l							0.5-1.00	
Algae	ug/l Chl-a							10-20	

VS7: VAAL DAM ON VAAL RIVER: DOWN STREAM WEIR									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.14	0.25	0.41	0.66	**0.5-3**	**0.10-0.25**	Vaal Dam water quality is good. Current RWQOs can be maintained as long as Katse Dam water continues to enter the system. A change to the upper limit RWQO for sulphate has been proposed to protect current status, align RWQO to upstream objectives and to maintain good water quality status to meet water user requirements. Nutrients must also be managed with more stringent objectives as indicated. Increased phosphate trends could pose a threat if not managed. Increased levels of aluminium have been detected in Vaal Dam. Aluminium is becoming mobilised from the clays (natural sources) due to poor buffering capacity of the water in Vaal Dam.
Ammonia	(mg/l) as N	0.04	0.04	0.04	0.07	0.10	**<0.5**	**0.03-0.05**	
Sulphate	(mg/l)	7	12	17	22	30	**20-100**	**20-50**	
Chloride	(mg/l)	5	9	10	11	14	**5-50**	**None**	
EC	(mS/m)	13	18	22	24	27	**18-30**	**None**	
TDS	(mg/l)	94	126	155	175	198	**117-195**	**None**	
Phosphate	(mg/l) as P	0.01	0.02	0.03	0.05	0.10	**<0.03**	**0.02-0.05**	
Aluminium	mg/l							**0.10-0.25**	
TP	mg/l							**0.05-0.10**	
TN	mg/l							**0.30-0.50**	
F. coliforms	#/100ml							**50-150**	
Algae	ug/l Chl-a							**10-20**	

VS8: VAAL BARRAGE ON VAAL RIVER NEAR BARRAGE WALL									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l) as N	0.17	0.70	1.28	2.29	3.91	**0.5-3**	**0.25-1.50**	Vaal Barrage is the most critical area in the system. Current status indicates an overall non-compliance to RWQOs. RWQOs of tributaries are also not aligned to those of the Barrage. Need to improve the WQ to meets users' requirements in the Barrage and of those downstream. 450mg/l is class 0 drinking WQ standard. However the Barrage TDS objective needs a lot more interrogation. Can be increased to 600mg/l (current dilution rule). Any measure to remove the Grootvlei mine discharge from the system will be of benefit to the Barrage. Waters are hypertrophic (hotspot area). Nutrients levels also need to more strictly controlled to manage the increasing phosphate and nitrogen trends.
Ammonia	(mg/l)	0.02	0.02	0.04	0.13	0.51	**<0.5**	**0.10-0.25**	
Sulphate	(mg/l)	37.5	68.9	160.0	183.3	222.7	**20-100**	**None**	
Chloride	(mg/l)	14.3	23.3	56.0	68.2	76.8	**5-50**	**None**	
EC	(mS/m)	27.5	40.8	73.5	83.2	91.7	**18-30**	**70**	
TDS	(mg/l)	180.4	259.0	471.0	559.0	647.8	**117-195**	**450 vs 600**	
Phosphate	(mg/l) as P	0.06	0.12	0.18	0.25	0.61	**<0.03**	**0.10-0.25**	
Aluminium	mg/l							**0.15-0.30**	
TP	mg/l							**0.15-0.30**	
TN	mg/l							**1.00-3.00**	
F. coliforms	#/100ml						**<126**	**None**	
Algae	ug/l Chl-a							**25-50**	

VS9: VAAL RIVER LOW WATER BRIDGE AT KROMDRAAI									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
TDS	(mg/l)	285.41	444.44	539.45	580.14	619.6	**397**	**450 vs 600**	Will depend on Vaal Barrage Objective. However in terms of current status a TDS objective of 500-550mg/l would be an acceptable management target (accounts for upstream impact and caters for downstream impactors. Objective is suitable for acceptable drinking water standard). Currently nutrient RWQOs are adequate; however source control needs to improve as eutrophication problems occur from this point downstream. Nutrients are high enough to stimulate algal growth.
Nitrate	(mg/l) as N						**0.7**	**0.50-0.75**	
Sulphate	(mg/l)							**20-100**	
Chloride	(mg/l)							**5-50**	
Ammonium	(mg/l)						**0.015**	**0.1-0.15**	
Phosphate	(mg/l) as P						**0.077**	**0.05-0.10**	
Aluminium	mg/l						**0.03**	**0.15-0.30**	
TP	mg/l							**0.10-0.30**	
TN	mg/l							**0.75-1.50**	
F. coliforms	#/100ml							**50-150**	
Algae	ug/l Chl-a							**20-40**	

VS10: VERMAASDRIFT									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQO**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.4	0.5	0.5	2.3	2.5	**3**	**0.50-0.75**	RWQOs dependant on Vaal Barrage RWQOs as well as that of the Mooi catchment. The current RWQO for TDS is not unreasonable however need to consider user requirements (Water boards), future discharges and the desired protection level. A eutrophication problem exists through the Middle Vaal River to Bloemhof Dam. Waters are hypertrophic. Phosphate and nitrate concentrations are high. Nutrient levels thus require much more stringent control. Impacts are ecological, social and economic.
Ammonia	(mg/l) as N						**0.1**	**0.10-0.15**	
Sulphate	(mg/l)	49.12	109	149	178	209	**250**	**100**	
Chloride	(mg/l)	21.8	51	66	72	86.6	**100**	**50**	
EC	(mS/m)	35.6	63	78	84	90.6	**90**	**70 vs 92.5**	
TDS	(mg/l)	249.2	441	546	588	634.2	**630**	**450 vs 600**	
Phosphate	(mg/l) as P	0.1	0.19	0.34	0.53	0.9	**0.03**	**0.05-0.10**	
Aluminium	mg/l							**0.15-0.30**	
TP	mg/l							**0.10-0.30**	
TN	mg/l							**0.75-1.50**	
F. coliforms	#/100ml						**1**	**50-150**	
Algae	ug/l Chl-a							**20-40**	

VS11: MIDVAAL INTAKE

Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	RWQO	Proposed Changes	Reasoning
Nitrate	(mg/l)	0.5	0.5	0.55	2.3	2.5	3	0.50-0.75	RWQOs dependant on Vaal Barrage/upstream RWQOs. The current RWQO for TDS is not unreasonable however need to consider user requirements (Water boards), future discharges and the desired protection level. A TDS RWQO of 450 would suit the users in the catchment. A eutrophication problem exists through the Middle Vaal River to Bloemhof Dam. Waters are hypertrophic. Nutrient levels thus require much more stringent control. Impacts are ecological, social and economic. Water boards experience problems with bacteriological pollutants and organics as well.
Ammonia	(mg/l) as N						0.1	0.10-0.15	
Sulphate	(mg/l)	57.5	118	156	186.25	220.5	250	100	
Chloride	(mg/l)	24.75	54.75	69	74.5	86.5	100	50	
EC	(mS/m)	41	66	77	85	95	90	70 vs 92.5	
TDS	(mg/l)	287	463.75	539	596.75	665	630	450 vs 600	
Phosphate	(mg/l) as P	0.11	0.20	0.33	0.53	0.90	0.03	0.05-0.10	
Aluminium	mg/l							0.15-0.30	
TP	mg/l							0.10-0.30	
TN	mg/l							0.75-1.50	
F. coliforms	#/100ml						1	50-150	
Algae	ug/l Chl-a							20-40	

