

DETERMINATION OF WATER RESOURCE CLASSES AND ASSOCIATED RESOURCE QUALITY OBJECTIVES IN THE UPPER ORANGE RIVER CATCHMENT, WP11422

Project Steering Committee meeting – Bloemfontein

Presented by: Lee Boyd, Oliver Maletle and Eddie van Wyk of WSP Africa Group and Karen Eatwell of Prime Africa Consult

Designation: PSP

Directorate: for Chief Directorate Water Ecosystems Management

Date: 28 August 2024

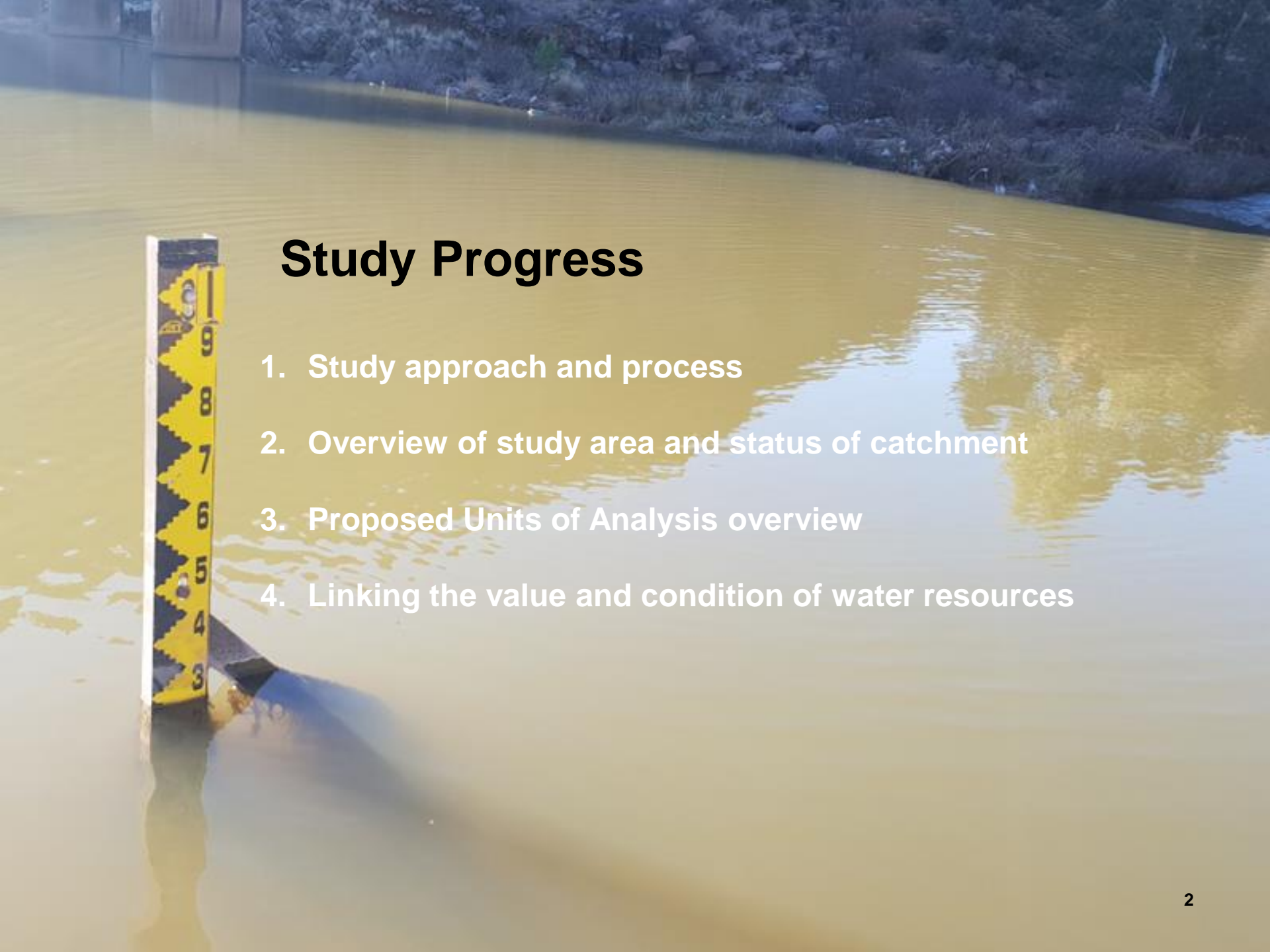
WATER IS LIFE - SANITATION IS DIGNITY



water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA



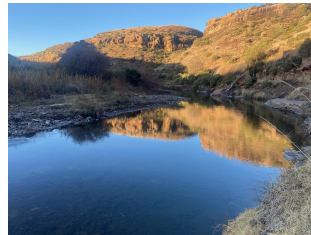


Study Progress

1. Study approach and process
2. Overview of study area and status of catchment
3. Proposed Units of Analysis overview
4. Linking the value and condition of water resources

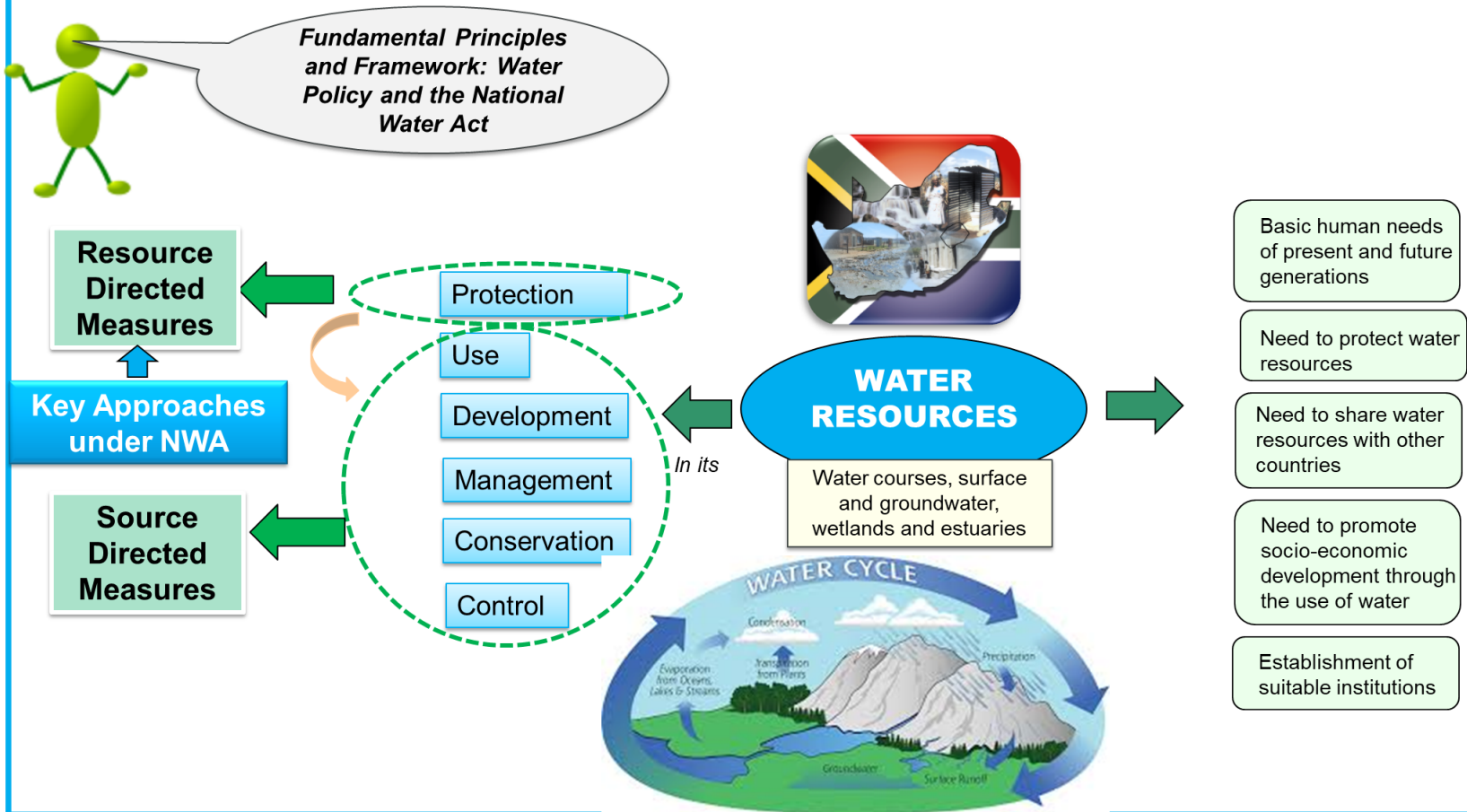
Study Objectives

To determine appropriate *water resource classes* and *Resource Quality Objectives (RQOs)* for all significant water resources in the Upper Orange River catchment (*rivers, dams, wetlands and groundwater*) to facilitate sustainable use of the water resources while maintaining ecological integrity, specifically maintaining or improving the present ecological state of the water resources.



What does this mean?

IWRM FRAMEWORK



How does national government determine the level of protection required for a particular water resource?

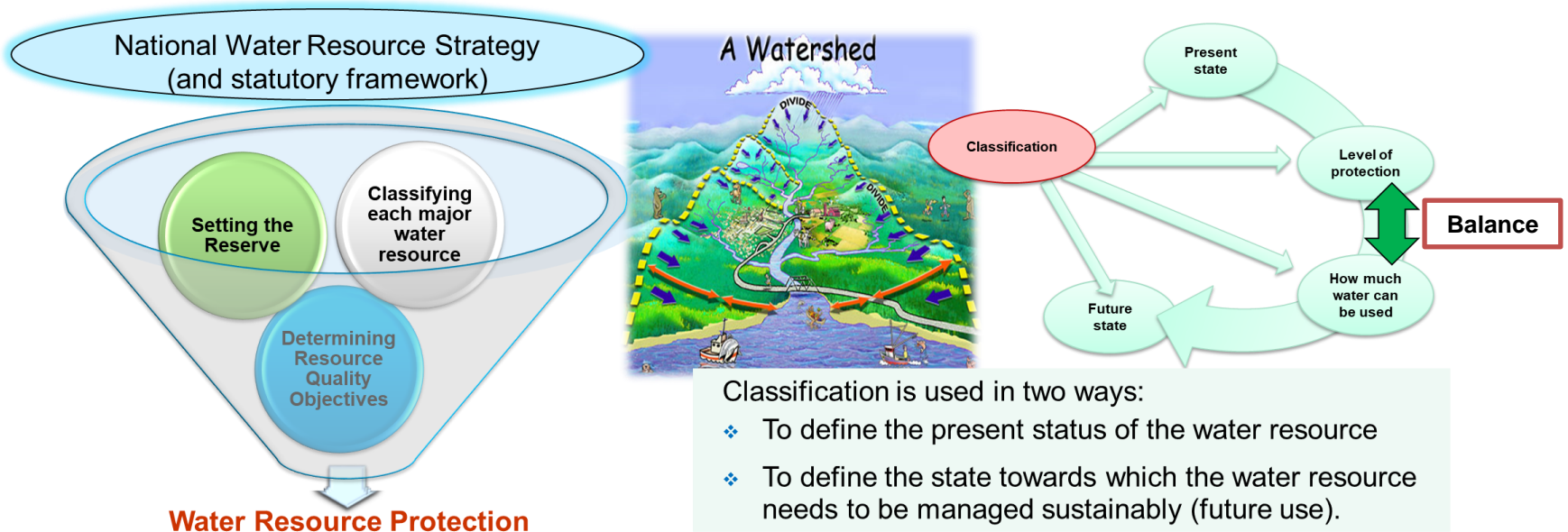
- Very few water sources that are in a natural state and therefore our water resources require protection
- Water in SA is scarce and unevenly distributed throughout the country
- Thus, different water resources require different levels of protection
- Chapter 3 of the NWA specifies a series of resource directed measures (RDM) which together are intended to ensure the comprehensive protection of all water resources.

These include:

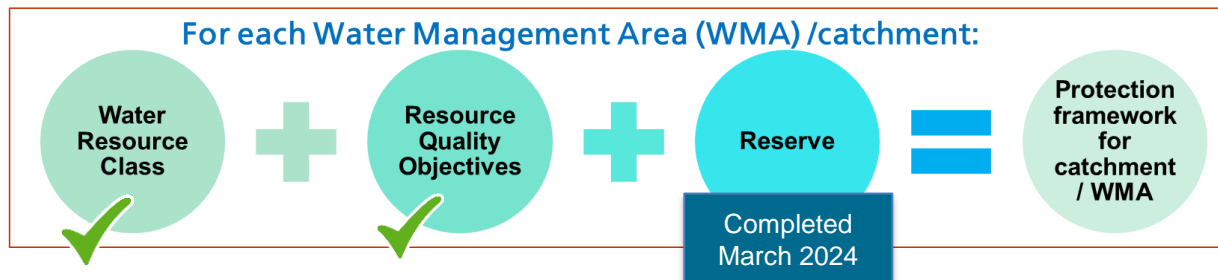
- the classification of water resources,
- setting the Reserve, and
- establishing resource quality objectives.



Achieving integration



The water resource class, RQOs and Reserve are developed for the instream condition of the water resource and implemented within the context of national water resource strategy and respective catchment management strategies.



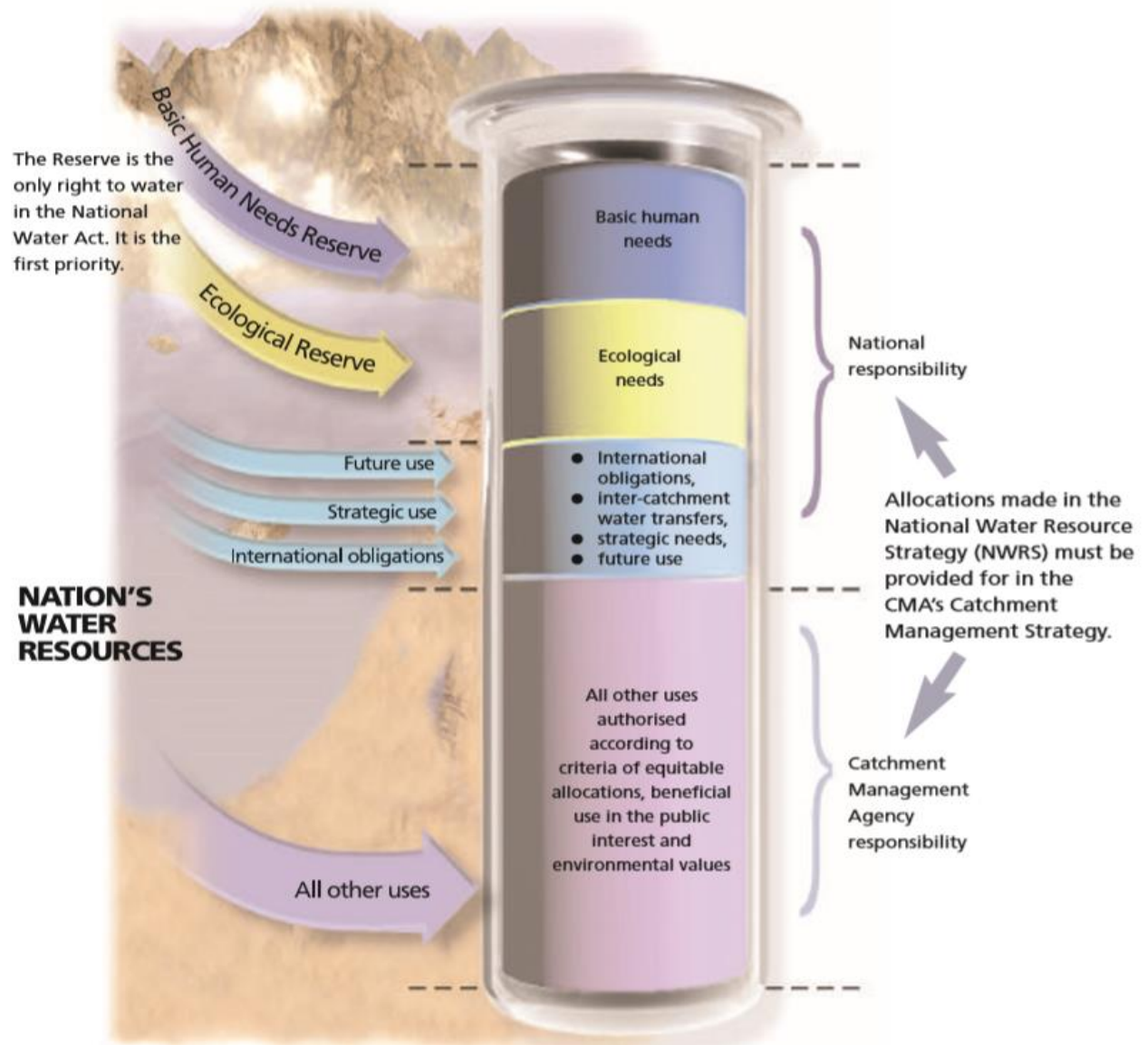
Setting the Reserve

Only *RIGHT* in the NWA

The Reserve is part of the water resource that is under the direct control of the Minister.

It has priority over all other water use.

Reserve must be met before water resources can be allocated to other water users



Classifying each major resource

- Surface water
 - Rivers
 - Dams
- Groundwater
- Wetlands (including pans), and
- Estuaries (not relevant to the Upper Orange but what is done here impacts the estuary in the Lower Orange, a RAMSAR site)

Each class represents:

- A different level of protection that is required for the water resource, and
- The extent to which water can be used.

	Description of use	Ecological Category	Description of resource
Class I	Minimally used	A-B	Minimally altered
Class II	Moderately used	C	Moderately altered
Class III	Heavily used	D	Heavily altered

Determining Resource Quality Objective (RQOs)

Resource quality objectives provide statements about:

- What the quantity of water should be (water level, pattern, timing)
- What the water quality should be (physical, chemical, biological)
- What the condition of the instream and riparian (riverbank) habitat should be, and
- What the condition of the aquatic (water) animal and plant life should be.



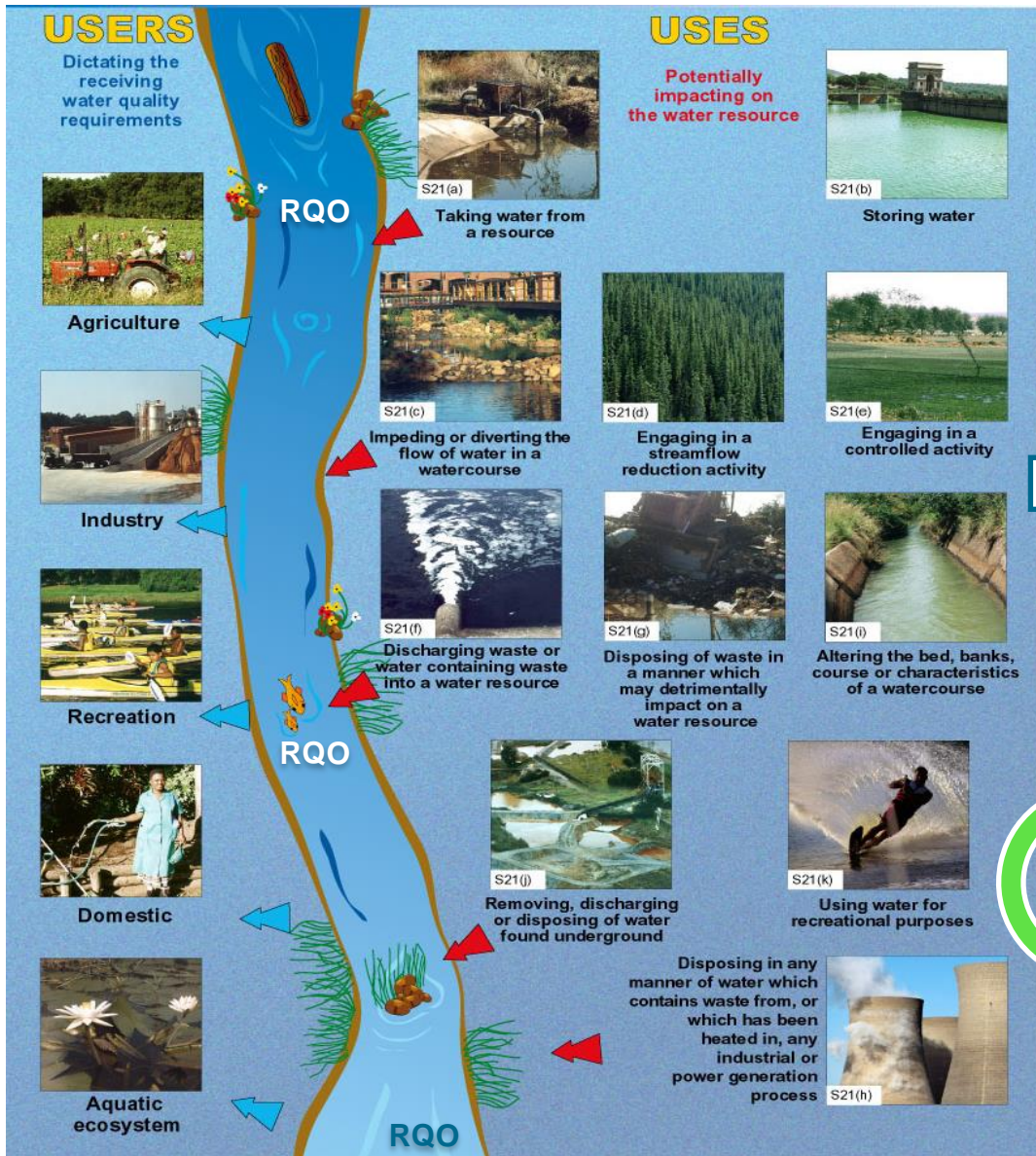
Releases are looking good for the downstream users



This is perfect for me



HELP!

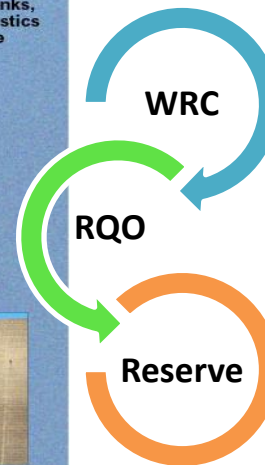


We all live downstream

Resource Management

Source Control

Resource Protection



- Setting requirements in water resources – Water Resource Class
- Resource Requirements:
 - Human Needs
 - Aquatic System Health (Ecospecs)
 - **Resource Quality Objectives**



**WATER RESOURCE CLASSES AND ASSOCIATED RQOs:
UPPER ORANGE RIVER CATCHMENT, WP11422**

Study Approach and Process

In Summary

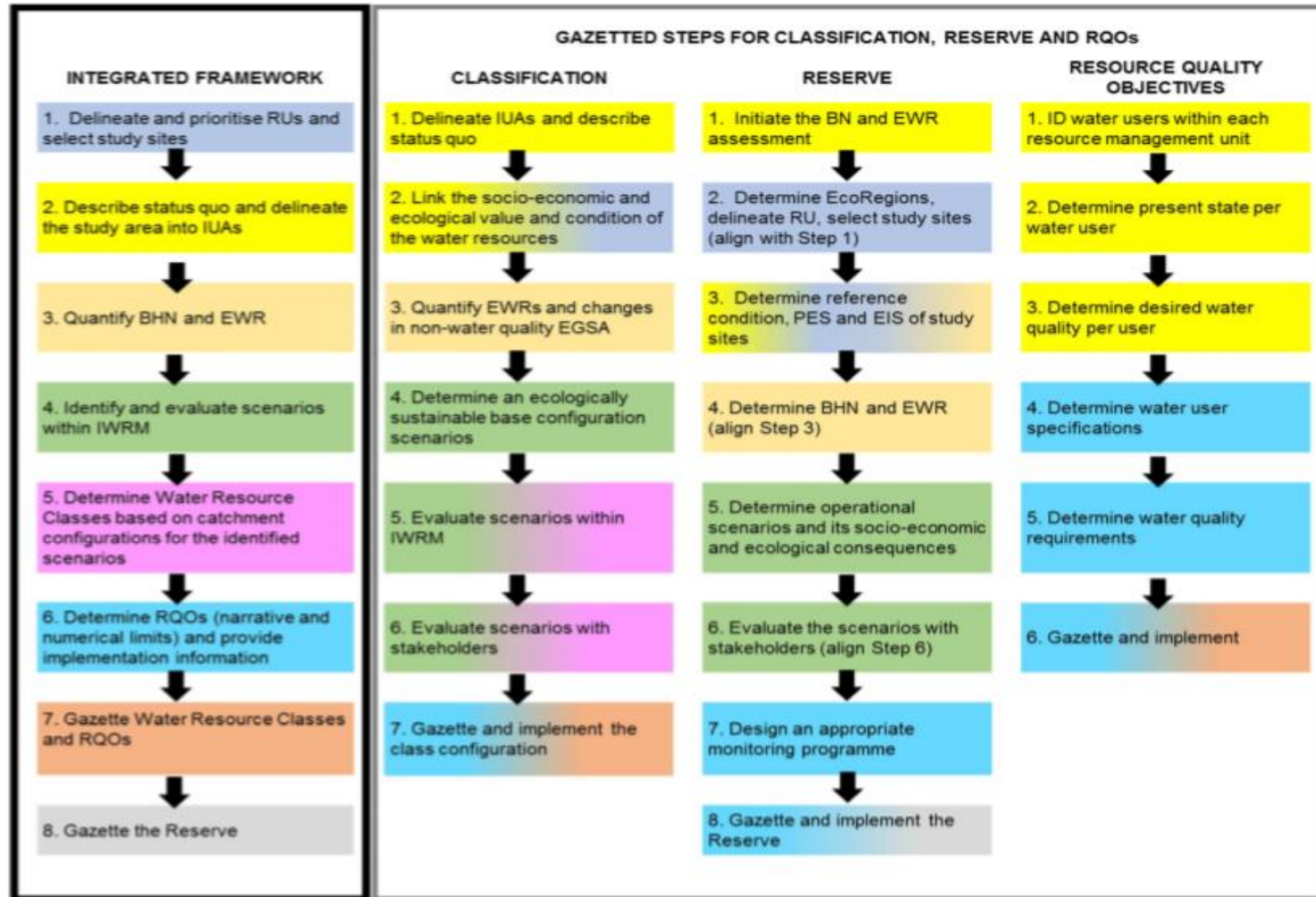
- RDM = sustainability indicators of the water resource
- Compliance = desired level of protection being achieved = sustainable water resource systems
- The water resource class and the RQOs form an integral component of IWRM and inform the current and future planning, use, development, management and control of the water resources in the catchment areas.
- Implementation and achievement extends across institutional, functional and operational levels of the DWS as well as other institutions, water users and stakeholders.
- Achievement of the protection measures are fundamental in ensuring sustainable water resources into the future.



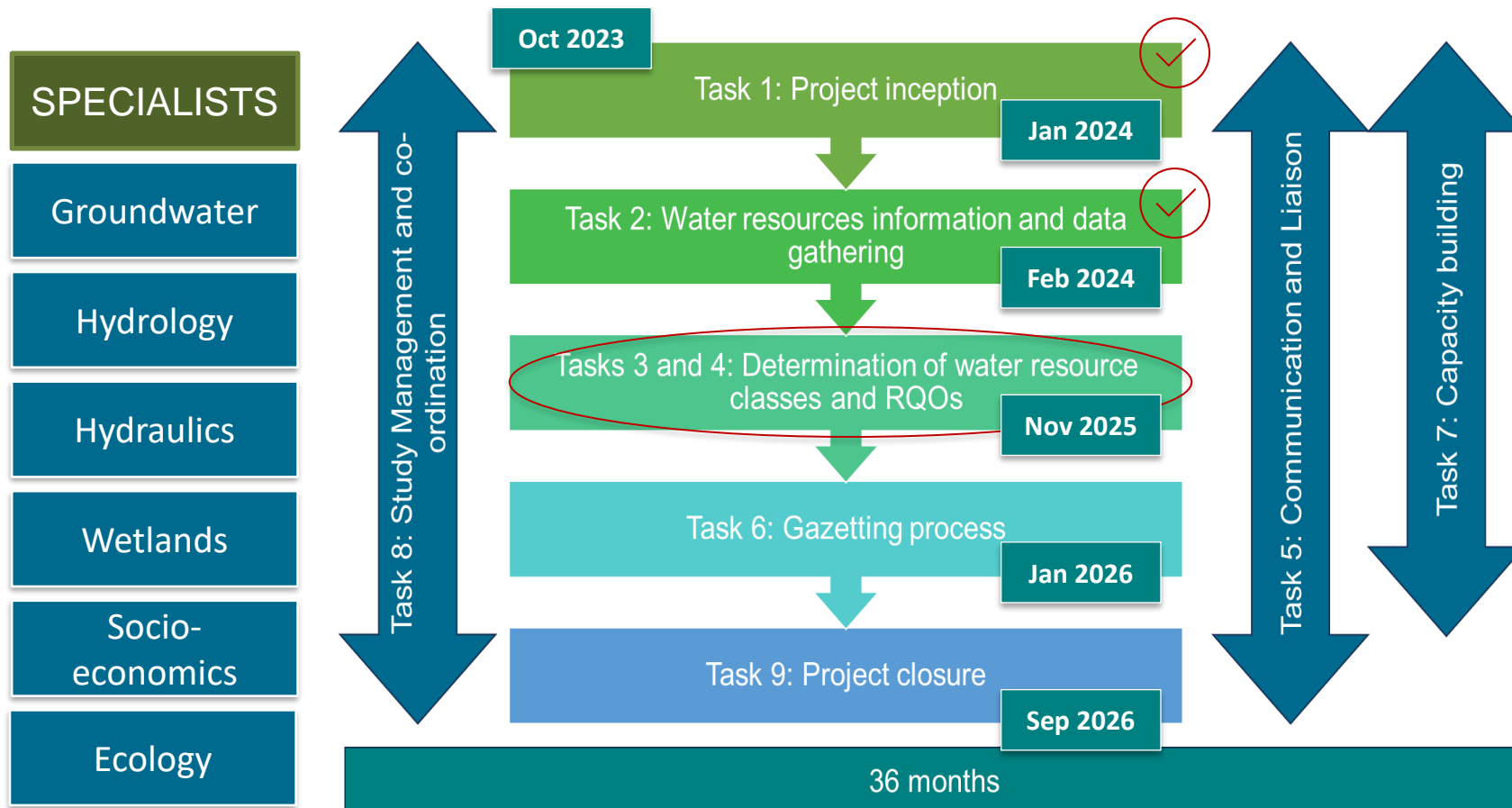
Key aims of this study

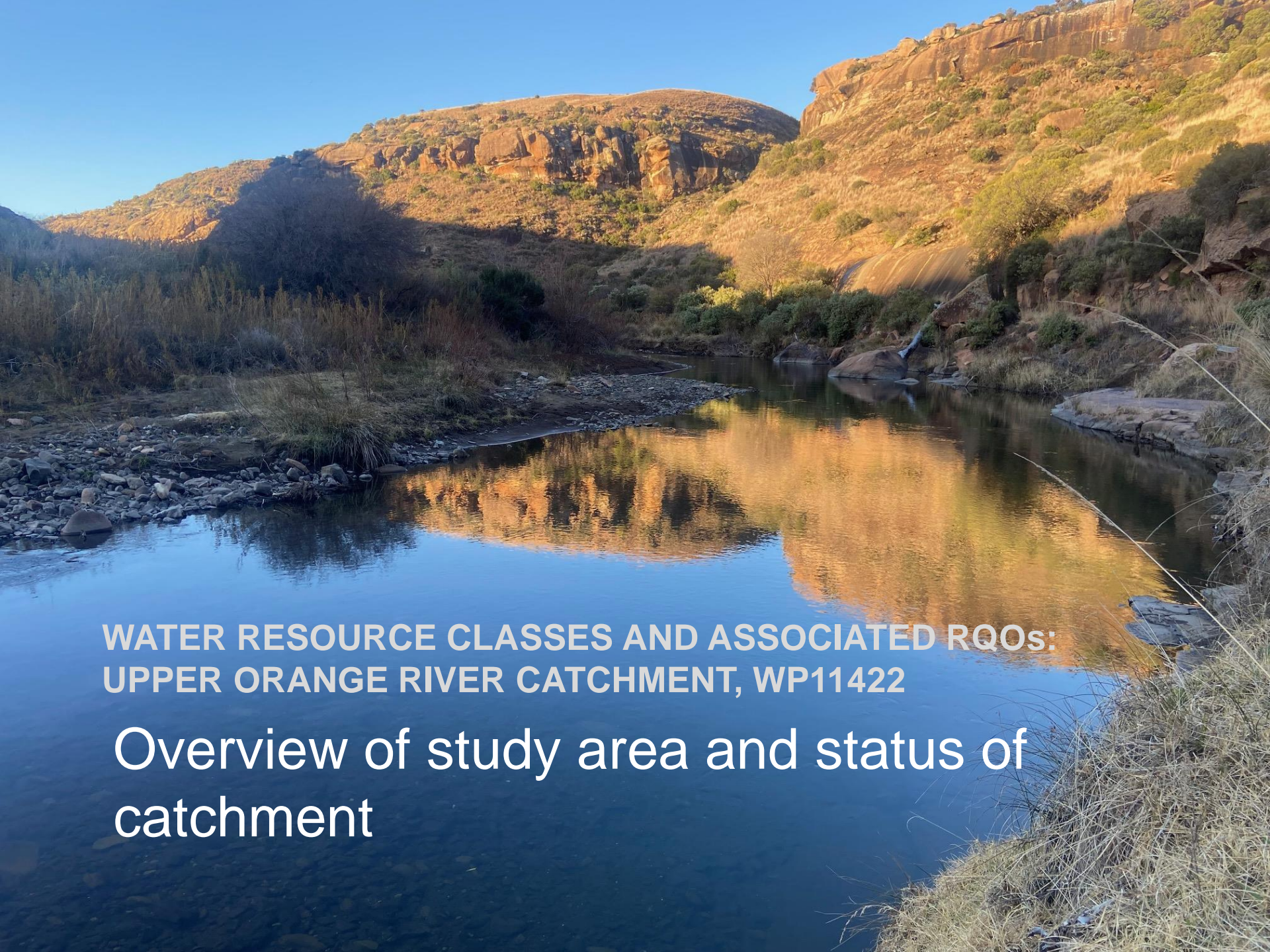
- Co-ordinating the implementation of the Water Resource Classification System (WRCS) by:
 - Undertaking the determination of water resource classes and RQOs
-
- It is noted that the study is linked to the previous high confidence Reserve determination studies and other water resource management initiatives.

