Determination of Water Resource Classes and Associated Resource Quality Objectives for the Berg Catchment (WP10987)

August 2018

Revision: Final

Evaluation of Resource Units Report

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Bold type indicates this Report.

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17	RDM/WMA9/00/CON/CLA/0718	Final Project Close Out Report.

List of Abbreviations

DWA	*(Previous) Department of Water Affairs*
DWAF	*(Previous) Department of Water Affairs and Forestry*
DWS	*Department of Water and Sanitation*
EC	*Ecological Category (A to E based on Kleynhans et al, 1996)*
EIS	*Ecological Importance and Sensitivity*
EWR	*Ecological Water Requirements*
HGM	*Hydro-geomorphic Unit*
IUA	*Integrated Unit of Analysis*
NFEPA	*National Freshwater Ecosystem Priority Area*
nMAR	*Natural Mean Annual Runoff*
NWA	*National Water Act*
PES	*Present Ecological Status*
REC	*Recommended Ecological Condition*
RQOs	*Resource Quality Objectives*
RU	*Resource Unit*
WMA	*Water Management Area*
WRC	*Water Resource Classes*
WRCS	*Water Resources Classification System*

Executive Summary

The Chief Directorate: Water Ecosystems of the Department of Water and Sanitation has commissioned a study to determine Water Resource Classes and Resource Quality Objectives for all significant water resources in the Berg Catchment in line with Section 12 of the NWA which established a Water Resources Classification System (WRCS) that is formally prescribed by Regulations 810 dated 17 September 2010.

The Water Resources Classification procedure have been completed in the Berg Catchment and the determination of the RQOs follows on from this process. The 7-step procedure established by the Department of Water Affairs in 2011 (DWA, 2011) is being applied to determine the Resource Quality Objectives (RQOs) for river, estuary, wetland, dam and groundwater resources in the Berg Catchment. These procedural steps to determine RQOs in the Berg Catchment include the following:

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

In terms of the RQO determination process, Step 1 (Delineation) and Step 2 (Visioning) have been completed as part of the Classification phase of this study. The Resource Unit Prioritisation Report (DWS, 2018) documents the approach adopted and the outcomes of the implementation of Step 3 of the RQO determination procedure. This report documents the approach adopted and the outcomes of the implementation of Step 4 (Evaluation) of the RQO determination procedure.

A total of 49 sub-components were selected for RQO determination during Step 4 of the RQO determination procedure in the Berg Catchment (shown in Table 0.1), including:

- 12 sub-components were selected to represent river resources from 20 prioritised RUs.
- 13 sub-components were selected to represent estuaries resources from 7 prioritised RUs.
- 9 sub-components were selected to represent dam resources from 6 prioritised RUs.
- 9 sub-components were selected to represent wetlands resources from 24 prioritised RUs.
- 6 sub-components were selected to represent groundwater resources from 11 prioritised RUs.

Table 0.1 comprises a summary of the selected sub-components on the different significant water resources for the Berg Catchment.

Table 0.1 Summary of sub-component prioritisation selection for the Berg Catchment

Component	Sub-component	Rivers	Estuaries	Dams	Wetlands	Ground water
Quantity	Abstraction					X
	High flows	X	X	X	X	
	Low flows	X	X	X		X
	Discharge					X
	Hydroperiod				X	
Quality	Nutrients	X	X	X	X	X
	Salts	X		X		X
	System variables (temperature, salinity, oxygen, pH, turbidity	X	X	X		
	Toxins	X	X	X		
	Pathogens	X	X	X	X	X

Component	Sub-component	Rivers	Estuaries	Dams	Wetlands	Ground water
Habitat	Ecological Condition	X				
	Geomorphology	X			X	
	Sedimentary processes		X			
	Mouth state		X			
	Vegetation / Riparian Vegetation	X			X	
Biota	Fish	X	X	X		
	Frogs				X	
	Invertebrates	X	X			
	Micro-algae		X			
	Macrophytes		X			
	Phytoplankton			X	X	
	Birds		X			
	Benthic algae				X	
	Totals	**12**	**13**	**9**	**9**	**6**

There are key limitations and uncertainties which may influence the confidence of the outcomes of the resource unit evaluation process. These are discussed for each significant water resource.

The next step of the RQO determination process, Step 5, comprises the proposed draft ROQs and numerical limits (NL) for the prioritised water resource units in the Berg Catchment. RQOs are narrative statements, but sometimes provide broad quantitative descriptions of the water resource. Numerical limits translate the narrative RQOs into numerical values which can be monitored and assessed for compliance.

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1 Introduction

1.1 Background

Chapter 3 of the National Water Act (NWA) lays down a series of measures which are together intended to ensure protection of the water resources. In accordance with these measures, the Department of Water and Sanitation (DWS) in line with Section 12 of the NWA, established a Water Resources Classification System (WRCS) that is formally prescribed by Regulations 810 dated 17 September 2010.

The WRCS provides guidelines and procedures for determining Water Resource Classes (WRCs), Resource Quality Objectives (RQOs) and the Reserve.

Section 13 of the NWA states that "as soon as reasonable practicable after the Minister prescribed a system for classifying water resources, the Minister must, subject to subsection (4), by notice in the gazette, determine for all or part of every significant water resource-

a) A class in accordance with the prescribed classification system; and

b) Resource quality objectives based on the class determined in terms of paragraph (a)."

In this context, the Chief Directorate: Water Ecosystem has therefore commissioned a study to determine Water Resource Classes (WRCs) and associated Resource Quality Objectives (RQOs) for all significant water resources in the Berg / Olifants-Doring Water Management Area (WMA) that lie outside the Olifants-Doring section of the WMA. This includes the area of the former Berg WMA (i.e. former WMA 19)

The Berg River is the largest catchment in the Study Area, which also includes a number of smaller catchments such as the Diep, Kuils, Eerste, Lourens, Sir Lowry's, Steenbras, as well as various small catchments on the Cape Peninsula and along the West Coast.

With the Classification phase of this study completed, the current next phase of the study comprises the 7-step procedure towards determination of RQOs (DWA, 2011) for all significant water resources in the Berg Catchment.

Previous RQO determination studies were reviewed to determine an appropriate approach for the current study. Reports of relevant previous studies that are referred to are the RQO determination reports for the Crocodile (West), Marico, Mokolo and Matlabas catchments (DWS, 2015), for the Olifants WMA (DWS, 2014) and the Upper Vaal WMA (DWS, 2014).

1.2 Scope of this phase of the study

The main objective of this study is to determine Resource Quality Objectives (RQOs) for all significant water resources in the Berg Catchment that must give effect to the Water Resources Classes that have been determined in the previous phase of the study. To this end, the 7-step process for determining RQOs, described in DWA (2011) and depicted in Figure 1.1, is being implemented.

Once gazetting has been finalised, implementation, monitoring and review would then follow.

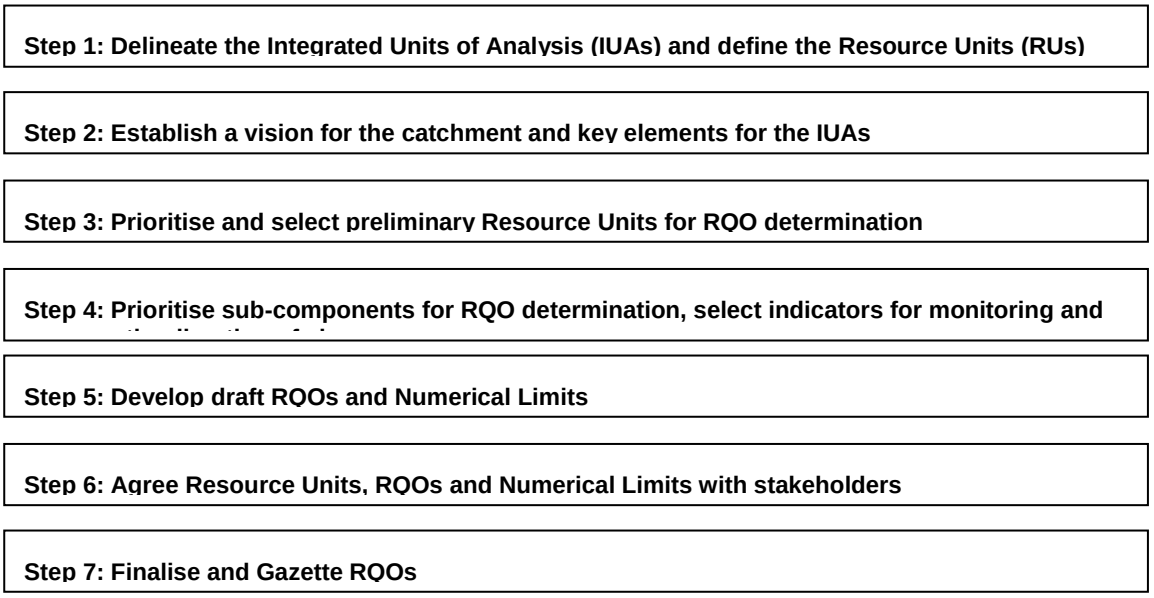

Figure 1.1The seven-step process for RQO determination (DWA, 2011)

In terms of the RQO process outlined in Figure 1.1, Step 1 (Delineation) and Step 2 (Visioning) have been completed as part of the Classification phase of this study. Step 3 (Prioritisation) involved the iterative process of prioritizing Resource Units using the RU prioritization tool and it is documented in the Resource Units Prioritization Report (DWS, 2018).

This report documents the approach adopted and the outcomes of the implementation of **Step 4 (Evaluation) of the RQO determination procedure**. Step 4 involves the use of the RU Evaluation Tools to select sub-components for RQO determination, select indicators for monitoring and propose the direction of change. The list of sub-components, indicators selected for monitoring and the rationale for consideration (where applicable) for the rivers, estuaries, dams, wetlands and groundwater in the Berg Catchment are documented in this report. This will form the basis for development of RQOs and numerical limits (Step 5).

1.3 Study area

The study area covers all significant water resources of the Berg Catchment. The Berg River is the largest catchment in the Study Area, which also includes a number of smaller catchments such as the Diep, Kuils, Eerste, Lourens, Sir Lowry's, Steenbras, as well as various small catchments on the Cape Peninsula and along the West Coast. The study area includes secondary catchments G1 and G2 and G40A.

During the Classification phase of the study, resource units for rivers, wetlands, dams, groundwater and estuaries as well as a total of 12 Integrated Units of Analysis (IUAs) were delineated in the Berg Catchment.

The IUAs approximate socio-economic boundaries, delineated to facilitate the integration of ecological and socio-economic aspects required for the evaluation of scenarios during the Classification phase of the study (DWS, 2017). The delineation of the Resource Units and the IUAs is described in the *Resource Unit and Integrated Units of Analysis Delineation Report* (DWS, 2016b).

A visioning exercise for the Berg Catchment was undertaken with key stakeholders in the Classification phase of the study. The purpose of the visioning exercise was to articulate the aspirations of the various stakeholders for the future of the catchment. The stakeholders highlighted the key water resource issues relevant to their respective sectors, including issues relating to policy and legislation, resources, administration, capacity/empowerment and technology, and then presented their critical considerations for determining the water resource class. These were also taken into account when evaluating the RQOs.

1.4 Prioritisation of RUs outcomes

A summary of the priority RUs for rivers, estuaries, dams, wetlands and groundwater resource units are presented below. These represent the list of proposed RUs for which RQOs should be developed.

The prioritized RUs for determining RQOs have been identified using the following criteria:

- All river RUs in the Berg Catchment irrespective of their scores
- All estuaries in the Berg Catchment irrespective of their scores. However, none of the river outlets in the catchment were prioritised
- Dams determined from prioritisation process with a priority weighting of > 0.6
- Wetlands RUs as determined from the prioritisation process
- Groundwater RUs scoring >40 in the scoring system and designated as a priority "3".

The prioritisation approach is resource-specific, for example enabling different areas to be prioritised for surface water and groundwater respectively. This is necessary, given that the criteria for each differ. However, in certain circumstances, the RQO for one resource may require the RQO of another resource to be developed to support it. These likely interactions have also been considered in terms of determining the final list of prioritised RUs and will also be reflected in the proposed RQOs for different RUs.

The resource units listed in Table 1-1 are mapped in Figure 1.2.

Table 1-1 Summary of results of the prioritisation process for the Berg Catchment

IUA	Prioritised Resource Units (RUs)				
	River	Estuary	Dam	Wetland	Groundwater
D8 Upper Berg	Bviii1 Bvii13 Biii3		Berg River Dam Wemmershoek Dam	SWSA* SEEP	G10A G10B
D9 Middle Berg	Bvii5 Bviii11 Bvii3			West Coast Shale Renosterveld FLOODPLAIN (Berg)	
C5 Berg Tributaries	Biii4 Bi1			SWSA* SEEP	G10E
B4 Lower Berg	Bvii12 Bvii6		Voëlvlei Dam Misverstand Dam	West Coast Shale Renosterveld FLOODPLAIN (Berg) Northwest Sandstone Fynbos SEEP and FLOODPLAIN (Boesmans River) Kiekoesvlei DEPRESSION Koekiespan DEPRESSION	G10J G10L
A1 Berg Estuary		Berg (Groot)		Southwestern Shale Fynbos UNCHANNELED VALLEY BOTTOM (Berg)	G10M
A2 Langebaan		Langebaan		Salt marsh SEEP (Geelbek)	G10M
A3 West Coast				Southwest Sand Fynbos DEPRESSION (Yzerfontein)	G21B
D10 Diep	Bv1 Biv6	Rietvlei/ Diep		Rietvlei Southwest Sand Fynbos FLOODPLAIN and Dune Strandveld FLOODPLAIN (seasonal) Riverlands DEPRESSION and SEEP	G21D
E11 Peninsula	Bviii6 Bvii20	Wildevoelvlei		Sand Fynbos DEPRESSION (Pick n Pay Reedbeds) Sand Fynbos DEPRESSION (Wildevoelvlei) Sand Fynbos DEPRESSION (seasonal) SWSA* UNCHANNELLED VALLEY-BOTTOM	

IUA	Prioritised Resource Units (RUs)				
	River	Estuary	Dam	Wetland	Groundwater
E12 Cape Flats	Bvii7	Zandvlei		Zeekoeivlei DEPRESSION (open water and seasonal) Rondevlei DEPRESSION (open water and seasonal) Nooiensfontein FLOODPLAIN Blouvlei DEPRESSION Princessvlei DEPRESSION DUNE SLACK (Phillipi: Denel seasonal wetlands)	G22C G22D G22E
D6 Eerste	Biii6 Biv8	Eerste		SWSA* SEEP	
D7 Sir Lowry's	Bvii22 Bvii21 Bviii9	Lourens	Steenbras Reservoir Steenbras Upper Dam	SWSA* SEEP	
TOTAL	**20**	**7**	**6**	**24**	**11**

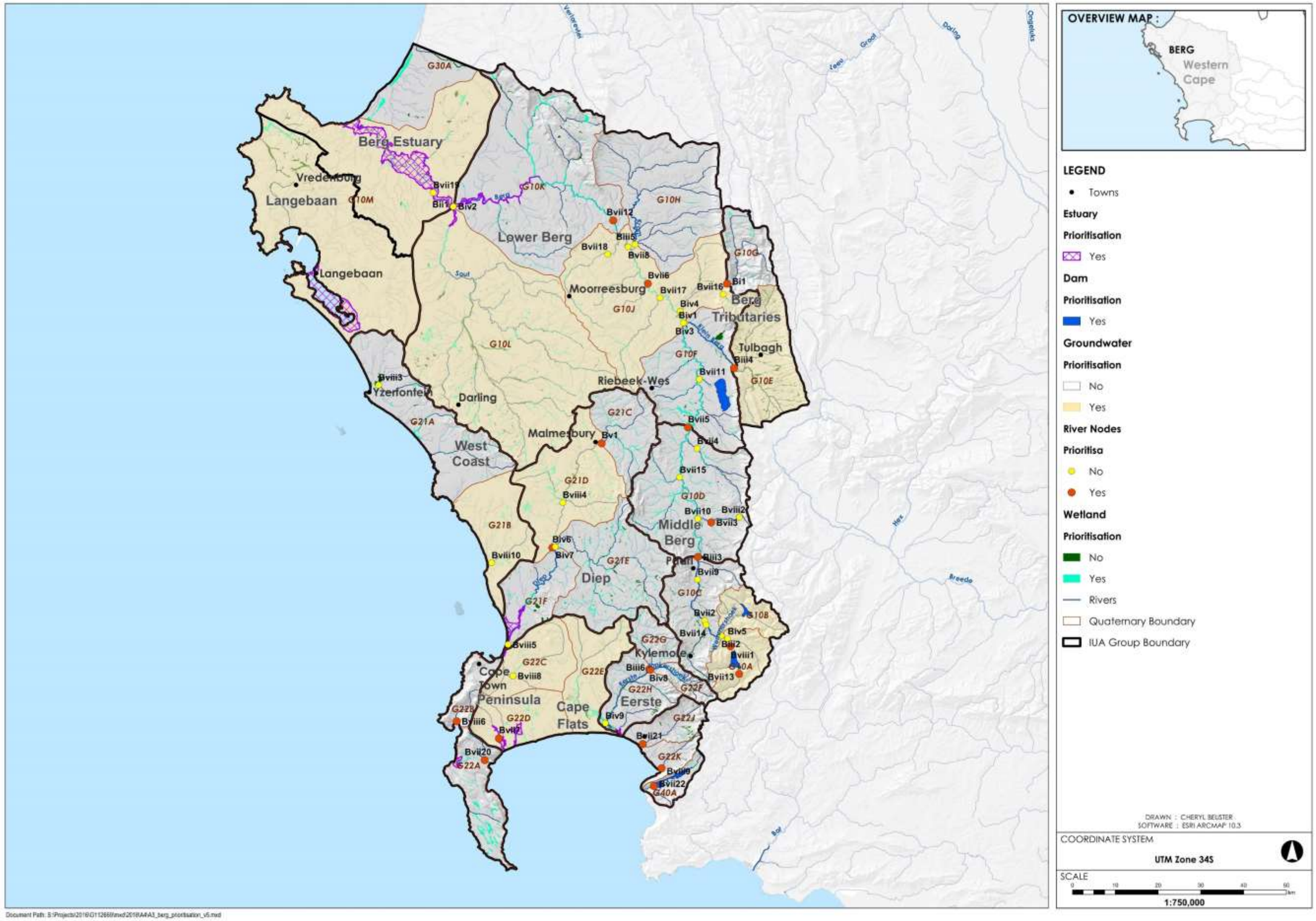

Figure 1.2 Summary of results of the prioritisation process for the Berg IUAs

2 Approach

2.1 Resource Quality Objectives process overview

For the determination and implementation of RQOs, a seven-step procedure was established (DWA, 2011). This process is interlinked with the Water Resources Classification process and forms part of an Adaptive Management Cycle that is used as an improved water resources management practice. Overall the Adaptive Management Cycle process consists of delineating the resource units (RU), setting a vision for the catchment, prioritise, select and evaluate RU for RQO, drafting RQOs and numerical limits, agree these with the stakeholders to finalise and Gazette the RQOs, and finally moving to implementing, monitoring and reviewing before restarting the process for corrections and improvements.

Ideally the RQOs should be set for each Resource Unit, as per the Water Resource Classification System recommendations. In reality, however, due to the large number of Resource Units within Berg catchment, it is necessary to prioritise and select the most useful Resource Units for RQO determination. In terms of the seven step RQO determination process, Step 1 (Delineation) and Step 2 (Visioning) have been explained and completed as part of the Classification phase of this study (Figure 2.1). The Step 3 of the Procedure to Determine and Implement Resource Quality Objectives (DWA, 2011) purpose is to select and prioritise preliminary Resource Units using the RU prioritisation tool for RQO determination. The evaluation of the RU priority ratings for selection are then done (Step 4), and the RQOs and numerical limits are drafted (Step 5). These will then be discussed and agreed at the stakeholder engagement workshops (Step 6). This process will allow to select at least one RU to represent each IUA that will then be monitored after the gazetting of the RQOs (Step 7).

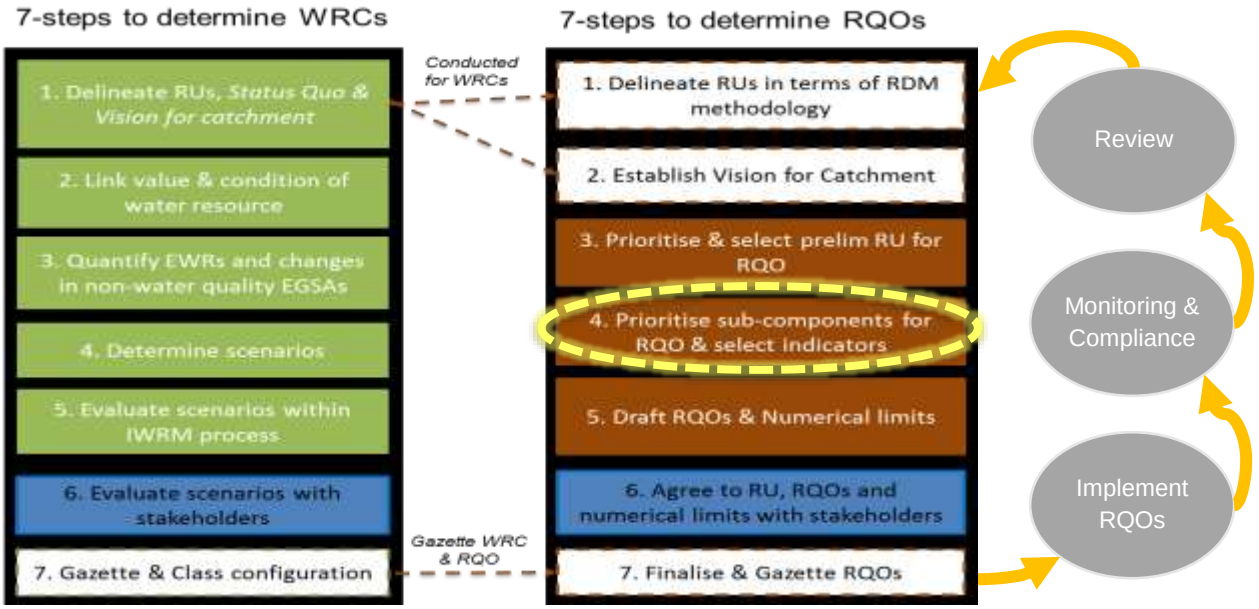

Figure 2.1: Integration of the seven-step processes for WRC determination and the RQO determination (DWA, 2011), incorporating the three additional steps to implement the Adaptive Management Cycle

Management, monitoring and compliance are the three additional steps of the Adaptive Management Cycle to be implemented after the seven step RQO process. This introduces a continual learning and improvement procedure to be in place which allows to make changes to align the RQOs with the vision for the resource. The changes, if needed, will indicate that the measures in place to protect the water resource are not sufficient to comply with the RQOs set, or alternatively that the RQOs set are not realistic, and it will be required to restart the process to correct these issues.