VS12: VAAL RIVER AT PILGRIMS ESTATE/ORKNEY

Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	RWQO	Proposed Changes	Reasoning
Nitrate	(mg/l)	0.28	0.5	0.6	2.3	2.5	3	0.50-0.75	RWQOs dependant on upstream RWQOs. The current RWQO for TDS is not unreasonable however need to consider user requirements (Water boards), future discharges and the protection level. The RWQO set for the Vaal Barrage will influence the RWQO set here. A eutrophication problem exists through the Middle Vaal River to Bloemhof Dam. Waters are hypertrophic. Nutrient levels thus require much more stringent control. Impacts are ecological, social and economic.
Ammonia	(mg/l) as N						0.1	0.10-0.15	
Sulphate	(mg/l)	53	125	179	208	242.4	250	100	
Chloride	(mg/l)	22.8	55	72	79	87.4	100	50	
EC	(mS/m)	39	69	82	92	103	90	70 vs 92.5	
TDS	(mg/l)	250.9	448.5	533	598	670.8	630	450 vs 600	
Phosphate	(mg/l) as P	0.05	0.17	0.29	0.53	0.98	0.03	0.05 -0.10	
Aluminium	mg/l							0.15-0.30	
TP	mg/l							0.10-0.30	
TN	mg/l							0.75-1.50	
F. coliforms	#/100ml						1	50-150	
Algae	ug/l Chl-a							20-40	

VS13: REGINA BRIDGE								
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQO**	**Proposed Changes**
Nitrate	(mg/l)	0.5	0.5	0.5	2.025	2.5	**3**	**0.50-0.75**
Ammonia	(mg/l) as N						**0.1**	**0.10-0.15**
Sulphate	(mg/l)	58	128	165.5	201	226.55	**250**	**100**
Chloride	(mg/l)	23	51.75	66	78.75	91.1	**100**	**50**
EC	(mS/m)	41	69	79	90	104	**90**	**70 vs 92.5**
TDS	(mg/l)	266.5	445.25	513.5	583.375	673.075	**630**	**450 vs 600**
Phosphate	(mg/l) as P	0.09	0.22	0.27	0.53	0.96	**0.03**	**0.05 -0.10**
Aluminium	mg/l							**0.15-0.30**
TP	mg/l							**0.10-0.30**
TN	mg/l							**0.75-1.50**
F. coliforms	#/100ml						**1**	**50-150**
Algae	ug/l Chl-a							**20-40**

Reasoning

RWQOs dependant on upstream RWQOs. The current RWQO for TDS is not unreasonable however need to consider user requirements (Water boards), future discharges and the desired protection level. The RWQO set for the Vaal Barrage will influence the RWQO set here. A eutrophication problem exists through the Middle Vaal River to Bloemhof Dam. Waters are hypertrophic. Nutrient levels thus require much more stringent control. Impacts are ecological, social and economic.

VS14: VAAL RIVER AT KLIPPLAATDRIFT								
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQO**	**Proposed Changes**
Nitrate	(mg/l)	0.04	0.04	0.1	0.4	0.9	**3**	**0.50-0.75**
Ammonia	(mg/l) as N	0.03	0.04	0.04	0.05	0.11	**0.1**	**0.10-0.15**
Sulphate	(mg/l)	40.3	86.2	163.4	217.4	265.4	**250**	**100**
Chloride	(mg/l)	13.6	27.6	56.2	76.3	96.0	**100**	**50**
EC	(mS/m)	30.1	48.0	74.6	91.8	106.2	**90**	**70 vs 92.5**
TDS	(mg/l)	211	362	528	650	807	**630**	**450 vs 600**
Phosphate	(mg/l) as P	0.03	0.06	0.09	0.15	0.27	**0.03**	**0.05 -0.10**
Aluminium	mg/l							**0.15-0.30**
TP	mg/l							**0.10-0.30**
TN	mg/l							**0.75-1.50**
F. coliforms	#/100ml						**1**	**50-150**
Algae	ug/l Chl-a							**20-40**

Reasoning

RWQOs dependant on upstream RWQOs. The current RWQO for TDS is not unreasonable however need to consider user requirements, future discharges and a certain protection level. The RWQO set for the Vaal Barrage will influence the RWQO set here. A eutrophication problem exists through the Middle Vaal River to Bloemhof Dam. Waters are hypertrophic. Phosphate and nitrogen concentrations are high. Nutrient levels thus require much more stringent control. Impacts are ecological, social and economic.

VS16: BLOEMHOF DAM ON VAAL RIVER: DOWN STREAM WEIR

Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	RWQO	Proposed Changes
Nitrate	(mg/l)	0.04	0.04	0.09	0.16	0.70	3	0.05 -0.15
Ammonia	(mg/l) as N	0.03	0.04	0.04	0.07	0.25	0.1	0.05-0.08
Sulphate	(mg/l)	37	60	103	139	204	250	100
Chloride	(mg/l)	12	24	38	54	83	100	50
EC	(mS/m)	28	42	54	68	91	120	70 vs 92.5
TDS	(mg/l)	204	270	373	450	599	840	450 vs 600
Phosphate	(mg/l) as P	0.01	0.02	0.03	0.04	0.07	0.04	0.02-0.03
Aluminium	mg/l							0.05-0.10
TP	mg/l							0.05-0.07
TN	mg/l							0.5 - 0.7
Algae	ug/l Chl-a							20-30

Reasoning

RWQOs need to be more stringent. The current RWQO for TDS is too high - based on current status. System cannot be managed to this level, Need to cater for the users and the ecosystem as well for future use. A eutrophication problem also exists through parts of the Lower Vaal River. Dam experiences frequent algal blooms and intense growth of water hyacinths. Nutrient levels thus require more stringent control. Impacts are ecological, social and economic.

VS17: VAALHARTS BARRAGE ON VAAL RIVER: DOWN STREAM WEIR

Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	RWQO	Proposed Changes
Nitrate	(mg/l)	0.04	0.04	0.06	0.14	0.59	3	0.10 -0.20
Ammonia	(mg/l) as N	0.02	0.04	0.04	0.05	0.09	0.1	0.05-0.10
Sulphate	(mg/l)	31	60	95	131	202	250	100
Chloride	(mg/l)	12	24	33	54	87	100	50
EC	(mS/m)	27	41	51	67	92	120	70 vs 92.5
TDS	(mg/l)	204	256	328	424	626	840	450 vs 600
Phosphate	(mg/l) as P	0.01	0.02	0.02	0.04	0.07	0.04	0.03 - 0.05
Aluminium	mg/l							<0.03-0.05
TP	mg/l							0.05-0.10
TN	mg/l							0.30-0.75
F. coliforms	#/100ml						1	50-150
Algae	ug/l Chl-a							10-15

Reasoning

RWQOs need to be more stringent. The current RWQO for TDS is too high - based on current status. System cannot be managed to this level. Need to cater for the users and the ecosystem as well for future use. A eutrophication problem also exists through parts of the Lower Vaal River. Significant growth of water hyacinth is observed. Nutrient levels thus require more stringent control. Impacts are ecological, social and economic.