Integrated Framework of the Gazetted steps for Classification, Reserve and RQO Determination (DWS)



Flow of the study tasks and high-level timeframes





**WATER RESOURCE CLASSES AND ASSOCIATED RQOs:
UPPER ORANGE RIVER CATCHMENT, WP11422**

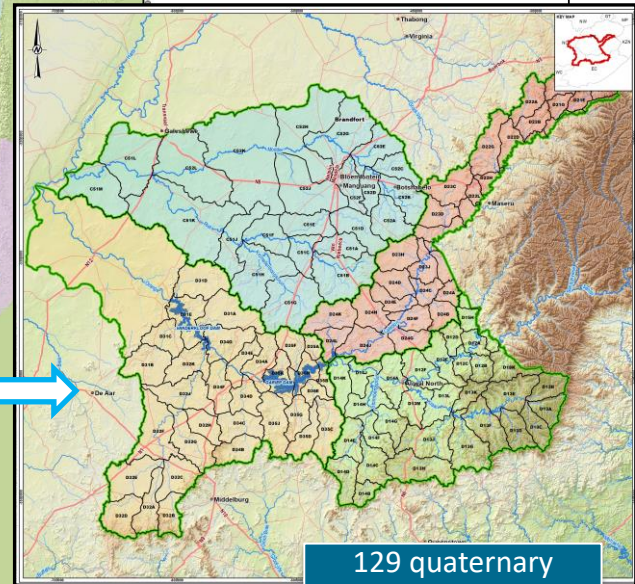
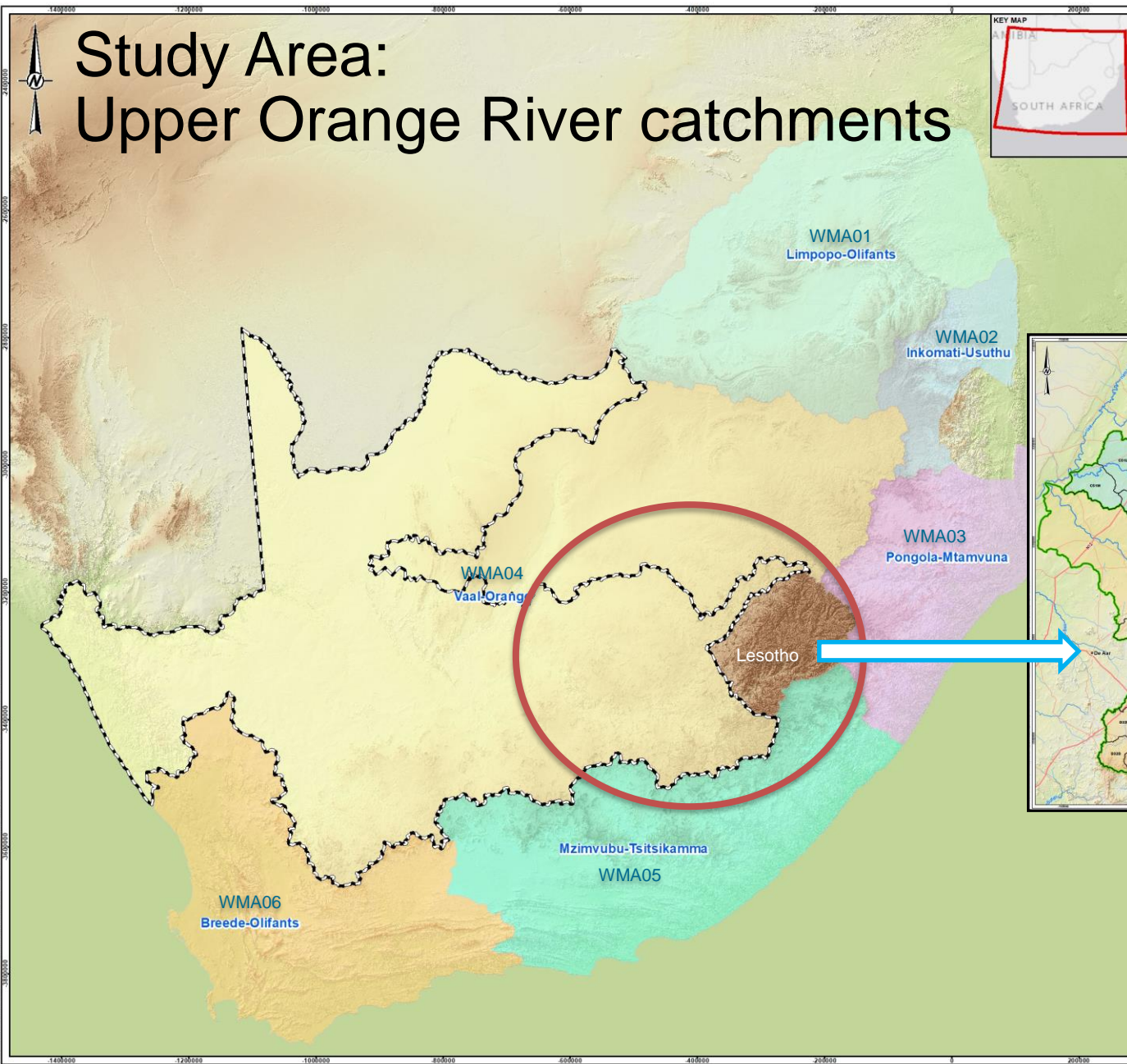
**Overview of study area and status of
catchment**

Study Area: Upper Orange River catchments



LEGEND

- Water Management Area - Orange WMA & D42 Catchments
- Water Management Areas (DWS, 2023)**
 - 1, Limpopo-Olifants
 - 2, Inkomati-Usuthu
 - 3, Pongola-Mtamvuna
 - 4, Vaal-Orange
 - 5, Mzimvubu-Tsitsikamma
 - 6, Breede-Olifants



129 quaternary catchments

CLIENT
DEPARTMENT OF WATER AND SANITATION

PROJECT
UPPER ORANGE WRC AND RQOS DETERMINATION

TITLE
WATER MANAGEMENT AREAS (2023) IN RELATION TO ORANGE WMA (2012)

CONSULTANT	water & sanitation Department of Water and Sanitation REPUBLIC OF SOUTH AFRICA	YYYY-MM-DD	2024/02/23
DESIGNED	TS	PREPARED	MB
REVIEWED	LB	APPROVED	LB

PROJECT NO. 41104900 CONTROL REV. 0 FIGURE 0

Water Resource Components

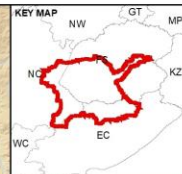
This study focuses on the classification of significant water resources and determination of RQOs in the Upper Orange River catchments. This will include an identified network of significant resources comprising rivers, dams, wetlands and groundwater through the catchment.

- Rivers
- Dams
- Wetlands
- Groundwater



Sub-catchments

Class	Coefficient of Variation Index	Hydrological character
Class I	CV_Index 1-4	Perennial
Class II	CV_Index 5	Seasonal
Class III	CV_Index 6 - 9	Ephemeral



- LEGEND**
- Towns
 - Water Management Area - Upper Orange Catchment (DWA 2012)
 - Dam
 - Rivers

Secondary catchment areas

- C5
- D1
- D2
- D3

The Caledon/ Mohokare River from its headwaters and tributaries to the Gariep Dam

Modder-Riet River (main tributaries of the Vaal River system)

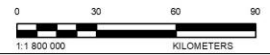
The Orange River from the Gariep Dam, through Vanderkloof Dam to Marksdrift weir, just before the confluence with the Vaal River, including the Seekoei River

The Orange River from the Lesotho Border to the Gariep Dam, including the main tributaries namely Kornetspruit, Sterkspruit, Stormbergespruit and Brandwaterspruit

The Kraai River catchment

The Upper Orange River catchments stretch across the Northern Cape, Free State and Eastern Cape provinces and across three ecoregions: the Eastern Escarpment Mountains, Nama Karoo and Highveld

SWSA: Maloti Drakensberg area and the Eastern Cape Drakensberg.



NOTE(S)

REFERENCE(S)
 COORDINATE SYSTEM: HARTERBEESTHOEK84 LQ31
 SERVICE LAYER CREDITS:

CLIENT
 DEPARTMENT OF WATER AND SANITATION

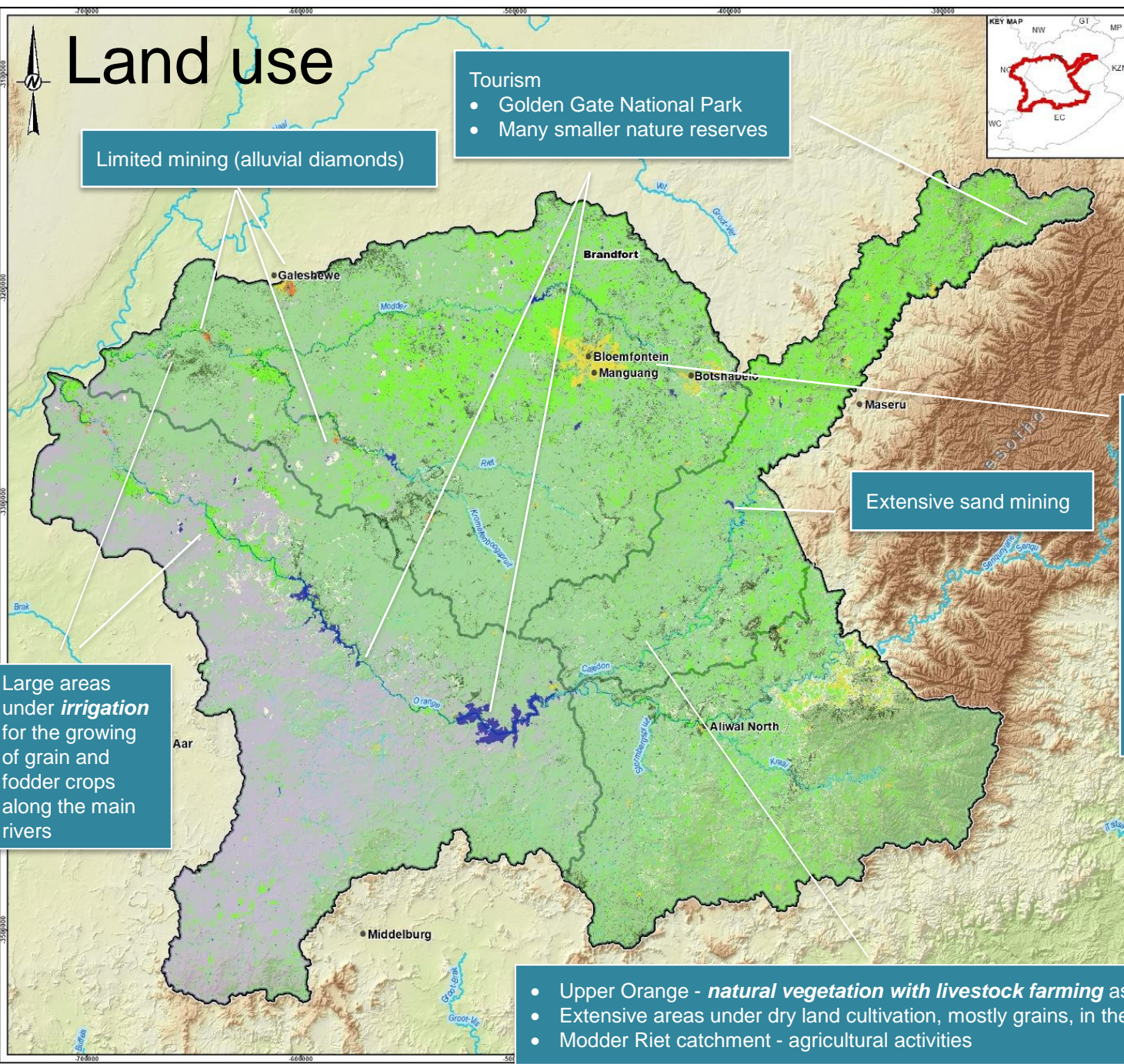
PROJECT
 UPPER ORANGE WRC AND RQOS DETERMINATION

TITLE
 UPPER ORANGE RIVER CATCHMENTS FOR CLASSIFICATION AND RESOURCE QUALITY OBJECTIVES SETTING (WP11422)

CONSULTANT	YYYY-MM-DD	2023/11/22
DESIGNED	TS	
PREPARED	MB	
REVIEWED	LB	
APPROVED	LB	

PROJECT NO. 41104900 CONTROL REV. 0 FIGURE 0

Land use



LEGEND

- Towns
- ▭ Water Management Area - Upper Orange Catchment (DWAF 2012)
- Rivers

Landcover (Level 1)

- Barren Land
- Built-up
- Cultivated
- Forested Land
- Grassland
- Mines & Quarries
- Shrubland
- Waterbodies
- Wetlands

Tourism

- Golden Gate National Park
- Many smaller nature reserves

Limited mining (alluvial diamonds)

Extensive sand mining

Large areas under *irrigation* for the growing of grain and fodder crops along the main rivers

Urban areas and associated wastewater treatment works

- **Mangaung MM**, Botshabelo and Thaba 'Nchu, Maletswai - main urban and industrial developments.
- Smaller towns: Clarens, Ficksburg, Hobhouse, Fouriesburg, Hlohlowane, Winnie Mandela, Ladybrand, Vanstadensrus, Wepener, Smithfield, Hanover and Noupport

- Upper Orange - **natural vegetation with livestock farming** as main economic activity
- Extensive areas under dry land cultivation, mostly grains, in the north-eastern parts.
- Modder Riet catchment - agricultural activities

NOTE(S)

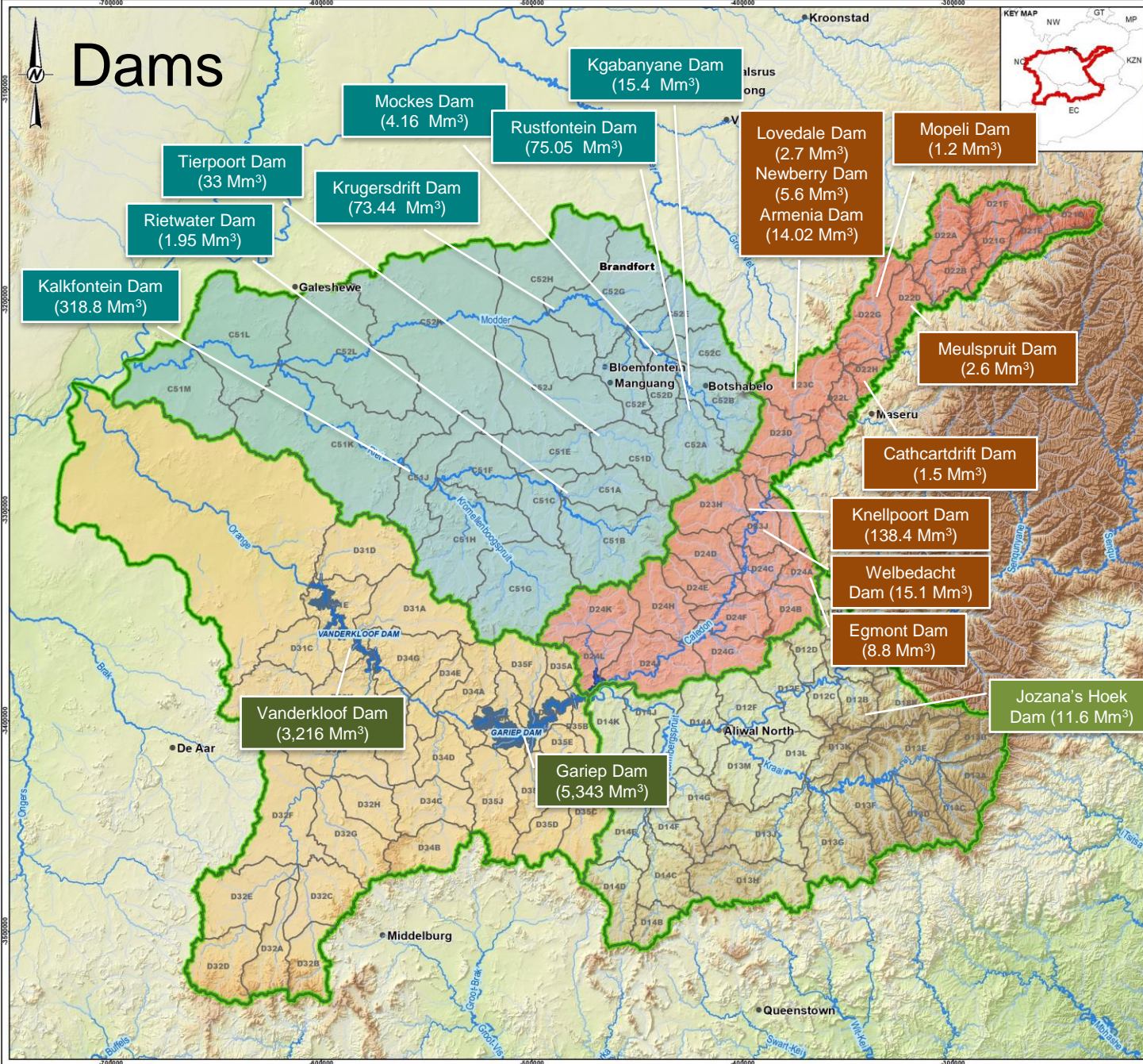
REFERENCE(S)
 COORDINATE SYSTEM: HARTBEESTHOEK94 L031
 SERVICE LAYER CREDITS:

CUSTOMER
 DEPARTMENT OF WATER AND SANITATION

PROJECT
 UPPER ORANGE WRC AND RQOS DETERMINATION

TITLE
UPPER ORANGE RIVER LAND COVER MAP

Dams



LEGEND

- Towns
- Water Management Area - Upper Orange Catchment (DWAf 2012)
- Dam
- Rivers

Secondary catchment areas

- C5
- D1
- D2
- D3



NOTE(S)

REFERENCE(S)
 COORDINATE SYSTEM: HARTEBEESTHOKS4 L031
 SERVICE LAYER CREDITS:

CLIENT
 DEPARTMENT OF WATER AND SANITATION

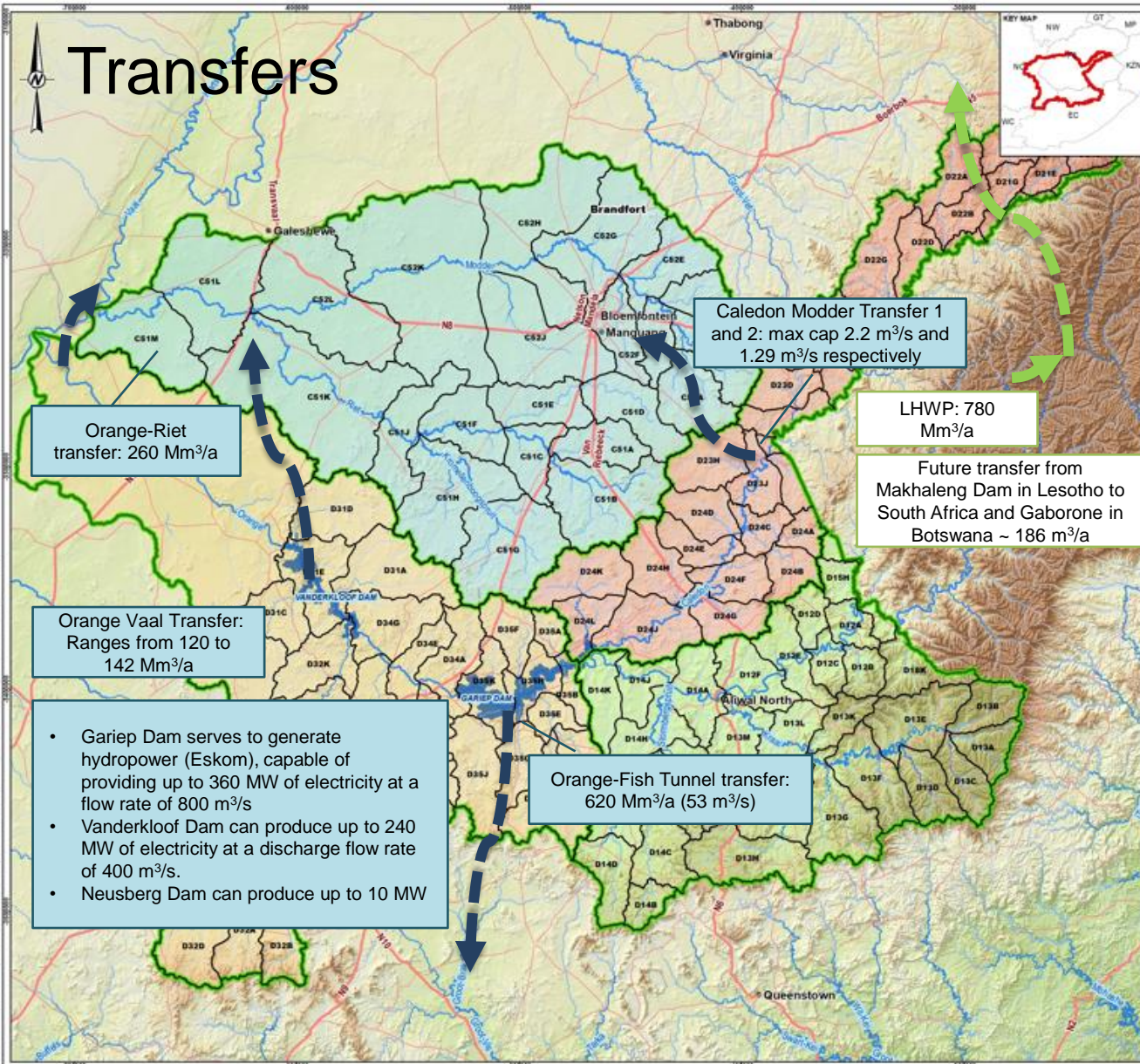
PROJECT
 UPPER ORANGE WRC AND RQOS DETERMINATION

TITLE
 UPPER ORANGE RIVER CATCHMENTS FOR CLASSIFICATION AND RESOURCE QUALITY OBJECTIVES SETTING (WP11422)

CONSULTANT	YYYY-MM-DD	2023/11/22
DESIGNED	TS	
PREPARED	MB	
REVIEWED	LB	
APPROVED	LB	

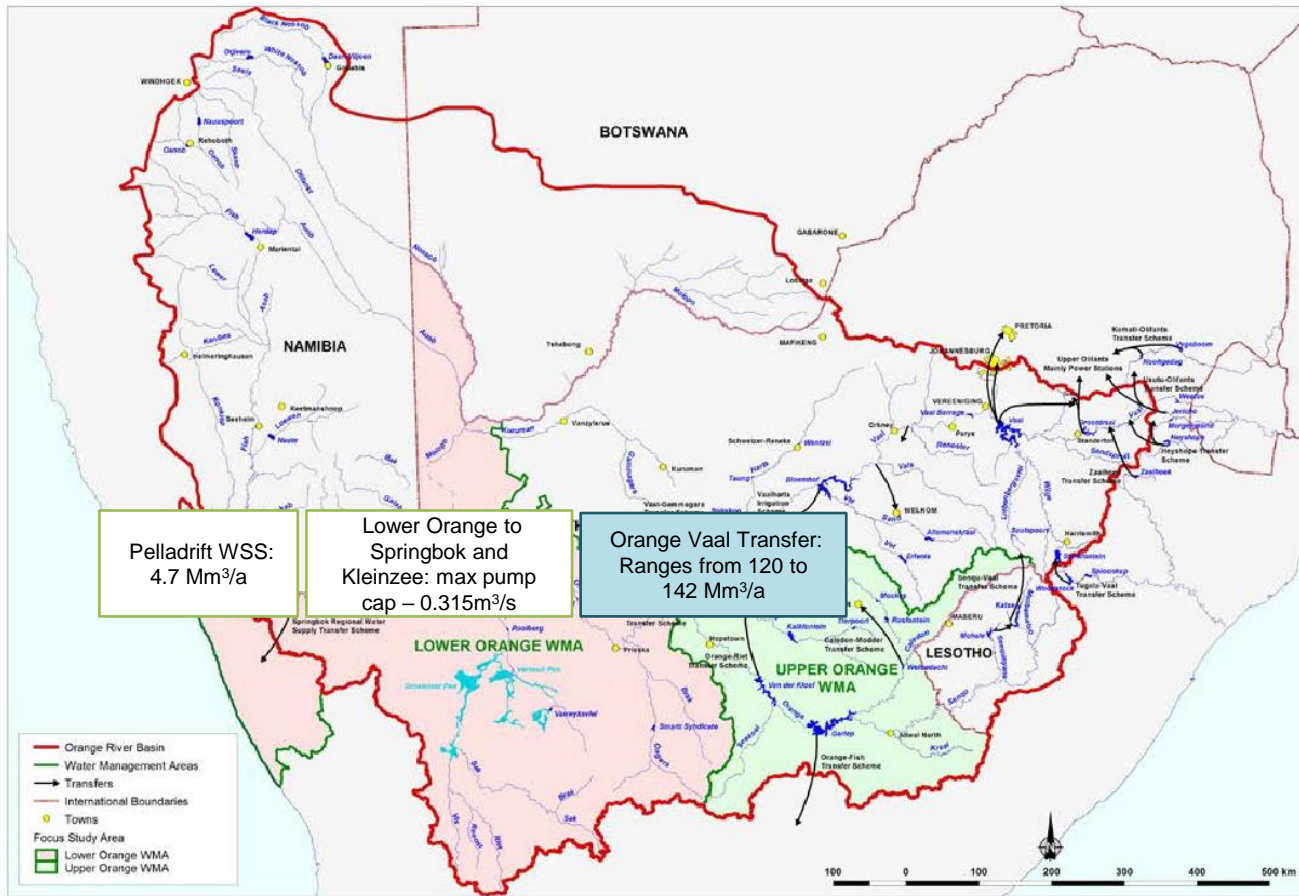


Transfers



- LHDP to Upper Vaal
- Caledon River via Knellpoort Dam to Mangaung area (domestic and industrial)
- Orange-Fish Tunnel from Gariep Dam to the Fish/Tsitsikamma WMA
- Vanderkloof Dam to the Riet River catchment for irrigation purposes
- Marksdrift Weir to the Vaal River upstream Riet River confluence for irrigation purposes
- Orange-Vaal Transfer to the Lower Orange WMA
- Transfer from Muela Dam in Lesotho to the Caledon River during droughts to supply water to Maseru and surrounding areas

Description of Water Resource Systems and Analysis



Augments the Vaal River System through the Lesotho Highlands Water Project and supplies the economic heartland of South Africa as well as supplying water to the Eastern Cape via the Gariep to Great Fish transfer scheme.

It supplies thermal power stations on the Highveld, irrigation schemes covering large areas along the Vaal, middle and lower portions of the Orange River as well as hydroelectric power generation at the Gariep and Vanderkloof dams.

The Orange-Senqu River basin - highly complex and integrated water resource system with numerous large inter-basin transfers which allow water to be moved from one part of the basin to another as well as into and out of neighbouring basins.

The system is regulated by more than thirty-one major dams. Two of these major dams are situated in Lesotho, five in Namibia and 24 in South Africa. The largest five are the Gariep, Vanderkloof, Sterkfontein, Vaal and Katse Dams

Three major water supply systems within the Orange Senqu:

- **Lesotho Highlands Water Project (LHWP)** Phase I - Phase II is currently in the planning phase - feeds the IVRS of which the **Bloemhof sub-system** - core of the **IVRS**: Grootdraai Dam, Vaal Dam, Vaal Barrage, Bloemhof Dam and Sterkfontein Dam as the main storage dams as well as Woodstock and Driel Barrage in the Upper Thukela that forms part of the Thukela transfer system
- **Orange River Project (ORP)** - Gariep and Vanderkloof dams with its entire supply area, covering the Eastern Cape Sundays/Fish area, the entire Orange River from Gariep Dam to the river mouth at Alexander Bay and Oranjemund as well as transfers to the Riet/Modder
- **Greater Bloemfontein water supply system** (Caledon-Modder System).

Water availability

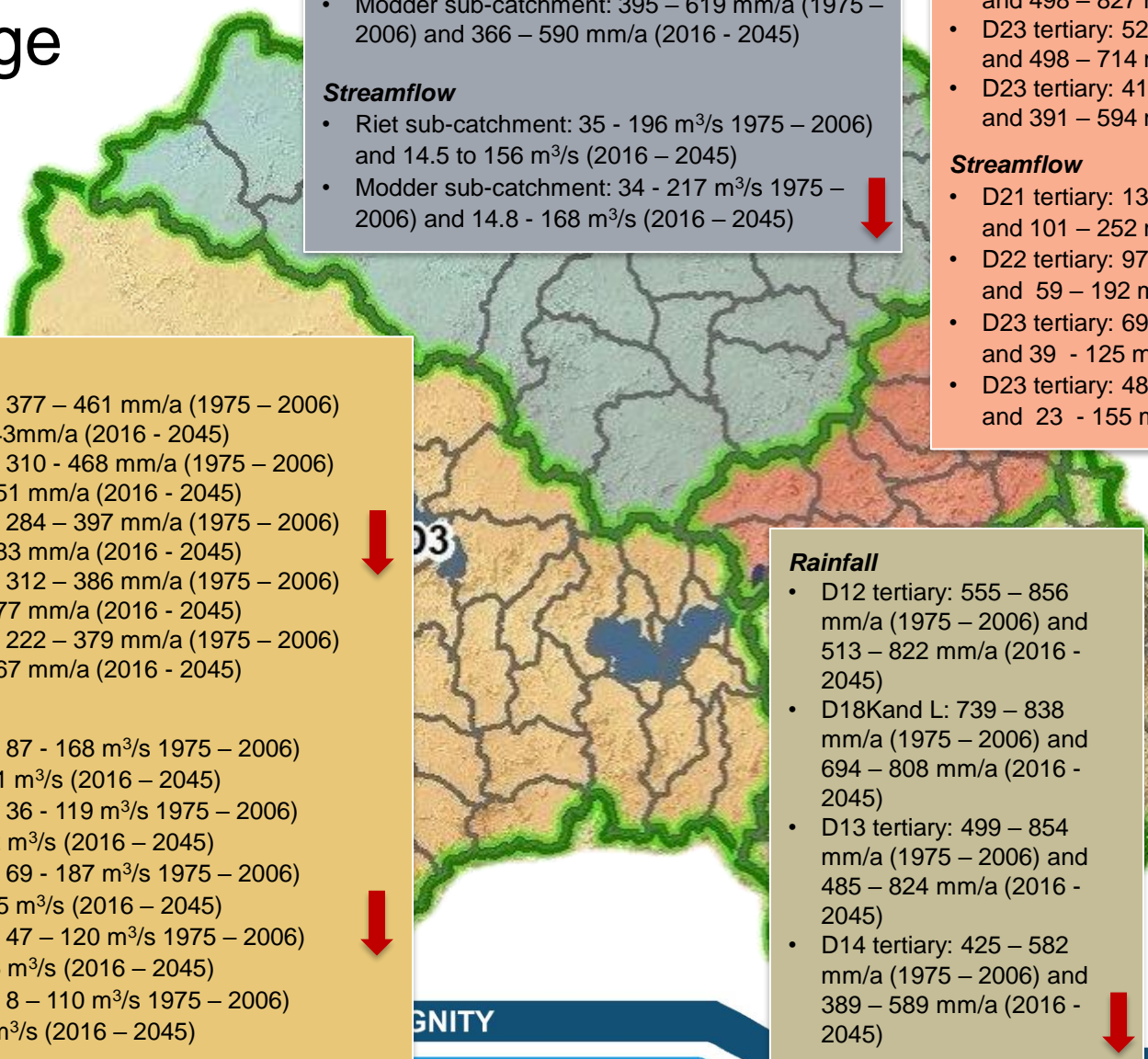
Natural runoff:

- 57% - Lesotho
- 33% - Upper Orange River catchment
- 10% - Lower Orange River catchment

Analysis of the Upper Orange indicates possible deficits and as such several intervention options will be required to maintain a +ve water balance for planning period (2025-2050)

Description	Million m ³ /a	
	2018	2020
Orange-Senqu		
Total Irrigation Demands	2 183	2 174
Total Domestic/ Urban	294	292
Transfer from Katse Dam to Vaal Dam	780	780
Total River and Operating requirements	1 083	1 083
Demand Imposed Gariep & Ven Der Kloof		3 325
Total Orange River Demand	4 339	4 329
Namibia: Fish, Nossob, Auob and Lower Orange River		
Total Irrigation Water Requirements	107.5	109.5
Total Urban Water Requirements	14.7	15.0
Total Mining Water Requirements - Only Lower Orange	19.5	19.2
Total Water Requirements	141.7	143.6
Botswana: Molopo River		
Total Irrigation Water Requirements	10.0	10.0
Total livestock requirements	9.0	9.0
Total Mining Water Requirements	7.6	12.0
Total Urban Water Requirements	28.0	29.0
Total Water Requirements	54.6	60.0
Lesotho: Senqu/Caledon River		
Total Irrigation Demands	6.7	6.7
Total Domestic/Industrial Demands	38.4	51.3
Transfer to Lesotho Botswana and RSA from Makhaleng	0.0	0.0
Total Water Requirements	45.2	58.1

Climate change



Rainfall

- Riet sub-catchment: 349 - 613 mm/a (1975 - 2006) and 320 - 595 mm/a (2016 - 2045)
- Modder sub-catchment: 395 - 619 mm/a (1975 - 2006) and 366 - 590 mm/a (2016 - 2045)

Streamflow

- Riet sub-catchment: 35 - 196 m³/s 1975 - 2006 and 14.5 to 156 m³/s (2016 - 2045)
- Modder sub-catchment: 34 - 217 m³/s 1975 - 2006 and 14.8 - 168 m³/s (2016 - 2045)

Rainfall

- D21 tertiary: 720 - 846 mm/a (1975 - 2006) and 704 - 839 mm/a (2016 - 2045)
- D22 tertiary: 691 - 878 mm/a (1975 - 2006) and 498 - 827 mm/a (2016 - 2045)
- D23 tertiary: 522 - 767 mm/a (1975 - 2006) and 498 - 714 mm/a (2016 - 2045)
- D23 tertiary: 413 - 638 mm/a (1975 - 2006) and 391 - 594 mm/a (2016 - 2045)

Streamflow

- D21 tertiary: 136 - 284 m³/s 1975 - 2006 and 101 - 252 m³/s (2016 - 2045)
- D22 tertiary: 97 - 217 m³/s 1975 - 2006 and 59 - 192 m³/s (2016 - 2045)
- D23 tertiary: 69 - 187 m³/s 1975 - 2006 and 39 - 125 m³/s (2016 - 2045)
- D23 tertiary: 48 - 208 m³/s 1975 - 2006 and 23 - 155 m³/s (2016 - 2045)

Rainfall

- D35 tertiary: 377 - 461 mm/a (1975 - 2006) and 359 - 443 mm/a (2016 - 2045)
- D34 tertiary: 310 - 468 mm/a (1975 - 2006) and 298 - 451 mm/a (2016 - 2045)
- D32 tertiary: 284 - 397 mm/a (1975 - 2006) and 261 - 383 mm/a (2016 - 2045)
- D31 tertiary: 312 - 386 mm/a (1975 - 2006) and 292 - 377 mm/a (2016 - 2045)
- D33 tertiary: 222 - 379 mm/a (1975 - 2006) and 204 - 367 mm/a (2016 - 2045)

Streamflow

- D35 tertiary: 87 - 168 m³/s 1975 - 2006 and 58 - 131 m³/s (2016 - 2045)
- D34 tertiary: 36 - 119 m³/s 1975 - 2006 and 19 - 82 m³/s (2016 - 2045)
- D32 tertiary: 69 - 187 m³/s 1975 - 2006 and 39 - 125 m³/s (2016 - 2045)
- D31 tertiary: 47 - 120 m³/s 1975 - 2006 and 27 - 86 m³/s (2016 - 2045)
- D33 tertiary: 8 - 110 m³/s 1975 - 2006 and 5 - 80 m³/s (2016 - 2045)

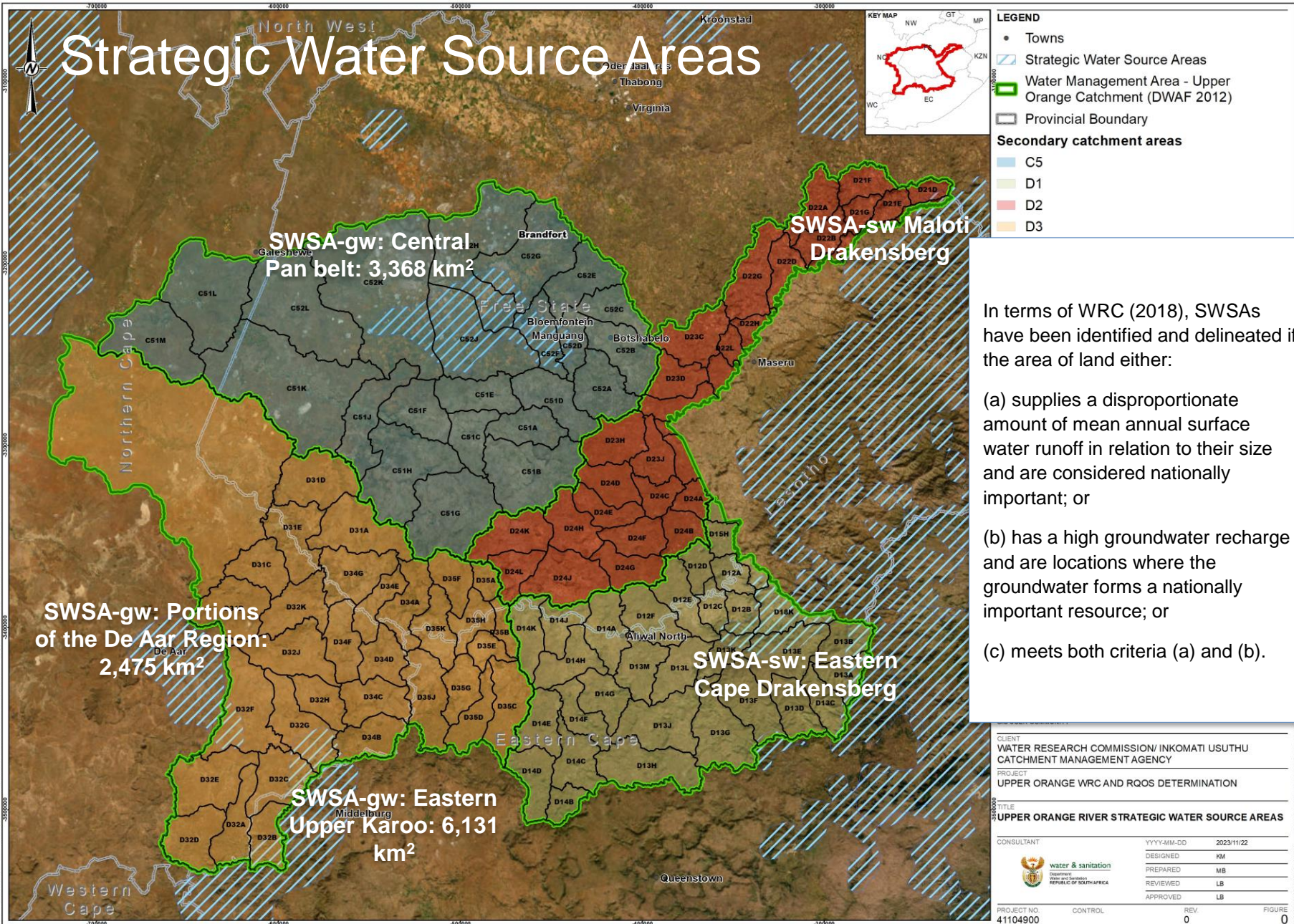
Rainfall

- D12 tertiary: 555 - 856 mm/a (1975 - 2006) and 513 - 822 mm/a (2016 - 2045)
- D18K and L: 739 - 838 mm/a (1975 - 2006) and 694 - 808 mm/a (2016 - 2045)
- D13 tertiary: 499 - 854 mm/a (1975 - 2006) and 485 - 824 mm/a (2016 - 2045)
- D14 tertiary: 425 - 582 mm/a (1975 - 2006) and 389 - 589 mm/a (2016 - 2045)

Streamflow

- D12 tertiary: 69 - 277 m³/s 1975 - 2006 and 36 to 193 m³/s (2016 - 2045)
- D18K and L: 155 - 187 m³/s 1975 - 2006 and 98 - 130 m³/s (2016 - 2045)
- D13 tertiary: 49 - 240 m³/s 1975 - 2006 and 30 - 175 m³/s (2016 - 2045)
- D14 tertiary: 68 - 149 m³/s 1975 - 2006 and 33 - 95 m³/s (2016 - 2045)

Strategic Water Source Areas



LEGEND

- Towns
- ▨ Strategic Water Source Areas
- ▭ Water Management Area - Upper Orange Catchment (DWAF 2012)
- ▭ Provincial Boundary

Secondary catchment areas

- C5
- D1
- D2
- D3

In terms of WRC (2018), SWSAs have been identified and delineated if the area of land either:

(a) supplies a disproportionate amount of mean annual surface water runoff in relation to their size and are considered nationally important; or

(b) has a high groundwater recharge and are locations where the groundwater forms a nationally important resource; or

(c) meets both criteria (a) and (b).