2.2 Sub-component prioritisation and indicator selection overview

Step 4 (Prioritise sub-components for RQO determination, select indicators for monitoring and propose the direction of change) of the RQOs process comprises of two main objectives: firstly, the identification and prioritisation of sub-components that may be important to either users of the environment; and secondly, the selection of those sub-components and associated indicators for which RQOs and Numerical Limits should be developed. In order to complete the activities of Step 4 of the RQOs process, specialist workshops are held wherein the Resource Evaluation Tool is used for the selection of sub-components for RQO determination, and indicators for RUs in the study area.

The Resource Evaluation tool is a decision support tool for the prioritisation process, which serves two main functions:

i. Determine the level of threat posed to each of the sub-components by impacting activities in the catchment
ii. Identify which sub-components should be protected in order to support water resource dependent activities and/or maintain the integrity and ecological functioning of the water resource (DWS< 2011:57)

The information from the resource Evaluation Tool is then used to prioritise sub-components.

The sub-steps that form the activities of Step 4 include:

1. Identify and assess the impact of current and anticipated future use on water resource components
2. Assess the importance of activities in driving resource change
3. Determine the anticipated level of impact on each sub-component
4. Determine the anticipated consequences of the impacting activities on each sub-component

The specific approaches used to prioritise sub-components and select indicators for estuaries, dams, wetlands and groundwater RUs within the Berg Catchment are discussed below.

2.2.1 River sub-component prioritisation and indicator selection

The RU evaluation tool for river was used to prioritise sub-components that may be important to users and the environment and to select indicators for which RQOs and Numerical Limits (NLs) should be developed by following the guidelines provided:

- Identify and assess the impact of current and anticipated future use on water resource components
    - Assess the importance of activities in driving resource change
    - Determine the anticipated level of impact on each sub-component
    - Determine the cumulative level of impact on each sub-component
    - Determine the anticipated consequences of the impacting activities on each sub-component
- Identify requirements of important user groups
    - Identify important user groups within the ‘protection of the water resource’ and ‘water resource dependent activity’ user group types
    - Rate the importance of sub-components for the ‘protection of the water resource’ and ‘water resource dependent activities’
    - Summarise the aspirations of each important user group
    - Review the present state information
    - Propose the desired direction and magnitude of change for each sub-component for important user-groups
- Selection of sub-components for RQO determination
    - Review the ecosystem and user prioritisation ratings
    - Select sub-components and associated indicators for RQO determination

- Establish the desired direction of change for selected sub-components
    - Where applicable, understand the trade-offs that have been made between user groups in the Water Resource Classification
    - Propose an acceptable direction of change for each selected sub-component
    - Align the outcomes of each RU assessment across the catchment
    - Complete the information sheet for the Resource Unit Evaluation Tool

The content of the RQOs will be formatted to be the same as much as possible, within the limits of the data. The studies used to source the data for the high priority RUs have been written at different times in the past and so the content is not the same between studies. Cognisance is also given to the fact that RQOs need to be meaningful but also implementable by the Department, who are all trained in assessing river condition using the Ecostatus modules developed by Neels Kleynhans, amongst other things.

For this reason, condition scores for different river attributes calculated using the Ecostatus modules are also included as RQOs. With this in mind Table 2-1 below summarises the indicators for each RU and describes the reasons for their choice and Table 2-2 indicates what kinds of RQOs will be written for each RU.

Table 2-1 Sub-component and indicator selection for prioritized river RUs in the Berg Estuary IUA

Discipline	Sub-component	Reason for selection	Example of indicator
Quantity	Low flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Flow RQOs given are a monthly average volumes (MCM) that include maintenance low and high flows combined i.e. they include the inter-annual floods with a return period greater than 1:2 years
	High flows		
Quality	Nutrients	Nutrients affects primary productivity and the growth of attached (periphyton) or free-floating algae (phytoplankton). Algae is a food source for biota, both aquatic invertebrates and vertebrates such as fish. High nutrient concentrations promote excessive algal growth which causes taste and odour problems in drinking water, and cause obstructions in irrigation equipment.	Specifications for maximum and minimum level for key properties of and contaminants in water
	Salts	Salts affect the osmoregulation of aquatic organisms. High salt concentrations reduce the yield of irrigated crops, cause corrosion of household appliances, and cause taste problems in drinking water.	Electrical conductivity
	System variables	pH, temperature, and dissolved oxygen are important for the maintenance of ecosystem health. pH describes the acidity or alkalinity of water which in turn affects the solubility of metals and distribution of aquatic organisms. It also affects corrosion or scaling in household appliances. Temperature affects the distribution of biota and migration/breeding signals. All biota is dependent on dissolved oxygen; some species are more sensitive to low DO than more tolerant species. Dissolved oxygen saturation is affected by water temperature. Anoxic conditions affect the solubility of metals.	pH range Dissolved oxygen concentration Temperature
	Toxins	The presence of toxic substances can have a chronic or acute impact on aquatic biota. Some toxins can bioaccumulate in fish. In humans, toxic substances can be carcinogenic.	Conservative approach is followed, no agrochemicals should be present in water.
	Pathogens	Pathogens cause waterborne diseases such as diarrhoea, cholera, dysentery, etc in human users. Although human pathogens in general don't affect aquatic biota they are often associated with high organic loads (related to untreated or partially treated sewage) which affects the dissolved oxygen concentration of the water.	Fitness for use categories for treated domestic water supply and contact recreation.

Discipline	Sub-component	Reason for selection	Example of indicator
Habitat	Ecological condition	Provides an overall score for ecological condition.	Index of Habitat Integrity
	Geomorphology	Instream habitat influences aquatic biota. Riparian habitat influences river channel structure and also protects agricultural land from erosion and provides habitat to riparian organisms.	Index of Habitat Integrity Provides an overall score for ecological condition. PAI Provides a score for the water quality condition. (1) GAI provides a score for the geomorphology condition. (1)
	Riparian vegetation	Riparian habitat influences river channel structure and also protects agricultural land from erosion and provides habitat to riparian organisms	VEGRAI provides a score for the vegetation condition. (1) % cover of indigenous and riparian plant species.
Biota	Fish	Indigenous fish are of conservation importance.	FRAI provides a score for the fish condition. (1) Catch per Unit Effort (CPUE) of fish species present. Frequency of occurrence (FROC) of key fish species.
	Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	MIRAI Provides a score for the macroinvertebrate condition. (1) SASS and ASPT scores from SASS. The number of macroinvertebrate families present. Presence of key families.

(1) Scores are ranked as: A natural; B near natural; C moderately modified with natural functions still in place; D moderately modified with a loss of natural functions; E severely modified, F critical modified with a total loss of biota and function

Table 2-2 RQO components and sub-components for each Resource Unit in the Berg WMA

IUA	Quat#	Node	River	Node code	Rank	Quantity	Quality					Habitat		Biota		
						Hydrology	Nutrients	Salts	System variables	Toxins	Pathogens	Ecological condition	Geomorphology	Fish	Riparian vegetation	Invertebrates
D8 Upper Berg	G10A	Bvii13	Berg	Bvii13	1	x	x	x	x	x	x	x	x	x	x	x
	G10A	Bviii1	Berg	Bviii1	1	x	x	x	x	x	x	x	x	x	x	x
	G10A	Biv5	Franschoek	Biv5	3	x						x				
	G10B	Biii2	Wemmershoek	Biii2	3	x						x				
	G10C	Bvii14	Dwars	Bvii14	4	x						x				
	G10C	Bvii2	Berg	Bvii2	4	x						x				
	G10C	Biii3	Berg	Biii3	2	x	x	x	x	x	x	x	x	x	x	x
D9 Middle Berg	G10C	Bviii11	Pombers	Bviii11	1	x	x	x	x	x	x	x	x	x	x	x
	G10D	Bvii3	Kromme	Bvii3	2	x	x	x	x	x	x	x	x	x	x	x
	G10D	Bvii10	Berg	Bvii10	5	x						x				
	G10D	Bvii15	Doring	Bvii15	5	x						x				
	G10D	Bvii4	Kompanjies	Bvii4	5	x						x				
	G10D	Bvii5	Berg	Bvii5	1	x	x	x	x	x	x	x	x	x	x	x

IUA	Quat#	Node	River	Node code	Rank	Quantity	Quality					Habitat		Biota		
						Hydrology	Nutrients	Salts	System variables	Toxins	Pathogens	Ecological condition	Geomorphology	Fish	Riparian vegetation	Invertebrates
C5 Berg Tributaries	G10E	Biii4	Klein Berg	Biii4	2	x	x	x	x	x	x	x	x	x	x	x
	G10G	Bi1	Vier-en-Twintig	Bi1	2	x	x	x	x	x	x	x	x	x	x	x
B4 Lower Berg	G10F	Bvii11	Berg	Bvii11	4	x						x				
	G10J	Biv3	Klein-Berg	Biv3	4	x						x				
	G10J	Biv1	Berg	Biv1	4	x						x				
	G10J	Bvii16	Leeu	Bvii16	4	x						x				
	G10H	-	Krom	G10H	4	x						x				
	G10J	Biv4	Vier-en-twintig	Biv4	5	x						x				
	G10J	Bvii17	Sandspruit	Bvii17	5	x						x				
	G10J	Bvii6	Berg	Bvii6	2	x	x	x	x	x	x	x	x	x	x	x
	G10J	Biii5	Matjies	Biii5	5	x						x				
	G10J	Bvii8	Berg	Bvii8	4	x						x				
	G10J	Bvii18	Moreesburg Spruit	Bvii18	4	x						x				
	G10K	Bvii12	Berg	Bvii12	1	x	x	x	x	x	x	x	x	x	x	x
	G10L	Bii1	Sout	Bii1	5	x						x				
	G10L	Biv2	Berg	Biv2	4	x						x				
	G21B	Bviii10	Sout	Bviii10	3	x						x				
A1 Berg Estuary	G10M	Bvii19			5	x						x				
A3 West coast	G21A	Bviii3		Bviii3	3	x						x				
D10 Diep	G21C	-	Riebecks	G21C	3	x						x				
	G21D	Bv1	Diep	Bv1	2	x	x	x	x	x	x	x	x	x	x	x
	G21D	Bviii4	Swart	Bviii4	3	x						x				
	G21D	Biv6	Diep	Biv6	2	x	x	x	x	x	x	x	x	x	x	x
	G21E	Biv7	Mosselbank	Biv7	3	x						x				
	G21F	Bviii5	Diep	Bviii5	5	x						x				
E11 Peninsula	G22B	Bviii6	Hout Bay	Bviii6	1	x	x	x	x	x	x	x	x	x	x	x
	G22A	Bvii20	Silvermine	Bvii20	2	x	x	x	x	x	x	x	x	x	x	x
E12 Cape Flats	G22C	Bviii8	Elsieskraal	Bviii8	3	x						x				
	G22D	Bvii7	Keysers	Bvii7	2	x	x	x	x	x	x	x	x	x	x	x
	G22E	-	Kuils River	G22E	3	x						x				
D6 Eerste	G22F	Biii6	Jonkershoek	Biii6	1	x	x	x	x	x	x	x	x	x	x	x
	G22G	Biv8	Klippies	Biv8	2	x	x	x	x	x	x	x	x	x	x	x
	G22H	Biv9	Kuils	Biv9	3	x						x				
D7 Sir Lowry's	G22J	Bvii21	Lourens	Bvii21	1	x	x	x	x	x	x	x	x	x	x	x
	G22K	Bviii9	Sir Lowry's Pass	Bviii9	1	x	x	x	x	x	x	x	x	x	x	x
	G40A	Bvii22	Steenbras	Bvii22	1	x	x	x	x	x	x	x	x	x	x	x

2.2.2 Estuary sub-component prioritisation and indicator selection

The RU evaluation tool for estuaries was used to prioritise estuaries that may be important to users and the environment and to select indicators for which RQOs and Numerical Limits should be developed by following the same guidelines provided as for river nodes. A total of 18 estuaries were evaluated in this manner.

2.2.3 Dam sub-component prioritisation and indicator selection

To determine the subcomponents to be included per priority dam for which Resource Quality Objectives should be determined, the 'Resource Unit Evaluation' tool for dams was used. Minor improvements to the tool was made, mainly to improve clarity with respect to evaluation criteria.

Evaluation criteria were included for quantity, quality, habitat and biotic requirements associated with dams. The specific indicators for each of these include:

- Quantity – low flows or maintenance flows and high flows, including freshets and 1:2 year floods. Note that this includes releases of water to the downstream river, for the ecology and for other users, as well as inflows.
- Quality – nutrients, salts, system variables, toxics, pathogens
- Habitat – riparian and in-dam habitats
- Biota – fish, aquatic and riparian plants, mammals, birds, amphibians, phytoplankton and aquatic invertebrates/zooplankton

The evaluation criteria for each of the above indicators are:

i) *Cumulative level of impact* - This is the anticipated level of impact of current and future use/activities in the upstream catchments on the inflows to the dam and the quality, habitat and biota in the dam. The 'impact rating' can be Very High: -1; High: -0.75; Moderate: -0.5; Low: -0.25; None: 0. Positive scores can be used where a positive impact on the resource quality is expected.
ii) *Trajectory of change* – These are indicated by arrows to show a positive (↑), negative (↓) or stable (→**)** trajectory.
iii) Confidence in the scoring indicated as 'very low' to 'high'.
iv) *Protection of the Resource*: Rating of importance of components for the protection of the water resource, i.e. importance to releases of water for downstream EWRs. Scores given are Very High: 1; High: 0.75; Moderate: 0.5; Low: 0.25; Not important: 0.
v) *Water Resource Dependent Activities*: Rating of importance of components for protection of the water resource for in-dam activities and releases of water for downstream use (irrigation, domestic/rural supply, etc.). Scores given are Very High: 1; High: 0.75; Moderate: 0.5; Low: 0.25; Not important: 0.
vi) Components with importance scores of 0.5 and higher for the 'importance for protection' or 'importance for other water use' are then selected to be included as an EcoSpec and/or UserSpec and will form part of the final set of RQOs for that specific dam.

A total number of six dams were prioritised based on the criteria for selection in Step 3 of the RQO process. Table 2-3 includes some information on the selected dams.

Table 2-3 Prioritised dams considered in this sub-component and indicator phase of the RQO determination procedure

IUA	Name of dam	Quaternary Drainage Area	Completion year	River	Capacity (1000 m^3)	Purpose / use	Owner
D8 Upper Berg	Berg River Dam	G10A	2008	Berg River	130 000	Domestic and industrial water supply to the Western Cape Water Supply System (City of Cape Town), agricultural water supply to irrigation users in the Berg River, and ecological flow releases.	TCTA
D8 Upper Berg	Wemmershoek	G10B	1957	Wemmershoek	58 644	Domestic and Industrial supply	City of Cape Town
B4 Lower Berg	Voëlvlei Dam	G10F	1971	Off-channel storage dam, supplied from Klein Berg, Twenty-four and Leeu rivers	168 000	Domestic and industrial water supply to the Western Cape Water Supply System (City of Cape Town via the Voëlvlei WTW, and towns in the Swartland via the Swartland WTW).	DWS
B4 Lower Berg	Misverstand Weir	G10K	1977	Berg River	7 737	Domestic and industrial water supply to towns in the West Coast via the Withoogte WTW, irrigation and compensation releases to users in the lower Berg River.	DWS
D7 Sir Lowry's	Steenbras Upper Dam	G40A	1977	Steenbras River	31 767	Domestic and industrial water supply to the Western Cape Water Supply System (City of Cape Town) via the Faure WTW, hydropower production via the Steenbras Pumped Storage Scheme, and releases to Steenbras Lower Dam.	City of Cape Town
D7 Sir Lowry's	Steenbras Lower Dam	G40A	1921 Raised 1954	Steenbras River	36 133	Domestic and industrial water supply to the Western Cape Water Supply System (City of Cape Town) via the Steenbras WTW, and ecological flow releases to the lower Steenbras River and estuary.	City of Cape Town

2.2.4 Wetland sub-component prioritisation and indicator selection

As discussed in the Resource Unit Prioritisation Report, the use of the Wetland Resource Unit Prioritisation Tool (WRPT) is considered problematic for wetland resources, due to the unrealistic input data requirements and the cumbersome and time-consuming process involved in using the tool (INR, 2017). An updated methodology is currently being developed and was used to determine high priority wetland resource units, according to ecological importance and provision of ecosystem services. These wetland resource units were considered per wetland region in order to allow for representation across the WMA. Although these priority wetland resource units are still to be workshopped with stakeholders, particular wetlands considered important were assessed in this report in terms of the wetland sub-component prioritisation and indicator selection. These were wetlands considered in Reserve Determination as well as all other wetlands identified in the Resource Unit Prioritisation Report.

Named wetlands from the Western Cape Wetlands Directory were reviewed from the Status Quo Report (DWS, 2017). These wetlands were reviewed according to the Wetland Region they occurred in, the typical wetland types that occur in each Wetland Region, and the key threats to wetlands in the Region. These wetlands were reviewed in terms of the prioritised wetlands (Appendix A). Although the prioritisation process did not include all wetlands in the study area, it is clear that there is a representative sample of wetlands to be taken forward to the RQO phase. Some of the wetlands identified through the prioritisation process included wetlands which have had more detailed studies as part of City of Cape Town studies or rehabilitation programmes. This information was reviewed in order to develop a conceptual understanding of specific wetland functioning and key threats. This understanding was then used to inform the development of RQOs for prioritised wetlands.

There are no wetlands considered as part of Reserve Determination. For all prioritised wetlands the overall land use impact and ecological categories were identified. From these processes relevant indicators and numerical values were then extracted, the outcome being a set of measurable indicators.

The priority wetlands which have been worked on by the Working for Wetlands Program are:

- South Western Coastal Belt_Sand (WR1)
    - Rietvlei
- Southern Folded Mountains_Peninsula (WR5)
    - Noordhoek

The priority wetlands which were worked on by Malan et al. are:

- Southern Folded Mountains_Peninsula (WR5)
    - Noordhoek Salt Pan

The priority wetlands which have had detailed studies in the City of Cape Town jurisdiction are:

- South Western Coastal Belt_Sand (WR1)
    - Rietvlei
    - Nooiensfontein
    - Blouvlei
    - Zeekoeivlei
    - Rondevlei
    - Princess Vlei
- Southern Folded Mountains_Peninsula (WR5)
    - Pick & Pay Reedbeds

Ecological Reserve monitoring is a process whereby the following is required:

1. Determining the Present Ecological Status (PES) of the resource
2. Formulating the Recommended Ecological Category (REC)
3. Specifying the Resource Quality Objective (RQO)

4. Specifying the ecological attributes that would indicate the attainment of the REC.

These steps are reliant on measuring a trend of how the resource is changing over time, with change being measured against a baseline or reference condition for driver and response components.

In most cases wetland RQOs are low confidence data measured over a short temporal scale, with limited long-term monitoring. Wetlands do not have the same level of data available in which to make appropriate recommendations, as opposed to the relatively well understood dynamics of other water resources, particularly rivers and estuaries. It is therefore critical that the first step in the development of a monitoring program for wetlands is the development of a reference condition understanding of ecological functioning with a higher level of confidence.

Through this study HIGH priority wetlands have been defined according to Ecological importance and provision of important Ecosystem Services. Wetlands defined as important through this process may have a low level of data associated with them (i.e. Riverlands Depression Wetland) and even where relatively large amounts of data are available they may be inherently complex systems (i.e. Rondevlei/ Zeekoeivlei). It is therefore difficult to design a "one size fits all" monitoring program for wetlands due to the limited conceptual understanding there is for these varied systems.

Note: Although HIGH priority wetlands have been identified, these may be considered a sample of wetlands in the study area. All wetlands are still to be considered under the National Water Act for triggering activities and will need to be assessed fully. The benefit of identifying HIGH priority wetlands is to identify a representative sample of wetlands whereby further information is required, or where information is available to ensure that monitoring occurs.

Conceptual understanding of wetland systems

It is proposed that the first step in monitoring is to develop a conceptual understanding of the HIGH priority wetland system, then to apply the WET-Health assessment methodology (Hydrology/Geomorphology/Vegetation: Macfarlane et al. 2008) in order to develop an understanding of the baseline condition and threats of the wetland system before monitoring commences. Strictly speaking the responder component (i.e. vegetation or biota) of an ecosystem should be easier to rehabilitate than the underlying driver conditions (i.e. hydrology, water quality and geomorphology) due in part to drivers being able to mitigate change over a longer time period.

Drivers and Responders: The drivers of a wetland are primarily responsible for the presence and maintenance of the system, whilst responders may react to short term fluctuations.

In all wetland types the most important driver is hydrology, followed by geomorphology and water quality. Vegetation is both a driver and a responder (i.e. vegetation acts as habitat for biota but also is driven by the underlying soil/water availability) and biota is considered to be a responder to the other underlying components. Understanding the complex interactions and relationships between drivers and responders allows for the identification of important components and sub-components of wetland systems which will allow for effective indicators to be developed (Figure 2.2).

Indicator selection relates to the prioritisation process, which means that an indicator may be related to monitoring an important ecological characteristic, threat or provision of an important ecosystem service of the wetland.