VS18: VAAL RIVER AT DE HOOP

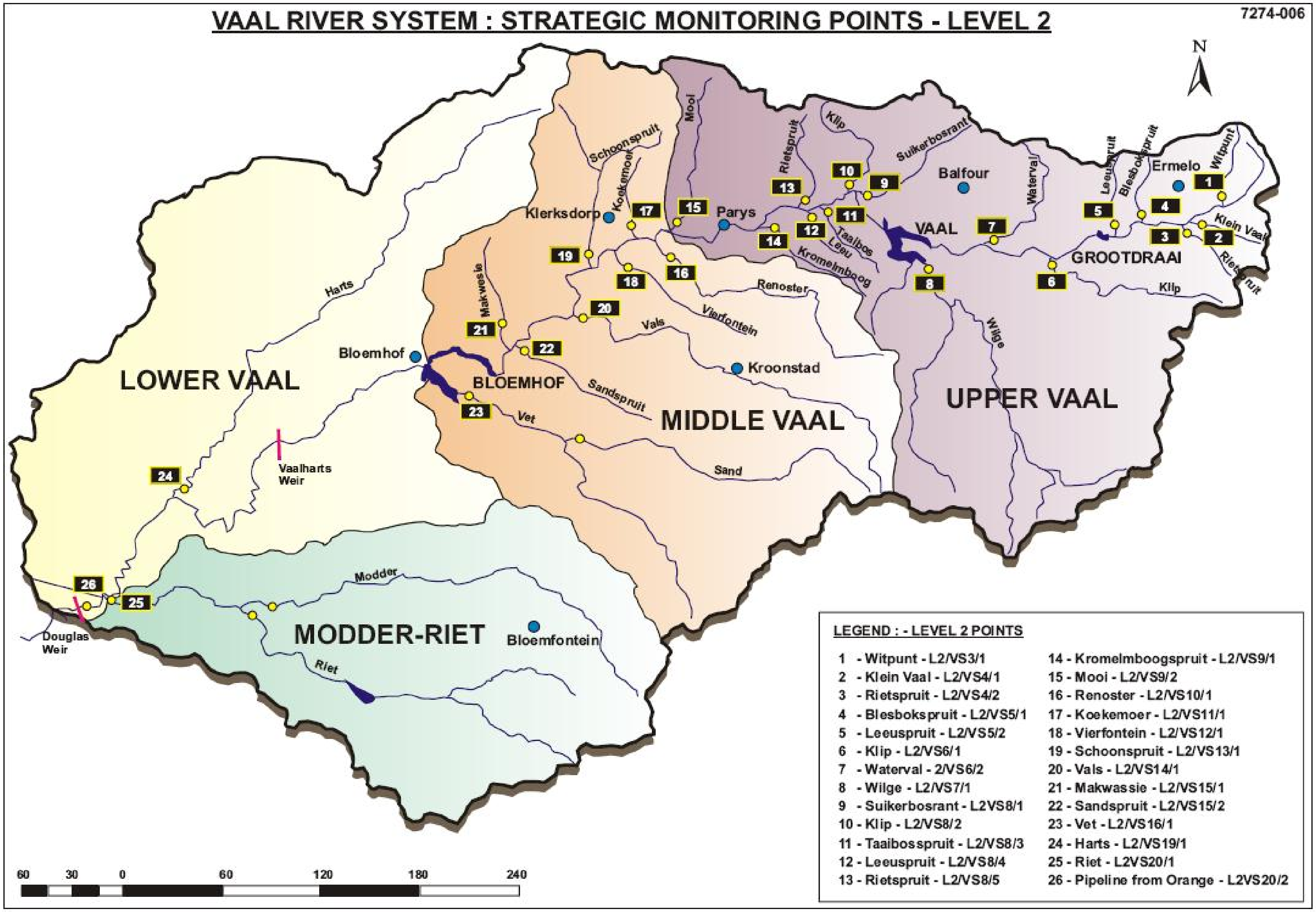
Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	RWQO	Proposed Changes	Reasoning
Nitrate	(mg/l)	0.04	0.04	0.04	0.08	0.55	3	0.10 -0.20	RWQOs need to be more stringent. The current RWQO for TDS is too high - based on current status. System cannot be managed to this level. Need to cater for the users and the ecosystem as well for future use. A eutrophication problem also exists through parts of the Lower Vaal River. Nutrient levels thus require more stringent control. Impacts are ecological, social and economic.
Ammonia	(mg/l) as N	0.02	0.04	0.04	0.04	0.08	0.1	0.05-0.10	
Sulphate	(mg/l)	37	65	88	150	250	250	100	
Chloride	(mg/l)	15	23	33	63	118	100	50	
EC	(mS/m)	32	41	51	75	113	120	70 vs 92.5	
TDS	(mg/l)	228	291	360	463	701	840	450 vs 600	
Phosphate	(mg/l) as P	0.01	0.01	0.02	0.03	0.07	0.04	0.03 - 0.05	
Aluminium	mg/l							<0.03-0.05	
TP	mg/l							0.05-0.10	
TN	mg/l							0.30-0.75	
F. coliforms	#/100ml						1	50-150	
Algae	ug/l Chl-a							10-15	

VS19: AT SCHMIDTSDRIFT (WEIR) ON VAAL RIVER

Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	RWQO	Proposed Changes	Reasoning
Nitrate	(mg/l)	0.04	0.04	0.04	0.09	0.39	3	0.10 -0.20	RWQOs need to be more stringent. The current RWQO for TDS is too high - based on current status. System cannot be managed to this level, Need to cater for the users and the ecosystem as well for future use. A eutrophication problem also exists through parts of the Lower Vaal River. Nutrient levels thus require more stringent control. Impacts are ecological, social and economic.
Ammonia	(mg/l) as N	0.02	0.04	0.04	0.04	0.07	0.1	0.05-0.10	
Sulphate	(mg/l)	51	84	135	169	230	250	100	
Chloride	(mg/l)	19	39	72	99	132	100	50	
EC	(mS/m)	36	53	76	89	120	120	70 vs 92.5	
TDS	(mg/l)	255	354	523	614	821	840	450 vs 600	
Phosphate	(mg/l) as P	0.01	0.01	0.02	0.03	0.08	0.04	0.03 - 0.05	
Aluminium	mg/l							<0.03-0.05	
TP	mg/l							0.05-0.10	
TN	mg/l							0.30-0.75	
F. coliforms	#/100ml						1	50-150	
Algae	ug/l Chl-a							10-15	

VS20: DOUGLAS BARRAGE ON VAAL RIVER: NEAR BARRAGE WALL										
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQO**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.05	0.12	0.24	0.57	**3**	**0.10 -0.20**	RWQOs need to be more stringent. The current RWQO for TDS is too high - based on current status. System cannot be managed to this level, Need to cater for the users and the ecosystem as well for future use. Harts River is a contributing factor to high toxic algal blooms as well as very high TDS. A local management strategy is needed for the Harts River if the WQ in the Vaal is to be improved. A eutrophication problem also exists through parts of the Lower Vaal River. Nutrient levels thus require more stringent control. Impacts are ecological, social and economic.
Ammonia	(mg/l) as N	0.03	0.04	0.04	0.06	0.12	**0.1**	**0.05-0.10**	
Sulphate	(mg/l)	26	69	118	180	235	**250**	**100**	
Chloride	(mg/l)	14	34	82	136	195	**100**	**50**	
EC	(mS/m)	28	47	73	103	135	**120**	**70 vs 92.5**	
TDS	(mg/l)	151	298	516	698	961	**840**	**450 vs 600**	
Phosphate	(mg/l) as P	0.01	0.02	0.02	0.03	0.07	**0.04**	**0.03 - 0.05**	
Aluminium	mg/l							**<0.03-0.05**	
TP	mg/l							**0.05-0.10**	
TN	mg/l							**0.30-0.75**	
F. coliforms	#/100ml						**1**	**50-150**	
Algae	ug/l Chl-a							**10-15**	