CLIENT WATER RESEARCH COMMISSION/ INKOMATI USUTHU CATCHMENT MANAGEMENT AGENCY	
PROJECT UPPER ORANGE WRC AND RQOS DETERMINATION	
TITLE UPPER ORANGE RIVER STRATEGIC WATER SOURCE AREAS	
CONSULTANT	DATE
 Water & Sanitation Department of Water and Sanitation REPUBLIC OF SOUTH AFRICA	YYYY-MM-DD
	DESIGNED KM
	PREPARED MB
	REVIEWED LB
APPROVED LB	
PROJECT NO 41104900	CONTROL
REV 0	FIGURE 0

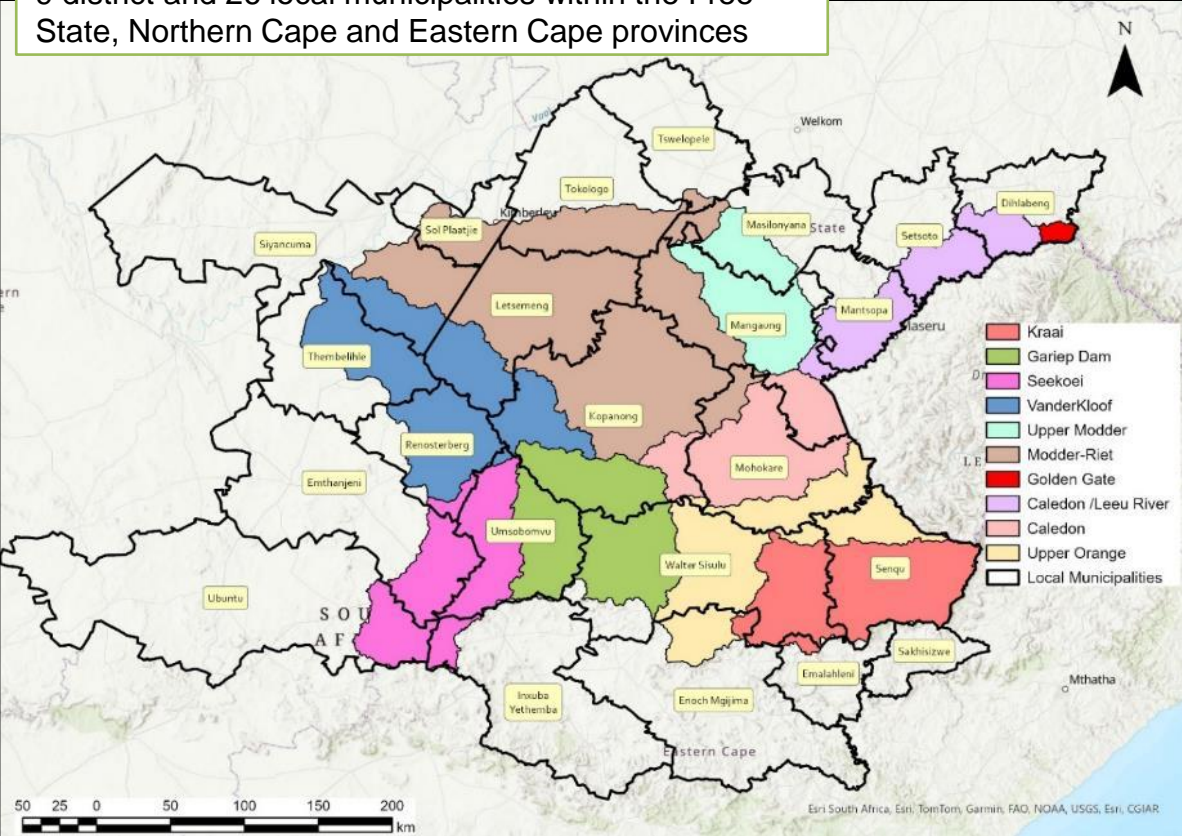
An aerial photograph of a river system. In the upper portion, a calm river flows through a landscape with sparse trees and grass. A concrete dam or weir spans the river, with white water cascading over it. Below the dam, the river flows over a rocky and gravelly bed. A small white boat with a green stripe is visible on the right side of the river in the lower right quadrant. The surrounding terrain is a mix of brownish-green grass and bare trees, suggesting a semi-arid or temperate climate.

WATER RESOURCE CLASSES AND ASSOCIATED RQOs:
UPPER ORANGE RIVER CATCHMENT, WP11422

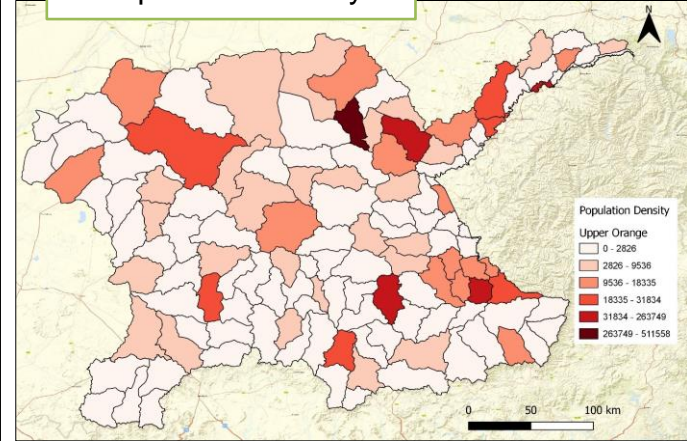
Socio-economics and Ecosystem Services

Socio-economics

9 district and 26 local municipalities within the Free State, Northern Cape and Eastern Cape provinces



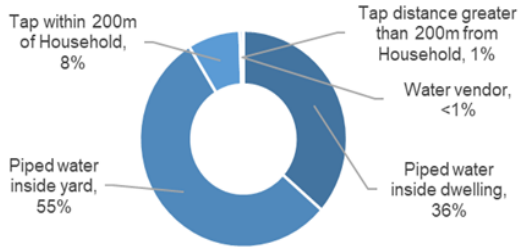
Population Density



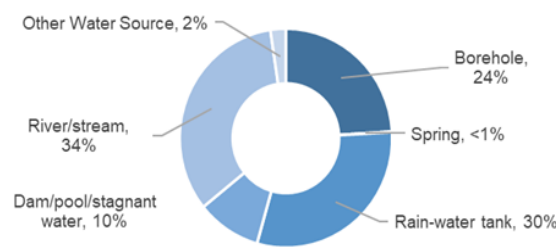
Economic Sector

Economic Sector	% GDP contribution	% Employment contribution
Agriculture, forestry and fishing	4%	11%
Mining	1%	<1%
Manufacturing	12%	6%
Electricity & water	3%	<1%
Construction	6%	5%
Wholesale & retail trade; catering and accommodation	17%	23%
Transport & communication	12%	4%
Financial services	20%	14%
General government	15%	17%
Community, social & personal services	10%	19%
Total GDP	100%	100%

Upper Orange Catchment Formal Water Sources

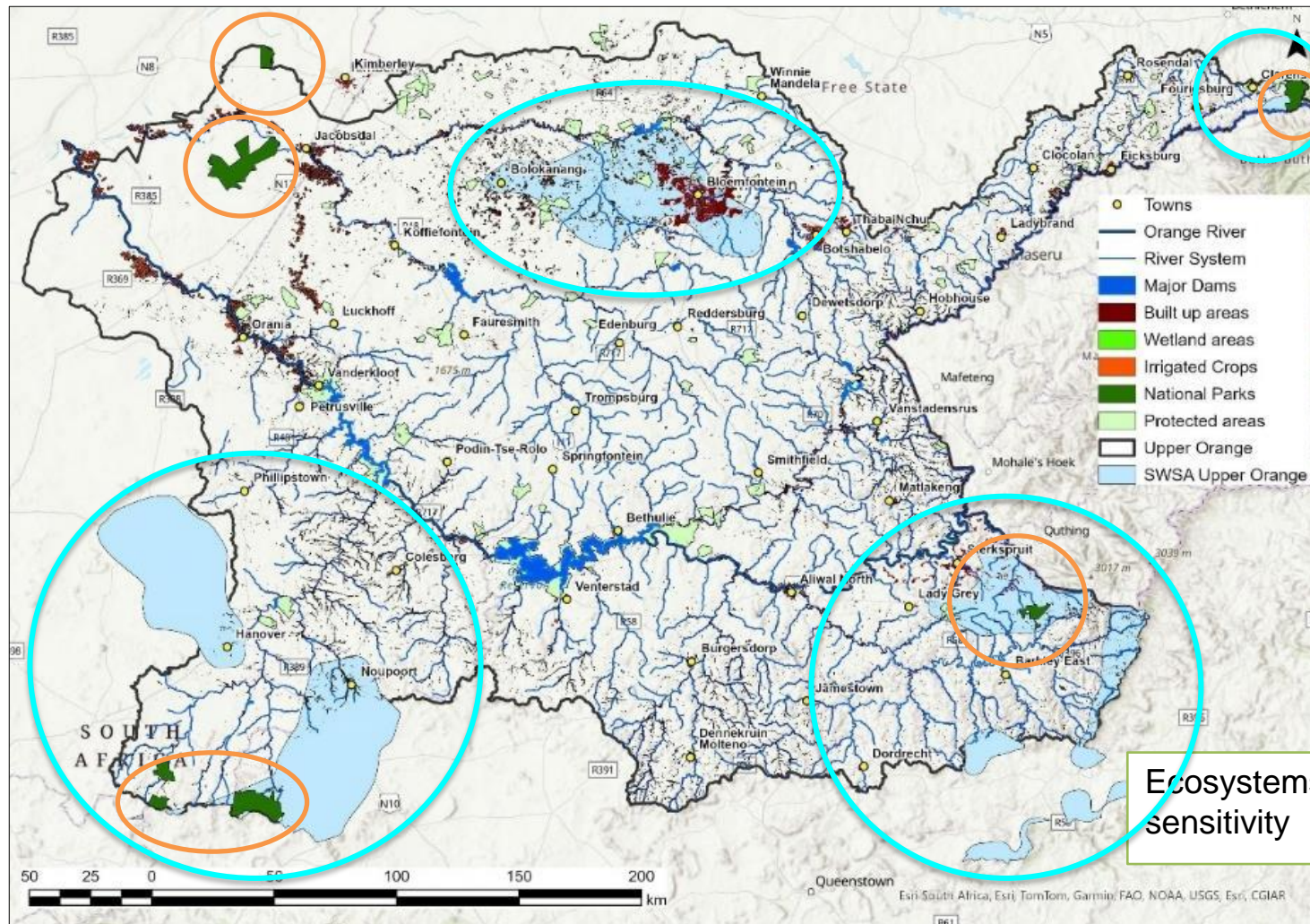


Upper Orange Catchment Informal Water Sources



Access to water services in the Upper Orange River catchment

Ecological Infrastructure

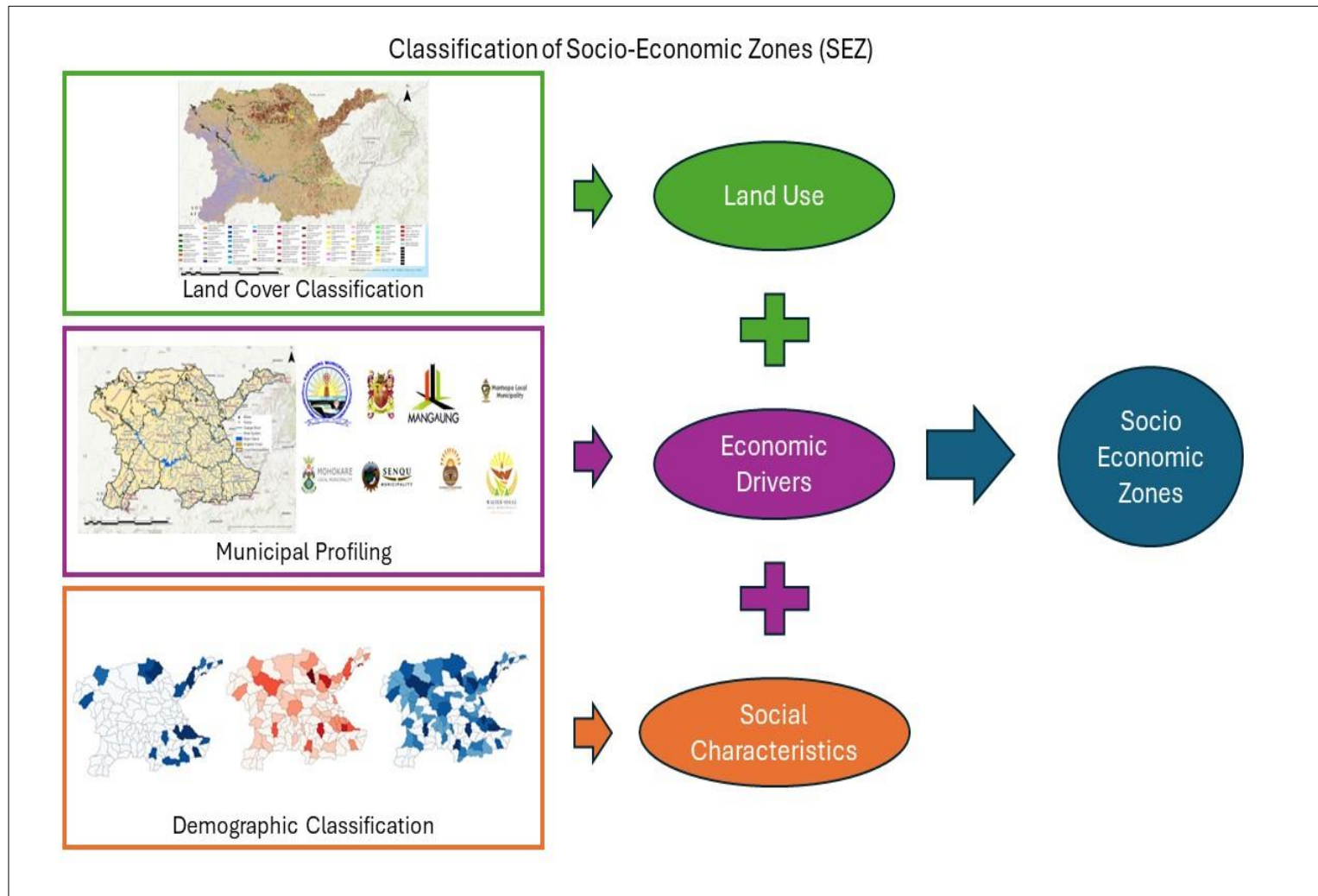


Ecosystems defined as:

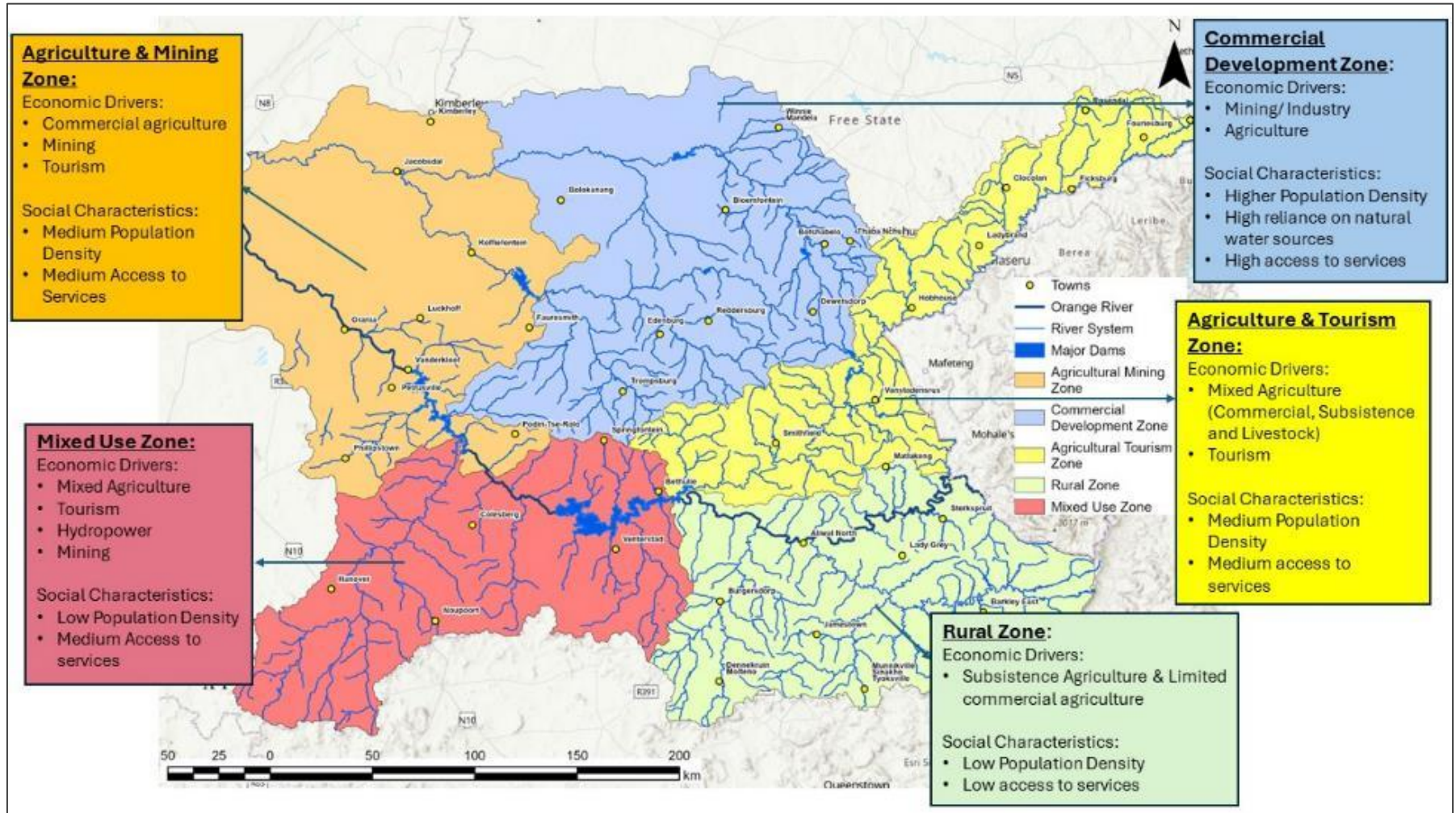
- Provisioning services
- Regulating services
- Cultural services
- Ecosystem service

Ecosystems sensitivity

Socio-economic Zones (SEZ)



Socio-economic Zones (SEZ)



WATER RESOURCE CLASSES AND ASSOCIATED RQOs: UPPER ORANGE RIVER CATCHMENT, WP11422

Rivers

The status of the rivers within the Upper Orange River catchment have been characterised based on:

- Eco-regions
- Geomorphological zonation,
- Present ecological state
- Ecological importance and sensitivity (EIS)



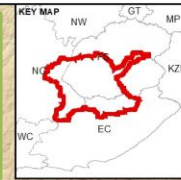
Eco-regions

Terrain morphological types consist of plains with low to moderate relief in the east, and open hills, lowlands and mountains with moderate to high relief in the west. The western part of the region consists of dune hills.

Plains with a moderate to low relief, as well as various grassland vegetation types (with moist types present towards the east and drier types towards the west and south), define this high lying region.

Topography is diverse but plains with a moderate to high relief and lowlands, hills and mountains with moderate to high relief are dominant. Vegetation consists almost exclusively of Nama Karoo types.

Lowlands, hills and mountains with moderate and high relief, and closed hills and mountains with moderate and high relief, are characteristic of this region. Southeastern Mountain Grassland and Eastern Mixed Nama Karoo are the dominant vegetation types.

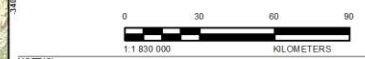
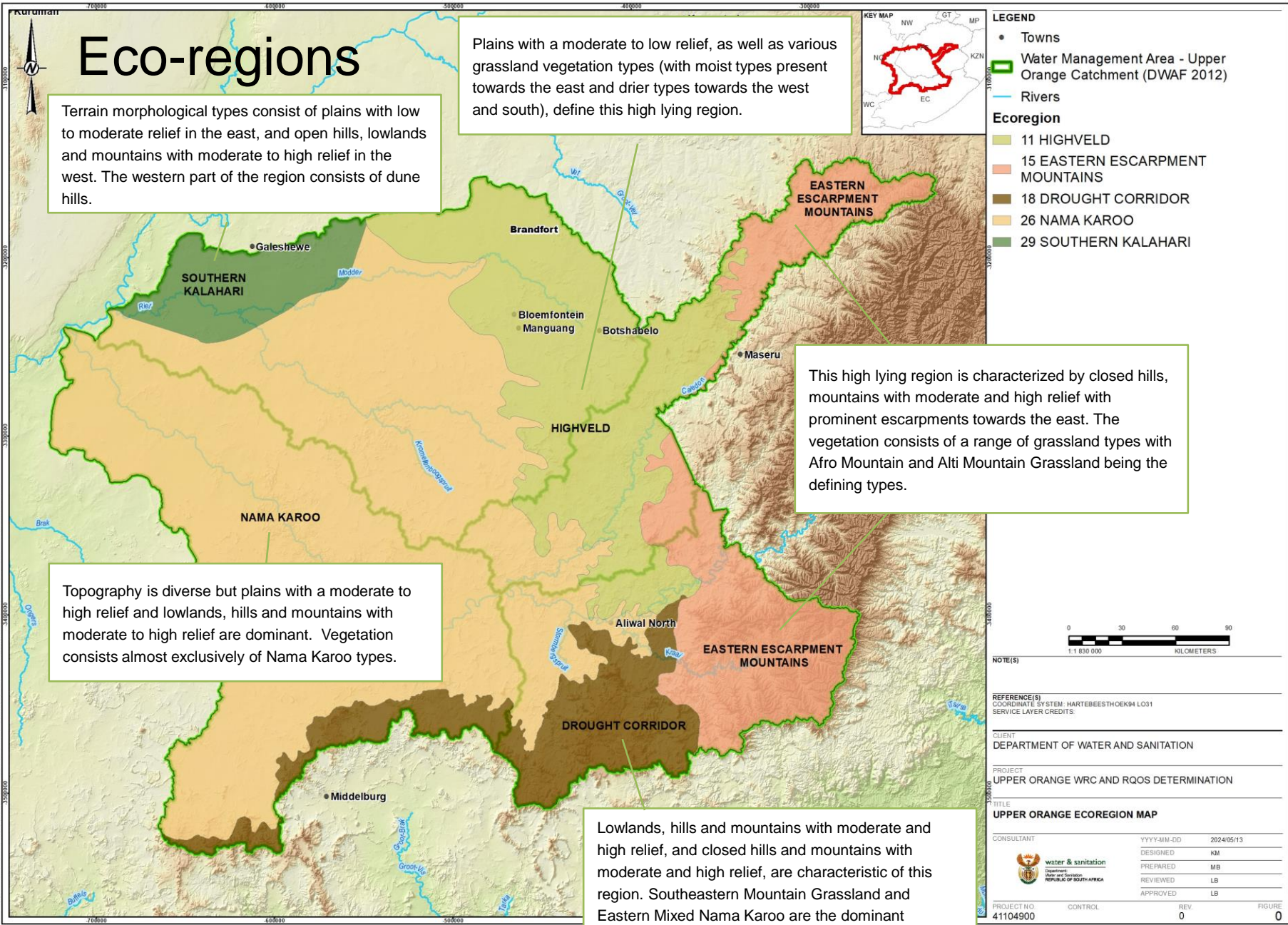


LEGEND

- Towns
- Water Management Area - Upper Orange Catchment (DWA 2012)
- Rivers

Ecoregion

- 11 HIGHVELD
- 15 EASTERN ESCARPMENT MOUNTAINS
- 18 DROUGHT CORRIDOR
- 26 NAMA KAROO
- 29 SOUTHERN KALAHARI



NOTE(S)

REFERENCE(S)
 COORDINATE SYSTEM: HARTEBEESTHOEK/4 L031
 SERVICE LAYER CREDITS:

CLIENT
 DEPARTMENT OF WATER AND SANITATION

PROJECT
 UPPER ORANGE WRC AND RQOS DETERMINATION

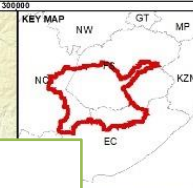
TITLE
UPPER ORANGE ECOREGION MAP

CONSULTANT	Water & sanitation Department of Water and Sanitation REPUBLIC OF SOUTH AFRICA	YYYY-MM-DD	2024/05/13
DESIGNED	KM		
PREPARED	MB		
REVIEWED	LB		
APPROVED	LB		

PROJECT NO: 41104900 CONTROL: REV: 0 FIGURE: 0

Geomorphological zones

Geomorphology: the study of the Earth's physical features, including its landforms, topography, and processes that resulted in their formation. This field also examines the changes these physical structures undergo due to natural events such as erosion, weathering and the impact of human activities.



LEGEND

Water Management Area - Upper Orange Catchment (DWA 2012)

Geomorphological zones

- A
- B
- C
- D
- E
- F
- Z

Secondary catchment areas

- C5
- D1
- D2
- D3



Zone class	Zone	Gradient class	Characteristic Features
C	Transitional	0.02 – 0.039	Moderately steep stream dominated by bedrock or boulder – reach types include plane-bed, pool-rapid or pool-riffle. Confined or semi-confined valley floor with limited floodplain development.

WATER RESEARCH COMMISSION/ INKOMATI USUTHU CATCHMENT MANAGEMENT AGENCY

Zone class	Zone	Gradient class	Characteristic Features
D	Upper Foothills	0.005 – 0.019	Moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plane-bed, pool-riffle, or pool-rapid reach types. Length of pools and riffles/rapids similar. Narrow floodplain of sand, gravel or cobble often present.
E	Lower Foothills	0.001 – 0.005	Lower gradient mixed bed alluvial channel with sand and gravel dominating the bed, locally may be bedrock controlled. Reach types - pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Floodplain often present.
F	Lowland River	0.0001 – 0.0009	Low gradient alluvial fine bed channel, typically regime reach type. May be confined, but fully developed meandering pattern within a distinct floodplain develops in unconfined reaches where there is an increased silt content in bed or banks.

Sedimentation

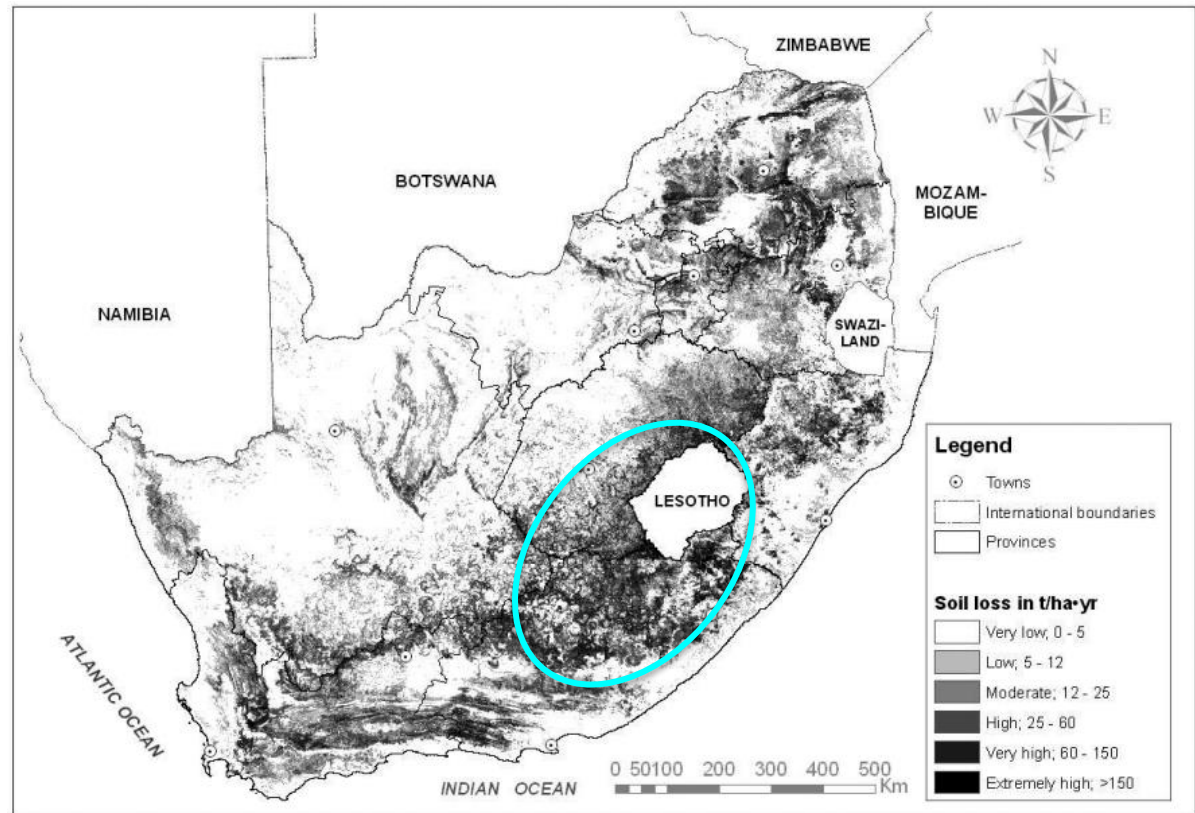
Because of its high suspended sediment load, the Orange River is among the **continent's most turbid rivers**. In areas with relatively high rainfall and little vegetation cover, erodible soils formed from Karoo sedimentary rocks (mudstones and shales of the Stormberg and Beaufort groups) account for most of the sediment that is eroded.

Farming and grazing practices on soils derived from the Karoo sedimentary rocks = tenfold increase in sediment output (Compton et al. 2010), their estimation suggests that the comparatively modest sediment delivery ratios could result in a 100-fold increase in erosion rate, as the **silting of the Welbedacht Dam** indicates.

Sediment quality:

Sediment from 61 sites across the larger Orange River basin in 2010. Pollution levels were highest along the eastern part of the basin (Upper Orange and Vaal), decreasing towards the west (Lower Orange). The highest levels were observed for the Riet and Modder Rivers and two sites in Lesotho. **Areas of concern: selenium, arsenic and chromium**. In general, the observed metal concentrations in sediment in 2010 were below the sediment quality guideline threshold (low probability of toxic effect). **Increases noted between 2010 and 2015 for 16 sites**

Decreases noted in JBS 2021 sampling – ascribed to the preceding large floods that possibly scoured and diluted fine sediment deposits to some extent. Nevertheless, high levels of metals were noted in the upper Caledon River and the Orange River upstream of Douglas. POPs were relatively high for the Orange River downstream of the Vanderkloof Dam



Ecological Classification/ EcoClassification

- Determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers compared to the natural or close to natural reference condition.
- Insights into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river.
- The PES of the river is expressed in terms of various components:
 - Drivers (physico-chemical, geomorphology, hydrology) and
 - Biological responses (fish, riparian vegetation and aquatic invertebrates), as well as an integrated state, the EcoStatus.
- Different processes are followed to assign a category (A → F ; A = Natural, and F = critically modified) to each component – continuum, so can have boundary categories e.g., B/C, C/D

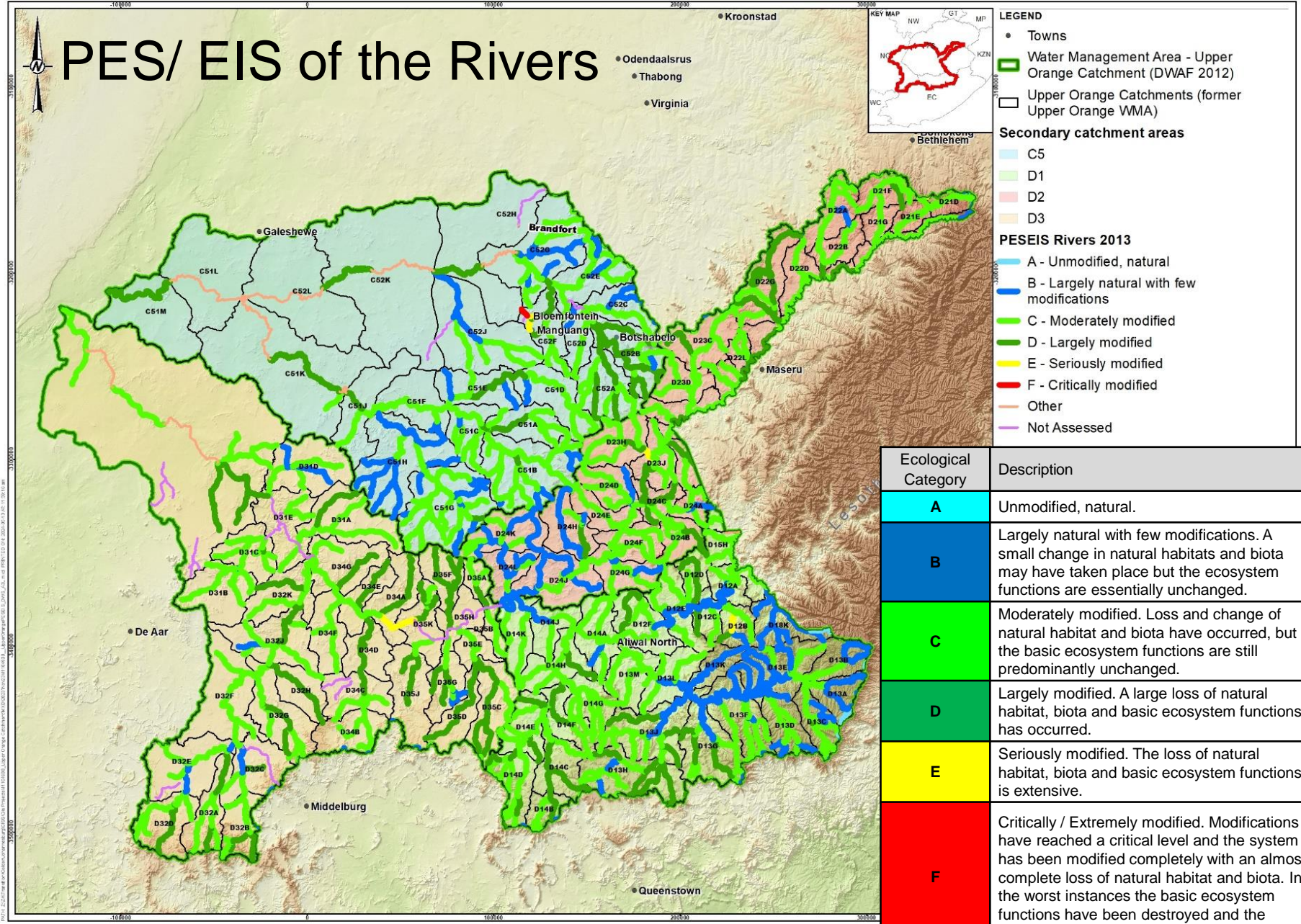


Totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna.