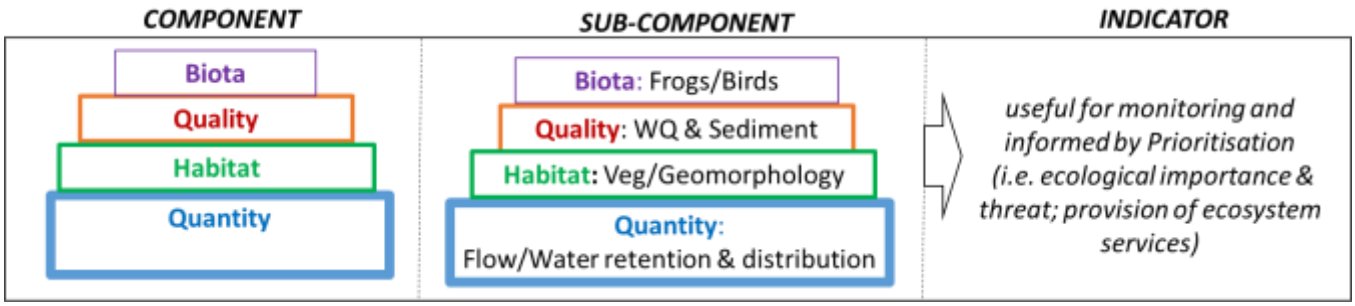

Figure 2.2General conceptualisation of the important components and sub-components of wetlands, which lead to effective indicator selection

Table 2.4 Representation of the important drivers of different wetland types

Wetland HGM type	QUANTITY		HABITAT	WQ	HABITAT	BIOTA
	Flow	Hydroperiod	Geomorphology	Water Quality	Vegetation	Benthic algae
Floodplain	**xx**	**xx**	**xx**	x	x	
Channelled Valley-Bottom		**xx**	**xx**	x	x	
Unchanneled Valley-Bottom		**xx**	**xx**	x	x	x
Seep		**xx**	**xx**	x	x	**xx**
Depression		**xx**	**xx**	x	x	**xx**
Flat		**xx**		x	**xx**	**xx**

As defined above the most important consideration for wetland monitoring is the development of a conceptual model of wetland hydrological and geomorphological functioning in order to determine the most relevant indicator to select for monitoring. Although in some cases, the most important indicator may be related to Biota (i.e. RAMSAR sites) it is still considered important to understand the functioning of the wetland system.

The steps for evaluation were as follows (with steps 2-3 being conducted as part of developing a baseline):

1. Develop a conceptual model of:
    a. Wetland hydrological functioning and geomorphology
    b. Wetland water quality
    c. Wetland vegetation
    d. Wetland biota

> **Wetland Water Quality:** Wetland biota are well-adapted to widely varying water quality conditions because of the stagnant, low-oxygen conditions that naturally exist in wetland environments. In the Western Cape wetland systems are exposed to increased nutrient loads and other water quality related impacts, pushing some wetland systems beyond a threshold (Wilkinson et al., 2016).

2. Validation and site selection (Required as part of monitoring):
    a. Visit the wetland in the field to determine if the defined wetland type and delineation is correct
    b. Site selection should focus on the representability, access to site, reliability of hydrology and hydraulics (if applicable), and diversity of ecological cues.
    c. Set a monitoring point relevant for particular RQO for particular wetland resource unit

3. Monitoring should take account of the relevant RQO and if required develop a baseline of:
    a. Wetland hydrology (WET-Hydrology module: Macfarlane et al. 2008)
    b. Wetland geomorphology (WET-Geomorphology module: Macfarlane et al. 2008)
    c. Wetland vegetation (WET-Vegetation module: Macfarlane et al. 2008)

In some cases, there has already been detailed monitoring of BIOTA (i.e. River Biomonitoring program) associated with other studies/programmes. Where possible this detailed information should be reviewed and incorporated into the Wetland Monitoring programme.

Wetland hydrological functioning and geomorphology

As the classification of wetlands relies on defining wetland type, this was used as the precursor to understand the hydrological and geomorphological functioning of the wetland resource units. This can be defined for flow and water distribution and retention patterns (i.e. baseflow/surrounding runoff) (Table 2.5), which in turn can be related to potential threats through surface water/groundwater usage and indirect land management impacts. Consideration of water distribution and retention patterns (i.e. hydroperiod) relates to the seasonal inundation of different types of wetlands (i.e. temporary, seasonal and permanently waterlogged zones of a wetland: Figure 2.3). The key drivers and threats of different wetland types are provided in Figures 2.3 to Figure 2.8.

Table 2.5 Conceptualisation of hydrological impacts for different wetland types

Wetland HGM type	Floods	Hydroperiod		
	High flows	Baseflow	Surrounding runoff	Standing water
Floodplain	x	x	x	
Channelled Valley-Bottom	x	x	x	
Unchanneled Valley-Bottom		x	x	
Seep		x	x	
Depression		x	x	
Flat		x	x	x

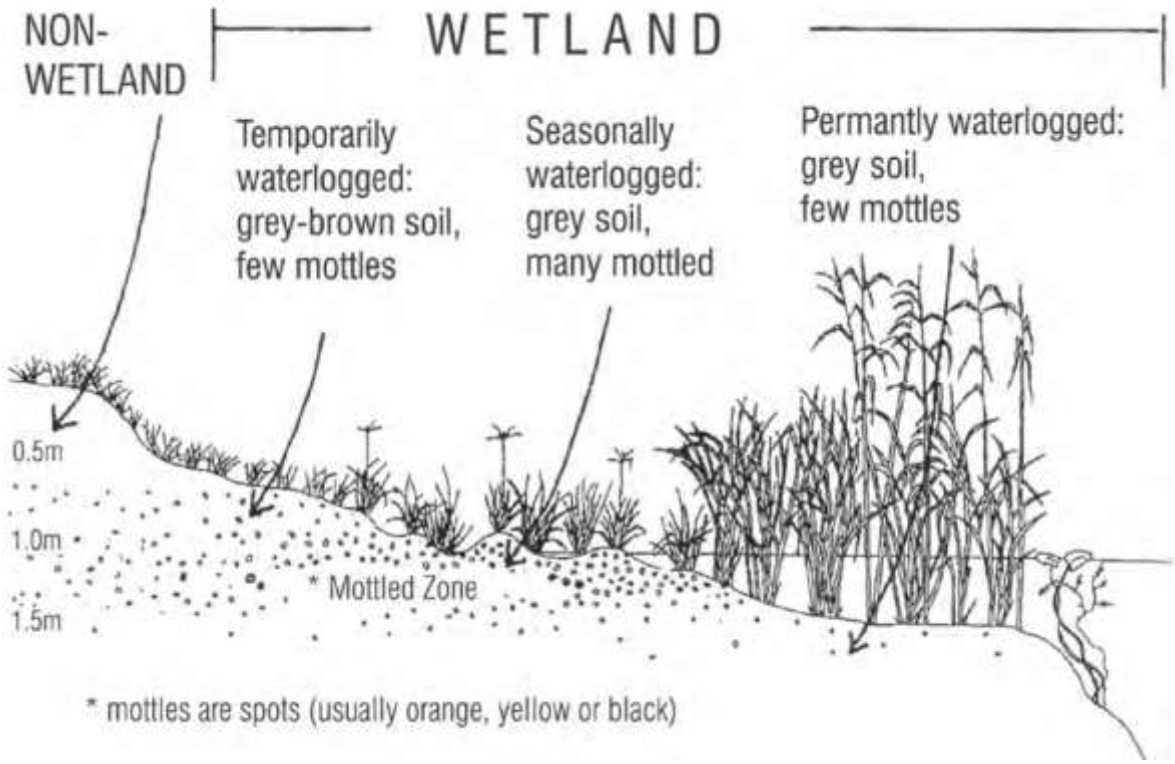

Figure 2.3 Conceptualisation of the water retention patterns within a wetland (DWAF, 2009)

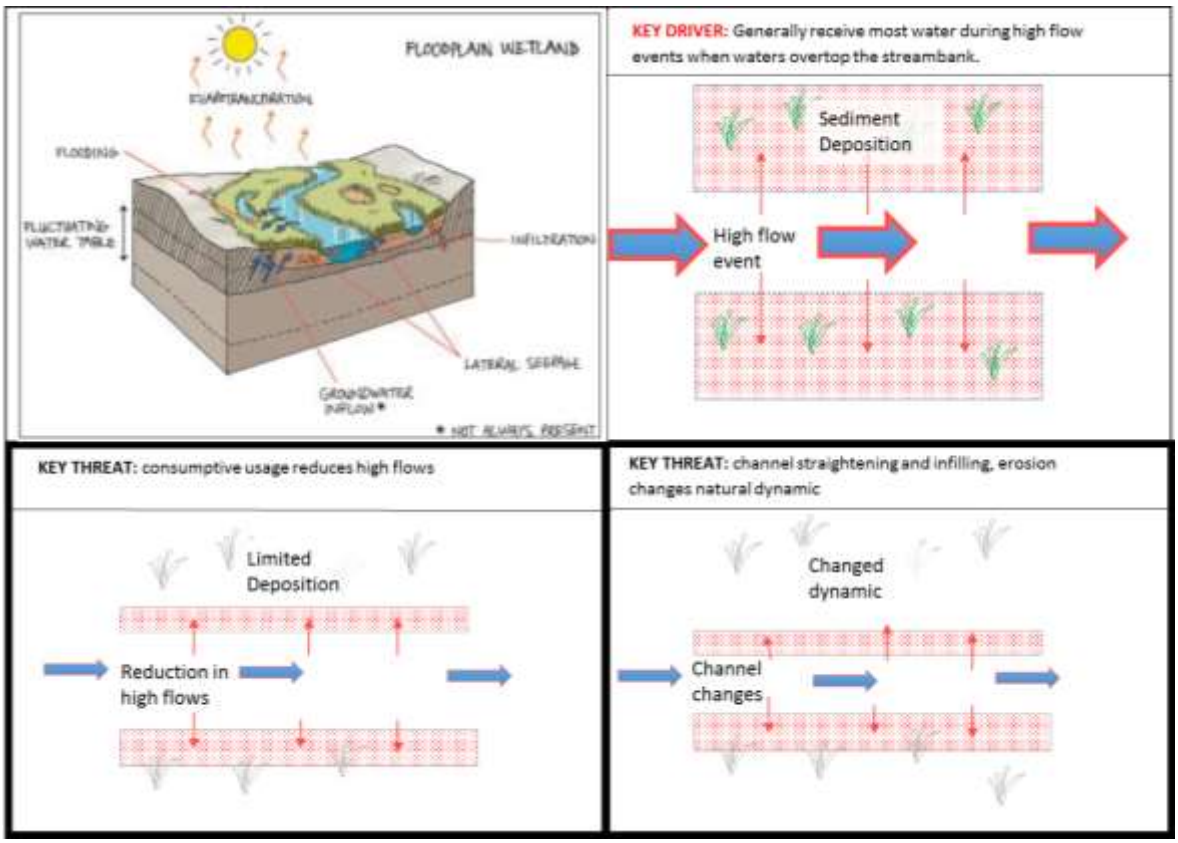

Figure 2.4 Conceptualisation of the key drivers and threats to floodplain wetlands

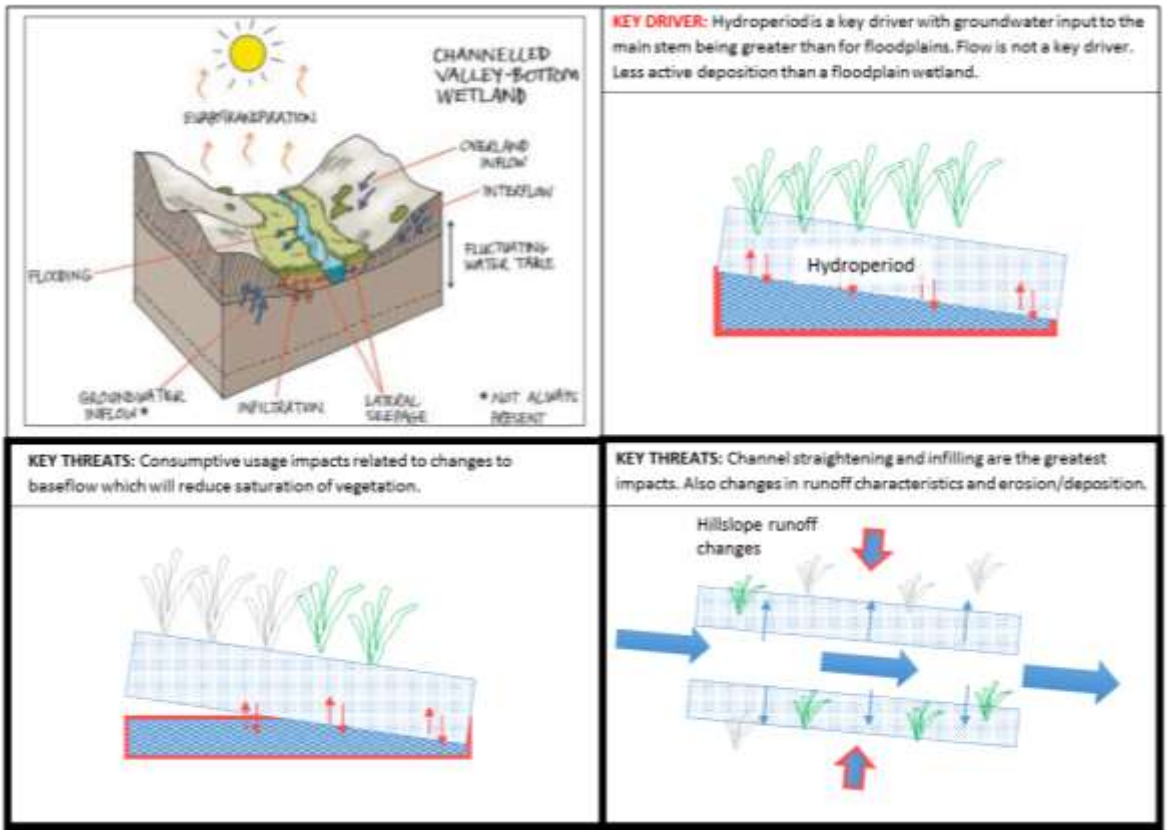

Figure 2.5 Conceptualisation of the key drivers and threats to channelled valley-bottom wetlands

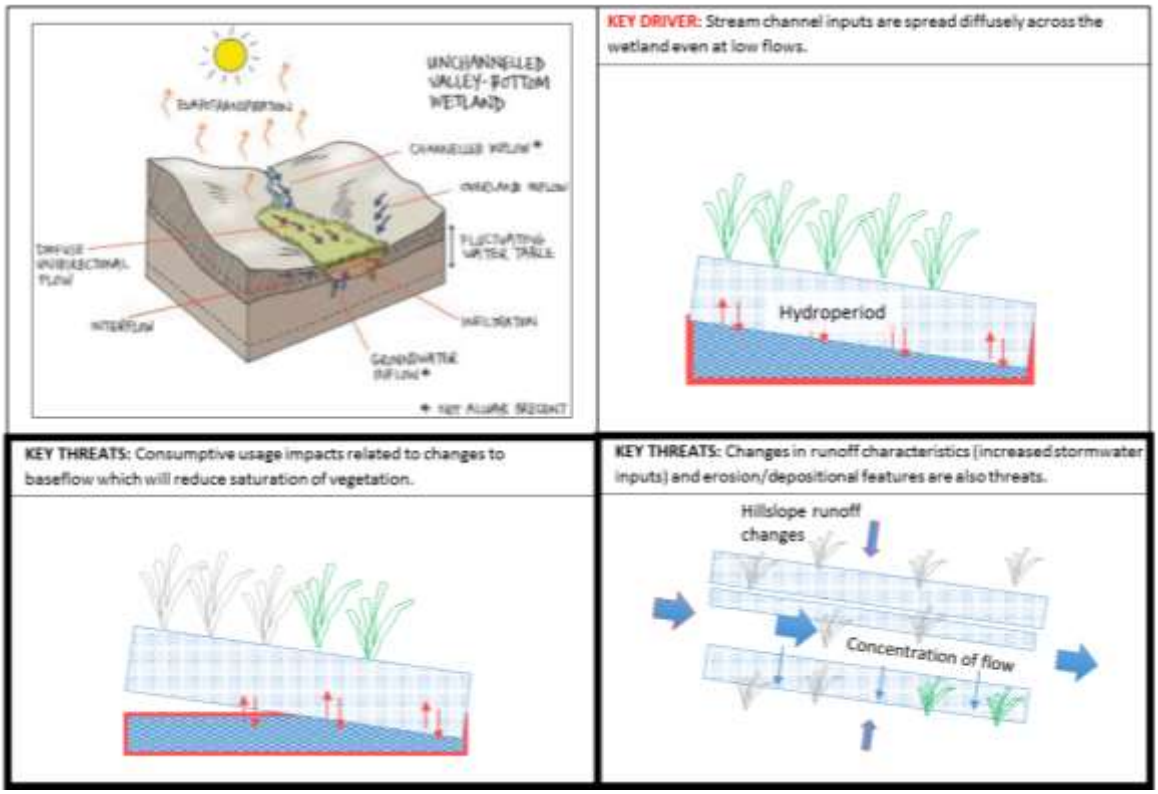

Figure 2.6 **Conceptualisation of the key drivers and threats to unchanneled valley-bottom wetlands**

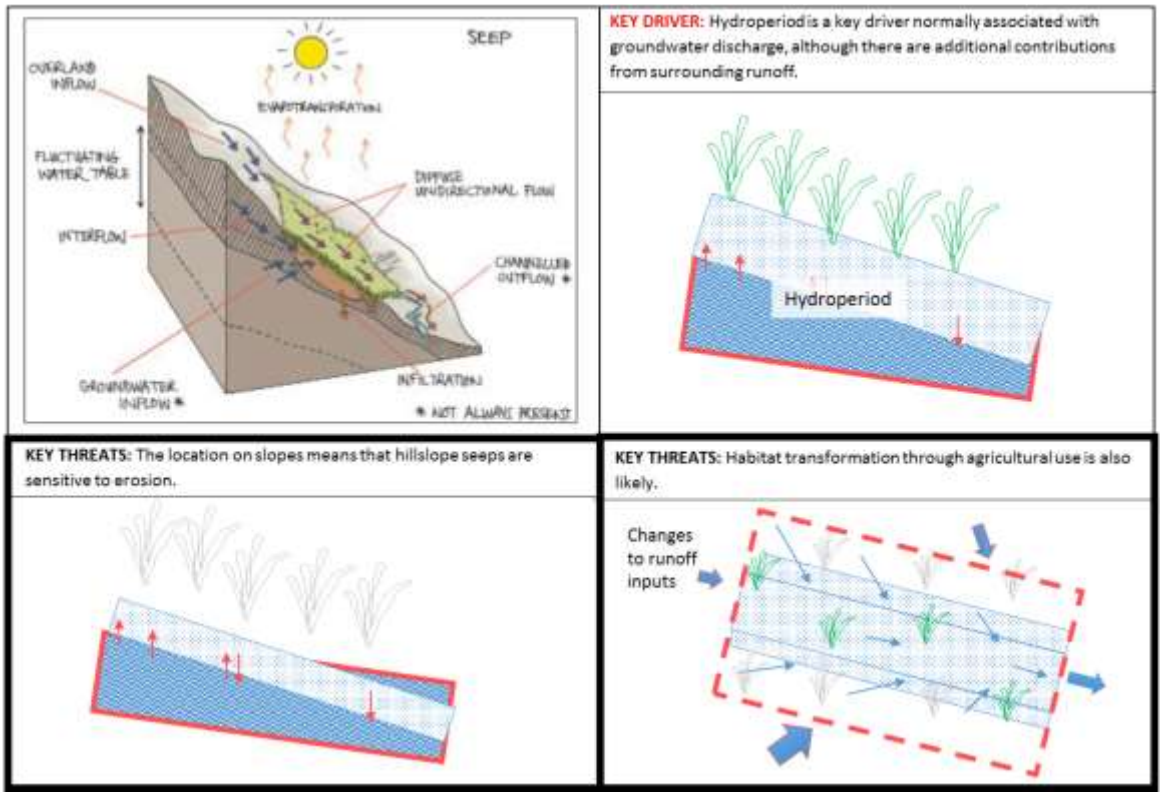

Figure 2.7 **Conceptualisation of the key drivers and threats to seep wetlands**

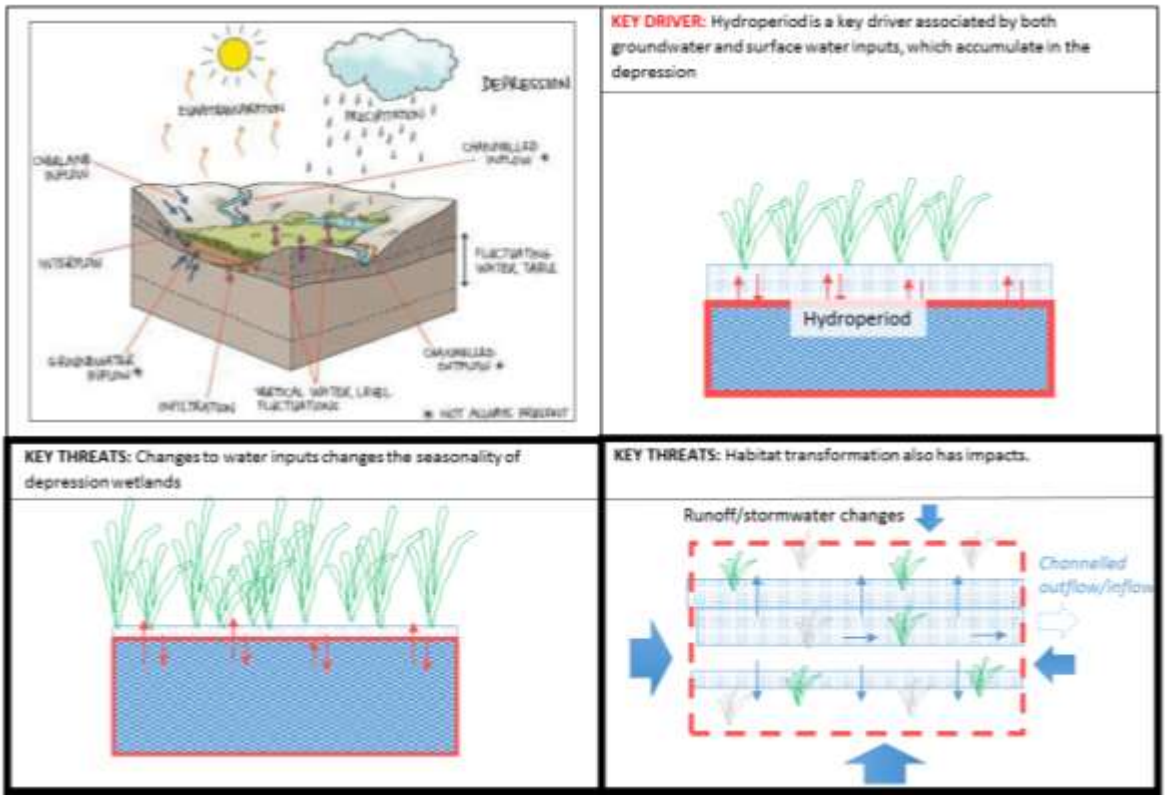

Figure 2.8 Conceptualisation of the key drivers and threats to depression wetlands