LEVEL 2



VAAL RIVER SYSTEM : STRATEGIC MONITORING POINTS - LEVEL 2
7274-006
N
LOWER VAAL
MIDDLE VAAL
UPPER VAAL
MODDER-RIET
Bloemhof
BLOEMHOF
Klerksdorp
Parys
Balfour
Ermelo
VAAL
GROOTDRAAI
Kroonstad
Bloemfontein
Vaalharts Weir
Douglas Weir
Harts
Schoonspruit
Koekemoer
Mooi
Rietspruit
Klip
Suikerbosrant
Waterval
Leeuspruit
Blesbokspruit
Witpunt
Klein Vaal
Rietspruit
Klip
Taaibos
Leeu
Kromelmboog
Renoster
Vierfontein
Vals
Makwassie
Sandspruit
Vet
Sand
Wilge
Modder
Riet
LEGEND : - LEVEL 2 POINTS
1 - Witpunt - L2/VS3/1
2 - Klein Vaal - L2/VS4/1
3 - Rietspruit - L2/VS4/2
4 - Blesbokspruit - L2/VS5/1
5 - Leeuspruit - L2/VS5/2
6 - Klip - L2/VS6/1
7 - Waterval - 2/VS6/2
8 - Wilge - L2/VS7/1
9 - Suikerbosrant - L2VS8/1
10 - Klip - L2/VS8/2
11 - Taaibosspruit - L2/VS8/3
12 - Leeuspruit - L2/VS8/4
13 - Rietspruit - L2/VS8/5
14 - Kromelmboogspruit - L2/VS9/1
15 - Mooi - L2/VS9/2
16 - Renoster - L2/VS10/1
17 - Koekemoer - L2/VS11/1
18 - Vierfontein - L2/VS12/1
19 - Schoonspruit - L2/VS13/1
20 - Vals - L2/VS14/1
21 - Makwassie - L2/VS15/1
22 - Sandspruit - L2/VS15/2
23 - Vet - L2/VS16/1
24 - Harts - L2/VS19/1
25 - Riet - L2VS20/1
26 - Pipeline from Orange - L2VS20/2
60 30 0 60 120 180 240

Tributary 1: Witpuntspruit

Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Acceptable	Proposed Changes	Reasoning
Nitrate	(mg/l)	0.0	0.1	0.1	0.3	0.5	0.05-0.25	0.05-0.10	Current status of catchment indicates poor water quality. Attributable to seepage. TDS and sulphate levels in tributary very high. Proposed changes needed to manage reality of the situation. Local catchment management strategy required to prevent further deterioration. Vaal main stem will be able to assimilate impact, however source control must happen. Stricter RWQOs for nutrients are also proposed to protect Vaal main stem. Current nutrient levels border on unacceptable RWQO concentrations and thus require some intervention.
Ammonia	(mg/l) as N	0.1	0.2	0.8	1.2	4.2	0.02-0.5	0.05-0.10	
Sulphate	(mg/l)	143.4	380.0	720.0	1280.0	3064.0	10-20	150	
Chloride	(mg/l)	5.0	10.3	14.0	17.8	27.0	10-15	None	
EC	(mS/m)	40.9	80.5	140.0	212.5	420.2	10-15	50	
TDS	(mg/l)	265.9	523.3	910.0	1381.3	2731.3	65 -97.5	325	
Phosphate	(mg/l) as P	0.05	0.05	0.10	0.14	0.91	0.05-0.08	0.02-0.04	
Aluminium	mg/l							0.05-0.10	
TP	mg/l							0.03-0.05	
TN	mg/l							0.20-0.30	
F. coliforms	#/100ml							10-50	
Algae	ug/l Chl-a							5-10	

Tributary 2: Klein Vaal

Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Acceptable	Proposed Changes	Reasoning
Nitrate	(mg/l)	0.05	0.05	0.05	0.20	0.24	0.05-0.25	None	Current water quality status also indicates tributary being highly impacted. Relaxation of RWQO for TDS is proposed as it is unrealistic to manage current quality back to existing RWQO. Vaal main stem is able to accept higher TDS level due to dilution coming in from inter-basin transfer. Local catchment strategy and source management must however take place to prevent further deterioration of resource. Current nutrient RWQOs are adequate as current status reflects low concentrations.
Ammonia	(mg/l) as N	0.05	0.05	0.20	0.20	0.34	0.02-0.5	None	
Sulphate	(mg/l)	5.00	16.00	16.00	26.00	39.60	10-20	None	
Chloride	(mg/l)	4.80	12.00	14.00	17.00	19.80	10-15	None	
EC	(mS/m)	13.80	20.00	32.00	33.00	38.80	10-15	15-25	
TDS	(mg/l)	89.70	130.00	208.00	214.50	252.20	65 -97.5	97.5-162.5	
Phosphate	(mg/l) as P	0.05	0.05	0.05	0.05	0.05	0.05-0.08	None	

Tributary 3: Rietspruit (Grootdraai)									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.05	0.05	0.13	0.30	0.95	**0.05-0.25**		No RWQO changes proposed. Although current water quality status does show non-compliance to TDS RWQOs, the situation can be managed to RWQO targets by local source management strategies (e.g. for agriculture). Also the Vaal main stem (VS4) is currently not complying to its RWQOs thus cannot assimilate further load.
Ammonia	(mg/l) as N	0.05	0.05	0.20	0.30	2.22	**0.02-0.5**		
Sulphate	(mg/l)	15.85	28.25	33.50	38.00	57.05	**10-20**	**None**	
Chloride	(mg/l)	9.50	10.75	12.00	16.25	21.75	**10-15**	**None**	
EC	(mS/m)	11.85	14.75	22.50	29.75	50.30	**10-15**	**None**	
TDS	(mg/l)	77.03	95.88	146.25	193.38	326.95	**65 -97.5**	**None**	
Phosphate	(mg/l) as P	0.05	0.05	0.05	0.05	0.25	**0.05-0.08**		

Tributary 4: Blesbokspruit (Grootdraai)									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.04	0.04	0.10	0.43	**0.05-0.25**	**None**	Current RWQO for sulphate should continue to be applied however local impacts must be managed to protect sulphate levels in Grootdraai Dam. Current TDS status of tributary does not allow it to be managed to RWQO of 30. A RWQO of 50 is more realistic, as proposed. However this objective as well, is reliant on catchment to dilute TDS. Impact of tributary is not yet felt in Grootdraai Dam. Present RWQOs for nutrients are aligned to those proposed - current concentrations do not pose an immediate threat however some intervention is required to manage nutrients to RWQOs.
Ammonia	(mg/l) as N	0.04	0.04	0.04	0.06	0.13	**0.02-0.5**	**0.10-0.5**	
Sulphate	(mg/l)	13	22	36	51	67	**15-35**	**None**	
Chloride	(mg/l)	9	14	20	36	71	**25-50**	**None**	
EC	(mS/m)	21	31	45	61	82	**15-30**	**50**	
TDS	(mg/l)	137.48	204.1	291.2	398.45	531.7	**97.5-195**	**325**	
Phosphate	(mg/l) as P	0.01	0.02	0.06	0.11	0.35	**0.05-0.25**	**0.10-0.30**	
Aluminium	mg/l							**0.03-0.10**	
TP	mg/l							**0.30-0.50**	
TN	mg/l							**0.50-1.50**	
F. coliforms	#/100ml							**50-150**	
Algae	ug/l Chl-a							**10-20**	