Ecological Importance/ Ecological Sensitivity

- Ecological Importance (EI) of a river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales.
- Ecological sensitivity (ES) (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity).
- Categorised as: very low, low, moderate, high and very high
- EI and ES are assessed to obtain an ***indication of its vulnerability to environmental modification within the context of the PES. This would relate to the ability of the river reach to endure, resist and able to recover from various forms of human use.***

PES/ EIS of the Rivers



Ecological Category	Description
A	Unmodified, natural.
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

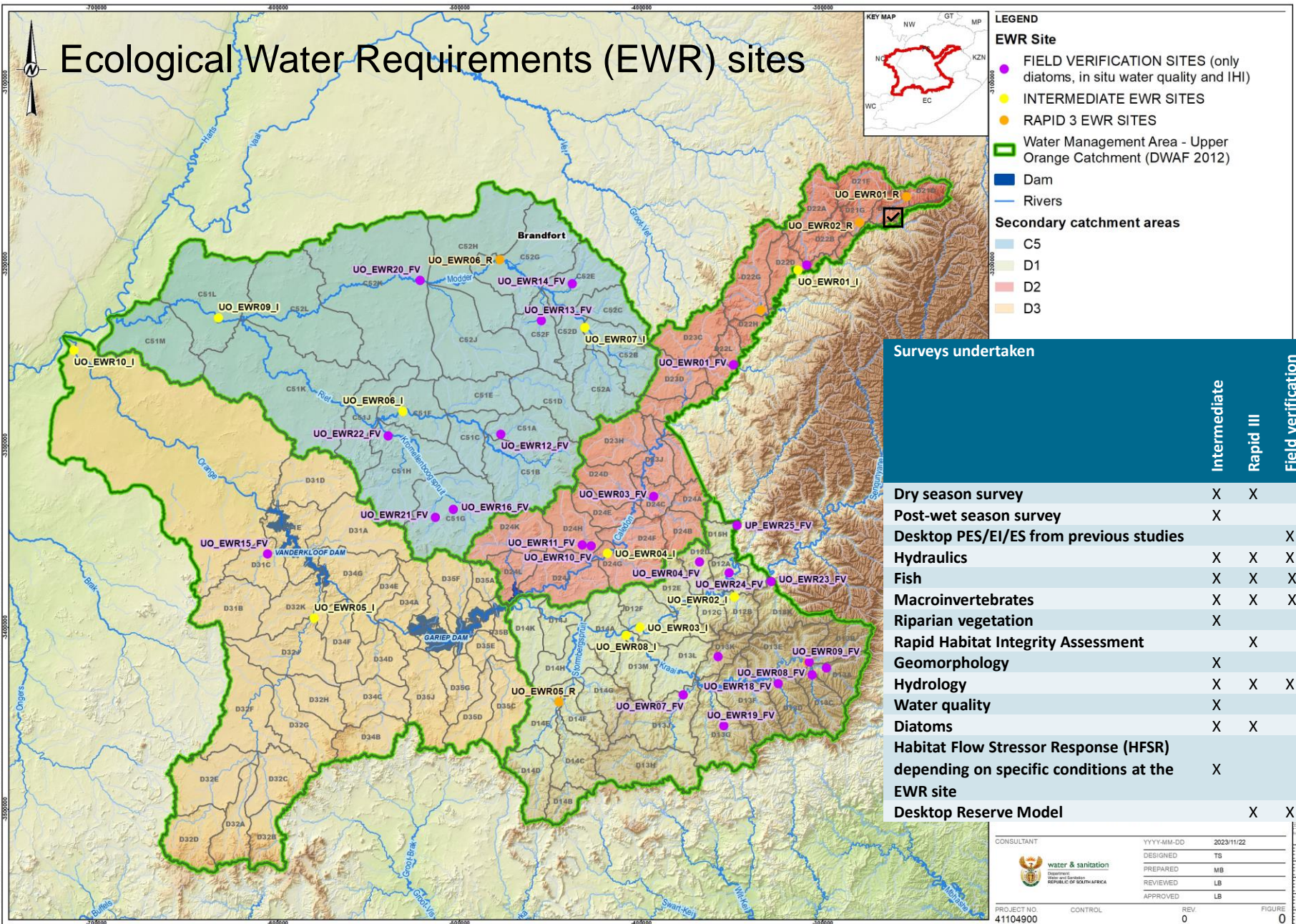
Ecological Water Requirements (EWR)

Environmental water requirements (EWR) refer to the specific needs of natural ecosystems for water:

- Quantity - how much water is needed, and
- Quality - what is the condition (chemical, physical and microbiological) of the water that is essential for maintaining ecological balance and supporting biodiversity of aquatic habitats.
- Natural water flow patterns are crucial for ecosystem health. EWR aims to ensure that rivers and streams receive adequate water to maintain their ecological functions - fish migration, sediment transport, and nutrient cycling,
- Setting EWR helps protect critical habitats, such as:
 - Wetlands which rely on consistent water levels to support diverse plant and animal species.
 - The vegetation along riverbanks (riparian zones) that plays an important role in filtering pollutants and stabilizing soil, and
 - Other aquatic ecosystems such as the downstream estuary that is a RAMSAR site and requires sufficient water for aquatic life.
- Setting EWR involves striking a balance between human water use (for agriculture, industry, and domestic purposes) and the needs of the environment.

EWR ensures that water resources are managed holistically, benefiting both people and the natural world

Ecological Water Requirements (EWR) sites



KEY MAP NW GT MP NO EC WC KZN

LEGEND

EWR Site

- FIELD VERIFICATION SITES (only diatoms, in situ water quality and IHI)
- INTERMEDIATE EWR SITES
- RAPID 3 EWR SITES
- Water Management Area - Upper Orange Catchment (DWAf 2012)
- Dam
- Rivers

Secondary catchment areas

- C5
- D1
- D2
- D3

Surveys undertaken

	Intermediate	Rapid III	Field verification
Dry season survey	X	X	
Post-wet season survey	X		
Desktop PES/EI/ES from previous studies			X
Hydraulics	X	X	X
Fish	X	X	X
Macroinvertebrates	X	X	X
Riparian vegetation	X		
Rapid Habitat Integrity Assessment		X	
Geomorphology	X		
Hydrology	X	X	X
Water quality	X		
Diatoms	X	X	
Habitat Flow Stressor Response (HFSR) depending on specific conditions at the EWR site	X		
Desktop Reserve Model		X	X

CONSULTANT: water & sanitation
 DESIGNED: TS
 PREPARED: MB
 REVIEWED: LB
 APPROVED: LB

PROJECT NO: 41104900 CONTROL: REV 0 FIGURE 0

Ecological Water Requirements (EWR) results

EWR site code	River	Quaternary catchment	PE S	EI	ES	REC	
Intermediate BWR	UO_EWR01_I	Middle Caledon	D22D	D/E	Moderate	Moderate	D
	UO_EWR02_I	Sterkspruit	D12B	D	Moderate	Moderate	C/D
	UO_EWR03_I	Upper Orange	D12F	D	Moderate	Moderate	D
	UO_EWR04_I	Lower Caledon	D24J	D	Moderate	Moderate	C/D
	UO_EWR05_I	Seekoei	D32J	C	Moderate	Moderate	C
	UO_EWR06_I	Upper Riet	C51F	C	High	Moderate	C
	UO_EWR07_I	Upper Modder (Sannaspos)	C52G	D	Low	Moderate	C
	UO_EWR08_I	Lower Kraai	D13M	C	High	High	B/C
	UO_EWR09_I	Lower Riet	C51L	C	Very high	High	B/C
	UO_EWR10_I	Lower Orange	D33K	C	Moderate	Moderate	C
Rapid III BWR rates	UO_EWR01_R	Little Caledon	D21D	C	High	High	B/C
	UO_EWR02_R	Brandwater (Groot)	D21G	C	High	Moderate	B/C
	UO_EWR03_R	Mopeli	D22G	D	Moderate	Moderate	C/D
	UO_EWR04_R	Upper Kraai	D13E	C	High	High	B
	UO_EWR05_R	Wonderboomspruit	D14E	D	Moderate	Moderate	C/D
	UO_EWR06_R	Middle Modder (Soetdoring)	C52H	D	High	Moderate	C/D
	UO_EWR01_FV	Meulspruit	D22B	D	Moderate	Moderate	D
	UO_EWR02_FV	Witspruit	D24C	C/D	Moderate	Moderate	C
	UO_EWR03_FV	Gryskopspruit	D12D	C	Moderate	Moderate	C
	UO_EWR04_FV	Karringmelkspruit	D13K	B	Very high	High	B
Field verification	UO_EWR05_FV	Bokspruit	D13A	B/C	Moderate	High	B
	UO_EWR06_FV	Holspruit	D13J	C	High	Moderate	C
	UO_EWR07_FV	Sterkspruit, tributary of the Kraai	D13C	C	Moderate	High	B/C
	UO_EWR08_FV	Bell	D13B	B/C	Moderate	High	B
	UO_EWR09_FV	Groenspruit	D24H	C/D	Moderate	Moderate	C
	UO_EWR10_FV	Skulpspruit	D24H	C	Moderate	Moderate	C
	UO_EWR11_FV	Fouriespruit	C51A	C	High	Moderate	C
	UO_EWR12_FV	Renoster	C52F	D/E	Moderate	Moderate	D
	UO_EWR13_FV	Os-spruit	C52E	B/C	High	Moderate	B/C
	UO_EWR14_FV	Hondeblaf	D31C	B	Low	Moderate	B
	UO_EWR15_FV	Tributary of VanZylspruit	C51G	C	High	Moderate	C
UO_EWR16_FV	Slykspruit	D24L	B/C	Moderate	Moderate	B/C	
UO_EWR17_FV	Langkloofspruit	D13D	B/C	High	High	B	
UO_EWR18_FV	Wasbankspruit	D13G	C	Moderate	High	B/C	
UO_EWR19_FV	Lower Modder	C52K	C/D	Very high	High	C	
UO_EWR20_FV	Upper Kromellenboog	C51G	B	Moderate	Moderate	B	
UO_EWR21_FV	Lower Kromellenboog	C51H	C	Moderate	Moderate	B/C	

Additional biological data

Joint Basin Survey (JBS)(2023)

DWS River Ecstatus Monitoring Programme (REMP)

NGO, Gariiep Watch monitoring – Hopetown monitoring site (Clean Stream, 2021)

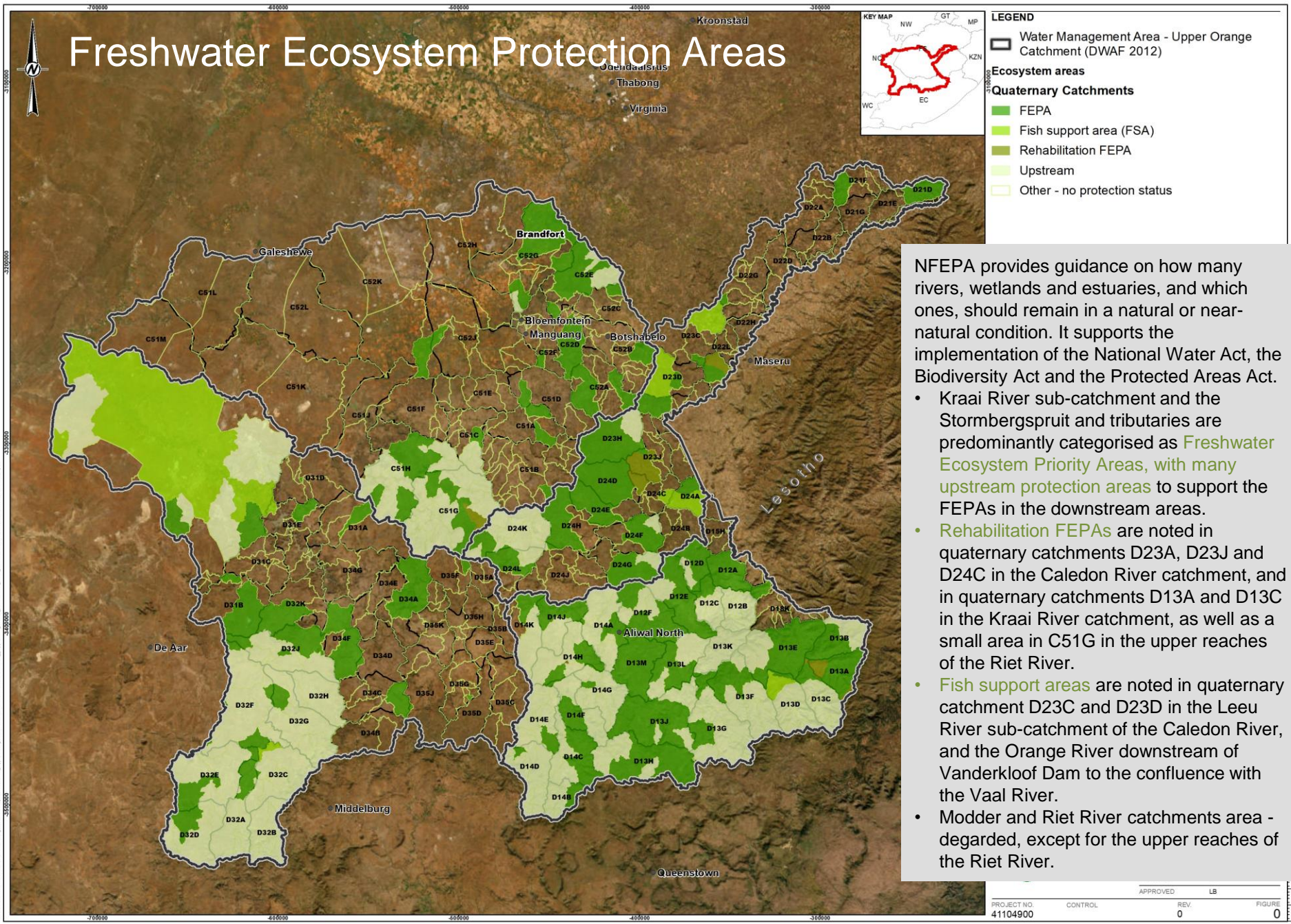
Code	River	Ecological Category
OSAEH_11_18	Modder	C
OSAEH_11_19	Modder	C/D
OSAEH_26_10	Riet	D - not fully assessed
OSAEH_29_5	Riet	E
OSAEH_15_1	Caledon	C/D - not fully assessed
OSAEH_15_6	Caledon	C/D
OSAEH_11_20	Leeuspruit	C
OSAEH_15_2	Matsuko	D - not fully assessed
OSAEH_15_3	Sengou	D/E
OSAEH_15_5	Sengunyane	E
OSAEH_11_22	Orange	D - not fully assessed
OSAEH_26_11	Kraai	D - not fully assessed
OSAEH_26_13	Stormbergspruit	E
OSAEH_26_14	Orange	D
OSAEH_26_8	Caledon	C/D
OSAEH_26_15	Orange	D
OSAEH_26_12	Seekoei	D - not fully assessed
OSAEH_26_2	Orange	D - not fully assessed
OSAEH_26_3	Orange at Marksdrift weir	D/E

DWS REMP Site	River	Ecoregion	Geozone	Ecological category
Secondary Catchment C5				
C5KORA-MOCKU	Korannaspruit	11.03	E	No longer monitored
C5MODD-MODDE	Modder	29.02	F	C/D
C5MODD-SANNA	Modder	11.03	E	D
C5MODD-SOETD	Modder	11.08	F	No longer monitored
C5RIET-DEKRA	Riet	29.02	E	C
C5RIET-IFR03	Riet	26.01	E	D
C5RIET-LILYD	Riet	29.02	E	No longer monitored
C5RIET-JACOB	Riet	29.02	F	C
C5RIET-RICHI	Riet	29.02	F	No longer monitored
C5VANZ-DWNWR	VanZylspruit	26.03	E	C
Secondary catchment D1				
D1KRAA-ALIWA	Kraai	26.03	F	C
Secondary catchment D2				
D2CALE-EWR03	Caledon	15.01	F	No longer monitored
D2CALE-LADYB	Caledon	15.01	F	No longer monitored
D2GROO-FARM1	Brandwater	15.01	E	D
D2LCAL-WILGE	Little Caledon	15.03	D	C
D2LCAL-EWR01	Little Caledon	15.03	E	C/D
D2LCAL-EWR02	Little Caledon	15.01	E	C
D2LEEU-EWR06	Leeu	11.03	E	D/E
D2GLEN-GLENR	Glen Reenen	15.03	C	B/C
D2RIBB-RIBBO	Ribbok Spruit	15.03	C	C
D2RIBB-UWWTW	Ribbok Spruit	15.03	D	C
D2RIBB-DWWTW	Ribbok Spruit	15.03	D	C
Secondary catchment D3				
D3ORAN-HOPET	Orange	26.01	F	C
D3ORAN-MARKS	Orange	26.01	F	D

Hopetown, downstream of Vanderkloof Dam and the Hopetown wastewater treatment works

- *Instream habitat integrity* - moderately to largely modified condition - category C/D. Most notable impacts on habitat integrity were associated with abstraction, flow modification, bed modification and water quality
- *Riparian habitat integrity* - largely to seriously modified category C. Most notable impacts on the riparian zone are vegetation removal, AIP, bank erosion, and abstraction, flow modification and water quality
- *Macroinvertebrates*: MIRAI score of 61% calculated, Category C/D (moderately/largely modified). Confirmed that water quality deterioration impacted the invertebrate assemblage negatively, followed by habitat and flow alterations
- *Fish assessment*: A Fish Assemblage Integrity Index (FAII) score of 41% was calculated falling in a category D, and a Fish Response Assessment Index (FRAI) score of 59% was calculated falling in an ecological category C/D with the following metrics of concern: flow modification, water quality, migratory impacts

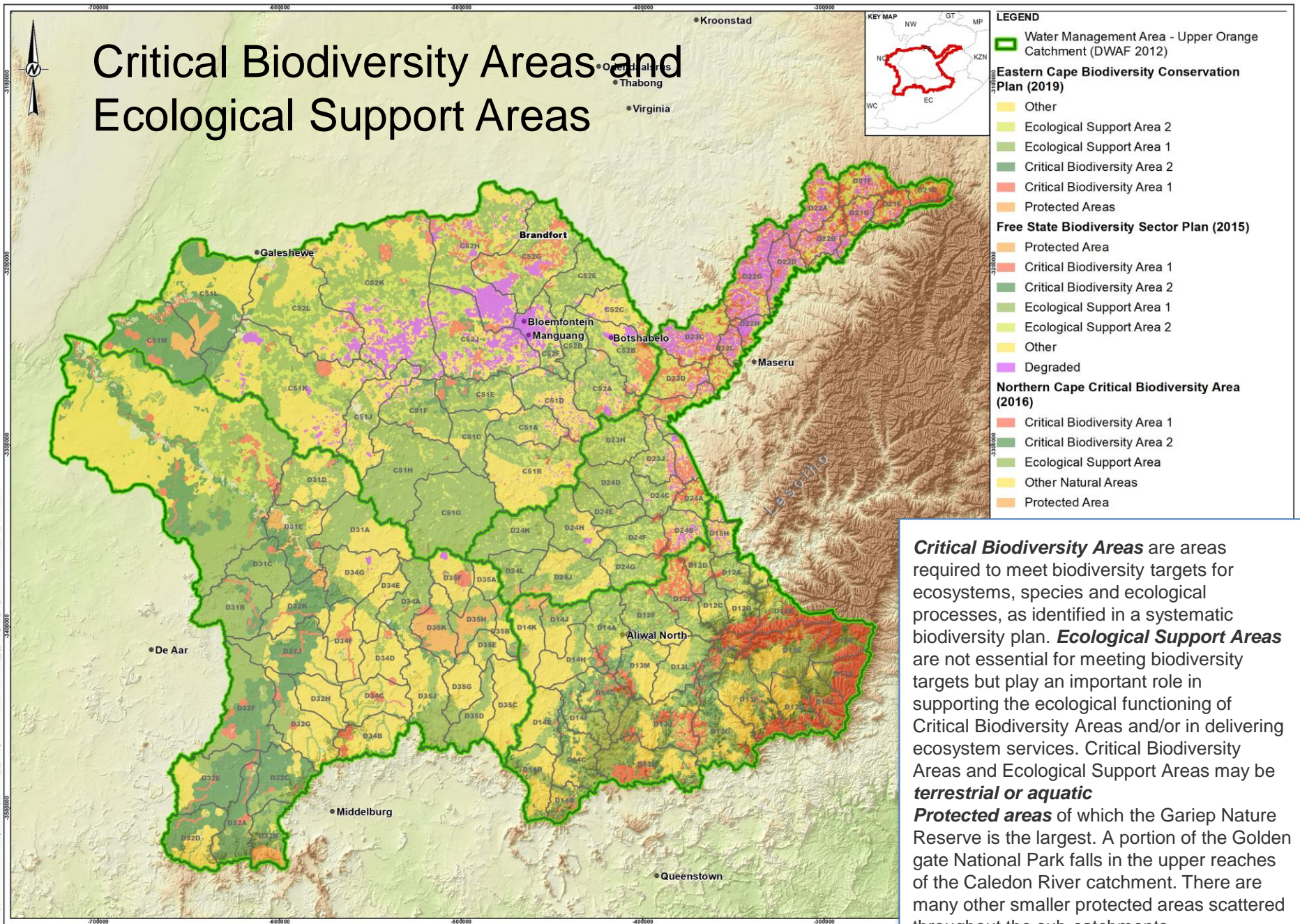
Freshwater Ecosystem Protection Areas



NFEPA provides guidance on how many rivers, wetlands and estuaries, and which ones, should remain in a natural or near-natural condition. It supports the implementation of the National Water Act, the Biodiversity Act and the Protected Areas Act.

- Kraai River sub-catchment and the Stormbergsspruit and tributaries are predominantly categorised as **Freshwater Ecosystem Priority Areas**, with many **upstream protection areas** to support the FEPAs in the downstream areas.
- **Rehabilitation FEPAs** are noted in quaternary catchments D23A, D23J and D24C in the Caledon River catchment, and in quaternary catchments D13A and D13C in the Kraai River catchment, as well as a small area in C51G in the upper reaches of the Riet River.
- **Fish support areas** are noted in quaternary catchment D23C and D23D in the Leeu River sub-catchment of the Caledon River, and the Orange River downstream of Vanderkloof Dam to the confluence with the Vaal River.
- Modder and Riet River catchments area - degraded, except for the upper reaches of the Riet River.

Critical Biodiversity Areas and Ecological Support Areas



- LEGEND**
- Water Management Area - Upper Orange Catchment (DWF 2012)
 - Eastern Cape Biodiversity Conservation Plan (2019)**
 - Other
 - Ecological Support Area 2
 - Ecological Support Area 1
 - Critical Biodiversity Area 2
 - Critical Biodiversity Area 1
 - Protected Areas
 - Free State Biodiversity Sector Plan (2015)**
 - Protected Area
 - Critical Biodiversity Area 1
 - Critical Biodiversity Area 2
 - Ecological Support Area 1
 - Ecological Support Area 2
 - Other
 - Degraded
 - Northern Cape Critical Biodiversity Area (2016)**
 - Critical Biodiversity Area 1
 - Critical Biodiversity Area 2
 - Ecological Support Area
 - Other Natural Areas
 - Protected Area

Critical Biodiversity Areas are areas required to meet biodiversity targets for ecosystems, species and ecological processes, as identified in a systematic biodiversity plan. **Ecological Support Areas** are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of Critical Biodiversity Areas and/or in delivering ecosystem services. Critical Biodiversity Areas and Ecological Support Areas may be **terrestrial or aquatic**

Protected areas of which the Gariep Nature Reserve is the largest. A portion of the Golden Gate National Park falls in the upper reaches of the Caledon River catchment. There are many other smaller protected areas scattered throughout the sub-catchments.

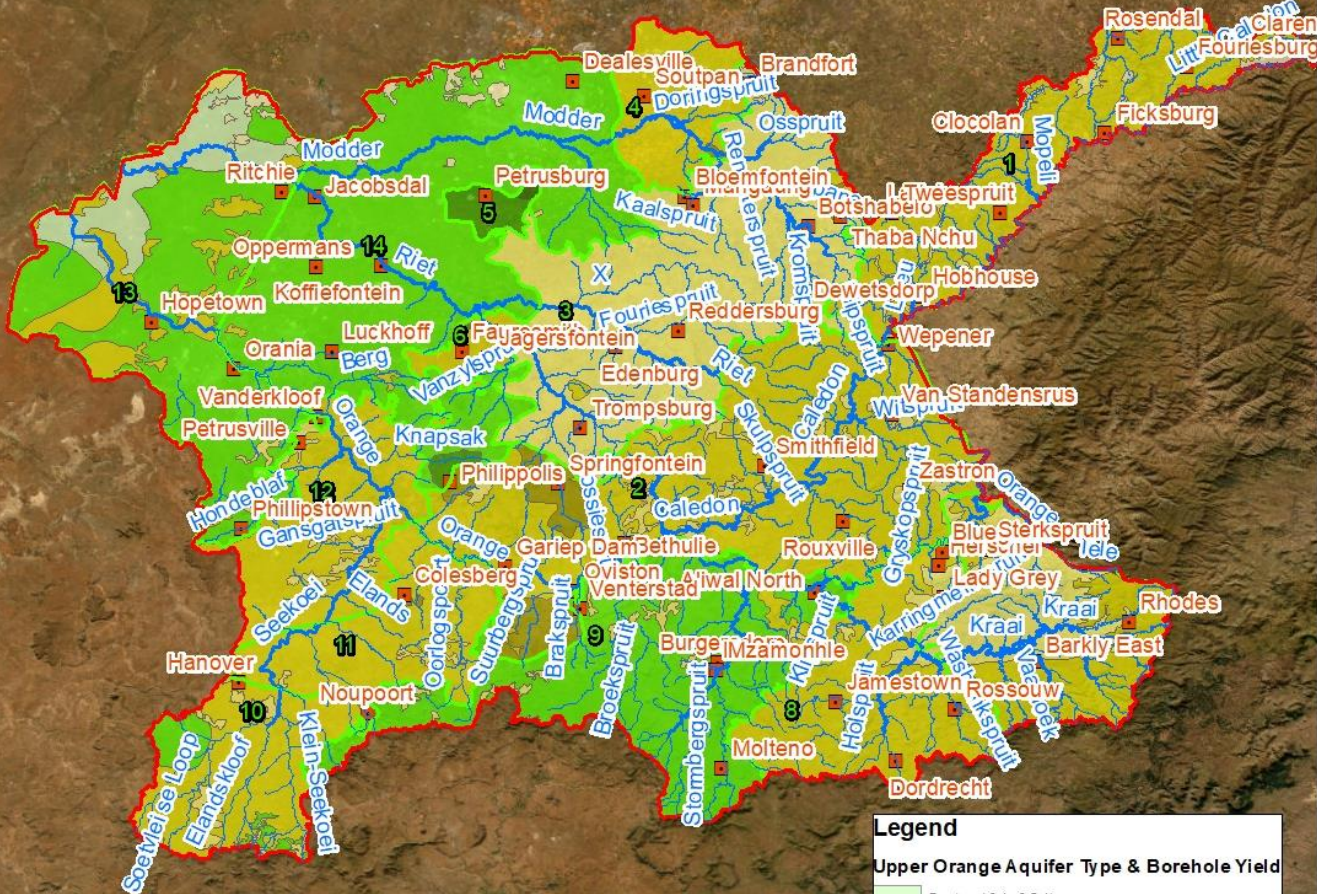
Groundwater

Characteristics of the Groundwater System:

- The Upper Orange catchments consists mostly of the Ecca Supergroup (Ecca-Beaufort Groups associated 'cap' formations) consisting of:
 - Sandstone-mudrock (shale and siltstones) layer (**main aquifers**)
 - Intruded by dolerite sills (horizontal) and dykes (sub-vertical) and basaltic lava (**contact zone secondary aquifers**); and
 - (Overlying) surface limestone (**calcretes- sporadic saturation- Petrusburg Area**) and alluvial deposits in major river channels (**limited saturation – local aquifers**)
 - Older Pre-Karoo Supergroup rock formations – present in the extreme lower reaches of the catchment (Allanridge Lavas – **secondary aquifers**)



Regional Hydrogeology: Aquifer categories



Legend

Upper Orange Aquifer Type & Borehole Yield

Lightest Green	Fractured 0.1 - 0.5 l/s
Light Green	Fractured 0.5 - 2.0 l/s
Medium Green	Fractured 2.0 - 5.0 l/s
Dark Green	Fractured > 5.0 l/s
Lightest Yellow	Intergranular and Fractured 0.0 - 0.1 l/s
Light Yellow	Intergranular and Fractured 0.1 - 0.5 l/s
Yellow	Intergranular and Fractured 0.5 - 2.0 l/s
Dark Yellow	Intergranular and Fractured 2.0 - 5.0 l/s

Hydrogeology: Aquifer type categories:

- Fractured (Secondary), Low to High Yield Class, Median Yield = ±0.75L/s)
- Fractured and Intergranular (Main, Low to High Yield Class, Median Yield = ±1.0L/s)

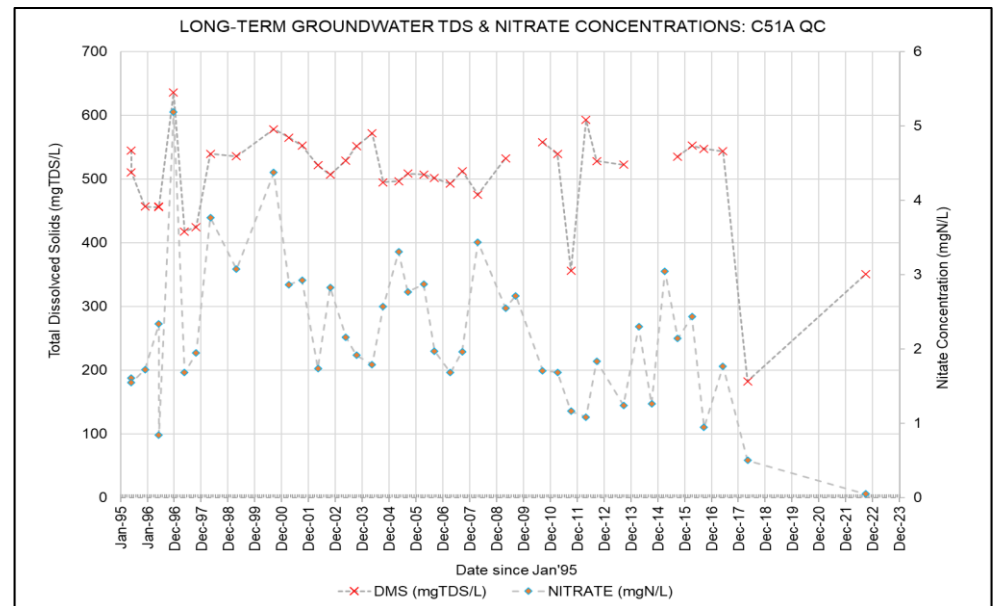
Source: Esri, DeLorme, Garmin, GeoEye, IGN, AerGRID, GeoEye, and the GIS User Community



Groundwater Status

- Allocable Groundwater
 - Groundwater reserve in 7 quaternary catchments - over allocated (Allocable GWater is $<0.0 \text{ Mm}^3/\text{a}$) – indicating that the EWR component is relatively high (i.e., almost equal to rainfall recharge) - upper Kraai River and a few quaternary catchments along the Stormbergsspruit.
 - The remainder of the catchment’s “Allocable Groundwater” varies from $3.54 \text{ Mm}^3/\text{a}$ to $41 \text{ Mm}^3/\text{a}$.
- Groundwater base flow estimates are probably too high as in some cases these baseflow values are higher than the groundwater recharge values.
- The groundwater levels (aquifer saturation levels) of the catchment vary between 2.5 mbgl to 50 mbgl, however, the mean water level depth is in the order of 20 to 25 mbgl. These water level estimates are (based on historic datasets, i.e., pre-2000).
- The effect of climate change(s)/variations since ~1995 could lower these groundwater levels due to lower groundwater recharge values.
- 38 groundwater quality monitoring - water supply boreholes at farms (domestic/stock water), schools, hospitals or police stations, and rural village water supply schemes.

- The time series water quality datasets shows that the long-term hydrochemistry status shows stable water quality conditions with a few long-term rising/decreasing trends.
- Seasonal oscillations, however, occurs at several monitoring sites, and demonstrates the importance of annual/bi-annual effective recharge conditions – as the decreased TDS values noted after May 2017. This illustration also shows the impact of rainfall recharge on the water quality composition, i.e., significant decrease in the TDS and nitrate concentrations after the 2017 winter season.



Groundwater Status (cont)

- **Recharge**

Recharge figures for the Upper Orange River catchment were estimated for the 2024 Groundwater Reserve - total groundwater recharge volume is in the order of $\pm 2,000 \text{ Mm}^3/\text{a}$.

- **Water levels**

Groundwater levels in the Upper Orange River Catchment varies between shallow ($<10 \text{ mbgl}$) and moderately deep ($45 \pm 10 \text{ mbgl}$). Water levels depths in the upper part of the catchment $<20 \text{ mbgl}$, and gradually gets deeper to $\pm 50 \text{ mbgl}$ in the lower part of the catchment.

Groundwater level depths are a function of the topographic elevations and water levels will vary substantially due to the relief profiles of each quaternary catchment – deepest along the quaternary catchment boundary and shallowest at the associated drainage system discharging the catchment.

- **Contribution to baseflow**

Baseflow contributions driven/generated by each quaternary catchment were assessed for the 2024 Reserve Determination - based on estimations/measurements of the “lowest average monthly flows” (the 100% of the lowest monthly flows were regarded as the groundwater contribution to the total baseflow estimates). These values represent at least the minimum ecological water requirements for a specific quaternary catchment.

The Maximum Groundwater Baseflow contribution was estimated as $\pm 65 \text{ Mm}^3/\text{a}$, and the minimum was estimated as $<0.1 \text{ Mm}^3/\text{a}$.

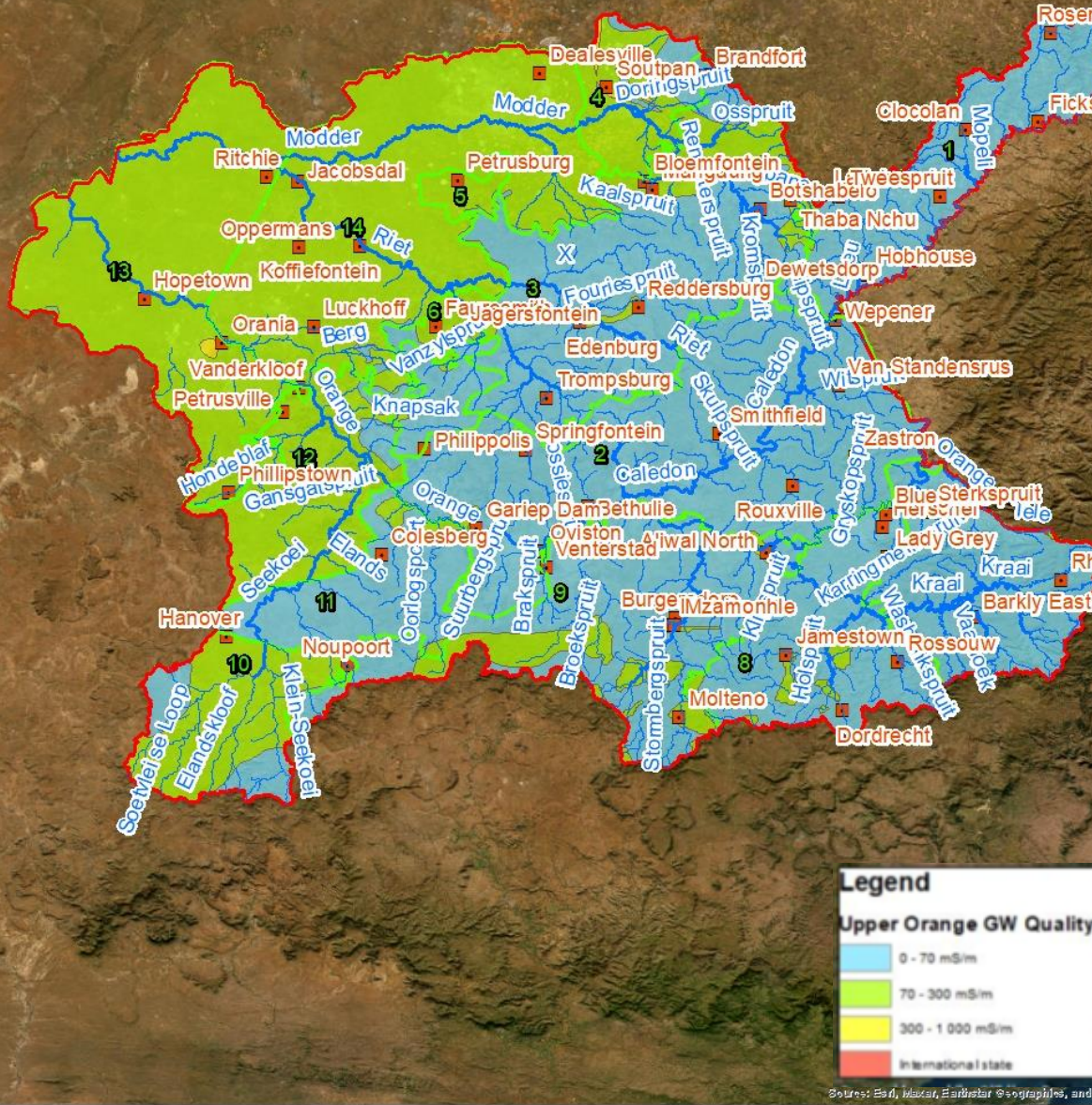
These values, based on the individual quaternary catchment estimations will be accepted for the water resource classification and the quality objective settings.

- **Groundwater use**

Groundwater use figures for the Upper Orange River catchment Reserve are likely from the Groundwater Resource assessment II (GRA II) assessment conducted by DWS in the early 2000's - outdated if these values were not updated during the 2024 assessment - will need to be re-calculated for this water resource classification and RQOs study.