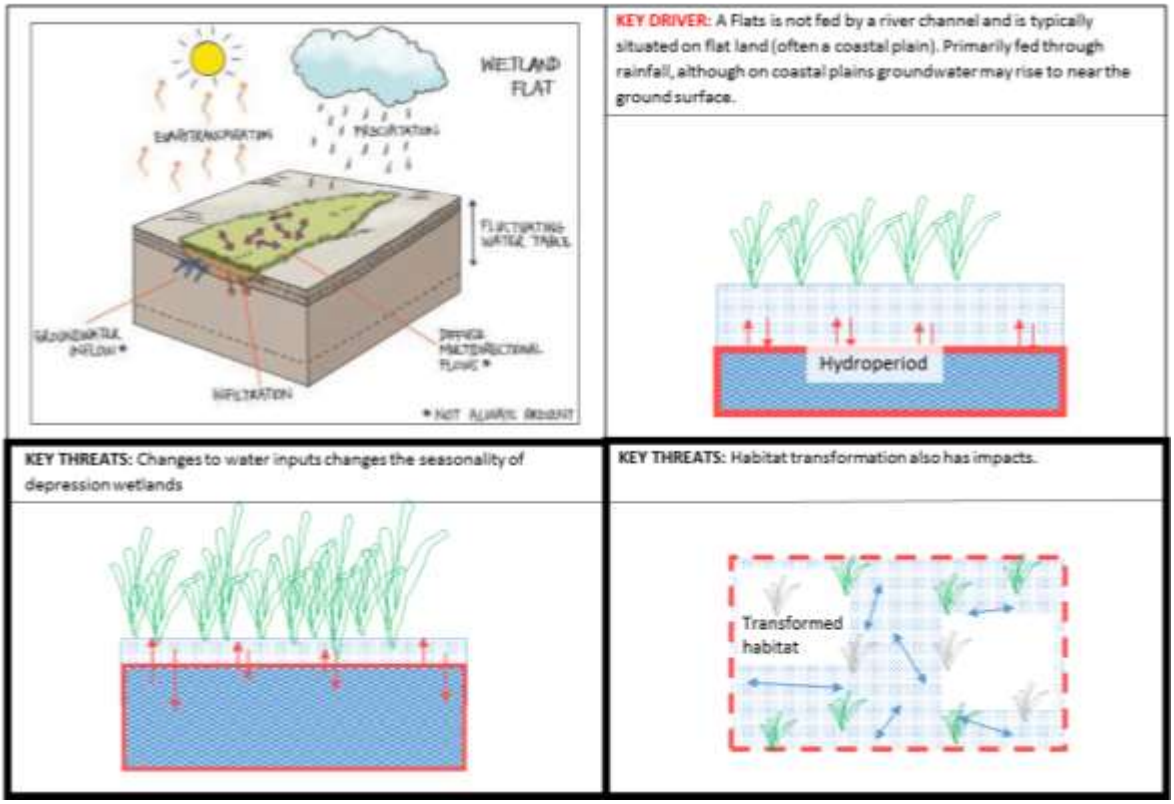

Figure 2.9 Conceptualisation of the key drivers and threats to wetland flats

In addition to the above-mentioned conceptualisation of wetland hydrological functioning, it is also important to note the particular hydrological functioning in the Cape Town area. The Cape Flats is characterised by an expansive low-lying plain of tertiary to recent deposits comprising calcareous sands of the Sandveld Group overlying basement rocks of the Malmesbury Group. The transition between sands and the Malmesbury rocks is

characterised by a clay layer, a product of weathering of the shale. The Sandveld Group deposits constitute the Cape Flats Aquifer which is regionally unconfined and is essentially free of geological boundaries which may influence regional behaviour. This influences the occurrence and seasonality of wetlands in this Wetland Region as it allows for perched water tables and temporary flooding during the winter months.

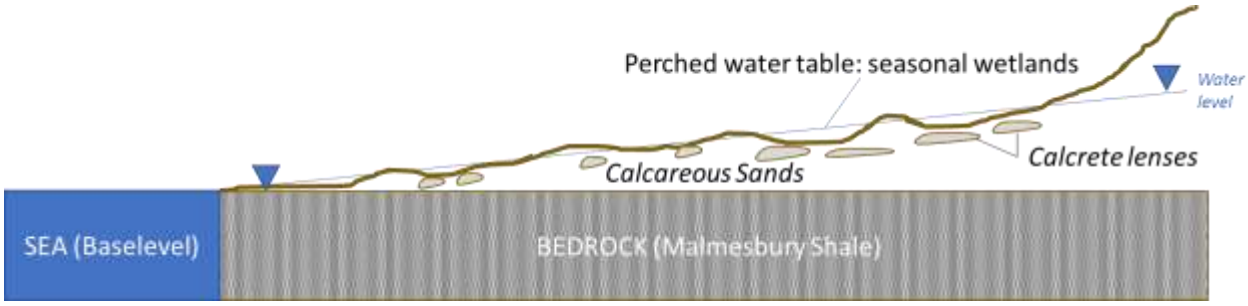

Figure 2.10 **The geological influence on the seasonality of wetlands in the Cape Flats**

2.2.5 Groundwater sub-component prioritisation and indicator selection

The Resource Unit Evaluation Tool addresses the prioritisation of sub-components that may be important to users and the environment and assists in the selection of indicators for which RQOs and Numerical Limits should be developed. The RU Evaluation Tool is however focussed on river, estuary, and wetland RUs, and there is no standard tool for the selection of indicators for groundwater RUs.

Therefore, the Resource Unit Evaluation Tool was used only as a guideline. The components routinely considered for rivers (quality, quantity) are equally applicable to groundwater. Relevant sub-components were selected based on the tool and also following recent examples from other catchments, specifically the Olifants-Doorn (DWS, 2014), and the Inkomati-Usuthu (DWS, 2015).

3 Results

3.1 Selected user sub-components and indicators for rivers

The RU evaluation tool for river was used to prioritise sub-components that may be important to users and the environment and to select indicators for which RQOs and Numerical Limits should be developed.

Two different levels of numerical and descriptive RQOs will be written. Hydrological and ecological condition RQOs will be written for all RUs. In addition to this, water quality, geomorphology, riparian vegetation, macroinvertebrates and fish RQOs will be written for the high priority RQOs.

The 20 high priority RUs in the Berg WMA where detailed RQOs for hydrology, water quality, geomorphology, riparian vegetation, macroinvertebrates and fish will be written are shown in Table 3-1.

Table 3-1 Priority River Resource Units (RUs) selected for evaluation in the Berg Catchment

IUA	Quat #	SQ Code	River	Node	Rationale	Score	Rank
D8 Upper Berg	G10A	G10A-09172	Berg	Bviii1	D/s of Berg River dam at EWR 1 - C	0.71	1
D8 Upper Berg	G10A	G10A-09199	Berg	Bvii13	Gauge	0.55	1
D8 Upper Berg	G10C	G10D-08957	Berg	Biii3	At gauging weir G1H020	0.49	2
D9 Middle Berg	G10D	G10F-08726	Berg	Bvii5	At gauging weir G1H036 and u/s of EWR 3 - D	0.52	1
D9 Middle Berg	G10C	G10D-08928	Pombers	Bviii11	At EWR 7 u/s of confluence with Kromme - C	0.51	1
D9 Middle Berg	G10D	G10D-08928	Kromme	Bvii3	North of Wellington, G1H037, d/s EWR 6 - D	0.51	2
C5 Berg Tributaries	G10E	G10F-08505	Klein Berg	Biii4	At gauging weir G1H008	0.50	2
C5 Berg Tributaries	G10G	G10G-08382	Vier-en-Twintig	Bi1	At gauging weir G1H028, pristine wilderness 100%	0.44	2
B4 Lower Berg	G10K	G10K-08197	Berg	Bvii12	3.5 km d/s of Misverstand reservoir, at EWR 5 - D	0.52	1
B4 Lower Berg	G10J	G10J-08414	Berg	Bvii6	D/s of EWR 4, above Misverstand Dam G1H013 - D	0.42	2
D10 Diep	G21D	G21D-08761	Diep	Bv1		0.45	2
D10 Diep	G21D	G21D-08906	Diep	Biv6	At EWR Die1	0.42	2
E11 Peninsula	G22B	G22B-09261	Hout Bay	Bviii6	At EWR site	0.75	1
E11 Peninsula	G22A	G22A-09324	Silvermine	Bvii20	Town	0.49	2
E12 Cape Flats	G22D	G22D-09294	Keysers	Bvii7	At EWR site	0.46	2
D6 Eerste	G22F	G22F-09205	Jonkershoek	Biii6	At EWR Eer1	0.66	1
D6 Eerste	G22G	G22G-09120	Klippies	Biv8		0.46	2
D7 Sir Lowry's	G40A	G40A-09346	Steenbras	Bvii22	At EWR 8, u/s of estuary mouth - B/C	0.73	1
D7 Sir Lowry's	G22J	G22J-09266	Lourens	Bvii21	At EWR Lou1	0.62	1
D7 Sir Lowry's	G22K	G22K-09315	Sir Lowry's Pass	Bviii9	Cumulative at outlet G22K	0.56	1

Table 3-2 Sub-component and indicator selection for prioritized rivers in the Upper Berg IUA

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D8 Upper Berg	II	D8-R01	Berg	Bviii1	Quantity	Low flows High flows	This site measures the EWR outflows from the Berg River dam set to sustain the ecological condition at EWR site 1, to maintain conditions in the river downstream.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	This is one of the few least disturbed upper foothill Western Cape rivers left and maintaining its condition as an example of this is important.	Index of Habitat Integrity
						Geomorphology	The river here is naturally shaped exhibiting well-structured riffle-pool sequences. The channel banks meander through the floodplain and are not straightened nor canalized.	GAI score
						Riparian vegetation	The riparian zone here is recovering following a recent fire and the clearing of alien plants. The associated wetland on either side of the channel provides important aquatic habitat.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	The river here is a FEPA and supports important indigenous fish species that are important from a conservation perspective.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D8 Upper Berg	II	D8-R02	Berg	Bvii13	Quantity	Low flows High flows	This site records important inflows into the Berg River Dam, from which water is transferred to the Skuifraam supplement scheme, Voelvlei and Theewaterskloof dams.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	This is one of the last unregulated upper foothill rivers in the Western Cape and is in good condition. It is important as a critically threatened river type.	Index of Habitat Integrity
						Geomorphology	The river exhibits rapid-pool sequences with well sorted bed and bank sediments.	GAI score
						Riparian vegetation	The surrounding catchment has been cleared from Pine afforestation and is now returning back to mountain fynbos. There are still some exotic plant species but predominantly the riparian and aquatic plant communities are indigenous.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This river is a FEPA and supports important endangered populations of indigenous fish.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D8 Upper Berg	II	D8-R03	Berg	Biii3	Quantity	Low flows High flows	The river here is canalized but still remains important from a water resource perspective since flows must be maintained to support agriculture downstream.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	Improvements to the poor condition of this river can be made through non-flow related interventions, such as re-establishing aquatic and riparian plant species.	Index of Habitat Integrity
						Geomorphology	The river is canalised, and it is unlikely that any improvement in its geomorphological condition may be realized without a serious restoration initiative.	GAI score
						Riparian vegetation	There are few indigenous species here, but effort could be made to re-establish indigenous plant species. There are a number of exotic plant species present that must be monitored and removed regularly.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	There are no indigenous fish of importance here but there are some exotic fish species present whose presence must be monitored.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The aquatic invertebrates present here are one of the few remaining biota present in this severely transformed river channel. They also provide a useful indicator of water quality, which can be quite poor in this urban river reach.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

Table 3-3 Sub-component and indicator selection for prioritized rivers in the Middle Berg IUA

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D9 Middle Berg	III	D9-R04	Berg	Bvii5	Quantity	Low flows High flows	The river here is upstream of Voelvlei dam and so the gauge records the regulation of agricultural releases made through Hermon before the outlet from Voelvlei releases further flow.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The farming activities in this section of the river are intense and take place up and onto the river banks. The river is in poor condition.	Index of Habitat Integrity
						Geomorphology	The channel is naturally shaped, and the bed sediments are well sorted, exhibiting riffle-run sequences.	GAI score
						Riparian vegetation	There are few indigenous plant species present, some robust indigenous aquatic and riparian plant species remain. The predominant flora are disturbance triggered annuals and perennials, along with some exotic tree species, notably Eucalyptus. Clearing has been done and is ongoing, so recovery efforts should be monitored.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	There are no indigenous fish here, but there is an array of exotic fish species whose presence must be monitored.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The invertebrate fauna here are hardy and generally tolerant to pollution. Improved conditions of aquatic and riparian habitat would increase the abundance of more sensitive taxa.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D9 Middle Berg	III	D9-R05	Pombers	Bviii11	Quantity	Low flows High flows	The Pombers receives an inter-basin transfer from the upper Witte River (Breede River basin) via a canal named Gawie se water. From here these flows are delivered to the Kromme River from which they are transferred.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The River is in poor condition and would benefit from non-flow related improvements.	Index of Habitat Integrity
						Geomorphology	The channel banks are straightened and have been bulldozed. The bed sediments are poorly structured.	GAI score
						Riparian vegetation	There are few indigenous plant species present. The flora are dominated by disturbance triggered annuals and perennials and exotic trees.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	There are no indigenous fish species present and few fish present in general.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	Hardy and tolerant invertebrates are present due to the poor conditions of the river channel habitats and the lack of indigenous plant species.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D9 Middle Berg	III	D9-R06	Kromme	Bvii3	Quantity	Low flows High flows	The Kromme receives the inter-basin transferred water from the Pombers river before it is transferred elsewhere.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in poor condition due to a combination of flow and non-flow related impacts.	Index of Habitat Integrity
						Geomorphology	The river channel has cut banks and poorly sorted bed sediments.	GAI score
						Riparian vegetation	There are few indigenous riparian and aquatic plant species present. The dominant taxa are exotic woody plants and disturbance triggered annuals and perennials.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	There are no indigenous fish present, only a handful of exotic fish whose present must be monitored.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	Hardy and pollution tolerant invertebrates are present that can persist despite the poor habitat conditions, elevated flows in summer and exotic plant dominated flora.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

Table 3-4 Sub-component and indicator selection for prioritized rivers in the Berg Tributaries IUA

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
C5 Berg Tributaries	II	C5-R07	Klein Berg	Biii4	Quantity	Low flows High flows	The Klein Berg is one of the most important tributaries sustaining farming through the Tulbagh valley and providing inflows into Voelvlei dam. Flow here is largely unregulated.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in good condition overall, despite the intensity of farming along its banks and the town of Tulbagh.	Index of Habitat Integrity
						Geomorphology	The river channel is naturally shaped and exhibits riffle-pool sequences along a meandering channel.	GAI score
						Riparian vegetation	There is good representation of aquatic and riparian plant species despite the present of some exotic trees here and there.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	Despite this not being a FEPA the river is likely to support some indigenous fish populations.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The invertebrate fauna are well represented in this river despite the presence of farming pollutants, due to the good quality bed and bank habitat.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
C5 Berg Tributaries	II	C5-R08	Vier-en-Twintig	Bi1	Quantity	Low flows High flows	This is an important tributary that meets agricultural demands of the neighbouring farmers. Upstream of the offtake the river flows naturally.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in good condition upstream of the offtake. Downstream, conditions change rapidly as the floodplain has been infilled and bulldozed over.	Index of Habitat Integrity
						Geomorphology	The river exhibits clean and clear riffle-pool sequences and comprises naturally shaped bed and banks.	GAI score
						Riparian vegetation	There is a good representation of indigenous aquatic and riparian plant species in the channel and on the banks.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This river is a FEPA and supports critically endangered indigenous fish species.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	There is a diverse and abundant invertebrate community present in this river.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

Table 3-5 Sub-component and indicator selection for prioritized rivers in the Lower Berg IUA

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
B4 Lower Berg	III	B4-R09	Berg	Bvii12	Quantity	Low flows High flows	This gauge records outflows from Misverstand Dam that are important to support the Berg River estuary. The gauge is unfortunately unreliable and requires maintenance.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in poor condition overall, being heavily regulated but also receiving many agricultural pollutants.	Index of Habitat Integrity
						Geomorphology	The channel is naturally shaped and exhibits riffle-pool sequences and well sorted bed sediments.	GAI score
						Riparian vegetation	There are some indigenous aquatic and riparian plant species present both in the channel and on the banks but there are also a number of exotic plant species that must be cleared.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	There are no indigenous fish species here but there are a number of exotic fish that must be monitored.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	There are hardy and tolerant invertebrate families present that shift seasonally.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
B4 Lower Berg	III	B4-R10	Berg	Bvii6	Quantity	Low flows High flows	This site records the inflows into Misverstand Dam that supports the agricultural activities downstream but also flows for the Berg River estuary.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in poor condition overall largely due to the heavy invasion of exotic trees.	Index of Habitat Integrity
						Geomorphology	The channel banks are naturally shaped and the river meanders naturally through its floodplain comprising riffle-pool sequences.	GAI score
						Riparian vegetation	There are some indigenous aquatic plant species present in the channel but few on the banks. The dominant plants are Eucalypt trees.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	There are only exotic fish present here whose present must be monitored.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The invertebrates present are hardy and tolerant to pollution. Monitoring of their condition provides insight into the conditions of habitat and water quality.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

Table 3-6 Sub-component and indicator selection for prioritized rivers in the Diep IUA

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D10 Diep	III	D10-R11	Diep	Bv1	Quantity	Low flows High flows	This gauge measures flow upstream of the town of Malmesbury. The river does not flow in summer and it is critical to reinstate low flows to this river.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in poor ecological condition due to a combination of flow and non-flow related issues.	Index of Habitat Integrity
						Geomorphology	The channel is naturally shaped upstream of the town but canalised through Malmesbury. There is an unnaturally high proportion of fines in the channel due to erosion in the catchment upstream.	GAI score
						Riparian vegetation	There are few indigenous plant species present in the channel or on the banks. The flora are dominated by exotic trees and disturbance triggered annuals and perennials.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This river is a rehabilitation FEPA so improvements in conditions overall would bolster local aquatic fauna.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	Reinstating low flows in the dry season would improve the abundance and diversity of aquatic invertebrates.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D10 Diep	III	D10-R12	Diep	Biv6	Quantity	Low flows High flows	The river does not flow in the dry season and reinstating low flows would improve conditions downstream and to the estuary.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river flows through agricultural land and is in poor condition.	Index of Habitat Integrity
						Geomorphology	The channel is naturally shaped, but the bed sediments are poorly sorted, comprising mainly fines, sand and gravel. There is some bank erosion.	GAI score
						Riparian vegetation	The flora comprise mainly disturbance triggered grasses. There are some exotic trees present but generally a low diversity of plant species present.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This is a fish support area, so it is important to re-instate low flows to support these communities.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The invertebrate fauna are low in diversity due to poor habitat conditions and a lack of aquatic and riparian vegetation.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

Table 3-7 Sub-component and indicator selection for prioritized rivers in the Peninsula IUA

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
E11 Peninsula	II	E11-R13	Hout Bay	Bviii6	Quantity	Low flows High flows	The Hout Bay River flows through the town of Hout Bay and discharges onto Hout Bay beach as a small river outlet.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in poor condition at this point, being lower down the system and on the receiving end of many urban and agricultural runoff.	Index of Habitat Integrity
						Geomorphology	The channel is naturally shaped despite the floodplain being infilled and inhabited. There is good representation of riffle-pool sequences and well sorted bed sediments.	GAI score
						Riparian vegetation	There are indigenous and aquatic riparian plant species present in the channel and on the bank. There are also some exotic trees present.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This is a fish support area and harbours critically endangered fish populations that must be monitored.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	There is a good diversity of aquatic invertebrates sustained by the low flows in the dry season and the diversity of bed and bank habitats.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
E11 Peninsula	II	E11-R14	Silvermine	Bvii20	Quantity	Low flows High flows	The Silvermine River is one of two perennially flowing rivers on the Peninsula that flows through the Table Mountain National Park. The entire river, apart from the extreme lower reaches, is protected.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in good condition overall and must be maintained.	Index of Habitat Integrity
						Geomorphology	This river provides good examples of natural habitat all along its length and in the different geomorphological zones.	GAI score
						Riparian vegetation	The riparian flora are still recovering from the intensive farming in the floodplain of this river. The lower reaches flow through Clovelly Golf Course.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This river is a FEPA and supports critically endangered fish species.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The invertebrate fauna are diverse and abundant all along the river's length.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

Table 3-8 Sub-component and indicator selection for prioritized rivers in the Cape Flats IUA

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
E12 Cape Flats	III	E12-R15	Keysers	Bvii7	Quantity	Low flows High flows	The Keysers River flows through the affluence suburb of Constantia and is one of the most heavily trafficked urban rivers in Cape Town. It also provides important inflows into Sandvlei, a coastal wetland.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in a poor ecological condition being confined laterally through the urban areas.	Index of Habitat Integrity
						Geomorphology	The river banks are naturally shaped, but the channel habitats comprise mostly fines and small gravels, due to erosion upstream.	GAI score
						Riparian vegetation	There are some indigenous trees and shrubs on the banks and some aquatic plant species present in the channel. These co-exist with disturbance triggered annual grasses and perennial shrubs.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This river is not described to be important from a fish perspective but there are likely Cape Galaxias present.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The invertebrate fauna is poor to moderate due to a combination of low flows in the dry season and a lack of suitable rock and vegetated channel habitat.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

Table 3-9 Sub-component and indicator selection for prioritized rivers in the Eerste IUA

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D6 Eerste	III	D6-R116	Jonkershoek	Biii6	Quantity	Low flows High flows	This river flows through Stellenbosch and flows are important to maintain water quality conditions due to heavy sewage loads discharged into the river.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in good condition overall, despite being urban.	Index of Habitat Integrity
						Geomorphology	The channel is confined in some parts, but the aquatic and bank habitats are well structured and diverse.	GAI score
						Riparian vegetation	There are a few exotic tree species present, but the flora is dominated by indigenous riparian trees on the banks and aquatic plants in the channel.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This river is a FEPA and supports critically endangered fish populations.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	There is a diverse and abundance aquatic invertebrate fauna present.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D6 Eerste	III	D6-R117	Klippies	Biv8	Quantity	Low flows High flows	This is an important tributary of the Eerste River that assists to bolster flows through Stellenbosch and dilute urban pollutants.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in poor condition overall, being laterally confined and canalised in part.	Index of Habitat Integrity
						Geomorphology	The banks are canalised, and the instream habitats poorly represented due to an excess of fine sediment and the presence of urban litter.	GAI score
						Riparian vegetation	There are some aquatic plant species present as well as some indigenous trees and shrubs on the bank. The dominant flora however are disturbance triggered annuals and grasses and exotic tree species.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	There are no fish of conservation importance here, only a few species of exotic fish remain.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The invertebrate community is poorly represented comprising largely tolerant and hardy families.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