Tributary 5: Leeuspruit (Grootdraai)									
Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Acceptable	Proposed Changes	Reasoning
Nitrate	(mg/l)	0.04	0.04	0.04	0.11	0.445	0.05-0.25	0.05-0.15	Current water quality status indicates tributary being highly impacted. Relaxation of RWQO for TDS is proposed as it is unrealistic to manage current quality back to existing RWQO. Grootdraai Dam is able to accept higher TDS level due to dilution coming in from inter-basin transfer. Need to manage local impacts. Rely on catchment to dilute TDS. Stricter RWQOs for nutrients also proposed, as current nutrient levels are high (cyanobacterial blooms observed). Threat to Grootdraai Dam if such nutrient rich water continues to flow in. Management of local impacts required.
Ammonia	(mg/l) as N	0.04	0.04	0.04	0.069	0.129	0.02-0.5	0.05-0.30	
Sulphate	(mg/l)	13.61	31.096	46.8	81.8	272.14	15-35	None	
Chloride	(mg/l)	8.6	16.3	27.6	75.5	306.7	10-20	None	
EC	(mS/m)	19.56	30.8	45.8	75.8	216.22	15-30	50	
TDS	(mg/l)	127.14	200.2	297.7	492.7	1405.43	97.5-195	325	
Phosphate	(mg/l) as P	0.008	0.023	0.043	0.085	0.2036	0.05-0.25	0.03-0.10	
Aluminium	mg/l							0.03-0.10	
TP	mg/l							0.05-0.25	
TN	mg/l							0.30-1.00	
F. coliforms	#/100ml							50-150	
Algae	ug/l Chl-a							10-20	

Tributary 6: Klip River (Free State)									
Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	Acceptable	Proposed Changes	Reasoning
Nitrate	(mg/l)	no data available					0.1-0.2	None	No changes proposed (No data available). RWQOs are aligned to Vaal Dam. The impact of atmospheric pollution on water quality on the catchment needs to be investigated.
Ammonia	(mg/l) as N						0.2-0.5	None	
Sulphate	(mg/l)						20-45	None	
Chloride	(mg/l)						25-50	None	
EC	(mS/m)						10-30	None	
TDS	(mg/l)						65-195	None	
Phosphate	(mg/l) as P						0.05-0.25	None	

Tributary 7 - Waterval River									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.02	0.05	0.1	0.5	2.32	**2.5**	**0.1-0.25**	Proposal to make RWQO for TDS more stringent in order to maintain current status. Need to manage local impact in order to minimise current impact observed on the Vaal main stem (as seen at VS 6). Stricter RWQO for TDS will assist in reducing impact of tributary on Vaal River. Stricter nutrient RWQOs are also proposed to control high concentrations observed.
Ammonia	(mg/l) as N	0.02	0.05	0.05	0.5	1.22	**0.3**	**0.05-0.30**	
Sulphate	(mg/l)	29.42	41.75	60.61	80.75	200.25	**100**	**None**	
Chloride	(mg/l)	12.33	26.29	38.50	57.47	74.04	**150**	**None**	
EC	(mS/m)	21.75	40.95	56	69.5	80.25	**90**	**80**	
TDS	(mg/l)	141.375	266.175	364	451.75	521.625	**585**	**520**	
Phosphate	(mg/l) as P	0.02	0.05	0.092	0.2	0.5	**0.025**	**None**	
Aluminium	mg/l							**0.03-0.10**	
TP	mg/l							**0.05-0.30**	
TN	mg/l							**0.30-1.50**	
F. coliforms	#/100ml							**150-500**	
Algae	ug/l Chl-a							**10-20**	

Tributary 8: Wilge River									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.11	0.198	0.3155	0.62	**0.1-0.2**	**0.05-0.10**	Currently more stringent than Vaal Dam. Current status within RWQOs for sub-catchment - creates allocatable water quality/assimilative capacity. No requirement to change. (however situation is as a result of water releases from Katse Dam). Stricter RWQOs for nutrients are proposed to manage impacts of sewage pollution.
Ammonia	(mg/l) as N	0.04	0.04	0.05	0.07	0.14	**0.05-0.10**	**0.03-0.10**	
Sulphate	(mg/l)	4.00	7.10	10.50	15.68	23.70	**5-10**	**None**	
Chloride	(mg/l)	3.26	5.30	8.90	10.69	17.04	**5-10**	**None**	
EC	(mS/m)	9.30	12.40	16.70	23.50	41.90	**10-30**	**None**	
TDS	(mg/l)	60.45	80.60	108.55	152.75	272.35	**65-195**	**None**	
Phosphate	(mg/l) as P	0.01	0.02	0.03	0.05	0.12	**0.05-0.15**	**0.02-0.05**	
Aluminium	mg/l							**0.05-0.25**	
TP	mg/l							**0.05-0.10**	
TN	mg/l							**0.30-0.50**	
F. coliforms	#/100ml							**100-250**	
Algae	ug/l Chl-a							**10-20**	

Tributary 9: Suikerbosrant River									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.02	0.05	0.3	0.5385	2.286	**0.5-3.0**	**0.05-0.25**	Aim to achieve existing RWQOs for salts, however the RWQOs are ultimately dependent on those set for the Vaal Barrage. Thus once the Vaal Barrage objectives have been confirmed, the tributary RWQOs must be re-evaluated (based on the varying user requirements). Currently RWQOs for the Suikerbosrant are more lenient than those of the Barrage, and the tributary is impacting significantly on the main stem river. Nutrient concentrations are also high - stricter RWQOs are proposed. Local source management required as well.
Ammonia	(mg/l) as N	0.02	0.02	0.041	0.08	0.3	**0.1-1.5**	**0.03-0.15**	
Sulphate	(mg/l)						**150-300**	**None**	
Chloride	(mg/l)	35.445	82.175	119.2	161.4	213.425	**80-150**	**None**	
EC	(mS/m)	46.95	90	110.7	160	250	**45-70**	**None**	
TDS	(mg/l)	305.175	585	719.55	1040	1625	**292.5-455**	**None**	
Phosphate	(mg/l) as P	0.006	0.015	0.029	0.066	0.71675	**0.2-0.4**	**0.03-0.15**	
Aluminium	mg/l						**<0.3**	**0.05-0.10**	
TP	mg/l							**0.05-0.25**	
TN	mg/l							**0.25-0.50**	
F. coliforms	#/100ml						**<126**	**130-500?**	
Algae	ug/l Chl-a							**10-20**	

Tributary 10: Klip River (Gauteng)									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	1.205	3.25	4.35	5.2	6.58	**2-4**	**0.30-3.0**	Aim to achieve existing RWQOs for salts, however the RWQOs are ultimately dependent on those set for the Vaal Barrage. Thus once the Vaal Barrage objectives have been confirmed, the tributary RWQOs must be re-evaluated (based on the varying user requirements). Currently RWQOs for the Klip River is more lenient than those of the Barrage, and the tributary are impacting significantly on the main stem river. Nutrient concentrations are also very high - stricter RWQOs are proposed. Local source management required as well.
Ammonia	(mg/l) as N	0.01	0.05	0.1	0.4	0.9	**0.5-1.5**	**0.10-0.30**	
Sulphate	(mg/l)	117	140	160	193	229.6	**200-350**	**None**	
Chloride	(mg/l)	43.15	60.75	68	74	81.7	**50-75**	**None**	
EC	(mS/m)	66.25	73	76	84.8	94.1	**80-100**	**None**	
TDS	(mg/l)	430.625	474.5	494	551.2	611.65	**520-650**	**None**	
Phosphate	(mg/l) as P	0.3	0.5	0.65	0.88	1.56	**0.2-0.5**	**0.10-0.50**	
Aluminium	mg/l							**0.05-0.10**	
TP	mg/l							**0.15-1.00**	
TN	mg/l							**1.0-4.0**	
F. coliforms	#/100ml						**1000-5000**	**500-2500**	
Algae	ug/l Chl-a							**10-15**	