Groundwater Quality



Source: Esri, Maxar, Earthstar Geographics, and others

Groundwater quality in the catchment varies significantly and is affected by the following conditions:

Natural/primary conditions, i.e.,

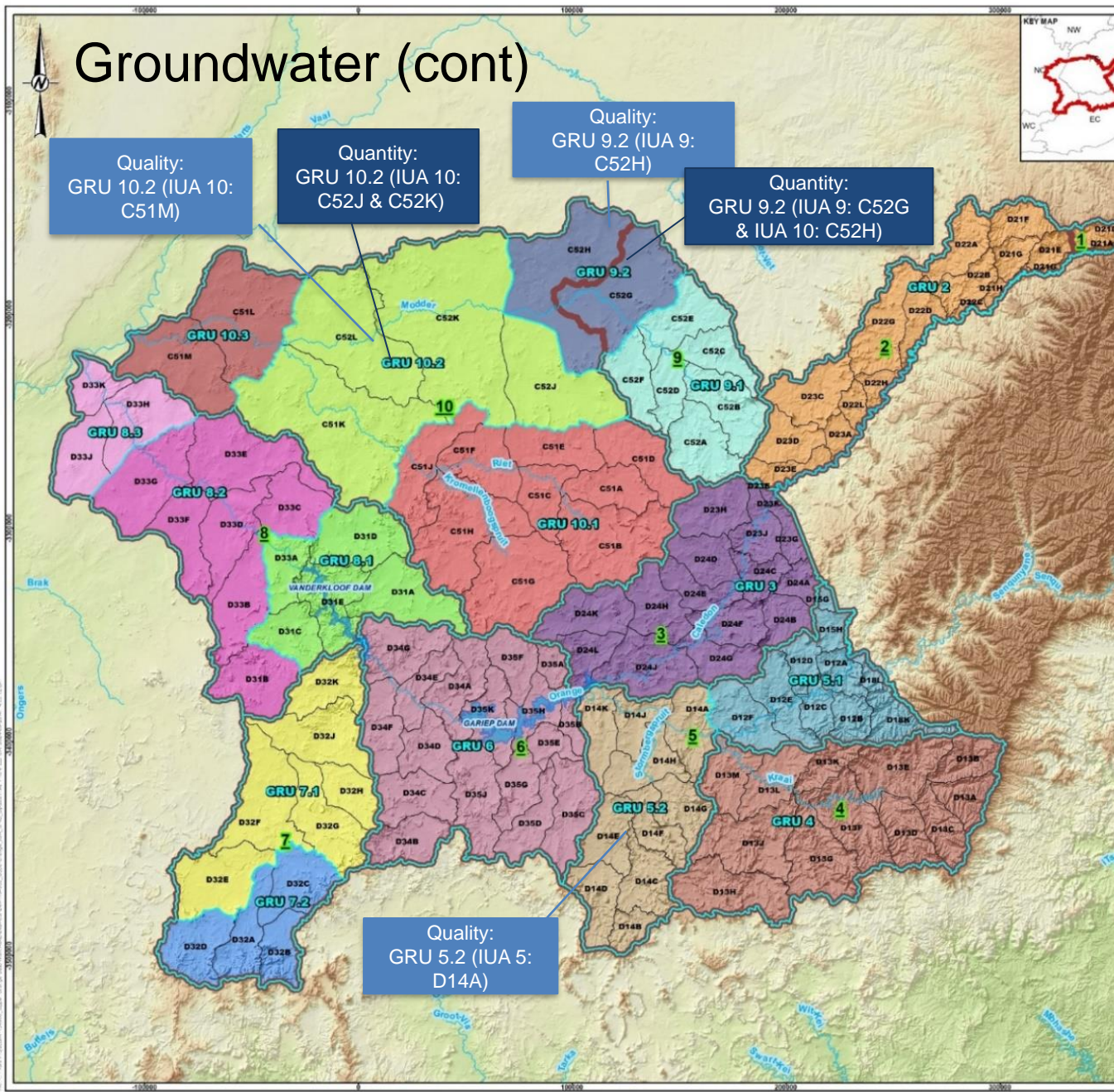
- Geological, e.g., Salinity affected by specific sedimentary rock formations, i.e., marine tillite and mudrock.
- In the Upper Orange River catchment, this is applicable to the lower formation groups in the Karoo Supergroup sequence, e.g., the Dwyka (marine) Tillites and the Ecca (marine) mudrocks.

Climatological conditions, i.e.,

- Aquifer systems need frequent rainwater recharge to “flush” or “refresh” the water quality of the water bearing rock formations, i.e., tillite, mudrock and silty sandstone formations.
- Generally, this process occurs on an annual base in the subtropical/tropical climate regions in southern Africa, however, in the semi-arid and arid northwestern parts of South Africa, this process has not been an annual event since 1974 – ‘76.
- The recurrence rate groundwater recharge events of 1:5 to 7-years is probably more realistic for the northwestern part of the study area.

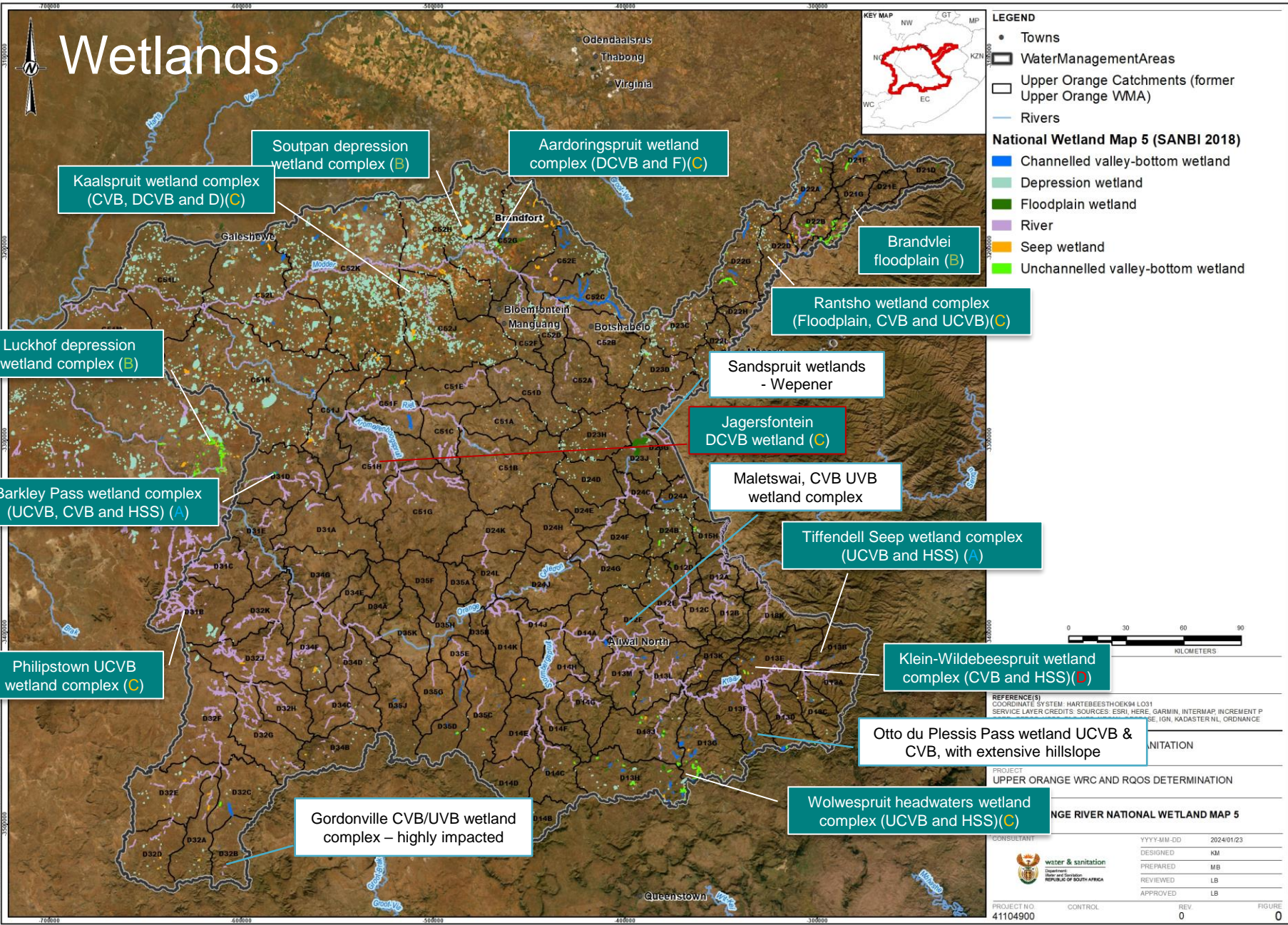
Anthropogenic effects, i.e., Groundwater pollution due to poor solid waste management (rock/waste dumps), poor leachate management (tailings storage facilities), and poor wastewater management (water treatment work discharges).

Groundwater (cont)



- ### Stress Index/ Hotspots
- Both criteria indicated that the groundwater quantities in the Upper Orange River catchment are classified “Natural” (5% SI) to “Good” (<20% SI)
 - Are a few quaternary catchments where the groundwater quantities fall in the “Poor to Seriously Modified” (60% to 70% SI).
 - A Stress Index of 50% indicates that 50% of the long-term recharged water is groundwater used.
- ### Contribution to baseflow
- The Upper Orange-Senqu River basin coincides with a major transboundary aquifer, the Karoo Sedimentary Aquifer. The Stormberg Group of the Karoo Supergroup underlying the transboundary area comprises horizontal to sub-horizontal dipping sedimentary rocks of the Burgersdorp, Molteno, Elliot and Clarens Formations.
 - Estimated groundwater contribution to the surface water systems in the upper parts of the Catchment, i.e., IUA3, 4 and 5 is expected to be high, e.g., for quaternary catchment D13E (GRU-IUA 4) was estimated as $\pm 65 \text{ Mm}^3/\text{a}$.
 - Further downstream, GRU-IUA 6, the groundwater contribution is much lower at $\pm 0.75 \text{ Mm}^3/\text{a}$.

Wetlands

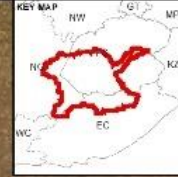


Wetlands



- Brandwater floodplain
- Soutpan depression wetland complex - salt pans support vegetation that is distinct from the surrounding vegetation
- Philipstown unchannelled valley-bottom (UCVB) - provides important habitat diversity
- Wolwespruit headwaters wetland complex - foraging site by blue and crowned cranes; possibly also a breeding site for the crowned cranes
- Klein-Wildebeespruit wetland complex - key in providing ecosystem services such as water quality enhancement and sediment trapping
- Luckhof depression wetland complex - form unique features in the broader landscape and provide important habitats for both fauna and flora
- Kaalspruit wetland complex comprising several depression wetlands, and a discontinuously channelled valley-bottom (DCVB) wetland - unique feature in this complex is a depression wetland nested within CVB wetland
- Aardoringspruit a large wetland complex that includes a large wetland flat and a DCVB wetland which encompasses the Aardoringspruit River - unusual to find a wetland flat in this part of the country
- Rantsho wetland complex - unique in that it consists of three VB hydrogeomorphic (HGM) unit types which have formed because of a unique geomorphic setting and a unique set of geomorphic processes. A series of VB wetlands is unique and can provide significant streamflow regulating services
- Jagersfontein DCVB wetland – after the dam burst this wetland will have been negatively impacted
- Barkley Pass wetland complex - located at approximately 2 000 masl, characterised by a unique vegetation assemblage, representative of rare intactness for wetlands in South Africa
- Tiffindell Seep a high-altitude wetland complex - 2 000 masl, characterised by a unique vegetation assemblage.
- Maletswai, CVB/UVB wetland complex: moderately disturbed, the wetland complex still contains extensive intact areas and is likely to have a high importance in terms of water quality enhancement, particularly given that much of the runoff from Maletswai (Aliwal North) town passes through this wetland complex before entering the Orange River.
- Sandspruit wetland: given that the entire runoff from the town of Wepener and the discharge from the town's WWTW pass through this still reasonably intact wetland before entering the Caledon River, its importance in terms water quality enhancement is likely to be high.
- Otto du Plessis Pass wetland UCVB and CVB, with extensive hillslope seeps: unusually large wetland for its high altitude. Much of the wetland vegetation remains intact.
- Gordonville CVB/UVB: severely eroded, but with flood-out portions where sediment is currently accumulating. It is representative of many other similarly impacted wetlands in the landscape.

Wetlands



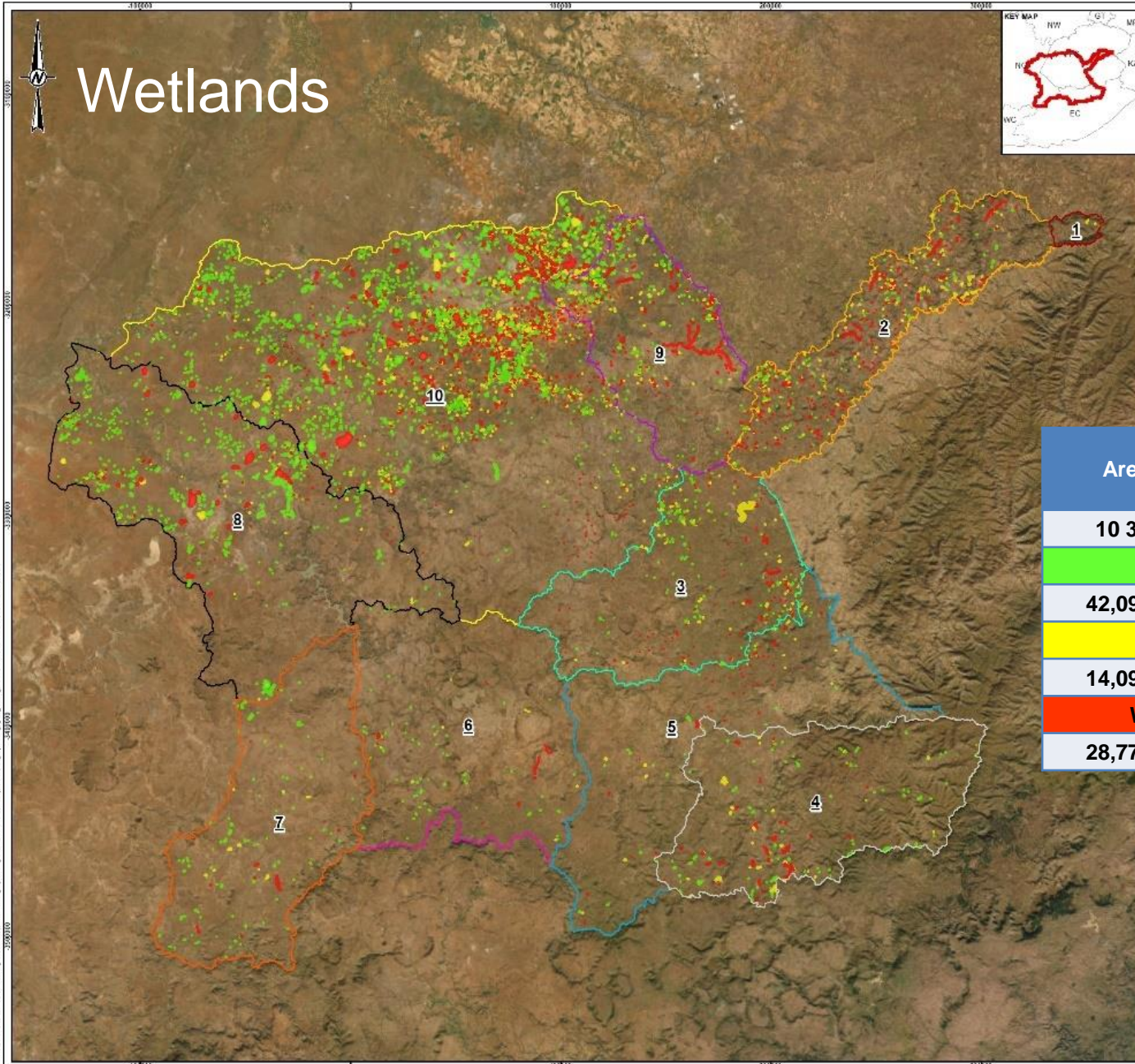
LEGEND

Integrated Units of Analysis

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

National Wetland Map 5 (SANBI 2018)
National Wetland Map 5 PES

- A/B: Natural to near Natural
- C: Moderately Modified
- D/E/F: Largely to Critically Modified



Area (ha)	Extent of wetlands (ha) in IUA
10 352 148	139 046.90
Wetland Condition A/B	
42,093.27 ha	30%
Wetland Condition C	
14,096.83 ha	10%
Wetland Condition D/E/F	
28,771.20 ha	21%

REFERENCES
 COORDINATE SYSTEM: HARTBEESTHORN LOGS
 SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY

CUSIT
 DEPARTMENT OF WATER AND SANITATION

PROJECT
 UPPER ORANGE WRC AND RQOS DETERMINATION

TITLE
 PRELIMINARY INTEGRATED UNITS OF ANALYSIS AND NATIONAL WETLANDS MAP 5 PES

CONTROL SHEET

DESIGNED	TS
DRAWN	MB
REVIEWED	LU
APPROVED	LU

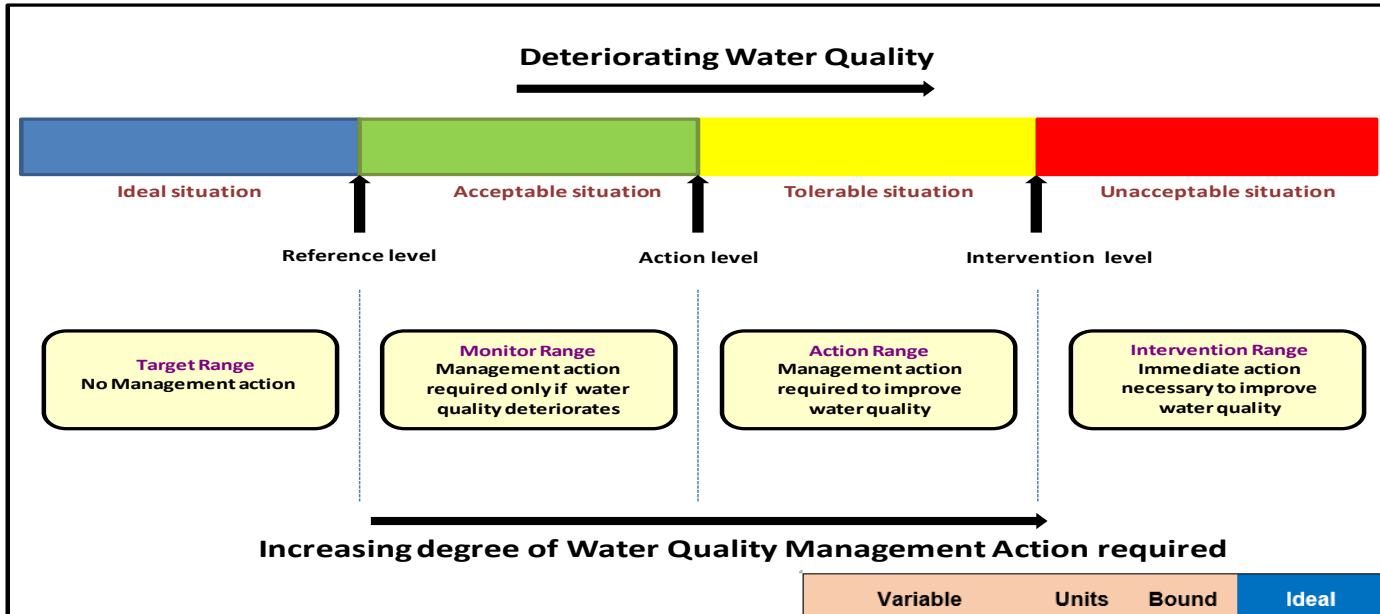
PROJECT NO: 41104900

DATE: 2024/05/31

REVISION: 0

SCALE: 1:50000

Surface water quality



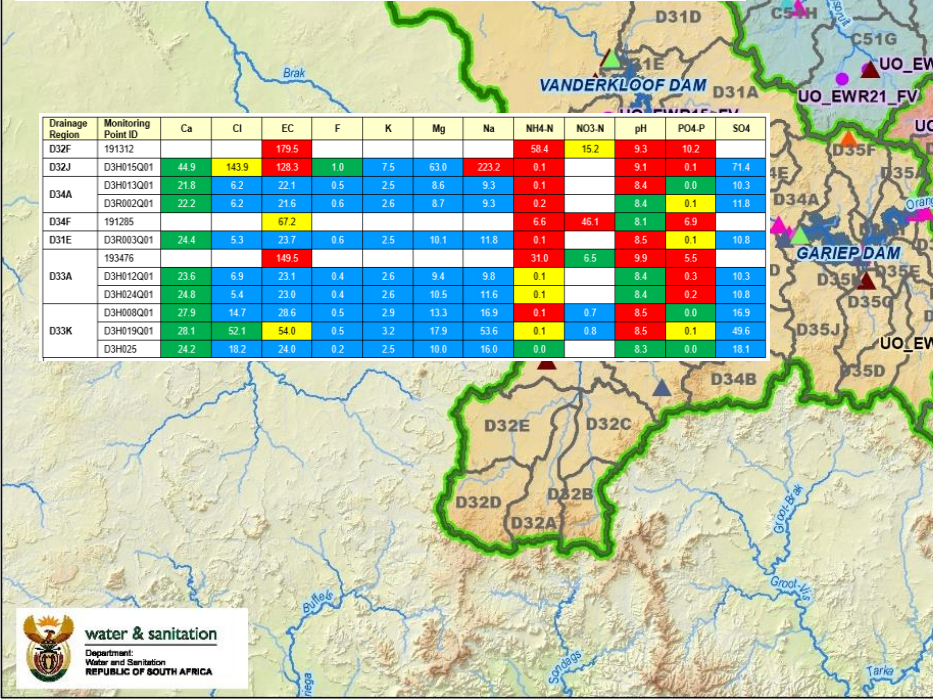
Relationship between assessment rating and degree of water quality management action required

Variable	Units	Bound	Ideal	Acceptable	Tolerable	Unacceptable
Calcium (Ca)	mg/l	Upper	10	80	80	<80
Chloride (Cl)	mg/l	Upper	40	120	175	<175
Total Dissolved Solids DMS (TDS)	mg/l	Upper	200	350	800	<800
Electrical Conductivity (EC)	mS/m	Upper	30	50	85	<85
Fluoride (F)	mg/l	Upper	0.7	1	1.5	<1.5
Potassium (K)	mg/l	Upper	25	50	100	<100
Magnesium (Mg)	mg/l	Upper	70	100	100	<100
Sodium (Na)	mg/l	Upper	70	92.5	115	<115
Ionised Ammonia (NH ₄ -N)	mg/l	Upper	0.015	0.044	0.073	<0.073
Nitrate (NO ₃ -N)	mg/l	Upper	6	10	20	<20
pH	units	Upper	≤8	≤8.4	≤8.4	
		Lower	≥6.5	≥6.5	≥6.5	
Orthophosphate (PO ₄ -P)	mg/l	Upper	0.025	0.075	0.125	<0.125
Sulphate (SO ₄)	mg/l	Upper	80	165	250	<250

Water quality criteria used to assess the present water quality status

Drainage Region	Monitoring Point ID	Ca	Cl	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
C52H	191171	39.8	77.0	78.4	0.5	22.9	59.2	61.4	1.0	2.5	9.1	0.9	59.0
	C5H039Q01	43.0	64.6	67.4	0.6	10.7	24.8	64.4	0.8		8.6	0.4	38.3
C52L	189076	220.4	645.5	336.8		94.0	208.8	245.6	1.3	2.5	8.4	1.6	621.4
	C5H018Q01										7.9		
C52M	C5H035Q01	68.6	122.8	98.0	0.5	26.3	54.0	77.4	1.0	2.1	8.5	0.5	103.6
	191192			75.1							16.4	12.6	8.7
C52N	C5H012Q01	67.5	90.3	111.3	0.8	6.7	54.1	101.6	0.1	0.1	8.8	0.2	148.0
C52P	191160			89.4					23.4	8.9	10.0	4.7	
C52Q	189023	72.8	513.5	211.0		39.5	239.0	237.8	1.0	0.9	8.5	0.5	69.5
C52R	191429			68.0					7.4	7.8	10.0	3.6	
C52S	189022	48.7	160.6	148.1		78.5	151.3	167.8	1.1	0.3	8.7	9.9	161.3
	189026	59.8	72.8	100.3		38.3	82.7	94.0	1.0	0.3	8.5	0.5	78.0
C52T	191169			107.0					18.7	15.6	9.5	4.6	
	C5H040Q01	37.2	75.2	74.4	0.9	9.2	33.6	79.3	0.5		8.7	0.1	62.6
C52U	C5R002Q01	37.4	95.0	82.6	1.0	12.5	36.2	92.7	0.6		8.7	0.5	73.1
	188763			411.8					17.3	11.4	8.5	3.2	
C52V	189047	37.4	60.0	64.3		28.8	59.8	62.0	1.2	0.3	8.8	0.5	50.0
	189078	35.0	45.6	56.0		9.1	26.5	52.0	1.0	0.3	8.7	0.5	50.0
C52W	191167			306.4					81.4	7.9	8.3	17.0	
	88779	79.5	345.4	264.2	0.4	20.5	94.1	260.4	1.0	0.5	8.5	0.6	191.4
C52X	C5H030Q01	22.5	6.9	23.2	0.2	2.6	8.5	9.0	0.1		8.4	0.0	9.5
	C5H049	34.4	222.6	134.9	0.7	5.6	39.6	181.5	0.1		8.8	0.0	123.1
C52Y	189020	46.1	92.6	152.9	0.0	15.0	48.5	66.5	1.0	0.4	8.5	0.5	99.8
	191175	47.6	111.2	87.6		17.8	43.5	99.5	1.0	0.3	8.5	0.5	106.3
C52Z	191251			94.9					5.4	6.9	9.9	4.1	
	189075	38.2	86.1	59.3	0.2	6.3	23.3	37.7			8.8	0.0	58.2
C52AA	189096	62.0	239.9	147.9		42.7	112.9	172.6	1.0	0.3	8.5	0.5	208.9
	C5H016Q01	59.5	227.7	162.2	0.4	31.8	80.0	163.9	1.0	0.5	8.4	0.5	216.5

Drainage Region	Monitoring Point ID	Ca	Cl	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
C52A	189024	31.4	9.9	30.4		11.7	19.0	19.7	1.0	0.7	8.6	3.6	50.0
	191187	19.7	14.0	927.2	1.0		12.6			1.1	8.1	8.2	7.9
C52B	C5H037Q01	25.6	9.7	29.2	0.4	6.0	11.1	16.6	0.1		8.4	0.0	10.3
	C5H055	24.5	26.7	47.8	0.6	8.0	10.7	61.5	0.4		8.6	0.3	33.9
C52C	C5H056	48.1	51.8	66.5	0.8	10.2	35.6	55.4	1.0	2.4	8.6	0.5	50.0
	C5R003Q01	30.7	16.0	31.4	0.6	6.2	12.7	20.9	0.1		8.5	0.2	17.7
C52D	189017	52.0	73.0	71.1		15.8	61.2	62.8	4.1	12.5	9.0	3.1	50.0
	189027	47.0	89.8	72.2		14.5	39.7	76.0	1.0	0.7	8.8	1.1	50.0
C52E	C5H003Q01	52.5	62.8	69.2	0.6	13.0	24.2	64.4	1.0	8.0	8.7	1.6	50.0
	C5H022Q01	47.2	29.5	70.0	0.9	6.0	43.3	81.7	0.1		8.9	0.1	17.1
C52F	C5R005Q01	32.8	19.3	57.2	0.6	8.3	25.2	34.6	1.6		8.5	0.9	16.3
	C5R007Q01	48.5	61.8	65.6	0.7	11.3	26.2	62.3	0.2		8.6	0.4	31.9
C52G	189015	48.8	61.0	72.0	0.3	16.4	40.0	62.0	1.4	7.7	8.8	3.7	50.0
	189021	43.2	39.9	56.0	0.4	13.3	26.8	41.0	1.0	2.2	8.9	4.0	50.0
C52H	C5R006Q01	42.0	53.6	61.4	0.7	8.7	21.8	56.9	0.1		8.5	0.2	31.1
	189013	52.0	86.3	89.4		16.0	66.3	75.3	22.0	20.3	7.9	8.0	50.0
C52I	C5H006Q01		12.9	23.4	0.0	4.5		11.2	0.1		8.3	0.0	14.1
	C5H007Q01	49.2	57.4	72.5	0.7	13.0	25.0	69.7	8.6		8.5	4.7	58.1
C52J	C5H054Q01	56.2	79.4	86.4	0.6	12.4	30.2	86.4	6.9		8.6	3.0	60.3
	189018	45.7	70.3	66.2		26.1	24.0	62.8	8.3	0.3	8.4	15.2	50.0
C52K	189019	157.8	1788.8	888.2	0.5	25.2	483.9	526.2	2.0	7.8	9.0	1.9	50.0
	191145	42.1	90.1	86.7		26.0	84.0	97.4	21.8	15.2	7.9	8.3	50.0
C52L	191156	46.3	38.9	56.9		21.5	42.8	11.9	5.9	4.5	7.7	1.8	50.0
	C5H053Q01	58.2	76.9	83.2	0.6	13.1	34.9	82.8	8.1	15.0	8.6	2.6	59.3
C52M	C5R004Q01	40.3	61.8	65.9	0.6	9.7	22.4	60.4	0.7		8.6	0.6	38.1



Drainage Region	Monitoring Point ID	Ca	Cl	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
D21C	191335	39.7	5.0	36.9		12.4	17.8	13.8	1.0	0.3	8.3	2.2	50.0
	D2H012	43.9	12.2	43.0	0.5	3.3	20.2	20.5	0.1		8.6	0.1	21.1
D21D	191336	48.7	15.6	45.1		19.1	21.0	19.8	1.0	0.3	8.5	0.5	50.0
	191337	47.6	5.0	41.5		19.2	21.8	14.0	1.0	0.3	8.3	0.5	50.0
D21G	191347			92.4						21.0	10.7	9.2	8.0
D21H	D2H039	35.9	5.6	33.7	0.4	3.0	15.0	11.9	0.0		8.3	0.0	15.4
D22C	D2H034	43.8	22.0	47.7	0.6	21.1	19.8	32.1	0.2		8.6	0.3	39.0
	D2H035Q01	34.6	10.2	32.6	0.4	2.7	15.2	14.3	0.1		8.5	0.0	15.8
D22G	191341			175.3						109.3	71.8	7.9	30.3
D22H	187060												7.9
	191354	40.7	28.3	42.5		6.2	18.4	23.0	3.3	0.3	8.4	16.0	50.0
D22L	191360			81.6						27.0	20.0	8.2	5.2
	191353	41.1	28.4	43.8		6.5	19.4	27.0	1.0	0.8	8.4	0.5	50.0
D23E	D2R002Q01	26.5	21.2	41.2	0.6	15.5	12.4	40.1	0.2		8.5	0.2	21.6
	D2H022Q01	37.3	37.0	54.6	0.5	5.8	21.8	53.8	0.1		8.6	0.1	59.6
	D2H037Q01	33.9	15.0	49.7	0.2	3.6	15.9	23.9	0.1		8.6	0.1	19.8

Drainage Region	Monitoring Point ID	Ca	Cl	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
D12A	D1H009Q01	28.8	5.0	24.1	0.4	2.3	11.0	7.1	0.1		8.4	0.0	12.4
	D1R001Q01	22.3	3.4	18.7	0.4	2.1	7.3	7.2	0.1		8.4	0.0	6.8
D12D	191410	39.0	80.9	90.7		23.6	84.5	70.6	31.8	17.4	8.5	5.2	50.0
	191423	38.9	87.4	107.6		23.0	53.4	68.9	37.4	16.3	8.5	4.9	50.0
D13D	191431	45.9	5.0	40.5		15.6	25.0	11.9	1.0	0.3	8.7	0.5	50.0
	191432	47.6	5.0	41.1		14.7	24.8	11.0	1.0	0.3	8.4	0.5	50.0
D13H	191436			75.3					24.9	15.7	8.7	4.9	
	191430			69.5					39.4	9.0	8.8	4.0	
D13L	D1H011Q01	37.0	8.1	33.0	0.5	2.5	16.5	16.5	0.1		8.6	0.1	13.3
	D1H006Q01	30.8	5.3	25.9	0.5	2.5	11.2	9.9	0.1		8.5	0.1	15.4
D14A	191387	35.0	12.9	32.1		8.0	14.9	12.0	1.5	0.9	8.2	0.5	50.0
	D1H003Q01	32.5	6.8	28.9	0.4	2.3	12.7	9.8	0.1		8.5	0.1	12.2
D14C	191422			120.0					21.9	7.2	10.0	4.4	
	D1H001Q01	66.4	61.4	95.5	0.6	10.9	39.2	80.8	4.9		8.8	1.7	53.5
D14J	191414	34.9	10.4	29.7		8.6	14.0	11.9	1.0	0.3	8.7	1.6	50.0
	191415	33.0	11.0	31.0		7.5	12.9	11.8	1.5	0.3	8.5	23.0	50.0
	191423	38.9	87.4	107.6		23.0	53.4	68.9	37.4	16.3	8.5	4.9	50.0

FIFI D VERIFICATION SITES (only diatoms,
 ner Upper
 Orange



Surface water quality: D/s Hopetown

In-situ water quality measurements taken during the October 2021 survey undertaken by Clean Stream for NGO Gariep Watch:

- Electrical Conductivity: 19mS/m
- pH: 7.1 – within the target for fish health (DWAF, 1996)
- Oxygen saturation 74.8%
- Dissolved Oxygen: 6.3mg/L - above the minimum guideline (>5mg/l) as set by Kempster et al. (1982) and should therefore not be limiting to aquatic biota
- Water temperature 18.6 °C
- Turbidity (visual): Slightly turbid
- *Escherichia coli* values increased to a database-high of 649 CFU/100 mL at the De Bron locality downstream of Hopetown during September 2021.

Sediment:

- most variables below the detection limit, however, calcium, magnesium, sodium, potassium, manganese, strontium, iron, barium, silicon, phosphorous, gallium and titanium > strictest SAWQG limit, where available.
- Sediment toxicity test performed for site Hopetown was classified as having a “slight acute/chronic environmental toxicity hazard” (Class II) based on the 30% growth inhibition effect (chronic) and 40% mortality effect (acute) noted during the *Heterocypris incongruens* testing (Clean Stream, 2021).

Diatoms - reliable indicators of specific water quality problems such as organic pollution, eutrophication, acidification and metal pollution, as well as for general water quality. The results indicate:

- Biological water quality in October 2021 was classified as **Good and the SPI score was 14.7 (B/C Ecological Category)**.
- Salinity concentrations and nutrient levels were elevated while organic load was low.
 - Elevated nutrient levels were reflected by the dominance of *Stephanodiscus minutulus* which occurred in highest abundance. This species is found in strongly polluted water with high electrolyte content.
 - *Nitzschia dissipata* was also dominant, which has an intermediate tolerance for nutrient levels and is an indicator of alkaline, hard water (calcium-based salinity). The dominance of this species indicates possible increased in salinity concentration.
 - *Diatoma vulgare* was also dominant and is found in mesotrophic to eutrophic waters with average electrolyte content; an alkalibiontic species and key indicator associated with pH change.
 - No valve deformities were noted suggesting that metal toxicity was below detection limits or bioavailability was limited (Clean Stream, 2021).

Green Drop assessment

The Green Drop scores provide an *indication of potential water quality impacts of the wastewater treatment works on the receiving water resources*, specifically in relation to microbiological quality and nutrients.

The higher the CRR, the worse the situation is.

The results indicate that the WWTWs in the Upper Orange River catchment are a *threat to water quality*.