Table 3-10 Sub-component and indicator selection for prioritized rivers in the Sir Lowry's IUA

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D7 Sir Lowry's	II	D7-R18	Steenbras	Bvii22	Quantity	Low flows High flows	The river here is situated downstream of the two Steenbras Dams. Flow is restricted to spills or leakage and then any incremental flow received as runoff downstream of the dams.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in good condition despite flows being severely reduced.	Index of Habitat Integrity
						Geomorphology	The channel is naturally shaped and comprises rapid-pool reaches and well sorted large sediment particles.	GAI score
						Riparian vegetation	There is an abundant and diverse riparian and aquatic plant community present.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This river is a FEPA and supports indigenous fish species.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	There is a diverse and abundant invertebrate fauna present.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D7 Sir Lowry's	II	D7-R19	Lourens	Bvii21	Quantity	Low flows High flows	The Lourens River flows through agricultural land and is one of the major urban rivers on the Cape Flats that flows through the town of Somerset West. Flows are important to sustain the estuary as it empties into False Bay.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in poor condition at this point as it receives much agricultural and urban runoff and pollutants here.	Index of Habitat Integrity
						Geomorphology	The channel is naturally shaped, despite being laterally confined through the town of Somerset West. The channel habitats are well represented by clean and clear riffle-pool sequences.	GAI score
						Riparian vegetation	There are some indigenous riparian and aquatic plant species present that co-exist with a multitude of disturbance triggered annuals, grasses and shrubs.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This river is a fish support area and supports populations of indigenous fish.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The invertebrate community is moderate to good due to a combination of good aquatic habitat and sustained flows in the dry season.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

IUA	Class	RU	River	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D7 Sir Lowry's	II	D7-R20	Sir Lowry's Pass	Bviii9	Quantity	Low flows High flows	The Sir Lowry's Pass River is another large perennially flowing tributary through the Cape Flats and flows through a mixture of upmarket residential property, a historical village, low cost housing and informal settlements before it empties at the estuary into False Bay. A variety of social groups use the river and sustained flows are important to support this use.	Maintenance low flows Drought flows Maintenance high flows
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users. Excessive nutrients stimulate undesirable algal blooms in dams, and periphyton and macrophyte growth in rivers.	Nutrient concentrations (phosphate and total inorganic nitrogen)
						Salts	High salt concentrations affect crops yields, unpalatable drinking water, and interferes with the osmoregulation of aquatic organisms.	Electrical conductivity
						System variables	System variables such as pH, water temperature, suspended sediment, affect aquatic biota and uses.	pH range Dissolved oxygen concentration Temperature
						Toxins	Agrochemicals (pesticide & herbicides residues) can have chronic or acute impacts on aquatic biota.	Ammonia Atrazine & Endosulfan
						Pathogens	Water-borne diseases negatively affect domestic water supplies.	Escherichia coli
					Habitat	Ecological condition	The river is in good condition overall, being unregulated and there being few impacts higher up in the catchment.	Index of Habitat Integrity
						Geomorphology	The channel banks are naturally shaped, and the bed sediments are well sorted, exhibiting clean and clear riffle-pool sequences.	GAI score
						Riparian vegetation	There are aquatic plant species present, but the riparian flora are poorly represented due to the presence of Eucalypt trees.	VEGRAI score % cover of indigenous and riparian plant species
					Biota	Fish	This river is a fish support area and support indigenous fish populations.	FRAI score Catch per Unit Effort (CPUE) of fish species present Frequency of occurrence (FROC) of key fish species
						Invertebrates	The invertebrate fauna is moderate to good being sustained by low flows in the dry season and the presence of aquatic plants and well structure channel habitat.	MIRAI score SASS and ASPT scores from SASS The number of macroinvertebrate families present Presence of key families

3.2 Selected user sub-components and indicators for estuaries

The RU evaluation tool for estuaries was used to prioritise sub-components that may be important to users and the environment and to select indicators for which RQOs and Numerical Limits should be developed.

Two different levels of numerical and descriptive RQOs will be provided. Hydrological and ecological condition RQOs will be written for all micro-estuaries (but excluding river outlets) while more detailed RQOs including those for sedimentary processes, mouth condition, water quality, microalgae, macrophyte, invertebrate, fish and avifauna for the significant (high priority) estuaries.

The eight significant estuaries where detailed RQOs for hydrology, water quality, microalgae, macrophyte, invertebrate, fish and avifauna will be prepared are shown in Table 3-11 and the nine micro-estuaries for which hydrological and ecological condition RQOs will be written are listed in Table 3-12.

Table 3-11 Significant estuaries in the Berg catchment for which detailed RQOs will be provided

Estuary	Type[1]	Area (ha) incl. floodplain	Channel area (ha)	Catchment size (km^2)	Present day MAR Mm^3	PES	REC
Berg (Groot)	PO	9197.4	643.8	7764.9	562	D	C
Langebaan	EB	6 260.8	4112.9	501.6		B	A
Rietvlei/ Diep	TOC	834.0	229.1	1521.7	37	D	D
Wildevoelvlei	TOC	266.4	22.0	7.1	5.9	D	C
Sand	TOC	307.3	119.0	86.	30	D	D
Zeekoe	PO	366.5	327.3	60.1	17	E	D
Eerste	TOC	55.6	9.0	628.5	101	E	D
Lourens	TOC	38.2	2.0	27.3	59	D	C

1. PO = Permanently open, TOC = Temporary Open-Closed, EB = Estuarine Bay

Table 3-12. Micro-estuaries in the Berg catchment for which simplified RQOs will be provided

Estuary	Type[1]	Area (ha) incl. floodplain	Channel area (ha)	Catchment size (km^2)	Present day MAR Mm^3	PES	REC
Modder	TOC	11.3	0.3	174.3	2.6	C	C
Hout bay	TOC	9.1	0.3	37.4	16.8		D
Bokramspruit	TOC	7.0	<0.1	10.4	1.9	E	D
Schuster	TOC	6.8	<0.1	15.4	2.4	A	A
Buffels Wes	TOC	2.3	<0.1	2.8	0.4	F	D
Elsies	TOC	8.1	0.3	17.8	1.6	E	D
Silvermine	TOC	5.9	0.2	23.3	3.5	D	D
Sir Lowry's Pass	TOC	2.8	0.0	8.4	1.5	E	D
Steenbras	TOC	2.1	0.2	72.4	16.6	B	B

1. TOC = Temporary Open-Closed

The content of the RQOs will be formatted to be the same as much as possible, within the limits of the data. Reserve determination studies used as the main source of data for these significant estuaries were prepared different times in the past (between 2008 and 2017) and so the content is not the same between studies. Cognisance is also given to the fact that RQOs need to be meaningful but also implementable by DWS.

With this in mind, prioritised indicators for each significant estuary in each IUA are listed in Table 3-13 to Table 3-19, along with the reasons for their choice.

Table 3-13 Sub-component and indicator selection for significant estuaries in the Berg Estuary IUA

IUA	Class	RU	Estuary	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
A1 Berg Estuary	II	A1-E01	Berg	Bv1119	Quantity	Low flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Flow RQOs given are a monthly average volumes (MCM) that include maintenance low and high flows combined i.e. they include the inter-annual floods with a return period greater than 1:2 years
						High flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Floods are important for resetting the estuary and for scouring out sediment that has accumulated in the estuary
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key nutrients (NH4, NO_2, NO_3, PO_4) in water
						System variables	Temperature, salinity, oxygen, and pH all influence habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key properties of water
						Toxins	Toxin levels influence habitat quality for organisms and also fitness for use for users	Trace metals, hydrocarbons and pesticides
						Pathogens	Provide an indication of fitness for human use	Faecal coliforms, E. coli and Enterococci
					Habitat	Sedimentary processes	Provides an overall score for ecological condition.	Narrative account of the flow and/or tidal regime required to maintain sedimentary processes and habitat integrity at a specified level
						Mouth state	Provides a score for the water quality condition.	Specifications for the state of the mouth
					Biota	Fish	Estuaries are important as nursery areas for marine fish.	Community composition and abundance of fish
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	Community composition and abundance of benthic invertebrates and/or zooplankton
						Micro-algae	Benthic microalgae and phytoplankton provide a useful indicator of water quality and are also an important source of food for other estuarine biota	Chlorophyll a
						Macrophytes	Macrophytes provide important habitat and food for other estuarine biota	% cover of indigenous aquatic macrophytes
						Birds	Estuaries are important feeding, roosting and breeding areas for birds	Community composition and abundance

Table 3-14 Sub-component and indicator selection for significant estuaries in the Langebaan IUA

IUA	Class	RU	Estuary	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
A2 Langebaan	II	A2-E2	Langebaan		Quantity	Low flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Flow RQOs given are a monthly average volumes (MCM) that include maintenance low and high flows combined i.e. they include the inter-annual floods with a return period greater than 1:2 years
						High flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Floods are important for resetting the estuary and for scouring out sediment that has accumulated in the estuary
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key nutrients (NH4, NO_2, NO_3, PO_4) in water
						System variables	Temperature, salinity, oxygen, and pH all influence habitat quality for organisms and fitness for use for users	Specifications for maximum and minimum level for key properties of water
						Toxins	Toxin levels influence habitat quality for organisms and fitness for use for users	Trace metals, hydrocarbons and pesticides
						Pathogens	Provide an indication of fitness for human use	Faecal coliforms, E. coli and Enterococci
					Habitat	Sedimentary processes	Provides an overall score for ecological condition.	Narrative account of the flow and/or tidal regime required to maintain sedimentary processes and habitat integrity at a specified level
						Mouth state	Provides a score for the water quality condition.	Specifications for the state of the mouth
					Biota	Fish	Estuaries are important as nursery areas for marine fish.	Community composition and abundance of fish
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	Community composition and abundance of benthic invertebrates and/or zooplankton
						Micro-algae	Benthic microalgae and phytoplankton provide a useful indicator of water quality and are also an important source of food for other estuarine biota	Chlorophyll a
						Macrophytes	Macrophytes provide important habitat and food for other estuarine biota	% cover of indigenous aquatic macrophytes
						Birds	Estuaries are important feeding, roosting and breeding areas for birds	Community composition and abundance

Table 3-15 Sub-component and indicator selection for significant estuaries in the Diep IUA

IUA	Class	RU	Estuary	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D10 Diep	III	D10-E03	Rietvlei/Diep	Bvii5	Quantity	Low flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Flow RQOs given are a monthly average volumes (MCM) that include maintenance low and high flows combined i.e. they include the inter-annual floods with a return period greater than 1:2 years
						High flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Floods are important for resetting the estuary and for scouring out sediment that has accumulated in the estuary
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key nutrients (NH4, NO_2, NO_3, PO_4) in water
						System variables	Temperature, salinity, oxygen, and pH all influence habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key properties of water
						Toxins	Toxin levels influence habitat quality for organisms and also fitness for use for users	Trace metals, hydrocarbons and pesticides
						Pathogens	Provide an indication of fitness for human use	Faecal coliforms, E. coli and Enterococci
					Habitat	Sedimentary processes	Provides an overall score for ecological condition.	Narrative account of the flow and/or tidal regime required to maintain sedimentary processes and habitat integrity at a specified level
						Mouth state	Provides a score for the water quality condition.	Specifications for the state of the mouth
					Biota	Fish	Estuaries are important as nursery areas for marine fish.	Community composition and abundance of fish
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	Community composition and abundance of benthic invertebrates and/or zooplankton
						Micro-algae	Benthic microalgae and phytoplankton provide a useful indicator of water quality and are also an important source of food for other estuarine biota	Chlorophyll a
						Macrophytes	Macrophytes provide important habitat and food for other estuarine biota	% cover of indigenous aquatic macrophytes
						Birds	Estuaries are important feeding, roosting and breeding areas for birds	Community composition and abundance

Table 3-16 Sub-component and indicator selection for significant estuaries in the Peninsula IUA

IUA	Class	RU	Estuary	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
E11 Peninsula	II	E11-E04	Wildevoelvlei		Quantity	Low flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Flow RQOs given are a monthly average volumes (MCM) that include maintenance low and high flows combined i.e. they include the inter-annual floods with a return period greater than 1:2 years
						High flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Floods are important for resetting the estuary and for scouring out sediment that has accumulated in the estuary
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key nutrients (NH4, NO_2, NO_3, PO_4) in water
						System variables	Temperature, salinity, oxygen, and pH all influence habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key properties of water
						Toxins	Toxin levels influence habitat quality for organisms and also fitness for use for users	Trace metals, hydrocarbons and pesticides
						Pathogens	Provide an indication of fitness for human use	Faecal coliforms, E. coli and Enterococci
					Habitat	Sedimentary processes	Provides an overall score for ecological condition.	Narrative account of the flow and/or tidal regime required to maintain sedimentary processes and habitat integrity at a specified level
						Mouth state	Provides a score for the water quality condition.	Specifications for the state of the mouth
					Biota	Fish	Estuaries are important as nursery areas for marine fish.	Community composition and abundance of fish
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	Community composition and abundance of benthic invertebrates and/or zooplankton
						Micro-algae	Benthic microalgae and phytoplankton provide a useful indicator of water quality and are also an important source of food for other estuarine biota	Chlorophyll a
						Macrophytes	Macrophytes provide important habitat and food for other estuarine biota	% cover of indigenous aquatic macrophytes
						Birds	Estuaries are important feeding, roosting and breeding areas for birds	Community composition and abundance

Table 3-17 Sub-component and indicator selection for significant estuaries in the Cape Flats IUA

IUA	Class	RU	Estuary	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
E12 Cape Flats	III	E12-E05	Sand	Bvii7	Quantity	Low flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Flow RQOs given are a monthly average volumes (MCM) that include maintenance low and high flows combined i.e. they include the inter-annual floods with a return period greater than 1:2 years
						High flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Floods are important for resetting the estuary and for scouring out sediment that has accumulated in the estuary
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key nutrients (NH4, NO_2, NO_3) in water
						System variables	Temperature, salinity, oxygen, and pH all influence habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key properties of water
						Toxins	Toxin levels influence habitat quality for organisms and also fitness for use for users	Trace metals, hydrocarbons and pesticides
						Pathogens	Provide an indication of fitness for human use	Faecal coliforms, E. coli and Enterococci
					Habitat	Sedimentary processes	Provides an overall score for ecological condition.	Narrative account of the flow and/or tidal regime required to maintain sedimentary processes and habitat integrity at a specified level
						Mouth state	Provides a score for the water quality condition.	Specifications for the state of the mouth
					Biota	Fish	Estuaries are important as nursery areas for marine fish.	Community composition and abundance of fish
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	Community composition and abundance of benthic invertebrates and/or zooplankton
						Micro-algae	Benthic microalgae and phytoplankton provide a useful indicator of water quality and are also an important source of food for other estuarine biota	Chlorophyll a
						Macrophytes	Macrophytes provide important habitat and food for other estuarine biota	% cover of indigenous aquatic macrophytes
						Birds	Estuaries are important feeding, roosting and breeding areas for birds	Community composition and abundance

IUA	Class	RU	Estuary	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
E12 Cape Flats	III	E12-E06	Zeekoe		Quantity	Low flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Flow RQOs given are a monthly average volumes (MCM) that include maintenance low and high flows combined i.e. they include the inter-annual floods with a return period greater than 1:2 years
						High flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Floods are important for resetting the estuary and for scouring out sediment that has accumulated in the estuary
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key nutrients (NH4, NO_2, NO_3, PO_4) in water
						System variables	Temperature, salinity, oxygen, and pH all influence habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key properties of water
						Toxins	Toxin levels influence habitat quality for organisms and also fitness for use for users	Trace metals, hydrocarbons and pesticides
						Pathogens	Provide an indication of fitness for human use	Faecal coliforms, E. coli and Enterococci
					Habitat	Sedimentary processes	Provides an overall score for ecological condition.	Narrative account of the flow and/or tidal regime required to maintain sedimentary processes and habitat integrity at a specified level
						Mouth state	Provides a score for the water quality condition.	Specifications for the state of the mouth
					Biota	Fish	Estuaries are important as nursery areas for marine fish.	Community composition and abundance of fish
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	Community composition and abundance of benthic invertebrates and/or zooplankton
						Micro-algae	Benthic microalgae and phytoplankton provide a useful indicator of water quality and are also an important source of food for other estuarine biota	Chlorophyll a
						Macrophytes	Macrophytes provide important habitat and food for other estuarine biota	% cover of indigenous aquatic macrophytes
						Birds	Estuaries are important feeding, roosting and breeding areas for birds	Community composition and abundance

Table 3-18 Sub-component and indicator selection for significant estuaries in the Eerste IUA

IUA	Class	RU	Estuary	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D6 Eerste	III	D6-E07	Eerste	Biv9	Quantity	Low flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Flow RQOs given are a monthly average volumes (MCM) that include maintenance low and high flows combined i.e. they include the inter-annual floods with a return period greater than 1:2 years
						High flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Floods are important for resetting the estuary and for scouring out sediment that has accumulated in the estuary
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key nutrients (NH4, NO_2, NO_3, PO_4) in water
						System variables	Temperature, salinity, oxygen, and pH all influence habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key properties of water
						Toxins	Toxin levels influence habitat quality for organisms and also fitness for use for users	Trace metals, hydrocarbons and pesticides
						Pathogens	Provide an indication of fitness for human use	Faecal coliforms, E. coli and Enterococci
					Habitat	Sedimentary processes	Provides an overall score for ecological condition.	Narrative account of the flow and/or tidal regime required to maintain sedimentary processes and habitat integrity at a specified level
						Mouth state	Provides a score for the water quality condition.	Specifications for the state of the mouth
					Biota	Fish	Estuaries are important as nursery areas for marine fish.	Community composition and abundance of fish
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	Community composition and abundance of benthic invertebrates and/or zooplankton
						Micro-algae	Benthic microalgae and phytoplankton provide a useful indicator of water quality and are also an important source of food for other estuarine biota	Chlorophyll a
						Macrophytes	Macrophytes provide important habitat and food for other estuarine biota	% cover of indigenous aquatic macrophytes
						Birds	Estuaries are important feeding, roosting and breeding areas for birds	Community composition and abundance

Table 3-19 Sub-component and indicator selection for significant estuaries in the Sir Lowry's IUA

IUA	Class	RU	Estuary	Node	Component	Sub-component	Rationale for sub-component choice	Indicator
D7 Sir Lowry's	II	D7-E08	Lourens	Bvii21	Quantity	Low flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Flow RQOs given are a monthly average volumes (MCM) that include maintenance low and high flows combined i.e. they include the inter-annual floods with a return period greater than 1:2 years
						High flows	Component selected as part of original Reserve baseline information and standard for measuring all other ecosystem responses	Floods are important for resetting the estuary and for scouring out sediment that has accumulated in the estuary
					Quality	Nutrients	WQ influences habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key nutrients (NH4, NO_2, NO_3, PO_4) in water
						System variables	Temperature, salinity, oxygen, and pH all influence habitat quality for organisms and also fitness for use for users	Specifications for maximum and minimum level for key properties of water
						Toxins	Toxin levels influence habitat quality for organisms and also fitness for use for users	Trace metals, hydrocarbons and pesticides
						Pathogens	Provide an indication of fitness for human use	Faecal coliforms, E. coli and Enterococci
					Habitat	Sedimentary processes	Provides an overall score for ecological condition.	Narrative account of the flow and/or tidal regime required to maintain sedimentary processes and habitat integrity at a specified level
						Mouth state	Provides a score for the water quality condition.	Specifications for the state of the mouth
					Biota	Fish	Estuaries are important as nursery areas for marine fish.	Community composition and abundance of fish
						Invertebrates	Invertebrates provide a useful measure of aquatic biodiversity and also are indicators of water quality.	Community composition and abundance of benthic invertebrates and/or zooplankton
						Micro-algae	Benthic microalgae and phytoplankton provide a useful indicator of water quality and are also an important source of food for other estuarine biota	Chlorophyll a
						Macrophytes	Macrophytes provide important habitat and food for other estuarine biota	% cover of indigenous aquatic macrophytes
						Birds	Estuaries are important feeding, roosting and breeding areas for birds	Community composition and abundance

3.3 Selected user sub-components and indicators for dams

The following tables provides a summary of the findings for each of the priority dams for which numerical limits will be determined during step 6 of the RQO determination process:

- Berg River Dam sub-component and indicator selection for Upper Berg IUA (Table 3-20).
- Wemmershoek Dam sub-component and indicator selection for Upper Berg IUA (Table 3-21)
- Voëlvlei Dam sub-component and indicator selection for the Lower Berg IUA (Table 3-22).
- Misverstand Dam sub-component and indicator selection for the Lower Berg IUA (Table 3-23).
- Upper Steenbras Dam sub-component and indicator selection for the Sir Lowry's IUA (Table 3-24).
- Lower Steenbras Dam sub-component and indicator selection for the Sir Lowry's IUA (Table 3-25).

Although most of the dams could attempt to meet high EWR flows, high flows have only been specified at two dams, namely the Berg River Dam and the Lower Steenbras Dam, because of the lack of adequately sized dam outlet structures to make flood releases at the other dams. Releases from dams is therefore mainly to maintain dam levels for the release of water for irrigation, rural and domestic purposes.