Tributary 11: Taaibosspruit									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.044	0.1	0.28	1.7662	**0.5-3.0**	**0.25-0.50**	Aim to achieve existing RWQOs for salts, however the RWQOs are ultimately dependent on those set for the Vaal Barrage. Thus once the Vaal Barrage objectives have been confirmed, the tributary RWQOs must be re-evaluated (based on the varying user requirements). Currently RWQOs for the Taaibosspruit are more lenient than those of the Barrage. While the tributary itself is highly impacted it is not significantly impacting on the WQ of the main stem river. Nutrient concentrations are also high - stricter RWQOs are proposed. Stricter source control/ reduction is required.
Ammonia	(mg/l) as N	0.04	0.045	0.06	0.11	0.5265	**0.25-0.50**	**0.10-0.30**	
Sulphate	(mg/l)	9.11	17.6	27.05	57.55	220.395	**150-300**	**None**	
Chloride	(mg/l)	7.845	11.5	19.5	51.5	157.345	**50-60**	**None**	
EC	(mS/m)	13.17	20	28	56.225	134.21	**42-60**	**None**	
TDS	(mg/l)	85.605	130	182	365.4625	872.365	**273-390**	**None**	
Phosphate	(mg/l) as P	0.011	0.028	0.04	0.08	0.4265	**0.2-0.4**	**0.05-0.10**	
Aluminium	mg/l						**0.15-0.5**	**0.05-0.15**	
TP	mg/l							**0.10-0.50**	
TN	mg/l							**1.0-3.0**	
F. coliforms	#/100ml						**<126**	**130-500**	
Algae	ug/l Chl-a							**10-20**	

Tributary 12: Leeuspruit									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)						**0.5-3.0**	**0.20-0.50**	Aim to achieve existing RWQOs for salts, however the RWQOs are ultimately dependent on those set for the Vaal Barrage. Thus once the Vaal Barrage objectives have been confirmed, the tributary RWQOs must be re-evaluated (based on the varying user requirements). Currently RWQOs for the Leeuspruit are more lenient than those of the Barrage. While the tributary itself is impacted to some extent, it does not impact on the WQ of the Vaal Barrage (small tributary). Nutrient concentrations are high - stricter RWQOs are proposed.
Ammonia	(mg/l) as N	0.05	0.05	0.3	0.6	2.6	**0.1-1.5**	**0.20-0.50**	
Sulphate	(mg/l)	12	17	48	114	166	**150-300**	**None**	
Chloride	(mg/l)	13	31	36	49	86	**80-150**	**None**	
EC	(mS/m)	22	34	48	54	107	**45-70**	**None**	
TDS	(mg/l)	143	221	312	351	695.5	**293-455**	**None**	
Phosphate	(mg/l) as P	0.05	0.05	0.2	0.3	0.4	**0.2-0.4**	**0.10-0.20**	
Aluminium	mg/l						**<0.3**	**0.03-0.10**	
TP	mg/l							**0.20-0.50**	
TN	mg/l							**1.0-2.0**	
F. coliforms	#/100ml						**<126**	**130-500**	
Algae	ug/l Chl-a							**10-20**	

Tributary 13: Rietspruit									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	1.7853	3.991	5.269	6.8555	9.8723	**1.0-3.0**	**None**	Aim to achieve existing RWQOs for salts, however the RWQOs are ultimately dependent on those set for the Vaal Barrage. Thus once the Vaal Barrage objectives have been confirmed, the tributary RWQOs must be re-evaluated (based on the varying user requirements). Currently RWQOs for the Rietspruit are more lenient than those of the Barrage. The tributary is significantly impacted and does impact on the WQ of the Vaal Barrage to some extent. Nutrient concentrations are very high (water is hypertrophic). Stricter RWQOs are proposed.
Ammonia	(mg/l) as N	0.02	0.13	0.7315	2.23925	7.2415	**0.25-5.0**	**0.1-1.00**	
Sulphate	(mg/l)						**100-200**	**None**	
Chloride	(mg/l)	46.11	76	95.5	117.05	170.15	**50-100**	**None**	
EC	(mS/m)	64	89	99	110	140	**30-70**	**None**	
TDS	(mg/l)	416	578.5	643.5	715	910	**195-455**	**None**	
Phosphate	(mg/l) as P	0.01	0.093	0.497	1.0635	1.9576	**0.25-0.50**	**0.1-0.5**	
Aluminium	mg/l						**0.15-0.30**	**0.03-0.1**	
TP	mg/l							**0.30-1.0**	
TN	mg/l							**1.0-4.0**	
F. coliforms	#/100ml						**131-4000**	**500-2500**	
Algae	ug/l Chl-a							**20-50**	

Tributary 14: Kromelmboogspruit									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.05	0.05	0.05	1.2	613.04	**0.5-3.0**	**0.1-0.25**	Data set is very limited. Need more monitoring to identify any issues. However water quality does appear to be fairly good. Some changes to RWQOs for nutrients are proposed.
Ammonia	(mg/l) as N	0.05	0.05	0.05	1.6	208.32	**<0.5**	**0.1-0.3**	
Sulphate	(mg/l)	29.2	46	68	101	222.6	**20-100**	**None**	
Chloride	(mg/l)	21.6	24	41	64	146.4	**5-50**	**None**	
EC	(mS/m)	20.4	26	29	56	69.6	**18-30**	**None**	
TDS	(mg/l)	132.6	169	188.5	364	452.4	**117-195**	**None**	
Phosphate	(mg/l) as P	0.05	0.05	1	1.4	41.88	**<0.03**	**0.1-0.3**	
Aluminium	mg/l						**<0.3**	**0.03-0.1**	
TP	mg/l							**0.2-0.5**	
TN	mg/l							**0.75-2.0**	
F. coliforms	#/100ml						**<126**	**130-250**	
Algae	ug/l Chl-a							**10-20**	

Tributary 15: Mooi River									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.09	0.29	0.75	1.48	2.32	**0.3**	**0.1-0.5**	Existing RWQOs are fairly stringent. Current status indicates general non-compliance to RWQOs. RWQOs for salts could be relaxed to a certain extent, however the RWQOs are ultimately dependent on those set for the Vaal Barrage. Thus once the Vaal Barrage objectives have been confirmed, the tributary RWQOs must be re-evaluated (based on the varying user requirements). The tributary is significantly impacted and does impact on the WQ of the Vaal main stem. Nutrient concentrations are high, with algal blooms posing a threat. Stricter RWQOs are proposed.
Ammonia	(mg/l) as N	0.03	0.04	0.06	0.10	0.40	**0.03**	**0.1-0.2**	
Sulphate	(mg/l)	63	92	105	112	127	**75**	**To be decided**	
Chloride	(mg/l)	27	34	39	47	64	**36**	**To be decided**	
EC	(mS/m)	57	71	76	80	90	**57**	**To be decided**	
TDS	(mg/l)	367.25	463.45	490.75	520.65	584.35	**370.5**	**To be decided**	
Phosphate	(mg/l) as P	0.31	0.49	0.72	1.11	2.32	**0.4**	**0.1-0.5**	
Aluminium	mg/l						**0.18**	**0.03-0.075**	
TP	mg/l							**0.1-0.5**	
TN	mg/l							**1.0-1.5**	
F. coliforms	#/100ml							**130-500**	
Algae	ug/l Chl-a							**20-30**	