Province	Local Municipality	WWTW Name	WWTW Process Type	Design capacity (ML/d)	Resource discharged to	Green Drop 2021	CRR 2021
FREE STATE	Dhlabeng	Clarens STW	Oxidation ponds	2.5	Little Caledon River	52	47
		Fouriesburg STW	Oxidation ponds	No data	Caledon River	No data	65*
		Rosendal STW	Oxidation ponds	No data		No data	65*
	Kopanong	Fauresmith STW1	Oxidation ponds	1	Riet River	16	94
		Edenburg	Oxidation ponds	No data	Riet River	41	47
		Bethulie	Oxidation ponds	No data	Orange River	44	47
		Philippolis	Oxidation ponds	0.5	No data	52	47
		Jagersfontein	Oxidation ponds	2.2	Re-use	14	94
		Gariepdam	Oxidation ponds	1	Natural Pan	12	94
		Reddersberg STW1	Oxidation ponds	1	Fouriespruit	16	94
		Springfontein	Oxidation ponds	0.5	Bossiespruit	49	47
		Trompsberg (New)	Oxidation ponds	0.7	Tributary of the Van Zylsspruit	46	47
	Letsemeng	Petrusburg	Oxidation ponds	2	Evaporation ponds	61	47
		Luckhoff STW	Oxidation ponds	0.95	Riet River	46	47
		Jacobsdal STW	Oxidation ponds	1.5	Riet River	33	88
		Koffiefontein	Oxidation ponds	2.5	Riet River	29	94
		Mine (Koffiefontein)	Oxidation ponds	No data	Riet River	29	94
		Oppermansgronde	Oxidation ponds	0.5	Evaporation ponds	26	94
	Mangaung	Bloemspruit	Activated sludge	56	Bloemspruit	32	84
		Bainsvlei	Oxidation ponds	5	Unknown stream to farmer	35	68
		Welvaart	Oxidation ponds	5	Kaalspruit	32	77
		Northern Works	Oxidation ponds	5	Bree River	30	68
		Bloemdundia	Oxidation ponds	0.9	Renosterspruit	30	82
		Suid-oostelike (Dewetsdorp Pad)	Oxidation ponds	0.05	No data	24	94
		North-eastern WWTW	Activated sludge	20	Irrigation - botanical gardens and farmer	32	77
		Van Stadensrus	Oxidation ponds	0.03	Unknown	33	83
		Botshabelo STW	Activated sludge	20	Small Modder River	36	77
		Dewetsdorp STW	Oxidation ponds	0.05	No data	24	94
	Mantsopa	Wepener STW	Oxidation ponds	2	Caledon River	21	94
		Ladybrand STW	Oxidation ponds	17.5	Cathcart Dam	29	96
		Hobhouse	Oxidation ponds	0.5	No discharge	31	82
	Masilonyana	Thaba Patchoa	Oxidation ponds	No data	No discharge	33	83
		Brandfort	Oxidation ponds	No data	No data	11	100
	Mothokare	Souloan STW	Oxidation ponds	1	Small Modder River	18	94
		Rouxville	Oxidation ponds	1.5	Caledon River	24	94
		Smithfield	Oxidation ponds	1	Caledon River	30	82
Zastron STW		Oxidation ponds	1	Montagu Dam	15	94	
Setsoto	Clocolan Treatment Plant	Oxidation ponds	4.2	Mopedi River	24	88	
	Ficksburg STW	Activated sludge	12.2	Caledon River	14	96	
Tokologo	Dealesville STW	Oxidation ponds	0.8	No discharge	46	47	
	Noupoort	Oxidation ponds	0.18	Zeeikoei River	17	94	
NORTHERN CAPE	Umsobomvu	Colesburg	Oxidation ponds	2.4	Orange River	18	88
	Norvalspont	Oxidation ponds	0.142	No information	17	94	
	Dordrecht	Oxidation ponds	2.8	Anderson Dam	27	82	
EASTERN CAPE	Emalahleni	Venterstad	Activated sludge	1	Natural Pan	44	77
		Gariep	Ovision	Activated sludge	0.2	Gariep Dam	37
	Inkwanca	Burgersdorp	Activated sludge	2.5	Stormberg River	35	82
		Mollena	Maturation Ponds	2.7	Stormberg River	51	88
	Maletswai	Jamestown	Oxidation ponds	0.75	No discharge	68	65
		Aliwal North	Activated sludge	3	Orange River	40	68
	Senqu	Sterkspruit	Oxidation ponds	0.2	Sterkspruit	39	94
		Lady Grey	Oxidation ponds	1.84	No data	70	65
		Barkley East (New)	Oxidation ponds	0.6	Langkloof River	48	71
		Barkley East (old)	Oxidation ponds	0.728	Langkloof River	57	53
Herschel		Activated sludge	0.7	No data	36	100	



**WATER RESOURCE CLASSES AND ASSOCIATED RQOs:
UPPER ORANGE RIVER CATCHMENT, WP11422**

Integrated Units of Analysis

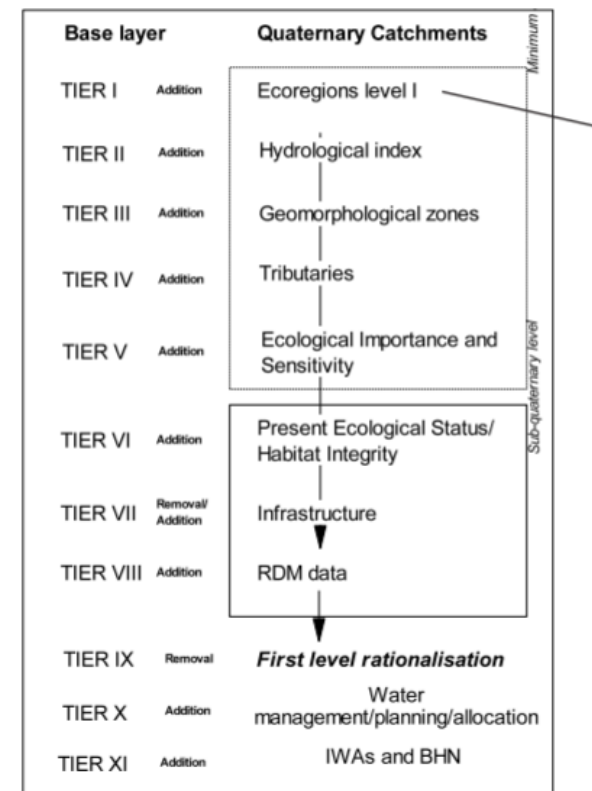
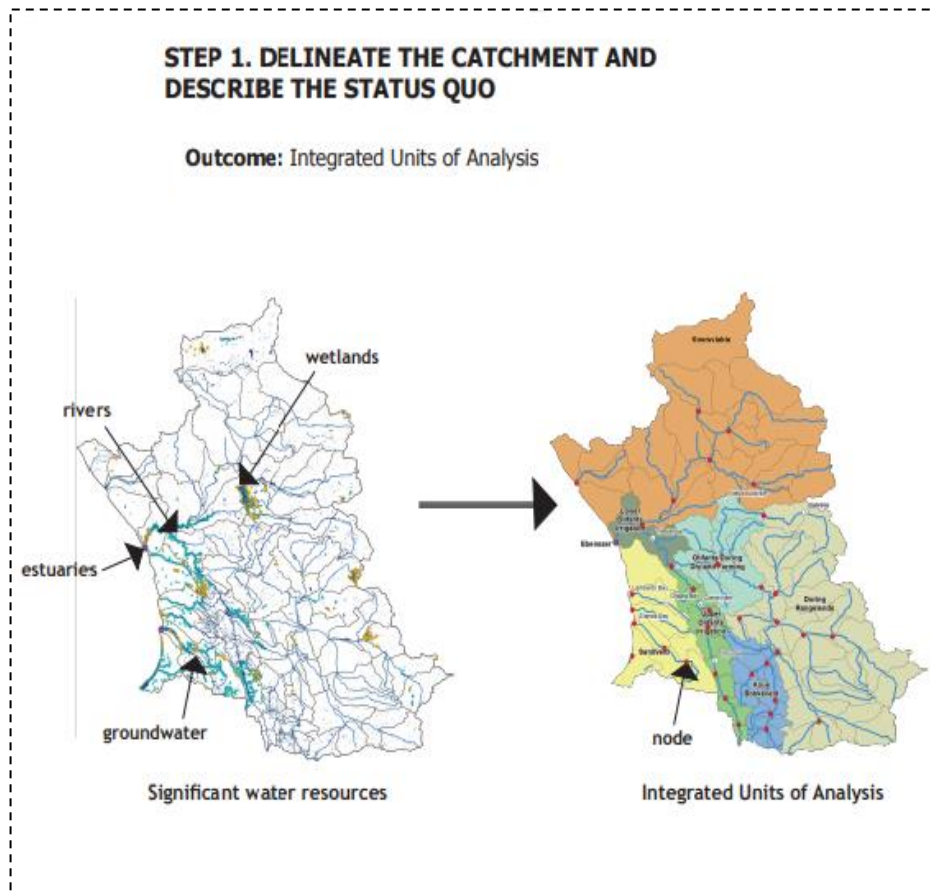
Integrated Units of Analysis delineation

- Suite of characteristics assessed to inform delineation
- Broader scale spatial units that are defined as significant water resources
- Basic unit of assessment for the classification of water resources
- Socio-economic zones (SEZs)
- Catchment area boundaries (drainage regions and water resource systems)
- The resolution of the hydrological analysis and available water resource network configurations within the water resource models.
- Location of significant water resource infrastructure.
- Land use characteristics.
- Distinctive functions of the catchments in context of the larger system.
- The Present Ecological State (PES) of each biophysical node was considered, the type of impacts and the homogeneity of the status and impacts.
- The practicalities of the existing model setup and network in terms of the scenario evaluation of each proposed IUA.
- Present status of water resources.
- Stakeholder input.

Water Resource Classification

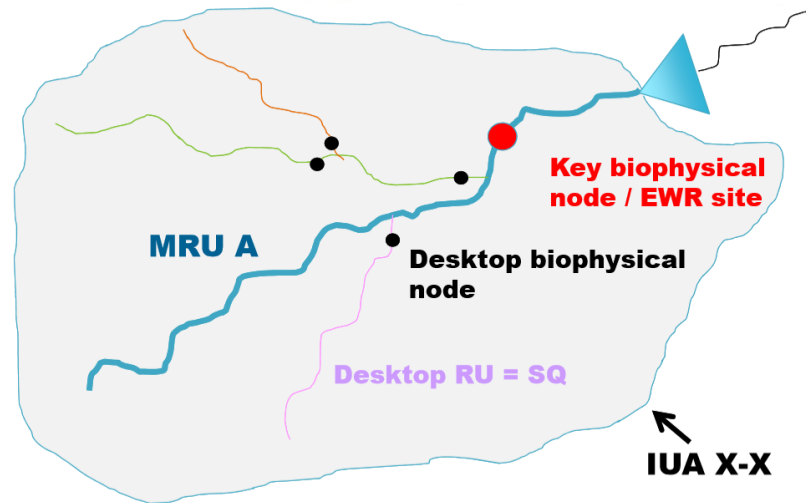
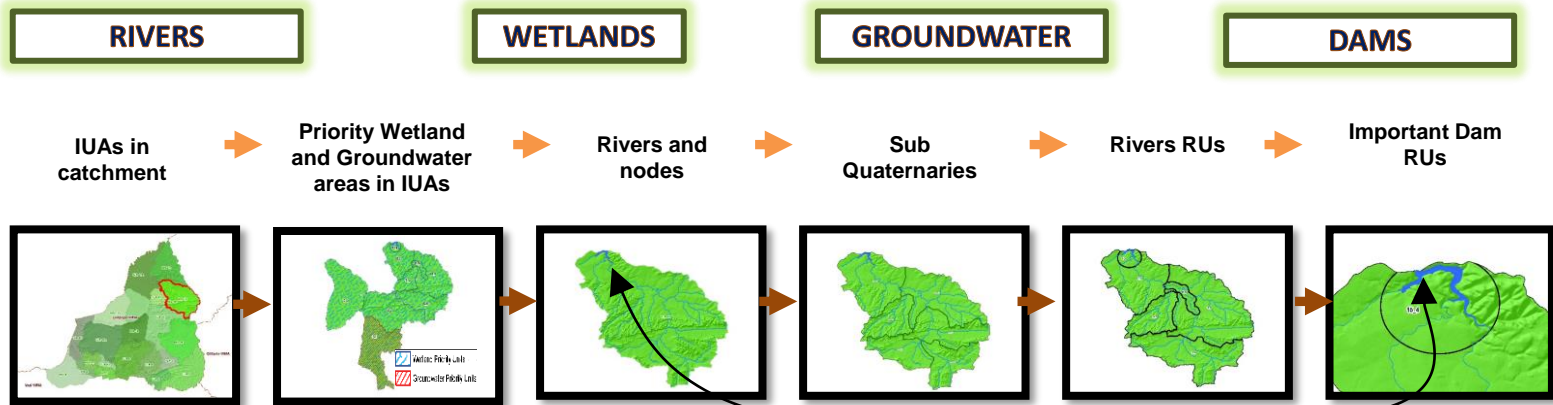
Step 1: delineate the catchment and describe the status quo

- Identify a network of significant resources, describe water resource infrastructure and identify water user allocations.
- Define a network of significant resources and establish biophysical nodes.
- Define Integrated Units of Analysis.

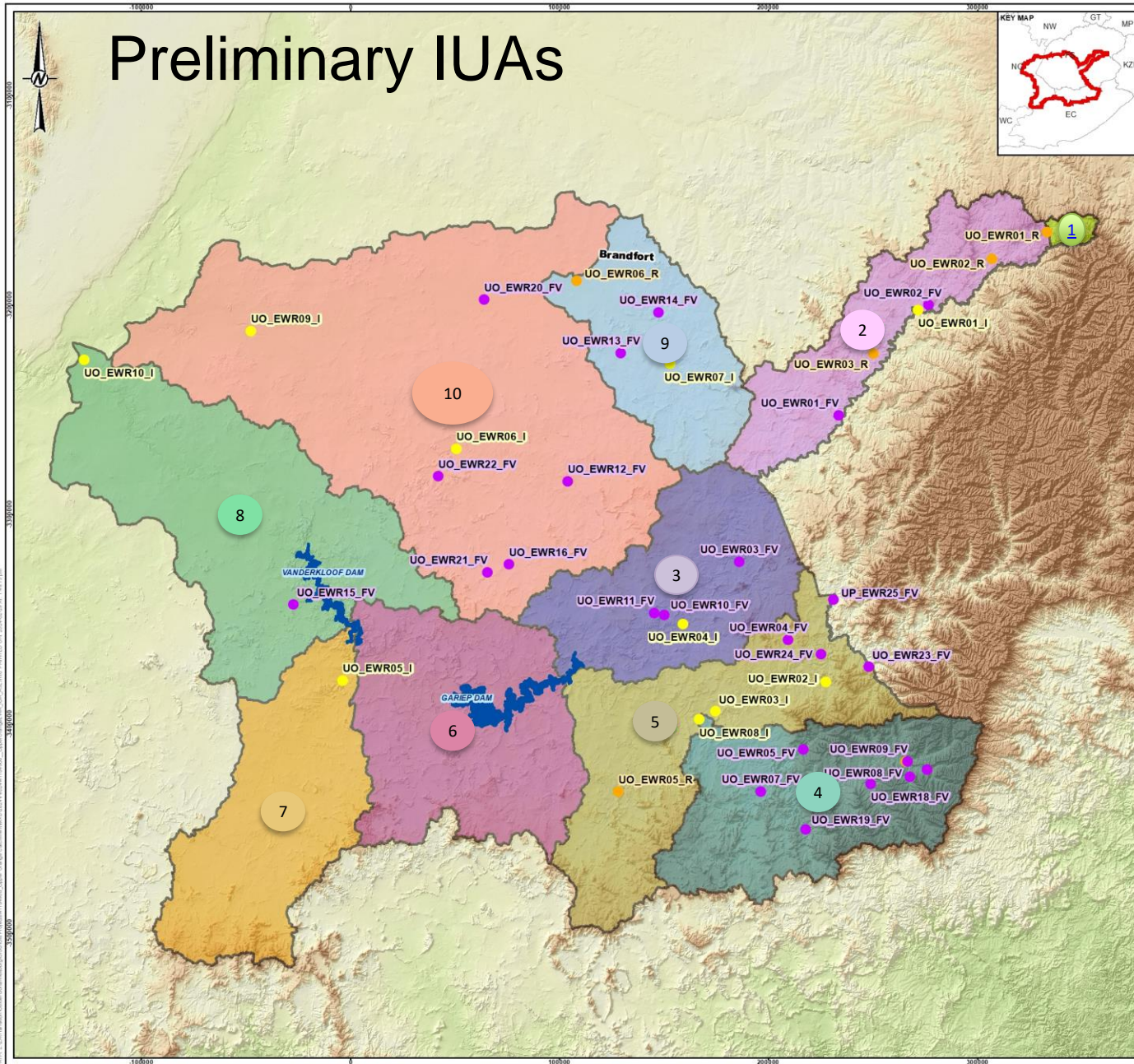


STEP 1: Describe the status quo and delineate IUAs and RUs

Resource Units



Preliminary IUAs



LEGEND

Dam

Integrated Units of Analysis

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

EWR Site

- FIELD VERIFICATION SITES (only diatoms, in situ water quality and IHI)
- INTERMEDIATE EWR SITES
- RAPID 3 EWR SITES

10 IUAs delineated

0 30 60 90
1:1 800 000
KILOMETERS

NOTE(S)

REFERENCE(S)
COORDINATE SYSTEM: HARTEBEESTHOEK94 L025
SERVICE LAYER CREDITS:

CLIENT
DEPARTMENT OF WATER AND SANITATION

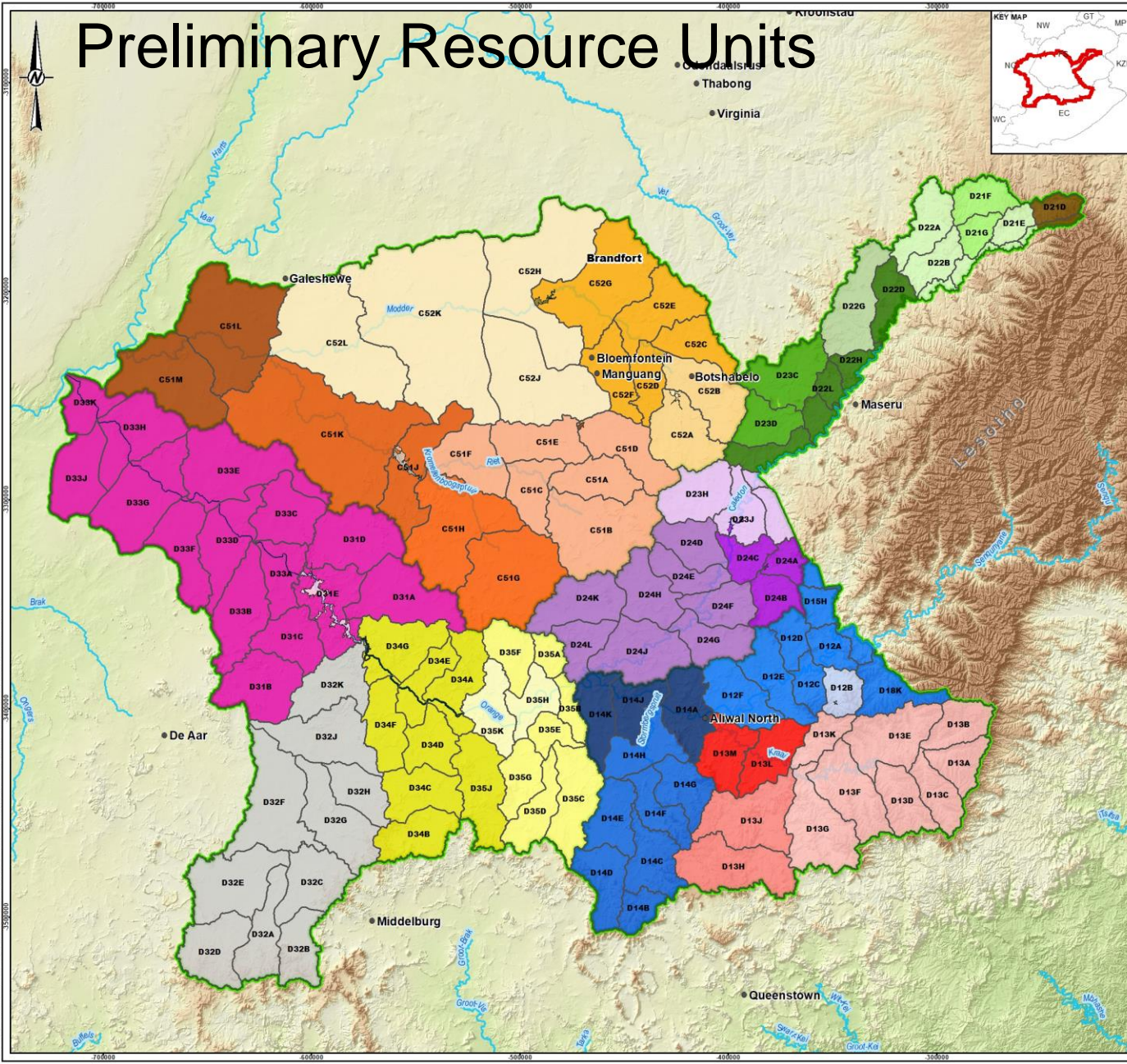
PROJECT
UPPER ORANGE WRC AND RQOS DETERMINATION

TITLE
PRELIMINARY INTEGRATED UNITS OF ANALYSIS

CONSULTANT	Water & sanitation Department of Water and Sanitation REPUBLIC OF SOUTH AFRICA	YYYY-MM-DD	2024/02/29
		DESIGNED	TS
		PREPARED	MB
		REVIEWED	LB
		APPROVED	LB

PROJECT NO 41104900 **CONTROL** **REV** 0 **FIGURE** 0

Preliminary Resource Units



LEGEND

- Towns
- Rivers
- Water Management Area - Upper Orange Catchment (DWAf 2012)
- Upper Orange Catchments (former Upper Orange WMA)

Resource Units

1.1	8.1 Vanderkloof Dam
2.1	8.2
2.2	8.3 Orange River
2.3	8.4
2.4	9.1 Rustfontein Dam
2.5 Armenia	9.2 Kgabanyane Dam (Groothoek Dam)
2.6	9.3
3.1	9.4 Krugersdrift Dam
3.2 Welbedacht Dam	10.1
3.3	10.2
3.4	10.3
3.5 Egmont Dam	10.4
4.1	10.5
4.2	10.6 Tierpoort Dam
4.3	10.7 Kalkfontein Dam
5.1	
5.2 Jozana's Hoek Dam	
5.3	
5.4	
5.5	
6.1 Gariep Dam	
6.2	
6.3	
6.4	
7.1	

0 30 60 90
1:1 800 000 KILOMETERS

REFERENCE(S)
COORDINATE SYSTEM: HARTEBEESTHOEK94 L031
SERVICE LAYER CREDITS:

CLIENT
DEPARTMENT OF WATER AND SANITATION

PROJECT
UPPER ORANGE WRC AND RQOS DETERMINATION

TITLE
UPPER ORANGE RESOURCE UNIT MAP

CONSULTANT	WATER & SANITATION Department of Water and Sanitation REPUBLIC OF SOUTH AFRICA	YYYY-MM-DD	2024/06/27
DESIGNED	KM		
PREPARED	MB		
REVIEWED	LB		
APPROVED	LB		

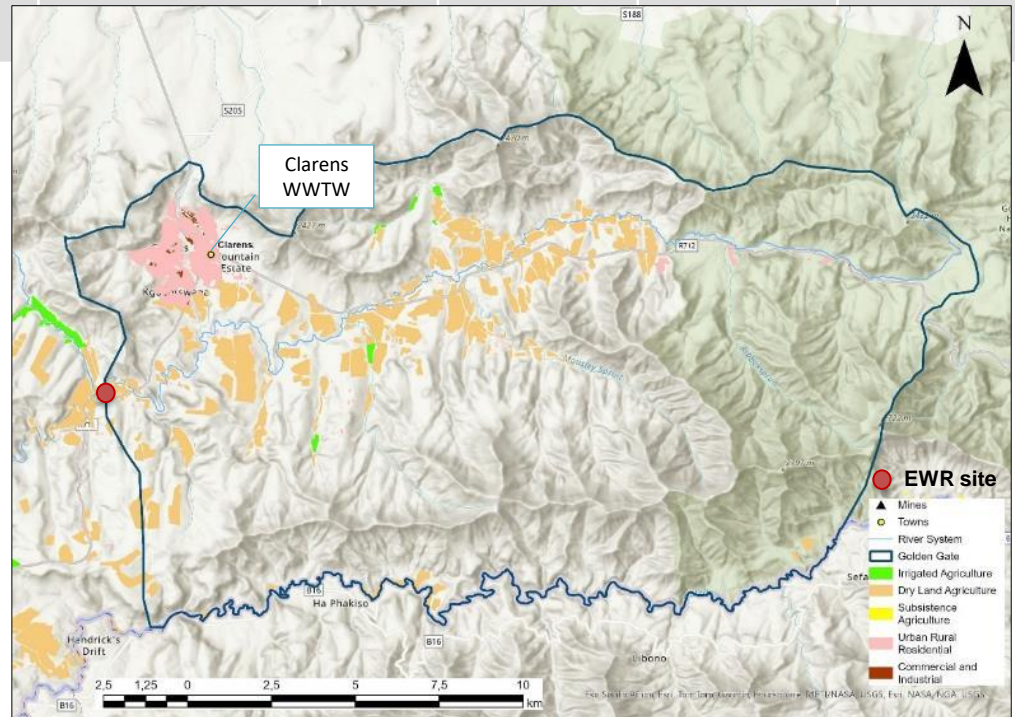
PROJECT NO 41104900 CONTROL REV 0 FIGURE 0

IUA 1: Golden Gate

Rivers	Description	SEZ	EWR site	Dams	Quaternaries	Protected Areas	PES
Little Caledon River and Caledon River in the portion of D21A along the Lesotho border	<ul style="list-style-type: none"> River SWSA Predominantly natural Tourism - Golden Gate National Park in the upper half of the IUA with several lodges, hotels and tarred roads Town of Clarens with the Clarens wastewater treatment works (WWTW) Agriculture in lower catchment of the quaternary catchment; small game farms; may be limited abstraction from the Caledon for subsistence agriculture 	Agriculture and Tourism zone	UO_EWR 01_R on the Little Caledon River at the outlet of the IUA DWS REMP sites: <ul style="list-style-type: none"> D2LCAL-WILGE D2LCAL-EWR01 D2GLEN-GLENR D2RIBB-UWWTW D2RIBB-DWWTW 	None	D21D and a portion of D21A	Golden Gate National Park	The current PES = C, however it is likely to be higher and the team will consider doing a diatom sample as it leaves the park to assess this

Groundwater	Water Quality hotspots
Upper part of the Karoo Supergroup formations with merely silty sandstones/siltstones and limited intrusive Karoo Dolerite features. Relatively high groundwater recharge (± 20 mm/a, $360 \text{ Mm}^3/\text{a}$), but also high contribution to baseflow. Groundwater quality Class 0 (Ideal water quality type), and borehole yield class (BYC) is a d3-Class (i.e., 0.5 – 2.0 L/s). Groundwater use is low (stress index are a Natural Condition) and Allocable ground water still $\pm 270 \text{ Mm}^3/\text{a}$	<ul style="list-style-type: none"> Tourism activities Overgrazing in Lesotho causing erosion which leads to sedimentation in the rivers Town of Clarens Clarens Wastewater Treatment Works (WWTW) – critical risks rating (CRR) of 47% - low risk and showed improvement in the 2021 GD assessment.

Priority wetlands	RUs
No priority wetlands	1.1 Little Caledon River with Caledon River in the D21A portion in SA



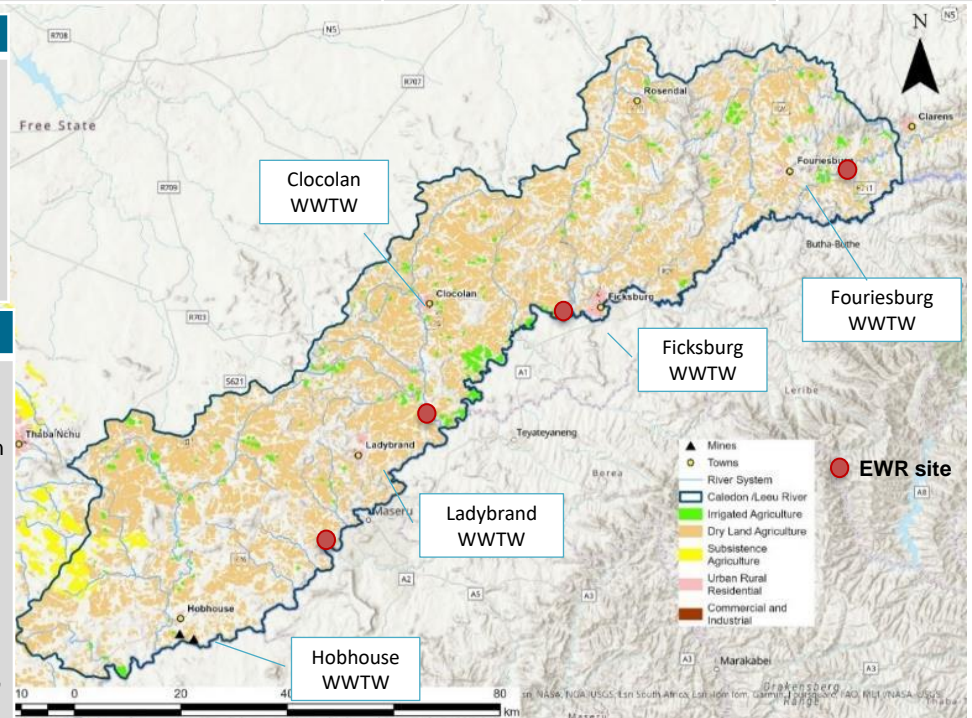
Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Floodplain		Channelled VB		River	
			ha	%	ha	%	ha	%
30,718	43.53	0.14%	34.63	0.11	1.99	0.01	6.92	0.02

IUA 2: Caledon/ Leeu River

Rivers	Description	SEZ	EWR site	Dams	Quaternaries	Protected Areas	PES
Caledon River along the Lesotho Border; Little Caledon and Leeu River	<ul style="list-style-type: none"> Extensive agriculture including dryland cultivation and irrigation (crops and livestock farming) Tourism Towns and associated WWTW <ul style="list-style-type: none"> Ficksburg Fouriesburg Clocolan Ladybrand Hobhouse 	Agriculture and Tourism zone	<ul style="list-style-type: none"> UO_EWR 02_R UO_EWR 03_R UO_EWR 01_I UO_EWR 02_FV <p>JBS3 sites:</p> <ul style="list-style-type: none"> OSAEH_15_1 OSAEH_11_22 <p>REMP sites:</p> <ul style="list-style-type: none"> D2CALE-EWR03 D2GROO-FARM1 D2LCAL-EWR02 	<ul style="list-style-type: none"> D22B: Meulspruit Dam (FSC: 2.6 Mm3) on the Meulspruit; D23C: Armenia Dam (FSC: 14.02 Mm3) on the Leeu River – small storage dam for irrigation Small farm dams: <ul style="list-style-type: none"> Lucretia Dam Lovedale Dam Wonderkop Dam Newbury's Gift Dam 	D21E, D21F and D21G; portion of D21C; D22A and D22B; portions of D21H and D22C along the SA/ Lesotho border; Portions of D22D, D22G, D22H; D22L, Portion of D23A, D23C, D23D and portion of D23E; D22B; and D23C	Several protected areas scattered through the IUA	C/D (an unnamed tributary of the Meulspruit = B)

Groundwater	Water Quality hotspots
<p>Relatively high groundwater recharge (± 20 mm/a, 360 Mm³/a), but also high contribution to baseflow. Groundwater quality Class 0 (Ideal water quality type), and borehole yield class (BYC) is a d3-Class (i.e., 0.5 – 2.0 L/s). Groundwater use is low (stress index are a Natural Condition) and Allocable ground water still ± 270 Mm³/a.</p>	<p>Sediments from Maseru and surrounding areas, Irrigation return-flows, Towns and associated poor performing WWTW:</p> <ul style="list-style-type: none"> Ficksburg: CRR 96% - critical risk Fouriesburg: CRR 65% - medium risk Clocolan: CRR 80% - high risk Ladybrand: CRR 73% - high risk Hobhouse: 82% - high risk

Priority wetlands	RUs
<ul style="list-style-type: none"> Brandwater Floodplain (prioritised for Reserve, 2023) – D21G Rantsho wetland complex (prioritised for Reserve, 2023) – D22G 	<p>2.1- Little Caledon River and Caledon River along the Lesotho Border including tributaries Moolmanspruit and Meulspruit, and the Meulspruit Dam</p> <p>2.2 - Swartspruit and Brandwater River, tributaries of the Caledon River</p> <p>2.3 - Caledon River along the Lesotho Border to the Leeu River confluence including tributaries: Modderpoortspruit, Tenniskopspruit, Tweelingspruit, Appledoespruit and Bokpoortspruit, including Cathcartdrift Dam</p> <p>2.4 - Leeu River and tributaries Klein-Leeu River and Mokopu River, and including Lovedale and Newberry dams</p> <p>2.5 - Armenia Dam on the Leeu River</p> <p>2.6 - Mopeli River and tributaries: Rantsho River, Morakabi River, McCabesspruit, Beytelspruit and Modderpoortspruit, and Mopeli Dam</p>



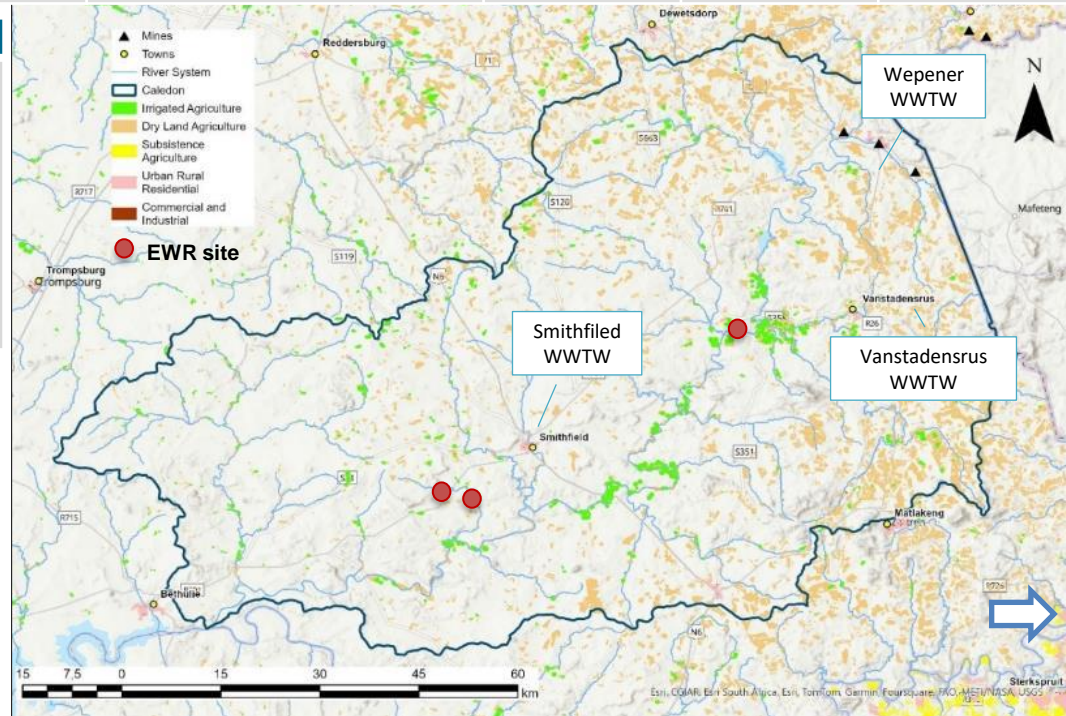
Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchannelled VB		River	
			ha	%	ha	%	ha	%	ha	%	ha	%		
631,886	3 022.03	0.48%	1 170.17	0.19			109.18	0.02	681.96	0.11	700.88	0.11	359.84	0.06



IUA 3: Caledon

Rivers	Description	SEZ	EWR site	Dams	Quaternaries	Protected Areas	PES
Caledon River along the Lesotho Border, and tributaries	<ul style="list-style-type: none"> Irrigated agriculture dominates along the main river and tributaries. Transfers from Caledon River, e.g. to Modder from the Welbedacht Dam, through Rietspruit. Welbedacht WTW Main towns and associated WWTW <ul style="list-style-type: none"> Vanstadensrus Wepener on Sandveld River Smithfield on Skulpspruit (tributary) 	Agriculture and Tourism	<ul style="list-style-type: none"> UO_EWR 03_FV UO_EWR 10_FV UO_EWR 11_FV UO_EWR 04_I TBCR4-E1 Bolikela in D23F (transboundary site) JBS3: OSAEH_26_8 	<p>Egmont Dam (FSC: 8.8 Mm³) in D24A</p> <p>Welbedacht Dam (FSC: 5.5 Mm³) in D24C on the Caledon River - Small storage dam for irrigation and transfer to Bloemfontein; the dam is highly silted</p> <p>Knellpoort Dam (off-channel) in Rietspruit sub-catchment (FSC: 138.4 Mm³) in D23H</p> <p>Rolandshoek Dam on the Blaasbak River (FSC: 5,4 Mm³) in D24C</p> <p>Vanstadensrus Dam (FSC: 1.8 Mm³) in D24C</p> <p>Smithfield Dam on the Groenspruit (FSC: 4.64 Mm³)</p>	D23H, D23J and D23F, D23J, D23H, D24A, D24B, D24C, D24D, D24E, D24F, D24G, D24H, D24J, D24K and D24L	Caledon Nature Reserve around the Welbedacht Dam and Tussendie-Riviere Nature Reserve in the lower reaches of the Caledon River	Predominantly C/D