Table 3-20 Dam sub-component and indicator selection for the Berg River Dam in the Upper Berg IUA

IUA	Class	RU	Dam	Component	Sub-component	Rationale for sub-component choice	Indicator
D8 Upper Berg	II	D8-D01	Berg River Dam	Quantity	Low flows	The Berg River Dam is a key domestic and irrigation water supply dam in the Western Cape Water Supply System. Dam levels must remain sufficient to provide for transfers and for releases for irrigation, urban and industrial water use, as well as ecosystem functioning in the downstream Berg River.	Dam levels EWR
					High flows	During the wet season, the dam levels must be maintained such that they are able to support releases for ecosystem functioning and for irrigation, urban and industrial water use. During the summer, releases for irrigation exceed dry-season EWR flows in the Berg River main stem below the Berg River Supplement Scheme.	EWR
				Quality	Nutrients	Low nutrient concentrations and an unfavourable underwater light climate probably keeps alga growth low (no in-lake chlorophyll monitoring). At present the dam is in an oligo- to mesotrophic state. There is a risk of nutrient enrichment via transfers from the Theewaterskloof Dam and transfers via the Berg River Supplement Scheme. Elevated algal concentrations would affect water treatment costs and would obstruct drip irrigation equipment. Targets should be set to maintain the system in a mesotrophic (moderately enriched) state or better to protect against nuisance algal blooms and excessive water treatment costs.	Ortho-phosphate, Total inorganic nitrogen
					Salts	Salt concentrations in Berg River Dam are low and in an ideal category for domestic and irrigation water users. Irrigation releases in summer maintains the upper and middle Berg River in a good state when salt concentrations would normally have increased, as flow decreased, and the impacts of return flows continue. Salt levels should be maintained at concentrations where they do not impact negatively on the ecosystem and are maintained in an Ideal category for domestic and irrigation water supply.	Electrical conductivity
					System variables	The water in the dam is high in organic acids, resulting in tea-coloured waters. The water is naturally acidic, and it should be maintained within the historical acidity range.	pH
				Biota	Fish	Fish numbers in the dam is probably low due to low productivity. Exotic trout are probably present as trout have been found in streams feeding the dam. No recreational angling is currently allowed at the dam. The wellbeing of the fish community of Berg River Dam must be maintained in a suitable condition to contribute to, or not impact negatively on regional biodiversity.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011)
					Phytoplankton	Refer to nutrient comments. The system should be maintained in a mesotrophic state or better to protect the water supplied to WTWs, and to irrigation users in the upper and middle Berg River.	Chlorophyll a

Table 3-21 Dam sub-component and indicator selection for the Wemmershoek Dam in the Upper Berg IUA

IUA	Class	RU	Dam	Component	Sub-component	Rationale for sub-component choice	Indicator
D8 Upper Berg	II	D8-D02	Wemmershoek Dam	Quantity	Low flows	Wemmershoek Dam is an important domestic and industrial water supply source to the City of Cape Town, Paarl and some irrigation. Dam levels must remain sufficient to provide for urban and industrial water use, irrigation from the supply pipeline and releases for irrigation.	Dam levels
				Quality	Nutrients	Nutrients are in an oligotrophic state because the Wemmershoek catchment is close to natural. The system should be maintained in an oligotrophic state to protect domestic water supply.	Ortho-phosphate, Total inorganic nitrogen
					Salts	The salt concentrations are low, in an Ideal category for domestic water supply and aquatic ecosystem health. This should be maintained to protect domestic water supply and downstream ecosystems.	Electrical conductivity
				Biota	Fish	The dam is not open to recreational angling. Populations of indigenous fish species should be protected.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011)
					Phytoplankton	Refer to nutrient comments. The system should be maintained in an oligotrophic state to protect the water supplied to WTWs.	Chlorophyll a

Table 3-22 Dam sub-component and indicator selection for the Voëlvlei Dam in the Lower Berg IUA

IUA	Class	RU	Dam	Component	Sub-component	Rationale for sub-component choice	Indicator
B4 Lower Berg	III	B4-D03	Voëlvlei Dam	Quantity	Low flows	Voëlvlei Dam, an off-channel storage dam, is an important water supply source to the City of Cape Town and to Swartland towns. Dam levels must remain sufficient to make releases for irrigation to the lower Berg River, and to provide for urban and industrial water use. • At present the following sorts of releases are made: 3-6 Mm^3 to Swartland (taken out of canal before it reaches the Berg River) 10-15 Mm^3 to Misverstand Dam on the Berg River for Withhoogte WTW 18-43 Mm^3 to irrigators on the Berg River. Allocation is 18 from the Voëlvlei Dam and 10 from Theewaterskloof but they tend to exceed their quota even when restricted CCT via pipeline. No EWR releases and there is no gauge to measure inflow into the estuary. The gauge may be constructed as part of the Berg River augmentation of Voëlvlei Dam and then it is intended to maintain a baseflow of about 0.5 m^3/s into the estuary in summer. Spot readings a while ago measured base inflows of 0.5 m^3/s	Dam levels
				Quality	Nutrients	During the drought of 2004/5, the dam changed from a stable, clear water state to a stable, turbid state dominated by phytoplankton. Nutrient concentrations are currently high, and the dam is in an eutrophic state. Water transferred from the Klein Berg River is the main external source of nutrients, although internal recycling keeps concentrations high. The condition of the dam should be improved to a mesotrophic state or better to protect the two WTWs against harmful algal blooms and taste and odour problems in the treated domestic water.	Ortho-phosphate, Total inorganic nitrogen
					Salts	Salt levels are low and should be maintained at concentrations where they do not impact negatively on the ecosystem and are in an Ideal category for domestic water use and for irrigation water use.	Electrical conductivity
					Pathogens	The dam has important recreational value and should be maintained in a state that is safe for contact recreation and does not pose a health risk to the two WTWs located at the dam.	E coli Faecal coliforms
				Biota	Fish	The dam is a well-known angling venue, although the impacts of the 2004/5 drought changed a reservoir dominated by exotic bass to one dominated by exotic carp and catfish. The wellbeing of the angling fish community of Voëlvlei Dam must be maintained in a suitable condition to support the local recreational angling industry. Consumption of fish must not pose a health risk to consumers.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011), fish health evaluation
					Phytoplankton	Refer to the nutrient comments. The frequency of nuisance algal blooms has increased since the change in character of the dam and it is now a phytoplankton dominated system. This has a negative impact on the WTWs and incidents of taste and odour problems in the treated water has also increased. The system should be improved to a mesotrophic state, or better, in order to protect domestic water supplied to consumers.	Chlorophyll a

Table 3-23 Dam sub-component and indicator selection for the Misverstand Weir in the Lower Berg IUA

IUA	Class	RU	Dam	Component	Sub-component	Rationale for sub-component choice	Indicator
B4 Lower Berg	III	B4-D04	Misverstand Weir	Quantity	Low flows	Misverstand Weir is an important domestic and industrial water supply source to the West Coast area, and for irrigation and compensation releases to users in the lower Berg River. Dam levels must remain sufficient to make releases for irrigation to the lower Berg River, and to provide for urban and industrial water use.	Dam levels
				Quality	Nutrients	Nutrients are in an eutrophic range, due to domestic and agricultural sources in the middle Berg and Klein Berg catchments. Nutrient concentrations are currently in a meso- to eutrophic range and it should be improved to a mesotrophic state or better to protect the water supplied to the Langebaan, Saldanha, and smaller West Coast towns.	Ortho-phosphate, Total inorganic nitrogen
					Salts	Salt levels must be maintained at concentrations where they do not impact negatively on the ecosystem and are in an Ideal category for domestic and industrial water use, and for irrigation water use.	Electrical conductivity
					Pathogens	The reservoir should be maintained in a state that is safe for domestic water use (with treatment) and for contact recreation as the dam is a popular recreation venue.	E coli, Faecal coliforms
				Biota	Fish	The weir is a popular angling venue and the fish community appears to be dominated by exotic species such as bass, carp, catfish and tilapia. The wellbeing of the angling fish community should be maintained in a suitable condition to support local recreational angling. Consumption of fish must not pose a health risk.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011), fish health evaluation
					Phytoplankton	Refer to the nutrient comments. NEMP data indicate that chlorophyll concentrations vary between oligotrophic to mesotrophic conditions, with occasional concentrations in the eutrophic range. Elevated turbidity and short water residence times probably historically kept algal concentrations low. Monitoring stopped in 2010. The weir should be maintained in a mesotrophic state or better.	Chlorophyll a

Table 3-24 Dam sub-component and indicator selection for the Upper Steenbras Dam in the Sir Lowry's IUA (D7)

IUA	Class	RU	Dam	Component	Sub-component	Rationale for sub-component choice	Indicator
D7 Sir Lowry's	II	D7-D05	Upper Steenbras Dam	Quantity	Low flows	Dam levels must remain sufficient to provide for water supply to the Western Cape Water Supply System (City of Cape Town) via the Faure WTW, hydropower production via the Steenbras Pumped Storage Scheme, and releases to Steenbras Lower Dam.	Dam levels
				Quality	Nutrients	Nutrient concentrations are probably similar to the lower dam, i.e. oligo- to mesotrophic (unenriched to moderately) state (no in-lake monitoring had been undertaken). As a key domestic water supply source to the City of Cape Town, and a hydropower reservoir, this status should be maintained and protected from deteriorating.	Ortho-phosphate, Total inorganic nitrogen
					Salts	Salt concentrations are currently low and in an Ideal category for domestic water supply and hydropower production. Salt levels should be maintained at concentrations where they do not impact negatively on the ecosystem and are in an Ideal category for domestic and industrial water use.	Electrical conductivity
					Toxins	Concerns have been expressed about elevated iron and manganese concentrations that might arise from emergency groundwater drilling to supplement water in the upper and lower dams. Iron and manganese concentrations should be maintained in a state that does not impact negatively on the ecosystem and are in an Ideal category for domestic water supply.	Iron Manganese
					Pathogens	As a key domestic water supply reservoir, the dam should be protected and maintained in a state that is safe for contact recreation (should recreational use be restored) and for domestic water supply, with treatment.	E coli, Faecal coliforms
				Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity. Consumption of fish must not pose a health risk.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011)
					Phytoplankton	No in-lake or satellite chlorophyll monitoring data are available. Protective targets should be set to protect the lower dam and the supply of water to the Faure WTW. The system should be maintained in a mesotrophic state or better.	Chlorophyll a

Table 3-25 Dam sub-component and indicator selection for the Lower Steenbras Dam in the Sir Lowry's IUA (D7)

IUA	Class	RU	Dam	Component	Sub-component	Rationale for sub-component choice	Indicator selection
D7 Sir Lowry's	II	D7-D06	Lower Steenbras Dam	Quantity	Low flows	Dam levels must remain sufficient to provide for releases for the Western Cape Water Supply System (City of Cape Town) via the Steenbras WTW, and low flows to the lower Steenbras River and estuary.	Dam levels EWR
					High flows	Spills from the dam should be managed to contribute to EWR high flows in the lower Steenbras River and estuary.	EWR
				Quality	Nutrients	Nutrients are in an oligo- to mesotrophic (unenriched to moderately) state because the Steenbras catchment is largely natural, and the upstream dam acts as a trap for nutrients exported from the catchment. The system should be maintained in a mesotrophic state or better to protect domestic water supply.	Ortho-phosphate, Total inorganic nitrogen
					Salts	The salt concentrations are low, in an Ideal category for domestic water supply and aquatic ecosystem health. This should be maintained to protect domestic water supply and downstream ecosystems.	Electrical conductivity
					Toxins	Concerns have been expressed about elevated iron and manganese concentrations that might arise from emergency groundwater drilling to supplement water in the upper and lower dams. Iron and manganese concentrations should be maintained in a state that does not impact negatively on the ecosystem and are in an Ideal category for domestic water supply.	Iron Manganese
					Pathogens	There is a low risk of microbial pollution in the lower dam, due to the protection afforded by the upper dam (no recreation is allowed) and there are no microbial pollution sources of concern in the Steenbras catchment. A target should be set to protect the integrity of the dam as a safe source of drinking water.	E coli Faecal coliforms
				Biota	Fish	No recreational fishing is allowed. The wellbeing of the fish community should be maintained in a suitable condition to contribute to regional biodiversity.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011)
					Phytoplankton	No in-lake chlorophyll monitoring is available. Satellite imagery, provided by Cyanolakes, indicate that chlorophyll concentrations were in a mesotrophic state or better. However, during the 2017/18 drought, chlorophyll concentrations in the eutrophic range were observed. Protective targets should be set to maintain the reservoir in a mesotrophic state or better.	Chlorophyll a

3.4 Selected user sub-components and indicators for wetlands

The conceptual understanding of priority wetland resource units was used to define indicators for each Wetland Resource Unit and describes the reasons for their choice.

Table 3-26 Selected user sub-components and indicators for wetlands

Component	Sub-component	Reason for selection	Example of indicator
Quantity	High flows	Floodplain wetlands require high flow events in order to overtop banks. River flow RQOs are given as monthly average volumes (MCM) that include maintenance low and high flows combined.	High flow (i.e. The frequency and size of flood events that overtop the banks and inundated the floodplain)
	Hydroperiod	In order to maintain wetland functioning water needs to be retained and distributed, often with seasonal fluctuations. Wetlands have a dynamic hydrology varying daily, seasonally and annually. Due to this dynamic nature it is difficult to define the frequency and duration of water retention and distribution. An approach to define prolonged saturation up to the temporary zone relies on defining the wetland plants and wetland soils. The hydrological regime (Hydroperiod) describes the behaviour of water within the system and, for wetlands, in the underlying soil. For wetlands and inland water bodies the hydrological regime may be classified according to the period of inundation and saturation, as well as inundation depth class for permanently inundated waterbodies.	Ground water level for seasonal wetlands and extent of open water inundation for seasonally or permanently inundated water bodies
Water quality	Nutrients	Nutrient concentration defines the trophic status (i.e. level of enrichment) of a system	Phosphate (PO4-P), Total Inorganic Nitrogen (TIN-N)
	Pathogens	Pathogens cause waterborne diseases in humans such as diarrhoea, cholera, dysentery, etc. Although human pathogens in general don't affect aquatic biota they are often associated with high organic loads (untreated or partially treated sewage) which affects the dissolved oxygen concentration of the water.	E coli
Habitat	Geomorphology	The relationship of water and sediment creates a stable equilibrium for a wetland. Any change to this equilibrium will push a wetland into a vulnerable state of either aggradation (sediment deposition) or degradation (sediment removal).	Sediment accumulation and erosion features
	Vegetation	Wetland vegetation is an important indicator of a wetland boundary. Alien invasive vegetation encroachment into a wetland may	Wetland vegetation community structure and extent of alien invasion

Component	Sub-component	Reason for selection	Example of indicator
		result in reduction of water distribution and push the wetland into a vulnerable state geomorphically.	
Biota	Frogs	Frogs require wetland habitats as important stepping stones. A decline in frog populations may be an indicator of a decline in wetland water quality.	Frog diversity
	Phytoplankton	Refer to nutrients as algae is an indicator of enrichment.	Chl-a
	Benthic algae	Free floating algae is referred to as Phytoplankton for open water wetland systems. Benthic algae are the most dominant and conspicuous of freshwater algae, and this is the most important group of primary producers in autotrophic aquatic ecosystems, particularly for seasonal wetlands. Algal species are very responsive to changes in nutrient levels or the level of inundation or saturation. Changes in nutrient and water levels can lead to changes in the species composition and biomass of the algal assemblages in a wetland. Although the nature of these changes is not yet well understood in South Africa, monitoring of algal assemblages is considered to be a useful means of tracking natural or anthropogenic shifts in surface aquatic ecosystems.	Benthic algae community structure

Table 3-27 Sub-components selected for prioritised wetlands within each IUA

IUA	Wetland Region	RU	Wetland Name	Component	Sub-component	Indicator/ measure	Rationale for sub-component choice
D8	Southern Folded Mountains (WR4)	D8-W1	Strategic Water Source Wetlands_SEEP	Quantity	Hydroperiod	Ground water level	Hydrological functioning of seeps in Strategic Water Source Areas to be maintained. Ability to provide water to downstream rivers require maintenance of wetland vegetation.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
D9	Southern Folded Mountains (WR4)	D9-W2	West Coast Shale Renosterveld FLOODPLAIN (Berg)	Quantity	High flow	High flow from EWR	High flows need to be maintained in order to overtop banks and inundate floodplain vegetation.
				Habitat	Geomorphology	Alien invasive plants on floodplain banks	
				Habitat	Vegetation	Wetland vegetation community structure	
C5	Western Folded Mountains (WR3)	C5-W3	Strategic Water Source Wetlands_SEEP	Quantity	Hydroperiod	Ground water level	Hydrological functioning of seeps in Strategic Water Source Areas to be maintained. Ability to provide water to downstream rivers require maintenance of wetland vegetation.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
B4	South Western Coastal Belt_Sand (WR1) and South Western Coastal Belt_Shale (WR2)	B4-W4	West Coast Shale Renosterveld (Berg FLOODPLAIN)	Quantity	High flow	High flow from EWR	High flows need to be maintained in order to overtop banks and inundate floodplain vegetation.
				Habitat	Geomorphology	Alien invasive plants on floodplain banks	
				Habitat	Vegetation	Wetland vegetation community structure	

IUA	Wetland Region	RU	Wetland Name	Component	Sub-component	Indicator/ measure	Rationale for sub-component choice
	South Western Coastal Belt_Shale (WR2)	B4-W5	Northwest Sandstone Fynbos SEEP (Boesmans River)	Quantity	Hydroperiod	Ground water level	Hydrological functioning of seeps in Strategic Water Source Areas to be maintained. Ability to provide water to downstream rivers require maintenance of wetland vegetation.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
			West Coast Shale Renosterveld FLOODPLAIN (Boesmans River)	Quantity	High flow	High flow from EWR	High flows need to be maintained in order to overtop banks and inundate floodplain vegetation to provide important NFEPA frog habitat.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Frogs	Frog diversity	
	South Western Coastal Belt_Shale (WR2)	B4-W6	West Coast Shale Renosterveld DEPRESSION (Kiekoesvlei)	Quantity	Hydroperiod	Ground water level	Freshwater depression to maintain wetland extent in order to provide important habitat. Presence of certain invertebrate taxa indicative of salinity, hydroperiod and acidity.
				Quality	Nutrients	Phosphate (PO4-P), Total Inorganic Nitrogen (TIN-N)	
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
	South Western Coastal Belt_Shale (WR2)	B4-W7	West Coast Shale Renosterveld DEPRESSION (Koekiespan)	Quantity	Hydroperiod	Ground water level	Hydrological functioning of saline depression to be maintained in order to provide important habitat. Presence of certain invertebrate taxa indicative of salinity, hydroperiod and acidity.
				Quality	Nutrients	Phosphate (PO4-P), Total Inorganic Nitrogen (TIN-N)	

IUA	Wetland Region	RU	Wetland Name	Component	Sub-component	Indicator/ measure	Rationale for sub-component choice
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
A1	South Western Coastal Belt_Sand (WR1)	A1-W8	Southwestern Shale Fynbos UNCHANNELED VALLEY BOTTOM (Berg)	Quantity	Hydroperiod	Ground water level	Water distribution and retention is important in unchanneled valley-bottom wetlands in order to provide requirements for vegetation. Erosion reduces this retention therefore needs to be controlled. Endangered vegetation to be maintained and alien invasive plants managed. Maintain connectivity of vegetation habitat between NFEPA wetland clusters.
				Habitat	Geomorphology	Erosion features	
				Habitat	Vegetation	Wetland vegetation community structure	
A2	South Western Coastal Belt_Sand (WR1)	A2-W9	Salt marsh SEEP (Geelbek)	Quantity	Hydroperiod	Ground water level	Hydrological functioning to be maintained for wetland vegetation. Wetland vegetation to be maintained in order to provide important habitat for Ramsar wetland.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
A3	South Western Coastal Belt_Sand (WR1)	A3-W10	Southwest Sand Fynbos DEPRESSION (Yzerfontein)	Quantity	Hydroperiod	Ground water level	Saline depressions to maintain wetland extent in order to provide important habitat. Depth of depression to be maintained at levels that maintain hydroperiod. Saline depression to be maintained as unique and important habitat.
				Habitat	Geomorphology	Depth of depression	
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	

IUA	Wetland Region	RU	Wetland Name	Component	Sub-component	Indicator/ measure	Rationale for sub-component choice
D10	South Western Coastal Belt_Sand (WR1)	D10-W11	Southwest Sand Fynbos FLOODPLAIN (Rietvlei)	Quantity	High flow	High flow from EWR	High flows need to be maintained in order to overtop banks and inundate floodplain vegetation. Vegetation to be maintained and invasive plants managed.
				Habitat	Vegetation	Wetland vegetation community structure	
			Dune Strandveld FLOODPLAIN (Rietvlei)	Quantity	Hydroperiod	Ground water level	Seasonality to be maintained in order to retain and distribute water for wetland vegetation. Vegetation to be maintained and invasive plants managed.
				Habitat	Vegetation	Wetland vegetation community structure	
	South Western Coastal Belt_Sand (WR1)	D10-W12	Depression and Seeps (Riverlands)	Quantity	Hydroperiod	Ground water level	Seasonality to be maintained in order to retain and distribute water for wetland vegetation. Critically endangered vegetation to be maintained and alien invasive plants managed.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
E11	Southern Folded Mountains_Peninsula (WR5)	E11-W13	Sand Fynbos DEPRESSION (Wildevoelvlei: open water)	Quantity	Hydroperiod	Wetland water inundation extent	Water levels and water retention to be maintained. Use of the open water necessitates water quality monitoring. Nutrient levels for present state rating value at a tolerable (D) level. High nutrient concentrations promote excessive algal growth. Pathogen levels for recreational use (intermediate contact) need to be maintained at an acceptable level.
				Quality	Nutrients and Pathogens	Phosphate (PO4-P), Total Inorganic Nitrogen (TIN-N)	
						E. coli	
				Biota	Phytoplankton	Chl-a	
					Vegetation	Invasive aquatic plant presence	

IUA	Wetland Region	RU	Wetland Name	Component	Sub-component	Indicator/ measure	Rationale for sub-component choice
	Southern Folded Mountains_Peninsula (WR5)	E11-W14	Sand Fynbos DEPRESSION (Seasonal)	Quantity	Hydroperiod	Ground water level	Seasonality to be maintained in order to provide requirements for vegetation. Endangered vegetation to be maintained and alien invasive plants managed.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
	Southern Folded Mountains_Peninsula (WR5)	E11-W15	Sand Fynbos Depression (Pick n Pay Reedbeds)	Quantity	Hydroperiod	Wetland water inundation extent	Water levels and water retention to be maintained in order to provide habitat for frogs. Nutrients and vegetation extent to be monitored. NFEPA frogs require wetland habitats as important stepping stones. A decline in frog population may be an indicator of a decline in water quality.
				Quality	Nutrients	Phosphate (PO4-P), Total Inorganic Nitrogen (TIN-N)	
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Frogs	Frog presence	
	Southern Folded Mountains_Peninsula (WR5)	E11-W16	Strategic Water Source Wetlands_FLAT	Quantity	Hydroperiod	Ground water level	Hydrological functioning of wetlands in Strategic Water Source Areas to be maintained. Ability to provide water to downstream rivers require maintenance of wetland vegetation.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	