Tributary 16: Renoster River									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQO**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.05	0.16	0.33	0.61	**0.6**	**0.10-0.20**	Aim to achieve existing RWQOs for salts, however the RWQOs are ultimately dependent on those set for the Vaal main stem. The tributary RWQOs must be re-evaluated once the main stem objectives are confirmed. Currently RWQOs (95%tile values) for salts are adequate. The tributary does exhibit fairly good quality and does not appear to impact on the WQ of the Vaal River. Stricter RWQOs for nutrients are proposed due to some algal growth observed.
Ammonia	(mg/l) as N	0.04	0.04	0.04	0.07	0.15	**0.15**	**0.01-0.03**	
Sulphate	(mg/l)	5.76	12.99	21.70	28.60	39.43	**40**	**None**	
Chloride	(mg/l)	6.90	12.30	17.20	21.90	28.41	**30**	**None**	
EC	(mS/m)	12.00	19.00	23.90	36.10	45.10	**45**	**None**	
TDS	(mg/l)	78.00	123.50	155.35	234.65	293.15	**293**	**None**	
Phosphate	(mg/l) as P	0.01	0.02	0.04	0.08	0.19	**0.2**	**0.10-0.20**	
Aluminium	mg/l							**0.03-0.1**	
TP	mg/l							**0.20-0.5**	
TN	mg/l							**0.5-1.0**	
Algae	ug/l Chl-a							**10-30**	

Tributary 17: Koekemoerspruit									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.20	0.99	2.58	5.44	11.91	**0.2-1.0**	**0.2-2.0**	Tributary exhibits poor water quality. Highly impacted, possibly requiring relaxation of RWQOs as it is unrealistic to manage current state back to existing RWQOs. TDS levels are very high and the RWQO set will depend on the quality required for the Vaal main stem. Local source management is required. High phosphate and nitrate levels were detected, with the tributary showing severe signs of eutrophication. Stricter RWQOs for nutrients are proposed. Removal of the mine decant will alleviate the situation.
Ammonia	(mg/l) as N	0.05	0.12	0.50	2.09	7.47	**0.25-1.0**	**0.20-1.50**	
Sulphate	(mg/l)	25.76	70.13	152.70	287.68	455.88	**100-200**	**To be decided**	
Chloride	(mg/l)	14.03	34.38	70.32	135.88	170.30	**50-100**	**To be decided**	
EC	(mS/m)	44.67	73.30	107.00	147.20	171.46	**31-62**	**To be decided**	
TDS	(mg/l)	290.36	476.45	695.50	956.80	1114.49	**200-400**	**To be decided**	
Phosphate	(mg/l) as P	0.09	0.47	1.45	3.30	5.56	**0.2-0.4**	**0.10-1.00**	
Aluminium	mg/l						**0.15-3.0**	**0.05-0.15**	
TP	mg/l							**0.20-1.50**	
TN	mg/l							**0.75-4.0**	
F. coliforms	#/100ml						**150-200**	**250-2500**	
Algae	ug/l Chl-a							**25-50**	

Tributary 18: Vierfontein									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQO**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	No data available - newly established point					**0.6**	**0.10-0.20**	Aim to achieve existing RWQOs for salts, however the RWQOs are ultimately dependent on those set for the Vaal main stem. The tributary RWQOs must be re-evaluated once the main stem objectives are confirmed. Currently RWQOs for are set based on those for the Rhenoster. Monitoring data is required to determine current status. The tributary does exhibit strong algal growth which is indicative of high phosphate concentrations. Stricter RWQOs for nutrients are proposed.
Ammonia	(mg/l) as N						**0.15**	**0.01-0.03**	
Sulphate	(mg/l)						**40**	**To be decided**	
Chloride	(mg/l)						**30**	**To be decided**	
EC	(mS/m)						**45**	**To be decided**	
TDS	(mg/l)						**293**	**To be decided**	
Phosphate	(mg/l) as P						**0.2**	**0.10-0.20**	
Aluminium	mg/l							**0.03-0.1**	
TP	mg/l							**0.20-0.5**	
TN	mg/l							**0.5-1.0**	
Algae	ug/l Chl-a							**10-30**	

Tributary 19: Schoonspruit									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**Acceptable**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.54	1.79	3.35	6.20	12.23	**0.2-1.0**	**0.2-2.0**	Tributary exhibits poor water quality. Highly impacted, possibly requiring relaxation of RWQOs as it is unrealistic to manage current state back to existing RWQOs. TDS levels are very high and the RWQO set will depend on the quality required for the Vaal main stem. Local source management/intervention is required. High phosphate and nitrogen levels were detected, with the tributary showing severe signs of algal growth. Stricter RWQOs for nutrients are proposed.
Ammonia	(mg/l) as N	0.04	0.12	0.48	2.24	7.79	**0.25-1.0**	**0.20-1.50**	
Sulphate	(mg/l)	33	78	147	240	351	**100-200**	**To be decided**	
Chloride	(mg/l)	18	40	72	125	168	**50-100**	**To be decided**	
EC	(mS/m)	45	75	103	142	163	**31-62**	**To be decided**	
TDS	(mg/l)	293.18	487.50	666.90	923.00	1059.34	**200-400**	**To be decided**	
Phosphate	(mg/l) as P	0.21	0.69	1.77	3.60	5.89	**0.2-0.4**	**0.10-1.00**	
Aluminium	mg/l						**0.15-3.0**	**0.05-0.15**	
TP	mg/l							**0.20-1.50**	
TN	mg/l							**0.75-4.0**	
F. coliforms	#/100ml						**150-200**	**250-2500**	
Algae	ug/l Chl-a							**25-50**	

Tributary 20: Vals River									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQO**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.13	0.45	0.93	2.18	**2**	**0.25-0.75**	Existing RWQOs for salts need to be revised, however the RWQOs are ultimately dependent on those set for the Vaal main stem. The tributary RWQOs must be re-evaluated once the main stem objectives are confirmed. Currently RWQOs (95%tile values) for salts are lenient. The tributary is fairly impacted and does appear to impact on the WQ of the Vaal River. Stricter RWQOs for nutrients are proposed due to high nutrient concentrations observed.
Ammonia	(mg/l)	0.04	0.04	0.06	0.12	0.55	**0.15**	**0.02-0.08**	
Sulphate	(mg/l)	7.00	21.60	42.12	76.19	139.86	**120**	**To be decided**	
Chloride	(mg/l)	9.26	16.80	29.80	54.90	98.40	**100**	**To be decided**	
EC	(mS/m)	16.83	28.10	47.20	71.70	100.35	**98**	**To be decided**	
TDS	(mg/l)	109.36	182.65	306.80	466.05	652.28	**637**	**To be decided**	
Phosphate	(mg/l)	0.02	0.07	0.16	0.43	1.12	**1**	**0.1-0.5**	
Aluminium	mg/l							**0.1-0.25**	
TP	mg/l							**0.2-1.0**	
TN	mg/l							**0.5-2.5**	
Algae	ug/l Chl-a							**25-50**	