Groundwater	Water Quality hotspots
Relatively high groundwater recharge (± 20 mm/a, 159 Mm ³ /a), but also high contribution to baseflow (27 Mm ³ /a). Groundwater quality Class 0 (Ideal water quality type), and borehole yield class (BYC) is a d3-Class (i.e., 0.5 – 2.0 L/s). Groundwater use is low (stress index are a Natural Condition) and Allocable ground water still ± 129 Mm ³ /a	<ul style="list-style-type: none"> Mainly irrigation along river, thus return-flows possible. Sedimentation Main towns and associated poor performing WWTW: <ul style="list-style-type: none"> Vanstadensrus WWTW: CRR 94% - critical risk Wepener WWTW: CRR 94% - critical risk Smithfield WWTW: CRR 82% - High risk



Priority wetlands	RUs
Caledon Floodplan Sandspruit near Wepener	<p>3.1 - Caledon River and tributaries Klipspruit, Rietspruit, Nuwejaarspruit and Bloemspruit</p> <p>3.2 - Welbedacht Dam in the Caledon Nature Reserve</p> <p>3.3 - Caledon River and tributaries Boesmanskopspruit, Vaalspruit, Wilgeboomspruit, Vinkelspruit, Grahamstadspruit, Sandveld, Skulpspruit, Slykspruit and Hartbeesfontein</p> <p>3.4 - Caledon River and tributaries Klipspruit, Elandspruit, Witspruit and Blaasbalkspruit</p> <p>3.5 - Egmont Dam</p>

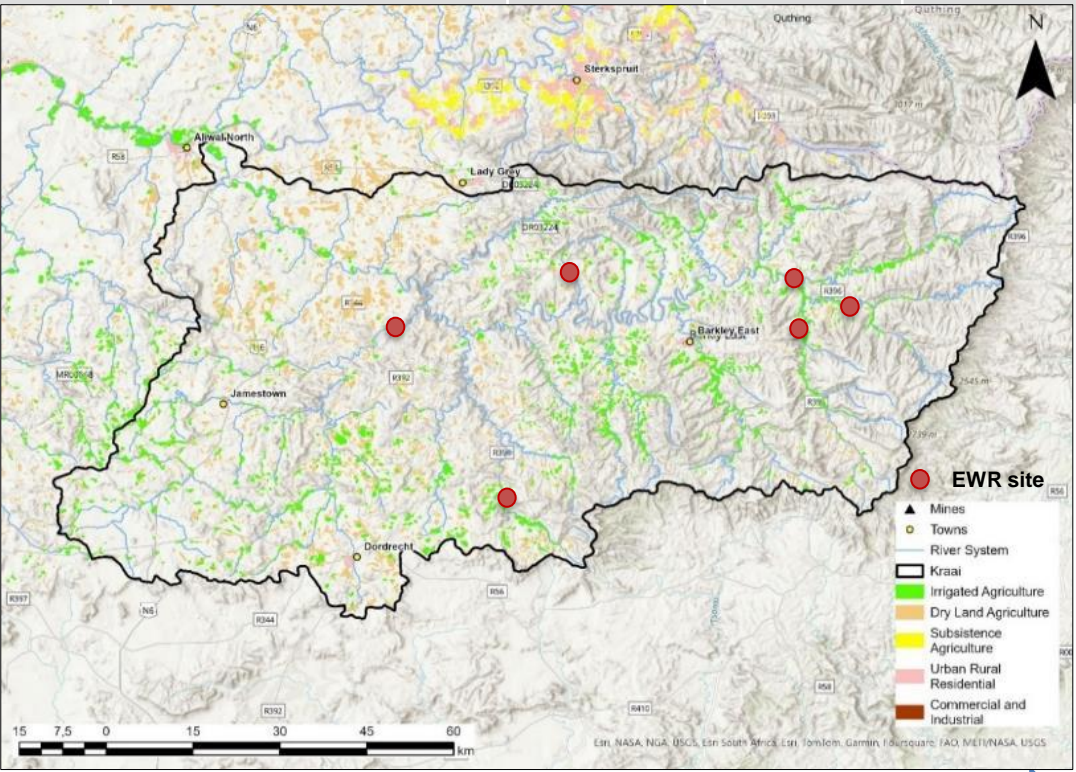
Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchannelled VB		River	
			ha	%	ha	%	ha	%	ha	%	ha	%		
822 797	4 935.94	0.60%	887.86	0.11	2 509.67	0.31	12.45	0.00%	40.67	0.0	42.69	0.01	1 442.61	0.18

IUA 4: Kraai River

Rivers	Description	SEZ	EWR site	Dams	Quaternaries	Protected Areas	PES
Kraai River and tributaries	<ul style="list-style-type: none"> • SWSA-sw: Eastern Cape Drakensburg in D13A, D13A, D13E and D13K • Scattered rural settlements • Cultivation (irrigated and dry land crops) and predominantly subsistence farming 	Rural	<ul style="list-style-type: none"> • UO_EWR05_FV • UO_EWR07_FV • UO_EWR08_FV • UO_EWR09_FV • UO_EWR18_FV • UO_EWR19_FV <p>REMP:</p> <ul style="list-style-type: none"> • D1KRAA-ALIWA <p>JSB3:</p> <ul style="list-style-type: none"> • OSAEH_26_11 	Small farm dams in western portion of the IUA in the tributaries in quaternary catchments: D13G, H, J, M and L	D13A – D13M	Small protected area in D13K	A (SWSA), B - C

Groundwater	Water Quality hotspots
<p>Moderate to high groundwater recharge (~20 mm/a, 277 Mm³/a), with high contribution to baseflow (baseflow indicated as higher-than-recharge). Groundwater quality Class 0 (Ideal water quality type), and borehole yield class (BYC) is a d3-Class (i.e., 0.5 – 2.0 L/s). Groundwater use is low (stress index are a Natural Condition) and Allocable groundwater is in question due to proposed high contribution to baseflow.</p>	<ul style="list-style-type: none"> • Limited irrigation return-flows • Run-off from rural areas • Limited sedimentation

Priority wetlands	RUs
<ul style="list-style-type: none"> • Tiffindell Seep Wetland Complex (Cat A) • Wolwespruit headwaters wetland complex (UCVB and HSS)(category C) • Klein-Wildebeespruit wetland complex (CVB and HSS)(category D) • Otto du Plessis Pass wetland complex 	<p>4.1 - Kraai River and tributaries Malpas River, Riflespruit, Bokspruit, Koffiehoekspruit, Bamboeshoekspruit, Sterkspruit, Klein-Wildebeespruit, Diepspruit, Three Drifts, Joggemspruit, Vlookraalspruit, Langkloofspruit, Rytjiesvlaktespruit, Vrouenshoekspruit, Noodshulpspruit, Vaalhoek River, Saalboomspruit, Wasbankspruit and Wolwespruit</p> <p>4.2 - Holspruit and tributarie Braklaagtespruit, Leeuspruit, Skulpspruit and Telemachuspruit</p> <p>4.3 - Kraai River and tributaries Windvoelspruit, Bossielaagtespruit, Oslaagte, Rondefonteinspruit, Klipspruit ad Elandspruit</p>



Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchannelled VB		River	
			ha	%	ha	%	ha	%	ha	%	ha	%		
934 709	4 902.46	0.52%	555.53	0.06	407.61	0.04	199.88	0.02	743.24	0.08	553.52	0.06	2 442.68	0.26

IUA 5: Upper Orange River

Rivers	Description	SEZ	EWR site/ additional sites	Dams	Quaternaries	Protected Areas	PES
Orange River (upstream from the Caledon confluence and Stormbergspruit)	Extensive subsistence agriculture (cultivation with limited irrigation, and extensive livestock grazing) in the upper portions Irrigation along the river in the middle to lower portions Sand mining (on main stem) Towns: <ul style="list-style-type: none"> Zastron Aliwal North (Maletswai) Burgersdorp Witkop Stormberg, and Molteno 	Mixed use zone with some rural areas	<ul style="list-style-type: none"> Main stem Orange River: UO_EWR02_I (Sterkspruit), UO_EWR03_I (Upper Orange) Tributary: UO_EWR05_R (Wonderboomspruit) UO_EWR23_FV (Tele) UO_EWR25_FV (Makhaleng) UO_EWR24_FV (Upper Orange) UO_EWR03_FV (Gryskopspruit) <p>JBS3 (2021):</p> <ul style="list-style-type: none"> OSAEH 11_22 (Orange) OSAEH 26_14 (Orange) OSAEH 26_13 (Stormberg) 	<p>Main stem Orange (Lesotho – Khatze, Polihali (proposed), Makhaleng Dam (proposed)</p> <p>Jozannashoek Dam (upper reaches Sterkspruit – D12B)</p> <p>JI De Bruin Dam (D14C) (Klein-Buffelspruit)</p> <p>Many small farm dams on the tributaries and specifically in the D14 tertiary catchment</p>	D12A – D12F; D14A – D14K; D15H and D18K	None noted	C - C/D - D

Water Quality hotspots

Towns and associated poor performing WWTW:

- Zastron WWTW: CRR 94% - critical risk
- Aliwal North WWTW: CRR 68% - medium risk
- Burgersdorp: CRR 94% - critical risk
- Molteno WWTW: CRR 88%

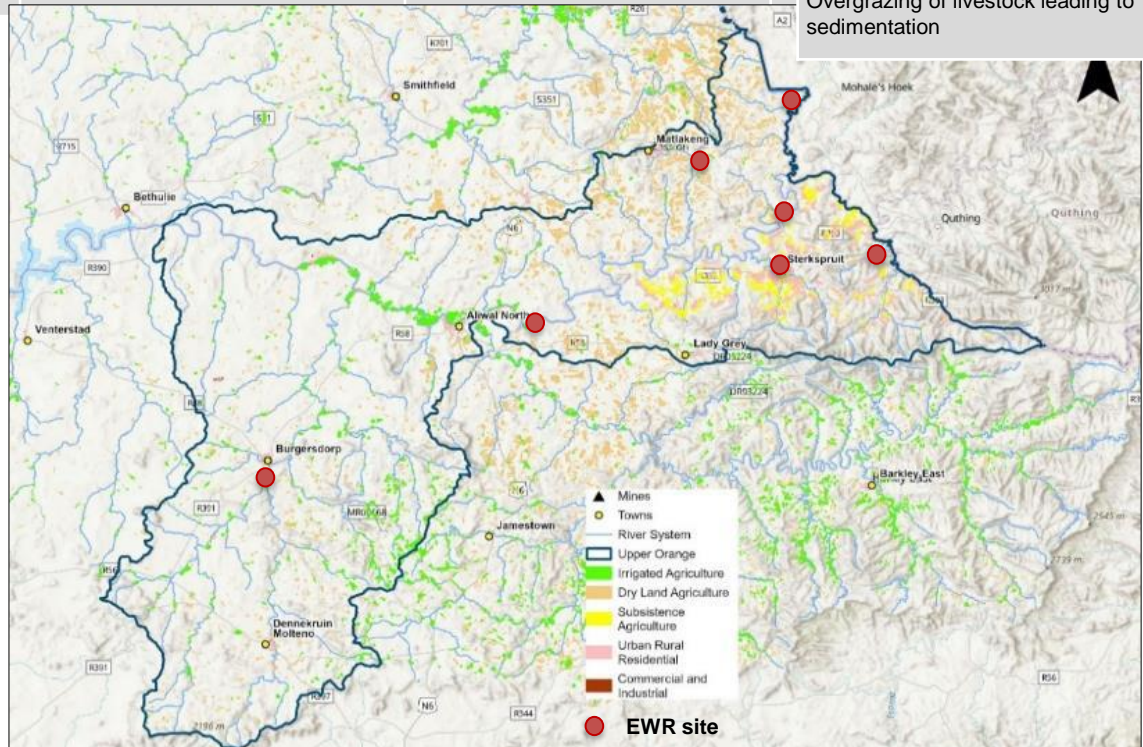
Irrigation return-flows
Run-off from the extensive rural villages
Overgrazing of livestock leading to sedimentation

RUs

- 5.1 - Sterkspruit and tributaries Mlangeni River, Mbongo River and Kromspruit
- 5.2 - Jozana's Hoek Dam on the Sterkspruit
- 5.3 - Orange River and tributaries Tele River along the Lesotho border, Blikana River, KwaSijora, Pelendaba, Mantikoana River, Deklerkspruit, Worsfonteinspruit, Hendrik Smitstroom, Bamboespruit, Wilgespruit, Gryskopspruit, Winnaarspruit, Knoffelspruit, Beeskraalspruit, Nuwejaarspruit, Kop-en-pootjiespruit and Wilgerspruit
- 5.4 - Stormbergspruit and tributaries Wonderhoekspruit, Wilgespruit, Klein-Buffelsvleispruit, Witkopspruit, Barnardspruit, Mooiplaasspruit, Elandsplaagte and Wikopspruit
- 5.5 - Orange River and tributaries Gladdegrond, Melkspruit, Sanddrijspruit, Modderbuirspruit and Palmietspruit

Priority wetlands

Groundwater
Valley Bottom wetlands Maletswai CVB/ UVB complex
Moderate to high groundwater recharge (~20 mm/a, 430 Mm ³ /a), with contribution to baseflow (430 Mm ³ /a). Groundwater quality Class 0 (ideal water quality type), and borehole yield class (BYC) is a d3-Class (i.e., 0.5 – 2.0 L/s). Groundwater use is low (stress index are a Natural Condition) and Allocable ground water at ±67 Mm ³ /a



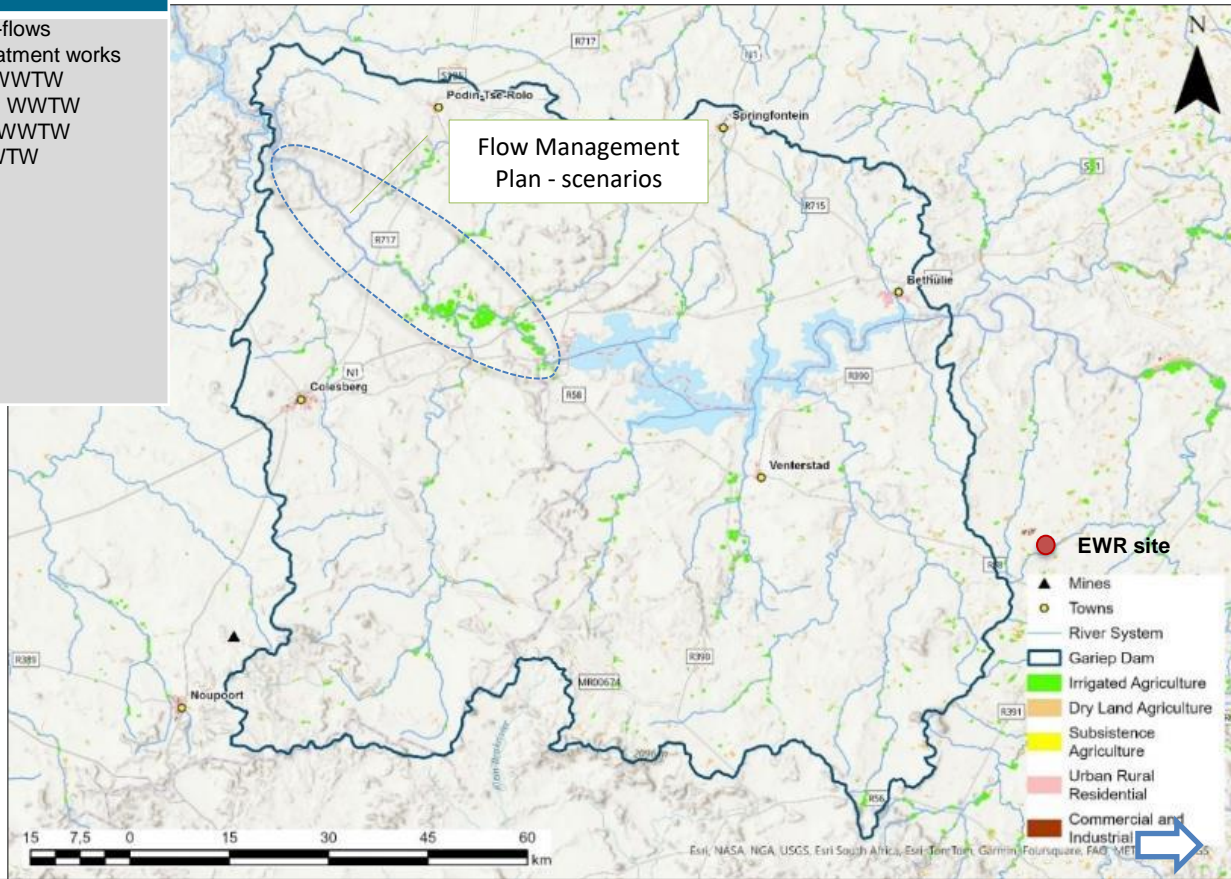
Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchannelled VB		River	
			ha	%	ha	%	ha	%	ha	%	ha	%		
1 024 091	6 904.29	0.67%	142.31	0.01	99.41	0.01	39.66	0.00	150.59	0.01	36.76	0.00	6 435.56	0.63

IUA 6: Gariep Dam

Rivers	Description	SEZ	EWR site	Dams	Quaternaries	Protected Areas	PES
Orange River main stem and tributaries	<ul style="list-style-type: none"> Gariep Dam (Orange-Fish transfer and hydropower) Livestock grazing Irrigation below the dam Towns of Colesburg, Norvalspont, Venterstad and Oviston 	Mixed use zone	<ul style="list-style-type: none"> None JBS3 site OSAEH_26_15 	Gariep Dam (FSC: 4,903.5Mm ³) Many small dams	D34A, D34B, D34C, D34D, D34F, D34G, D35J, D35G, D35D, D35C, D35E, D35B, D35A, D35F, D35H, D35K,	<ul style="list-style-type: none"> Gariep Nature Reserve Doornkloof Provincial Nature Reserve 	D/C and E (downstream)

Groundwater	Water Quality hotspots
<p>Moderate to high groundwater recharge (<20 mm/a, 131 Mm³/a), with contribution to baseflow becoming lower (±15 Mm³/a). Groundwater quality Class 0 (Ideal water quality type), but parts of QUATERNARY CATCHMENTS D34D, D35J and D35D have Class 1/2 water quality types. Borehole yield class (BYC) is a b3-Class (i.e., 0.5 – 2.0 L/s), a d3-Class (i.e., 0.5-2.0 L/s) in the Colesburg (quaternary catchment D34F), with a d4-BYC in GRU D35K (Gariep Dam quaternary catchment). Groundwater use is low (i.e. <13 Mm³/a, with stress index are a Natural to Good Conditions) and Allocable ground water at ±104 Mm³/a.</p>	<p>Irrigation return-flows</p> <p>Wastewater treatment works</p> <ul style="list-style-type: none"> Colesburg WWTW Norvalspont WWTW Venterstad WWTW Oviston WWTW

Priority wetlands	RUs
<p>No priority wetlands</p> <p>Few depression wetlands in D34B, C, D and F</p> <p>Seeps in D34B and D34F</p>	<p>6.1 - Gariep Dam</p> <p>6.2 - Orange River and tributaries Rooirantjies, Oudagspruit, Winnaarbakespruit, Brandspruit, Broekspruit, Bossiespruit, Swarthoekspruit and Brakspruit</p> <p>6.3 - Main stem Orange River between Gariep and Vanderkloof dams</p> <p>6.4 - Orange River and tributaries Suurbergspruit, Donkerpoortspruit, Oorlogspruit, Klipfonteinspruit, Rietkuilspruit and Vanderwalfonteinspruit</p>



Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchanneled VB		River	
			ha	%	ha	%	ha	%	ha	%	ha	%		
1 064 786	4 090.80	0.38%	126.75	0.01	-	-	92.34	0.01%	63.29	0.01	42.08	0.00%	3 766.34	0.35

IUA 7: Seekoei River

Rivers	Description	SEZ	EWR site	Dams	Quaternaries	Protected Areas	PES
Seekoei River	<ul style="list-style-type: none"> Main activity is livestock farming mainly with sheep for wool and meat. Rural and livestock agriculture Main towns Hanover and Noupport and associated WWTW 	Mixed Use zone	<ul style="list-style-type: none"> UO_EWR05_I (D32J) 	No major dams, however many small farm dams and weirs	D32A, D32B, D32C, D32D, D32E, D32F, D32G, D32H, D32J, D32K		C

Groundwater

Moderate to low groundwater recharge (<20 mm/a, 430 Mm³/a), with low contribution to baseflow (7 Mm³/a). Groundwater quality Class 1/2 (Good/Marginal water quality type) in GRU 7.2, and the northern part of GRU 7.1 – probably related to primary salinity in the aquifer rock formation. Borehole yield class (BYC) is a b3-Class (i.e., 0.5 – 2.0 L/s in a fractured aquifer system), and a d3-Class (i.e., 0.5-2.0 L/s in a fractured & weathered aquifer system). Groundwater use is low (stress index are merely a Natural Condition) and Allocable ground water at ±85 Mm³/a.

Water Quality hotspots

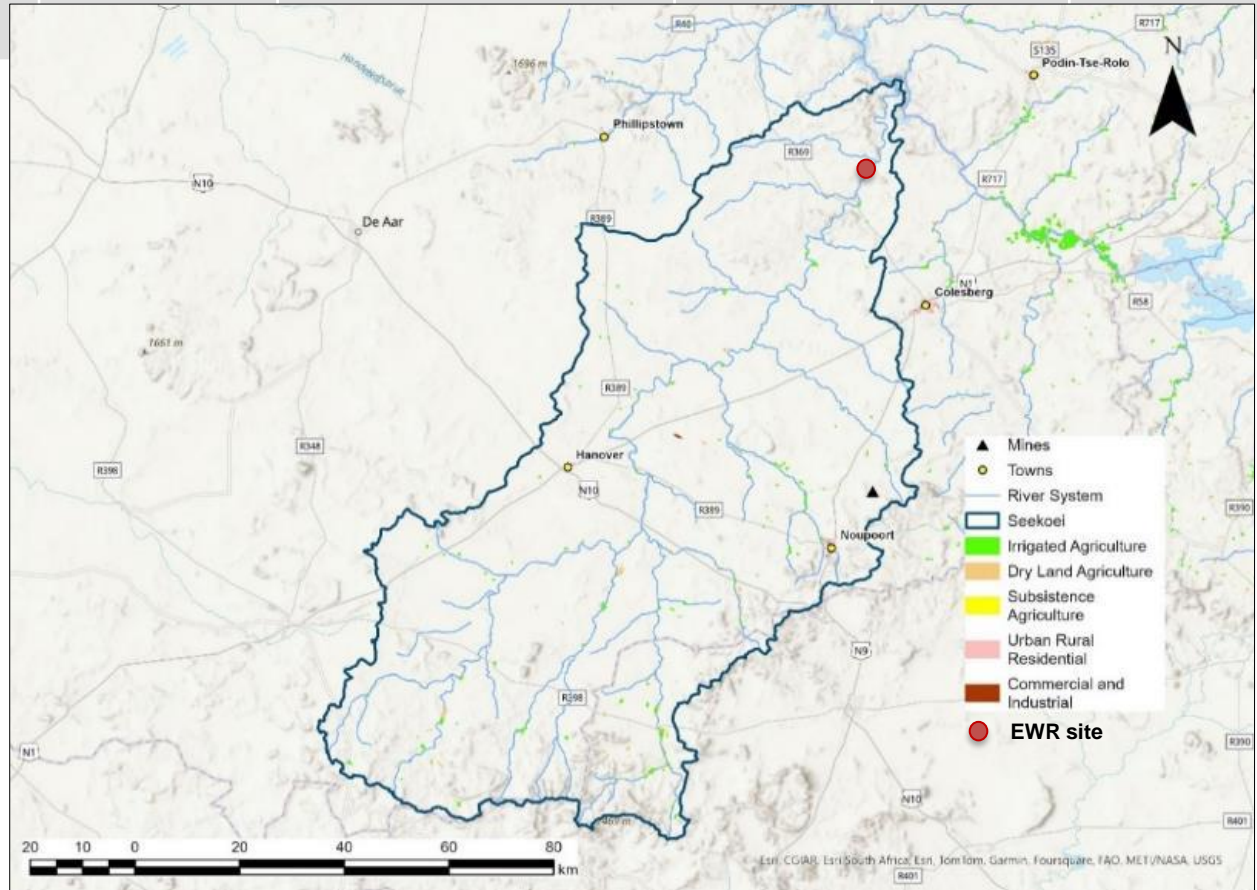
- Limited run-off from livestock agriculture
- Urban run-off from the towns of Hanover and Norvalspont
- Hanover WWTW (no discharge) – CRR: 94%
- Norvalspont WWTW – CRR: 94%

Priority wetlands

- Seekoei wetlands
- Few depression wetlands throughout
 - Few seeps in D32E
 - At the EWR site in D32K – blue cranes in wetland area
 - Gordonville wetland in D32B

RUs

7.1 Seekoei River



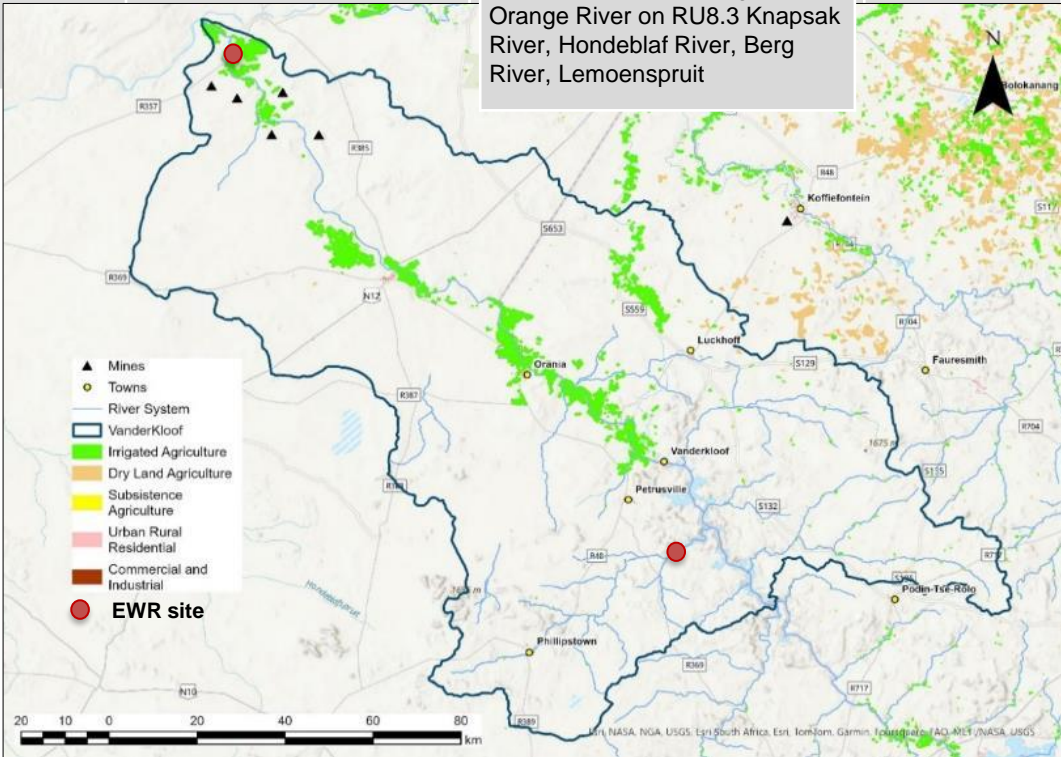
Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchannelled VB		River	
			ha	%	ha	%	ha	%	ha	%	ha	%		
915 159	9 811.74	1.07%	804.37	0.09	-	-	308.67	0.03%	352.70	0.04	59.23	0.01%	8 286.77	0.91%

IUA 8: Vanderkloof Dam

Rivers	Description	SEZ	EWR site	Dams	Quaternaries	Protected Areas	PES
Orange River and tributaries	Vanderkloof Dam (transfer to Riet River catchment and hydropower) Extensive Irrigation downstream and at the outlet of the IUA Hopetown and associated WWTW	Agriculture and Mining zone	<ul style="list-style-type: none"> • UO_EWR10-I • UO_EWR15-FV JBS3 sites: <ul style="list-style-type: none"> • OSAEH_26_2 • OSAEH_26_3 REMP sites <ul style="list-style-type: none"> • D3ORAN-HOPET • D3ORAN-MARKS 	Vanderkloof Dam (FSC: 3,092.4 Mm ³) - major storage dam – irrigation, domestic, hydropower and recreation	D33A – D33K	Nature reserves around the dam and in D33C and D33D	Predominantly C, some D's and some unassessed areas

RUs
8.1 - Vanderkloof Dam
8.2 - Orange River below Vanderkloof Dam
8.3 - Orange River mainstem
8.4 - Tributaries draining to the Orange River on RU.8.3 Knapsak River, Hondeblaf River, Berg River, Lemoenspruit

Groundwater	Water Quality hotspots
<p>Moderate to low groundwater recharge (<10 mm/a, 164 Mm³/a), with low contribution to baseflow (8 Mm³/a. Groundwater quality Class 1/2 (Good/Marginal water quality type), and borehole yield class (BYC) is a b3-Class (i.e., 0.5 – 2.0 L/s in a fractured aquifer system), and a d3-Class (i.e., 0.5-2.0 L/s in a fractured & weathered aquifer system). Groundwater use is low (±4 Mm³/a stress index are merely a Natural Condition) and Allocable ground water at ±153 Mm³/a.</p> <p>Groundwater conditions (specifically the BYC and quality) in GRU 8.3 are different due to pre-Karoo Supergroup formations present in the GRU area. BYC are a b2/b3 (0.1-0.5/0.5-2.0 L/s) Classes.</p>	<p>Return-flows from irrigation Limited urban run-off from Hopetown Hopetown WWTW (poor performance) – CRR: 82%</p>



Priority wetlands

Unchanneled Valley Bottom wetlands *Philipstown UCVB wetland complex (C)* provides important habitat diversity.

Channelled valley bottomed wetlands Hillslope seeps *Barkley Pass wetland complex (UCVB, CVB and HSS) (A)* located at approximately 2 000 mamsl, characterised by a unique vegetation assemblage, representative of rare intactness for wetlands in South Africa.

Depression wetlands throughout with *Luckhof depression wetland complex (B)* which forms a unique feature in the broader landscape and provides important habitats for both fauna and flora

Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Seep		Channelled VB		Unchanneled VB		River	
			ha	%	ha	%	ha	%	ha	%		
1 449 349	36 231.46	2.50%	13 937.18	0.96	199.71	0.01	101.23	0.01	492.45	0.03%	21 500.89	1.48

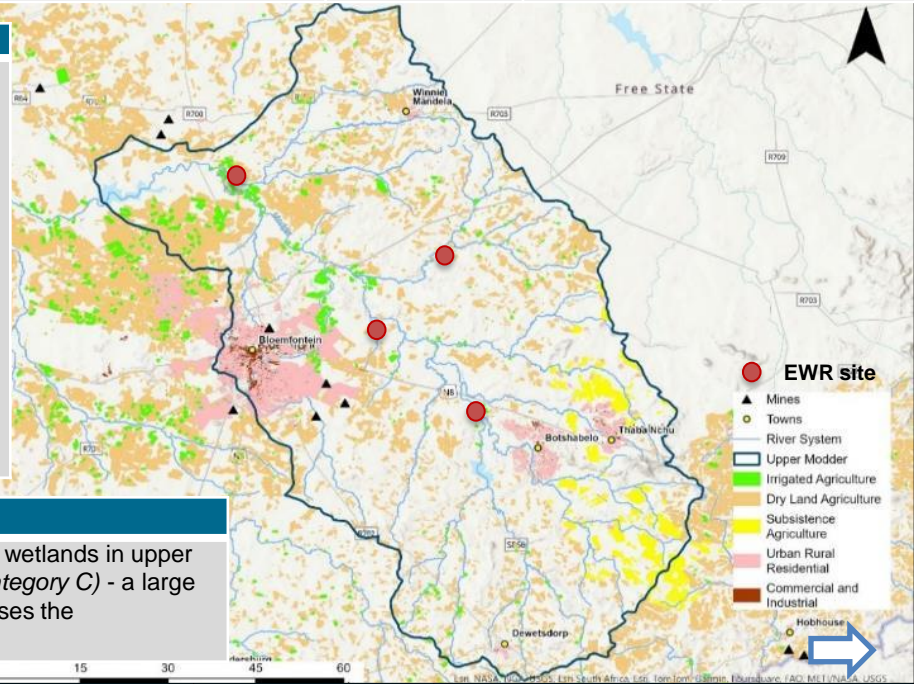


IUA 9: Upper Modder River

Rivers	Description	SEZ	EWR site	Dams	Quaternaries	Protected Areas	PES
Upper Modder River and tributaries	<ul style="list-style-type: none"> • SWSA-gw across quaternaries C52D, C52F and C52G • Mangaung Metropolitan Municipality - urban Area (Towns) • Agricultural areas (dryland, and some irrigation, in the lower portions of the Modder catchment around Krugersdrift Dam • Extensive subsistence agriculture in the upper reaches of the IUA 	Commercial Development Zone	<ul style="list-style-type: none"> • UO_EWR14_FV • UO_EWR13_FV • UO_EWR07_I • UO_EWR06_R <p>JBS3 site</p> <ul style="list-style-type: none"> • OSAEH_11_18 <p>REMP site</p> <ul style="list-style-type: none"> • C5MODD-SANNA 	<ul style="list-style-type: none"> • Kgabanyane Dam (FSC: 15.4 Mm³) in C52B on the Modder River • Rustfontein Dam (FSC: 75.05 Mm³) in C52A on a tributary of the Modder River - small storage dam for domestic and irrigation use • Mockes Dam (FSC: 4.16 Mm³) in C52D on the Modder River - small storage dam for domestic and irrigation • Krugersdrift Dam (FSC: 73.44 Mm³) in C52G at the IUA outlet 	C52G, C52E, C52C, C52F, C52D, C52B and C52A		C & D (and F in Renoster and Bloemspruit)

RUs
9.1 - Rustfontein Dam on the Modder River
9.2 - Kgabanyane Dam (Groothoek Dam) on the Kgabanyane River
9.3 - Modder River and tributaries Steynspruit, Korannespruit, Koringspruit, Matjiesspruit, Osspruit, Renosterspruit, Doringspruit, Rietspruit and Stinkhoutspruit
9.4 - Krugersdrif Dam on the Modder River at the outlet of quaternary catchment C52G

Groundwater	Water Quality hotspots
Moderate to low groundwater recharge (<10 mm/a, 166 Mm ³ /a), with low contribution to baseflow (13 Mm ³ /a. Groundwater quality Class 0 (Ideal water quality type) in the upstream part of GRU 9.1 and a Class 1/2 in the centre part of GRU 9.1 (around the upstream section of the Modder River. Borehole yield class (BYC) is a d2/d3-Class (i.e., 0.1-0.5/0.5-2.0 L/s in a fractured & weathered aquifer system). Groundwater use is moderate (±36 Mm ³ /a, and the stress index in GRU 9.1 is a Natural to Good Condition, but in the GRU 9.2, it is a Fair to Poor Condition) and Allocable ground water at ±116 Mm ³ /a.	<ul style="list-style-type: none"> • Urban run-off from Botshabelo and Bloemfontein • Poor performing wastewater treatment works: <ul style="list-style-type: none"> • Northeastern WWTW (20ML/d) (effluent for irrigation) – CRR: 77% • Sterkwater WWTW (20ML/d) (Renosterspruit) – CRR: 86% • Bloemindustria (0.9 ML/d) (Renosterspruit) – CRR: 82% • Bloemspruit WWTW (56 ML/d) (Bloemspruit) – CRR: 84% • Northern Works WWTW (5ML/d) (Bree River) – CRR: 68% • Bainsvlei WWTW (5ML) (effluent for irrigation) – CRR: 68% • Botshabelo WWTW (20 ML/d) (Small Modder River) – CRR: 77%



Priority wetlands

Depression wetlands in C52G and discontinuous channelled valley bottom and floodplain wetlands in upper reaches in C52C and C52G *Aardoringsspruit wetland complex (DCVB and F)(ecological category C)* - a large wetland complex that includes a large wetland flat and a DCVB wetland which encompasses the Aardoringsspruit River - unusual to find a wetland flat in this part of the country.

Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchannelled VB		River	
			ha	%	ha	%	ha	%	ha	%	ha	%		
632 039	6 122.45	0.97%	2 859.67	0.45	418.69	0.07	246.91	0.04	1 813.85	0.29	35.45	0.01%	747.89	0.12

IUA 10: Modder/ Riet Rivers

Rivers	Description	SEZ	EWR site	Dams	Quaternaries	Protected Areas	PES
Modder and Riet Rivers	<ul style="list-style-type: none"> SWSA-gw across D52J, D52H and D52K Irrigation agriculture along the Riet River Diamond mine at Koffiefontein 	Agriculture and mining	<ul style="list-style-type: none"> UO_EWR09_I UO_EWR06_I UO_EWR20_FV UO_EWR16_FV UO_EWR21_FV UO_EWR22_FV <p>JBS3 sites</p> <ul style="list-style-type: none"> OSAEH_26_100 SAEH_26_5 <p>REMP sites</p> <ul style="list-style-type: none"> C5RIET-DEKRA C5RIET-IFR03 C5RIET-LILYD C5RIET-JACOB C5RIET-RICHI C5VANZ-DWNWR 	<ul style="list-style-type: none"> Rietwater Dam (FSC: 1.95 Mm³), a small storage dam at the outlet of D51A Kalkfontein Dam (FSC: 325.2 Mm³) on the Riet River in C51J – small storage dam for irrigation Tierpoort Dam (FSC: 34 Mm³) on the Riet River in C51J - small storage dam for irrigation 	C51M, C51L, C51K, C51J, C51F, C51H, C51G, C51C, C51B, C51A, C51E and C52L, C52K, C52J, C52H		C and D

Water Quality hotspots

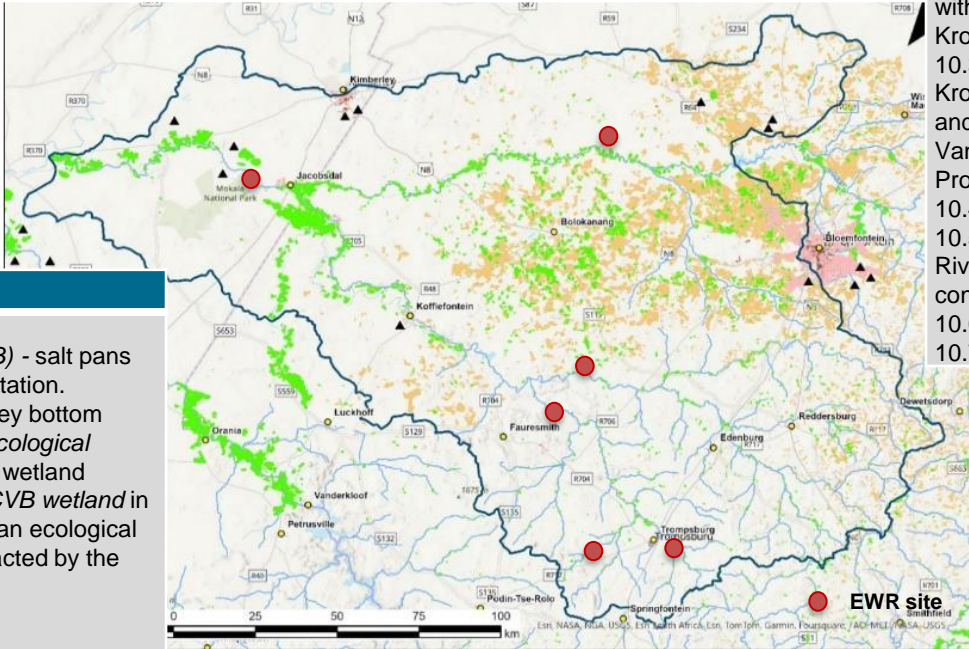
- Irrigation return-flows
- Mining impacts from the diamond mines in the Riet River catchment, specifically C51H, C51K and C51L.

RUs

- 10.1 - Modder River and tributaries Klein Kaalspruit and Kaalspruit
- 10.2 - Fouriespruit and tributaries including Fouriespruit Dam, Rietspruit and tributaries, X River and tributaries up and downstream of the Tierpoort Dam; Riet River to confluence with Kromellenboogspruit
- 10.3 - Kromellenboogspruit and tributaries Vanzylspruit and Prosserspruit
- 10.4 - Riet River
- 10.5 - Main stem Riet River to Vaal River confluence
- 10.6 - Tierpoort Dam
- 10.7 - Kalkfontein Dam

Groundwater

GRUs 10.1 and -10.2: Moderate to low groundwater recharge (<10 mm/a, 342 Mm³/a), with low contribution to baseflow (21.84 Mm³/a). Groundwater quality Class 2/3 (Good/Marginal water quality type), and borehole yield class (BYC) is a b2/b3/d2-Class (i.e., 0.1-0.5 L/s/0.5-2.0 L/s/0.1-0.5L/s in a fractured and fractured & weathered aquifer system). Groundwater use is moderate (±81 Mm³/a, and the stress index is a Good to Fair Condition, and Allocable ground water at ±239 Mm³/a.



Priority wetlands

Extensive depression wetlands throughout the IUA

- Soutpan depression wetland complex (ecological category B)* - salt pans support vegetation that is distinct from the surrounding vegetation.
- Discontinuous channelled valley bottom and channelled valley bottom wetlands Kaalspruit wetland complex (CVB, DCVB and D)(ecological category C)* - unique feature in this complex is a depression wetland nested within the channelled valley-bottom *Jagersfontein DCVB wetland* in C51H on the Kromellenboogspruit (this was categorised as an ecological category C for the Reserve studies but may have been impacted by the Jagersfontein spill, and may need to be reassessed)
- Few seeps in C52K and C51K

Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchannelled VB		River	
			ha	%	ha	%	ha	%	ha	%	ha	%		
2 846 614	62 982.20	2%	50 721.99	2	156.05	0.00	1 873.43	0.00	999.72	0.00	134.91	0.00	9 096.09	0.00%



A landscape photograph showing a river in the foreground with a dark, sandy bank. In the background, a steep, rocky cliff rises on the left, and a grassy hillside with a prominent ridge extends to the right under a clear blue sky. The scene is brightly lit, suggesting a sunny day.

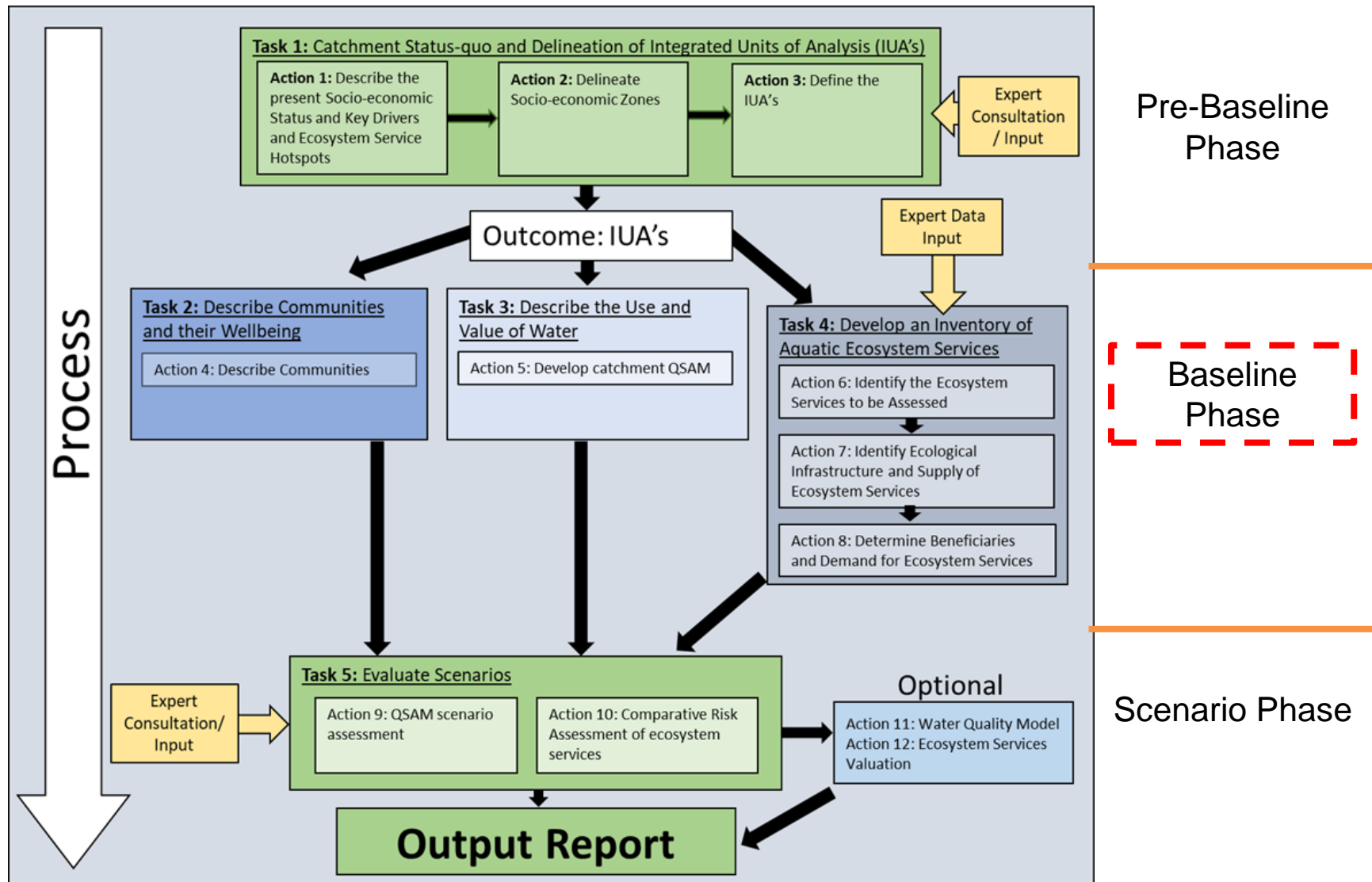
**WATER RESOURCE CLASSES AND ASSOCIATED RQOs:
UPPER ORANGE RIVER CATCHMENT, WP11422**

**Linking the value and condition of the water
resources**

Purpose

- *Step 2* of the water resource classification process, requires that:
“the quantification of the relationships that link the change in the configuration of scenarios to a resulting change in economic value and social wellbeing as they relate to the water resources”, be defined.
- This linkage step will be used to inform the evaluation of scenarios at a later stage in the WRCS process
- Linkages are assessed through to an Integrated Economic Model
- *The aim of this step* is to demonstrate the linkages between the socio-economic and ecological value and condition of water resources as they currently stand in the Upper Orange River catchment.

Socio-Economic – WRCS Process

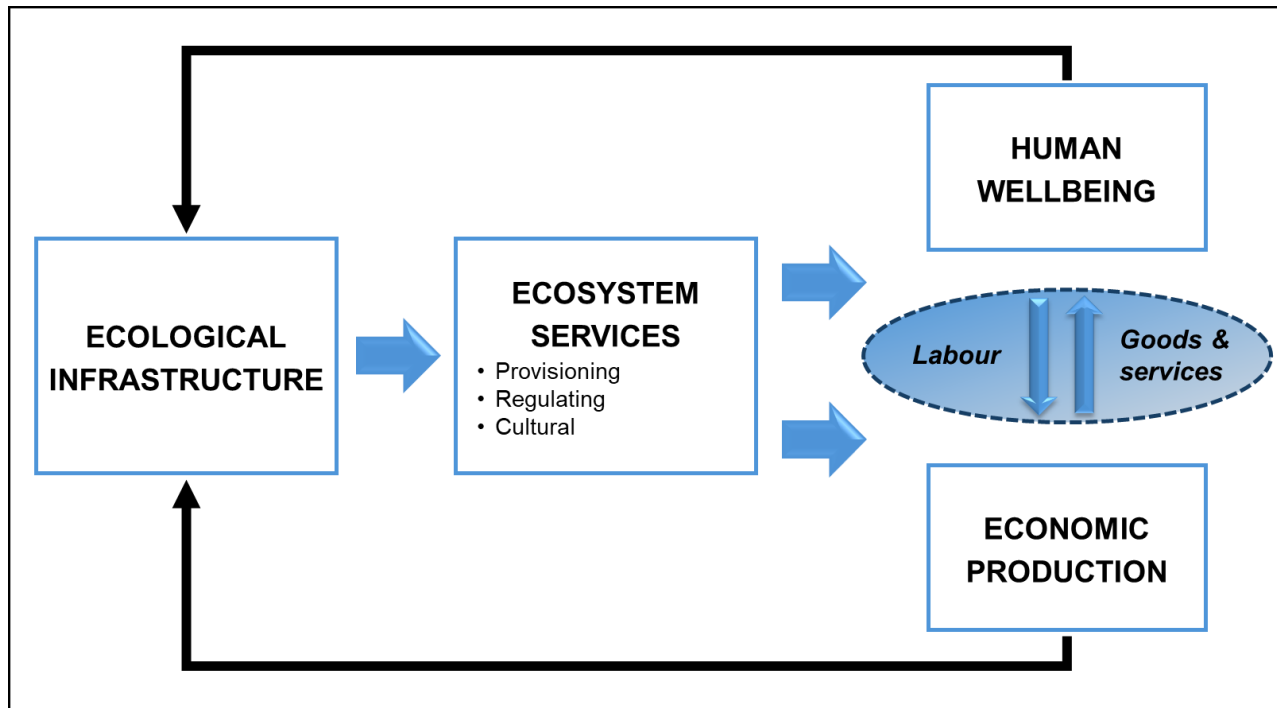


Rationale

- Ecosystems as natural features in the landscape of the catchment
Provide environmental, social and economic benefits to communities.
 - “Free” ecosystem services to a range of formal and informal beneficiaries.
- There is recognition of their importance to human well-being at various scales
- Impacts or changes to these [ecosystems](#) (or Ecological Infrastructure) alters the ability to supply valuable services to beneficiaries.
- Classification of cause-and-effect relationships (or linkages) between ecological infrastructure and beneficiaries of ecosystem services is vital to appropriately manage natural resources (e.g. water resources) in a sustainable manner

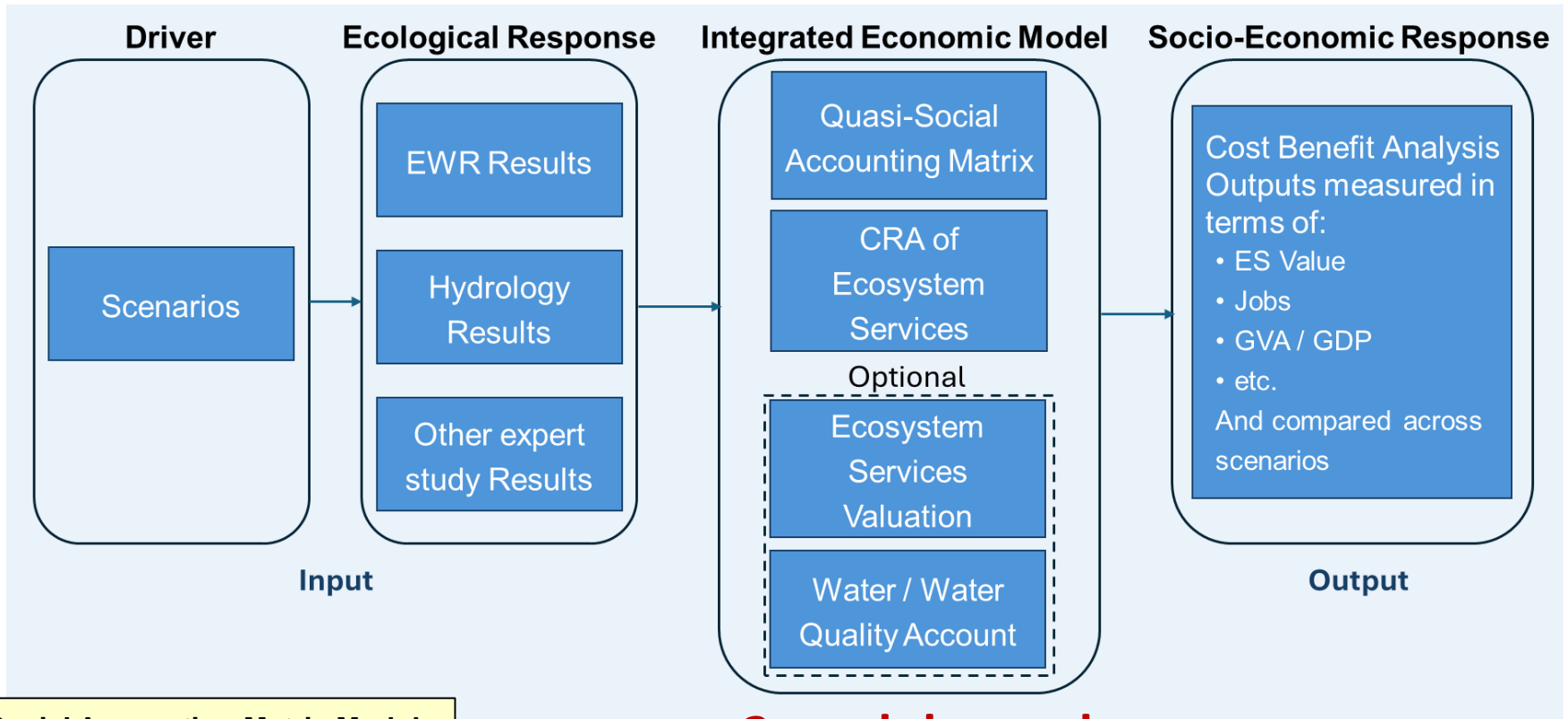
Classification of these linkages requires an understanding of role that ecological infrastructure and presence of beneficiaries (at a landscape, local & regional scale) plays in delivery of ecosystem services

Decision Analysis Framework



- Demonstrating these linkages required application and integration of numerous socio-ecological, and econometric methodologies.
- This integration required the development of Ecosystem Services Classification and Modelling, Quasi-Social Accounting Matrix (QSAM) and water account information for the Upper Orange River catchment.
- The outcome: development of an Integrated Economic Model (IEM) for the catchment towards demonstrating socio-economic and ecological linkages.
- Identification of linkages through development of IEM is precursor to quantifying these linkages, which will be conducted during scenario evaluation step.
- At that step, through the use of ecosystem service valuation the natural benefits provided by ecosystems (*identified here*) will be quantified in socio-economic terms.

Approach



Social Accounting Matrix Module

Aims to quantify the size of the Upper Orange Catchment economy. (combines the suppliers and consumers of economic products into a single matrix in order to determine the magnitude of the macro-economic indicators of the Upper Orange economy)

3 modular tools

The Water / Water Quality Account Module

Aims to define the use of water through physical flows and financial transactions. (how economic changes impact the environment, and how water availability impacts the economy)

Ecosystem Services Valuation Module

Aims to link the presence and condition of ecological infrastructure with key beneficiaries through the use of ecosystem services frameworks (TEEB framework)

Results: Ecosystem Services

- Catchment is divided into 10 Integrated Units of Analysis (IUAs)
- Broadly represent diverse socio-economic drivers, well-being & characteristics of beneficiaries of ecosystem services in catchment
- Based on variation in distribution of ecological infrastructure:
 - each IUA benefits to varying degrees from flow and direct use of ecosystem services.
 - Variation between beneficiaries is further subdivided into formal and informal users.

Results: Ecosystem Services

Key ecosystem services identified and prioritised across the Upper Orange River catchment include:

1. Fresh Water Provisioning
2. Water Quantity Regulation
3. Food, Raw Materials and Wild Collected Products Provisioning
4. Erosion Regulation
5. Water Quality Regulation: Purification and Waste Management
6. Tourism, Recreational and Amenity Services; and
7. Biodiversity Support.

Ecosystem Services in the Upper Orange

	Fresh Water Provisioning	Water quantity regulation (Flow Regulation)	Erosion control/Soil Stability	Water Quality Regulation: Purification and waste management	Food, Raw Materials and Wild Collected Products Provisioning	Tourism, Recreational and Amenity Value	Biodiversity Support
Key Ecological infrastructure	Rivers, Streams, Dams and Aquifers	Wetlands, and Strategic Groundwater Areas	Rivers, Tributaries, and Wetlands	Wetlands and Strategic groundwater areas	Orange River and its tributaries; Wetlands	Protected Areas, Orange River and its tributaries and Wetlands	Protected Areas and nature reserves
Beneficiaries	Agriculture; Mining; Manufacturing ; General Government; Wholesale & retail trade, catering & accommodation; Community Services	Agriculture; Mining; Manufacturing; General Government; Wholesale & retail trade, catering & accommodation; Community Services	Agriculture	Agriculture; Mining; Manufacturing; General Government; Wholesale & Retail Trade, Catering & Accommodation; Community Services	Community, Social & Personal Services; Agriculture (subsistence and commercial)	Community, Social & Personal Services; Trade, Catering & Accommodation	Agriculture; Community, Social & Personal Services; Trade, Catering & Accommodation
Use	Direct use value	Direct and indirect use	Indirect use	Indirect use	Direct use	Direct use	Indirect use

Upper Orange Catchment Economy

- Stretches across an area that covers parts of the Free State, Northern Cape and Eastern Cape provinces, with the largest proportion within the Free State province.
- Catchment contributes an estimated Gross Domestic Product (GDP) of R82.3 billion (based on municipal economic data of 2019) (NT, 2021).
- Largest contribution to the GDP of the catchment is from the tertiary sector (74.5%) with the key contributions from financial services (20%), the wholesale & retail, catering & accommodation sectors (tourism playing an important role) contributing 17%, followed by general government (15%).
- Manufacturing, part of the secondary sector contributes 12% to the overall catchment GDP. The primary sector's main contribution to the catchment GDP is from agriculture (4%).

Ecosystem Services Linkages

Final Ecosystem, Services	General Sector	QSAM Beneficiary Class	
Food Provisioning	Informal Households	Informal, illicit, non-profit, and households	
	Agriculture	Agriculture	
Fresh Water (water quantity) Provisioning	Households (formal and informal)	Informal, illicit, non-profit, and households Households	
	Agriculture (irrigation)	Agriculture	
	Mining	Stone	
	Manufacturing		Meat, fish, fruit, vegetables, oils and fats, dairy, grain and animal feeds, other food products, beverages, tobacco
			Textiles; Other textiles; Knitted fabrics; Wearing apparel; Leather; Footwear; Sawmilling of wood Wood products; Paper; Publishing; Printing and reproduction; Basic chemicals; other chemicals Rubber; Plastic; Glass; Non-metallic minerals
			Iron and steel; Casting of metals; Structural metal; Other fabricated metal
	Manufacturing	General purpose machinery; Special purpose machinery; Household appliances; Computing machinery; Electric motors; Other electric components; Television and radios; Medical appliances; Motor vehicles; Vehicle bodies; Vehicle parts; Equipment; Furniture; Other manufacturing and recycling.	
	Government Services	Electricity; Water; Sewage and refuse	
Raw Materials Provisioning	Informal Households	Informal, illicit, non-profit, and households	
Medicinal resources Provisioning	Informal Households	Informal, illicit, non-profit, and households	
Tourism, Recreational and Amenity Services	Catering & accommodation	Hotels; Restaurants	
		Real estate activities (Lease and Fee basis)	
	Households	Informal, illicit, non-profit, and households	
		Households	
Community, social & personal services		Recreation (Sporting and other recreational activities)	

Ecosystem Services Linkages

- Sectors identified to be directly linked as beneficiaries of ecosystem services are :
 - predominantly through provisioning and regulation of fresh water
 - also links through cultural services including tourism, recreational and amenity values
- The agricultural sector (irrigated agriculture), agro-processing, households and government sectors are highlighted as key contributors to the water economy within the Upper Orange catchment. These contributions indicate linkages between the requirement of freshwater provisioning services on the sectors themselves and thus indicate linkages between production and natural benefits.
- It is important to note contributions to water economy do not directly translate to quantity of water utilised by a sector due to different allocated tariffs for water purchased
- Tourism, as a prominent formal sector present within the catchment, although not a significant water consumer, is directly underpinned by cultural services provided by the ecosystems that are present within the catchment. The water provisioning services include natural water and treated water.
- The agricultural sector is composed of dryland, irrigated and livestock agriculture with the latter two directly reliant on water provisioning services - largely due to irrigation demand through the significant proportion of irrigation agriculture within the catchment, but additionally to livestock watering demand from the extensive livestock agriculture taking place within the Upper Orange River catchment. Agricultural manufacturing contributes to the catchment water economy through both natural (raw water) and treated water purchases.
- This sector, particularly food processing and beverages, represents an important part of the overall manufacturing sector within the catchment.

Ecosystem Services Linkages

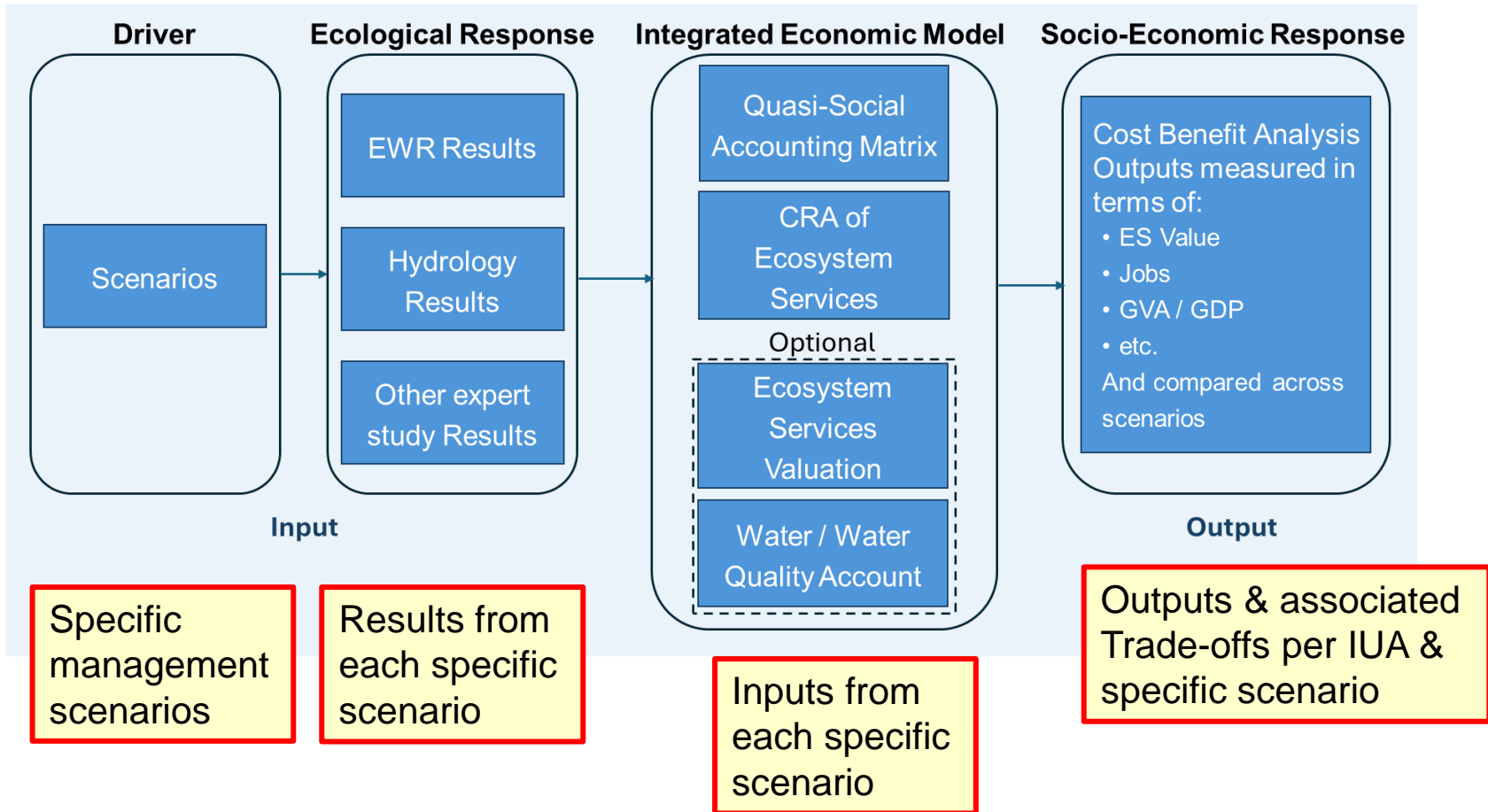
- Other manufacturing within the catchment such as light manufacturing, service orientated industries and brick manufacturing also contribute to natural and treated water purchases.
- The linkages with cultural ecosystem services provided by key ecological infrastructure have direct linkages to the presence of ecological features associated with tourism and recreational activities, such as dams, particularly the two large dams of Gariep and Vanderkloof and their adjacent nature reserves, national parks (Golden Gate, Mokala, and Vaalbos), several game farms and nature reserves (government and private) and protected areas.
- Several densely populated rural settlements throughout the catchment and these areas have a relatively small formal economy but where there is an important informal economy.
- Benefits are derived through provisioning of food, collection of raw materials, medicine and fresh water, regulation of water and soils and cultural and spiritual services provided by the rural landscape.
- The dynamic relationship observed here is twofold:
 - Firstly: the value of these natural benefits to communities who rely directly on them, coupled with limited access to alternatives translates very differently to Rands and Cents compared to economic production, *for example the value of drinking water (necessary for survival) versus the value of irrigation water (necessary for production)*.
 - Secondly: the cause-and-effect relationships of economic development and social wellbeing need to be carefully balanced when implementing management scenarios that influence these beneficiaries, *for example, an increased water allocation to industry may create jobs (economic wellbeing), however it could translate to a reduced condition of ecosystems and therefore impact on these vulnerable communities (reduced social wellbeing). Conversely, water management that increases flow (reduced abstraction) would likely benefit these vulnerable communities through increased ecosystem services flow.*

The way forward

- The analysis has demonstrated that the socio-economic structure of the catchment is highly reliant on various ecosystem services.
- These ecosystem services will be considered and included in the evaluation of scenarios step to follow in the WRCS process.
- The ecosystem services valuation approach will be utilised towards evaluating trade-offs against varying water management scenarios.

The way forward

During Scenario phase:



Definitions

- *Ecological infrastructure* refers:
 - to functioning ecosystems that deliver valuable services to people such as fresh water, water and climate regulation, cultural services and soil formation.
- *Ecological Infrastructure*:
 - is the nature-based equivalent of built or hard infrastructure which includes features such as wetlands, rivers and other watercourses, forests and entire catchments.

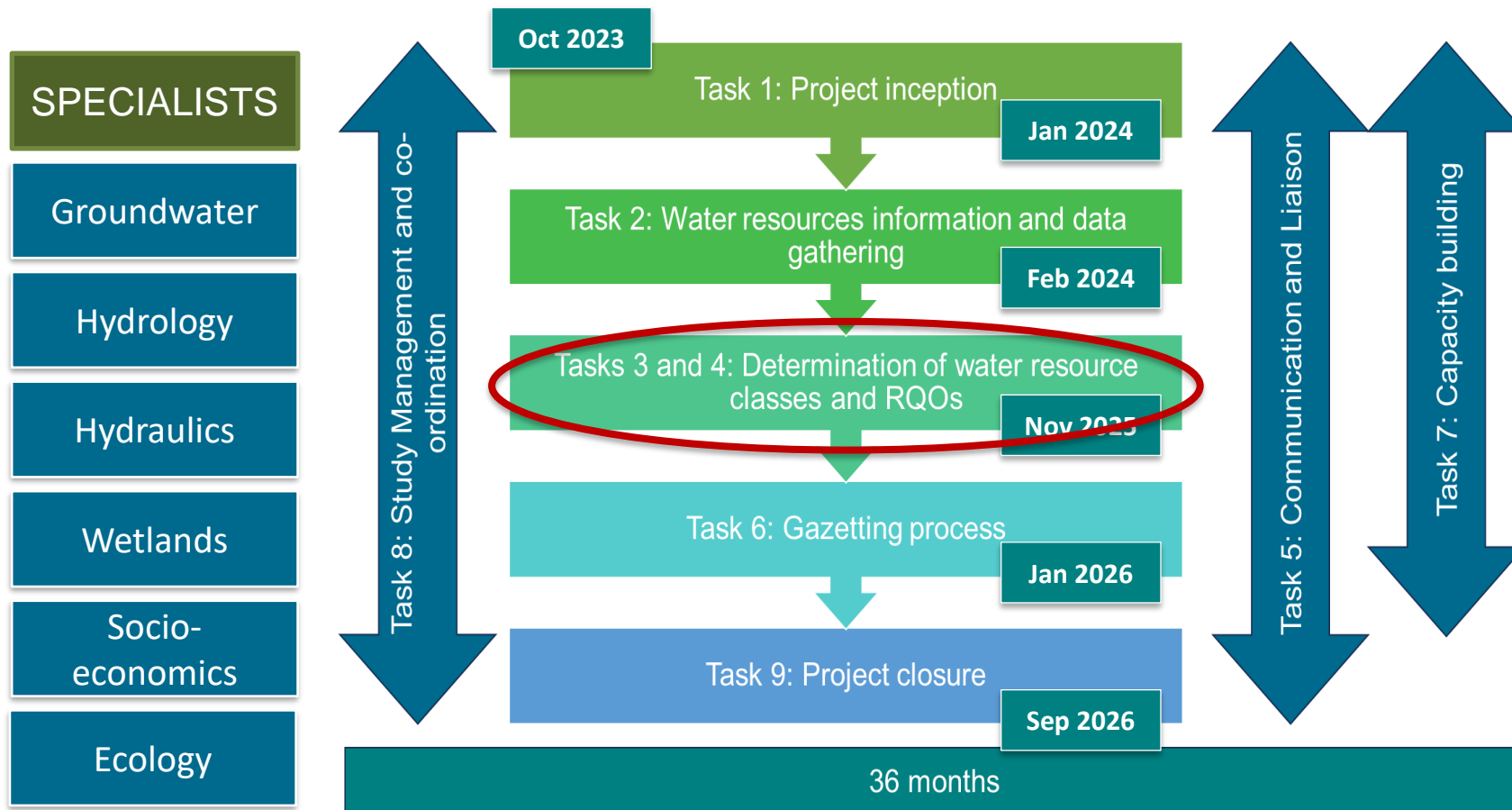
[Back](#)



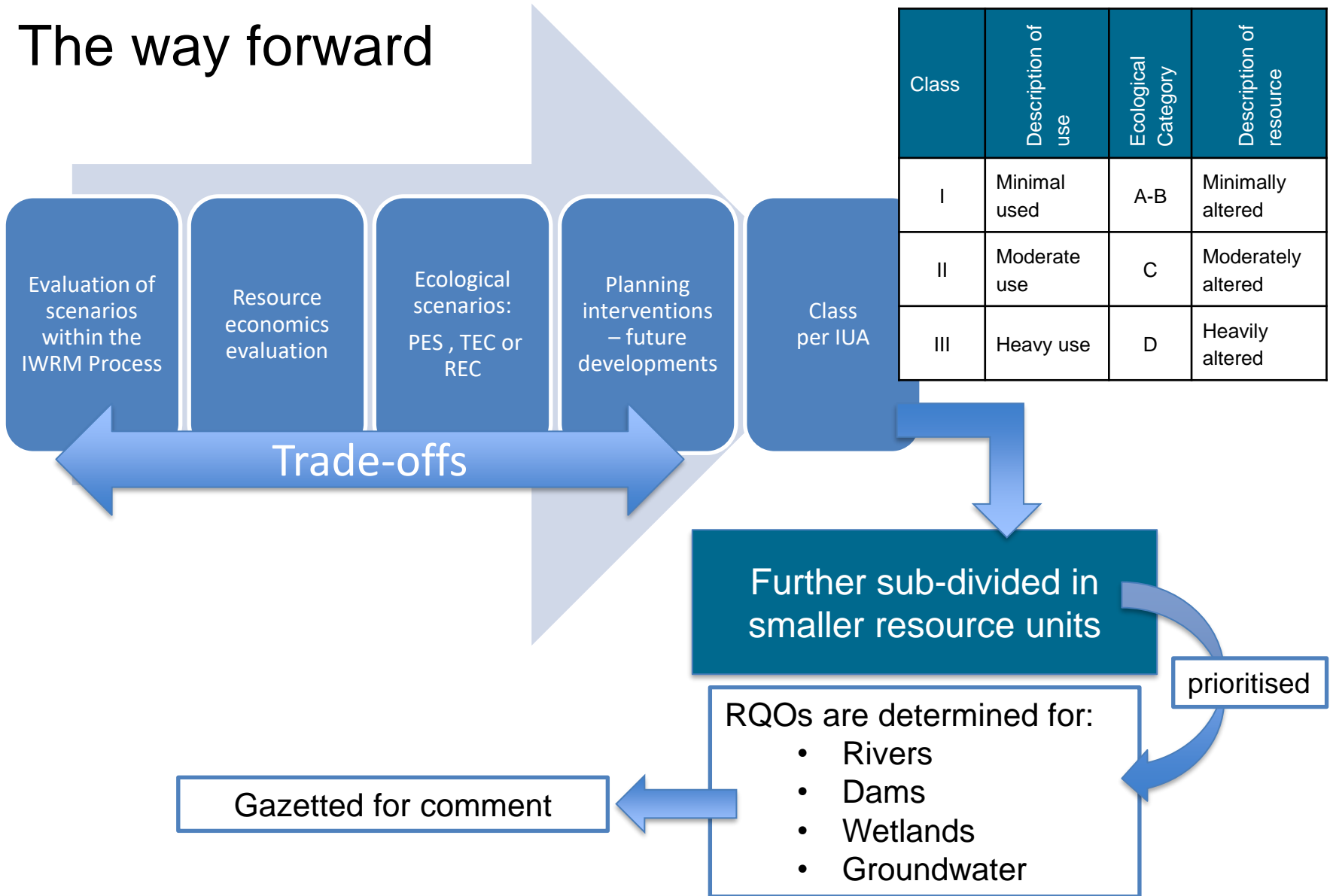
**WATER RESOURCE CLASSES AND ASSOCIATED RQOs:
UPPER ORANGE RIVER CATCHMENT, WP11422**

In Summary and next steps

Flow of the study tasks and high-level timeframes



The way forward





Thank You