IUA	Wetland Region	RU	Wetland Name	Component	Sub-component	Indicator/ measure	Rationale for sub-component choice
E12	South Western Coastal Belt_Sand (WR1)	E12-W17	DEPRESSION (Zeekoeivlei main waterbody)	Quantity	Hydroperiod	Wetland water inundation extent	Water levels and water retention to be maintained. Use of the open water necessitates water quality and water weed monitoring. Nutrient levels for present state rating value at a tolerable (D) level. High nutrient concentrations promote excessive algal and water weed growth. Pathogen levels for recreational use (intermediate contact) need to be maintained at an acceptable level.
				Quality	Nutrients and Pathogens	Phosphate (PO4-P), Total Inorganic Nitrogen (TIN-N)	
						E. coli	
				Biota	Vegetation	Water weed presence	
					Phytoplankton	Chl-a	
			DEPRESSION (Zeekoeivlei seasonal)	Quantity	Hydroperiod	Ground water level	Seasonality of wetland water inputs to be maintained for vegetation. Endangered vegetation to be maintained and invasive plants managed.
				Habitat	Vegetation	Wetland vegetation community structure	
	South Western Coastal Belt_Sand (WR1)	E12-W18	DEPRESSION (Rondevlei main water body)	Quantity	Hydroperiod	Wetland water inundation extent	Water levels and water retention to be maintained for biota and vegetation. Nutrient levels for present state rating value at an acceptable (C) level. High nutrient concentrations promote excessive algal and water weed growth.
				Quality	Nutrients	Phosphate (PO4-P), Total Inorganic Nitrogen (TIN-N)	
				Biota	Vegetation	Invasive aquatic plant presence	
					Phytoplankton	Chl-a	
			DEPRESSION (Rondevlei seasonal)	Quantity	Hydroperiod	Ground water level	Seasonality of wetland water inputs to be maintained for vegetation. Endangered vegetation to be maintained and invasive plants managed.
				Habitat	Vegetation	Wetland vegetation community structure	
	South Western Coastal Belt_Sand (WR1)	E12-W20	FLOODPLAIN (Nooiensfontein)	Quantity	High flow	High flow from EWR	High flows need to be maintained in order to overtop banks and inundate floodplain vegetation. Critically endangered vegetation to be maintained and alien invasive plants managed.
				Habitat	Vegetation	Wetland vegetation community structure	

IUA	Wetland Region	RU	Wetland Name	Component	Sub-component	Indicator/ measure	Rationale for sub-component choice
	South Western Coastal Belt_Sand (WR1)	E12-W19	DEPRESSION (Blouvlei)	Quantity	Hydroperiod	Ground water level	Seasonal water levels and water retention to be maintained for vegetation. Critically endangered vegetation to be maintained and alien invasive plants managed.
				Habitat	Vegetation	Wetland vegetation community structure	
	Southern Folded Mountains_Peninsula (WR5)	E12-W21	DEPRESSION (Princessvlei)	Quantity	Hydroperiod	Wetland water inundation extent	Water levels and water retention to be maintained for use and water quality monitoring required due to use. Nutrient levels for present state rating value at an acceptable (C) level. Pathogen levels for recreational use (intermediate contact) need to be maintained at an acceptable level.
				Quality	Nutrients and Pathogens	Phosphate (PO4-P), Total Inorganic Nitrogen (TIN-N)	
						E. coli	
	South Western Coastal Belt_Sand (WR1)	E12-W22	DUNE SLACK (Denel)	Quantity	Hydroperiod	Ground water level	Seasonal water levels and water retention to be maintained for vegetation. Critically endangered vegetation to be maintained and alien invasive plants managed.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
D7	Southern Folded Mountains (WR4)	D7-W23	SWSA* Southwest Sandstone Fynbos_Seep	Quantity	Hydroperiod	Ground water level	Hydrological functioning of seeps in Strategic Water Source Areas to be maintained. Ability to provide water to downstream rivers require maintenance of wetland vegetation.
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	
D6	Southern Folded Mountains (WR4)	D6-W24	SWSA* Southwest Sandstone Fynbos_ Seep	Quantity	Hydroperiod	Ground water level	Hydrological functioning of seeps in Strategic Water Source Areas to be maintained. Ability to provide water to downstream rivers require maintenance of wetland vegetation.

IUA	Wetland Region	RU	Wetland Name	Component	Sub-component	Indicator/ measure	Rationale for sub-component choice
				Habitat	Vegetation	Wetland vegetation community structure	
				Biota	Benthic algae	Benthic algae community structure	

3.5 Selected user sub-components and indicators for groundwater

The selected components, sub-components and indicators are listed in Table 3-28. These sub-components will be assessed in each prioritised resource unit. For each indicator, an RQO description will be developed, along with a numerical value where possible (i.e. for those that are numeric). In addition, the RQOs will, where possible, be aquifer specific within the prioritised resource unit.

Table 3-28 Selected user sub-components and indicators for groundwater

Component	Sub-Component	Indicator
Quantity	Abstraction	Seasonal abstraction: water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. Permanent abstraction: water level decline stabilises under consideration of aquifer response time.
	Groundwater level	Water level in boreholes close to coast
	Discharge	Relative water levels between groundwater and surface water
		Buffer zone
	Low flow in river	Compliance with the low flow requirements in the river
Quality	Nutrients	NO_3 (as N)
	Salts	EC
	Pathogens	E-coli, Total Coliform

Table 3-29 Sub-component and indicator selection for prioritized groundwater resource units in the Upper Berg IUA

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
D8 Upper Berg	II	4 – Paarl Upper Berg	G10A	Quantity	Abstraction (Available Yield)	Groundwater is used in the catchment to support agricultural use, and the catchment is currently categorised as minimally used. This is however being projected to increase to heavily used in future, with additional demands from domestic supply and in meeting the ecological reserve. It is therefore necessary to establish an RQO for sustainable abstraction (protecting the available yield). Whilst exploiting groundwater storage is acceptable for managing drought and could be acceptable for short periods, over the long-term, groundwater use should be sustainable for all users and the environment. Groundwater mining is assumed to be considered unacceptable in the long-term. Implementation of this RQO requires the authority to isolate the cause of groundwater level decline and identify over-abstraction (unacceptable) from transition to new dynamic equilibrium (unavoidable), drought and climate change (unavoidable).	Seasonal abstraction: water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. Permanent abstraction: water level decline stabilises under consideration of aquifer response time.
					Discharge	The area has a high groundwater contribution to surface water, relative to the established EWR, and is prioritised from a surface water ecology perspective for full RQOs. It is assumed that the maintenance low flow is derived from groundwater. Whilst all abstraction reduces natural discharge to some extent and at some point in time, it would be unacceptable for abstraction to cause groundwater discharge to reduce below the maintenance low flow value required in the catchment to meet the surface water RQOs.	Compliance with the low flow requirements in the river
				Quality	Nutrients	As groundwater is used in the catchment, and has strong interaction with surface water, groundwater quality must be protected to ensure there is no impact on users and the environment. Furthermore, given the high permeability of the superficial aquifers, and the land use, there is a risk from agricultural pollution. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts), and agricultural pollution (fertilisers). The numerical values represent either the 90 or the 95 percentiles for the listed aquifer within the GRU. This is taken as a limit of acceptable deviation from natural background.	NO_3 (as N)
					Salts		EC
					Pathogens	As groundwater is used in the catchment, and has strong interaction with surface water, groundwater quality must be protected to ensure there is no impact on users and the environment. The parameters selected will support identification of pollution from waste water (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	E-coli, Total Coliform

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
D8 Upper Berg	II	4 – Paarl Upper Berg	G10B	Quantity	Discharge	The catchment is currently minimally used and is expected to increase to moderately used in future, related to plans for abstraction by CCT. Groundwater use should be sustainable for all users and the environment. Groundwater from at least superficial aquifers and surface water are hydraulically connected in the area. Groundwater abstraction close to surface water (distance dependent on aquifer diffusivity), or groundwater abstraction rates that reduce aquifer water levels beneath that of the river, would reverse the gradient towards the river, and surface water would be 'lost' to groundwater (indirect recharge). The setting of this RQO assumes that this would be unacceptable (for surface water resources / ecology).	Relative water levels between groundwater and surface water
					Discharge	The groundwater-fed wetlands in the area are considered a priority. Whilst all abstraction reduces natural discharge to some extent and at some point in time, the timing of surface water depletion (the response time) is related to the distance to surface water, and the hydraulic diffusivity. It is therefore aquifer- and abstraction location- specific. Abstraction far from surface water, and in an aquifer with lower diffusivity, may for all practical purposes not impact on surface water (for millennia). Given the variability in hydraulic diffusivity even at different locations within the same aquifer, the data is not available in order to determine area-specific numerical values. The numerical value listed is in alignment with best-practice guidelines.	Buffer zones
				Quality	Nutrients	As groundwater is used in the catchment, and has strong interaction with surface water, groundwater quality must be protected to ensure there is no impact on users and the environment. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts), and agricultural pollution (fertilisers). There is insufficient data to establish robust statistics in this area, and numerical values are taken from the same aquifer in neighbouring G10A.	NO_3 (as N)
					Salts		EC
					Pathogens	As groundwater is used in the catchment, and has strong interaction with surface water, groundwater quality must be protected to ensure there is no impact on users and the environment. The parameters selected will support identification of pollution from waste water (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	E-coli, Total Coliform

Table 3-30 Sub-component and indicator selection for prioritized groundwater resource units in the Berg Tributaries IUA

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
C5 Berg Tributaries	II	5-Tulbagh Valley	G10E	Quantity	Abstraction (Available Yield)	Groundwater is used in the catchment to support agricultural use, and the catchment is currently categorised as moderately used. This is however being projected to increase to heavily used in future. It is therefore necessary to establish an RQO for sustainable abstraction (protecting the available yield). Whilst exploiting groundwater storage is acceptable for managing drought, and could be acceptable for short periods, over the long-term, groundwater use should be sustainable for all users and the environment. The RQO essentially implies that groundwater mining is considered unacceptable in the long-term. Implementation of this RQO requires the authority to isolate the cause of groundwater level decline and identify over-abstraction (unacceptable) from transition to new dynamic equilibrium (unavoidable), drought and climate change (unavoidable).	Seasonal abstraction: water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. Permanent abstraction: water level decline stabilises under consideration of aquifer response time.
					Discharge	The groundwater-fed wetlands in the area are considered a priority. Whilst all abstraction reduces natural discharge to some extent and at some point in time, the timing of surface water depletion (the response time) is related to the distance to surface water, and the hydraulic diffusivity. It is therefore aquifer- and abstraction location- specific. Abstraction far from surface water, and in an aquifer with lower diffusivity, may for all practical purposes not impact on surface water (for millennia). Given the variability in hydraulic diffusivity even at different locations within the same aquifer, the data is not available in order to determine area-specific numerical values. The numerical value listed is in alignment with best-practice guidelines.	Buffer zones
				Quality	Nutrients	As groundwater is used in the catchment, and supports priority wetlands, groundwater quality must be protected to ensure there is no impact on users and the environment. Agricultural pollution is the key threat. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts), and agricultural pollution (fertilisers). Local data is insufficient to establish numerical limits, and regional data is considered inapplicable for this area, and no numerical limit is set (only narrative).	NO_3 (as N)
					Salts		EC
					Pathogens	Groundwater management measures must ensure groundwater quality is protected. The parameters selected will support identification of pollution from waste water (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	E-coli, Total Coliform

Table 3-31 Sub-component and indicator selection for prioritized groundwater resource units in the Lower Berg IUA

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
B4 Lower Berg	III	6-24 Rivers	G10J	Quantity	Discharge	Groundwater is used for agricultural purposes, yet the catchment is categorised as minimally used. Groundwater and surface water are hydraulically connected in the area, and groundwater abstraction close to surface water (distance dependent on aquifer diffusivity), or groundwater abstraction rates that reduce aquifer water levels beneath that of the river, would reverse the gradient towards the river, and surface water would be 'lost' to groundwater (indirect recharge). The setting of this RQO assumes that this would be unacceptable (for surface water resources / ecology).	Relative water levels between groundwater and surface water
					Discharge	The groundwater-fed wetlands in the area are considered a priority. Whilst all abstraction reduces natural discharge to some extent and at some point in time, the timing of surface water depletion (the response time) is related to the distance to surface water, and the hydraulic diffusivity. It is therefore aquifer- and abstraction location- specific. Abstraction far from surface water, and in an aquifer with lower diffusivity, may for all practical purposes not impact on surface water (for millennia). Given the variability in hydraulic diffusivity even at different locations within the same aquifer, the data is not available in order to determine area-specific numerical values. The numerical value listed is in alignment with best-practice guidelines.	Buffer zones
					Discharge	The area has a high groundwater contribution to surface water, relative to the established EWR, and is prioritised from a surface water ecology perspective for full RQOs. It is assumed that the maintenance low flow is derived from groundwater. Whilst all abstraction reduces natural discharge to some extent and at some point in time, it would be unacceptable for abstraction to cause groundwater discharge to reduce below the maintenance low flow value required in the catchment to meet the surface water RQOs.	Compliance with the low flow requirements in the river
				Quality	Nutrients	As groundwater is used in the catchment for agricultural purposes, and supports priority wetlands, groundwater quality must be protected to ensure there is no impact on users and the environment. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts), and agricultural pollution (fertilisers). The numerical values represent either the 90 or the 95 percentiles for the listed aquifer within the GRU. This is taken as a limit of acceptable deviation from natural background.	NO_3 (as N)
					Salts		EC
					Pathogens	The parameters selected will support identification of pollution from waste water (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	E-coli, Total Coliform

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
B4 Lower Berg	III	9-Atlantis	G21B	Quantity	Abstraction (Available Yield)	Groundwater is used in the catchment for agricultural, domestic and industrial purposes. The catchment is heavily used and since the recent drought abstraction has increased further, with the CCT wellfields increasing abstraction, and other private users developing wellfields. It is therefore necessary to establish an RQO for sustainable abstraction (protecting the available yield). Whilst exploiting groundwater storage is acceptable for managing drought and could be acceptable for short periods to bridge the transition to other bulk water supplies (i.e. 5-10 years desalination/ re-use), over the long-term, groundwater use should be sustainable for all users and the environment. The RQO essentially implies that groundwater mining is considered unacceptable in the long-term. Implementation of this RQO requires the authority to isolate the cause of groundwater level decline and identify over-abstraction (unacceptable) from transition to new dynamic equilibrium (unavoidable), drought and climate change (unavoidable).	Seasonal abstraction: water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. Permanent abstraction: water level decline stabilises under consideration of aquifer response time.
					Groundwater level	The Atlantis aquifer is a coastal aquifer, with (some) municipal and private abstraction wells located within 2 km of the coast. A minimum groundwater level is set in abstraction boreholes within 2.5km from the ocean to avoid saline intrusion	Groundwater level
					Discharge	Groundwater and surface water are hydraulically connected in the area, and groundwater abstraction close to surface water (distance dependent on aquifer diffusivity), or groundwater abstraction rates that reduce aquifer water levels beneath that of the river, would reverse the gradient towards the river, and surface water would be 'lost' to groundwater (indirect recharge). The setting of this RQO assumes that this would be unacceptable (for surface water resources / ecology).	Relative water levels between groundwater and surface water
					Discharge	The groundwater-fed wetlands in the area are considered a priority. Whilst all abstraction reduces natural discharge to some extent and at some point in time, the timing of surface water depletion (the response time) is related to the distance to surface water, and the hydraulic diffusivity. It is therefore aquifer- and abstraction location- specific. Abstraction far from surface water, and in an aquifer with lower diffusivity, may for all practical purposes not impact on surface water (for millennia). Given the variability in hydraulic diffusivity even at different locations within the same aquifer, the data is not available in order to determine area-specific numerical values. The numerical value listed is in alignment with best-practice guidelines.	Buffer zones
				Quality	Nutrients	With the current land uses in the catchment, and the predominantly high groundwater vulnerability status (related to the sandy aquifer), there is a high risk of impact on groundwater quality. As groundwater is used in the catchment, and supports priority wetlands, groundwater quality must be protected to ensure there is no impact on users and the environment. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts), agricultural pollution (fertilisers), and saline intrusion. The numerical values represent either the 90 or the 95 percentiles for the listed aquifer within the GRU. This is taken as a limit of acceptable deviation from natural background.	NO_3 (as N)
					Salts		EC
					Pathogens	Groundwater management measures must ensure groundwater quality is protected. The parameters selected will support identification of pollution from waste water (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	E-coli, Total Coliform

Table 3-32 Sub-component and indicator selection for prioritized groundwater resource units in the West Coast IUA

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
A3 West Coast	III	8-West Coast	G10L	Quantity	Abstraction (Available Yield)	Groundwater supports domestic use in Hopefield and supports agricultural activities. It is therefore necessary to establish an RQO for sustainable abstraction (protecting the available yield). Whilst exploiting groundwater storage is acceptable for managing drought and could be acceptable for short periods to bridge the transition to other bulk water supplies (i.e. 5-10 years desalination/ re-use), over the long-term, groundwater use should be sustainable for all users and the environment. The RQO essentially implies that groundwater mining is considered unacceptable in the long-term. Implementation of this RQO requires the authority to isolate the cause of groundwater level decline and identify over-abstraction (unacceptable) from transition to new dynamic equilibrium (unavoidable), drought and climate change (unavoidable).	Seasonal abstraction: water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. Permanent abstraction: water level decline stabilises under consideration of aquifer response time.
					Discharge	Groundwater and surface water (the Sout River and tributaries) are hydraulically connected in the area, and groundwater abstraction close to surface water (distance dependent on aquifer diffusivity), or groundwater abstraction rates that reduce aquifer water levels beneath that of the river, would reverse the gradient towards the river, and surface water would be 'lost' to groundwater (indirect recharge). The setting of this RQO assumes that this would be unacceptable (for surface water resources / ecology).	Relative water levels between groundwater and surface water
					Discharge	The groundwater fed wetlands in G10L are considered a priority. Whilst all abstraction reduces natural discharge to some extent and at some point in time, the timing of surface water depletion (the response time) is related to the distance to surface water, and the hydraulic diffusivity. It is therefore aquifer- and abstraction location- specific. Abstraction far from surface water, and in an aquifer with lower diffusivity, may for all practical purposes not impact on surface water (for millennia). Given the variability in hydraulic diffusivity even at different locations within the same aquifer, the data is not available in order to determine area-specific numerical values. The numerical value listed is in alignment with best-practice guidelines.	Buffer zones
				Quality	Nutrients	As groundwater is used in the catchment, and supports priority wetlands, groundwater quality must be protected to ensure there is no impact on users and the environment. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts), agricultural pollution (fertilisers), and saline intrusion. The numerical values represent either the 90 or the 95 percentiles for the listed aquifer within the GRU. This is taken as a limit of acceptable deviation from natural background.	NO_3 (as N)
					Salts		EC
					Pathogens	Groundwater management measures must ensure groundwater quality is protected. The parameters selected will support identification of pollution from waste water (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	E-coli, Total Coliform

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
A3 West Coast	III	8-West Coast	G10M	Quantity	Abstraction (Available Yield)	Groundwater supports domestic use in Saldanha, Langebaan, Langebaanweg, and Aurora, and supports agricultural activities. It is therefore necessary to establish an RQO for sustainable abstraction (protecting the available yield). The catchment is currently minimally used, projected to increase to moderately used in future. Whilst exploiting groundwater storage is acceptable for managing drought and could be acceptable for short periods to bridge the transition to other bulk water supplies (i.e. 5-10 years desalination/ re-use), over the long-term, groundwater use should be sustainable for all users and the environment. The RQO essentially implies that groundwater mining is considered unacceptable in the long-term. Implementation of this RQO requires the authority to isolate the cause of groundwater level decline and identify over-abstraction (unacceptable) from transition to new dynamic equilibrium (unavoidable), drought and climate change (unavoidable).	Seasonal abstraction: water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. Permanent abstraction: water level decline stabilises under consideration of aquifer response time.
					Groundwater level	The Langebaan Road Aquifer System comprises coastal aquifers, with (some) private abstraction wells located within 1.5 km of the coast. A minimum groundwater level is set in abstraction boreholes within 2.5km from the ocean to avoid saline intrusion.	Groundwater level
					Discharge	Groundwater and surface water (the Berg River, Langebaan Lagoon and Geelbek) are hydraulically connected in the area, and groundwater abstraction close to surface water (distance dependent on aquifer diffusivity), or groundwater abstraction rates that reduce aquifer water levels beneath that of the river, would reverse the gradient towards the river, and surface water would be 'lost' to groundwater (indirect recharge). The setting of this RQO assumes that this would be unacceptable (for surface water resources / ecology).	Relative water levels between groundwater and surface water
					Discharge	The groundwater fed wetlands around Geelbek in G10M are considered a priority. Whilst all abstraction reduces natural discharge to some extent and at some point in time, the timing of surface water depletion (the response time) is related to the distance to surface water, and the hydraulic diffusivity. The establishment of a buffer zone can protect against this impact. The distance is aquifer- and abstraction location- specific. Abstraction far from surface water, and in an aquifer with lower diffusivity, may for all practical purposes not impact on surface water (for millennia). Given the variability in hydraulic diffusivity even at different locations within the same aquifer, the data is not available in order to determine area-specific numerical values. The numerical value listed is in alignment with best-practice guidelines.	Buffer zones
				Quality	Nutrients	With the current land uses in the catchment including various mining developments, and the predominantly high groundwater vulnerability status (related to the sandy aquifer), there is a high risk of impact on groundwater quality. As groundwater is relied upon in the catchment for domestic use, and supports priority wetlands, groundwater quality must be protected to ensure there is no impact on users and the environment. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts), agricultural pollution (fertilisers), and saline intrusion. The numerical values represent either the 90 or the 95 percentiles for the listed aquifer within the GRU. This is taken as a limit of acceptable deviation from natural background.	NO_3 (as N)
					Salts		EC
					Pathogens	The parameters selected will support identification of pollution from waste water (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	E-coli, Total Coliform

Table 3-33 Sub-component and indicator selection for prioritized groundwater resource units in the Diep IUA