Tributary 21: Makwassie

Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	RWQO	Proposed Changes
Nitrate	(mg/l)	0.04	0.04	0.12	0.89	3.52	**3.5**	**0.05-0.1**
Ammonia	(mg/l)	0.04	0.04	0.04	0.06	0.14	**0.14**	**0.025-0.10**
Sulphate	(mg/l)	4	11	17	23	38	**38**	**None**
Chloride	(mg/l)	7	14	24	38	52	**52**	**None**
EC	(mS/m)	16	29	44	58	69	**69**	**None**
TDS	(mg/l)	106.6	185.25	286	375.7	447.85	**449**	**None**
Phosphate	(mg/l)	0.01	0.01	0.02	0.05	0.11	**0.10**	**0.05-0.1**
Aluminium	mg/l							**0.03-0.1**
TP	mg/l							**0.10-0.2**
TN	mg/l							**0.5-1.0**
Algae	ug/l Chl-a							**10-30**

Reasoning

Aim to achieve existing RWQOs for salts, however the RWQOs are ultimately dependent on those set for the Vaal main stem. The tributary RWQOs must be re-evaluated once the main stem objectives are confirmed. Currently RWQOs (95%tile values) for salts are adequate. The tributary does exhibit fairly good quality and does not appear to impact on the WQ of the Vaal River. Stricter RWQOs for nutrients are proposed due to an increasing trend being observed for phosphate.

Tributary 22: Sandspruit

Variable	Units	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	RWQO	Proposed Changes
Nitrate	(mg/l)	0.04	0.04	0.04	0.10	0.86	**0.9**	**0.10-0.50**
Ammonia	(mg/l)	0.04	0.04	0.05	0.08	0.20	**0.2**	**0.03-0.75**
Sulphate	(mg/l)	4.00	8.65	14.15	25.78	60.08	**60**	**To be decided**
Chloride	(mg/l)	6.40	11.90	17.65	29.95	107.26	**107**	**To be decided**
EC	(mS/m)	11.37	20.80	28.10	40.15	93.56	**94**	**To be decided**
TDS	(mg/l)	73.91	135.20	182.65	260.98	608.14	**611**	**To be decided**
Phosphate	(mg/l)	0.01	0.02	0.05	0.13	0.39	**0.4**	**0.15-0.50**
Aluminium	mg/l							**0.03-0.1**
TP	mg/l							**0.25-1.0**
TN	mg/l							**0.75-2.0**
Algae	ug/l Chl-a							**10-30**

Reasoning

Existing RWQOs for salts need to be revised, however the RWQOs are ultimately dependent on those set for the Vaal main stem. The tributary RWQOs must be confirmed once the main stem objectives are confirmed. Currently RWQOs (95%tile values) for salts are lenient. The tributary has exhibited WQ deterioration over the past few years. It does not appear to impact on the WQ of the Vaal River to any significant extent. Stricter RWQOs for nutrients are proposed.

Tributary 23: Vet River									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQOs**	**Proposed RWQOs**	**Reasoning**
Nitrate	(mg/l)	0.04	0.04	0.06	0.23	0.66	Awaiting RWQOs from study	**0.05-0.20**	RWQOs for salts are ultimately dependent on those set for Bloemhof Dam. The tributary RWQOs must be confirmed once the main stem objectives are confirmed. The tributary does exhibit high salt levels. WQ impact of tributary is not observed due to dilution by water in Bloemhof Dam. However this must be monitored. Local source management is required. RWQOs for nutrients are proposed.
Ammonia	(mg/l)	0.04	0.04	0.05	0.09	0.21		**0.02-0.05**	
Sulphate	(mg/l)	5.13	13.35	22.50	49.07	125.80		**To be decided**	
Chloride	(mg/l)	8.20	14.70	26.85	63.62	174.03		**To be decided**	
EC	(mS/m)	19.68	25.00	34.15	53.23	111.20		**To be decided**	
TDS	(mg/l)	127.89	162.50	221.98	345.96	722.80		**To be decided**	
Phosphate	(mg/l)	0.01	0.02	0.04	0.07	0.16		**0.05-0.1**	
Aluminium	mg/l							**0.03-0.1**	
TP	mg/l							**0.15-0.30**	
TN	mg/l							**0.5-1.50**	
Algae	ug/l Chl-a							**10-30**	

Tributary 24: Harts River									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQOs**	**Proposed Changes**	**Reasoning**
Nitrate	(mg/l)	0.04	0.08	0.25	0.45	1.85	**3**	**0.10-0.50**	Existing RWQOs for salts need to be revised (stricter), however the RWQOs are ultimately dependent on those set for the Vaal main stem. The tributary RWQOs must be re-evaluated once the main stem objectives are confirmed. Currently RWQOs for salts are lenient. TDS levels are very high and the RWQO set will depend on the quality required for the Vaal main stem. Local source management/intervention is required. The tributary is impacting on the WQ of the Vaal River fairly significantly. Stricter RWQOs for nutrients are proposed.
Ammonia	(mg/l)	0.04	0.05	0.07	0.10	0.28	**0.1**	**0.05-0.10**	
Sulphate	(mg/l)	197.42	264.81	334.93	408.60	521.90	**250**	**To be decided**	
Chloride	(mg/l)	102.93	173.47	214.70	268.40	347.62	**100**	**To be decided**	
EC	(mS/m)	103.46	136.75	162.00	190.00	228.85	**120**	**To be decided**	
TDS	(mg/l)	672.49	888.88	1053.00	1235.00	1487.53	**840**	**To be decided**	
Phosphate	(mg/l)	0.01	0.02	0.02	0.04	0.12	**0.04**	**0.01-0.05**	
Aluminium	mg/l							**0.03-0.075**	
TP	mg/l							**0.05-0.1**	
TN	mg/l							**0.5-1.0**	
F. coliforms	#/100ml							**150-250**	
Algae	ug/l Chl-a							**10-20**	

Tributary 25: Riet River									
Variable	**Units**	**5th percentile**	**25th percentile**	**50th percentile**	**75th percentile**	**95th percentile**	**RWQOs**	**Proposed RWQOs**	**Reasoning**
Nitrate	(mg/l)	0.04	0.04	0.06	0.15	0.41	Awaiting RWQOs from study	**0.10-0.25**	RWQOs for salts are ultimately dependent on those set for Douglas Barrage. The tributary RWQOs must be confirmed once the main stem objectives are confirmed. The tributary does exhibit high salt levels. WQ impact of tributary is not observed due to dilution by water from the Orange River that enters Douglas Barrage. However this impact must be monitored. Local source management/intervention is required to alleviate situation in the Barrage. RWQOs for nutrients are proposed.
Ammonia	(mg/l)	0.03	0.04	0.04	0.05	0.11		**0.05-0.1**	
Sulphate	(mg/l)	61.88	124.67	171.80	234.52	344.06		**To be decided**	
Chloride	(mg/l)	74.25	161.49	231.40	299.30	452.64		**To be decided**	
EC	(mS/m)	59.42	100.00	137.00	179.00	243.20		**To be decided**	
TDS	(mg/l)	386.23	650.00	890.50	1163.50	1580.80		**To be decided**	
Phosphate	(mg/l)	0.01	0.01	0.02	0.03	0.05		**0.05-0.10**	
TP	mg/l							**0.10-0.25**	
TN	mg/l							**0.25-0.75**	
F. coliforms	#/100ml							**150-250**	
Algae	ug/l Chl-a							**10-20**	