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
D10 Diep	III	10-Malmesbury	G21D	Quantity	Abstraction (Available Yield)	Groundwater supports domestic supply in Malmesbury and Abbotsdale and is used for agricultural purposes. The catchment is currently moderately used, projected to increase to heavily used in future. It is therefore necessary to establish an RQO for sustainable abstraction (protecting the available yield). Whilst exploiting groundwater storage is acceptable for managing drought and could be acceptable for short periods, over the long-term, groundwater use should be sustainable for all users and the environment. The RQO essentially implies that groundwater mining is considered unacceptable in the long-term. Implementation of this RQO requires the authority to isolate the cause of groundwater level decline and identify over-abstraction (unacceptable) from transition to new dynamic equilibrium (unavoidable), drought and climate change (unavoidable).	Seasonal abstraction: water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. Permanent abstraction: water level decline stabilises under consideration of aquifer response time.
					Discharge	Groundwater and surface water (the Diep River) are hydraulically connected in the area, and groundwater abstraction close to surface water (distance dependent on aquifer diffusivity), or groundwater abstraction rates that reduce aquifer water levels beneath that of the river, would reverse the gradient towards the river, and surface water would be 'lost' to groundwater (indirect recharge). The setting of this RQO assumes that this would be unacceptable (for surface water resources / ecology).	Relative water levels between groundwater and surface water
					Discharge	The groundwater fed wetlands in G21D are considered a priority. Whilst all abstraction reduces natural discharge to some extent and at some point in time, the timing of surface water depletion (the response time) is related to the distance to surface water, and the hydraulic diffusivity. It is therefore aquifer- and abstraction location- specific. Abstraction far from surface water, and in an aquifer with lower diffusivity, may for all practical purposes not impact on surface water (for millennia). Given the variability in hydraulic diffusivity even at different locations within the same aquifer, the data is not available in order to determine area-specific numerical values. The numerical value listed is in alignment with best-practice guidelines.	Buffer zones
					Discharge	The area has a high groundwater contribution to surface water, relative to the established EWR, and is prioritised from a surface water ecology perspective for full RQOs. It is assumed that the maintenance low flow is derived from groundwater. Whilst all abstraction reduces natural discharge to some extent and at some point in time, it would be unacceptable for abstraction to cause groundwater discharge to reduce below the maintenance low flow value required in the catchment to meet the surface water RQOs.	Compliance with the low flow requirements in the river
				Quality	Nutrients	As groundwater is relied upon in the catchment for domestic use, and supports priority wetlands, groundwater quality must be protected to ensure there is no impact on users and the environment. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts), agricultural pollution (fertilisers), and saline intrusion. The numerical values represent either the 90 or the 95 percentiles for the listed aquifer within the GRU. This is taken as a limit of acceptable deviation from natural background.	NO_3 (as N)
					Salts		EC
					Pathogens	The parameters selected will support identification of pollution from waste water (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	E-coli, Total Coliform

Table 3-34 Sub-component and indicator selection for prioritized groundwater resource units in the Cape Flats IUA

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
E12 Cape Flats	III	2-Cape Flats	G22C, G22D, G22E	Quantity	Abstraction (Available Yield)	Groundwater is used in the catchment for agricultural and industrial purposes. The catchment is currently moderately used which is projected to increase to heavily used in future, related to planned abstraction for domestic supply, but the CCT. Groundwater development across the Cape Flats aquifer has increased significantly since the recent drought It is therefore necessary to establish an RQO for sustainable abstraction (protecting the available yield). Whilst exploiting groundwater storage is acceptable for managing drought and could be acceptable for short periods to bridge the transition to other bulk water supplies (i.e. 5-10 years desalination/ re-use), over the long-term, groundwater use should be sustainable for all users and the environment. The RQO essentially implies that groundwater mining is considered unacceptable in the long-term. Implementation of this RQO requires the authority to isolate the cause of groundwater level decline and identify over-abstraction (unacceptable) from transition to new dynamic equilibrium (unavoidable), drought and climate change (unavoidable).	Seasonal abstraction: water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. Permanent abstraction: water level decline stabilises under consideration of aquifer response time.
					Groundwater level	The Langebaan Road Aquifer System comprises coastal aquifers, with (some) private abstraction wells located within 2.5 km of the coast. A minimum groundwater level is set in abstraction boreholes within 2.5km from the ocean to avoid saline intrusion.	Groundwater level
					Discharge	Groundwater and surface water are hydraulically connected in the area, and groundwater abstraction close to surface water (distance dependent on aquifer diffusivity), or groundwater abstraction rates that reduce aquifer water levels beneath that of the river, would reverse the gradient towards the river, and surface water would be 'lost' to groundwater (indirect recharge). The setting of this RQO assumes that this would be unacceptable (for surface water ecology).	Relative water levels between groundwater and surface water
					Discharge	The groundwater fed wetlands in the Cape Flats are considered a priority. Whilst all abstraction reduces natural discharge to some extent and at some point in time, the timing of surface water depletion (the response time) is related to the distance to surface water, and the hydraulic diffusivity. It is therefore aquifer- and abstraction location- specific. Abstraction far from surface water, and in an aquifer with lower diffusivity, may for all practical purposes not impact on surface water (for millennia). Given the variability in hydraulic diffusivity even at different locations within the same aquifer, the data is not available in order to determine area-specific numerical values. The numerical value listed is in alignment with best-practice guidelines.	Buffer zones
					Discharge	The area has a high groundwater contribution to surface water, relative to the established EWR, and is prioritised from a surface water ecology perspective for full RQOs. It is assumed that the maintenance low flow is derived from groundwater. Whilst all abstraction reduces natural discharge to some extent and at some point in time, it would be unacceptable for abstraction to cause groundwater discharge to reduce below the maintenance low flow value required in the catchment to meet the surface water RQOs.	Compliance with the low flow requirements in the river
				Quality	Nutrients		NO_3 (as N)

IUA	Class	GRU	Quat #	Component	Sub-component	Rationale for sub-component choice	Indicator selection
					Salts	With the predominantly urban land uses across the Cape Flats, and the predominantly high groundwater vulnerability status (related to the sandy aquifer), there is a high risk of impact on groundwater quality. As groundwater is used in the catchment, and supports priority wetlands, groundwater quality must be protected to ensure there is no impact on users and the environment. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts), agricultural pollution (fertilisers), and saline intrusion. The numerical values represent either the 90 or the 95 percentiles for the listed aquifer within the GRU. This is taken as a limit of acceptable deviation from natural background.	EC
					Pathogens	The parameters selected will support identification of pollution from waste water (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	E-coli, Total Coliform

4 Conclusion

4.1 Summary of sub-component prioritisation and indicator selection

A total of 49 sub-components were selected for RQO determination during Step 4 of the RQO determination procedure in the Berg Catchment (shown in Table 0.1), including:

- 12 sub-components were selected to represent river resources from 20 prioritised RUs.
- 13 sub-components were selected to represent estuaries resources from 7 prioritised RUs.
- 9 sub-components were selected to represent dam resources from 6 prioritised RUs.
- 9 sub-components were selected to represent wetlands resources from 24 prioritised RUs.
- 6 sub-components were selected to represent groundwater resources from 11 prioritised RUs.

Table 4-1 comprises a summary of the selected sub-components on the different significant water resources for the Berg Catchment.

Table 4-1 Summary of sub-component prioritisation selection for the Berg Catchment

Component	Sub-component	Rivers	Estuaries	Dams	Wetlands	Ground water
Quantity	Abstraction					X
	High flows	X	X	X	X	
	Low flows	X	X	X		X
	Discharge					X
	Hydroperiod				X	
Quality	Nutrients	X	X	X	X	X
	Salts	X		X		X
	System variables (temperature, salinity, oxygen, pH, turbidity	X	X	X		
	Toxins	X	X	X		
	Pathogens	X	X	X	X	X
Habitat	Ecological Condition	X				
	Geomorphology	X			X	
	Sedimentary processes		X			
	Mouth state		X			
	Vegetation / Riparian Vegetation	X			X	
Biota	Fish	X	X	X		
	Frogs				X	
	Invertebrates	X	X			
	Micro-algae		X			
	Macrophytes		X			
	Phytoplankton			X	X	
	Birds		X			
	Benthic algae				X	
	Totals	**12**	**13**	**9**	**9**	**6**

4.2 Addressing uncertainties

Some of the key limitation and uncertainties which may influence the confidence of the outcomes of the resource unit evaluation process which should be considered when implementing the RQOs are described below.

4.2.1 Rivers

Unsurprisingly the high priority RUs aligned quite well with the location of the Intermediate and Comprehensive EWR sites since the location of EWR sites is chosen using much the same criteria as the RU evaluation tool. In fact, it would have been strange if the EWR hotspot tool, used to identify the location of EWR sites, and the RU evaluation tool produced different results. Nonetheless, the two *tools* are just that and are simply there to guide and facilitate the process. The location of RUs and their priority also requires input from the Department and the stakeholders, so adjustments may be necessary following the TTG meetings.

4.2.2 Estuaries

Some large discrepancies were evident between importance scores allocated using the Resource Unit Prioritisation Tool and the conservation importance ranking that has been established for estuaries in South Africa (Turpie *et al*. 2013). This was taken into consideration when selecting estuaries for which detailed RQOs were developed. However, there will always be some estuaries which stakeholders feel merit more detailed RQOs than those that have been prepared as part of this study, and this may require increasing the subset of estuaries for which RQO will ultimately be developed.

4.2.3 Dams

The following limitations and uncertainties are relevant to the outcomes of this assessment:

- Implementing the EWR in the lower Steenbras River will be a challenge, given the restriction of the inadequate outlet structure at the Lower Steenbras Dam.
- There are instances where the assessment is based on desktop information. There is a risk that some sub-components could have been omitted from the assessment, especially where data is not readily available.
- This assessment is largely based on the probability that the sub-components and indicators selected will be suitable indicators of the protection and/or water dependent activities of the water resources considered. This probability consideration is largely based on qualitative information and expert solicitations. These outcomes should be monitored and updated using quantitative data where possible.

4.2.4 Wetlands

The use of the outputs from the updated Wetland Prioritisation Tool was useful in that the determination of the wetlands that provide certain services and the threats to these services used a GIS application. This allowed for a desktop review of the identification of sub-components, with reference to the more detailed studies in order to determine realistic indicators for sub-components. Refinement of these indicators is necessary with consultation with varied stakeholders in order to ensure effective representation.

4.2.5 Groundwater

Appropriate indicators have been selected for groundwater which give effect to the management of groundwater yield quantity and quality. No significant limitations or uncertainties affected the selection of these sub-components and indicators for groundwater.

4.3 Way forward

The next step of the RQO determination process, Step 5, comprises the proposed draft ROQs and numerical limits (NL) for the prioritised water resource units in the Berg Catchment. RQOs are narrative statements, but sometimes provide broad quantitative descriptions of the water resource. Numerical limits translate the narrative RQOs into numerical values which can be monitored and assessed for compliance.

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Appendix A
Representation of typical wetlands through prioritisation

The typical wetland types, IUA and named wetlands (according to the Western Cape Wetlands Directory) within each WRU across the study area.

Wetland Region	Typical wetlands	IUA	Named Wetlands	Key Threats	Importance	Prioritised
South Western Coastal Belt_Sand (WR1)	Floodplain	A1	Wamakersvlei	The City of Cape Town efforts to conserve individual wetlands (e.g. Khayelitsha Wetland Park, Witsand Recharge Area) has helped to improve ecological condition (Malan et al., 2015). Alien invasive vegetation has had a severe impact on ecological health of some wetlands (e.g. Yzerfontein), with associated impacts such as reduced runoff, reduced biodiversity and increased vulnerability to erosion (Malan, et al., 2015). Development of housing has had a major impact on wetlands in urban areas, with accompanying changes to hydrology, reductions in connectivity of wetlands to surrounding biodiversity and pollution threats. Alluvial floodplains in the Wetland Region are highly threatened by water abstraction, which is threatening the seasonal inundation of the floodplain, and the persistence of floodplain vegetation and wetlands (Job et al., 2008). The False Bay Nature Reserve has been declared a Wtland of International Importance (Ramsar Site no. 2219) and is South Africa's 22nd Ramsar Wetland. This consists of Rondevlei (a lake within a protected area) and Zeekoeivlei (a recreational lake within a residential area). Both lakes support large populations of waterbirds, including pelicans and flamingos and up to 60% of the bird species in the South-western Cape (228 species). The site is also important due to the populations of mammals (including hippopotamus, cape clawless otter, water mongoose) and diversity of plant species (about 256 indigenous plants, including two endemic plant species currently listed as extinct in the wild: Erica turgida and Erica vericillata).	The Berg River has alluvial floodplain wetlands which are characterised by wide river valleys, where periodic inundation of the floodplain sustains wetland habitat. These wetlands are highly threatened by water abstraction, which threatens the seasonal inundation of the floodplain, the persistence of floodplain vegetation and wetlands (Job et al., 2008). The Berg Estuary has RAMSAR status but no formal protection.	Yes, Berg Floodplain and associated wetlands have been prioritised.
			La Rochelle			
			Cerebos Saltpans			
			Die Plaat			
			Hotel Saltpans			
			Springersbaai Floodplain wetlands			
			Kliphoek saltpans			
			Kliphoek River and Floodplain wetlands			
			Bloemendal Pan			
			Melkplaas Floodplain wetlands			
			Olifantskraal marsh			
			Kruispad floodplain wetlands			
			Langrietvlei floodplain wetlands			
			Doornfontein floodplain wetlands			
			Kersefontein floodplain wetlands			
			Helderwater pan			
			Heuwelfontein			
			Kersefontein floodplain wetlands			
			Berg River floodplain wetlands			
		A2	Ultra Soutpan		Strandveld valley bottom wetlands are located almost exclusively in the Saldanha Peninsula. They are seasonal wetlands, tend to be saline and occur on neutral to alkaline sands or granite-derived soils (Job et al., 2008). As opposed to Langebaan these wetlands are generally fed by hillslope seeps lying on higher ground and are not particularly groundwater dependent (Job et al., 2008). Threats to these wetlands are both cultivation and urban expansion, with changes to the flow regime being of particular concern.	Yes, Geelbek prioritised
			Saldanha Lagoon			

Wetland Region	Typical wetlands	IUA	Named Wetlands	Key Threats	Importance	Prioritised
		A3	Yzerfontein Soutpan		Yzerfontein salt pan, a saline depression wetland, is currently being mined for gypsum. Alien invasive vegetation in the area and deepening of the main pan due to dredging activities may have contributed to the loss of wetland area (Malan et al., 2015). The wetland has a PES of B, with a degrading trajectory due to mining, and an EIS of 6.1, due to employment provided by mining and the habitat provided for water birds (Malan et al., 2015). The wetland provides habitat for important water birds and water amelioration benefits, and it has an overall EIS of 5.2 (Malan et al., 2015).	No
			Rooipan			
			Jakkalfontein Private Reserve			
			Dwars River Mouth lagoon			
			Rondeberg			
			Modder River Riparian Wetlands			
			Silwerstroom Spring			
			Witsand Aquifer recharge			
		E12	Blouvlei		Zeekoeivlei is the largest of the Cape Flats wetlands, it is U-shaped with most of the present day surface inflow coming from the north basin via Big and Little Lotus “rivers” and the outflow being from the south basin through the Zeekoe Canal (Brown and Magoba, 2009). Princessvlei is a small, shallow, eutrophic freshwater coastal vlei to the north of Rondevlei (a smaller vlei next to Zeekoeivlei). These wetlands (along with the Strandfontein Wastewater Treatment Works) form part of the False Bay Nature Reserve, which was proclaimed as South Africa’s 22nd Ramsar site in 2015. The importance of this area stems from the endemic vegetation type and important bird species. Most of the birds within this wetland system are concentrated at the Strandfontein Wastewater Treatment Works due to the wide range of wetland habitats present and the proximity to the ocean (Wright, 2015). Key bird species are in decline, possibly in response to changes in water level and quality (Wright, 2015). Water hyacinth has also invaded some of the settling ponds, impacting the biodiversity.	Yes, Zeekoeivlei, Rondevlei prioritised
			Zoarvlei			
			Athlone Waste Water Treatment			
			Kreupelboom			
			Amandel			
			Retention dam/vlei of UWC campus			
			Bellville South Waste Disposal			
			Kuils River Wetlands			
			Nooiensfontein			
			Driftsands Nature Reserve			
			Padvlei			
			Wetvlei			
			Cape Corps			
			Khayelitsha Pool			
			Edith Stevens Wetland Park			
			Pelican Park			
			False Bay Nature Reserve wetlands (Zeekoeivlei, Rondevlei, Strandfontein Sewage Works, Papkuilsvlei, Grootvlei)			

Wetland Region	Typical wetlands	IUA	Named Wetlands	Key Threats	Importance	Prioritised
		D6	Klavervlei		Limited literature on importance of these wetlands	No
		B4	Kleigat Pan		Two depression wetlands occur on a tributary of the Berg River to the north of Darling. The Koekispan and Kiekoesvlei occur within agricultural lands and are host to a variety of water birds. Koekispan is a saline pan which still bears a berm from salt mining. It has a low EIS of 2.8 (Malan et al., 2015), due to the remaining impacts of the wetland modifications and high nutrient levels within the wetland. Kiekoesvlei is a freshwater pan within pasture lands. It has an EIS of 4.9 due to the occurrence of red data birds (flamingos) and Oxalis disticia, but the wetland is also under the effects of elevated nutrients (Malan et al., 2015).	No
			Droevlei			
			Burgerspan			
			Koekispan			
			Kiekoesvlei			
			Egbertsvlei			
			Hamburg Pan			
			Klein Hamburg Pan			
		D10	Rietvlei		Rietvlei floodplain and seasonal wetlands associated with the estuary.	Yes
South Western Coastal Belt_Shale (WR2)	Floodplain	B4	Middelskilpadvlei	Water abstraction is threatening floodplain wetlands within this Wetland Region. The expansion of towns and urban areas (e.g. northern expansion of the City of Cape Town) is likely to increase pressures due to habitat degradation and pollution which may lead to complete loss of some wetlands.	The Berg River has alluvial floodplain wetlands which are characterised by wide river valleys, where periodic inundation of the floodplain sustains wetland habitat. These wetlands are highly threatened by water abstraction, which threatens the seasonal inundation of the floodplain, the persistence of floodplain vegetation and wetlands (Job et al., 2008).	Yes
			Skulpadsvlei			
			Voelvlei Dam			
			Brakvlei Dam			
			Misverstand Dam			
			Piketberg Dam			
			Radyn Dam			
			Berg River Floodplain			
		D10	Driefontein Farm Dam		Limited literature on importance of these wetlands although Riverlands has been assessed recently. Rare and critically endangered vegetation identified in Riverlands.	Yes, Riverlands prioritised
			Droevlei			
			Riverlands Nature Reserve			
			Rozenburg			
			Byways Dam			
			Uitkoms II dam			
			Joosfontein			
			Joostenbergkloof Dam			

Wetland Region	Typical wetlands	IUA	Named Wetlands	Key Threats	Importance	Prioritised
			Damara Dam			
			Matjieskuil			
		D9	Paarl Sewage Works		Limited literature on importance of these wetlands	No
			Noord Agter Paarl Irrigation			
			Wellington Waste Water Works			
			Silent Farm Dam			
			Olyfenboomen Dam			
			Berg River Floodplain			
		D8	Skuifraam Dam		Limited literature on importance of these wetlands	No
			Bethel Dam (Paarl)			
			Nanties Dam (Paarl)			
			Sonstraal Dam			
		D6	Elsenberg Dam		Limited literature on importance of these wetlands	No
			Klapmuts Dam			
			Landskroon Dam			
			Idas Valley Dam			
			Vlottenburg Dam			
			Vredenburg Dam			
			Meerlust Dam			
Western Folded Mountains (WR3)	Small valley bottom and seep wetlands.	C5	No named wetlands	There are limited wetlands within this area, but the main impact to wetlands in this area would be transformation for agriculture. Some high altitude seeps are important as they contribute to the source of rivers flowing out of the mountains.	Limited literature on importance of these wetlands	Yes, wetlands prioritised due to Strategic Water Supply Area
Southern Folded Mountains (WR4)	Seeps and valley bottom wetlands.	D8	Dwarsberg Wetlands	There are limited wetlands within this area, but the main impact to wetlands in this area would be transformation for agriculture. Some high altitude seeps are important as they contribute to the source of rivers flowing out of the mountains.	Limited literature on importance of these wetlands	No
			Wemmershoek Dam			
		D7	Paardevlei		Paardevlei lies on the site of a natural, shallow, seasonal vlei. It lies within the Southern Folded Mountains WRU4 and has been impacted by various changes in use over the years, particularly related to fishing. In recent years it has had several rehabilitation efforts aimed at reinstating indigenous biota (Brown and Magoba, 2009). The surrounding area has been	No
			Helderberg Nature Reserve			
			Steenbras River Dam			

Wetland Region	Typical wetlands	IUA	Named Wetlands	Key Threats	Importance	Prioritised
					identified for significant mixed-use developments.	
Southern Folded Mountains_Peninsula (WR5)	Range from mountain seeps, riverine systems and isolated depressions	E12	Kenilworth Racecourse	The proclamation of the Table Mountain National Park has helped to conserve many wetlands in the Peninsula area on a large scale and the effort by the City of Cape Town to conserve individual wetlands (i.e. Silvermine, Kenilworth) has helped on a smaller scale (Malan et al., 2015).		Yes
			Princess Vlei			
		E11	Kleinplaats West		Noordhoek Valley consists of many wetlands scattered about between the developed part of the catchment and the beach. Three permanent waterbodies occur in this area: Lake Michelle (developed from former salt pans) and the Wildevoelvlei. These wetlands are of great conservation importance as they provide refuge to various rare plant and animal species. The Noordhoek Salt Pan (Lake Michelle) has an EIS of 5.9 according to Malan et al., (2015). Along the Southern Peninsula towards Cape Point there are numerous seasonal vleis, seeps and streams, which mostly dry up in Summer (Brown and Magoba, 2009). The waters of this area are usually dark brown and acidic due to the leaching fynbos vegetation. Silvermine River emerges from the Silvermine Valley into the Fish Hoek plain whereby it joins the sea at the Silvermine Estuary. The area at upstream of the Silvermine Dam has a high EIS (5.9) due to the occurrence of rare plant species and amphibians and the area at the lower Silvermine River floodplain has an even higher EIS (7.3) due to the occurrence of red data species (otters) and as it improves water quality amelioration and reduces flooding (Malan et al., 2015). It also has important recreational value.	Yes, Noordhoek and Strategic Water Source Area wetlands
			Noordhoek Soutpan			
			Silvermine Dam			
			Sirkelsvlei			
			Schusters vlei			
			Glencairn Vlei			